FORAMINIFERAL ASSEMBLAGES FROM A SEDIMENT CORE FROM THE INNER SCOTIAN SHELF: IMPLICATIONS FOR TILL-TONGUE STRATIGRAPHY AND PALEOCEANOGRAPHY

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Abstract

The inner Scotian Shelf juxtaposes the Nova Scotia coastline, ending at the 100 m bathymetric contour, and consists of several zones based on seismic sequences and sea-bottom morphology. At the maximum extent of the last glaciation (Wisconsinan), ice covered almost the entire Scotian Shelf. Micropaleontological and lithological analysis of a 534 cm sediment core (Secunda 93 Core 5), collected from the Basin Zone of the inner Scotian Shelf using the Rossfelder® vibracorer, provides information that permits reinterpretation of till-tongue sediment stratigraphy and determination of new paleoceanographic implications for the inner shelf. Core 5 was subsampled, examined for foraminifera, and divided into foraminiferal assemblage zones based on visual interpretation of foraminiferal species composition and abundance. Seismically, Core 5 penetrates through La Have Clay into acoustically incoherent sediments previously interpreted as till-tongues. Lithologically, the acoustically incoherent section of Core 5 exhibits deformation. Foraminiferal assemblages present in the incoherent sediments are identical to the *Elphidium excavatum* forma *clavatum/Cassidulina reniforme* assemblage typical of the acoustically coherent glacial marine Emerald Silt, implying that till-tongues, believed to be wedge-shaped lenses of till formed by oscillations of the glacial margin, are instead deformed glacial marine sediments. Tertiary-Cretaceous (T-K) foraminifera occur in the lower part of Core 5, eroded from their original depositional site by glacial activity. Presence of T-K foraminifera suggests that the present contact location between the sedimentary Mesozoic-Cenozoic (M-C) wedge and the Meguma basement is inaccurately mapped and: a) the contact was once inland of Core 5, rather than the present contact location seaward of Core 5; or b) M-C sediments still underlie the late Quaternary sediments; or c) outliers of M-C sediments still underlie the late Quaternary sediments. Unlike previous studies from further offshore, Core 5 foraminiferal assemblages suggest no mid-Holocene warming period, indicating that the warmer Gulf Stream waters did not influence the inner Scotian Shelf as strongly as the outer Scotian Shelf. An *Adercotryma glomerata/Spiroplectammina biformis* assemblage, indicating a cold water period, occurs from approximately 160 cm to 260 cm in Core 5, but is absent in cores from previous studies. Carbon-14 dates of approximately 8500 years before present occur just above and just below this cold water assemblage, but have no explanation at this time.

KEYWORDS: benthic foraminifera, reworked Tertiary-Cretaceous foraminifera, inner Scotian Shelf, till-tongues, Mesozoic-Cenozoic sedimentary wedge, paleoceanography

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CHAPTER 1 INTRODUCTION

1.1 Introduction

At the maximum extent of the late Pleistocene (Wisconsinan) glaciation, ice probably covered the entire Scotian Shelf, and the retreat of this ice sheet resulted in deposition of a series of recessional moraines, originally defined as end-moraines (King 1969). End-moraines are glacial deposits of till that indicate the terminus of glacial advance, and recessional moraines are similar deposits at intervals as the glacial ice is retreating.. King (1969) first described submarine end-moraines at the seaward edge of the inner Scotian Shelf, which borders mainland Nova Scotia out to 25-30 km offshore, ending at the 100 m bathymetric contour. King (1970) mapped the surficial geology of this area. A synthesis of work carried out on the Quaternary geology of the Scotian Shelf between 1969 and 1986 appears in King and Fader (1986). That work defines the surficial geology of the Scotian Shelf; summarizes the geological formations present (King 1970), including the Scotian Shelf Drift (a till deposit), the Emerald Silt (a stratified proglacial deposit formed immediately beyond the ice terminus), and the La Have Clay (a Holocene pelagic sediment); and describes newly-recognized geological features such as till-tongues.

King and Fader (1986) introduced the term till-tongue to refer to wedge-shaped lateral extensions of ice-margin till deposits, the poorly-sorted debris deposited directly from glacial ice. Till-tongues interbed with stratified glacial-marine sediments deposited beyond the ice margin, and King *et al.* (1991) believed that till-tongues result from oscillations of the grounding-line of the glacial ice sheet. Till-tongues commonly occur within the Emerald Silt Formation and at the transition between the Scotian Shelf Drift and Emerald Silt Formations, on the continental shelf, offshore Nova Scotia. Because till-tongues are defined as till on the basis of seismic traces only, the origin and nature of till-tongue sediment is problematic.

King and Fader (1986) first described till-tongues based on seismic reflections, and King *et al.* (1991) detailed till-tongue stratigraphy. The core examined in this study comes from a known till-tongue section, as determined by seismic records from Stea *et al.* (1994). Because this core is one of the first samples of till-tongue sediment, its micropaleontological and lithological documentation should help to define the depositional origin and nature of such deposits.

The core examined in this study comes from a region of the inner shelf not previously sampled. Studies on this area of the inner Scotian Shelf include those by Forbes *et al.* (1991), who described surficial sediments and acoustic stratigraphy, and Stea *et al.* (1994), who examined morphology and seismic stratigraphy. Paleoceanographic information from this core is relevant to previous paleoceanographic work, which is either offshore (*e.g.* Scott *et al.* 1984) or on the edge of a deltaic sequence (Costello 1994).

Another aspect of this investigation is the occurrence of Tertiary-Cretaceous (T-K) foraminifera in the Emerald Silt sequence. These T-K forms are well-known reworked components offshore, but the specimens in this core are the first discovered inshore of the mapped contact of the Mesozoic-Cenozoic (M-C) wedge with the Meguma basement (King and MacLean 1974). Scott and Medioli (1988) discussed reworked T-K material on the Scotian Shelf.

Foraminifera belong to the Subphylum Sarcodina, Class Rhizopoda (Loeblich and Tappan 1964). Foraminifera are unicellular organisms that differ from other Sarcodina by possessing one of three types of mineralized unichambered or multichambered tests: i) calcareous tests secreted by the organism, ii) agglutinated tests consisting of particles cemented together by the organism, and iii) chitinous tests (Boersma 1978). Foraminifera can be free-floating (planktonic), although the majority of foraminiferal species are bottom dwellers (benthic). Because of the relationship foraminifera have to various physical and chemical environmental variables, such as temperature and salinity, foraminiferal assemblages are useful indicators of particular environments and, by inference, paleoenvironments. Williamson (1983) and Williamson *et al.* (1984) documented foraminiferal distributions on the Scotian Shelf and their correlation to various aspects of the marine environment, including depth, temperature, salinity, and substrate composition.

1.2 Physical Setting And Regional Geology

Stea *et al.* (1994) used sea-bottom morphology and seismic sequences and facies to divide the inner Scotian Shelf into five coast-parallel zones: (i) the Truncation Zone, (ii) the Morainal Zone, (iii) the Outcrop Zone, (iv) the Basin Zone, and (v) the Scotian Shelf End-Moraine Zone. The Truncation Zone shows muted acoustic topography, extensive planar erosional surfaces truncating bedrock, and sediments covering bedrock (Stea *et al.* 1994). The Morainal Zone shows unmodified ridges of till overlying bedrock (*e.g.* King 1969; King and Fader 1986; Forbes *et al.* 1991). The Outcrop Zone shows high relief bedrock with ridges and valleys, without significant surficial sediments (Forbes *et al.* 1991). The Basin Zone consists of closed basins in water depths greater than 150m, containing three seismic facies: the Scotian Shelf Drift, the Emerald Silt, and the La Have Clay (King and Fader 1986). The Scotian Shelf End-Moraine Complex is a series of large ridges occurring 30-40 km offshore, at the seaward edge of the inner shelf (King 1969).

Three main water masses (Fig. 1.1) dominate the present surface-water oceanography on the Eastern Canadian Shelf: i) the Inner Labrador Current, which flows around Newfoundland and across the Scotian Shelf to the southwest, has a salinity of 31-33 ‰ and a temperature of 0-3 °C; ii) the Outer Labrador Current, which diverges off the coast of Newfoundland and flows around the Grand Banks, has a salinity of 34-35 ‰ and a temperature of 2-4 °C; and iii) a Gulf Stream-Slope water mixture, which flows across the southwest part of the Scotian Shelf, has a salinity of 34.5 ‰ and a temperature of 8-10 °C (Williamson *et al.* 1984; Scott *et al.* 1984). Bottom waters on the Scotian Shelf result from the mixing of these surface-water masses. Temperature and salinity variations, summarized in Figure 1.2, characterize the bottom-water masses.

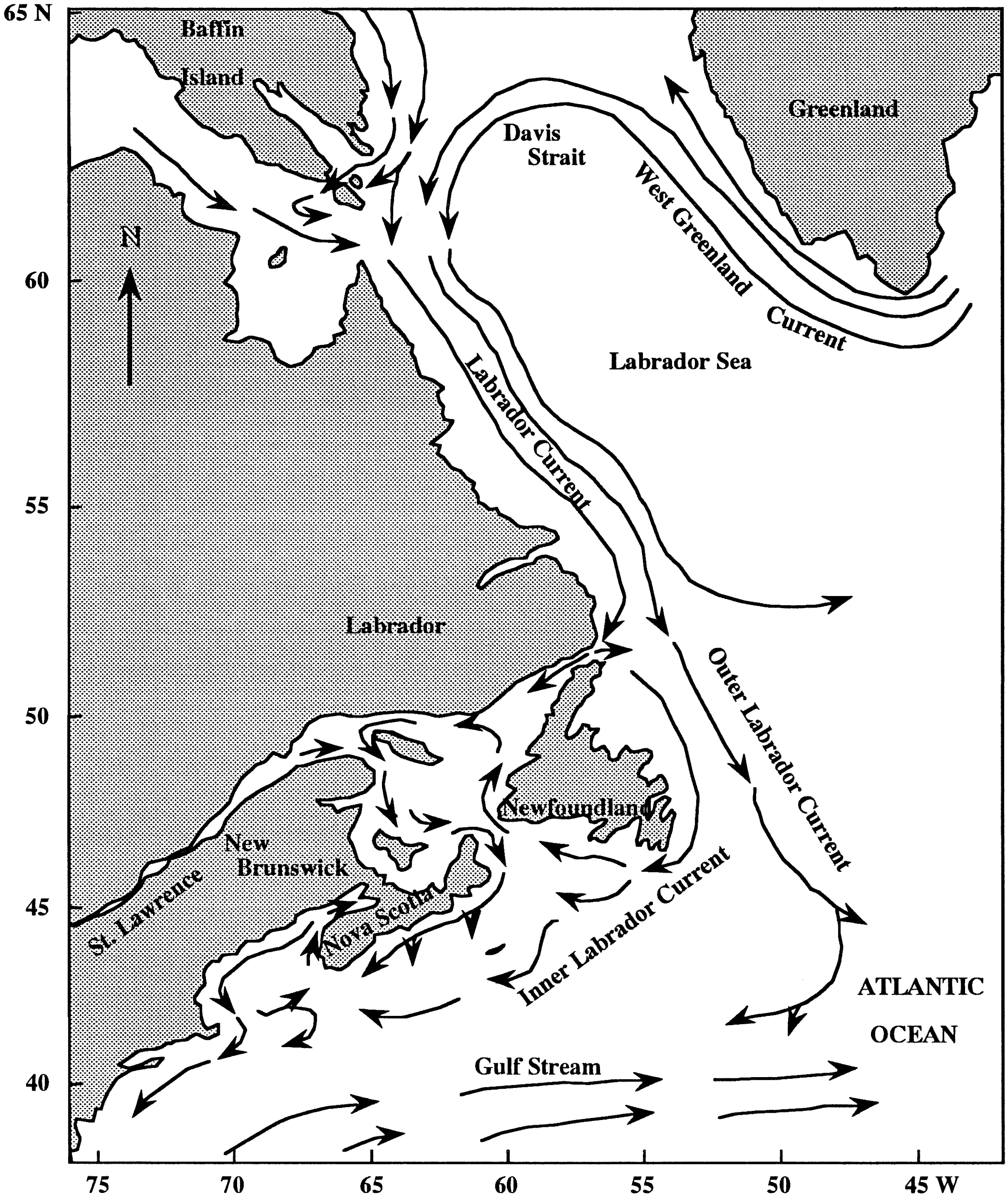
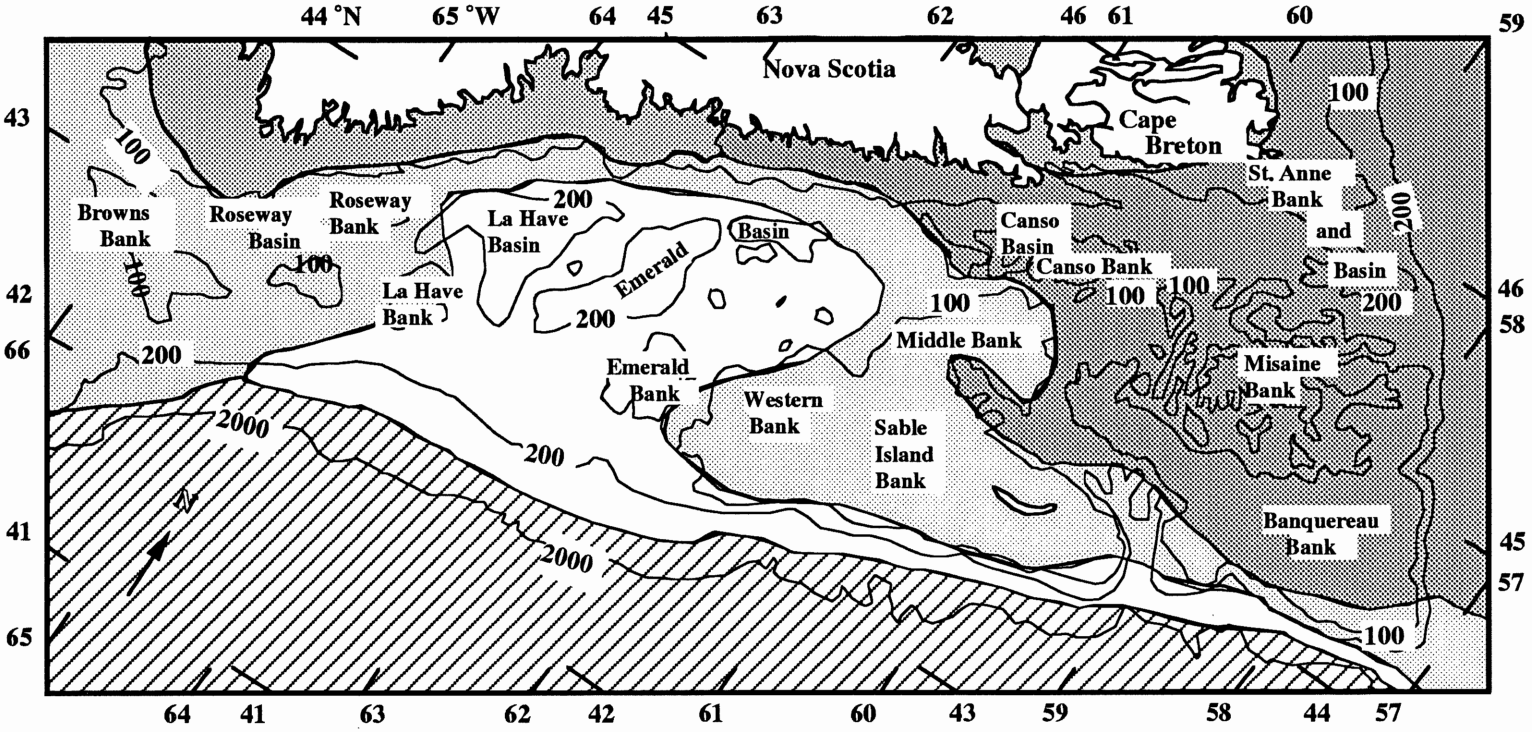


Figure 1.1 Modern surface oceanographic current patterns present offshore Nova Scotia (after Williamson 1983).



1 Salinity 32.3 ‰, temperature 0-4 °C. Subsurface water from Cabot Strait and St. Lawrence. Inner Labrador Current origin.

2 Salinity 31.8 ‰, temperature 3-6 °C. Surface water from Cabot Strait and St. Lawrence.

3 Salinity 33-34 ‰, temperature 4-8 °C. Similar to 1 but warmer. A product of 1 and 4 (slope waters).

4 Salinity 35 ‰, temperature 8-12 °C. Water dominated by slope characters of maximum temperature and salinity. Some mixing with 1 and 2.

5 Salinity 34.5-35 ‰, temperature 4-6 °C. Deep Atlantic water.

Figure 1.2 Bottom water masses and their characteristics on the inner Scotian Shelf (after Williamson 1983).

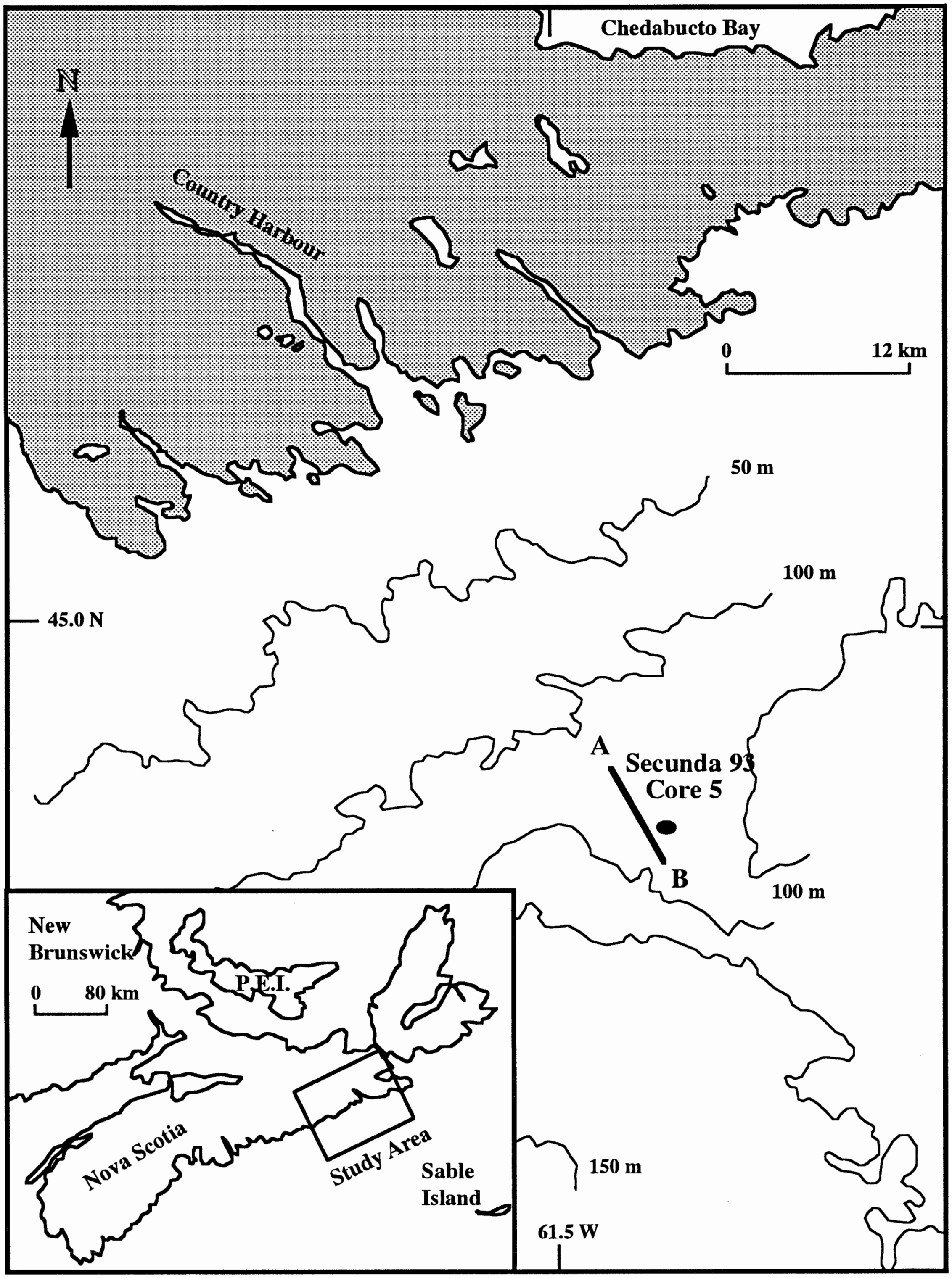


Figure 1.3 Map showing location of Core 5 (after Stea 1995). Line A-B is the portion of a seismic line (Fig. 3.2) from Cruise Dawson 91-018 that runs closest to Core 5.

The core in this study is located at 44°51.46' N and 61°24.07' W, on the inner Scotian Shelf, at a water depth of 150m, in the Basin Zone of Stea *et al.* (1994). Seismic data in Stea *et al.* (1994), collected in 1991, determined the location for coring (Fig. 1.3). The water mass now overlying the study area is the Inner Labrador Current.

1.3 Purpose And Scope

The purpose of this work is three-fold: (i) to use the sedimentological and micropaleontological examination of core Secunda 93 Core 5 to help define the origin and composition of till-tongues; (ii) to deduce paleoceanographic implications from this core, and to compare these implications with the results of previous work including Scott *et al.* (1984, 1989), Williamson *et al.* (1984), Freeman (1986), Souchen (1986), and Costello (1994); and (iii) to discuss implications of T-K foraminifera present in Core 5 with respect to the present boundary of the M-C sedimentary wedge.

The scope of this work includes lithological data, described by R.R. Stea and D.B. Scott, and micropaleontological data from Core 5, which covers a Late Quaternary sequence on the inner Scotian Shelf; carbon-14 dates obtained from Core 5; seismic stratigraphy of the area where the core was collected; and comparison with previous work.

1.4 Organization

Chapter 2 describes the methods used in obtaining and analyzing the core. This separate chapter for methodology is necessary because of the variety of available micropaleontological techniques. Chapter 3 describes observations and data, including core lithology, carbon-14 dating, seismic stratigraphy, and micropaleontology. A discussion of these results follows in Chapter 4, which expands the current definition of till-tongues, compares paleoceanographic implications of previous work, and examines the implications of T-K foraminifera in the lower part of Core 5. The final chapter summarizes the conclusions of the work and makes recommendations for future work.

CHAPTER 2 METHODS

2.1 Introduction

In 1993 Dalhousie University obtained a deep-sea vibracorer that can penetrate deposits that are impossible to obtain with standard techniques such as piston-coring. Availability of this equipment allowed collection of Core 5, in 1993, while seismic data from Stea *et al.* (1994) determined the coring location. This chapter describes the methods used for collecting the seismic data, obtaining the core, sampling the core, and processing and analyzing the samples.

2.2 Seismic Analysis

In the summer of 1991, during Cruise 91-018 on the *CSS Dawson*, Stea *et al.* (1994) collected seismic data used to determine the location for Core 5, using various methods including the Huntec Deep Tow boomer system, to generate high resolution analogue seismic data, and the Bedford Institute of Oceanography sidescan and Klein sidescan sonar systems, at varying frequencies, to obtain sea floor topography and reflectivity. The seismic data were accompanied by samples taken by grab or by shallow vibracore. Stea *et al.* (1994) presented details of the collection of seismic data used to determine coring location for Core 5.

2.3 Vibracoring

Vibracoring is an efficient method by which to obtain cores of unconsolidated sediments saturated with water. The instrument used to obtain Core 5 was the Rossfelder® Vibracorer, a concise description and figures of which appear in Edgecombe (1994). The vibracorer is submerged and, once it reaches the bottom, is turned on using electricity from the ship to supply the motor that then generates 11 000 lbs of vertical force to penetrate through muds, sands, and most stiff clays. This particular instrument has a buoyant frame which assists in operation of the equipment at depths of up to 500 m, greater than other conventional methods of vibracoring. During drilling and retrieval, the ship must maintain its position so that pull-out of the vibracorer is vertical. Non-vertical pull-out may result in loss of or damage to the core or equipment.

2.4 Core Analysis And Sampling

A core-splitting device located at the Bedford Institute of Oceanography cut the core lengthwise into two equal sections. The archive half of the core was then described and photographed by D.B. Scott and R.R. Stea. These descriptions and photographs appear in Appendices A and B respectively.

Sampling of the core involved removal of approximately 10 cc volumes of sediment at intervals down the length of the working half of the core. Samples were removed above and below any change in colour or lithology, and at 20 cm intervals when core material was homogeneous. After removal of material, gaps were filled with pieces of Styrofoam to maintain core integrity during storage. Core 5 is currently in refrigerated storage at the Atlantic Geoscience Centre, Bedford Institute of Oceanography, Dartmouth, Nova Scotia.

2.5 Sample Processing For Foraminiferal Analysis

Samples taken from the core were shaken gently to ensure disaggregation. Material was then placed in a 63 micron sieve, washed with household dish detergent, and rinsed clean. A 63 micron sieve allows the removal of smaller silts and clays while retaining larger particles, including sand grains and foraminiferal tests. The material remaining in the 63 micron sieve was placed in plastic vials and slowly dried at 50 °C in a drying oven.

After drying, the samples were floated using a heavy liquid, in this case carbon tetrachloride (CCl_4), which has a specific gravity of 1.59. Foraminifera, because of the hollow chambers of the tests, float on the CCl_4, whereas the denser sand grains sink. This procedure results in concentration of the foraminifera from the dried sample on the surface of the heavy liquid. The floating portion (the float) was then decanted into a filter paper and allowed to dry, and the remaining material (the sink) was allowed to dry and returned to the plastic vial.

2.6 Foraminiferal Analysis

The dried and concentrated floats were examined microscopically to determine abundance of foraminifera in each sample. Those samples that appeared to contain large amounts of foraminifera were split into fractions using an Otto dry splitter. Sufficient fractions of each sample were then examined to include at least 300 specimens, the minimum number of specimens at which the sample can be considered statistically valid for micropaleontological analysis. Foraminiferal specimens were identified and counted using a Zeiss binocular microscope with 10x, 12x, 16x, 20x, 25x, 32x, and 40x magnifications.

2.7 Carbon-14 Dating

Carbon is an element ubiquitous in living matter. Plants ingest carbon, as CO_2, for use in photosynthesis, and the carbon is incorporated into animals as they ingest the plants. Carbon occurs in two stable forms, carbon-12 and, less commonly, carbon-13, and a radioactive form, carbon-14. Carbon-14 forms in the upper atmosphere when high energy cosmic rays bombard various atoms in the atmosphere, causing their nuclei to split into protons and neutrons (Fig. 2.1). When a freed neutron strikes an atom of nitrogen-14, causing it to lose a proton, an atom of carbon-14 forms. Carbon-14 decays with a half-life of approximately 5730 years. After the organism dies, atmospheric carbon no longer replaces carbon in the tissues, and the decreasing ratio of carbon-14 to the non-radioactive carbon in a sample, as the carbon-14 decays back to nitrogen-14, allows dating of the organism, provided the sample is less than about 30 000 years old (Monroe and Wicander 1994).

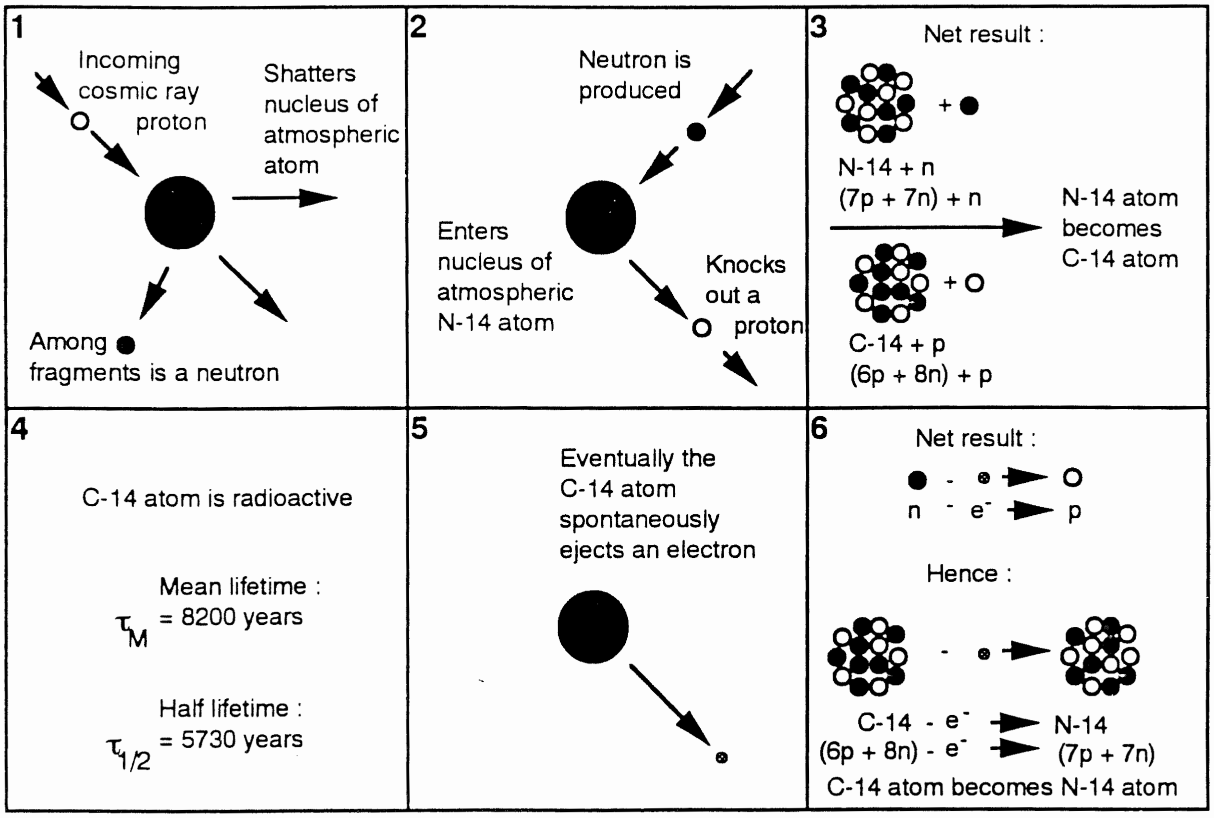


Figure 2.1 Generation of carbon-14 in the atmosphere (after Broecker 1974).

Carbon-14 recirculates longer in the ocean than on land before being taken up by organisms. Therefore, the carbon-14 taken up by an organism may be anywhere up to 1300 years older than the organism, meaning that the organism is younger than the carbon-14 date indicates. An average of 450 years for samples in the North Atlantic would be subtracted from the carbon-14 dates to give reservoir-corrected dates for the organisms being dated (Mangerud 1972).

Carbon-14 dates were obtained from two samples in Core 5, at 150-151 cm and 270-271 cm. All foraminifera in these samples were hand-picked to provide sufficient quantities of carbon for the accelerator mass spectrometry (AMS) dating process. Kreuger Enterprises, which carried out the AMS carbon-dating, hydrolyzed the sample with HCl under vacuum. The carbon dioxide released by this process is collected and analyzed with a mass spectrometer to obtain carbon-14/carbon-12 ratios.

CHAPTER 3 RESULTS

3.1 Introduction

This chapter presents the results of an analysis of Core 5, including the lithological core description, seismic stratigraphy of the area near Core 5, carbon-14 dates on core material, and the foraminiferal analyses carried out on the core.

3.2 Core Lithology

Core 5 is 534 cm in length (Fig. 3.1). The original core description appears in Appendix A and photographs of the core appear in Appendix B. From 534 cm to 391 cm, the sediment in the core, which appears to be originally layered, exhibits deformation, contortion, and overturning of the layers. The sediment is a mixture of brown sand and olive grey sandy mud, with shell fragments throughout the layer. From 391 cm to 360 cm the core contains light brown-olive grey sand, with a high concentration of shell material appearing between 386-388 cm. From 360 cm up to 260 cm the sediment is olive grey sandy mud, with some large shells appearing between 317-347 cm. From 260 cm to 180 cm the sediment is light brown, thinly layered mud, with some black layers present. From 180 cm up to 160 cm, a brown mud layer with black mottling occurs. A wavy contact occurs at 160 cm. From 160 cm to 120 cm the brown and black mottled layer reappears, alternating with olive grey mud. From 120 cm to 44 cm, the sediment is again olive grey mud, with shell material occurring throughout. The top 44 cm of the core consist of brown mud, with mottling and black layers present.

3.3 Foraminiferal Assemblages

Definition of foraminiferal assemblages involves determining abundances of each species and diversity of species present. Criteria used to determine assemblage boundaries are subjective and qualitative, and involve visual interpretation of the data (Figure 3.1;

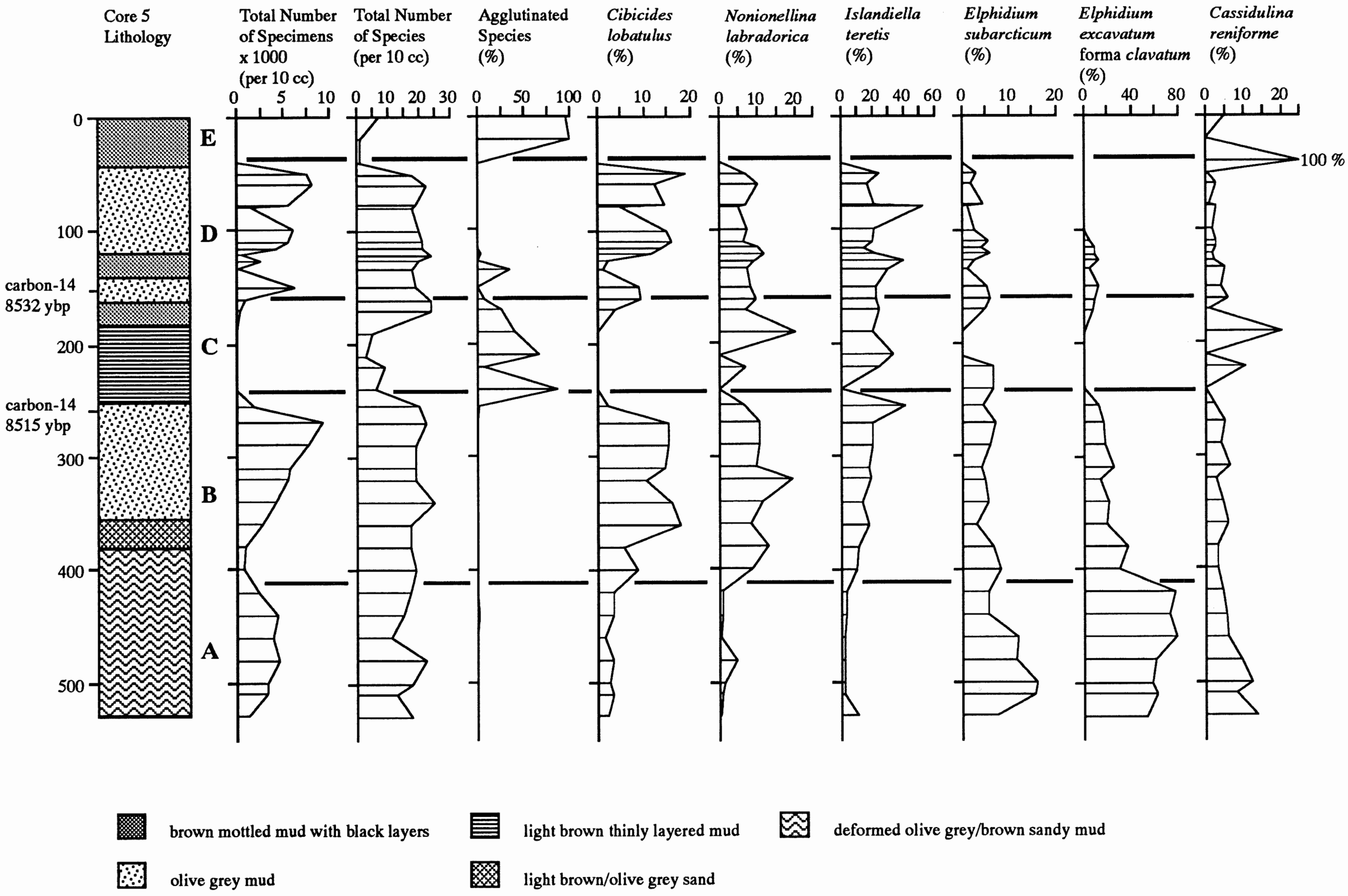


Figure 3.1 Profiles of foraminiferal abundances versus depth in cm, core lithology, and carbon-14 dates for Core 5. A-E are foraminiferal assemblages.

Appendix C), including species composition and abundance. Assemblage boundaries are based on changes in species dominance trends. Correlation with lithological boundaries also aids in locating assemblage boundaries. Figure 3.1 shows graphs of the total number of specimens and of the relative abundance of the dominant species plotted against depth in core, based on data in Appendix C. The assemblage definitions, A to E, are chronologically arranged, from the base of Core 5 upwards, in the following sections.

3.3.1 Assemblage A

Assemblage A occurs from the base of the core at 534 cm upwards to 420 cm. High abundances of *Elphidium excavatum* forma *clavatum*, *Cassidulina reniforme,* and *Elphidium subarcticum* define Assemblage A. The total number of species ranges from 11-22, and the total number of specimens ranges from 1268-4440. Some reworked T-K species are present throughout most of this assemblage (Appendix C).

3.3.2 Assemblage B

Assemblage B begins at approximately 400 cm and extends upwards to about 255 cm. The dominant species in this assemblage are calcareous, and include *Cibicides lobatulus, Nonionellina labradorica,* and *Islandiella teretis.* The total number of species ranges from 17-25, and the total number of specimens per 10 cc sample ranges from 784-9200. Some reworked T-K species are present in the interval from 340-341 cm (Appendix C).

3.3.3 Assemblage C

Between 250 cm and 180 cm the core is almost barren, with the total number of species ranging from 3-9, and the total number of specimens ranging from 3-29. Agglutinated species such as *Adercotryma glomerata* and *Spiroplectammina biformis* are present in this assemblage. All calcareous species present in Assemblage B decrease significantly or disappear completely.

3.3.4 Assemblage D

This assemblage extends upwards from approximately 170 cm to 50 cm. Species present are predominantly calcareous. The dominant species in this assemblage include *C. lobatulus*, *I. teretis*, and *N. labradorica*, as in Assemblage B. A significant increase in numbers of species and total number of specimens occurs, with the numbers of species ranging from 18-24, and the total number of specimens ranging from 82-8144 per 10 cc sample. Some agglutinated species occur between 171 cm and 121 cm.

3.3.5 Assemblage E

Assemblage E occurs in the top 45 cm of the core. The dominant species are agglutinated species such as *A. glomerata*, *S. biformis*, and *Cribrostomoides jeffreysi*. However, foraminifera are sparse. The total number of species ranges from 1-7, and the total number of specimens ranges from 1-20.

3.4 Carbon-14 Dating

The carbon-14 dates obtained for Core 5 are 8532 $^+/_-$ 75 years before present (ybp) for the sample at 150-151 cm (Kreuger Enterprises Sample No. GX-20467-AMS), and 8515 $^+/_-$ 66 ybp for the sample at 270-271 cm (Kreuger Enterprises Sample No. GX-20468-AMS). Reservoir-corrected dates would therefore be 8092 $^+/_-$ 75 ybp for 150-151 cm, and 8075 $^+/_-$ 66 ybp for 270-271 cm. Samples consisted of very small masses of hand-picked foraminifera, and were corrected for carbon-13.

3.5 Seismic Stratigraphy

Figure 3.2 shows the seismic profile from Cruise 91-018 of the *CSS Dawson*, in the vicinity of Core 5. Figure 3.3 is an expanded version of the section of the profile nearest the location of Core 5, as marked on Figure 3.2. The seismic profile shows transparent reflections overlying acoustically coherent stratified sediments, which in turn overlie rough, incoherent reflections. The coherent stratified sediments, representing the

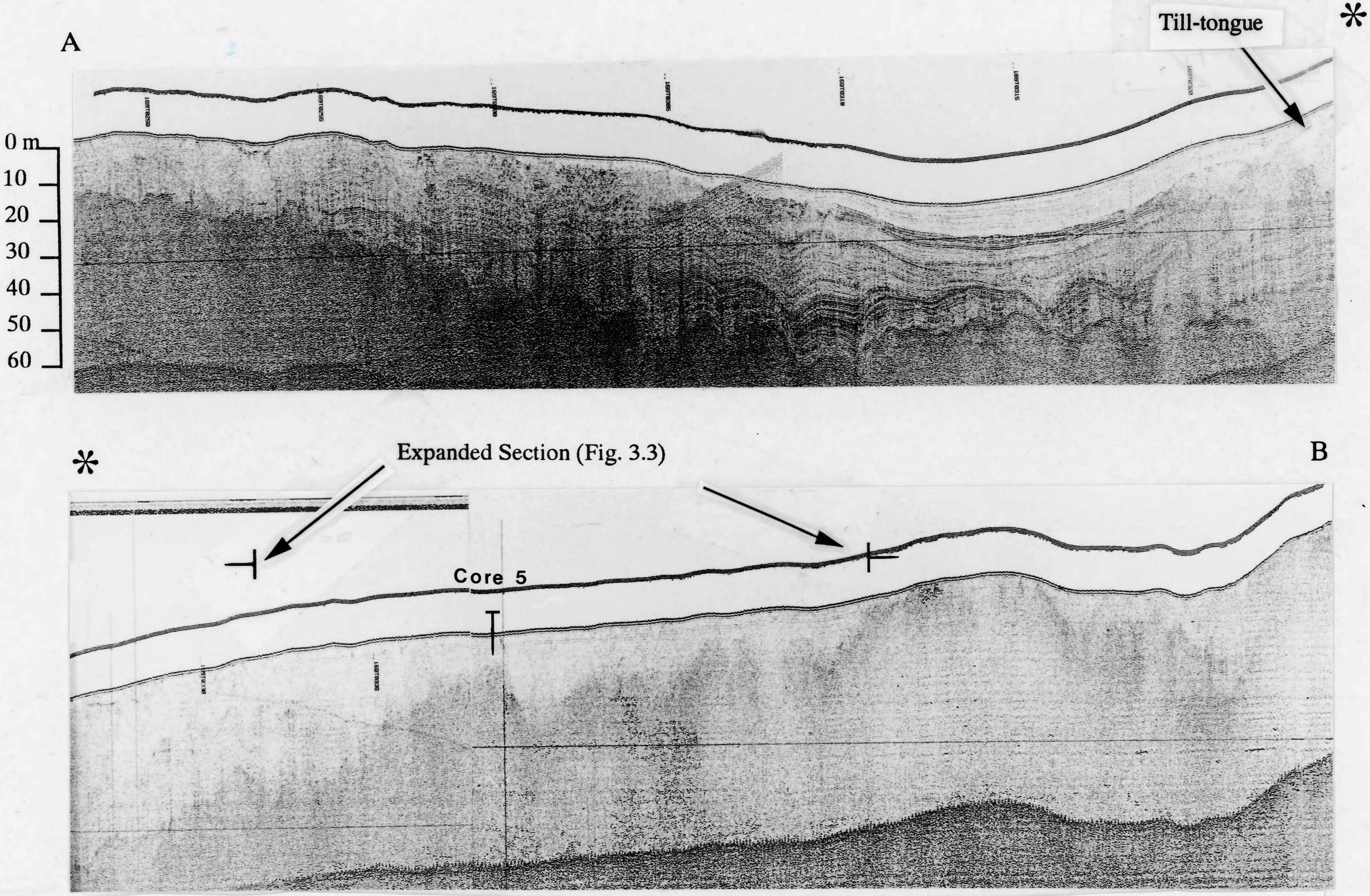


Figure 3.2 Huntec seismic profile from cruise Dawson 91-018, shown as line A-B in Figure 1.3. This section of the seismic line is approximately 9 km from A to B. Location of Core 5 is projected onto the seismic profile, and section shown in Figure 3.3 is indicated.

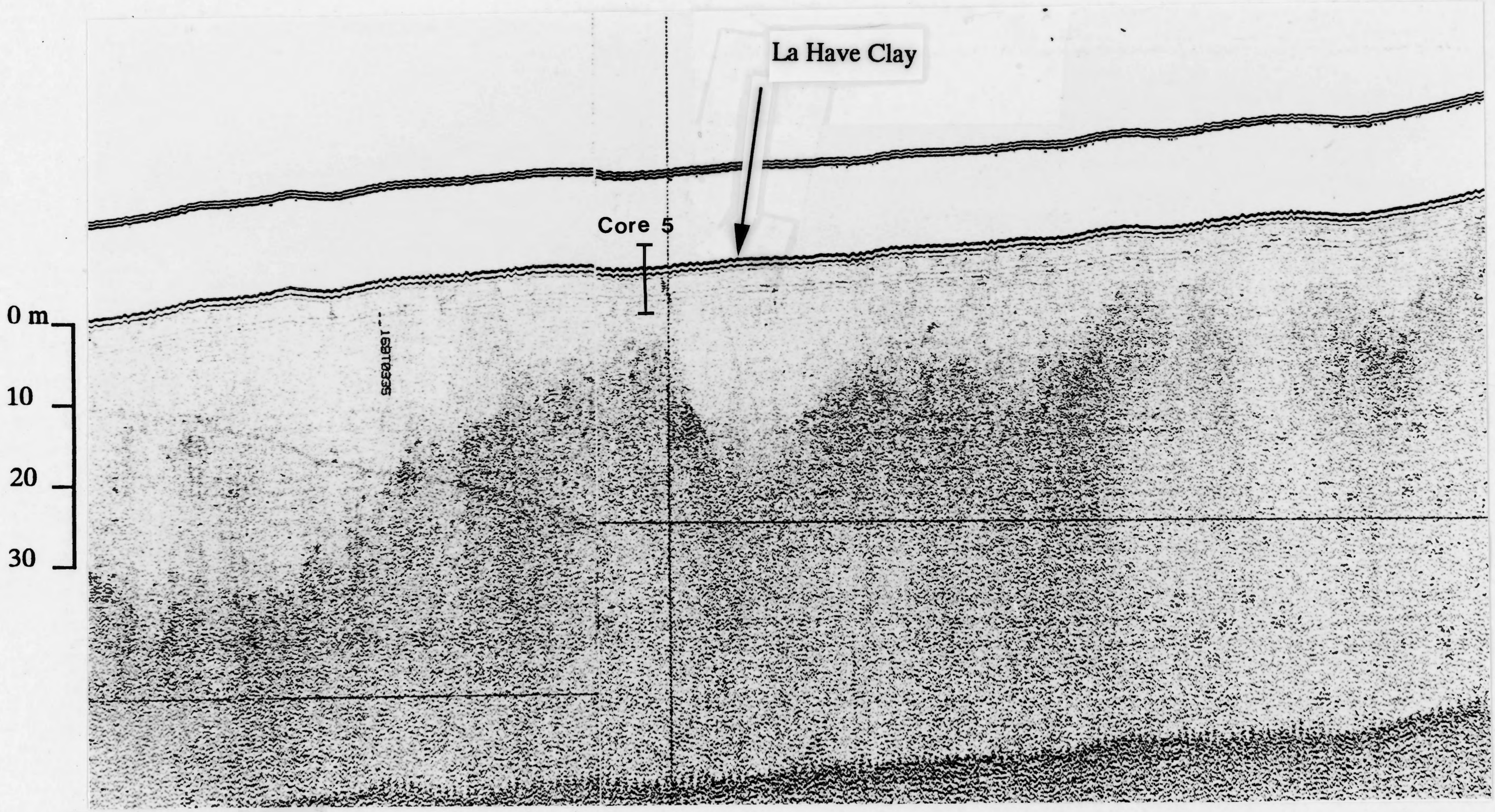


Figure 3.3 Expanded version of Huntec seismic profile from Figure 3.2 immediately surrounding Core 5. This section of the seismic line is approximately 2 km in length. Location of Core 5 is projected onto the seismic profile.

Emerald Silt Formation, change abruptly to incoherent sediments laterally, presumably representing till. Although Core 5 is located just off the seismic line, this is a well-known till area. Therefore, projecting core 5 onto the seismic line is probably valid.

3.6 Summary

Lithological units in Core 5 coincide with foraminiferal assemblage zones. Foraminiferal assemblages provide various paleoceanographic implications, are useful in determining the depositional environment, and, in this case, may help to determine the depositional history of till-tongues. Chapter 4 discusses the implications of these results and compares the results with previous work.

CHAPTER 4 DISCUSSION

4.1 Introduction

This chapter correlates foraminiferal assemblages with lithology, discusses paleoceanographic implications of the assemblages in comparison to implications from other studies in the same geographic area, examines the carbon-14 dated interval, discusses the definition of till-tongues and the impact of this work on that definition, and examines the importance of reworked T-K foraminifera present in Core 5.

4.2 Correlation Of Foraminiferal Assemblages With Lithology In Core 5

4.2.1 Assemblage A

The upper boundary of foraminiferal Assemblage A correlates with the lithological boundary at 391 cm, below which the sediment, brown sand and olive grey sandy mud, exhibits deformation and contortion. Assemblage A, which includes *E. excavatum* f. *clavatum*, *E. subarcticum*, and *C. reniforme*, is a warm ice-margin fauna, which usually dominates in the Emerald Silt lithofacies (Vilks 1981; Scott *et al.* 1984). Sediment below 391 cm is therefore defined as the Emerald Silt Formation.

4.2.2 Assemblage B

Assemblage B occurs between 400 cm and 255 cm in Core 5, corresponding with the olive grey sand (391-360 cm) and the olive grey sandy mud (360-260 cm) that occur above the deformed section of Core 5. *C. lobatulus*, *N. labradorica*, and *I. teretis* dominate Assemblage B. An assemblage of *N. labradorica* and *I. teretis* characterizes areas influenced by the Outer Labrador Current (2-4°C), found today on the outer parts of the Labrador Shelf (Scott *et al.* 1984). *C. lobatulus* currently occurs in shallow water or on banks, in depths of 50-100 m (Williamson *et al.* 1984).

4.2.3 Assemblage C

The section of Core 5 from 250 cm to 180 cm is almost devoid of foraminifera. The boundaries of this section correspond with the lithologic unit of light brown, thinly layered mud, as described by D.B. Scott and R.R. Stea, that occurs between 260 cm and 180 cm, and is bounded by the 8500 ybp carbon-14 dates. Those foraminifera present are mainly agglutinated, including *A. glomerata* and *S. biformis*. This assemblage is currently widespread over much of the inner and outer Scotian Shelf, and indicates the presence of the cold water (0-3°C) of the Inner Labrador Current found there today (Williamson *et al.* 1984).

4.2.4 Assemblage D

This assemblage, present from 170 cm to 50 cm in Core 5, correlates with the section where brown and black mottled mud alternates with olive grey mud. Species present are essentially the same as those present in Assemblage B, including *C. lobatulus*, *N. labradorica*, and *I. teretis*. However, a greater percentage of *E. excavatum* f. *magna*, a shallow turbulent water form (Scott *et al.* 1980), indicates that Assemblage D is probably from an even shallower water environment than Assemblage B. The presence of agglutinated species, dominated by *A. glomerata*, from 171 cm to 121 cm also indicates a cold water (0-3 °C) environment (Williamson *et al.* 1984).

4.2.5 Assemblage E

This assemblage corresponds with the upper lithological layer of brown and black mottled mud from 44 cm to the surface in the core description. The dominant species in this assemblage are agglutinated, including *A. glomerata, S. biformis, and C. jeffreysi,* similar to Assemblage C. Again, this assemblage is currently widespread and indicates the presence of the cold Inner Labrador Current water which occurs over this site at present (Williamson *et al.* 1984).

4.3 Comparison with Previous Studies

Interpretation of the foraminiferal assemblages from Core 5 requires comparison with results from previous studies in this area, including those of Scott *et al.* (1984, 1989) who examined cores from two basins on the outer Scotian Shelf. The Canso Bank Basin (Core 80-004-33, Scott *et al.* 1984, 1989) is located near Core 5 but further offshore. Freeman (1986) and Souchen (1986) examined two cores from the continental shelf off Cape Breton Island, also located near Core 5 but further offshore, in the St. Ann Basin. Costello (1994) examined a core from the inner shelf in the same water depth as Core 5, but located to the landward margin of the of the Emerald Basin (These localities are shown in Figure 1.2).

Core 80-004-33 (Scott *et al.* 1984, 1989), from 249 m water depth in the Canso Bank Basin, is 10.5 m long and penetrates through La Have Clay to the top of Emerald Silt. The base of Core 33 contains the *E.excavatum* f. *clavatum* and *C. reniforme* assemblage that typifies the warm ice-margin Emerald Silt (Assemblage A in Core 5). From 1050 to 900 cm the *N. labradorica and I. teretis* assemblage that characterizes the Outer Labrador Current is found (Assemblage B in Core 5). From 900-750 cm a fauna resembling the present-day Emerald Basin fauna (Williamson *et al.* 1984) exists, dominated by *Brizalina subaenariensis*. The warm waters (8-10°C) of the Gulf Stream influence the present-day Emerald Basin. This fauna indicates a warm period not evident in Core 5, where *B. subaenariensis* occurs only in very small amounts in Assemblages B and D, and never dominates. Above 750 cm in Core 33, the fauna indicate cooling as *I. teretis* increases in dominance. Above 50 cm, the *A. glomerata*-dominated agglutinated assemblage, currently present on much of the northern Scotian Shelf, exists (Assemblages C and E in Core 5), representing the colder waters (0-3°C) of the Inner Labrador Current.

Core 84-011-12 (Freeman 1986) is geographically near Core 5 but further offshore. Core 12 penetrates through an expanded La Have Clay section into Emerald Silt and shows a similar micropaleontological sequence to the Canso Bank Basin core described by Scott *et* *al.* (1984). At the base of the core, an *I. teretis, E. excavatum,* and *C. reniforme* assemblage represents the Emerald Silt (Assemblage A in core 5). The *I. teretis* and *N. labradorica* assemblage that resembles the modern Outer Labrador Current assemblage (Assemblages B and D in Core 5) is present above the *I. teretis, E. excavatum,* and *C. reniforme* assemblage. From 680 cm to 560 cm in Core 12, *B. subaenariensis* appears, indicating the warm period not evident in Core 5 but present in the Canso Bank Basin core of Scott *et al.* (1984). Above 560 cm, the Outer Labrador Current assemblage reappears, indicating cooling. An increase in agglutinated species in the top 14 cm, dominated by *A. glomerata*, also occurs in this core, representing the colder Inner Labrador Current conditions present today.

Core 84-011-11 (Souchen 1986) also penetrates through La Have Clay to Emerald Silt, with a fining upwards turbidite sequence separating the two. Again, the Emerald Silt assemblage of *E. excavatum* f. *clavatum* and *C. reniforme* (Assemblage A in Core 5) appears in the base of the core. Reworked Cretaceous foraminifera are common in the Emerald Silt and turbidite sequence sections of this core. The La Have Clay portion of Core 11 contains three foraminiferal assemblage groups. Directly above the turbidite sequence the dominant forms are *N. labradorica* and *Globobulimina auriculata,* with *B. subaenariensis* also present, indicating the warmer water period that occurs in the Canso Bank basin core and in Core 12, but not in Core 5. Above the first La Have Clay assemblage, *I. teretis* and agglutinated species increase, indicating cooling as a result of influx of Outer Labrador Current water, followed by even colder Inner Labrador current water, as in Core 12. The surface assemblage of this core exhibits a mixed warm and cold water fauna, which Souchen (1986) believed to be the result of reworked warmer calcareous species being deposited over the study area by a localized slump event.

Core 91-018-53 (Costello 1994) is 802 cm in length, and located near the front of the Emerald Basin. From 802 cm to 610 cm, the dominant assemblage is the warm ice-margin fauna of the Emerald Silt, *E. excavatum* f. *clavatum* and *C. reniforme* (Assemblage

A in Core 5). From 610 cm to 360 cm the *N. labradorica, I. teretis* assemblage characterizing the Outer Labrador Current occurs (Assemblages B and D in Core 5). From 360 cm to 260 cm the *E. excavatum* f. *clavatum* and *C. reniforme* assemblage of the warm ice-margin Emerald Silt reappears. From 260 cm to 123 cm the assemblage is almost exclusively *E. excavatum* f. *clavatum* . Costello (1994) believed that this assemblage indicates the Younger Dryas cold period, and gave carbon-14 dates of 10 377 to 9840 ybp. From 123 cm to 40 cm the assemblage present includes the warm water species *Bulimina marginata, G. auriculata, Cassidulina laevigata,* and *B. subaenariensis* (Scott *et al.* 1984), with *B. subaenariensis* and *B. marginata* increasing markedly in abundance above 90 cm. This assemblage indicates a warming period, similar to that in previously described studies but absent in Core 5. From 40 cm to the core surface, the species present are identical to those from 123 cm to 40 cm, except for increased abundance of *G. auriculata, N. labradorica, and B. subaenariensis.* This assemblage characterizes modern deposits in the Emerald, La Have, and Roseway basins (Williamson *et al.* 1984). The uppermost part of Core 53 is missing, so which fauna now occupies this area, the Inner Labrador Current agglutinated fauna or the warm water fauna typical in the Emerald Basin, is unknown.

The warming indicated by the presence of *B. subaenariensis* in previous studies does not appear in Core 5. The warming episode, indicative of the influence of the much warmer Gulf Stream water, may therefore not have occurred on the inner shelf. The Gulf Stream was directed closer to land than at present, but may not have come close enough to affect the northern part of the inner shelf that is more isolated from the Emerald Basin. Examination of more cores from this area should determine the extent of the influence of warmer Gulf Stream water. Also in Core 5, a cold interval appears between 250 cm and 150 cm downcore; this cold interval is not evident in cores from previous studies, and corresponds to the carbon-14 dated interval.

4.4 Carbon-14 Dated Interval

The two carbon-14 dates from Core 5 (8532 +/- 75 ybp at 150-151 cm, and 8515 +/- 66 ybp at 270-271 cm) are identical within analytical error. The samples chosen for dating were located above and below the part of Core 5 characterized by Assemblage C, which resembles the assemblage characterizing the cold water of the Inner Labrador Current. Dates obtained might, therefore, bracket the Younger Dryas cold period from approximately 11 000 ybp to 10 000 ybp; however, the dates do not indicate the Younger Dryas, being younger than expected. With dates of 8500ybp, the meaning of this interval is unclear.

Very rapid or even instantaneous sedimentation might result in deposition of a metre thick interval with nearly identical carbon-14 dates both above and below. Whether this interval is the result of slumping of sediment requires study of cores from nearby, to see if the same combination of lithology and assemblage appear elsewhere in the vicinity. The assemblage in this interval is not, however, currently known at 8500 ybp.

Whereas Assemblage C resembles the surficial assemblage typical of areas influenced by the cold Inner Labrador Current, as seen in Core 5, the lithology is different from the surface lithology in Core 5. If the vibracorer had bounced during coring, then the surface assemblages could have been repeated. However, the surface lithology would also have been repeated, which is not the case. Collection of Core 5 occurred on a clear day, in calm seas, and bouncing of the equipment, therefore, seems unlikely.

4.5 Implications For Defining Till Tongues On The Scotian Shelf

King and Fader (1986) first described till-tongues as wedge-shaped bodies of till that interbed with the stratified, acoustically coherent, glacial-marine sediments of the Emerald Silt. The Scotian Shelf Drift Formation (glacial till) shows uniform dense incoherent reflections (King and Fader 1986). The Emerald Silt formation contains three seismic facies: (i) high amplitude continuous coherent reflections; (ii) medium to low amplitude continuous coherent reflections; and (iii) discontinuous coherent reflections. Till-tongues, which exhibit incoherent reflections similar to those of the Scotian Shelf Drift, occur interbedded with the continuous coherent reflections of the Emerald Silt facies, within and at the edges of the Emerald Silt. Till-tongue morphology varies widely, with lengths ranging from several kilometres to 30 km, thicknesses ranging from a few metres to 100 m, and lateral extents ranging from 10 km to over 300 km (King *et al.* 1991). King *et al.* (1991) believed that till-tongues play an important role as ice-margin indicators, because they form through oscillations of the grounding-line of an ice sheet.

Core 5 penetrates a till-tongue, or area of incoherent reflections, as defined seismically by King and Fader (1986) and King *et al.* (1991). Micropaleontological and lithological analysis of Core 5 indicates that, for this particular till-tongue, the sediment that makes up the incoherent reflections is Emerald Silt, and not till. Examination of part of the seismic line from cruise 91-018 (Figs. 3.2, 3.3) shows that coherent Emerald Silt reflections abruptly change to incoherent reflections. The sediment below 391 cm in Core 5, which exhibits deformation of layers, correlates with these incoherent reflections. The foraminiferal assemblage present in this deformed sediment is a typical Emerald Silt assemblage (Vilks 1981, Scott *et al.* 1984), therefore the foraminiferal content of Core 5 shows that these incoherent sections are simply disturbed Emerald Silt. Till-tongues may not be lateral continuations of till, but rather areas of Emerald Silt that have been disturbed by grounding of marginal glacial ice; however, till-tongues would still function as ice-margin indicators.

4.6 Implications Of Reworked Tertiary-Cretaceous Foraminifera

Scott and Medioli (1988) discussed the presence of reworked T-K foraminifera in Pleistocene sediments of the Scotian Shelf and correlated the amount of reworked material present with the amount of erosive glacial activity. Glacial erosion and sedimentation as a result of grounding ice increase greatly when the glacier overrides soft M-C sediments

(Boulton and Jones 1979). The sediments, including foraminiferal tests, are resuspended and can then be transported away from the glacial front by currents and redeposited as glacial-marine sediments seaward of the glacier (*i.e.* Emerald Silt). Only trace amounts of T-K forms occur in Core 5, but cores deeper into this sequence, and therefore further into the glacial-active stage, should show more than traces (Scott and Medioli 1988).

The cross-section in Figure 4-1, running parallel to the seismic line in Figures 3.2 and 3.3, although located further to the south, shows the M-C sediments onlapping the Meguma basement. The present-day contact of this sedimentary wedge and the Meguma lies seaward of Core 5 (King and MacLean 1974). The presence of T-K foraminifera in Core 5 suggests that the glacier must have overridden M-C sediments landward of Core 5. To be landward of Core 5, the contact would have to be a minimum of 10 km closer to land before the last Wisconsinan (late Pleistocene) glaciation than the present-day contact. Alternatively, the presence of reworked T-K foraminifera in the basal part of Core 5 could indicate that the contact between M-C sediments and the Meguma basement is incorrectly located and that the M-C sedimentary wedge still underlies the late Quaternary sediments. The contact between basement and M-C sediment as mapped by King and MacLean (1974) is only approximately located, not actually sampled. The hypothesis that M-C sediments still underlie the late Quaternary sediments therefore seems plausible. A third alternative could be that the M-C contact with the Meguma is not as straightforward as shown in King and MacLean (1974) and that outliers of M-C sediments are still present landward of the contact, which is also a plausible hypothesis because of the approximate nature of the mapped contact. Reworked T-K material is absent from the Emerald Silt glacial sections of Core 53 (Costello 1994). The Emerald Silt material in Core 53 is probably derived from Lawrencetown Till (Costello 1994), and not from M-C sediments, which suggests that the M-C wedge contact with the Meguma was seaward of Core 53 in the Wisconsinan. Core 53 is located approximately 10 km closer to land than Core 5.

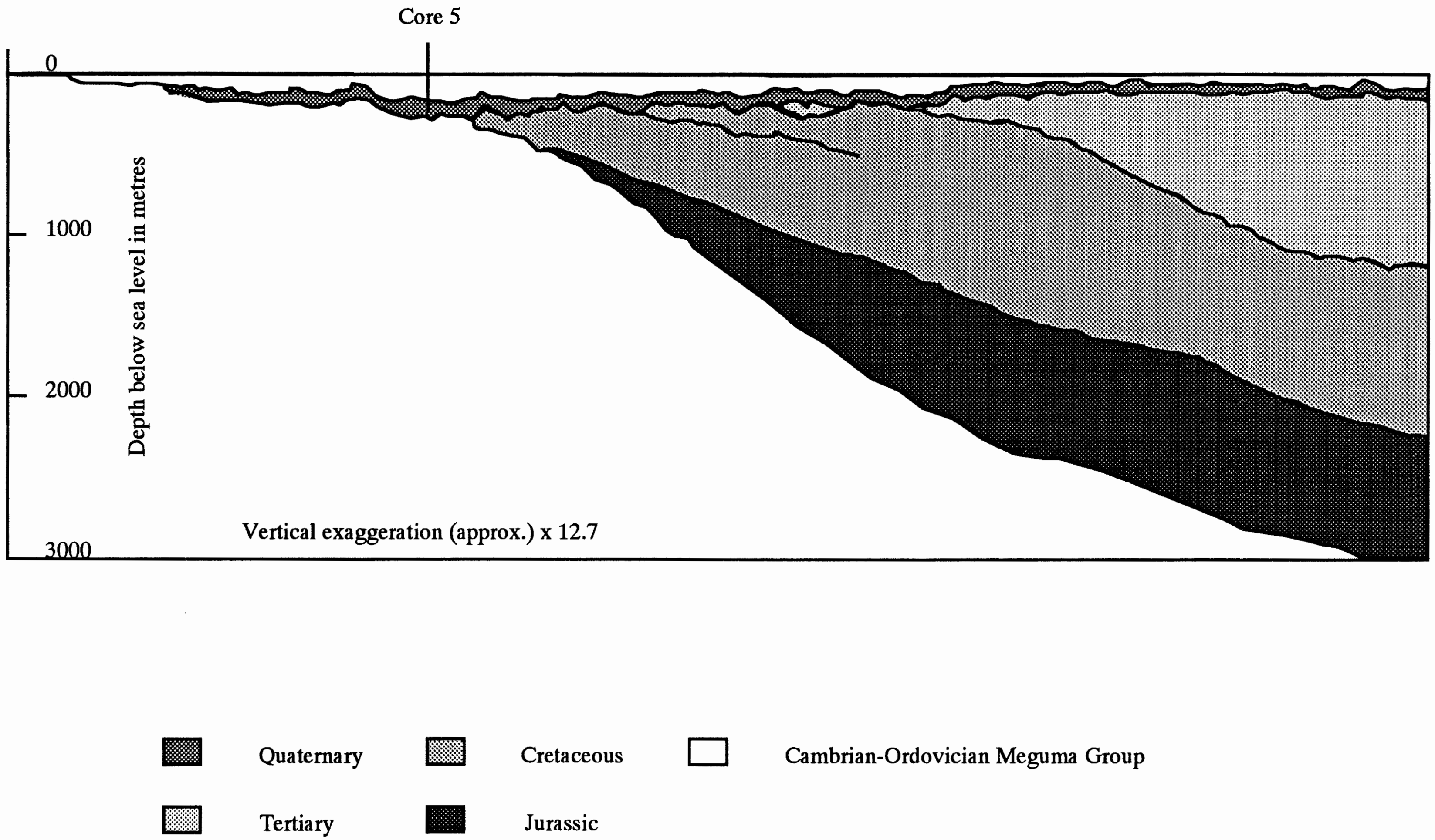


Figure 4.1 Cross section showing onlap of Mesozoic-Cenozoic sedimentary wedge onto Meguma basement rock (after King and MacLean 1974), running approximately parallel to line A-B in Figure 1.3 but continuing further offshore, with the approximate location of Core 5 indicated.

The presence or absence of T-K material in glacial marine sediments of the Scotian Shelf may permit indirect determination of the present contact between the Meguma basement and the M-C sedimentary wedge. Further coring in this vicinity, and examination of those cores for T-K foraminifera, would more clearly delineate the former and current positions of the M-C wedge. The M-C sediments may still be present further inland than previously believed. Or, if glacially eroded, then erosion by the latest glaciation and previous glaciations may have increased the distance between land and contact with each glaciation. Scott and Medioli (1988) also suggested that the submarine end-moraine complex offshore follows the contact between Meguma and softer M-C sediments, and that moraines formed when the ice encountered and dislodged the softer sediments. The end-moraine complex may form again farther offshore with each glaciation, a process which may explain why the present end-moraine complex relates only to the most recent glaciation.

4.7 Summary

Interpretation of lithological and micropaleontological data from Core 5 allows possible reinterpretation of till-tongue origin, may allow refinement of the boundary between the Meguma basement and the onlapping M-C sedimentary wedge, and allows enhancement of knowledge of the paleoceanographic history of the area. Chapter 5 will summarize these conclusions, and make recommendations for further work.

CHAPTER 5 CONCLUSIONS

5.1 Conclusions

Micropaleontological analysis of soft sediment cores permits determination of the paleoenvironment in chronological sequence throughout a core. Benthic foraminiferal assemblages correlate with present-day assemblages from known oceanographic conditions. These correlations, with knowledge of present-day circulation patterns, allow interpretation of the paleoceanography of an area. In this study, examination of foraminiferal assemblages results in possible reinterpretation of the depositional history of till-tongue deposits, in new paleoceanographic implications for the inner Scotian Shelf, and in possible changes in the position of the onlap contact between the M-C sedimentary wedge and the Meguma basement.

Previous studies from geographically-nearby areas further offshore give a reasonably consistent paleoceanographic history from the late Pleistocene to the present. The Emerald silt assemblage represents a warm ice-margin, and underlies a cold water assemblage that today characterizes areas affected by the Outer Labrador Current (2-4 °C). A fauna that indicates influx of warmer waters of Gulf Stream origin (8-10 °C) overlies the cold water assemblage. A cold water Inner Labrador Current (0-3 °C) fauna, which is widespread over much of the northern Scotian Shelf today, characterizes the surface sediments. Core 5 shows a similar history to these previous studies, except for the absence of the warmer period where the Gulf Stream influenced bottom waters, although other studies from similar water depths further south (Costello 1994) do show this warming period. This absence may indicate that the Gulf Stream did not affect the inner Scotian shelf, especially the northern inner Scotian shelf, as it did the outer Scotian Shelf.

Till-tongues are seismically-defined geological features. Core 5 suggests a possible reinterpretation of till-tongue lithology by direct sampling of a till-tongue. Micropaleontological analysis of the till-tongue material yields the warm ice-margin fauna that characterizes Emerald Silt sediments across the Scotian Shelf. Lithological analysis of Core 5 shows that the sediment correlated with the acoustically incoherent till-tongue is deformed and contorted. In Core 5, the origin of the seismic signal previously interpreted as a till-tongue is deformed Emerald Silt. Till-tongue origin was described as the result of oscillations of the ice margin causing lateral extensions of the boundary of the Scotian Shelf Drift. Core 5 indicates that till-tongues may originate when the ice margin grounds and deforms the underlying Emerald Silt, resulting in an incoherent reflection from normally coherent sediments. However, because till-tongues are formed at the grounding-line of the ice sheet, they maintain their usefulness as ice margin grounding-line indicators.

The contact between the Meguma basement and the onlapping wedge of M-C sediments is currently exposed seaward of Core 5 (Figure 4.1); however, the presence of reworked T-K foraminifera in the lower half of Core 5 indicates that this contact was either located landward of Core 5 at the time Core 5 was deposited, and was subsequently eroded by glacial ice. As the ice overrides the much softer T-K sediments, the glacial erosion and suspension of sediment is greatly increased, in this case resulting in complete erosion of the M-C wedge, pushing its present margin seaward of the Core 5 site, from a location almost certainly inland of Core 5 before the last glaciation. Sediment transport then carries these sediments seaward of the ice margin before redeposition. Alternatively, the contact may be incorrectly mapped, and M-C sediments or remnants of M-C sediments still underlie the late Quaternary sediments.

5.2 Recommendations For Future Work

The carbon-14 dated interval in this core is currently problematic. More dates from Core 5 above and below the known carbon-14 dated intervals, and further coring of the geographic area surrounding Core 5 would be useful in elucidating the origin of this anomalous lithologic section of Core 5 and the micropaleontological assemblage it contains. Further coring of the vicinity around Core 5 would also aid in determining if the reworked

T-K material is consistently present, and allow clearer delineation of the previous contact between the Meguma basement and the M-C wedge. Further study of sediment from till-tongues would refine this work and determine if the findings of this study, that till-tongue material is deformed Emerald silt, are anomalous or normal.

SYSTEMATIC TAXONOMY

Adercotryma glomerata (Brady)
Lituola glomerata BRADY 1878, v.1, p.433, pl.20, figs.1a-c.
Adercotryma glomerata (Brady).-LOEBLICH and TAPPAN 1953, p.26, pl.8, figs.1-4.-VILKS 1969, p.44, pl.1, fig.15.-GREGORY 1971, p.173, pl.11, figs.9-11.-COLE 1981, p.29, pl.4, figs.5-6.

Ammotium cassis (Parker)
Lituola cassis PARKER in Dawson 1870, p.177, fig.3.
Ammobaculites cassis (Parker).-CUSHMAN 1920, p.63, pl.12, fig.5.
Ammotium cassis (Parker).-LOEBLICH and TAPPAN 1953, p.33, pl.2, figs.12-18.-GREGORY 1971, p.176, pl.3, fig.5.

Astrononion gallowayi Loeblich and Tappan
Astrononian gallowayi LOEBLICH and TAPPAN 1953, p.90, pl.17, figs.4-7.-VILKS 1969, p.51, pl.3, fig.19.-COLE 1981, p.109, pl.13, fig.6.

Brizalina pseudopunctata (Höglund)
Bolivina pseudopunctata HÖGLUND 1947, p.273, pl.24, fig.5; pl.32, figs.23-24.-COLE 1981, p.87, pl.11, fig.12.

Brizalina subaenariensis (Cushman)
Bolivina subaenariensis CUSHMAN 1922, p.46, pl.7, fig.6.-WILLIAMSON 1983, p.218, pl.3, fig.11.

Buccella frigida (Cushman)
Pulvinulina frigida CUSHMAN 1921, p.144.
Eponides frigida (Cushman) var. *calida* CUSHMAN and COLE 1930, p.98, pl.13, figs.13a-c.-PHLEGER and WALTON 1950, p.277, pl.2, fig.21.-PARKER 1952a, p.449, pl.5, figs.3a-b.
Eponides frigidus (Cushman).-CUSHMAN 1942, p.37, pl.9, figs.16-17.-PARKER 1952a, p.449, pl.5, figs.2a-b.
Bucella frigida (Cushman).-ANDERSEN 1952, p.144, figs.4a-c, 5, 6a-c.-GREGORY 1971, p.220, pl.12, figs.1-3.-COLE and FERGUSON 1975, p.33, pl.8, figs.8-9.

Bulimina marginata d'Orbigny
Bulimina marginata d'ORBIGNY 1826, p.269, pl.12, figs.10-12.-PHLEGER and PARKER 1951, p.16, pl.7, figs.27-28.-FEYLING-HANSSEN 1964, p.303, pl.14, figs.2-3.-SCHNITKER 1971, p.195, pl.5, fig.5.

Cassidulina reniforme (Nørvang)
Cassidulina crassa var. *reniforme* NØRVANG 1945, p.41, test-figs.6c-h.
Cassidulina crassa (d'Orbigny).-Scott *et al.* 1980, p.226, pl.4, figs.1-2.
Cassidulina reniforme (Nørvang).-SEJRUP and GUILBAULT 1980, p.79-85, test-figs.1-3.

Cibicides lobatulus (Walker and Jacob)
Nautilus lobatulus WALKER and JACOB 1798, p.642, pl.14, fig.36.
Cibicides lobatulus (Walker and Jacob).-PARKER 1952a, p.449, pl.6, fig.26.-FEYLING-HANSSEN 1964, p.339, pl.19, figs.1-3.-VILKS 1969, p.50, pl.3, fig.17.-COLE 1981, p.104, pl.12, fig.4.

Cribrostomoides crassimargo (Norman)
Haplophragmium crassimargo NORMAN 1892, p.17.
Labrospira crassimargo (Norman).-HÖGLUND 1947, p.11, fig.1, text-figs.121-125.
Cribrostomoides crassimargo (Norman).-LESLIE 1965, p.158, pl.2, figs.2a-b.-WILLIAMSON 1983, p.209, pl.1, figs.6-7.

Cribrostomoides jeffreysi (Williamson)
Nonionina jeffreysi WILLIAMSON 1858, p.34, pl.3, figs.72-73.
Cribrostomoides jeffreysi (Williamson).-BARBIERI and MEDIOLI 1969, p.855, fig.4.-VILKS 1969, p.45, pl.1, figs.17a-b.-COLE 1981, p.30, pl.6, fig.6.

***Discorbis* spp.** (Remark: This genus was not identified to the species level)

Eggerella advena (Cushman)
Verneuilina advena CUSHMAN 1921, p.141.
Eggerella advena (Cushman).-CUSHMAN 1937, p.51, pl.5, figs.12-15.-SCOTT and MEDIOLI 1980, p.38, pl.2, fig.7.

Elphidium bartletti (Cushman)
Elphidium bartletti CUSHMAN 1933, p.4, pl.1, fig.9.
Cribrononion bartletti (Cushman).-SCOTT *et al.* 1980, p.226, pl.2, fig.7.

Elphidium excavatum (Terquem) group
Polystomella excavatum TERQUEM 1876, p.429, pl.2, figs.2a-d.
Elphidium excavatum (Terquem).-CUSHMAN 1944, p.26, pl.2, fig.40.

Elphidium excavatum (Terquem) **forma *clavatum*** Cushman
Elphidium incertm (Williamson) var. *clavatum* CUSHMAN 1930, p.20. pl.7, fig.10.
Elphidium incertum (Williamson) and variants PARKER 1952a, p.448, pl.3, fig.16.
Elphidium excavatum (Terquem) forma *clavatum* MILLER *et al.* 1982, p.124, pl.1, figs.5-8; pl.2, figs.3-8; pl.3, figs.3-8; pl.4, figs1-6; pl.5, figs.4-8; pl.6, figs.1-6.

Elphidium excavatum (Terquem) **forma *excavatum*** Terquem
Polystomella excavata TERQUEM 1876, p.429, pl.2, fig.2.
Elphidium excavatum (Terquem).-CUSHMAN 1930, p.21, pl.8, figs.1-7.-CUSHMAN 1944, p.26, pl.2, fig.40.-BENDA and PURI 1962, p.325, pl.1, fig.16.-HANSEN and LYKE-ANDERSEN 1976, p.10, pl.6, figs.1-6.
Elphidium excavatum (Terquem) forma *excavatum* (Terquem).-MILLER *et al.* 1982, p.128, pl.1, figs.9-12; pl.2. figs.1-2; pl.3, figs.1-2; pl.4, figs.13-16; pl.5, figs.15-16; pl.6, figs.6-8, 14.

Elphidium subarcticum Cushman
Elphidium subarcticum CUSHMAN 1944, p.27, pl.3, figs.34-35.-SCHNITKER 1971, p.198, pl.7, fig.3.-COLE 1981, p.101, pl.20, fig.4.

***Fissurina* spp.** (Remark: This genus was not identified to the species level)

Fursenkoina fusiformis (Williamson)
Bulimina pupoides (d'Orbigny) var. *fusiformis* WILLIAMSON 1858, p.64, pl.5, figs.129-130.
"Bulimina" fusiformis (Williamson).-HÖGLUND 1947, p.232, pl.20, fig.3; text-figs.219-233.
Virgulina fusiformis (Williamson).-PARKER 1952b, p.461, pl.4, fig.6; p.417, pl.6, figs.3-6.
Fursenkoina fusiformis (Williamson).-GREGORY 1971, p.232.-SCOTT 1977, p.172, pl.7, figs.9-10.

Glabratella wrightii (Brady)
Discorbina wrightii BRADY 1881, p.413, pl.21, fig.6.
Eponides wrightii (Brady).-PARKER 1952 a, p.450, pl.5, figs.4a-b.
Glabratella wrightii (Brady).-LESLIE 1965, p.161, pl.10, fig.7.-COLE and FERGUSON 1975, p.35, pl.8, figs.10-11.-SCOTT 1977, p.172, pl.7, figs.11-13.-SCHAFER and COLE 1978, p.28, pl.8, fig.5.

***Globigerinelloides* spp.** (Remark: This genus was not identified to the species level)

Globobulimina auriculata (Bailey)
Bulimina auriculata BAILEY 1851, p.12, pl.1, figs.25-27.
Globobulimina auriculata (Bailey) var. *arctica* HÖGLUND 1947, p.254, test-figs.266-267, 270-271.
Globobulimina auriculata arctica (Höglund).-LESLIE 1965, p.161, pl.9, figs.6a-c.
Globobulimina auriculata (Höglund).-COLE 1981, p.90.

Glomospira gordialis (Jones and Parker)
Trochammina squamata var. *gordialis* JONES and PARKER 1860, p.304.
Glomospira gordialis (Jones and Parker).-CUSHMAN and McCULLOCH 1939, p.70, pl.5, figs.5-6.

***Guerbetria* spp.** (Remark: This genus was not identified to the species level)

Haynesina orbiculare (Brady)
Nonionina orbicularis BRADY 1881, p.414, pl.21, fig.5.
Haynesina orbiculare (Brady).-BANNER and CULVER 1978, p.188.

***Heterohelix* spp.** (Remark: This genus was not identified to the species level)

Islandiella islandica (Nørvang)
Cassidulina islandica NØRVANG 1945, p.41, figs.7-8.-LESLIE 1965, p.57, pl.10, figs.4a-c.
Islandiella islandica (Nørvang).-VILKS 1969, p.49, pl.3, fig.3.-BARBIERI and MEDIOLI 1969, p.857, pl.52, figs.3a-c.-GREGORY 1971, p.213, pl.11, fig.1.

Islandiella teretis (Tappan)
Cassidulina laevigata (d'Orbigny).-BRADY 1884, p.428, pl.54, figs.1-3.
Cassidulina teretis TAPPAN 1951, p.7, pl.1, figs.30a-c.
Islandiella teretis (Tappan).-VILKS 1969, p.49, pl.3, fig.5.

***Lagena* spp.** (Remark: This genus was not identified to the species level)

***Nonion* spp.** (Remark: This genus was not identified to the species level)

Nonion barleeanum (Williamson)
Nonionina barleeana WILLIAMSON 1858, p.32, pl.3, figs.68-69.
Gavelinonion barleeanum (Williamson).-BARKER 1960, p.224, pl.109, figs.8-9.
Nonion barleeanum (Williamson).-PHLEGER 1952, p.85, pl.14, fig.6.-PHLEGER *et al.* 1953, p.30, pl.6, fig.4.

Nonionella turgida (Williamson)
Rotalina turgida WILLIAMSON 1858, p.50, pl.4, figs.95-97.
Nonionina turgida (Williamson).-BRADY 1884, 731, pl.109, figs.17-19.
Nonionella turgida (Williamson).-CUSHMAN 1930, p.15, pl.6, figs.1-4.-WILLIAMSON 1983, p.228, pl.4, fig.13.

Nonionellina labradorica (Dawson)
Nonionina labradorica DAWSON 1860, p.191, fig.4.
Nonion labradorica (Dawson).-CUSHMAN 1927, p.148, pl.2, figs.7-8.
Nonionellina labradorica (Dawson).-SCHAFER and COLE 1978, p.28, pl.9, fig.4.-COLE 1981, p.110, pl.13, fig.20.

***Oolina* spp.** (Remark: This genus was not identified to the species level)

Pseudopolymorphina novangliae (Cushman)
Polymorphina lactea novangliae CUSHMAN 1923, p.146, pl.39, figs.6-8.
Pseudopolymorphina novangliae (Cushman).-PARKER 1952a, p.410, pl.5, fig.1.-COLE 1981, p.72, pl.18, figs.38-39.

Pullenia subcarinata (d'Orbigny)
Nonionina subcarinata d'ORBIGNY 1839, p.28, pl.5, figs.23-24.

***Pyramidina* spp.** (Remark: This genus was not identified to the species level)

Quinqueloculina agglutinans d'Orbigny
Quinqueloculina agglutinans d'ORBIGNY 1839, p.168, pl.12, figs.11-13.

Quinqueloculina seminulum (Linné)
Serpula seminulum LINNÉ 1758, P.786.
Quinqueloculina seminulum (Linné).-d'ORBIGNY 1826, p.303.-GREGORY 1971, p.187, pl.6, fig.1.-COLE and FERGUSON 1975, p.40, pl.10, fig.7.-SCOTT 1977, p.175, pl.7, figs.3-5.-SCHAFER and COLE 1978, p.29, pl.12, fig.4.
Miliolina seminulum (Linné).-WILLIAMSON 1858, p.85, pl.7, figs.183-185.
Quinqueloculina seminula (Linné).-CUSHMAN 1929, p.59, pl.9, figs.16-18.-PARKER 1952a, p.456, pl.2, figs.7a-b.-PARKER 1952b, p.406, pl.3, figs.21a-b, 22a-b; pl.4, figs.1-2.

Reophax arctica (Brady)
Bigenerina arctica BRADY 1881, p.405, pl.21, figs.2a-b.-CUSHMAN 1944, p.31, pl.3, fig.9.
Reophax arctica (Brady).-PARKER 1952b, p.395, pl.1, figs.6-7.-GREGORY 1971, p.168, pl.2, fig.3.-COLE and FERGUSON 1975, p.40, pl.1, fig.9.-SCOTT 1977, p.175, pl.3, fig.5.-SCHAFER and COLE 1978, p.29, pl.2, fig.5.

Reophax fusiformis (Williamson)
Proteonina fusiformis WILLIAMSON 1858, p.1, pl.1, fig.1.
Reophax fusiformis (Williamson).-BRADY 1870, p.290, pl.30, figs.7-11.-PARKER 1952a, p.395, pl.1, figs.11-19.

Reophax nodulosa Brady
Reophax nodulosa BRADY 1879, v.19, p.52, pl.4, figs.7-8.-COLE 1981, p.25, pl.4, figs.7-8.

Robertinoides charlottensis (Cushman)
Cassidulina charlottensis CUSHMAN 1925, p.41, pl.6, figs.6-7.
Robertina charlottensis (Cushman).-CUSHMAN and PARKER 1936, p.97, pl.16, fig.12.
Robertinoides charlottensis (Cushman).-LOEBLICH and TAPPAN 1953, p.108, pl.20, figs.6-7.-COLE 1981, p.117, pl.11, fig.8.

Saccammina difflugiformis (Brady)
Reophax difflugiformis BRADY 1879, p.51, pl.4, figs.3a-b.
Proteonina difflugiformis (Brady).-PHLEGER and PARKER 1951, p.2, pl.1, figs.4-5.
Saccammina difflugiformis (Brady).-TODD and BRONNIMAN 1957, p.52, pl.1, fig.15.

Textularia torquata Parker
Textularia torquata PARKER 1952b, p.458 (footnote).-SCOTT and MEDIOLI 1980, p.227, pl.2, fig.1.

Trifarina fluens (Todd)
Angulogerina fluens TODD in Cushman and Todd 1947, p.67, pl.16, figs.6-7.
Trifarina angulosa (Williamson).-GREGORY 1971, p.217, pl.11, fig.5.
Trifarina fluens (Todd).-FEYLING-HANSSEN in Feyling-Hanssen *et al.* 1971, p.242, pl.7, figs.12-25; pl.18, fig.10.-COLEand FERGUSON 1975, p.42, pl.6, fig.10.-SCOTT 1977, p.177, pl.8, figs.12-13.-SCHAFER and COLE 1978, p.29, pl.7, fig.3.

Triloculina tricarinata d'orbigny
Triloculina tricarinata d'ORBIGNY 1826, p.299, no.7, mod. no.94.-PHLEGER *et al.* 1953, p.28, pl.5, fig.21.-FEYLING-HANSSEN 1964, p.258, pl.6, figs.7-8.-COLE 1981, p.55, pl.10, fig.2.

Trochammina globigeriniformis (Parker and Jones)
Lituola nautiloidea globigeriniformis PARKER and JONES 1865, p.407, pl.15, figs.46-47.
Trochammina globigeriniformis CUSHMAN 1910, pl.24, text-fig.193-195.-COLE 1981, p.37, pl.7, figs.2-3.

Trochammina lobata Cushman
Trochammina lobata CUSHMAN 1944, p.18, pl.2, fig.10.-PARKER 1952b, p.408, pl.4, figs.8a-b.-SCHNITKER 1971, p.212, pl.1, fig.18.-COLE and FERGUSON 1975, p.14, pl.4, figs.5-6.

Trochammina ochracea (Williamson)
Rotalina ochracea WILLIAMSON 1858, p.5, pl.4, fig.112; pl.5, fig.113.

Trochammina squamata Parker and Jones
Trochammina squamata PARKER and JONES 1865, p.407, pl.15, figs.30, 31a-c.-SCOTT and MEDIOLI 1980, p.41, pl.4, figs.6-7.

REFERENCES

Andersen, H.V. 1952. *Buccella*, a new genus of Rotalid Foraminifera. Journal of the Washington Academy of Science, 42: 143-151.

Bailey, J.W. 1851. Microscopical examination of soundings made by the U.S. Coast survey of the Atlantic Coast of the U.S. Smithsonian Contributions to Knowledge, 2: 1-15.

Banner, F.T. and Culver, S.J. 1978. Quaternary *Haynesina* nov. gen and Paleogene *Protelphidium* Haynes: their morphology, affinities and distribution. Journal of Foraminiferal Research, 8: 177-207.

Barbieri, F. and Medioli, F.S. 1969. Distribution of Foraminifera on the Scotian Shelf (Canada). Rivue Italiani di Paleontologica, 75(4): 849-878.

Barker, R.W. 1960. Taxonomic notes on the species figured by H.B. Brady in his "Report on the Foraminifera dredged by H.M.S. Challenger during the years 1873-1876". Accompanied by a reproduction of Brady's plates. Society of Economic Paleontology and Mineralogy Special Publication 9.

Benda, W.R. and Puri, H.S. 1962. The distribution of Foraminifera and Ostracoda off the Gulf Coast of the Cape Romano area, Florida. Transactions of the Gulf Coast Geological Society, 12: 303-341.

Boersma, A. 1978. Foraminifera. *In* Introduction to Marine Micropaleontology. *Edited by* Haq, B.U. and Boersma, A. Elsevier North-Holland Inc., New York, U.S.A.

Boulton, G.S. and Jones, A.S. 1979. Stability of temperate ice caps and ice sheets resting on beds of deformable sediment. Journal of Glaciology, 24(90): 29-43.

Brady, H.B. 1870. *In* Brady, G.S. and Robertson, D. 1870. The Ostracoda and Foraminifera of tidal rivers. With analysis and descriptions of Foraminifera by H.B. Brady. Part II. Annals of the Magazine of Natural History, 6: 273-306.

Brady, H.B. 1878. On the reticularian and radiolarian Rhizopoda (Foraminifera and Polycystina) of the North Polar expedition of 1875-1876. Annals of the Magazine of Natural History, 1(5): 425-440.

Brady, H.B. 1879. Notes on some of the reticularian Rhizopoda of the Challenger expedition. Quarterly Journal of Microscopic Science, 19: 20-63.

Brady, H.B. 1881. Notes on some of the reticularian Rhizopoda of the Challenger expedition: Part 3. Quarterly Journal of the Royal Micropaleontological Society, 21: 31-71.

Brady, H.B. 1884. Report on the Foraminifera dredged by the H.M.S. Challenger during the years 1873-1876. Challenger Report on Zoology, 9: 1-814.

Broecker, W.S. 1974. Chemical Oceanography. Harcourt Brace Jovanovich Inc., New York, U.S.A.

Cole, F.E. 1981. Taxonomic notes on the Bathyal Zone benthonic foraminiferal species off North East Newfoundland. Bedford Institute of Oceanography Report Series BI/R/81-7.

Cole, F.E. and Ferguson, C. 1975. An illustrated catalogue of Foraminifera and Ostracoda from Canso Strait and Chedabucto Bay, Nova Scotia. Bedford Institute of Oceanography Report Series BI/R/75-5.

Costello, O.P. 1994. Paleoceanographic Reconstruction of the inner Scotian Shelf during the Younger Dryas: a benthic foraminiferal study. Unpublished Bachelor of Science Honours thesis, Dalhousie University, Halifax.

Cushman, J.A. 1910. A monograph of the Foraminifera of the north Pacific Ocean. Part 1, Astrorhizidae and Lituolidae. U.S. National Museum Bulletin, 71: 1-134.

Cushman, J.A. 1920. The Foraminifera of the Atlantic Ocean. Part 2, Lituolidae. U.S. National Museum Bulletin, 71: 1-108.

Cushman, J.A. 1921. Results of the Hudson Bay expedition (1920). Contributions to Canadian Biology, 9: 135-147.

Cushman, J.A. 1922. The Foraminifera of the Atlantic Ocean. Part 3, Textularidae. U.S. National Museum Bulletin, 104: 1-149.

Cushman, J.A. 1923. The Foraminifera of the Atlantic Ocean. Part 4, Lagenidae. US National Museum Bulletin, 104: 1-228.

Cushman, J.A. 1925. Recent Foraminifera of British Columbia. Contributions to the Cushman Laboratory for Foraminiferal Research, 1(2): 38-42.

Cushman, J.A. 1927. Some characteristic Mexican fossil Foraminifera. Journal of Paleontology, 1: 147-172.

Cushman, J.A. 1929. The Foraminifera of the Atlantic Ocean. Part 6, Miliolidae, Ophthalmidiidae, and Fischerinidae. U.S. National Museum Bulletin, 104: 1-129.

Cushman, J.A. 1930. The Foraminifera of the Atlantic Ocean. Part 7, Nonionidae, Camerinidae, Peneroplidae, and Aleveolinellidae. U.S. National Museum Bulletin, 104: 1-79.

Cushman, J.A. 1933. New Arctic Foraminifera collected by Captain R.A. Bartlett from Fox Basin and off the northeast coast of Greenland. Smithsonian Miscellaneous Collection 89(9):1-8.

Cushman, J.A. 1937, A monograph on the foraminiferal family Valvulinidae. Cushman Laboratory for Foraminiferal Research Special Publication 8.

Cushman, J.A. 1942. The Foraminifera of the tropical Pacific collections of the “Albatross”, 1899-1900. Part 3, Heterohelicidae and Buliminidae. U.S. National Museum Bulletin, 161: 67.

Cushman, J.A. 1944. Foraminifera from the shallow water of New England coast. Cushman Laboratory for Foraminiferal Research Special Publication 12.

Cushman, J.A. and Cole, W.S. 1930. Pleistocene Foramniferida from Maryland. Contributions to the Cushman Laboratory for Foraminiferal Research, 6:94-100.

Cushman, J.A. and McCulloch, I. 1939. A report on some arenaceous Foraminifera. Allan Hancock Pacific Expedition, 6: 1-113.

Cushman, J.A. and Parker, F.L. 1936. Some species of *Robertina*. Contributions to the Cushman Laboratory for Foraminiferal Research, 12: 92-100.

Cushman, J.A. and Todd, R. 1947. A foraminiferal fauna from Amchikta Island, Alaska. Contributions to the Cushman Laboratory for Foraminiferal Research, 23: 60-72.

Dawson, G.M. 1860. Notice of Tertiary fossils from Labrador, Maine, etc. and remarks on the climate of Canada in the newer Pliocene or Pleistocene period. Canadian National and Quarterly Journal of Science, 5: 188-200.

Dawson, G.M. 1870. On Foraminifera from the Gulf and River St. Lawrence. Canadian National and Quarterly Journal of Science, 5: 172-180.

Edgecombe, R.B. 1994. Paleoenvironmental analysis of Halifax Harbour: sedimentology, paleoclimatology, and Holocene sea level. Unpublished Bachelor of Science Honours thesis, Dalhousie University, Halifax.

Feyling-Hanssen, R.W. 1964. Foraminifera in Late Quaternary deposits from the Oslofjord area. Norges Geologiske Undersoekelse Bulletin, 255: 1-383.

Feyling-Hanssen, R.W. 1971. Weischelian Interstadial Foraminifera from the Sandnes-Jaeren area. *In* Late Quaternary Foraminifera from Vendsyssel, Denmark, and Sandnes, Norway. *Edited by* Feyling-Hanssen, R.W., Jørgesen, J.A., Knudson, K.L., and Anderson, A.L.L. Meddelelser Fra Dansk Geologisch, Forening, Copenhagen, 21(2,3): 71-116.

Forbes, D.L., Boyd, R., and Shaw, J. 1991. Late Quaternary sedimentation and sea level changes on the inner Scotian Shelf. Continental Shelf Research, 11: 1155-1179.

Freeman, J.M. 1986. Paleoceanographic trends on the northern Scotian Shelf. Unpublished Bachelor of Science Honours thesis, Dalhousie University, Halifax.

Gregory, M.R. 1971. Distribution of benthonic Foraminifera in Halifax Harbour, Nova Scotia, Canada. Unpublished PhD thesis, Dalhousie University, Halifax.

Hansen, H.J. and Lyke-Andersen, A.L. 1976. Wall structure and classification of fossil and recent Elphidiid and Nonionid Foraminifera. Fossils and Strata, Univeritetsforlaget Oslo, 10: 1-37.

Höglund, H. 1947. Foraminifera in the Gullmar Fjord and Skagerak. Zool. Bidrag. Fran. Uppsalla, 26: 1-328.

Jones, T.R. and Parker, W.K. 1860. On the Rhizopodal fauna of the Mediterranean, compared with that of the Italian and some other Tertiary deposits. Geological Society of London Quarterly Journal, 16: 292-307.

King, L.H. 1969. Submarine end-moraines and associated deposits on the Scotian Shelf. Geological Society of America Bulletin, 80: 83-96.

King, L.H. 1970. Surficial Geology of the Halifax-Sable Island map area. Marine Sciences Branch, Department of Energy, Mines, and Resources, Ottawa. Paper 1.

King, L.H. and Fader, G.B. 1986. Wisconsinan glaciation of the Atlantic continental shelf--southeast Canada. Geological Survey of Canada Bulletin 363.

King, L.H. and MacLean, B. 1974. Scotian Shelf and adjacent areas. GSC Paper 74-31.

King, L.H., MacLean, B., and Drapeau, G. 1972. The Scotian Shelf submarine end-moraine complex. 24th International Geological Congress, Montreal, Section 8: 237-249.

King, L.H., Rokoengen, K., Fader, G.B.J., and Gunleiksrud, T. 1991. Till-tongue stratigraphy. Geological Society of America Bulletin, 103: 637-659.

Leslie, R.J. 1965. Ecology and paleoecology of Hudson Bay Foraminifera. Bedford Institute of Oceanography Report 65-6.

Linné, C. 1758. Systema natura per regna tria naturae, secundum classes, ordines, genera, species cum characteribus differentiis. synonimis locis. G. Engelmann (Lipsiae), 10th ed. 1: 1-824.

Loeblich, A.R. and Tappan, H. 1953. Studies of Arctic Foraminifera. Smithsonian Miscellaneous Collection, 121(7): 1-50.

Loeblich, A.R. and Tappan, H. 1964. Sarcodina, chiefly "Thecamoebians" and Foraminifera. *In* Treatise on Invertebrate Paleontology. Part C, Protista. *Edited by* R.C. Moore. Geological society of America and the University of Kansas Press.

Mangerud, J. 1972. Radiocarbon dating of marine shells, including a discussion of apparent age of Recent shells from Norway. Boreas, 1: 143-172.

Miller, A.A.L., Scott, D.B., and Medioli, F.S. 1982. *Elphidium excavatum* (Terquem): ecophenotypic versus subspecific variation. Journal of Foraminiferal Research, 12(2): 116-144.

Monroe, J.S. and Wicander, R. 1994. The Changing Earth. West Publishing Company, St. Paul, U.S.A.

Norman, A.M. 1892. *Museum Normanium*: a catalogue of the invertebrata of Europe and the Arctic and North atlantic Oceans, which are contained in the collection of A.M. Norman. Part 8: Rhizopoda. Durham, U.K.

Nørvang, A. 1945. Foraminifera. *In* The Zoology of Iceland 3, Part 2. Munksgard, Copenhagen, Denmark.

Orbigny, A.D. d'. 1826. Tableau methodique de la classe des Cephalopods. Annales des Sciences Naturelles, 1(7): 245-314.

Orbigny, A.D. d'. 1839. Voyage dans l'Amerique Meridonale. Foraminiferes, 5: 1-88.

Parker, F.L. 1952a. Foraminiferal distribution in the Long Island sound-Buzzards Bay area. Bulletin of the Harvard Museum of Comparative Zoology, 106(10): 425-473.

Parker, F.L. 1952b. Foraminiferal species off Portsmouth, New Hampshire. Bulletin of the Harvard Museum of Comparative Zoology, 106(9): 391-423.

Parker, W.K. and Jones, T.R. 1865. On some Foraminifera from the North Atlantic and Arctic Oceans, including Davis Strait and Baffin's Bay. Philosophical Transactions of the Royal Society, 155: 325-441.

Phleger, F.B. 1952. Foraminifera distribution in some sediment samples from the Canadian and Greenland Arctic. Contributions to the Cushman Foundation for Foraminiferal Research, 3: 80-89.

Phleger, F.B. and Parker, F.L. 1951. Ecology of Foraminifera, northwest Gulf of Mexico. Part 2, Foraminifera species. Geological Society of America Memoir, 46: 1-64.

Phleger, F.B., Parker, F.L., and Peirson, F.F. 1953. North Atlantic Foraminifera. Report of the Swedish Deep-Sea Expedition, 7:3-122.

Phleger, F.B. and Walton, W.R. 1950. Ecology of marsh and bay Foraminifera, Barnstable, Massachussets. American Journal of Science, 248: 274-294.

Schafer, C.T. and Cole, F.E. 1978. Distribution of Foraminifera in Chaleur Bay, Gulf of St. Lawrence. Geological Survey of Canada Paper 77-30.

Schnitker, D. 1971. Distribution of Foraminifera on the North Carolina continental shelf. Tulane studies in Geology and Paleontology, 8(4): 169-215.

Scott, D.B. 1977. Distributions and population dynamics of marsh-estuarine Foraminifera with applications to relocating Holocene sea-level. Unpublished PhD thesis, Dalhousie University, Halifax.

Scott, D.B., Baki, V., and Younger, D.C. 1989. Late Pleistocene-Holocene paleoceanographic changes on the eastern Canadian margin: stable isotopic evidence. Palaeogeography, Palaeoclimatology, Palaeoecology, 74: 279-295.

Scott, D.B. and Medioli, F.S. 1980. Quantitative studies of marsh foraminiferal distributions in Nova scotia: implications for sea level studies. Cushman foundation for Foraminiferal Research Special Publication 17.

Scott, D.B. and Medioli, F.S. 1988. Tertiary-Cretaceous reworked microfossils in Pleistocene glacial-marine sediments: an index to glacial activity. Marine Geology, 84: 31-41.

Scott, D.B., Mudie, P.J., Vilks, J., and Younger, D.C. 1984. Latest Pleistocene-Holocene paleoceanographic trends on the continental margin of eastern Canada: foraminiferal, dinoflagellate and pollen evidence. Marine Micropaleontology, 9: 181-218.

Scott, D.B. Schafer, C.T., and Medioli, F.S. 1980. Eastern Canadian estuarine Foraminifera: a framework for comparison. Journal of Foraminiferal Research, 10(3): 205-234.

Sejrup, H.P. and Guilbault, J.P. 1980. *Cassidulina reniforme* and *C. obtusa* (Foraminifera): taxonomy, distribution, and ecology. Sarsia 65(2): 79-85.

Souchen, D.W. 1986. Late Pleistocene-Holocene benthic Foraminifera from the northern Scotian Shelf. Unpublished Bachelor of Science Honours thesis, Dalhousie University, Halifax.

Stea, R.R. 1995. Late Quaternary glaciation and sea-level change along the Atlantic coast of Nova Scotia: correlation of land and sea events. Unpublished PhD thesis, Dalhousie University, Halifax.

Stea, R.R., Boyd, R., Fader, G.B.J., Courtney, R.C., Scott, D.B., and Pecore, S.S. 1994. morphology and seismic stratigraphy of the inner continental shelf off Nova Scotia, Canada: evidence for a -65 m lowstand between 11 650 and 11 250 C^{14} yr B.P. Marine Geology, 117: 135-154.

Tappan, H. 1951. Northern Alaska index Foraminifera. Contributions to the Cushman Foundation for Foraminiferal Research, 2(1): 1-8.

Terquem, O. 1876. Essai sur le classement des animaux qui vivent sur la plage et dans les environs de Dunkerque: première partie. Societé Dunquerqoise, Memoires (1874-1875), 19: (405-457).

Todd, R. and Bronniman, P. 1957. Recent Foraminifera and thecamoebians from the eastern Gulf of Paria. Cushman Foundation for Foraminiferal Research Special Publication 3.

Vilks, G. 1969. Recent Foraminifera in the Canadian Arctic. Micropaleontology, 15: 35-60.

Vilks, G. 1981. Late glacial-postglacial foraminiferal boundary in sediments of eastern Canada, Denmark, and Norway. Geoscience Canada, 8: 48-55.

Walker, G. and Jacob, E. 1798. A description of 383 animacula. *In* Adams' essays on the microscope, containing a practical description of the most improved microscopes; a general history of insects. Dillon and Keating, London, U.K.

Williamson, M.A. 1983. Benthic foraminiferal assemblages in the continental margin off Nova Scotia: a multivariate approach. Unpublished PhD thesis, Dalhousie University, Halifax.

Williamson, M.A., Keen, C.E., and Mudie, P.J. 1984. Foraminiferal distribution on the continental margin off Nova Scotia. Marine Micropaleontology, 9: 219-239.

Williamson, W.C. 1858. On the Recent Foraminifera of Great Britain. Royal Society Publications, 20:1-107.

APPENDIX A

Core Logs

ATLANTIC GEOSCIENCE CENTRE

Core 5

CRUISE NUMBER. 93 Secunda	SAMPLE NUMBER. 93-05	TOTAL LENGTH. 0-100 CM.
SAMPLE TYPE Vibracore	CALENDAR DATE. Sept. 9, 1993	PROJECT NUMBER.
GEOGRAPHIC LOCATION. Off Country Hbr		
DESCRIBED BY. D. Scott	PAGE 1 OF 6	

SYMBOL LEGEND

☐ 0-100 ☐ ____ ☐ ____

☐ ____ ☐ ____ ☐ ____

CORE DESCRIPTION

CORE DEPTH (CM.)	DEFORMATION	CONSISTENCY	CA CO3	COLOR (SOIL/ROCK)	X-RAY DESCRIPTION	VISUAL DESCRIPTION	SEDIMENT STRUCTURES	SUBSAMPLE WORK DONE
0–44						0-44 Brown mottled mud with black layers		
44 *								
44–100						44-100 Olive gray mud with shells 69cm big shell		

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

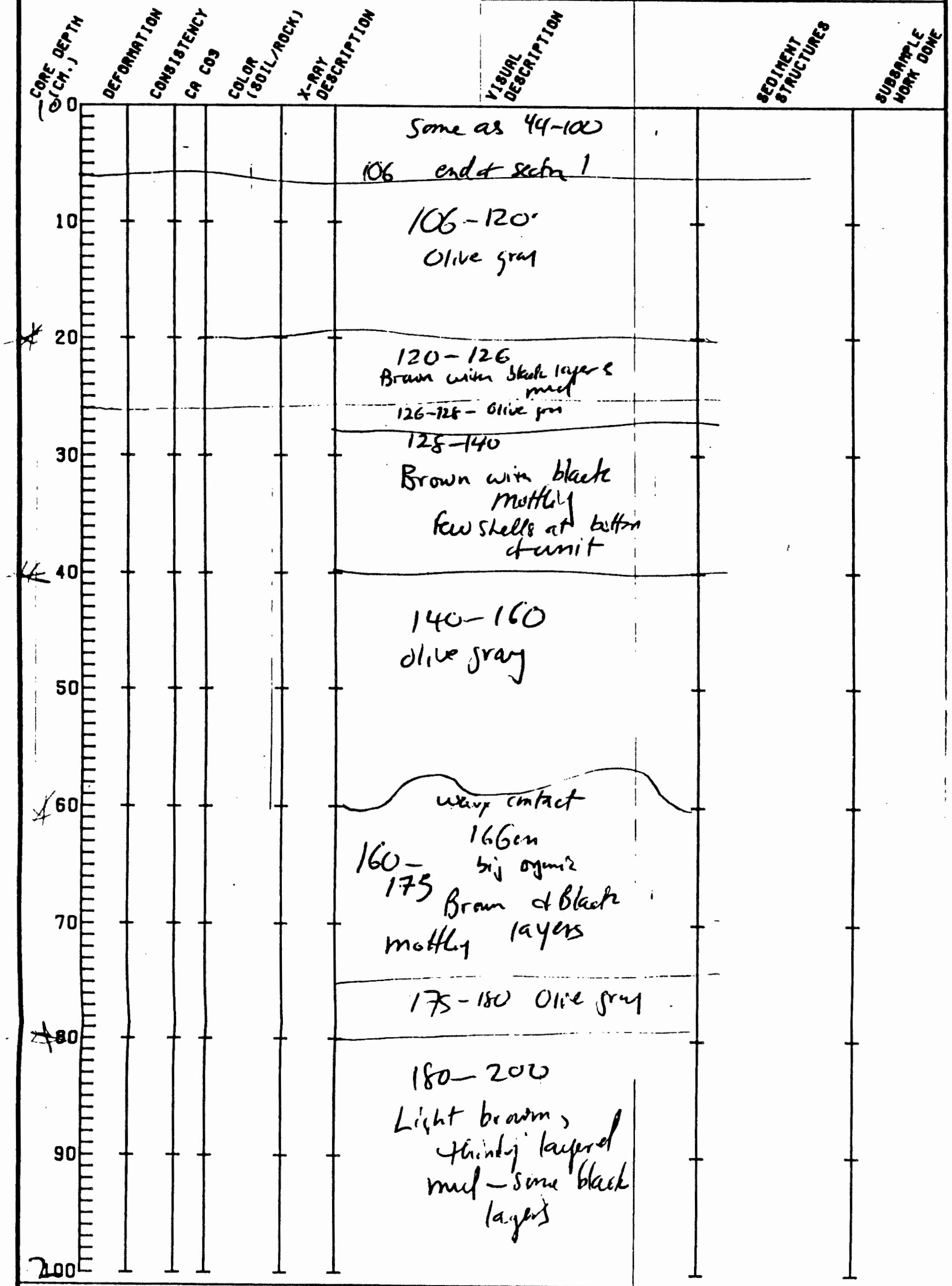
NOTES.

ATLANTIC GEOSCIENCE CENTRE

CRUISE NUMBER. 93 Secula	SAMPLE NUMBER. 93-05	TOTAL LENGTH. 100 - 200 CM.
SAMPLE TYPE Vibracore	CALENDAR DATE. Sept. 9, 1993	PROJECT NUMBER.
GEOGRAPHIC LOCATION. Canty Hbr Outside	SYMBOL LEGEND	
DESCRIBED BY. D. Scott	PAGE 2 OF 6	

CORE DESCRIPTION

☐ ____ ☐ ____ ☐ ____
☐ ____ ☐ ____ ☐ ____



Same as 44-100

106 end of section 1

106-120
Olive gray

120-126
Brown with black layers & mud

126-128 - Olive gray

128-140
Brown with black mottling
few shells at bottom of unit

140-160
olive gray

wavy contact
166cm
big organic
160-175
Brown & Black
mottling layers

175-180 Olive gray

180-200
Light brown, thinly layered mud - some black layers

NOTES.

ATLANTIC GEOSCIENCE CENTRE

Core 5

CRUISE NUMBER. 93 Seawla	SAMPLE NUMBER. ~~IB~~ 93-05	TOTAL LENGTH. 200-300 CM.
SAMPLE TYPE Vibracore	CALENDAR DATE. Sept 9 1992	PROJECT NUMBER.
GEOGRAPHIC LOCATION. County Hbr - offshore		
DESCRIBED BY. D. Scott	PAGE 3 OF 6	

CORE DESCRIPTION

SYMBOL LEGEND

☐ ____ ☐ ____ ☐ ____

☐ ____ ☐ ____ ☐ ____

CORE DEPTH (CM.)	DEFORMATION	CONSISTENCY	CA CO3	COLOR (SOIL/ROCK)	X-RAY DESCRIPTION	VISUAL DESCRIPTION	SEDIMENT STRUCTURES	SUBSAMPLE WORK DONE
200								
10						Same as 180 - 200		
20								
30								
40						247 end of sectn 2		
50						247 - 260 same as 180 - 200		
60						260 - 300		
70						Sandy olive gray mud with some shells		
80								
90								
300								

NOTES.

ATLANTIC GEOSCIENCE CENTRE

Core 5

CRUISE NUMBER. 93 Secunda	SAMPLE NUMBER. 93-05		TOTAL LENGTH. 300 - 400 CM.
SAMPLE TYPE Vibracore		CALENDAR DATE.	PROJECT NUMBER.
GEOGRAPHIC LOCATION. County Hbr - offsh			SYMBOL LEGEND
DESCRIBED BY. D Scott		PAGE 4 OF 6	

CORE DESCRIPTION

CORE DEPTH (CM.)	DEFORMATION	CONSISTENCY	CA CO3	COLOR (SOIL/ROCK)	X-RAY DESCRIPTION	VISUAL DESCRIPTION	SEDIMENT STRUCTURES	SUBSAMPLE WORK DONE
0						Olive gray Sandy mud 10		
10						large shells at 317 + 328cm 347cm		
20								
30						300 - 360		
40								
50								
60						360 - 391 Light brown - olive gray Sand beds alot of shells at 386 - 388		
70								
80								
90						391 - ends of sect 3 391 - 400 Deformed olive gray - brown shelly Sandy mud		
400								

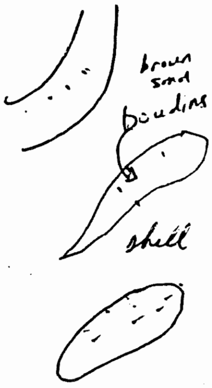
NOTES.

ATLANTIC GEOSCIENCE CENTRE

Core 5

CRUISE NUMBER. 93 Sezunda	SAMPLE NUMBER. 93-05	TOTAL LENGTH. 400-500 CM.
SAMPLE TYPE Vibracore	CALENDAR DATE. Sept. 9, 1993	PROJECT NUMBER.
GEOGRAPHIC LOCATION. County Hbr – offshore	SYMBOL LEGEND	
DESCRIBED BY. D.Scott / R. Sta	PAGE 5 OF 6	☐ ___ ☐ ___ ☐ ___
		☐ ___ ☐ ___ ☐ ___

CORE DESCRIPTION

CORE DEPTH (CM.)	DEFORMATION	CONSISTENCY	CA CO3	COLOR (SOIL/ROCK)	X-RAY DESCRIPTION	VISUAL DESCRIPTION	SEDIMENT STRUCTURES	SUBSAMPLE WORK DONE
400						Mixture of dark brown 7.5YR4/2 sand (little mud)!		
10						and olive grey (2.5Y4/2)		
20						~~muddy~~ sandy mud complexely deformed boudinaged		
30						shell fragments		
40								
50								
60								
70								
80								
90								
500								

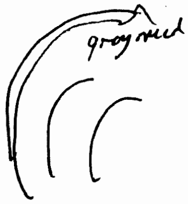
NOTES.

ATLANTIC GEOSCIENCE CENTRE Core 5

CRUISE NUMBER. 93 Scanda	SAMPLE NUMBER. 93-05	TOTAL LENGTH. 500-534 CM.
SAMPLE TYPE Vibracore	CALENDAR DATE. 9/93	PROJECT NUMBER.
GEOGRAPHIC LOCATION. Country Harbour-offshore		SYMBOL LEGEND
DESCRIBED BY. D Scott/RSTEA	PAGE 6 OF 6	☐ ☐ ☐ ☐ ☐ ☐

CORE DESCRIPTION

CORE DEPTH (CM.)	DEFORMATION	CONSISTENCY	CA CO3	COLOR (SOIL/ROCK)	X-RAY DESCRIPTION	VISUAL DESCRIPTION	SEDIMENT STRUCTURES	SUBSAMPLE WORK DONE
500 0						barnacle fragment		
10								
20						gray mud		
30								
40								
50								
60								
70								
80								
90								
100								



NOTES.

APPENDIX B

Core Photographs


0
93 SECUNDA
005
0 5 0
MUNSELL® SOIL COLOR CHART
VALUE
CURATION


93 SECUNDA
005
0 0 0
5YR MUNSELL® SOIL COLOR CHART
VALUE


0
1
2
3
93 SECUNDA
005
0 8 0
MUNSELL® SOIL COLOR CHART
VALUE
Black
Brown
White
Magenta
Red
Yellow
Green
Cyan
Blue

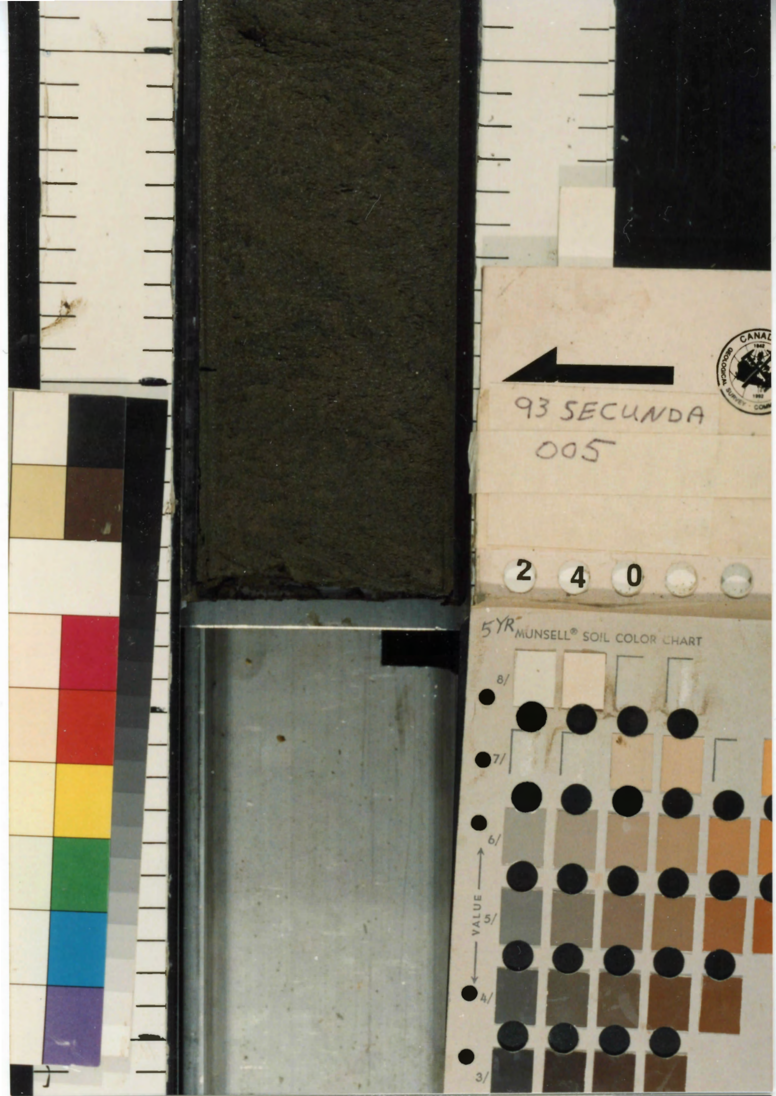

93 SECUNDA
005
0 2 0
5YR MUNSELL® SOIL COLOR CHART
VALUE


93 SECUNDA
005
1 3 0
5YR MUNSELL® SOIL COLOR CHART
VALUE
8/
7/
6/
5/
4/
3/


Black
Brown
White
Magenta
Red
Yellow
93 SECUNDA
005
1 0 0
MUNSELL® SOIL COLOR CHART
VALUE
8/
7/
6/
5/
4/
3/


0
1
93 SECUNDA
005
1 6 0
5YR MUNSELL® SOIL COLOR CHART
VALUE
8/
7/
6/
5/
4/
3/

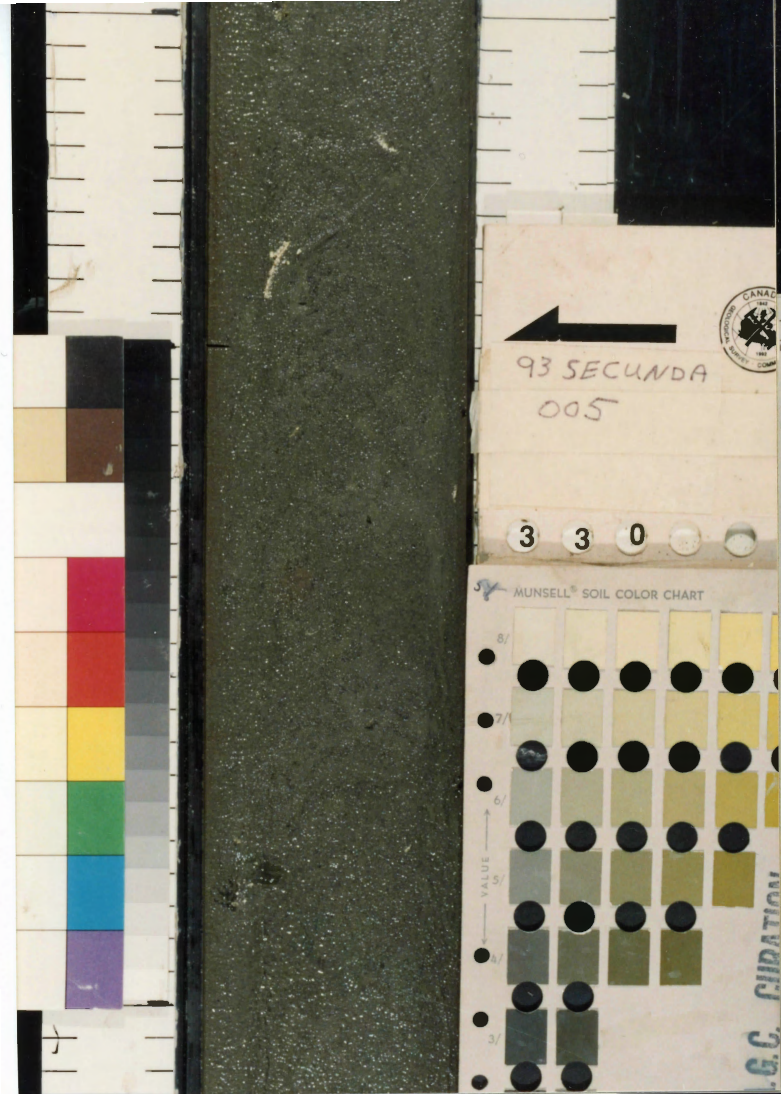

93 SECUNDA
005
1 1 0
5YR MUNSELL® SOIL COLOR CHART
VALUE
8/
7/
6/
5/
4/
3/


93 SECUNDA
005
240
5YR MUNSELL® SOIL COLOR CHART


1
2
3
4
93 SECUNDA
005
190
5YR MUNSELL® SOIL COLOR CHART


0
93 SECUNDA
005
250
MUNSELL® SOIL COLOR CHART


93 SECUNDA
005
220
5YR MUNSELL® SOIL COLOR CHART


93 SECUNDA
005
3 3 0
MUNSELL SOIL COLOR CHART
8/
7/
6/
5/
4/
3/
VALUE
CURATION
G.S.C.


0
1
2
Black
Brown
White
Magenta
Red
Yellow
Green
Cyan
Blue
93 SECUNDA
005
2 7 0
MUNSELL SOIL COLOR CHART
8/
7/
6/
5/
4/
3/
VALUE

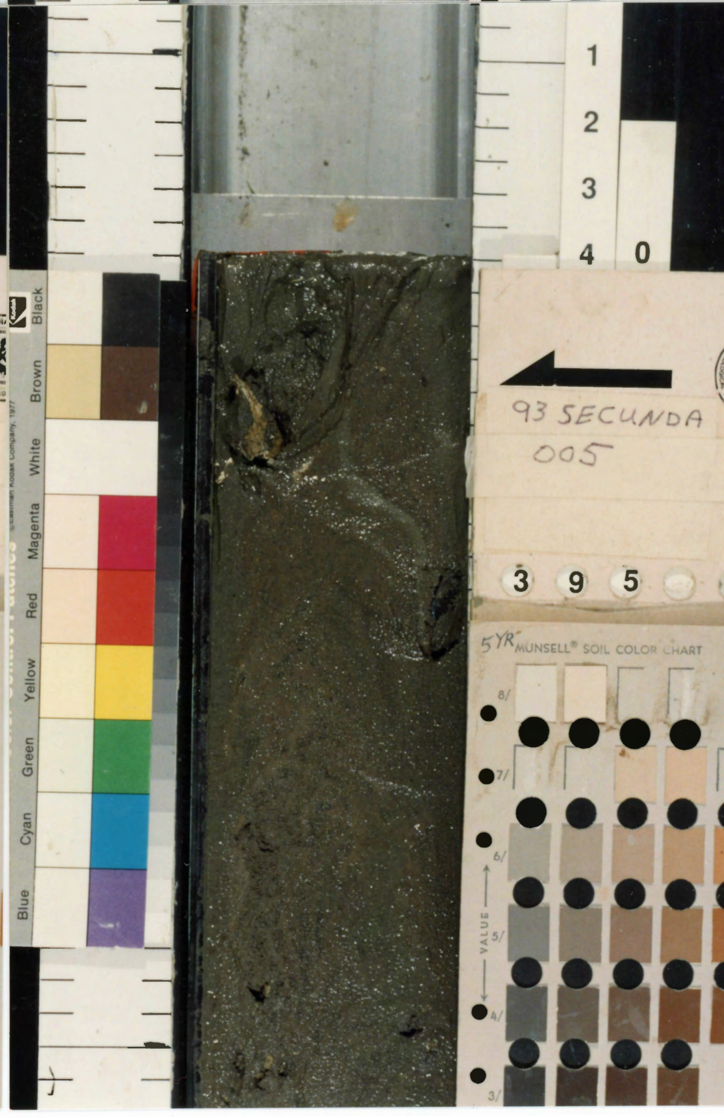

0
1
Black
Brown
White
Magenta
Red
Yellow
Green
Cyan
Blue
93 SECUNDA
005
3 6 0
MUNSELL SOIL COLOR CHART
8/
7/
6/
5/
4/
3/
VALUE
CURATION
G.S.C.


93 SECUNDA
005
3 0 0
MUNSELL SOIL COLOR CHART
8/
7/
6/
5/
4/
3/
VALUE


93 SECUNDA
005
4 2 0
5YR MUNSELL® SOIL COLOR CHART
VALUE
Blue
Cyan
Green
Yellow
Red


0
1
2
3
93 SECUNDA
005
3 8 0
MUNSELL® SOIL COLOR CHART
VALUE
Black
Brown
White
Magenta
Red
Yellow
Green
Cyan
Blue


0
93 SECUNDA
005
4 5 0
5YR MUNSELL® SOIL COLOR CHART
VALUE
Black
Brown
White
Magenta
Red
Yellow
Green
Cyan
Blue


1
2
3
4 0
93 SECUNDA
005
3 9 5
5YR MUNSELL® SOIL COLOR CHART
VALUE
Black
Brown
White
Magenta
Red
Yellow
Green
Cyan
Blue


0
93 SECUNDA
005
5 3 0
5YR MUNSELL® SOIL COLOR CHART
Black
Brown
White
Magenta
Red
Yellow
Green
Cyan
Blue
VALUE
8/
7/
6/
5/
4/


0
1
2
3
93 SECUNDA
005
4 8 0
5YR MUNSELL® SOIL COLOR CHART
Black
Brown
White
Magenta
Red
Yellow
Green
Cyan
Blue
VALUE
8/
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6/
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4/
3/


0
93 SECUNDA
005
5 1 0
5YR MUNSELL® SOIL COLOR CHART
Black
Brown
White
Magenta
Red
Yellow
Green
Cyan
Blue
VALUE
8/
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APPENDIX C

Data Table

Core 5 population density, total number of species, and foraminiferal percentage abundances versus depth in core.

Depth in core (cm)	0-2	20-21	41-42	51-52	60-61	78-79	80-81	100-101	110-111	116-117	121-122	127-128	134-135	150-151	161-162	170-171	190-191	210-211	220-221	240-241	255-256	270-271	290-291
Total # Species	7	1	1	18	22	19	18	20	21	21	24	20	18	19	24	24	5	3	9	6	20	22	19
Total # Specimens/10cc	20	4	1	7488	8144	5488	1492	6096	5552	4176	568	2480	82	6272	934	248	5	3	29	15	1848	9200	7824
Adercotryma glomerata	40	100									3.3		14.6		4.3	18.5				53.3	0.2		
Ammotium cassis																0.4							
Astrononion gallowayi				1.9	2.2	0.3		0.5	0.9	2.9	1.6	1.3		2.6	2.6						1.9	0.5	2.9
Brizalina pseudopunctata																							
B. subaenariensis					0.6			0.3	0.9		0.2			0.3	0.3							1.2	0.2
Bucella frigida				4.9	5.3	4.4	12.6	5	8.9	11.5	6.6	4.2	1.2	7.4	7.5	4			6.9		8.7	4.7	3.5
Bulimina marginata				1.1	2.6	1.2	0.5	0.5	0.3	0.8	0.5			1.5	1.1							1.4	2.9
Cassidulina reniforme	5		100	0.2	2.4	0.6	2.4	1.6	2.6	2.5	1.6	2.3	4.9	4.1	6	0.8	20		10.3		1.9	5	4.1
Cibicides lobatulus				18.8	12.4	14.3	4.8	15	16.1	13.8	11.3	2.3	1.2	8.9	9.4	3.6					2.2	15.3	15.1
Cribrostomoides crassimargo	15												1.2			2							
C. jeffreysi	5										0.2		1.2										
Discorbis spp.																							
Eggerella advena																			6.9	6.7			
Elphidium bartletti					0.8	0.3		0.8	2.6	0.8												0.2	
E. excavatum forma *clavatum*						0.6	0.5		4	8.8	8.9	11.3	4.9	12	8.4	7.7					11.7	16	17.4
E. excavatum forma *excavatum*				12	9.8	7.9	2.9	7.1	4	7.1	5.4	4.5		5.6	1.9						2.6	3	1.8
E. excavatum forma *magna*				13.7	16.9	19.2	2.1	19.2	14.7	11.3	10.8	2.3		5.9	1.7	2.8						2.3	2
E. groenlandicum														0.3							0.2		
E. subarcticum				3	2	4.7	1.3	2.6	5.5	4	5.9	2.6	1.2	5.4	6.2	4.8			6.9	6.7	4.5	7	6.1
Fissurina spp.				0.9	1.4	0.6	0.3	1.6	1.2	1.3		0.3		1	1.5	1.6					0.4	1.2	1
Fursenkoina fusiformis				1.9	2.9	3.2	1.1	3.1	1.2	0.6	1.9	2.3		1	2.1	0.4					1.3	1.7	
Glabratella wrightii																					0.2		
Globobulimina auriculata				1.5	2	2.3	0.8	2.1	1.4	0.4	0.9	0.3	4.9	1	3	4			3.4		0.9	1.2	1.4
Glomospira gordialis																0.4							
Haynesina orbiculare						0.3			0.3	1	0.2	0.6				0.4							
Islandiella islandica				6	8.1	9.9	6.7	7.1	5.8	4.8	2.6	13.5	4.9	10.5	4.9	8.5			3.4		9.1	5.4	8.8
I. teretis				24.6	17.1	20.7	52	21.5	19.9	14.6	21.8	40.3	30.5	22.7	21.8	24.2	20	33.3	24.1		41.3	20.3	20
Lagena spp.					0.2		0.3	0.5			0.2	0.3				0.4						0.2	
Nonion barleeanum										0.2													
Nonionella turgida				2.1	2	2.3	0.5	3.1	2.6	1.1	2.4	0.3		0.3	0.9						0.9	0.2	0.8
Nonionellina labradorica				6.8	9.8	6.7	4.8	7.3	6.3	10	11.7	9	7.3	7.9	9.4	6.5	20		6.9		6.3	10.3	10.6
Oolina spp.				0.4	0.2	0.6	0.3	0.3			0.2	0.3										0.3	0.4
Planktonics				0.2	0.2										0.2						0.2	0.5	0.4
Pseudopolymorphina novangliae										0.2		0.3											
Pullenia subcarinata					0.2																		
Quinqueloculina agglutinans									0.3														
Q. seminulum		-																					
Rheophax arctica																0.4							
R. fusiformis																		33.3					
R. nodulosa													1.2										
Robertinoides charlottensis															0.4								
Saccammina difflugiformis															0.2	0.8							
Textularia torquata															0.2	0.4	20						
Trifarina fluens				0.2	1.2		5.9	0.8	0.6	1.7	1.2	1.6	4.9	1.8	3.2	4.8			31	6.7	5.2	0.5	0.4
Triloculina tricarinata																							
Trochammina globigeriniformis													1.2										
T. lobata																0.8	20						
T. ochracea	10										0.2		6.1							6.7	0.2		
T. squamata																		33.3					
Turritella schoneana													1.2										
T-K forms																							
Globigerinelloides spp.																							
Guerbetria spp.																							
Heterohelix spp.										0.2													
Nonion spp.																							
Pyramidina spp.																							
Unidentified T-K forms																							

Depth in core (cm)	310-311	320-321	340-341	360-361	380-381	400-401	420-421	440-441	460-461	480-481	500-501	510-511	529-530
Total # Species	19	19	25	17	17	19	17	15	11	22	18	13	18
Total # Specimens/10cc	5776	5600	4216	2784	810	784	2408	4440	3920	4652	3280	3256	1268
Adercotryma glomerata													
Ammotium cassis													
Astrononion gallowayi	3	4.9	1.9	0.3	1.2	3.8	0.2		0.2	0.2			
Brizalina pseudopunctata			0.2			0.3				0.2	0.2		0.2
B. subaenariensis			0.2	0.3									
Bucella frigida	4.4	5.1	7	9.5	8.9	11	1	3.2	1.2	1.6	1.2	0.7	1.3
Bulimina marginata	0.6	1.7	0.4			0.3	0.2					0.2	
Cassidulina reniforme	6.1	2.6	4.4	5.7	3	3.1	4.5	5.4	5.9	9.3	12.2	8.1	13.7
Cibicides lobatulus	14.4	10.3	15.9	17.8	5.7	8.4	3.5	3.4	1.4	3.5	2.7	3.2	2.2
Cribrostomoides crassimargo													
C. jeffreysi													
Discorbis spp.											0.2		
Eggerella advena													
Elphidium bartletti					0.3	0.8	0.3						
E. excavatum forma *clavatum*	25.8	13.1	21.1	19.8	36.3	29.6	76.6	73.2	78	60.8	57.3	61.9	53.8
E. excavatum forma *excavatum*	1.4	1.7	3.8	2.9	1.7	2.8	2	2.2	2.7	1.9	2.9	4.7	3
E. excavatum forma *magna*	1.4	2.3	2.7	1.7									
E. groenlandicum													
E. subarcticum	4.2	4.9	5.7	3.2	6.7	8.4	5.8	5.6	11.8	11.6	16.1	15.5	7.4
Fissurina spp.	0.8	0.6	1.1	0.6	1.2	1.3		0.4			0.2		0.2
Fursenkoina fusiformis	0.8	2.3	1.5	2.3	1.5	0.8		0.4		0.7			0.6
Glabratella wrightii										0.2	1.2	0.7	0.2
Globobulimina auriculata		3.1	1.5	0.3	1.5					0.5	0.5		
Glomospira gordialis													
Haynesina orbiculare	1.1					2.8	0.5		0.8	0.3	0.2	0.5	2.8
Islandiella islandica	6.1	6	4.2	8.3	6.4	3.1	0.3	1.4	0.4	0.9	1	0.7	2.2
I. teretis	18.3	18.6	13.7	18.1	10.9	10.5	3.8	3.4	1.8	2.6	2	1.7	11.4
Lagena spp.	0.3	0.6	0.2		0.5	0.5	0.2			0.2			
Nonion barleeanum													
Nonionella turgida		0.6	0.4				0.2			0.2			
Nonionellina labradorica	9.7	19.4	11.4	8	12.6	8.7	0.5	0.7	0.2	4.3	1.2	0.5	0.2
Oolina spp.	0.3	0.6	0.4	0.6	0.5	1.3	0.3			0.3			0.3
Planktonics	0.6		0.4										0.2
Pseudopolymorphina novangliae													
Pullenia subcarinata													
Quinqueloculina agglutinans													
Q. seminulum												1.5	
Rheophax arctica													
R. fusiformis													
R. nodulosa													
Robertinoides charlottensis													
Saccammina difflugiformis								0.2					
Textularia torquata													
Trifarina fluens	0.8	1.7	1.5	0.6	1.2	2.8		0.2		0.2	0.2		
Triloculina tricarinata											0.2		
Trochammina globigeriniformis													
T. lobata													
T. ochracea													
T. squamata													
Turritella schoneana													
T-K forms													
Globigerinelloides spp.										0.2			
Guerbetria spp.								0.2					
Heterohelix spp.			0.2					0.2		0.2			0.2
Nonion spp.			0.2										
Pyramidina spp.			0.2							0.3	0.2		0.3
Unidentified T-K forms							0.2						