Lower Scotian Slope Benthic Foraminiferal Faunas Past and Present, with Taxonomic Outline

- F.C. Thomas

Atlantic Geoscience Centre

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The undersigned hereby certify that they have read and recommended to the Faculty of Graduate Studies for acceptance a thesis entitled " Lower Scotian Slope Benthonic Foraminiferal Faunas Past and Present, with Taxonomic Outline ."

by F.C. Thomas

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Author Francis C. Thomas

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When the still sea conspires in armor

And her sullen and aborted currents

Breed tiny monsters ....

- Jim Morrison

"Horse Latitudes"

1969

TABLE OF CONTENTS

PAGE

CHAPTER ONE - INTRODUCTION

CHAPTER TWO - METHODS

CHAPTER THREE - LATE PLEISTOCENE TO RECENT OCEANOGRAPHY OF THE LOWER SCOTIAN SLOPE AND RISE

TABLE OF CONTENTS - CONTINUED

PAGE

CHAPTER FOUR - RESULTS

CHAPTER FIVE - DISCUSSION

CHAPTER SEVEN - TAXONOMY

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

Abstract

24 samples of surface sediment from the lower Nova Scotia Slope (2000 - 5000 m depth) are analyzed for benthic foraminiferal content, along with over 100 samples from an 11 m piston core and corresponding gravity core from the same area, at 4046 m depth.

Analysis of the surface samples reveals the presence of 4 assemblages, apparently related to the corresponding ambient water masses. Assemblage I (2000 - 2500 m) is strongly dominated by *Elphidium excavatum* forma *clavata* and follows the range of Labrador Slope Water in the study area. Assemblage II (2500 - 3600 m) is a very diverse fauna with up to 70% agglutinated forms, and appears to be associated with North Atlantic Deep Water (NADW). Assemblage III is present on the slope from 3600 - 4000+ m, and is characterized by a strong presence of *Epistominella umbonifera*. Its areal extent seems to reflect the distribution of Antarctic Bottom Water (AABW) on the lower slope. Assemblage IV,, occurring from 4000+ m down to at least 4925 m (the lower limit of sampling), is a relatively impoverished benthic foraminiferal fauna dominated by small numbers of *Saccammina difflugiformis*. This biota may be subject to "abyssal storms" described by Hollister and McCave (1984) and exists within the "Cold Filament" water described by Weatherley and Kelley (1982).

Study of the core samples reveals dramatic changes in benthic foraminiferal populations at the sample site through time. The upper 30 or 50 cm of the piston core contain a fairly typical Assemblage III fauna (*Epistominella umbonifera* dominating), while below 90 cm the core is composed largely of sediments closely resembling the Facies 3b and 4 material described by Piper (1974) from cores in the same region. These sediments contain an assemblage not seen in any surface material, dominated by *Elphidium excavatum* forma *clavata* (a smaller, somewhat different variety from that seen in surface Assemblage I samples), *Uvigerina peregrina* and a few other forms, along with small numbers of an extinct Maastrichtian species, strong evidence of a turbiditic origin for these strata.

Indications are that these changes in fauna reflect the evolution of hydrographic conditions at the core site from the late Pleistocene to the present.

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ONE - INTRODUCTION

1.1 General

For almost two centuries foraminifera have been the subject of increasing scientific interest and scrutiny. Naturally, the scope of foraminiferal studies has become increasingly sophisticated with the passage of time and specializations now exist within the field of foraminiferal research which would surprise a scholar from the previous century.

In the past few decades fossil foraminifera have become an important tool for solving problems of correlation, age determination and paleoecology in exploration for fossil fuels. Their small size, relative abundance in marine sediments and sensitivity to environmental parameters all contribute to their utility.

Modern foraminifera, both benthic and planktonic, have also become the focus of much scientific effort in recent years. This is due largely to the continued acceptance of Lyell's uniformitarian belief that "the present is the key to the past". Applied to all groups of organisms of paleontological interest, including foraminifera, it contends that if a given modern organism occupies a certain ecological niche, its close relatives in the geologic past are likely to have occupied a similar niche. The same may be applied to modern and fossil assemblages, perhaps with even greater confidence. Scott et al. (1983) successfully used the concept with primitive agglutinated forms, showing a one to one correspondence between recent and Mesozoic forms. This same correlation cannot be expected for more advanced calcareous forms but assemblage characteristics certainly apply.

Interestingly, a cursory look through some of this literature shows a trend; the more nearshore a given marine area is, the more likely it is to be represented by a published foraminifera-related study. The corollary is all too true; the deeper the water, the more imperfectly known are its foraminiferal assemblages, particularly the benthic components. Of course, there are obvious reasons for this deficiency. The availability and expense of the ocean-going research vessels needed for study of the bathyal and abyssal sea bottom, along with related problems such as time and even weather considerations, make such surveys as difficult to organize as the results are rewarding.

1.2 Objectives

The primary objectives of this study are:

(a) To determine the present day composition and provenance of assemblages of benthic foraminifera on the lower slope and continental rise off Nova Scotia from 2000 m depth to 5000 m, the beginning of the abyssal plain.

(b) To examine assemblages encountered in one long piston core (82-022-78p) taken from 4046 m water depth in the same area and compare them to present assemblages.

(c) To establish a correlation between assemblages and sediment units or facies in the core.

(d) Correlate faunal changes within the core to hydrographic events in the water masses overlying the study area within the time frame represented by the deposition of the sediments in the core.

(e) Offer comments and formulate hypotheses regarding results and inferences arising from these data.

This study will take its place within a larger framework of multidisciplinary effort now being conducted on the coastal waters of Eastern Canada. As part of the overall plan, Pleistocene to recent sediments on and near the continental shelf are being investigated for palynological content, sedimentology, foraminiferal assemblages and other criteria. Obviously, the present and past oceanographic characteristics of the overlying water masses are centrally important to this research and relevant data will be incorporated and utilized in this present work.

1.3 Study Area

The study area of this work stretches over a rather large section of the continental slope and rise southeast of Nova Scotia, bounded by lines of latitude at 43°15'N and 40°30'N and by longitudinal meridians 58°45'W and 63°45'W (Fig. 1).

Water depths range from less than 200 m in the extreme northwest corner of the study area to greater than 5000 m in the southeast. Sample depths, however, range from 2000 m to 4925 m.

There is little topographic relief of the sea bottom in the survey area. Bathymetric charts reveal little directional disruption of northeasterly-trending isobath lines, indicative of a relatively flat, featureless surface of sea bottom below 3000 m, dipping very gently (<1°) to the southeast. Above 3000 m, some canyons appear in the steeper gradient of the upper slope (Hill, 1981). Sample 15 (80-004-65) is from the upper reaches of Dawson Canyon (see Fig. 1).

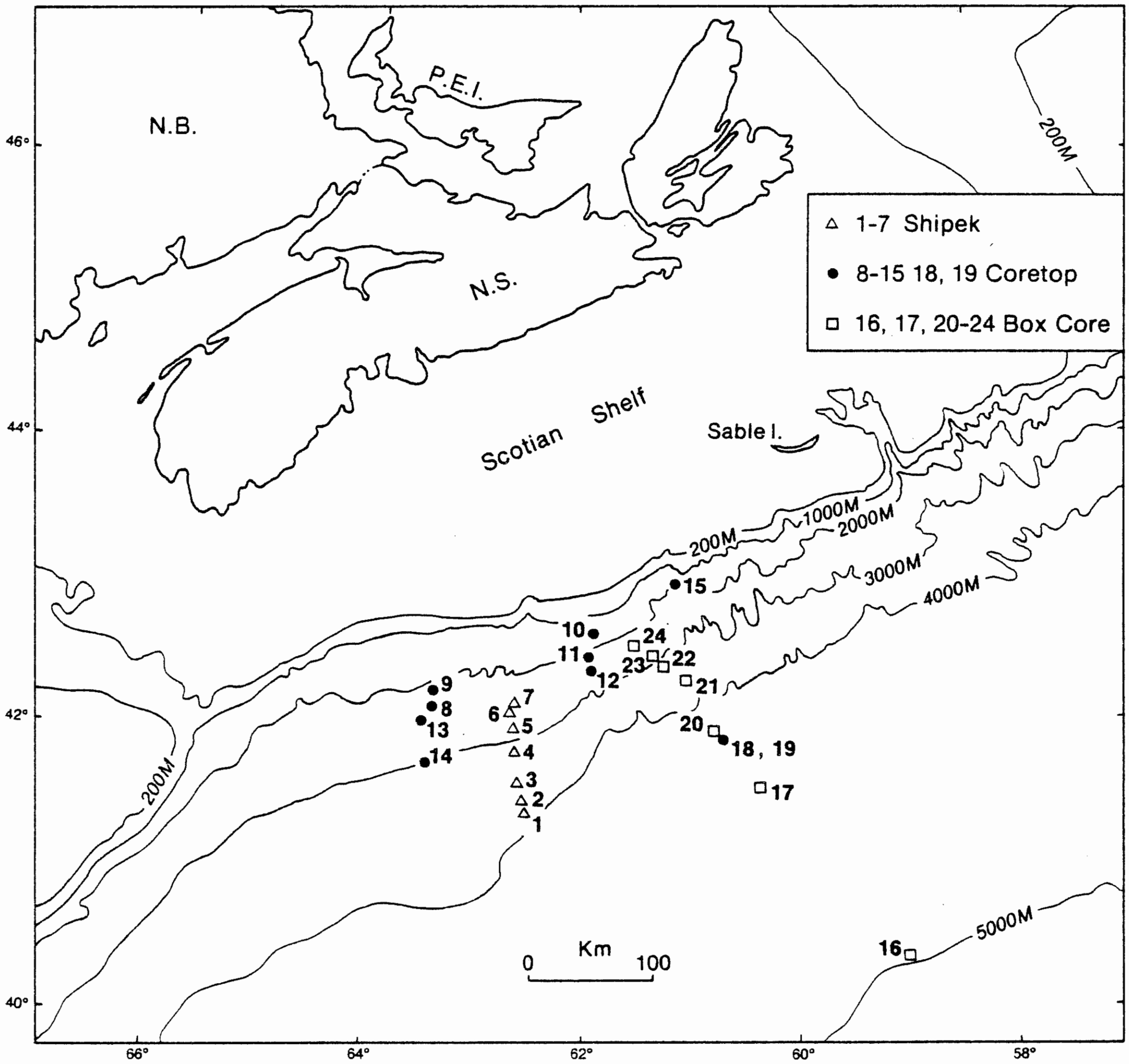


Figure 1. Location of study area and sample sites.

1.3.1 Surficial Geology

Most of the Nova Scotian slope and rise area is generally agreed to have been the site of heavy sediment accumulation since the initial opening of the North Atlantic in Jurassic time (Jansa and Wade, 1974). Emery and Uchupi (1972) have depicted the upper layer of this margin as being composed of a series of overlapping Pleistocene fans. The largest of these is the Laurentian fan, located at the seaward end of the Laurentian channel, several hundred kilometers northeast of the study area.

The surficial sediments of the slope and rise south of Nova Scotia have been core-sampled previously, usually at widely-spaced sites (Stanley et al., 1972; Piper, 1975). Stow (1976), in a study of some of these cores, thought that the olive gray mud facies so prevalent in the upper-most metre was probably the result of Holocene hemipelagic settling processes. Beneath this surface layer, the dominant "Wisconsinan" - latest glacial-facies is a reddish mud containing frequent laminae of silt along with occasional thicker muddy layers, whose origin is an unsettled question. Piper (1975) considers it to be a turbidite, generated by the occasional slumping of unstable soft sediments accumulating on the steeper upper slope, presumably during the Wisconsinan glacial advance. A rival theory, that of Heezen et al. (1966), Hollister (1967) and Bouma and Hollister (1973) holds that contour-current deposition is the principle agent of sediment accumulation on the lower slope and rise. In this model, the Western Boundary Undercurrent is thought to be the largest single mechanism, at least during interglacial periods.

1.3.2 Physical Oceanography

The water masses presently overlying the Nova Scotia continental slope have been the subject of many and varied studies, partly because of their proximity and obvious importance to the commercially important fisheries of the shelf edge region.

One of the more recent of these studies is that of Gatien (1976) who divided the general category of Slope Water into two separate entities; Warm Slope Water, composed of 80 - 90% North Atlantic Central Water and occupying the uppermost 300 or 400 m of the water column, and secondly Labrador Slope Water, containing cooler water from the Labrador Current and lying both below and slightly landward of the Warm Slope Water, to a depth of 1000 m or more. Both units show variable T-S characteristics. However, Gatien fails to indicate what water mass lies below this, in the outer, deeper portion of the slope and rise complex, where depths range to 5000 m and more.

The Gulf Stream frequently overlies the deeper portions of the slope area off Nova Scotia, providing warmer, saltier water to the area. This current however, normally overlies or replaces existing surface water, usually penetrating only a few hundred metres below the surface, exerting no direct influence on bottom conditions in the study area.

Physical oceanography of the deeper waters overlying the sample sites will be elaborated on in a later chapter.

1.4 Sample Locations

Sample locations are shown in Figure 1, illustrating the series of discrete transects lying normal to bathymetric lines on the upper slope and rise off Nova Scotia. Table 1 gives sample locations, water depths and sampling devices used in this study.

Table 1

No.	Sample	Location Latitude	 Longitude	Water Depth (m)	Type of Sample
1	81-016-01	41°27.0'	62°32.0'	3985	Shipek Grab
2	81-016-02	41°32.0'	62°33.0'	3880	Shipek Grab
3	81-016-03	41°43.0'	62°37.0'	3500	Shipek Grab
4	81-016-04	41°53.0'	62°37.5'	3247	Shipek Grab
5	81-016-05	42°02.6'	62°38.0'	2995	Shipek Grab
6	81-016-06	42°09.8'	62°39.0'	2750	Shipek Grab
7	81-016-07	42°14.5'	62°37.5'	2500	Shipek Grab
8	79-002-12	42°13.5'	63°25.0'	2200	Core Top
9	79-002-13	42°19.9'	63°25.0'	2000	Core Top
10	79-002-50	42°34.2'	61°53.5'	2000	Core Top
11	79-002-51	42°32.2'	61°54.0'	2200	Core Top
12	79-002-52	42°29.8'	61°54.0'	2400	Core Top
13	80-004-13	42°05.0'	63°30.3'	2500	Core Top
14	80-004-14	41°48.5'	63°28.7'	3050	Core Top
15	80-004-65	43°02.3'	61°05.8'	2120	Core Top
16	82-022-76	40°23.9'	58°58.1'	4925	Box Core
17	82-022-77	41°38.0'	60°19.5'	4495	Box Core
18	82-022-78g	41°57.4'	60°39.9'	4046	Core Top
19	82-022-78p	41°57.4'	60°39.9'	4046	Core Top
20	82-022-79	41°58.6'	60°41.9'	4030	Box Core
21	82-022-80	42°22.9'	60°59.6'	3543	Box Core
22	82-022-82	42°29.7'	61°13.8'	2996	Box Core
23	82-022-83	42°31.8'	61°17.3'	2750	Box Core
24	82-022-84	42°37.0'	61°30.4'	2487	Box Core

Table 1. Sample numbers, locations, water depths, and type of sample.

1.5 Previous Work

This section deals with earlier research on foraminifera from bathyal and shallower environments near the Scotian shelf and rise, and also surveys conducted on deep-sea foraminiferal faunas from other parts of the world.

1.5.1 Scotia Slope and Adjacent Areas

Carter et al. (1979) conducted a survey of the continental slope and rise east of Newfoundland, in which depositional environments and both macro and microscopic benthos were evaluated. They reported increases in benthic foraminiferal diversity and numbers with depth, particularly below 2000 m, independent of bottom sediments. Schafer et al. (1981) and Schafer and Cole (1982) made further investigations of the foraminifera of that region.

Rodriguez and Hooper (1982a) described benthic foraminiferal assemblages from the Gulf of St. Lawrence. Scotian Shelf faunas have been extensively documented by Barbieri and Medioli (1969) and especially by Williamson (1983), (1985) and Williamson et al. (1984). Various nearshore areas of Nova Scotian waters have been the subjects of studies by many authors including Scott and Medioli (1980a,b) Allen and Roda (1977), Gregory (1970) and Thomas and Schafer (1982), to name a few.

Most pertinent to the present topic are studies by Kaminski (1983), documenting taxonomy of some benthic foraminifera from a region overlapping the present study area on the Scotian slope and rise; and by Schröeder (unpublished), an ongoing taxonomic study of benthic foraminifera from all of the North Atlantic including some of the same samples used in this work.

1.5.2 Bathyal and Abyssal Faunas of Other Marine Areas

Studies of deep-water faunas from other parts of the North Atlantic Ocean in recent years include Streeter (1973), Poag et al. (1980), Culver and Buzas (1981, 1982), Bremer and Lohmann (1982), Miller and Lohmann (1982) and Streeter and Lavery (1982), and Hermelin and Scott, (1985).

Worldwide, there have been recent studies of deep-water benthic foraminifera by Lagoe (1977), dealing with the Arctic Ocean; Belanger and Streeter (1980) concerning Norwegian-Greenland Sea faunas; Anderson (1975) and Milam and Anderson (1981) describing Antarctic Sea faunas; and Lohmann's (1978) paper concerning abyssal benthic foraminifera in the western south Atlantic Ocean.

Benthic foraminiferal faunas of the Gulf of Mexico have been catalogued by Phleger and Parker (1951), LeRoy and Levinson (1974), Leroy and Hodgkinson (1975), and Culver and Buzas (1983).

Indian Ocean deep-water faunas have been reported by Boltovskoy (1977) and Corliss (1979). The foraminiferal faunas of the Peru-Chile Trench area have been outlined by Bandy and Rodolfo (1964) and Ingle et al. (1980).

In spite of the extensive taxonomic revisions conducted on Brady's (1884) work (Barker, 1960), that volume is still the best single source of descriptions and illustrations of the global varieties of bathyal benthic foraminifera.

TWO - METHODS

2.1 General

All samples used in the present study were collected from ships of the Bedford Institute of Oceanography, Dartmouth, N.S. during the following Dalhousie University cruises: 79-002 (C.S.S. Dawson, February, 1979) 80-004 (C.S.S. Dawson, March, 1980), 81-016 (C.S.S. Dawson, May 1981), 82-022 (C.S.S. Hudson, July, 1982). The author was present on the last two cruises; samples from the first two were kindly supplied by M. Williamson, Atlantic Geoscience Centre, B.I.O.

Since the various sample suites represent different sampling methods and received somewhat differing treatments, each set presents different problems. To simplify descriptions of shipboard and laboratory methods each suite of samples will be discussed separately in this chapter.

2.2.1 Core-top Samples

Samples obtained in cruises 79-002 and 80-004 represent the top two centimeters of gravity or piston cores. Each was disaggregated in water and washed through a 63-micron sieve. The residue was then dried and split, if necessary, to obtain a portion containing 200 or 300 benthic foraminiferal tests.

This portion was then examined under a binocular microscope and accurate counts were made of all benthic species present; all benthic foraminifera were removed and placed in 60-grid slides.

2.2.2 Shipek Grab Samples

Samples from cruise 81-016 were collected using a Shipek Grab sampler, a fairly small, spring-loaded device which consistently obtained a reasonably good quality sample. The grading system devised by Williamson (1983) was used for scaling sample quality and is shown in Table 2. All samples used for this study rated a 1 or 2 on this scale. The top 1 or 2 cm of part of the sample was scraped off at the time of collection and placed in a small vial containing a buffered formalin solution.

Later, in the lab, the subsample was disaggregated in water and washed through a 63-micron sieve. Again, the residue was dried, and split if necessary to obtain at least 200 benthic foraminifera, which were subsequently identified, counted, and placed in slides.

2.2.3 Box Core Samples

Most samples from cruise 82-022 represent surface subsamples derived from a predetermined section of a large (1/2 m) box core. Although no real grading system was used to qualify the condition of the box core samples as was done for the Shipek sample suite, most samples collected with this device appeared to be in excellent condition, with clear supernatant water and an undisturbed surface sediment layer. In some samples huge _Reophax bacillaris_ specimens were observed apparently _in situ_ on the sediment surface.

These samples were covered with a buffered formalin solution. In order to better preserve the fragile agglutinated forms in these samples care was taken to wash them very gently through a 63-micron sieve and to immediately re-immerse the residues in the buffered formalin solution, where they were subsequently stained with Rose Bengal (as described by Walton, 1952). In order to examine and perform counts

Rating Index for Shipek Grab samples

Rating	Requirements
1	Surface mm present over entire sample; supernatant water clear. Subsample recovery good.
2	Surface mm present over part of surface only; supernatant water moderate to slightly turbid. Subsample recovery fair.
3	Surface present over part of sample only; supernatant water strongly turbid due to ship movement and drainage.
4	Surface apparent, sufficient to warrant sample; very turbid waters.
5	Sample extremely poor in quality and quantity.
x	Sample not rated, seaweed/laminaria/pebbles.

Table 2. Rating index for Shipek grab samples (adapted from Williamson, 1983).

on these samples while still in a liquid medium, it was first necessary to split them, which presented a problem.

Many small commercially-made sample splitters are readily available for use in micropaleontological applications, but almost all are designed primarily to split a sample in a dry state, i.e. a mixture of sand, silt and microfossil tests. For this study, some mechanism was needed to divide into roughly equal parts a sample compound of microfossils and sediment grains in a liquid medium.

A solution to this problem was suggested by O. Hermelin (University of Stockholm) and designed and built locally. The apparatus consists of a 30 cm high tube, 12 cm in diameter, divided into 8 radiating sections at the bottom, (see Fig. 2), by 2 cm vertical walls. It is nearly filled with water, and the sample mix is poured into the center of the top of the cylinder. The foraminiferal tests and sediment grains settle slowly to the bottom, dispersing themselves in a reasonably random manner throughout the cylinder, before coming to rest on the bottom. A small stopcock on the side of the cylinder can be opened to allow most of the water to drain off after the sample has settled. Later, each of the 8 sections of the bottom can be separately drained, and the portions collected.

The author conducted extensive tests on this device, using preweighed silt samples suspended in water. Afterwards, the eight aliquots were weighed separately. The results repeatedly indicated that if care was taken pouring the sample into the top of the column, the eight splits would closely resemble one another in size and weight. It was concluded that the device was a reasonably accurate and unbiased way of obtaining splits of wet samples.

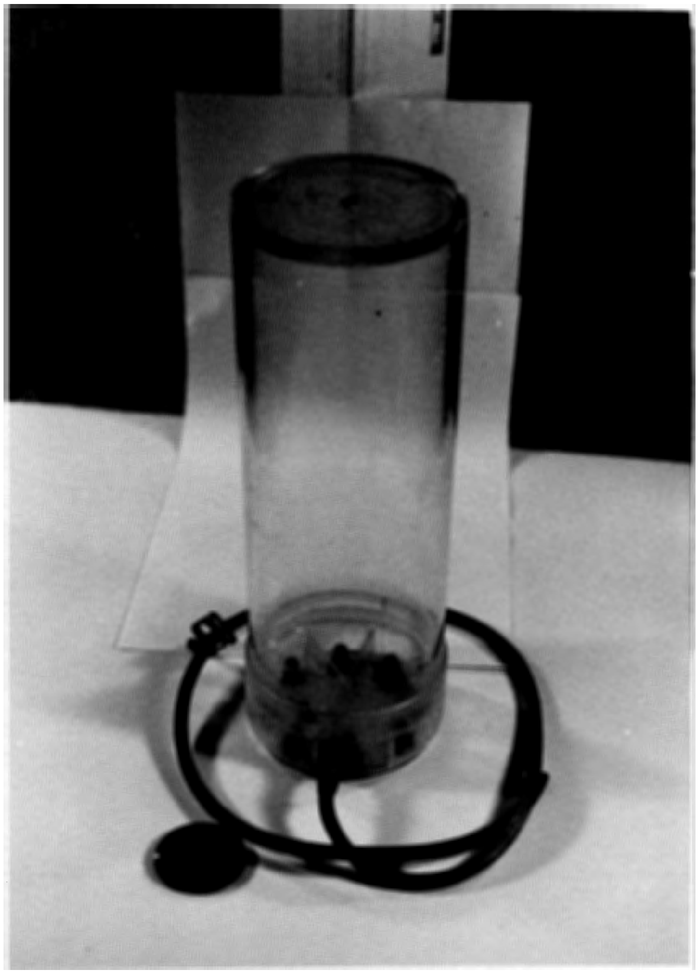


Figure 2. Apparatus for splitting wet samples.
(Note lens cap for scale)

2.2.4 Gravity and Piston Core Samples

At site 82-022-78, (4046 m) an 11.5 m piston-core was collected along with a 1.5 m trigger (gravity) core. The long piston core was then cut into 1.5 m lengths soon after coming aboard.

Later, at Dalhousie University, both cores were split, x-rayed, described (with advice from P. Mudie, Atlantic Geoscience Centre) and subsampled. These subsamples consisted of 10 cc of sediment, taken at 10 cm intervals, except for the bottom 2 m of the piston-core, which was sampled at somewhat longer intervals. All samples were then disaggregated, washed through a 63 micron sieve, dried and split if necessary.

2.3 Data Analysis Methods

All the data gleaned from the long piston-core were compiled into two sets, one set using all occurrences of all species regardless of how rare, and using all samples even those with few or no benthics. The other data set included only those samples containing at least 30 benthic foraminiferal specimens, and used only those species which composed at least 5.0% of at least one sample. In both cases samples taken from below 1070 cm were not used because of x-ray evidence of coring disturbance in the sediment below this level, as described by Stow and Aksu (1978).

Both data sets were coded and run using both Q and R mode cluster programs, kindly provided by B. Stam of Dalhousie University. In all cases the results were somewhat ambiguous and did not show any trends which were not obvious from visual examination of plotted data. They were, therefore, omitted from the present work.

All foraminiferal abundance data for the surface samples are provided in Appendix I A, and for piston and gravity cores in I B.

2.4 Oxygen Isotope Analysis

Specimens of one planktic species - Neogloboquadrina pachyderma (left and right-coiling forms separately) and one benthic taxon (Uvigerina peregrina) found in the core subsamples were analyzed for oxygen 18/16 ratios in an attempt to quantify changes in both overlying surface water mass and ambient bottom water temperature.

Unfortunately, in many samples, insufficient specimens were present to produce reliable data, so the results are inconclusive in some levels. The analysis data are illustrated in a later chapter.

2.5 Micrograph Illustrations

The micrographs of foraminiferal species assembled and presented as Plates 1-10 were all taken by the author. Optical micrographs were made using a Leitz Aristophot instrument incorporating a 35 mm camera with Kodak Panatomic X film, and the scanning electron micrographs were taken on the Atlantic Geoscience Centre's Cambridge S 180 instrument at Bedford Institute of Oceanography, using Polaroid N/P 55 film.

THREE - LATE PLEISTOCENE TO RECENT OCEANOGRAPHY OF THE LOWER SCOTIAN SLOPE AND RISE

This chapter surveys and summarizes recent literature dealing with oceanographic conditions, particularly of bottom water masses on the lower slope and rise off Nova Scotia, during the past 13,000 years.

There is not much literature available concerning these deep waters, particularly in a paleoceanographic sense. Most studies use recent assemblage data (usually derived from benthic foraminifera) to reconstruct conditions contained in the record of sediment cores. Since benthic foraminifera are the subject of this thesis, these studies complement the present one rather well.

Certain factors, such as possible downslope transportation of sediments and/or foraminifera, though obviously related to oceanographic conditions, will be discussed in a later chapter. The present discussion will deal only with water masses and their movements through time, especially in the western North Atlantic region.

3.1 Post-Glacial History of Deep-Sea Benthic Foraminiferal Assemblages

Streeter and Shackleton (1979) have described a piston-core taken from 3331 m at 44°N at the Mid-Atlantic Ridge. In this core Uvigerina peregrina is dominant in the lower portion but disappears in younger sections. They attribute this vertical distribution to the theory that this species thrives only in relatively oxygen-poor waters. In recent times the core site has been overlain by North Atlantic Deep Water (NADW) which is "new" water, formed partly from Norwegian Sea overflow water and partly of deep cold water from the Irminger and

Labrador Seas (Hollister et al., 1978a), and relatively rich in dissolved oxygen. Two other species, *Cibicides wuellerstorfi* and *Epistominella exigua*, do well in this water, and have apparently replaced *U. peregrina* in the upper part of the core. The causal factor of this succession of species appears to be related to the variation of water mass characteristics in the North Atlantic during and since the last glacial episode.

During the last ice advance, the Wisconsinan, the Norwegian Sea was presumably covered by permanent ice, and production of Denmark Strait Overflow water was suspended or severely curtailed, presumably adversely affecting production of NADW. With no "new" water supply, the bottom waters in the deeper parts of the North Atlantic were replaced by Antarctic Bottom Water (AABW) and became depleted in oxygen, and *U. peregrina* flourished. Later, when the ice front retreated, NADW production resumed and this species was supplanted by modern benthic assemblages (Streeter and Shackleton, 1979).

Closer to the North American continental margin, Balsam and Heusser (1976) studied two cores taken from between 3000 and 4000 m depth off Chesapeake Bay. Planktonic foraminiferal analyses show that both sample sites were overlain by warm surface water from 8000 yr B.P. until the present. Between 12,400 and 8000 yr B.P. the shallower site again showed evidence of warm surface waters, but the deeper one did not. They speculate that, when the Western Boundary Undercurrent (WBU) became established at about 12,400 yr B.P. (a result of renewed production of NADW as the ice began to retreat) the colder, less CaCO -saturated water of the WBU began preferentially dissolving warm water planktics (as described by Berger *in* Lipps, Berger et al. 1979) at the deeper site. The planktic evidence suggests that the Gulf Stream reached its maximum effect about 8000 yr B.P., then began to move back offshore by 4000 yr B.P. Balsam (1981) suggests that this oxygen-poor water supporting the abundance of Uvigerina intersected the eastern North American continental margin between depths of 2650 m and 4400 m. Beginning about 13,000 B.P. this water mass was eroded both from the top and bottom, and was entirely gone by 7300 B.P.

Schnitker (1979) has provided a more detailed glacial and post-glacial history of the Western North Atlantic. Benthic foraminiferal analysis was done on two cores from 3000 m and 4000 m depth, (36°N latitude) and from the deep basin further offshore, (approx. 5000 m). These analyses indicate that the deep basin site was overlain in late glacial time by cold, well oxygenated water, probably of local North Atlantic origin. Immediately above this (as detected at the shallower site) was at least 1900 m of "old" oxygen-deficient water (presumably from the Antarctic).

About 12,900 yrs. BP a basinwide change occurred. As the deepest water became isolated and began losing oxygen, the WBU became established. This current carried relatively well-oxygenated water southward at about 3000 m depth along the continental slope. "Old" oxygen-poor water reoccupied the levels between these two, facilitating the spread of the U. peregrina assemblage.

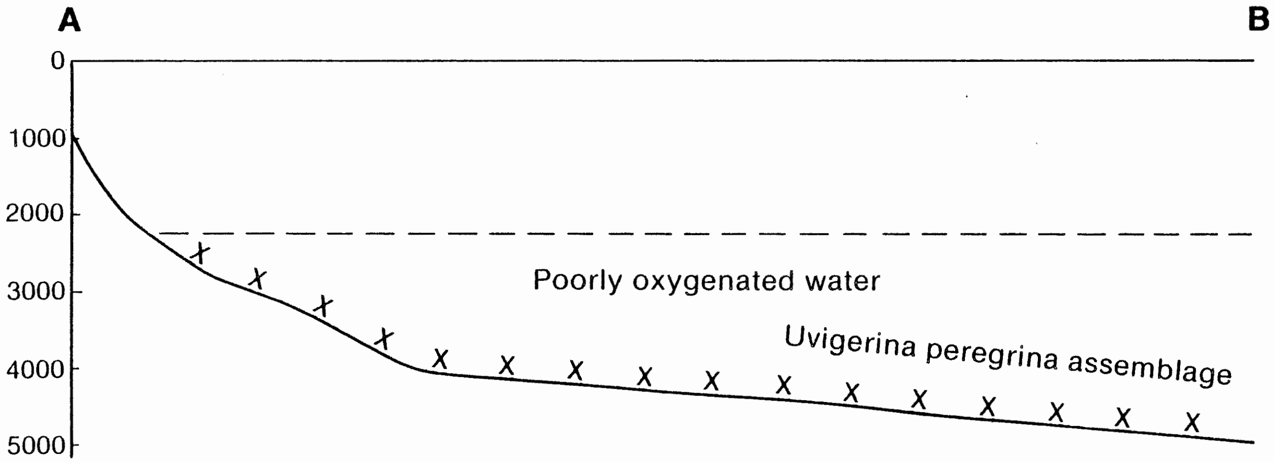
At about 9,000 yr B.P., the WBU enlarged, moved downslope and forced out the "old" glacial water. Overflow from the Norwegian Sea mixed with NADW and reached its maximum flux about 4000 yr B.P. The centre of the basin experienced the second change at about 8,000 yr B.P., when it filled with Norwegian Sea Overflow Water, and later, after

5000 yr B.P. began receiving an influx of Antarctic Bottom Water. It is possible that the Labrador Sea may have begun contributing oxygen-rich deep water to the continental margin area from about 9000 yr B.P. on, since, according to Ruddiman and McIntyre (1981), the Labrador Sea became ice-free year-round at about that time, as evidenced by CaCO concentrations and planktic foraminifera in cores. Figures 3a-c summarize these changes. Location of the transect is shown in Fig. 8.

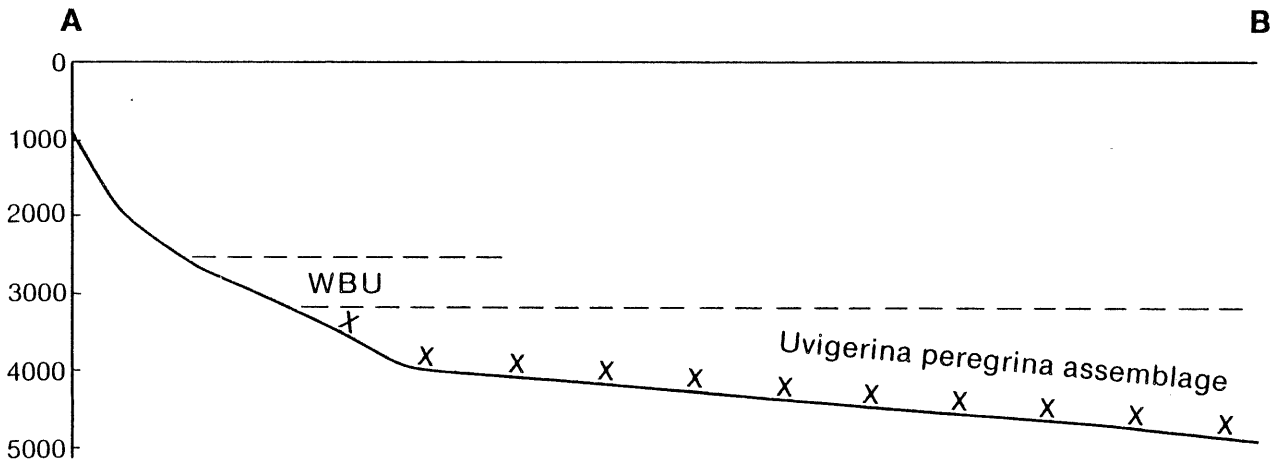
Streeter and Lavery (1982) have proposed a very similar circulation model, using radiocarbon dating of benthic foraminiferal faunas in cores from many parts of the North American continental margin between latitudes of 35° and 44°. They found that the transition from glacial to Holocene benthic foraminiferal faunas took place at 12,000 B.P. at 3,000 m, and at 8,000 B.P. at 4,000 m. They surmise from this evidence that the deeper waters were replaced from the top downward by NADW (which is composed largely of Norwegian Sea Overflow Water) as the Norwegian Sea ice cover cleared.

The modern Norwegian-Greenland Sea was the subject of a study by Belanger and Streeter (1980). They found that overlapping depth-dependent benthic foraminiferal biofacies existed in that region even though extensive studies of temperatures, salinities and oxygen content in the water masses at various depths showed no appreciable variability with depth. They suggest that such assemblages may be dependent on a complex set of variables including organic carbon, pH, nature of substrate and others, along with perhaps the obvious one of hydrostatic pressure. Belanger and Streeter wisely conclude that we simply don't yet know enough about these variables and the needs of individual foraminiferal species to confidently predict which variables

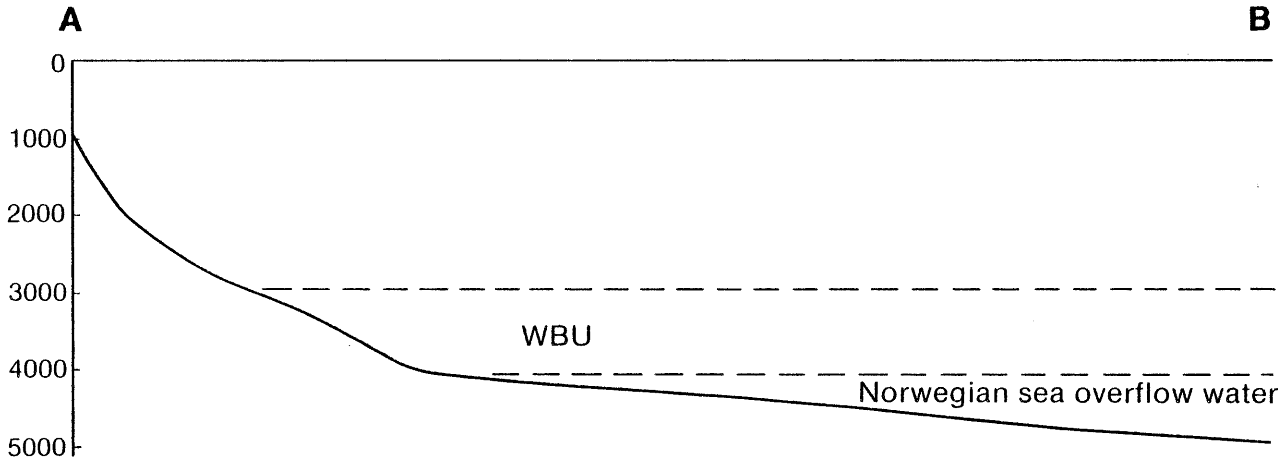
Figures 3a-c. Schematic cross sections of Lower Scotian Slope and Rise showing development of Wisconsinan to Recent water masses.



3a. Late Wisconsinan hydrography of transect AB in Fig. 8a.



3b. Hydrography of transect at 12,900 yr. BP. As the WBU becomes established, the *Uvigerina peregrina* assemblage begins to retreat down from 3000 m.



3c. Approximately 7300 yr. BP (Balsam, 1981), 1000-5000 yr. BP (Schnitker, 1979). The WBU has enlarged, moved downslope, and Norwegian Sea Overflow water has appeared at levels below 4000 m. Between these two water masses the "Uvigerina" water has been totally removed.

determine the distributions of deep benthic foraminiferal assemblages.

In a discussion based on cores from inshore waters, some from the Nova Scotia area, Vilks (1981) and Scott et al. (1984) indicate that the presence of a melting icecap on the Nova Scotia landmass may have provided enough meltwater to slightly reduce salinities in nearshore areas. Two benthic species, *Elphidium excavatum* forma *clavata*, and *Cassidulina reniforme* seem to prefer less saline waters, and cores show large concentrations of this species in shelf areas to depths of 500 m during late glacial times, with smaller numbers of the species still found in some localities at present. The *Elphidium-Cassidulina* assemblage has been termed a "warm" ice margin assemblage by Scott and Medioli (1980) and Scott et al. (1984).

Summing up these studies, it appears that the bulk of the evidence suggests the following sequence of events for the development of present deep oceanographic conditions near the Nova Scotian continental margin:

1. In the last glacial stage, the most northerly parts of the Atlantic Ocean, particularly the Norwegian Sea, were covered by permanent ice. The deeper parts of the Atlantic, at least in much of the northern hemisphere, were somewhat isolated, and levels of dissolved oxygen became quite low, presumably because of continuing biological activity.
2. At about 12,500 yr B.P., the northern ice sheets began retreating, and some well-oxygenated "new" water formed in these areas, and began flowing south at depth, diminishing the extent of the "old" oxygen-poor water mass. Melt water from the continental ice cap on Nova Scotia reduced salinities in nearshore areas

enough to enable the "warm" ice margin fauna to become established.

3. By about 8,000 yr B.P., the final retreat of the boreal ice pack was underway, and the modern WBU became fully estabished, bringing with it larger quantities of the "new" water, causing the widespread _U. peregrina_ fauna to be widely supplanted by other forms.

3.2 Recent Deep-Sea Circulation

Some recent studies conducted on the HEBBLE (High Energy Benthic Boundary Layer Experiment) area, which overlaps and includes the present study area, have confirmed the presence of a southward-flowing bottom current located at 4500-5000 m depth along the lower Scotian Slope. Measurements of dissolved silicates in the water mass indicate that it is composed of Antarctic Bottom Water, and may represent the return flow from the northward flowing North Atlantic Basin water from the Sohm Abyssal Plain to the southwest. Speeds of up to 73 cm/s have been recorded, and speeds in excess of 35 cm/s have been sustained for weeks at a time (Richardson et al. 1981).

Furthermore, CTD data indicate that this bottom layer of relatively cold ($<1.82°C$) and comparatively fresh ($S < 34.894°/_{\circ\circ}$) water lies in a narrow strip centered near the 4900 m isobath at the base of the continental rise (Weatherly and Kelley, 1982). The thickness of this bottom layer appears to be about 60 m, with a transition layer of similar thickness above it. This 'Cold Filament' extends along that isobath from about 50°W to at least 72°W, and its average velocity is approximately 9 cm/s. The direction of the current may vary somewhat, and sometimes the direction is reversed for a few days or weeks at a time.

The current speeds reported by Richardson et al. (1981) for this layer are certainly sufficient to produce the bedforms and erosional features which have been documented by Hollister et al. (1984) and certainly affect the area's macrobenthic communities. Photographs of the bottom reveal a relatively smooth, scoured-looking surface with tails of sediment in the lee of small mounds. The exact magnitude of erosional and redepositional processes in the area is as yet uncertain, but vertical distribution of radioactive isotopes (Cesium 137, from atmospheric nuclear tests in the 1950's) in the upper 12 centimeters of the bottom sediments indicate a very high rate of mixing (Hollister et al. 1984).

The exact mechanism causing these "abyssal storms" is as yet uncertain, but Hollister et al. (1984) mention evidence which links them to the appearance of warm-core eddies from the Gulf Stream.

Regardless of their provenance, such frequent and dynamic activity on the bottom would certainly affect benthic foraminiferal populations along with the macrobenthos and analysis of samples from that depth interval appear to substantiate this presumption as is seen in the next section.

3.3 Modern Lower Slope Foraminiferal Faunas

Schnitker (1974) has described 3 principle assemblages of Northwest Atlantic abyssal foraminifera from bottom samples. The first assemblage, dominated by Epistominella exigua, is found in latitudes above 45°N, and seems to closely follow the flow of Arctic Bottom Water (ABW), which is normally < 1.9°C in temperature and found at depths of approximately 5000 m in latitudes between Nova Scotia and Bermuda, shallower further north. South of 30°N, in Antarctic Bottom Water (AABW), an assemblage dominated by Osangularia (=Epistominella) umbonifera is found. AABW is reportedly quite cold (< 1.5°C). The transition point between these two faunas occurs around 35°N, where the two water masses meet and mingle. In the warmer waters of the NADW (2° - 4°C) lying above these faunas along the continental margin, faunas with abundant Hoeglundina, Uvigerina and Gyroidina spp. occur.

Strong evidence that at least the E. exigua assemblage is water-mass controlled, and not simply depth-dependent, is supplied by the northward extension of the assemblage into the shallower areas of ABW. Furthermore, in the southern direction, the same or a similar fauna approaches the Bermuda area, in much deeper water.

Further evidence for water-mass control of faunas is given by Streeter (1973). He found fluctuation of assemblages in piston-cores on a fairly rapid scale, precluding the possibility that such assemblages were simply depth-dependent.

In the western South Atlantic Ocean, Lohmann (1978) studied 29 abyssal benthic foraminifera species, showing correlation with deep water masses. He found that areas covered by Antarctic Bottom Water (AABW) produced assemblages strongly dominated by "Epistominella" umbonifera. Areas overlain by NADW are characterized by a more diverse fauna dominated by large numbers of Uvigerina peregrina, Planulina wuellerstorfi and Hoeglundina elegans, among others. He also found a positive correlation between P. wuellerstorfi and some miliolids with dissolved oxgyen; while U. peregrina, Globocassidulina subglobosa and Ehrenbergina sp. are more common in waters with less dissolved oxygen.

In the South Atlantic, the vertical transition between AABW and NADW occurs at approximately 4,000 m depth.

Evidence from cores in many parts of the North Atlantic continental margin indicated to Streeter and Lavery (1982) a regular succession of foraminiferal faunas at intervals down the slope. This succession appeared to be so regular that they felt that downslope transportation of faunas was probably not important except perhaps on a local scale. More will be said of possible downslope transportation in a later chapter.

In surface samples Streeter and Lavery (1982) found an assemblage dominated by *Hoeglundina elegans* on sea bottom from between 2600 - 3800 m. *Epistominella umbonifera* dominated below 3800 m. On the present North American continental margin, this 3800 m boundary divides AABW from NADW, in latitudes of about 45°N on southwards. Interestingly, an assemblage dominated by *Uvigerina peregrina* appears in many samples from the 1000 - 2600 m depth range. Further up slope, in samples from 100 - 2600 m depth, *Elphidium* spp. (usually *E. excavatum*) dominate assemblages in approximately 33% of all samples.

The *U. peregrina* assemblage has been investigated by Miller and Lohmann (1982). In contrast to other findings, they found that this assemblage at present shows no positive correlation with oxygen-reduced bottom water. It does appear, however, to be related to maximum values of organic carbon and silt in the sediments. This organic carbon, it is believed, could produce reduced oxygen levels in the interstitial waters of these sediments.

FOUR - RESULTS

4.1 Modern Benthic Foraminiferal Assemblages - Lower Scotian Slope

Visual analysis and comparison of 24 core-top, Shipek and box-core samples from depths ranging from 2000 - 4929 m on the Scotian Slope and Rise show the presence of four fairly well-differentiated benthic assemblages, based on dominant and subdominant species. These assemblages conform reasonably well to results of previous studies of faunas from similar depths on the North American continental margin. Figure 4 shows the distribution of dominant species in surface samples down the slope.

4.1.1 Assemblage I (2000-2500 m; 9 samples)

Samples from depths between 2000 and 2500 m in the study area typically contain a fauna strongly dominated by *Elphidium excavatum* forma *clavata*. This species comprises 19.1 - 81.0% of the total, with a fairly large component (9.2 - 29.8%) of *Uvigerina spinicostata* and smaller numbers of *Rhizammina indivisa* and *Fursenkoina concava*. The agglutinated component of this assemblage varies widely, from 1.2% to 40.6% of the total, though it is more often between 10.0% and 20.0%.

Although only a few species dominate this fauna, small numbers of many other forms are present. The number of total species present in these samples ranges from 26-49. In most cases, calcareous species outnumber agglutinated forms by a factor of 2-4, but in one sample, at 2487 m, 17 of the 37 species found were agglutinated.

According to Williamson (1983) the *E. excavatum* forma *clavata* fauna is common on the slope from approximately 1000 m depth down, and reaches an abundance peak at about 2000 m.

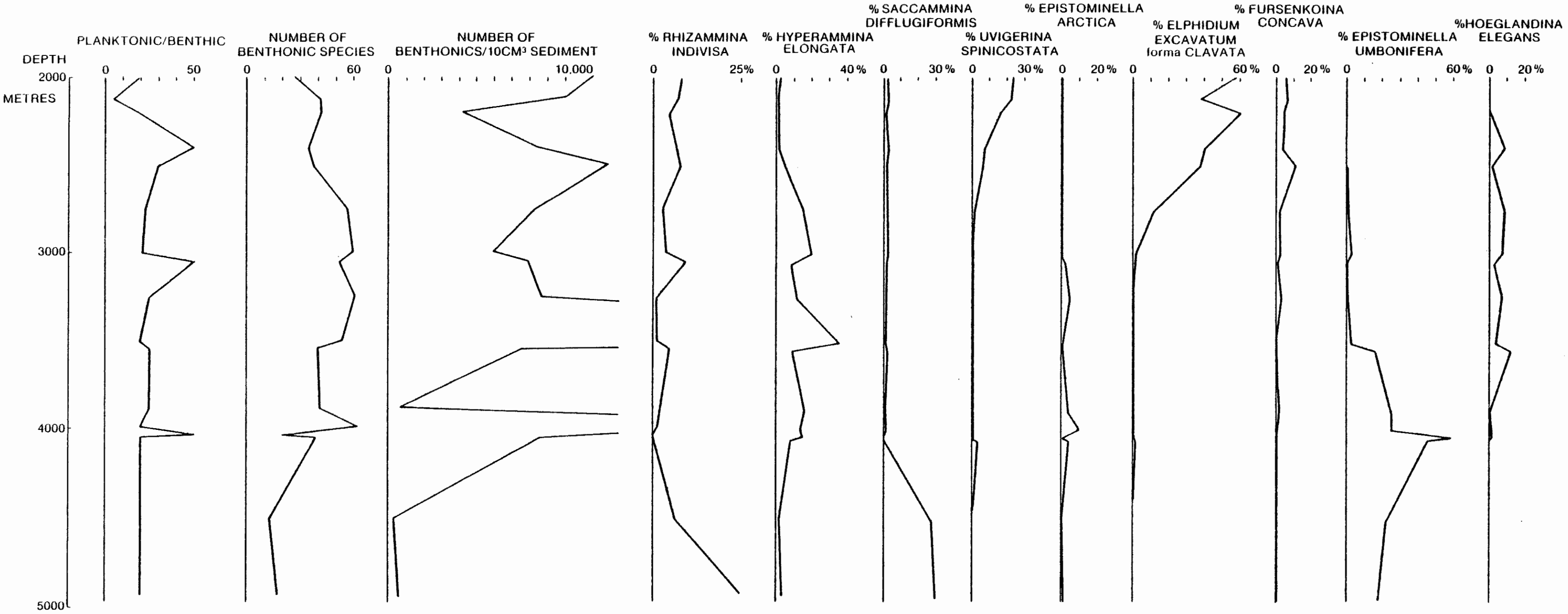


Figure 4. Distribution of dominant species in surface samples.

Although the numbers of benthic foraminifera in each 10 cm^3 sample vary somewhat, the average for this assemblage is about 2500/10 cm^3 sediment.

4.1.2 Assemblage II (2500-3543 m; 8 samples)

In this fauna the single most common component is Hyperammina elongata, composing from 7.2 - 34.2% of the fauna. Other important species include Hoeglundina elegans (5.9 - 11.6%) and Epistominella umbonifera (5.9 - 19.3%). Many other species are of minor importance, such as Rhizammina indivisa, Gyroidina spp. Nonion spp. and Planulina wuellerstorfi, among others. The agglutinated component of this fauna is typically larger than that of Assemblage I, ranging from 36.5% (at 3543, the deepest occurrence of this fauna) to 70.5%.

Assemblage II is a very diverse fauna, with the number of species ranging from 40 to 74. There are more calcareous forms than agglutinated ones in general, but in two samples the numbers are equal and in a few others they are very close.

The upper depth limit of this assemblage appears to lie somewhere between 2500 m and 2750 m and is marked by the shallowest occurrence of Epistominella umbonifera, and by consistent occurrences of Hoeglundina elegans and Hyperammina elongata. Also, at approximately this depth, occurrences of E. excavatum forma clavata, Fursenkoina concava and Uvigerina spinicostata show rapid decreases to low values.

As in Assemblage I, the average number of benthic foraminiferal specimens in a 10 cm^3 sample of this fauna is roughly 2500, but individual samples vary more widely in content than those of Assemblage I.

4.1.3 Assemblage III (3600-4000 m; 5 samples)

The uppermost limit of this fauna lies somewhere between 3543 - 3880 m, and is marked by the disappearance of *Hoeglundina elegans* and the increase in *Epistominella umbonifera* to 25.0% or more of the total fauna. The peak appearance of this foraminiferal facies appears to be at about 4000 m, with *E. umbonifera* reaching 58.3% of the total at 4030 m. No other single calcareous from is so common in this fauna, but a few species such as *Epistominella exigua* and *Planulina wuellerstorfi*, among others are common in some samples. An agglutinated species, *Hyperammina elongata*, averages about 10% of the total assemblage.

The number of species ranges from 21 to 63 in this fauna, somewhat less than that of Assemblage II. Again, calcareous species outnumber agglutinated taxa by up to 2:1. The agglutinated component may range from 13.5% to 32.9% of the total assemblage, substantially lower than that for Assemblage II.

The bottom limit of this fauna lies at somewhere between 4046 and 4495 m in depth, where it is supplanted by the next assemblage.

Again in this assemblage, a 10 cm sediment sample contains an average of roughly 2900 or so benthic specimens.

4.1.4 Assemblage IV (4000+—4925+ m; 2 samples)

Although this fauna is defined on the basis of only two samples, at 4495 and 4925 m depth, it is sufficiently distinct from the adjacent Assemblage III to justify its separate description. In this fauna the single most important taxa is the agglutinated *Saccammina difflugiformis* (26.5% and 28.6%) with slightly smaller numbers of *E. umbonifera* and *R. indivisa*.

This fauna is further differentiated by much lower numbers of specimens per sample than the other three (averaging just over 100 benthic specimens each) and by correspondingly lower numbers of taxa, (13 and 17). The agglutinated component is quite large, (61.8% and 78.6%) and these taxa outnumber calcareous species, in contrast to the composition of the other three assemblages.

4.2 Living vs. Total Assemblage Components

As described earlier, the box core samples used in this study were stained with Rose Bengal in an attempt to differentiate between specimens which were alive at the time of collection and those which were empty tests.

Counts were made of stained specimens, and the living and dead components in the original counts for these samples are included here as Table 3.

Table 4 shows the living component of each box core sample as a percentage of the total benthic foraminiferal assemblage. These range from 1.5% to 9.6%.

Unfortunately, one species that is very important in both Assemblage IV samples and present in smaller numbers in most others is _Saccammina_ _difflugiformis_. This form almost invariably stains pink because of the pseudochitinous lining of the test, making it impossible to distinguish "living" from dead specimens. For the sake of consistency, all representatives of this species were presumed to be dead.

It is noteworthy that the two Assemblage IV samples (from 4925 and 4495 m) exhibit the highest living component of any, even though their rather large components of _S._ _difflugiformis_ are presumed all

Table 3. Living:Dead data from box core samples given in total numbers of specimens

Species	76		77		79		80		82		83		84	
	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Adercotryma glomerata	-	3			-	8								
Alveophragmium ringens				1							-	2		
Ammobaculites agglutinans				1			-	2	-	5	-	10	-	3
Ammomarginulina foliacea					-	10	-	2	-	4				
Bolivina pseudopunctata							-	2						
Bulimina alazanensis											-	1		
Bulimina exilis									-	1				
Bulimina striata													-	4
Chilostomella oolina									-	5				
Cibicides lobatulus			5	10	-	5	-	10	-	5	-	5		
Cibicides robertsoni					-	14	-	1			-	3		
Cribrostomoides scitulus	-	1					-	2	1	2	-	1	-	3
Cribrostomoides subglobosum					-	4	-	3	-	3	-	7	-	4
Cribrostomoides weisneri									-	4				
Cyclammina cancellata													-	1
Cystammina pauciloculata	-	5	-	1							-	2	-	1
Dendrophyra arborescens	-	12							-	4	-	15	3	17
Dentalina inornata bradyensis											-	1		
Eggerella propinqua											-	2		
Elphidium excavatum forma clavata					-	3			-	1	-	4	-	62
Epistomina exigua	1	-					-	2						
Epistomina umbonifera	1	23			22	35	3	37	1	13	1	14		
Eponides bradyi													-	12
Fissurina alveolata	-	1												
Fissurina annectens									-	2				
Fissurina crebra							-	1						
Fissurina kerguelenensis							-	2					-	2
Fissurina orbignyana											-	2		
Fissurina sp.							-	1						

Table 3 (cont'd). Living:Dead data from box core samples given in total numbers of specimens

Species	76		77		79		80		82		83		84	
	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Fursenkoina concava									-	12	-	14	-	21
Globobulimina auriculata			2	-							-	6	-	6
Glomospira charoides											-	1		
Gyroidina orbicularis							-	2	-	6				
Gyroidina soldanii							-	11	-	9	-	7		
Haplophragmoides sphaeroloculus							-	12	-	4	-	15	-	4
Hoeglundina elegans					-	2	4	23	4	20	4	28	2	11
Hormosina globulifera							-	1	-	2	-	1	-	2
Hyperammina elongata	-	2			4	48	-	18	3	23	3	58	1	17
Karreriella apicularis					-	5			-	5	-	1		
Karreriella bradyi							-	2	-	3	1	2		
Karreriella novangliae											-	1		
Lagena gracilis									-	2				
Lagena hispidula													-	1
Lagena striata									-	1			-	1
Laryngosigma hyalascidia											-	5	1	3
Melonis pompilioides									-	5	-	2	-	3
Nodosaria albatrossi													-	1
Nonion barleeanum					-	3			-	4	-	3	-	5
Nonion depressulus					-	2	-	1	-	4	-	5	-	3
Oolina globosa							-	2						
Oridorsalis sp.			1	3										
Oridorsalis tener							-	4	-	12	-	11		
Oridorsalis umbonatus							-	6	-	11	-	8		
Parafissurina tectulostoma											-	2	-	3
Placopsilinella aurantiaca											-	2		
Planulina wuellerstorfi			-	1	-	5	-	16	-	8	-	7		
Pullenia bulloides							-	3	-	5	-	14		
Pullenia quinqueloba	-	1					-	3	-	7	-	7	2	8

Table 3 (cont'd). Living:Dead data from box core samples given in total numbers of specimens

Species	76		77		79		80		82		83		84	
	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Pyrgo murrhyna	-	1	-	5	-	6	-	10	-	10	-	6		
Pyrgo subsphaerica													-	1
Pyrulina cylindroides											-	3		
Recurvoides contortus					-	8	-	8	-	2	-	11	-	5
Reophax bacillaris					-	4	-	4	-	9	-	2		
Reophax dentaliniformis									-	1			1	2
Reophax spp.					-	14					-	2	1	4
Rhabdammina linearis							-	3			-	5	-	2
Rhabdammina scabra	2	-	-	4			-	5	-	8	-	10	-	3
Rhizammina indivisa	4	30	-	14			3	8	-	11	-	13	8	34
Rhizammina irregularis			-	1			-	6	-	10	3	18	-	12
Saccammina difflugiformis*	-	40	-	18			-	4	-	5	-	3	-	3
Sigmoilopsis schlumbergeri							-	3	-	1	-	11	-	4
Siphotextularia rolshauseni									-	2				
Tectinella legumen	-	1												
Tolypammina vagans											-	18		
Tosaia hanzawai											-	1		
Trifarina angulosa									-	2				
Triloculina oblonga									-	2				
Triloculina tricarinata	-	1							-	8	-	5	-	5
Trochammina malovensis	2	4	-	2	-	6	-	2			-	5		
Trochammina squamata gr.	1	3			-	10			-	4	-	5		
Uvigerina peregrina									-	1			-	17
Uvigerina spinicostata							-	1					-	21
Percent living	7.9		9.6		1.5		4.3		2.9		3.5		5.8	

* All specimens of S. difflugiformis stained pink because of their chitinous lining; for the purposes of this study, all were presumed dead.

Table 4

Sample No.	Water Depth	Assemblage	% Living
82-022-76	4925 m	IV	7.9%
82-022-77	4495	IV	9.6%
82-022-79	4030	III	1.5%
82-022-80	3543	Transitional II - III	4.3%
82-022-82	2996	II	2.9%
82-022-83	2750	II	3.5%
82-022-84	2487	I	5.8%

le 4. Comparison of water depth and type of benthic assemblage to "Living" component of foraminiferal fauna

dead.

Hollister and McCave (1984) have found evidence in the HEBBLE area that the abyssal storms indigenous to that region may rapidly erode bottom sediments in their initial phases, producing high concentrations of suspended sediment and creating characteristic bottom features such as grooved surfaces. Later, as the storms subside, blankets of sediment are deposited. They have recorded values as high as 1.42 cm/month for deposition of sediments, although their studies indicate that erosion rates may be just as high, and these rates may account for the high living percentages.

Furthermore, Hollister and McCave (1982) report very high biological mixing parameters for the sediments in this region, which effectively mask any unusual parameters in any single depositional event.

4.3 Late Pleistocene-Holocene Stratigraphy

4.3.1 Introduction

At site 82-022-78, in 4046 m water depth, an 11.5 m piston core and an accompanying 1.6 m gravity trigger weight core were taken. It was hoped that sedimentological analysis of this material would enable identification of its sedimentary units within the framework of Piper's (1975) facies classification, and that foraminiferal analysis would yield clues to the development of the modern Assemblage III benthic fauna presently inhabiting the site.

4.3.2 Sedimentology

A number of long piston cores from the lower Scotian slope and adjacent areas have been studied by Piper (1975), Stow (1980), and other workers with regard to sedimentology and inferred modes of deposition.

From these studies a number of facies have been described, based on colour, sedimentological structures, grain size, carbonate content and other parameters of the sediments. These facies are believed to represent distinct time periods and various modes of deposition, and can be traced in transects of cores down the slope.

The gravity core (82-022-78G) exhibits a markedly regular alternation of units representing Facies 1 and 3 (a & b) which indicate that at least the upper section of this core was "double-cored" (Scott, pers. comm. 1982). In view of this possible problem, serious attention will not be given to the sedimentary sequences observed in the gravity core.

The sedimentological sequences observed in the piston core, however, seem much more natural, and indeed, compare well with Piper's (1975) observed facies sequences for piston cores from nearby areas on the lower Scotian Slope.

At the top of this core (Fig. 5) is 90 cm of Facies I sediments; olive or yellowish brown muds with abundant foraminifera and evidence of extensive bioturbation. Planktic foraminifera outnumber benthics by approximately 20:1, and one or two samples from this unit contain abundant discoid diatoms. It is possible that some of the upper portion of this core is missing, a common event in piston cores according to Stow and Aksu (1978). In this case, 15 or 20 cm of the top of the core appears to be missing, because the top 20 cm of the gravity core contains a very abundant benthic fauna, with over 1000 benthic specimens present in each sample, while the upper 20 cm of the piston core contain much smaller numbers of specimens.

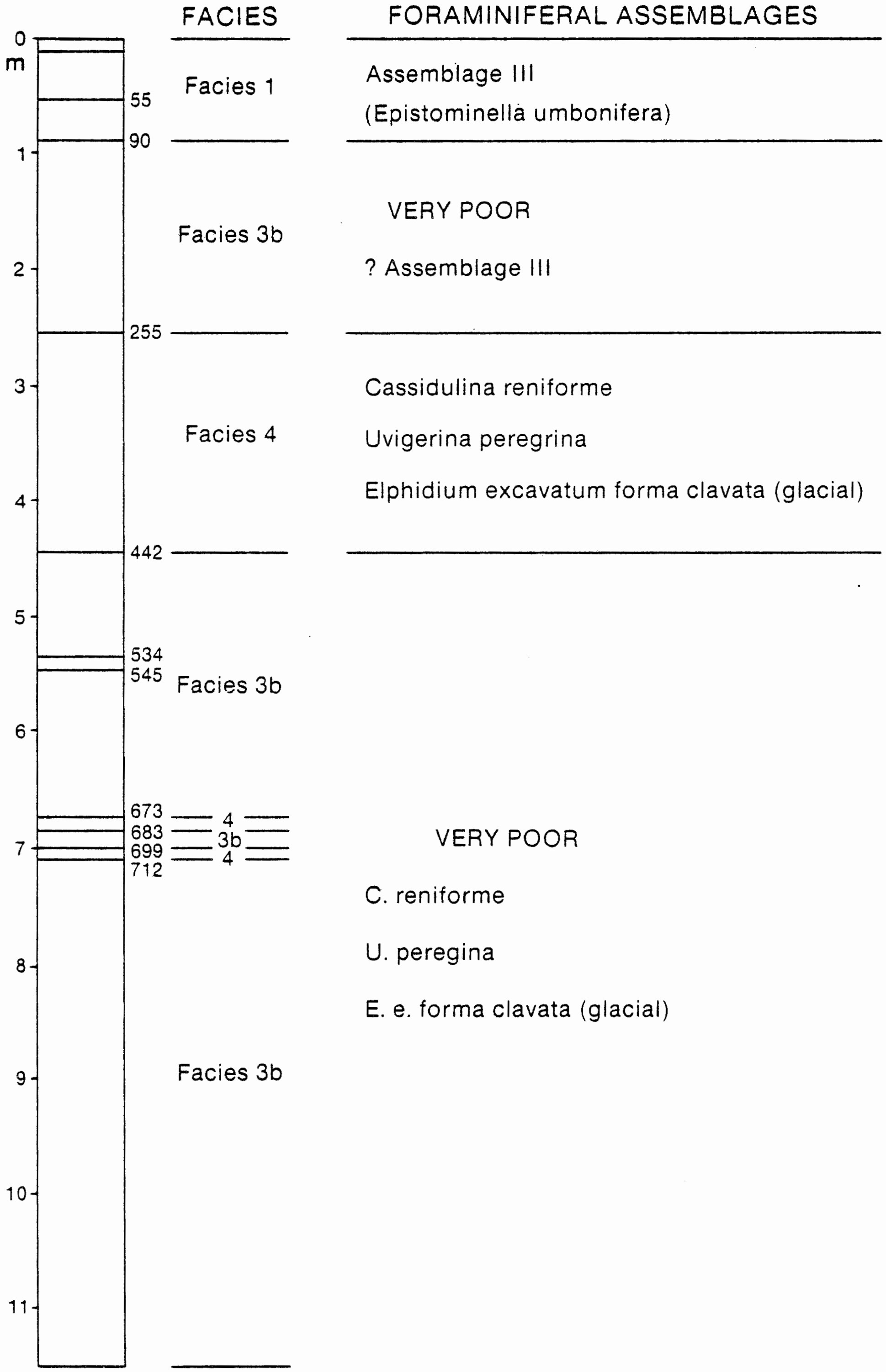


Figure 5. Piston core 82-022-78p, showing Facies and associated foraminiferal assemblages.

Some silt-sized volcanic ash is present in samples from the 20-60 cm levels, as described by Ruddiman and Glover, 1972. This ash level may represent Ash zone 1 as described by Ruddiman and McIntyre (1984) and dated at 9800 yr B.P. Underlying Facies 1 (90-255 cm) is a thick layer of weakly calcareous pale brownish clayey mud with common thin silt laminae and rare intervals of graded bedding closely resembling Piper's Facies 3b.

Below this, from 255-442 cm is a unit of Facies 4 (dark yellowish brown fine sandy clayey mud) characterized by abundant thin silty or sandy beds and extensive dark mottling.

From 442 cm down to the bottom of the core (1152 cm) there is more 3b material, interspersed with a few relatively thin units of Facies 4 at 534-545 cm, 673-683 cm and 699-712 cm, in addition to a few very thin silt or sand laminae at various locations. Two other ash levels are seen at 300 cm and 400 cm depth.

From approximately 1070 cm down to the bottom, however, x-rays reveal vertical lines of disturbance generally regarded as indicative of flow-in or suck-in, a common problem with piston cores described in some detail by Stow and Aksu (1978).

Figure 6 summarizes the relative abundances of dominant species in the piston core.

4.3.3 Foraminiferal faunas

Analysis indicates that the foraminiferal faunas within the piston core duplicate and are dependent upon, the various facies in the core.

The Facies 1 material at the top of the core (0-90 cm) contains

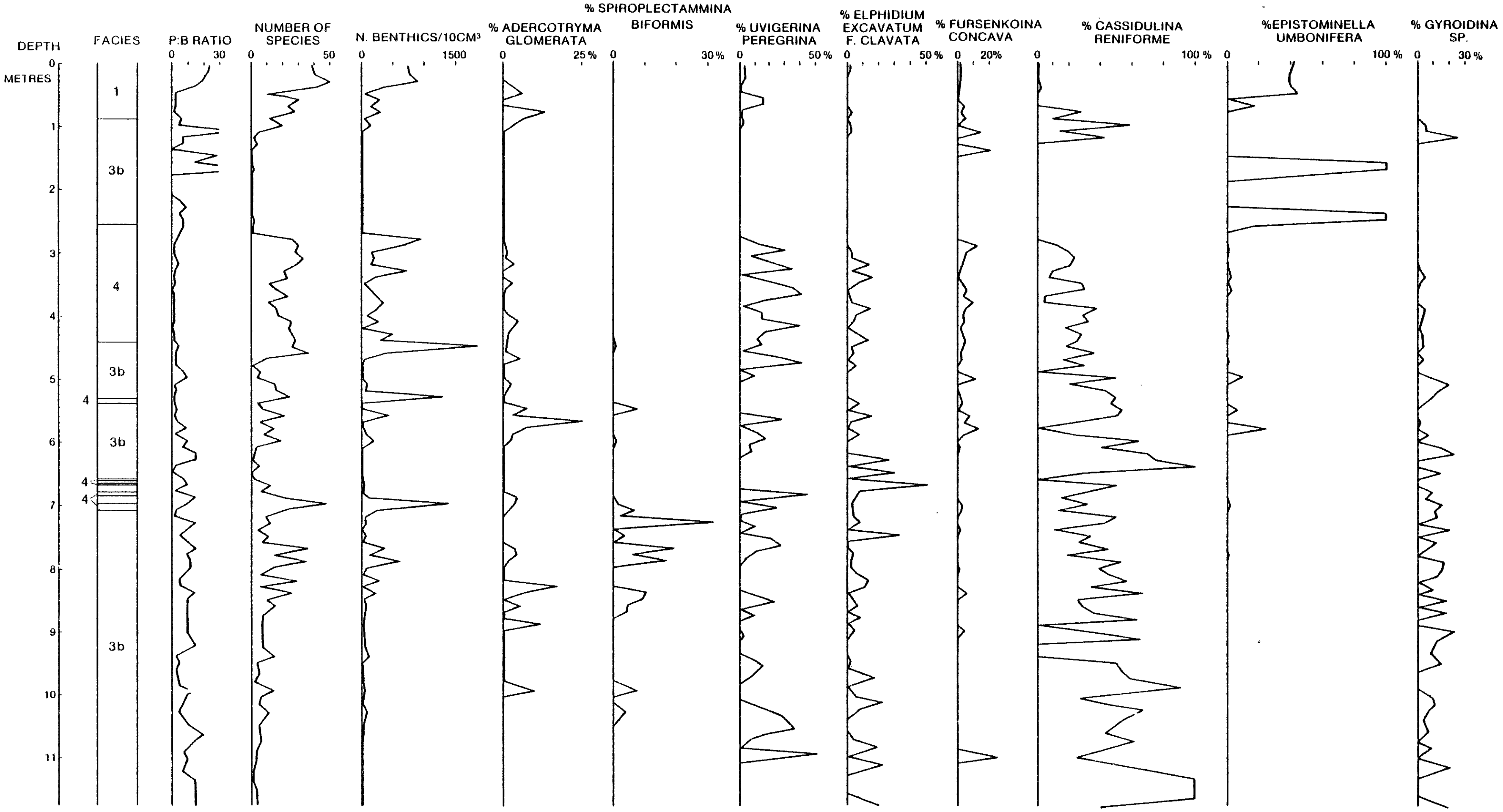


Figure 6. Distribution of dominant species in piston core.

in its upper half a fairly typical Assemblage III foraminiferal array, dominated strongly by Epistominella umbonifera and smaller numbers of 40 or 50 other species. A similar fauna is present in the upper 15-20 cm of the gravity core, whose analogue in the piston core is probably missing. 10 cm samples of this material contain an average of roughly 400 benthic specimens. From 55-90 cm, however, a somewhat different fauna appears, and this is mirrored by a slight change in colour of the sediment. This second assemblage is dominated by Cassidulina reniforme, C. laevigata, and somewhat smaller numbers of Bolivina aff. earlandi. The "background" species - those which constitute < 5% of the total fauna - are similar to those in the overlying unit. Planktics are somewhat less common here than in the upper part, (Planktic: benthic = approximately 8:1 as opposed to 20:1 for the upper part), and benthics are somewhat less common, averaging just over 100 per sample.

The Facies 3b unit below this (90-255 cm) is nearly devoid of foraminifera, and the few that are present display an abraded, poorly preserved appearance. The P:B ratio here averages 5:1, and each sample contains only an average of 2 benthic specimens.

From 255 - 442 cm, the Facies 4 unit contains a fairly rich, diverse benthic assemblage strongly dominated by Cassidulina reniforme, Uvigerina peregrina and Elphidium excavatum forma clavata. Planktics are less common than even the Facies 3b unit above, with the P:B ratio at 3:1, but each sample contains an average of 380 benthic specimens.

Below 442 cm, the Facies 3b material again contains a fairly sparse fauna usually dominated by small numbers of C. reniforme, U. peregrina, C. laevigata and E. excavatum forma clavata. Very often the foraminiferal specimens seen in these samples exhibit signs of etching and/or abrasion, and average only roughly 10 benthic specimens per sample.

The small intervals of Facies 4 which appear at various levels (534-545 cm, 673-683 cm, 699-712 cm) are, as above, typified by a similar but much richer benthic fauna (averaging over 300 specimens per sample) usually accompanied by a relatively larger number of planktics. The small layer of Facies 4 material at 699-712 cm is of a lighter colour than usual, and exhibits an unusually high (31%) proportion of Spiroplectammina biformis, a species almost absent from the upper 680 cm of the core.

Some samples of both Facies 3b and 4 contain small numbers of a reworked Maastrichtian planktic foraminifera, Heterohelix cf. americana. No other reworked Mesozoic species are present in the material, and the other facies found in the core do not contain this form.

The presence of Mesozoic fossils in these units prove their allochthonous nature and strongly support Piper's view of them as turbidity current deposits, a suggestion further strengthened by their bedding structures and sorting, which match the criteria for turbidites developed by Piper and Brisco (1975). H. cf. americana plus several other Tertiary forms are commonly found in glacial-marine Emerald silts on the Scotian Shelf (Scott, pers. comm., 1984).

4.3.4 Oxygen Isotope Data

The oxygen isotope data for both the piston core and gravity core are illustrated in Figure 7 and include analysis of one planktic species (Neogloboquadrina pachyderma - left and right-coiling, and one

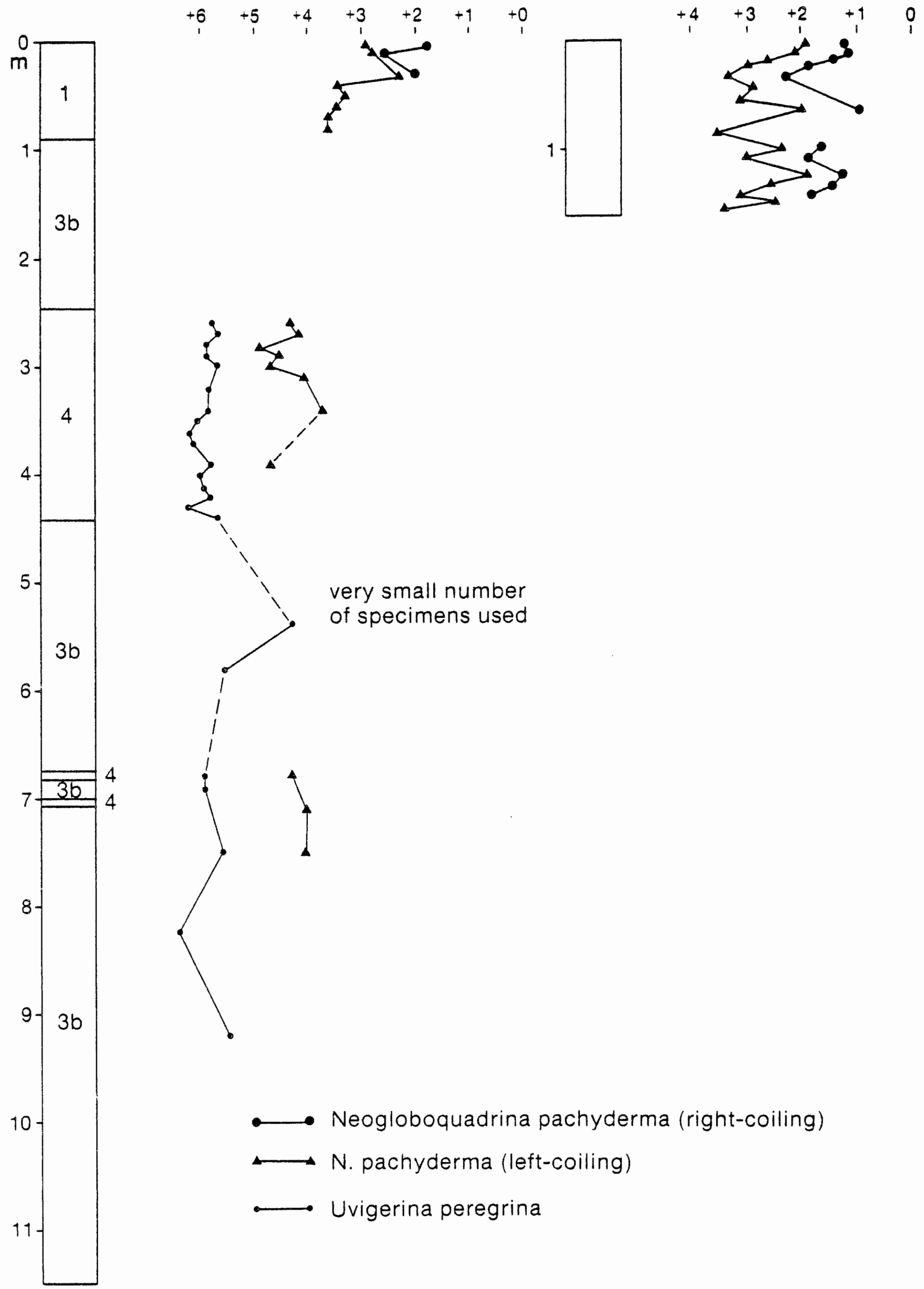


Figure 7. O_{18} analysis data for selected species in piston core 82-022-78p, and gravity core 82-022-78g.

Table 5

a) Oxygen$^{16/18}$ analysis data for 82-022-7g, (gravity core)

Depth (cm)	*Neogloboquadrina pachyderma*		*Uvigerina peregrina*
	left-coiling	right-coiling	
1 - 3	1.923	1.292	
7.5 - 9.5	2.115	1.195	
15 - 17	2.653	1.434	
20 - 22	3.035	2.783	
31 - 33	3.395	2.239	
41 - 43	2.818		
51 - 53	3.159		
61 - 63	1.927	0.984	
85 - 87	3.487		
95 - 97	2.274	1.630	
105 - 107	3.053	1.896	
123 - 125	1.886	1.305	
128 - 130	2.691	1.421	
139 - 141	3.101	1.887	
148 - 150	2.599		
193 - 155	3.331		

Table 5

b) Oxygen$^{16/18}$ analysis data for 82-022-78p, (piston core)

Depth	Neogloboquadrina	pachyderma	Uvigerina peregrina
(cm)	left-coiling	right-coiling	
3 - 5	2.898	1.834	
10 - 12	2.800	2.591	
30 - 31	2.277	2.062	
40 - 42	3.461		
50 - 52	3.265		
60 - 62	3.421		
70 - 72	3.652		
78 - 80	3.653		
260 - 262	4.364		5.743
270 - 272	4.171		5.689
280 - 282	4.952		5.899
290 - 292	4.547		5.902
300 - 302	4.648		5.701
310 - 312	4.096		
320 - 322			5.858
340 - 342	3.731		5.854
350 - 352			6.043
360 - 362			6.212
370 - 372			6.144
390 - 392	4.719		5.881
400 - 402			6.042
413 - 415			5.985
420 - 422			5.777
430 - 432			6.239
440 - 442			5.657
538 - 540			4.287
580 - 582			5.549
678 - 680	4.357		5.935
687 - 689			5.903
747 - 749	4.134		5.618
822 - 824			6.379
918 - 920			5.459

benthonic form (Uvigerina peregrina). Numerical values for these data are given in Table 5a and b.

Although there are paired values of left and right coiling N. pachyderma only in the upper 50 cm of the piston core, work from another North Atlantic core helps place a chronologic framework on this upper section (Scott, pers. comm., 1985). The small separation between right and left forms at 25-50 cm indicates the presence of a subdued seasonal regime caused by the large influx of meltwater and icebergs as deglaciation occurred. This corresponds to the Phase II of Ruddiman and McIntyre (1981) at 13,000 to 11,000 yr B.P. Sediments at the "top" of the truncated piston core represent a time when seasonality was developing, probably 8000-9000 ybp, but not the maximum seasonality which occurred at 6000 yr B.P. (Scott et al., submitted). Hence, approximately 6000 y of record are missing from the top of the piston core, but are probably contained in the upper 20 cm of the gravity core. Further examination of the fine sedimentary boundaries and structures in the upper portion of the gravity core may elucidate the chronostratigraphy of the sediments.

Unfortunately, because of the very small numbers of specimens available for study in the Facies 3b material below the 90 cm mark, this important boundary cannot be interpreted in terms of O-18/16 content.

Only Uvigerina peregrina provided a reasonably continuous record, and that only from the 260 cm mark in the piston core down to 440 cm (Facies 4). Throughout this range, O-18/16 values for this species remain close to the + 6 mark.

However, even for this limited range, barely enough specimens were available for analysis, and Hutson (1980) warns of errors inherent in using species of low abundance.

FIVE - DISCUSSION

The large amount of data collected in this project sheds light on the present day and postglacial deep-water benthic foraminiferal assemblages of the lower Scotian Slope and Rise. Comparison of this material with the findings of other researchers is a pivotal requirement for any attempt at interpretation of the results.

5.1 Surface Assemblages

5.1.1 Benthic Assemblages and Present Oceanography

The present study area lies just to the south of Schnitker's (1974) *Epistominella exigua* - dominated assemblage which he believed to follow the course of Arctic Bottom Water. In the surface samples of this survey, *E. exigua* is a fairly minor component of most assemblages, reaching 9% only in one sample from 3985 m. This would indicate that Arctic Bottom Water has become diluted and warmed to some degree by the time it reaches this study area, some 600 km to the south. Schnitker (1974) also reports faunas with abundant *Hoeglundina*, *Uvigerina* and *Gyroidina* forms upslope, in North Atlantic Deep Water (NADW). Though Schnitker (1974) gives no depths at all for his assemblage ranges, they appear to correspond with faunas from the 2000 m to 3247 m depth range in the present work. In areas south of 30°N latitude Schnitker reports the dominance of *Osangularia* (=*Epistominella*) *umbonifera*, a species he believed to be controlled by the presence of Antarctic Bottom Water.

Lohmann's (1978) study of the western South Atlantic Ocean had at least one somewhat different result. He found that deep areas covered by Antarctic Bottom Water contained faunas dominated by "*Epistominella*" *umbonifera*.

Areas overlain by NADW, according to Lohmann (1978), show a more diverse fauna dominated by Uvigerina peregrina, Planulina wuellerstorfi; and Hoeglundina elegans along with other forms. Again, this appears to correspond quite well with Assemblages I and II in the present study.

The Elphidium excavatum forma clavata - dominated Assemblage I observed in the present work has no real counterpart in any of the other studies cited above. Assuming that the Elphidium component is indigenous to the area and not a product of downslope transport, the assemblage could be regarded as a product of Gatien's (1976) Labrador Slope Water, the cooler, deeper-lying component of the Slope Water overlying the Scotian Slope.

Lohmann (1978) found the transition zone between AABW and NADW as defined by benthic foraminiferal faunas to lie at approximately 4000 m depth, compared to the 3500 m depth of transition between Assemblages II and III in the present study.

Streeter and Lavery's (1982) study of the North Atlantic continental margin found results very similar to those from the present study. They place the boundary between AABW and NADW at approximately 3800 m in latitudes of 45°N and southwards, a figure that coincides reasonably well with results here.

All previous studies are difficult to compare directly since they used larger sieve sizes and did not observe many of the species reported here.

5.1.2 Assemblage IV and Abyssal "Storms"

Assemblage IV, dominated by Saccammina difflugiformis found in depths greater than 4400 m in the present study, is not mentioned in any other reports, and may be restricted to areas north of 45° latitude. Alternatively, it may not be evident in the literature because many other deep-sea researchers place little importance on agglutinated forms. The relatively small numbers of specimens in the two samples containing this fauna are noteworthy, and it could be surmised that this is a result of winnowing out of numbers of dead tests by the "abyssal storms" described by Hollister et al. (1984). Alternatively, frequent removal or deposition of sediment masses in the area by these same storms could adversely affect foraminiferal population. The relatively high numbers of "living" specimens seen in these samples indicate the presence of some process not indigenous to the upslope areas, quite possibly the regime of high sediment dynamics described earlier.

Certainly the relative paucity of calcareous benthic foraminifera could be created or enhanced by the proximity of the lysocline in the western North Atlantic at this depth, as described by Thunnel (1982).

Figures 8a,b and 9 illustrate the present distribution of assemblages in surface samples.

5.1.3 Downslope Transport of Benthic Foraminifera

Williamson (1983) has described an assemblage found in some of the shallower areas of the Scotian Slope dominated by _Elphidium excavatum_ forma _clavata_ with smaller numbers of other species. Because no living specimens of _E. excavatum_ forma _clavata_ were found, and because of size range of the tests, he surmised that on the lower parts of its range at least, the _E. excavatum_ were transported to the site and did not represent an indigenous population.

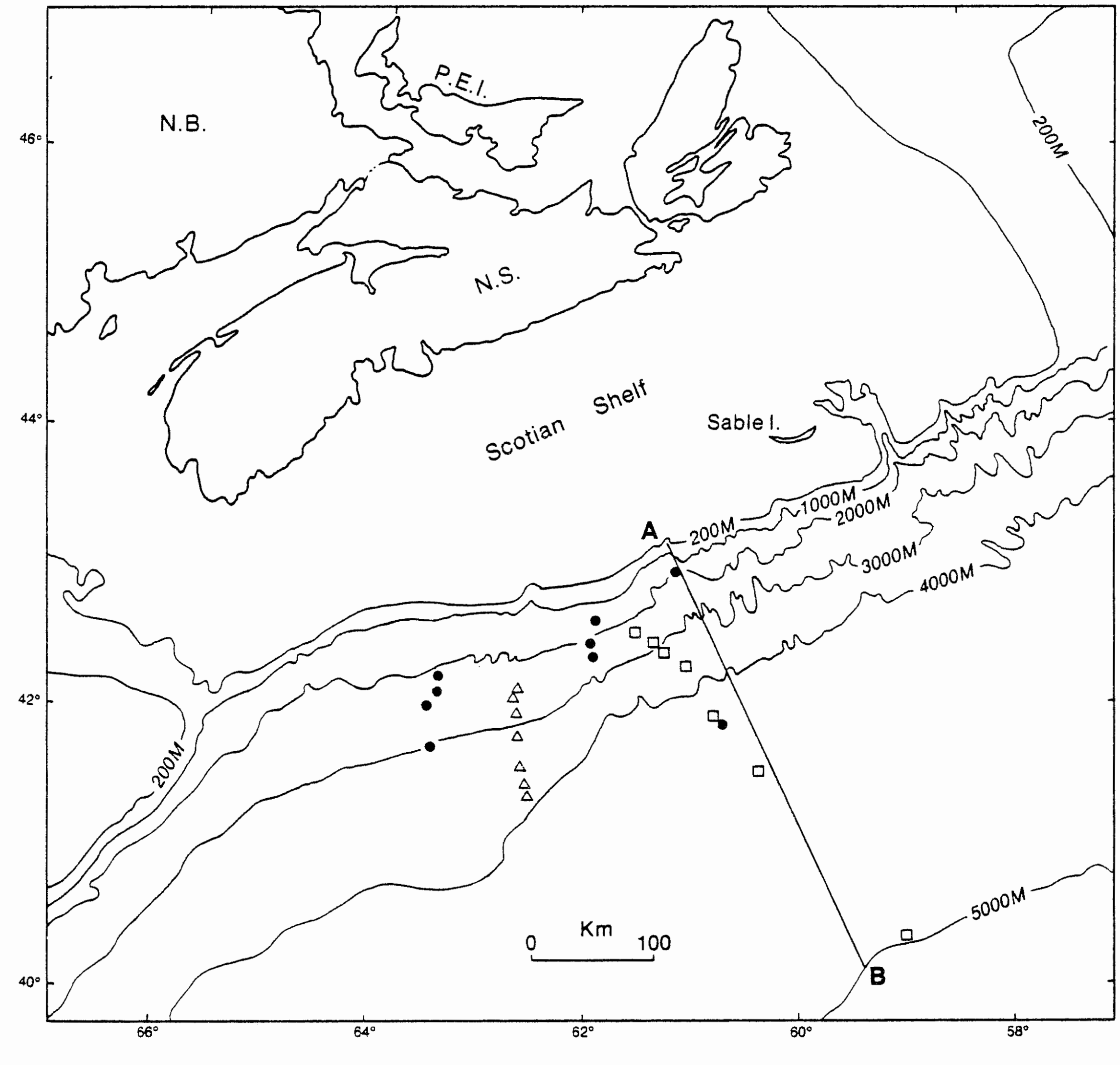


Figure 8a. Location of cross-section across Lower Scotian Slope.

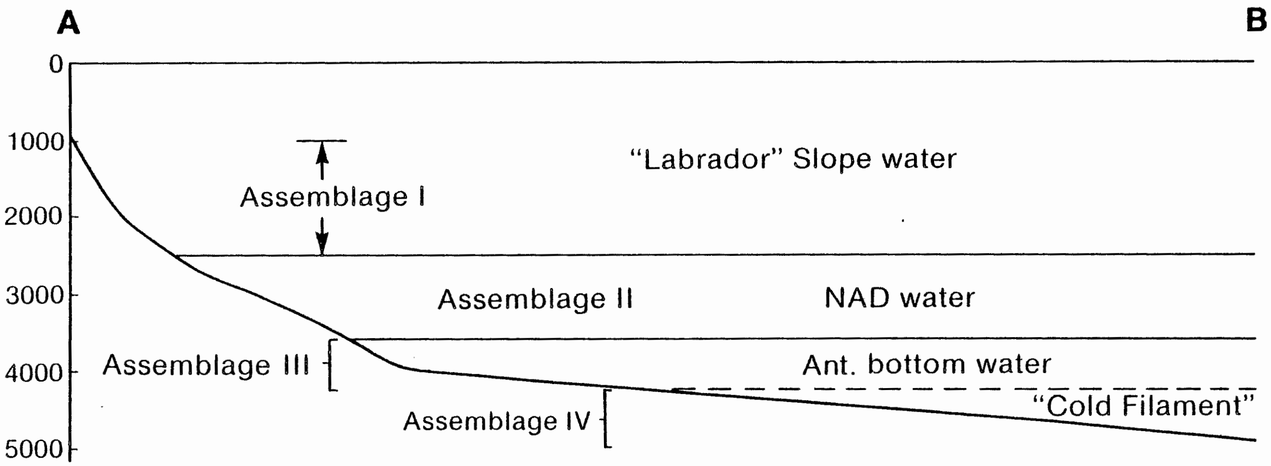


Figure 8b. Schematic cross-section across Lower Scotian Slope and Rise showing present assemblage distributions and associated hydrographic phenomena.

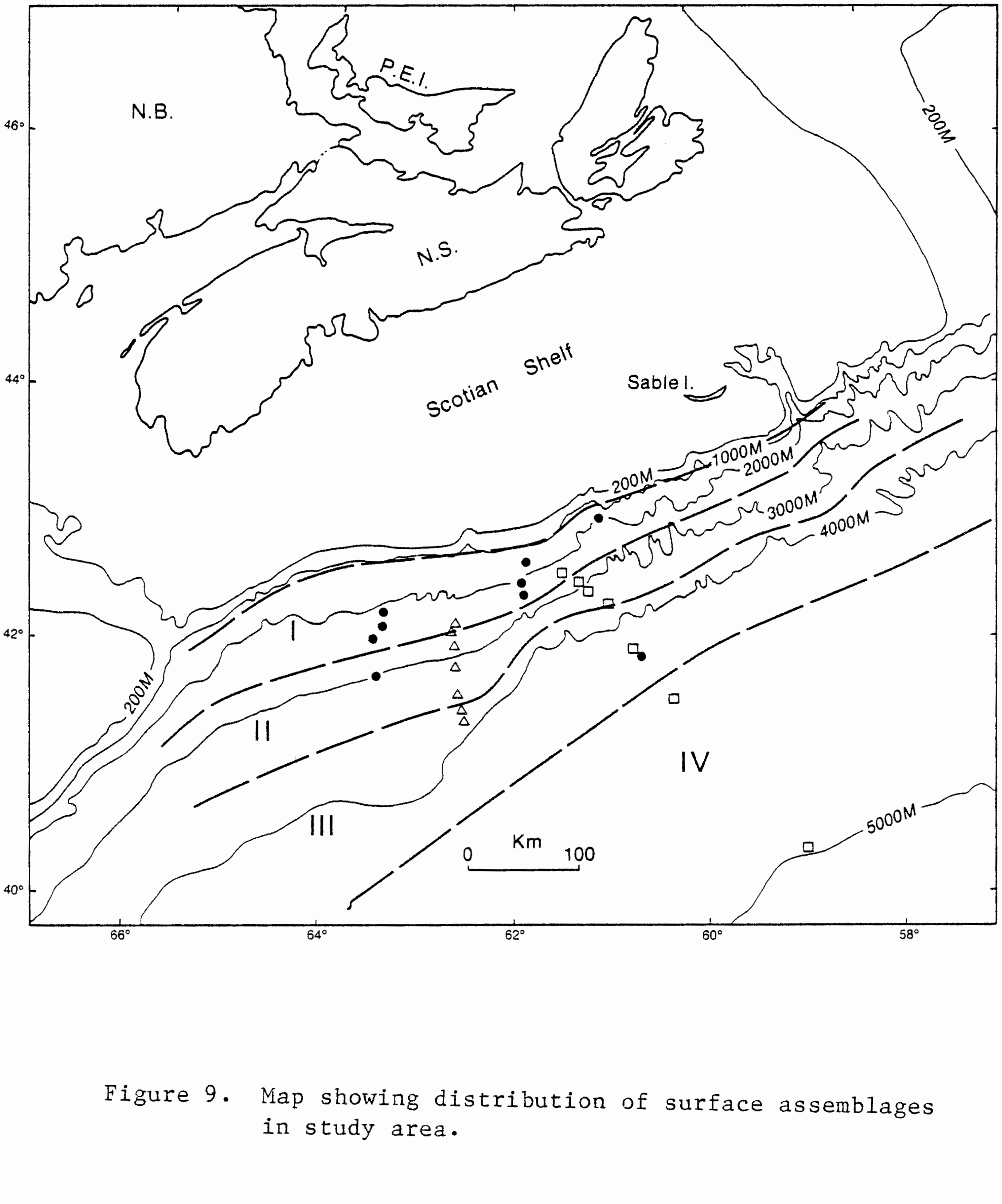


Figure 9. Map showing distribution of surface assemblages in study area.

The living-dead data collected for this study, though limited, (Tables 3 and 4) do tend to support the theory. The data given for sample 82-022-84 show that of 62 specimens of E. excavatum forma clavata seen in the sample, all were unstained, and so represented "dead" tests. Some of the other forms common in this sample, such as Uvigerina peregrina, U. spinicostata and Fursenkoina concava were also present only as "dead" specimens. However, Schroeder (unpubl.) observes many living Elphidium specimens in her material from similar depths.

Among Assemblages II, III and IV, however, their principal components seem so well defined and regular in the downslope progression of faunas that transportation of forms from upslope must be very limited. It is significant that E. excavatum forma clavata occurs only in very minute numbers in samples from further down the slope.

5.2 Assemblages in the Cores

Assemblages of benthic foraminifera in the cores, particularly the 11 m piston core, reflect changing paleoceanographic conditions at the core site during the time represented by the penetrated sediments.

5.2.1 Facies and Faunas

As stated in an earlier chapter, the benthic foraminiferal faunas observed in the cores show a high correlation with sedimentological units.

The oldest material in the core, below 442 cm, is composed of mostly Facies 3b sediments, with a rather sparse, generally poorly preserved fauna dominated by Cassidulina reniforme, Uvigerina peregrina, C. laevigata and Elphidium excavatum forma clavata. The planktic-benthic ratio is quite low. Interspersed with this material, the thin layers of Facies 4 sediment contain a similar but richer fauna, with even fewer planktics.

The poor state of preservation of so many specimens from these layers, along with the regular occurrence of the reworked Maastrichtian planktic species Heterohelix cf. americana strongly indicate an allocthonous origin for these sediments, presumably from upslope in the form of turbidity currents, as theorized by Piper (1974).

Further evidence for the turbidite nature of these 3b and 4 facies beds comes from their lack of bioturbation, lack of ice-rafted material, generally good size sorting and the small numbers of microfossils present.

The exact age of the 3b and 4 material is unclear. Piper (1974) infers a Late Wisconsin age for these strata presumably because this would have been the last period of heavy sedimentation for this area before the advent of Holocene conditions.

The foraminiferal assemblage seen in this material, dominated by Elphidium excavatum forma clavata and Cassidulina reniforme is described as late glacial in this area by Vilks (1981).

The uppermost portion of the core, 0-90 cm, containing Facies I material is almost certainly of Holocene, or late Wisconsinan age containing as it does a foraminiferal assemblage closely resembling the modern fauna found in the depth range from which the core was taken.

5.2.2 Late Wisconsinan to Recent Deep Hydrographic History at Core Site

During the Wisconsinan glacial maximum (roughly 18,000 yr B.P.)

the core site (at 4046 m depth at present) was overlain by "old" relatively oxygen-poor water, probably of Antarctic origin, and a benthic assemblage dominated by *Uvigerina peregrina* and *Cassidulina reniforme* was present.

Fairly rapid deposition of sediments (probably from turbidites) was occurring, and these allochthonous materials brought with them a transported benthic fauna consisting of *Elphidium excavatum* forma *clavata* and *Heterohelix* cf. *americana* along with perhaps other forms less easy to isolate. Presumably the *E. excavatum* forma *clavata* would have originated in shelf areas, and the *H.* cf. *americana* may have been picked up from some submarine outcrop of eroding Maastrichtian sediments.

The exact time that this period of rapid sedimentation ended and the "modern" regime of oceanographic conditions and a benthic fauna dominated by *Epistominella umbonifera* began at the core site is unknown, but is clearly marked by the presence of Piper's Facies I sediment in the uppermost 90 cm of the core. The figure of 8000 yr B.P. given by Streeter and Lavery (1982) for the transition from glacial to Holocene benthic assemblages at 4000 m may be appropriate for the transition seen at 90 cm depth in the core.

Future studies of core assemblages from sites up-and down-slope from 82-022-78 in the same general area could certainly elucidate the benthic foraminiferal history of these sediments, especially since the sediments and sediment units in the region have been so thoroughly studied in the past (Piper, 1975; Hill, 1981; Stow, 1976 and 1977).

SIX - CONCLUSIONS

Individual study and comparisons of suites of surface sediment samples from the lower Scotian Slope and Rise, along with the down-core variations in benthic foraminiferal faunas and sediment facies from the piston core 82-022-78 (4046 in depth) have allowed fairly detailed definition of modern benthic assemblages in the region and offered a glimpse into past oceanographic conditions at the core site.

The present day benthic foraminiferal assemblages of the lower Scotian Slope and Rise appear to be clearly defined and, given the incomplete coverage of the present study samples, follow bathymetric boundaries. It is the belief of the author, supported by most modern research into the subject, that the apparent bathymetric controls of these assemblages are coincidental, and the real controlling factors are the bodies of water in the region, which closely conform to bathymetric lines.

The benthic foraminiferal assemblages present on the lower Scotian Slope and Rise are:

Assemblage I - present in depths from 2000 to 2500 m this assemblage is strongly dominated by _Elphidium excavatum_ forma _clavata_, with smaller number of _Uvigerina spinicostata_ and some other species. Agglutinated species usually account for approximately 10 - 20% of the total. Other researchers, notably Williamson (1983) report this fauna continuing upslope to 1000 m depth. This fauna appears to be associated with Labrador Slope Water.

Assemblage II - found in depths ranging from 2500 m to approximately

3600 m, probably paralleling the occurrence of NADW, this very diverse fauna may be composed of up to 70% agglutinated species, the most common of which is *Hyperammina elongata*. Common calcareous forms include *Hoeglundina elegans*, *Epistominella umbonifera* and *Planulina wuellerstorfi*.

Assemblage III - from 3600 m down to somewhere between 4000 and 4500 this fauna occurs, typified by a large component of *Epistominella umbonifera*, with no other single species appearing in very large numbers. The agglutinated component is much smaller than in Assemblage II. This fauna probably mirrors the extent of Antarctic Bottom Water in the region.

Assemblage IV - Below 4500 m, this relatively impoverished fauna takes over, and is characterized by a large component (approximately 27%) of *Saccammina difflugiformis*. Less than 20 species are present in this fauna, most of them agglutinated ones. It may well be a product of the "Cold Filament" water described by Weatherly and Kelley (1982), and further impoverished by its proximity to the CCD lysocline.

Benthic foraminiferal assemblages seen in the piston core vary with sedimentological facies, as described by Piper (1974).

The upper 90 cm of the core (Piper's Facies I) contain an olive brown mud with abundant foraminifera and extensive bioturbation, deposited relatively slowly, under the modern conditions prevailing in the last 8000 years.

From the 90 cm level to the bottom of the core at 1152 cm there are units of Piper's 3b facies, interspersed with some material of Facies 4. Both contain reduced numbers of foraminifera and sedimentological structures indicating turbiditic origin. The relatively large numbers of *Uvigerina peregrina* in these sediments according to some researchers, indicate a late glacial age for these sediments, a period when water reduced in dissolved oxygen overlay the site. The presence of two allochthonous species, *Elphidium excavatum* forma *clavata* and *Heterohelix* cf. *americana* (a long-extinct Maastrichtian species) strongly support the turbiditic nature of the Facies 3b and 4 sediments in the core.

The isotope data are significant in that they support a late glacial provenance for the Facies 3b and 4 material.

SEVEN - TAXONOMY

7.1 Introduction

The suprageneric classification used in this outline is that of Loeblich and Tappan (1964), which, although it may not be the most recent, is at least widely recognized and is readily available to most researchers in the field.

No attempt was made in the taxonomy to supply a complete listing of synonyms, which would be somewhat irrelevant to the main thrust of this work. However, texts dealing with nearby geographic areas and/or faunas of similar depth ranges were consulted whenever possible. Such local literature is more likely to contain accurate descriptions and illustrations of the species, especially in those forms where ecophenotypic variation may occur.

Finally, an effort was made to give full reference (name of journal or book, and volume number) to each original designation of the species included. This facilitates further taxonomic study by the reader.

7.2 Directory of Species in Systematic Taxonomy

Directory continued

Directory continued

Directory continued

7.3 Systematic Taxonomy

Order FORAMINIFERIDA Eichwald, 1830

Suborder Allogromiina Loeblich and Tappan, 1961

Superfamily Lagynacea Schultze, 1854

Family Allogromiidae Rhumbler, 1904

Genus *Placopsilinella* Earland, 1934

Placopsilinella aurantica Earland

Plate 1, figure 1

Placopsilinella aurantica Earland, 1934. Discovery Reports, vol. 10,. p. 95, pl. 3, fig. 18; Echols, 1971, pl. 1, fig. 1; Cole, 1981, p. 3, pl. 16, fig. 1; Kaminski, 1983, p. 5, pl. 11, fig. 8.

Remarks. This attached form is easily recognized by its biserial, reddish chitinous test. For some reason it appears to favor relatively flat surfaces such as the test of *Globorotalia menardii* on which it is pictured here.

Distribution. This species occurs in approximately half the surface samples between 2200 and 4046 m depth. In samples from 2995-3500 m it reaches its greatest abundance (1-3%). Its appearance in the cores is limited to a few specimens at various levels in the top 130 cm of both cores.

Suborder Textulariina Delage and Hérouard, 1896

Superfamily Ammodiscacea Reuss, 1862

Family Astrorhizidae Brady, 1881

Subfamily Astrorhizinae Brady, 1881

Genus Astrammina Rhumbler in Weisner, 1931

Astrammina sp.

Plate 2, figure 1

Remarks. This form is composed of relatively large (up to 1.0 mm) coarsely agglutinated spherical bodies with one or more radial arms which may represent single broken chambers of larger forms. This classification as Astrammina sp. is very tentative.

Distribution. This form occurs in several surface samples, from 2500 to 4046 m, and reaching its greatest numbers (>2% Σ) at 4046 m. It is not seen in core samples.

Genus Astrorhiza Sandahl, 1858

Astrorhiza cf. crassatina Brady

Astrorhiza crassatina Brady 1881. Quart. Jour. Micr. Sci. vol. 21, p. 47.

Remarks. This form is represented by relatively large (up to 2.0 mm) loosely agglutinated roughly oval bodies with many broken areas which may indicate the former presence of radial arms. Its identity as A. crassatina is somewhat tentative.

Distribution. Occurs in small numbers in most samples from below 3000m depth. It is present only in the top 10 cm of the gravity core.

Genus Rhabdammina M. Sars in Carpenter, 1869

Rhabdammina cf. irregularis Carpenter

Plate 1, figure 2

Rhabdammina irregularis Carpenter, 1869. Proc. Roy. Soc. London, vol. 18, no. 114, p. 60.

Distribution: This form appears only as single specimens in a very few core samples, thus its identity is somewhat tentative.

Rhabdammina linearis Brady

Plate 2, figure 2

Rhabdammina linearis Brady, 1879 Quart. Jour. Micr. Sci., vol. 19, p. 37; LeRoy and Hodgkinson, 1975, pl. 1, fig. 12; Ingle et al. 1980, p. 144; Cole, 1981, p. 5, pl. 1, fig. 1; Milam and Anderson, 1981, pl. 1, fig. 2;

Rhabdammina cf. linearis Brady, Anderson, 1975, pl. 1 fig. 2.

Remarks. This large form is usually seen as a single fairly straight tube, with somewhat thinner walls than Hyperammina, which it superficially resembles.

Distribution. In surface samples this species is found at depths between 2200 and 3985 m in small numbers. R. linearis occurs only in the gravity core as a single individual at 123 - 125 cm.

Rhabdammina scabra Höglund

Rhabdammina scabra Höglund, 1947, Zool. Bidr. Uppsala, Bd. 26, p. 28, pl. 1, figs. 3,4; Cole, 1981, p. 5, pl. 2, fig. 8.

Remarks. R. scabra is usually seen as a tube entirely covered in the tests of planktonic foraminifera, as in the figured specimen.

Distribution. R. scabra occurs in almost all surface samples including shallowest and deepest, but is most common between 2750 and 4495 m. At 3050 m it exceeds 10% of Σ. It does not appear at all in core samples.

Subfamily Rhizamminae Rhumbler, 1895

Genus Rhizammina Brady, 1879

Rhizammina cf. algaeformis Brady

Rhizammina algaeformis Brady 1879 Quart. Jour. Micr. Sci. vol. 19, p. 39, pl. 4, figs. 16,17; Cushman, 1918, pl. 11, figs. 2,3; Barker, 1960, p. 58, pl. 28, figs. 1-11; Cole, 1981, p. 6, pl. 1, fig. 9

Remarks. R. algaeformis appears in these samples as a very thin-walled, crooked tube composed largely of a latticework of loosely bound needle-like fragments which appear to be sponge spicules.

Distribution. This rare form occurs in very small numbers in only 2 surface samples, at 2995 m and 4046 m. In both cores it occurs only as 1 or 2 specimens in a few samples from the top 130 cm.

Rhizammina indivisa Brady

Plate 1, figure 3

Rhizammina indivisa Brady 1884 Rep. Voy. Challenger Zoology, vol. 9, p. 277, pl. 29, figs. 5-7; Cushman, 1918, pl. 12, figs. 7-10; Cole, 1981, p. 6, pl. 2, fig. 16; Kaminski, 1983, p. 6, pl. 1, fig. 6.

Remarks. This species is encountered as fairly straight tubes of agglutinated material, usually branching, and often with one or two tests of planktonic foraminifera attached.

Distribution. One of the more common agglutinated forms in surface samples, R. indivisa occurs in varying abundances in almost all samples. It is oddly absent in three samples from around 4000 m but is most common (24.3% of Σ) at 4925 m. It is absent from the cores.

Subfamily Hippocrepininae Rhumbler, 1895

Genus Hyperammina Brady, 1878

Hyperammina elongata Brady

Plate 2, figures 3, 4

Hyperammina elongata Brady, 1878 Ann. Mag. Nat. Hist. ser. 5, vol. 1, p. 433, pl. 20, figs. 2a,b; Barker, 1960, p. 46, pl. 23, fig. 8; Vilks, 1969, p. 43, pl. 1, fig. 4; Cole and Ferguson, 1975, pl. 1, fig. 2; Cole, 1981, p. 9, pl. 2, fig. 2; Kaminski, 1983, p. 7-8, pl. 2, fig. 3. Williamson, 1983, p. 204-205, pl. 1, fig. 1.

Remarks. This species can be distinguished from other tubular forms by its thicker, more robust wall (usually of a yellowish-orange colour) and in some specimens by the presence of a bulbous proloculus.

Distribution. The single most common agglutinated form in surface samples, H. elongata exceeds 25% of Σ at 2995 m and at 3500 m but seems somewhat less common deeper, and is absent from several samples between 2000 and 2500 m. It is common in the uppermost 20 cm of both cores, and again fairly common at 120-150 cm of the short core but is otherwise not represented.

Genus Saccorhiza Eimer and Fickert, 1899

Saccorhiza ramosa (Brady)

Hyperammina ramosa Brady, 1879. Quart. Jour. Micr. Sci. vol. 19, p. 33, figs. 14,15.

Saccorhiza ramosa (Brady) Barker, 1960, p. 46, pl. 23, figs. 15-19; Vilks, 1969, p. 43, pl. 1, fig. 5; Anderson, 1975, pl. 1, fig. 4; Cole, 1981, p. 11, pl. 1, fig. 5; Kaminski, 1983, p. 9, pl. 2, fig. 7.

Remarks. This rare form closely resembles Brady's (1879) illustrated specimens, with a dense covering of fine spicules, perhaps from sponges.

Distribution. This species occurs only in limited members at 2205 m and 2995 m, never exceeding 1% of the total. It is not encountered in the core samples.

Subfamily Dendrophyrinae Haeckel, 1894

Genus Dendrophyra Wright, 1861

Dendrophyra arborescens (Norman)

Plate 1, figure 4

Psammatodendron arborescens Norman 1881. Norpod. - Exped. in der Jahren 1872-1874, vol. 13, p. 98; Barker, 1960, p. 58, pl. 28, figs. 12,13.

Dendrophyra arborescens (Norman) Cole, 1981, p. 12, pl. 1, fig. 10. Kaminski, 1983, p. 8.

Remarks. *D. arborescens* appears as a small, very thin tube of brownish appearance. The tube is always somewhat curved or bent, sometimes with abrupt changes of direction.

Distribution. This form enjoys a scattered and somewhat odd distribution, appearing in small numbers in a few samples from all depth ranges, exceeding 5% of at 2487 m and at 4925 m. A lone individual was found at 123-125 cm in the gravity core, but otherwise was not seen in subsurface samples.

Family Saccaminidae Brady, 1884

Subfamily Psammosphaerinae Haeckel, 1894

Genus *Psammosphaera* Schulze, 1875

Psammosphaera parva Flint

Psammosphaera parva Flint, 1899. Ann. Rep. U.S. Nat. Mus., 1897, pt. 1, p. 268, pl. 9, fig. 1; Barker, 1960, p. 36, pl. 18, figs. 2-4; Mendelson, 1982, pls. 2,3; Kaminski, 1983, p. 9, pl. 3, fig. 3.

Remarks. This very small, partially chitinous form usually stains strongly because of its composition.

Distribution. *P. parva* occurs as only one specimen at 3985 m in surface samples and is absent from the cores.

Subfamily Saccamininae Brady, 1884

Genus *Saccammina* M. Sars in Carpenter, 1869

Saccammina difflugiformis Brady

Plate 2, figures 10, 11, 12

Reophax difflugiformis Brady 1879. Quart. Jour. Micr. Sci. vol. 19, p. 51, pl. 4, figs. 3a-b; Barker, 1960, p. 62, pl. 30, figs. 1-4; Anderson, 1975, pl. 1, fig. 16; Cole, 1981, p. 23-24, pl. 4, fig. 6.

Reophax sp. 1 - Kaminski, 1983, p. 16, pl. 7, figs. 4-5.

Saccamina difflugiformis (Brady) Poag et al. 1980, pl. 1, figs. 1-4. Williamson, 1983, p. 205, pl. 1, fig. 3.

Remarks. This flask-shaped species normally stains pink in samples treated with Rose Bengal because of its pseudochitinous inner lining. For this and other reasons Cole (1981) indicates the species way actually belong in Proteonina. Williamson's (1983) description of the form as Saccamina difflugiformis may also be accurate, and I have chosen to retain this designation because of the close reltionship between Williamson's (1983) paper and the present study.

Distribution. S. difflugiformis is widespread in surface samples, composing up to 2.6% of the total in most, but is oddly absent at 4030 m and 4046 m. At 4495 m and 4925 m, however, this form comprises 26.5% and 28.6%, respectively, of the assemblages. This species is quite common in most of the gravity core, and the upper 80 cm of the piston core, although it is seen only in small numbers in the uppermost 20 cm of both cores. From 260-262 cm to 687-689 cm in the piston core S. difflugiformis is present in smaller numbers, and is absent below this.

Genus Technitella Norman, 1878

Technitella legumen Norman

Technitella legumen Norman, 1878, Ann. Mag. Nat. Hist. ser. 5, vol, 1, p. 274; Barker, 1960, p. 50, pl. 25, figs. 8-12; Cole and Ferguson, 1975, pl. 1, fig. 3

Remarks. The one specimen of T. legumen found in this survey is an elongated oval shape, covered with longitudinally oriented fine spines.

Distribution. T. legumen occurs as only a single well-preserved specimen at 4925 m in surface samples, not at all in the cores.

Family Ammodiscidae Reuss, 1862

Subfamily Ammodiscinae Reuss, 1862

Genus Glomospira Rzehak, 1885

Glomospira charoides (Jones and Parker)

Plate 2, figure 5

Trochammina squamata charoides Jones and Parker, 1860 Geol. Soc. London, Quart. Jour. vol. 16, p. 304.

Glomospira charoides (Jones and Parker) Barker, 1960 p. 78, pl. 38, figs. 10-16; Anderson, 1975, pl. 1, figs. 10a,b. LeRoy and Hodgkinson, 1975, pl. 2, figs. 1,2; Ingle et al. 1980, p. 136, pl. 9, fig. 6, Cole, 1981, p. 19-20, pl. 4, fig. 2; Poag, 1981, pl. 7, fig. 4; Kaminski, 1983, p. 11, pl. 5, fig. 6.

Remarks. This tightly-coiled form closely resembles most published illustrations of it, and is usually a yellowish-brown colour, often with some dark mineralization in the sutures.

Distribution. This species occurs in very small numbers (<1% of total) in most samples from between 2000 m and 3985 m. One specimen appears at 105-107 cm in the gravity core.

Subfamily Tolypammininae Cushman, 1928

Genus *Tolypammina* Rhumbler, 1895

Tolypammina vagans (Brady)

Plate 2, figure 6

Hyperammina vagans Brady, 1879. Quart. Jour. Micr. Sci. vol. 19, p. 33, pl. 3, fig. 5.

Tolypammina vagans (Brady) Rhumbler, 1895. Nachs. K. Ges. Wiss. Gottingen, p. 83; Barker, 1960, p. 48, pl. 24, figs. 1-5; LeRoy and Hodgkinson, 1975, pl. 2, fig. 3; Cole, 1981, p. 20-21, pl. 4, fig. 3.

Remarks. *T. vagans* appears in these samples in two forms, usually as a single yellowish-brown tube attached to and meandering over tests of other foraminifera, and very occasionally as a small tube with a few other tests attached to it.

Distribution: The form occurs in small numbers in most surface samples between 2200 m and 3500 m, exceeding 6% of the total assemblage at 3050 m. It appears again in very small numbers (<1%) at 4040 m and is also seen occasionally in small numbers in the upper metre or so of both cores.

Superfamily Lituolacea de Blainville, 1825

Family Hormosinidae Haeckel, 1894

Subfamily Hormosininae Haeckel, 1894

Genus _Hormosina_ Brady, 1879

Hormosina _globulifera_, Brady

Plate 2, figure 7

Hormosina _globulifera_ Brady, 1879. Quart. Jour. Micr. Sci. vol. 19, p. 60, pl. 4, figs. 4,5; Barker, 1960, p. 80, pl. 39, figs. 1-6; LeRoy and Hodgkinson, 1975, pl. 3, figs. 1-2; Ingle et al., 1980, p. 138, pl. 7, fig. 7; Cole, 1981, p. 27, pl. 4, fig. 7; Mendelson, 1982, pl. 4; Kaminski, 1983, p. 13, pl. 5, fig. 7.

Remarks. This sphaerical agglutinated form is quite distinctive and difficult to confuse with anything else.

Distribution. This form is found in some surface samples from between 2487 m and 3543 m, exceeding 1% of the total only at 2750 m, but is totally absent from the cores.

Genus _Reophax_ de Montfort, 1808

Reophax _bacillaris_ Brady

Plate 2, figures 8, 9

Reophax _bacillaris_ Brady, 1881 - Quart. Jour. Micr. Sci. vol. 21, p. 49. Barker, 1960, p. 62, pl. 30, figs. 23,24; Cole, 1981, pl. 2, fig. 12; Kaminski, 1983, p. 15, pl. 6, fig. 4.

Remarks. This large (up to 5.0 mm) form is well illustrated in the literature, and because of its size is quite distinct. Some specimens were observed by the author in apparent life position on the sediment-water interface of some box cores as they were landed.

Distribution. In surface samples this form is absent above 2500 m depth. It is most common (3%) at 2996 m disappearing again at 4046 m. _R. bacillaris_ also occurs in small numbers in the upper metre or so of both cores.

Reophax dentaliniformis Brady

Plate 1, figure 5

Lituola (Reophax) dentaliniformis Brady, 1881. Quart. Jour. Micr. Sci. vol. 21, p. 49.

Reophax dentaliniformis Brady. Barker, 1960, pl. 30, fig. 31; Anderson, 1975, pl. 1, fig. 15; Cole and Ferguson, 1975, pl. 1, fig. 10; Ingle et al. 1980, p. 144; Cole, 1981, p. 23, pl. 16, fig. 23; Kaminski, 1983, p. 15, pl. 6, figs. 9,10.

Remarks. This species is well illustrated in the literature, and the specimens encountered in this study conform quite closely to published descriptions.

Distribution. _R. dentaliniformis_ appears in only 5 surface samples (always less than 1.0 of the total) ranging in depth from 2000 m to 3500 m. It is seen as single specimens in only two core samples.

Reophax fusiformis (Williamson)

Proteonina fusiformis Williamson, 1858. Rec. Foram. Great Britain p. 1, pl. 1, fig. 1.

Reophax fusiformis (Williamson) Brady 1884. Rep. Voy. Challenger, Zool., vol. 9, p. 290, pl. 30, figs. 7-11; Barker, 1960, p. 62, pl. 30, figs. 7-11; Vilks, 1969, p. 44, pl. 1, figs. 8a-b; Cole and Ferguson, 1975, pl. 1, fig. 15; Ingle et al. 1980, p. 144; Milam and Anderson, 1981, pl. 2, fig. 1.

Reophax curtus Cushman, 1920. U.S. Nat. Mus. Bull. 104, (2), p. 8, pl. 2, figs. 2,3.

Reophax subfusiformis Earland, 1933, Discovery Repts. vol. 7, p. 74, pl. 2, figs. 16-19.

Remarks. This species as it appears in the study area closely resembles the published illustrations and descriptions.

Distribution. This rare form appears in very small numbers in several surface samples from between 2000 m and 4046 m depth, and is not seen in any subsurface core samples.

Reophax guttifer (Brady)

Plate 2, figure 13

Lituola (Reophax) guttifer Brady, 1881. Quart. Jour. Micr. Sci. vol. 21, p. 49.

Reophax guttifer (Brady) Barker, 1960, pl. 31, figs. 10-15; Anderson, 1975, pl. 1, figs. 18a-b; Ingle et al. 1980, p. 144.

Reophax guttifera (Brady) Brady, 1884. Rep. Voy. Challenger, Zool. vol. 9, p. 295, pl. 31, figs. 10-15; Vilks, 1969, p. 44, pl. 1, fig. 10; Cole, 1981, p. 25, pl. 2, fig. 11; Williamson, 1983, p. 207, pl. 1, fig. 10.

?Hormosina guttifer (Brady) Kaminski, 1983, p. 17, pl. 7, fig. 7

Remarks. This small, fragile form is easy to distinguish by its thin 'waist' between chambers.

Distribution. R. guttifer is a rare form, occurring in only 5 surface samples (2120 m - 4046 m) and is most common (1.19% of total) at 2120 m. It appears in only one core sample.

Reophax spp. fragments

Remarks. These vaguely circular or oval agglutinated forms usually consist of a single chamber, sometimes two. A few may actually represent Saccamina spp. but it was found most convenient to simply assign them all to this designation.

Distribution. Found in samples from a wide depth range and in cores from the upper two metres.

Family Lituolidae de Blainville, 1825

Subfamily Haplophragmoidinae Maync, 1952

Genus Haplophragmoides Cushman, 1910

Haplophragmoides bradyi (Robertson)

Plate 2, figure 14

Trochammina bradyi; Robertson, 1891. Ann. Mag. Nat. Hist. ser. 6, vol. 7, p. 388.

Haplophragmoides bradyi (Robertson) Phleger and Parker, 1951. Geol. Surv. Amer. Mem. 46, pt. II, pl. 1, fig. 10; Anderson, 1975, pl. 2, figs. 8a,b; Cole, 1981,

p. 28-29, pl. 4, fig. 10.

Remarks. This small, nearly planispiral form is similar to other illustrations given for it.

Distribution. This species appears in only 4 surface samples from depths ranging from 2995-3985 m. It never exceeds 1% of the total assemblage. It is present in one core sample (747-749 cm) as a single specimen.

Haplophragmoides sphaeroloculum Cushman, 1910

Plate 2, figure 15

Haplophragmoides sphaeroloculum Cushman, 1910. U.S. Nat. Mus. Bull., no. 71, p. 107.

Remarks. This form is usually rather small and can be distinguished from certain other low trochospiral agglutinated species by its nearly spherical chambers and almost planispiral chamber arrangement.

Distribution. *H. sphaeroloculum* is present in small numbers in most surface samples from between 2120 m and 4046 m, and is most common (5% of total) at 3543 m. Also present in some core samples from various depths, never in large numbers.

Genus *Adercotryma* Loeblich and Tappan, 1952

Adercotryma glomerata (Brady)

Plate 2, figure 16

Lituola glomerata Brady, 1878. Ann. Mag. Nat. Hist. ser. 5, vol. 1, p. 433, pl. 20, fig. 1.

Adercotryma glomerata (Brady). Barker, 1960, pl. 34, figs. 15-18. Barbieri and Medioli, 1969, p. 853-854; Vilks, 1969, p. 44, pl. 1, fig. 15; Anderson, 1975, pl. 2, figs. 4a-b; Cole and Ferguson, 1975, pl. 3, figs. 12,13; Ingle et al. 1980, p. 128; Cole, 1981, p. 29-30, pl. 4, fig. 8; Milam and Anderson, 1981, pl. 2, fig. 3; Kaminski, 1983, p. 17, pl. 7, figs. 9,10; Williamson, 1983, p. 208, pl. 1, fig. 16.

Remarks. In this study, *A. glomerata* was found to closely resemble published illustrations and descriptions given for it.

Distribution. This species appears in only 3 surface samples at 3247 m, 4030 m and 4925 m; its maximum abundance is in the last, at 2.14% of the total. In both cores the form is much more common sometimes exceeding 5% of the assemblage.

Genus *Cribrostomoides* Cushman, 1910

Cribrostomoides scitulum (Brady)

Plate 2, figure 17

Lituola (*Haplophragmium*) *scitulum* Brady, 1881. Quart. Jour. Micr. Sci. vol. 21, p. 50.

Alveophragmium scitulum (Brady) Barker, 1960, p. 70, pl. 34, figs. 11-13. Ingle et al., 1980, p. 128; Williamson, 1983, p. 210, pl. 2, fig. 6.

Cribrostomoides scitulum (Brady) Poag, 1981, pl. 11-12, fig. 4; Kaminski, 1983, p. 17-18, pl. 2, figs. 2a-b.

Cribrostomoides scitulus (Brady) Loeblich and Tappan, 1964, (2) vol. 1, p. C225; LeRoy and Hodgkinson, 1975, pl. 4, figs. 5,6; Cole, 1981, p. 30-31, pl. 4, fig. 12

Remarks. This involute, quite attractive species is often a bright yellow or yellowish-orange in colour, and usually closely resembles figured specimens.

Distribution. C. scitulum appears intermittently in surface samples from almost all depths. It is somewhat more common n the deeper half of the range, but never exceeds 1% of the total. It is absent from subsurface core samples.

Cribrostomoides subglobosa (G.O. Sars)

Plate 2, figure 18

Lituola subglobosa G.O. Sars, 1872. For. Vid. Selsk. Christiana, p. 253.

Cribrostomoides subglobosum (G.O. Sars) Poag, 1981, pl. 11-12, fig. 2. Cole, 1981, p. 31, pl. 4, fig. 13; Milam and Anderson, 1981, pl. 3, fig. 1; Williamson, 1983, p. 210, pl. 1, fig. 15.

Alveophragmium subglobosum (G.O. Sars) Barker, 1960, p. 70, pl. 34, figs. 7, 8, 10, 14; Ingle et al. 1980, p. 130, pl. 3, fig. 10.

Cribrostromoides subglobosus (Cushman) Vilks, 1969, p. 45, pl. 1, figs. 18a,b.

Cribrostomoides subglobosus (Sars) Anderson, 1975, pl. 2, fig. 7; LeRoy and Hodgkinson, 1975, pl. 4, figs. 2-4.

Remarks. Although variable in size (150μ-500μ) this form is easily recognized by its involute construction and globular chambers.

Distribution: This species is present in surface samples from 2000 m down to 4046 m and is most common (2% of total) at 2995 m. It is present only occasionally in core samples.

Cribrostomoides weisneri (Parr)

Plate 3, figure 1

Labrospira weisneri Parr, 1950. Brit. Austr. N. Zeal. Antarctic Res. Exped. 1929-31 Rep. ser. B (Zool.) vol. 5, pt. 6, p. 272, p. 4, figs. 25,26.

Cribrostomoides weisneri (Parr) Loeblich and Tappan, 1964. (2) vol. 1, p. C225; LeRoy and Hodgkinson, 1975, pl. 3, figs. 16,17; Cole, 1981, p. 31, pl. 4, fig. 11; Milam and Anderson, 1981, pl. 2, fig. 6.

Alveophragmium weisneri (Parr). Barker, 1960, p. 82, pl. 40, figs. 14,15. Anderson, 1975, pl. 2, figs. 11a,b.

Remarks. This small, laterally compressed nearly planispiral form is easily distinguished by its smooth, shiny wall and is yellowish-brown in colour.

Distribution. C. weisneri is present in surface samples only deeper than 2995 m and is most common (2% of total) at 3985 m. Very rare in core material, seen as only a few scattered individuals.

Genus Recurvoides Earland, 1934

Recurvoides contortus Earland

Plate 3, figure 2

Recurvoides contortus Earland, 1934. Discovery Reports, vol. 10, p. 91, pl. 10, figs. 7-19; Cole and Ferguson, 1975, pl. 3, figs. 4-5; LeRoy and Hodgkinson, 1975, p. 436, pl. 3, figs. 20-21; Cole, 1981, p. 31-32, pl. 5, fig. 1; Milam and Anderson, 1981, pl. 3, fig. 2; Resig, 1981, pl. 10, fig. 12; Kaminski, 1983, p. 18, figs. 5a,b-6.

Remarks. This species superficially resembles Cribrostomoides sulglobosum, but is irregularly coiled, not planispiral.

Distribution. R. contortus is present in most surface samples, occasionally accountng for over 30% of the total, as at 2995 m and 3543 m, but is very rare in core material.

Subfamily Cyclamminae Marie, 1941

Genus Cyclammina Brady, 1879

Cyclammina cancellata Brady

Plate 1, figure 6

Cyclammina cancellata Brady, 1879. Quart. Jour. Micr. Sci., vol. 19, p. 62; Barker, 1960, p. 76, pl. 37, figs. 8-16; Anderson, 1975, pl. 2, figs. 12a-b; LeRoy and Hodgkinson, 1975, pl. 4, figs. 15-17; Ingle et al. 1980, p. 132, pl. 2, fig. 1; Cole, 1981, p. 32, pl. 5, fig. 2; Kaminski, 1983, p. 20, pl. 10, figs. 1a-b, 2-3; Williamson, 1983, p. 210, pl. 2, fig. 10.

Remarks. This large species is quite distinct in appearance, and is often encrusted with dark mineral matter.

Distribution. Very rare in both surface and core material, occurring in only a few samples as lone individuals.

Genus *Alveophragmium* Shchedrina, 1936

Alveophragmium ringens (Brady)

Trochammina ringens Brady, 1879. Quart. Jour. Micr. Sci. vol. 19, p. 57, pl. 5, figs 12a-b.

Alveophragmium ringens (Brady) Parker 1954, p. 487; Barker, 1960, p. 82, pl. 40, figs. 17a-b, 18a-b.

Cribrostomoides ringens (Brady) Loeblich and Tappan, 1964. (2) vol. 1, p. C225; LeRoy and Hodgkinson, 1975, pl. 4, fig. 1.

Cystaminella ringens (Brady) Lukina, 1980, fig. 48; Kaminski, 1983, p. 17, pl. 9, figs. 3a-b.

Remarks. This highly distinctive species conforms very closely to illustrations in the literature.

Distribution. An occasional find in surface samples from below 2750 m, *A. ringens* appears in a very few core samples.

Subfamily Lituolinae de Blainville, 1825

Genus *Ammobaculites* Cushman, 1910

Ammobaculites agglutinans (d'Orbigny)

Plate 3, figure 3

Spirolina agglutinans d'Orbigny, 1846. Foram. Foss. Vienne, p. 137, pl. 7, figs. 10-12.

Ammobaculites agglutinans (d'Orbigny). Barker, 1960, p. 66, pl. 32, figs. 19-21, 24-26; Anderson, 1975, pl. 2, figs. 15a-b; Cole, 1981, p. 33, pl. 5, fig. 3; Resig, 1981, pl. 9, fig. 16; Kaminski, 1983, p. 19, pl. 9, fig. 4.

Distribution. This robust form is fairly common in surface samples, especially from 2750 m to 4046 m, occasionally composing 5% of the total. It is quite rare in core material.

Genus Ammomarginulina Weisner, 1931

Ammomarginulina foliacea (Brady)

Plate 1, figure 9

Lituola (Haplophragmium) foliaceum Brady, 1881. Quart. Jour. Micr. Sci., vol. 21, p. 50.

Ammomarginulina foliaceus (Brady). Barker, 1960, p. 68, pl. 33, figs. 20-25.

Ammomarginulina foliacea (Brady). Cushman, 1933a, pl. 10, figs. 6a,b. Cole, 1981, pl. 5, fig. 4; Kaminski 1983, p. 20, pl. 9, fig. 6.

Remarks. This form is found in both morphotypes, the small discoid form, and, more rarely, with a rectilinear portion.

Distribution. A. foliacea occurs only in those samples taken from 2995 m or greater depth, and is most common (over 2%) at 4030 m. It is also found very rarely in the upper 2 metres of both cores.

Genus *Ammoscalaria* Höglund, 1947

Ammoscalaria tenuimargo (Brady)

Plate 1, figure 8

Haplophragmium tenuimargo Brady, 1882. Proc. Roy. Soc. Edinburgh, vol. 11, p. 715

Ammomarginulina tenuimargo (Brady) Cushman, 1910, p. 117, figs. 100-183. Cole, 1981, p. 34, pl. 5, fig. 5

Ammoscalaria tenuimargo (Brady) Barker, 1960, p. 68, pl. 33, figs. 13-16. Blanc-Vernet, 1983, p. 504.

Remarks. This is a very fragile form which may sometimes resemble loosely aggregated plates of thin mineral flakes.

Distribution. *A. tenuimargo* occurs only in surface samples as a single specimen from 2000 m.

Family Textulariidae Ehrenberg, 1838

Subfamily Spiroplectammininae Cushman, 1927

Genus *Spiroplectammina* Cushman, 1927

Spiroplectammina biformis (Parker and Jones)

Plate 3, figures 4, 5

Textularia agglutinans biformis Parker and Jones, 1865. Philos. Trans. Roy. Soc., vol. 155, p. 370, pl. 15, figs. 23-24.

Spiroplectammina biformis (Parker and Jones) LaCroix, 1932. Bull. Inst. Ocean. Monaco, vol. 591, p. 5, fig. 1; Barker, 1960, p. 92, pl. 45, figs. 25-27; Vilks, 1969, p. 45, pl. 1, figs. 20a-b; Cole and Ferguson, 1975, pl. 3, fig. 3; Ingle et al. 1980, p. 144, pl. 5, fig. 9; Cole, 1981, p. 34, pl. 6, fig. 3; Rodriguez and Hooper, 1982b, p. 348; Williamson, 1983, p. 211-212, pl. 2, fig. 5.

Remarks. In general this form closely resembles published figures and discriptions.

Distribution. In surface samples, a few specimens occur at 3247 m and at 3500 m. In core material, S. biformis is fairly common below 669 cm, constituting 31% of the foraminiferal assemblage at 708-710 cm. Above 669 cm, it is quite rare.

Subfamily Textulariinae Ehrenberg, 1838

Genus Textularia Defrance in de Blainville, 1825

Textularia gracillima Höglund

Plate 3, figure 6

Textularia gracillima Höglund, 1947. Tod. Bidr. Uppsala, Bd. 26, p. 180, pl. 13, fig. 2; p. 173 text-fig. 15b.

Remarks. This is a small and very fragile form, easily broken by imprudent handling.

Distribution. Not present in any surface samples, and rare in a few core samples from between 290 cm and 749 cm.

Subfamily Pseudobolivininae Weisner, 1931

Genus Siphotextularia Finlay, 1939

Siphotextularia catenata Phleger and Parker

Plate 3, figure 7

Textularia catenata Cushman, 1911, p. 23, figs. 39-40.

Siphotextularia rolshauseni Phleger and Parker 1951. Geol. Soc. Amer. Mem. 46(2) p. 4, pl. 1, figs. 23-24; Cole, 1981, p. 36, pl. 5, fig. 7; Belanger and Streeter, 1980, p. 415.

Siphotextularia catenata (Cushman) Corliss, 1979, p. 5, pl. 1, figs. 1-2; Blanc-Vernet, 1983, p. 506.

Remarks. This species is usually of a distinctive white, "sugary" appearance.

Distribution. S. catenata appears in very small numbers in three surface samples, from 2996 m, 3247 m, and 3880 m. In core samples from between 270 cm and 440 cm this form is often found in small numbers, less commonly below this.

Family Trochamminidae Schwager, 1877

Subfamily Trochammininae, Schwager, 1877

Genus Trochammina Parker and Jones, 1859

Trochammina bullata Takayanagi

Plate 3, figure 8

Trochammina bullata Takayanagi 1960. Tohoku. Univ. Sci. Repts. Ser. 2, (Geol.) vol. 32, no. 1, p. 85, pl. 4, figs. 1a-c. Cole, 1981, p. 37, pl. 7, fig. 1.

Distribution. One specimen from a surface sample at 2995 m.

Trochammina _malovensis_ Heron-Allen and Earland

Plate 3, figures 9, 10

Trochammina _malovensis_ Heron-Allen and Earland, 1929, Roy. Micr. Soc. Jour., ser. 3, vol. 49, pt. 4, art. 27, p. 328.

Ammoglobigerina _globigeriniformis_ (Parker and Jones) Barker, 1960, p. 72, pl. 35, figs. 10,11.

Trochammina _globigeriniformis_ (Parker and Jones) LeRoy and Hodgkinson, 1975, pl. 5, figs. 6,7; Ingle et al. 1980, p. 146, pl. 5, figs. 12; 13; Williamson, 1983, p. 213, pl. 2, fig. 14.

Distribution. This species occurs commonly in surface samples from 2400 m down, exceeding 4.0% of the total at 4925 m. It is very rare in core material.

Trochammina _ochracea_ (Williamson)

Plate , figure

Rotalia _ochracea_ Williamson, 1858. Rec. Foram. Great Brit., p. 55, pl. 4, fig. 112; pl. 5, fig. 113.

Trochammina _ochracea_ (Williamson) Feyling-Hansen, 1964. Norges. Geol. Und. NR225, p. 220, pl. 13, figs. 11,12; Cole and Ferguson, 1975, pl. 4, figs. 9,10; Thomas, 1977, p. 48, pl. 1, figs. 11, 12.

Remarks. This small nearly planispiral form is commonly associated with somewhat shallower nearshore conditions than is the case in the present study (Cole and Ferguson, 1975; Thomas, 1977).

Distribution. In surface samples this species is found only as a few specimens at 3247 m. In the cores *T. ochracea* occurs in small numbers in several samples, somewhat more frequently in the bottom three metres.

Trochammina pusilla Höglund

Plate 3, figure 11

Trochammina pusilla Höglund, 1947. Univ. Zool. Bidr. Uppsala, Bd. 26, p. 201, pl. 17, fig. 4.

Remarks. This very small, high trochospiral form agrees very closely with Höglund's (1947) description and plates.

Distribution. *T. pusilla* occurs as only a few individuals from samples in various levels of the cores.

Trochammina squamata group Jones and Parker

Plate 3, figures 12, 13

Trochammina squamata Jones and Parker, 1860. Quart. Jour. Geol. Soc., vol. 16, p. 304; Cole and Ferguson, 1975, pl. 4, figs. 11-12; LeRoy and Hodgkinson, 1975, pl. 5, figs. 4-5; Ingle et al. 1980, p. 146; Cole, 1981, p. 39, pl. 6, figs. 10-11; Williamson, 1983, p. 213, pl. 2, fig. 8-9.

Tritaxis squamata (Jones and Parker) Anderson, 1975, pl. 4, figs. 2a-b.

Distribution. This somewhat variable group of forms enjoys a wide distribution in surface samples, found in most material from below 2400 m, and reaches nearly 3% of the total at 4925 m. It is fairly common in core material from between 260 cm and 400 cm, less so in other levels.

Genus Cystammina Newmayr, 1899

Cystammina pauciloculata (Brady)

Plate 3, figure 14

Trochammina pauciloculata Brady, 1879. Quart. Jour. Micr. Sci. vol. 19, p. 58, pl. 5, figs. 13,14.

Cystammina pauciloculata (Brady). Barker, 1960, p. 84, pl. 41, figs. 1-2. Anderson, 1975, pl. 4, figs. la-b; Ingle et al. 1980, p. 134, pl. 9, fig. 11; Cole, 1981, p. 39-40, pl. 5, fig. 8; Kaminski, 1983, p. 18, pl. 9, fig. 1.

Remarks. This distinctive and well-documented species often exhibits a very shiny, smooth surface.

Distribution. *C. pauciloculata* is present sporadically from 2120 m down to 4925 m, where it is most common (3%). Very rare, however, in subsurface material, present as only a single specimen at 123-125 cm.

Family Ataxophragmiidae Schwager, 1877

Subfamily Globotextulariinae Cushman, 1927

Genus *Eggerella* Cushman, 1933

Eggerella bradyi (Cushman)

Verneuilina bradyi Cushman, 1911. U.S. Nat. Mus. Bull. 71, pt. 2, p. 54, text figs. 87a,b; pl. 6, fig. 4.

Eggerella bradyi (Cushman) Barker, 1960, pl. 47, figs. 4-7; LeRoy and Levinson, 1974, p. 5, pl. 1, fig. 14; Anderson, 1975, pl. 4, fig. 3; LeRoy and Hodgkinson, 1975, pl. 6, fig. 4; Corliss, 1979, p. 5, pl. 1, figs. 3,4; Boltovsky, 1980a, pl. 4, figs. 5a,b; Ingle et al. 1980, p. 134; Cole, 1981, p. 43, pl. 5, fig. 9; Blanc-Vernet, 1983, p. 504, pl. 1, fig. 12; Kaminski, 1983, pl. 11, fig. 5.

Remarks. This species may sometimes be confused with the calcareous *Tosaia hanzawai*, except that *E. bradyi* is normally an orange or brownish hue in these samples.

Distribution. This form is found in surface samples from 2500m, 2750 m and 2995 m, always in very small numbers. It is absent from core samples.

Eggerella propinqua (Brady)

Plate 3, figure 15

Verneuilina propinqua Brady, 1884. Rep. Voy. Challenger, Zool. vol. 9, p. 387, pl. 47, figs. 8-12.

Eggerella propinqua (Brady) Barker, 1960, pl. 47, figs. 8-12; LeRoy and Hodgkinson, 1975, pl. 6, fig. 7f; Cole, 1981, p. 43, pl. 5, fig. 10; Kaminski, 1983, p. 22, pl. 11, fig. 6.

Distribution. This very rare form occurs in small numbers in only two surface samples (2750 m and 2995 m) and in no subsurface material.

Eggerella sp.

Distribution. This species of uncertain affinity is found only in small numbers in the upper metre or so of the cores, and is even scarcer further down. It is entirely absent from surface material.

Genus *Karreriella* Cushman, 1933

Karreriella apicularis (Cushman)

Plate 3, figure 16

Gaudryina apicularis Cushman, 1911. U.S. Nat. Mus. Bull. 71, pt. 2, p. 69, figs. 110a-b.

Karrieriella apicularis (Cushman). Poag, 1981, pl. 15-16, fig. 5; Barker, 1960, p. 94, pl. 46, figs. 17-19; LeRoy and Hodgkinson, 1975, pl. 6, fig. 5; Ingle et al. 1980, p. 138; Cole, 1981, p. 43-33, pl. 8, fig. 1; Blanc-Vernet, 1983, p. 505, pl. 1, fig. 11; Kaminski, 1983, p. 22, pl. 11, fig. 7.

Remarks. In the present study this species is found to closely resemble the published descriptions and illustrations given for it.

Distribution. *K. apicularis* occurs in very small numbers in surface samples from 2750 m down, most commonly between 2996 m and 3500 m. It also occurs as a single specimen from 2120 m. In the cores, this species occurs in very small numbers in a few samples at various depths.

Karreriella bradyi (Cushman)

Plate 3, figure 17

Gaudryina bradyi Cushman, 1911. U.S. Nat. Mus. Bull. 71, vol. 2, p. 67, text-fig. 107.

Karreriella bradyi (Cushman). Cushman, 1937. Cushman Lab. Foram. Res. Spec. Publ. 8, p. 135; Barker, 1960, p. 94, pl. 46, figs. 1-4; LeRoy and Levinson, 1974, p. 5-6, pl. 1, fig. 15; LeRoy and Hodgkinson, 1975, pl. 6, fig. 6; Corliss, 1979, p. 5, pl. 1, figs. 5-6; Ingle et al. 1980, p. 138; Cole, 1981, p. 44, pl. 6, fig. 5; Blanc-Vernet, 1983, p. 505, pl. 1, fig. 10; Williamson, 1983, p. 214, pl. 2, fig. 7.

Remarks. This large, distinctive species is easy to recognize by its inflated, rounded chambers and slit-like aperture.

Distribution. _K. bradyi_ occurs in surface samples from 2750 m to 3985 m in small numbers, exceeding 1.0% of the total only above 3050 m. Present in cores only in one sample, at 95-97 cm.

Karreriella novangliae (Cushman)

Plate 3, figure 18

Gaudryina barcata novangliae Cushman, 1922a. U.S. Nat. Mus. Bull. 104, vol. 3, p. 76, pl. 13, fig. 4.

Karreriella novangliae (Cushman) Cushman, 1937. Cushman Lab. Foram. Res. Spec. Publ. 8, p. 136; Barker, 1960, p. 94, pl. 46, figs. 8-10; LeRoy and Levinson, 1974, p. 6, pl. 1, fig. 16; Ingle et al., 1980, p. 140; Cole, 1981, p. 44-45, pl. 8, fig. 2.

Remarks. This form can be distinguished from _K. bradyi_ by its larger size and more "cubic" chambers.

Distribution. *K. novangliae* is found in only 2 surface samples, at 2750 m and 2995 m, in neither one exceeding 0.25% of the total. It is also present, usually as single specimens, in three core samples.

Subfamily Valvulininae Berthelin, 1880

Genus *Martinottiella* Cushman, 1933

Martinottiella communis (d'Orbigny)

Plate 1, figure 11

Clavulina communis d'Orbigny, 1846. Gide et Comp. p. 196, pl. 12, figs. 1,2.

Martinottiella communis (d'Orbigny) Cushman, 1933c. Contr. Cushman Lab. Foram. Res., vol. 9, p. 37; Barker, 1960, p. 98, pl. 48, figs. 3,4,6-8; Ingle et al. 1980, p. 140. Blanc-Vernet, 1983, p. 505.

Distribution. This small form is very rare in the present survey samples, occurring in surface material only once, at 3500 m. Two other specimens were found in the piston core, at 290-292 cm and 420-422 cm.

Martinottiella nodulosa (Cushman)

Plate 3, figure 19

Clavulina communis var. *nodulosa* Cushman, 1922a, U.S. Nat. Mus. Bull. 104, pt. 3, p. 85.

Martinottiella nodulosa (Cushman) Barker, 1960, p. 98, pl. 48, figs. 9-13.

Martinottiella nodulosus (Cushman) Miller and Lohmann, 1982, pl. 1, fig. 7.

Remarks. This form can be distinguished from the very similar *M. communis* by the slightly enlarged early multiserial portion of the test.

Distribution. This species occurs in only one surface sample, at 3880 m, and as single individuals in a few subsurface samples from various levels.

Suborder Miliolina Delage and Hérouard, 1896
Superfamily Miliolacea Ehrenberg, 1839
Family Nubeculariidae Jones, 1875
Subfamily Ophthalmidiinae Wiesner, 1920
Genus *Ophthalmidium* Kubler and Zwingli, 1870

Ophthalmidium pusilla (Earland)

Plate 8, figure 1

Spiroloculina pusilla Earland, 1934. Discovery Reports, vol. 10, p. 47.

Spirophthalmidium pusillum (Earland) Barker, 1960, p. 20, pl. 10, figs. 9-10; Cole, 1981, p. 48, pl. 9, fig. 1.

Ophthalmidium pusillum (Earland) Loeblich and Tappan, 1964, p. C448. Corliss, 1979, p. 5-6, pl. 1, figs. 7-8.

Distribution. Absent from surface samples, but two single specimens were found at 51.53 cm and 61-63 cm in the gravity core.

Family Miliodae Ehrenberg, 1839
Subfamily Quinqueloculininae Cushman, 1917
Genus *Quinqueloculina* d'Orbigny, 1826

Quinqueloculina sp.

Remarks. Only two imperfectly preserved specimens were taken of this form, which somewhat resembles *Q. tropicalis* depicted by Barker (1960, p. 10, pl. 5, figs. 3a-c), but its exact identity is unknown.

Distribution. This species is represented by only a few specimens from 2 piston core samples at 802-804 cm and 840-842 cm.

Genus *Pyrgo* De France, 1824

Pyrgo comata (Brady)

Plate 8, figure 2

Biloculina comata Brady, 1884. Rep. Voy. Challenger, Zool. 9, p. 144, pl. 3, fig. 9.

Pyrgo comata (Brady) Cushman, 1929b. U.S. Nat. Mus. Bull. 104, vol. 6, p. 73, pl. 19, fig. 8; LeRoy and Levinson, 1974, p. 6, pl. 2, fig. 4; Cole and Ferguson, 1975, pl. 10, figs. 1-3; LeRoy and Hodgkinson, 1975, pl. 7, figs. 7-8; Blanc-Vernet, 1983, p. 506.

Distribution. Very rare in study area; found in only one surface sample, at 2750 m (one specimen), and one individual from 678-680 cm in the piston core.

Pyrgo murrhyna (Schwager)

Plate 8, figure 3

Biloculina murrhyna Schwager, 1866. Novara-Exped. Geol. Thiel., vol 2, p. 203, pl. 4, figs. 15a-c.

Pyrgo murrhyna (Schwager) Cushman, 1929b. U.S. Nat. Mus. Bull. 104, vol. 6, p. 71; Barker, 1960, p. 4, pl. 2, figs. 10-11, 15; Ingle et al. 1980, p. 142; Cole, 1981, p. 52-53, pl. 8, fig. 9.

Pyrgo murrhina (Schwager) LeRoy and Levinson, 1974, p. 6, pl. 2, fig. 5. LeRoy and Hodgkinson, 1975, pl. 7, figs. 4-5; Corliss, 1979, p. 6, pl. 1, figs. 15-18; Boltovskoy, 1980b, p. 354, pl. 2, fig. 6; Corliss and Honjo, 1981, p. 362, 364, pl. 9, figs. 1-12; Blanc-Vernet, 1983, p. 506.

Remarks. This distinctive form closely resembles the many published descriptions and illustrations given for it.

Distribution. One of the more widely distributed species encountered in this survey, P. murrhyna ranges the whole suite of surface samples, but appears most persistently below 2750 m, comprising over 7.0% of the total fauna at 4495 m. It also occurs quite frequently in the upper 2 metres of both cores, but is much less common below.

Pyrgo subsphaerica (d'Orbigny)

Biloculina subsphaerica d'Orbigny, 1839. In de la Sagra, "Hist. Phys. Pol. Nat. Cuba", p. 162, pl. 8, figs. 25-27.

Pyrgo subsphaerica (d'Orbigny) Parker, 1952. Bull. Mus. Comp. Zool., vol. 106, no. 9, p. 405, pl. 3, fig. 17; Vilks, 1969, p. 46, pl. 2, figs. 7a,b; Cole, 1981, p. 53,54, pl. 9, fig. 9.

Remarks. This species can readily be distinguished from P. murrhyna by its rotund, almost spherical shape.

Distribution. P. subsphaerica occurs in only 4 widely scattered surface samples, ranging in depth from 2400 m to 4046 m, always in very small numbers. It is also present, though rare, in a few core samples.

Genus *Sigmoilopsis* Finlay, 1947

Sigmoilopsis schlumbergeri (Silvestri)

Plate 8, figure 4

Sigmoilina schlumbergeri Silvestri, 1904. Accad. Pont. Romana Nuovi Lincei, Mem. vol. 22, p. 267, 269.

Sigmoilopsis schlumbergeri (Silvestri) Finlay, 1947. Roy. Soc. New Zeal. Trans. vol. 28, no. 5 (B), p. 270; Barker, 1960, p. 16, pl. 8, figs. 1-4.; LeRoy and Levinson, 1974, p. 6, pl. 2, fig. 13; Cole and Ferguson, 1975, pl. 12, figs. 1-2; LeRoy and Hodgkinson, 1975, pl. 7, fig. 15; Blanc-Vernet, 1983, p. 506; Williamson, 1983, p. 215-216, pl. 3, fig. 4.

Remarks. This species is readily recognizable by its flattened, lenticular shape and fine agglutimated coating.

Distribution. *S. schlumbergeri* is present in small numbers in most surface samples, being most common (5.3%) at 2750 m.

Genus *Triloculina* d'Orbigny, 1826

Triloculina oblongum (Montagu)

Vermiculum oblongum Montagu, 1803. Test. Brit., pt. 2, p. 522, pl. 14, fig. 9.

Triloculina oblonga (Montagu) d'Orbigny, 1826. Ann. Sci. Nat. Paris, ser. 1, vol. 7, p. 300, no. 16, mod. 95; Cole and Ferguson, 1975, pl 11, fig. 10; Cole, 1981, p. 55, pl. 17, figs. 41-42.

Distribution. A very rare form. *T. oblongum* occurs as only a few specimens at 2996 m, and in very small numbers in various levels of the cores.

Triloculina tricarinata d'Orbigny

Plate 8, figure 5

Triloculina tricarinata d'Orbigny, 1826. Ann. Sci. Nat. Paris, ser. 1, vol. 7, p. 299, no. 7, mod. 94; Barker, 1960, p. 6, pl. 3, figs. 17a-b; Cole and Ferguson, 1975, pl. 11, fig. 11; Cole, 1981, p. 55-56, pl. 10, fig. 2; Blanc-Vernet, 1983, p. 506.

Distribution. *T. tricarinata* occurs in most surface samples in this study, being most common (1.0-3.0% of total) between 2487 m and 2996 m. It appears in many subsurface samples, sometimes comprising over 10% of the fauna in the upper 1.5 metres.

Subfamily Miliolinae Ehrenberg, 1839

Genus *Miliola* Lamarcke, 1804

Miliola sp.

Remarks. The exact affinities of this miliolid are unknown, but its overall form seems to place it in this genus.

Distribution. Found only as single specimens in two core samples, at 51-53 cm and 61-63 cm.

Suborder Rotaliina Delage and Hérouard, 1896

Superfamily Nodosariacea Ehrenberg, 1838

Family Nodosariidae Ehrenberg, 1838

Subfamily Nodosariinae Ehrenberg, 1838

Genus *Nodosaria* Lamarck, 1812

Nodosaria albatrossi Cushman

Plate 5, figure 1

Nodosaria albatrossi Cushman, 1923. U.S. Nat. Mus. Bull. 104, pt. 4, p. 87; Barker, 1960, p. 134, pl. 64, figs. 11-14.

Remarks: The distinctive appearance of this species makes it difficult to confuse with other nodosariids. In this form, both the initial and final chambers are of slightly greater diameter than the others.

Distribution. *N. albatrossi* appears in very small numbers in some surface samples from between 2000 m and 2750 m. One specimen was found in the piston core at 40-42 cm.

Genus *Astacolus* de Montfort, 1808

Astacolus crepidula (Fichtel and Moll)

Nautilus crepidula Fichtel and Moll, 1798. Test. Micr. alia. min. gen. Argon et Naut. ad nat. picta et descri. (2nd ed., 1803) p. 107, pl. 19, figs. g-i.

Astacolus crepidulus (Fichtel and Moll) Barker, 1960, p. 142, pl. 67, fig. 20; pl. 68, figs. 1-2; Cole, 1981, p. 57-58, pl. 17, fig. 47.

Distribution. This is a very rare form in the study area, present as a single specimen in only one surface sample (3880 m), and in similar concentrations in various core samples.

Genus Dentalina Risso, 1826

Dentalina inornata (Brady) bradyensis (Dervieux)

Plate 5, figure 2

Nodosaria inornata bradyensis Dervieux, 1894. Boll. Soc. Geol. Ital. vol. 12, p. 610.

Dentalina inornata bradyensis (Dervieux) Barker, 1960, p. 130, pl. 62, figs. 19-20; Cole, 1981, p. 60, pl. 18, fig. 7.

Dentalina inornata (Brady) bradyensis (Dervieux) Blanc-Vernet, 1983, p. 504.

Remarks. This species occurs sporadically in surface samples from between 2200 m and 4046 m, and is most prevalent (1% of total) at 3247 m. It also occurs in small numbers in several core samples, though not below 783 cm.

Genus Lagena Walker and Jacobs in Kanmacher, 1798

Lagena distoma (Parker and Jones)

Lagena laevis (Montagu) var. striata (Montagu) Parker and Jones, 1857, Ann. & Mag. Nat. Hist., 2nd ser., vol. XIX, pl. 11, fig. 24.

Lagena distoma Parker and Jones. Barker, 1960, p. 119, pl. 58, figs. 11-15; Anderson, 1975, pl. 5, fig. 4; Ingle et al., 1980, p. 140, pl. 4, fig. 12.

Distribution. As single specimens in a few surface samples and some subsurface material.

Lagena elegantissima (Reuss)

Lagena acuticosta Reuss. 1867, Sitzungsb. d. k. Akad. Wiss. Wien, vol. XLIV, p. 385, pl. i, fig. 4; Brady, 1844, pl. LVII, figs. 31,32.

Lagena elegantissima (Bornemann) Barker, 1960, p. 118, pl. 57, fig. 32.

Distribution. Very rare, occuring as single individuals in one surface sample (3985 m) and in a few core samples.

Lagena gracilis Williamson

Plate 5, figure 3; Plate 8, figure 7

Lagena gracilis Williamson, 1848, Ann. & Mag, Nat. Hist., London, ser. 2, vol, 1, p. 13, pl. 1, fig. 5; Barker, 1960, p. 119, pl. 58, figs. 2-3, 7-10, 22-24; Vilks, 1969, p. 47, pl. 2, fig. 17; Anderson, 1975, pl. 5, fig. 7; Ingle et al. 1980, p. 140.

Distribution. This lagenid is found only as a few scattered individuals at various levels in the cores.

Lagena hispidula Cushman

Plate 8, figure 8

Lagena hispidula Cushman, 1923. U.S. Nat. Mus. Bull., 104, pt. 4, p. 29. Barker, 1960, p. 114, pl. 56, figs. 10,11; Anderson, 1975, pl. 5, fig. 9; Ingle et al. 1980, p. 140.

Remarks. This species has a distinct "fuzzy" appearance caused by the numerous small spines or projections which give it its name.

Distribution. One of the more common Lagenids in surface samples, this form occurs in 9 from between 2000 m to 3985 m, exceeding 1.0% of the total only at 3050 m. Single specimens also occur in several core samples.

Lagena meridionalis Weisner

Lagena gracilis var. meridionalis Weisner, 1931, Foram. Deutsche Sudpolar Exped. 1901-1903, p. 117.

Lagena meridionalis Weisner. Loeblich and Tappan, 1953, Smith. Misc. Coll. vol. 121, no. 7, p. 59; Barker, 1960, p. 119, pl. 58, fig. 19; Vilks, 1969, p. 47, pl. 2, fig. 19; Anderson, 1975, pl. 5, fig. 11; Cole and Ferguson, 1975, pl. 5, fig. 15.

Distribution. Occurs very rarely in the present study area, seen only in one surface sample from 3050 m, and as another single specimen in a core at 61-63 cm.

Lagena striata (d'Orbigny)

Plate 8, figure 9

Oolina striata d'Orbigny, 1839, tome 5, pt. 5, p. 21, pl. 5, fig. 12.

Lagena striata (d'Orbigny) Barker, 1960, p. 118, pl. 57, figs. 19, 22, 24, 28; Ingle et al., 1980, p. 140, pl. 4, fig. 13.

Distribution. L. striata appears in one surface sample from 2750 m. Present as single specimens in three subsurface samples.

Lagena spp.

Remarks. This designation is applied to several small lagenid forms, usually poorly preserved or damaged, whose exact affinities are unknown.

Distribution. These forms occur as single individuals in one or two surface samples and a few core samples.

Genus Lenticulina Lamarcke, 1804

Lenticulina angulata (Reuss)

Plate 8, figure 10

Robulina angulata Reuss, 1851. Zeitschr. Deutsch. Geol. Ges., vol. 3, p. 54, pl. 8, fig. 6

Lenticulina angulata (Reuss) Feyling-Hanssen, 1964. Norges. Geol. Unders. NR 225, p. 277, pl. 9, figs. 9,10.

Cole, 1981, p. 67, pl. 13, fig. 12.

Remarks. The only species of Lenticulina found in the survey, this form is readily identifiable by its planispiral, lens-shaped test, with a somewhat angular polygonal outline.

Distribution. Occurs only in very small numbers in four samples from between 2205-2995 m.

Genus Marginulina d'Orbigny, 1826

Marginulina obesa Cushman

Marginulina obesa Cushman, 1923. U.S. Nat. Mus. Bull. 104, pt. 4, p. 128, pl. 37, fig. 1; Barker, 1960, p. 136, pl. 65, figs. 5,6; LeRoy and Levinson, 1974, p. 8, pl. 4, figs. 3,4; LeRoy and Hodgkinson, 1975, pl. 8, fig. 7; Cole, 1981, p. 68, pl. 13, fig. 14; Blanc-Vernet, 1983, p. 505

Distribution. This form occurs in only one surface sample, at the top of the gravity core. It occurs in small numbers at various levels in both cores.

Genus Pseudonodosaria Boomgart, 1949

Pseudonodosaria cf. torrida (Cushman)

Plate 8, figure 11

Nodosaria (Glandulina) laevigata var. torrida Cushman, 1923. U.S. Nat. Mus. Bull. 104, pt. 4, p. 65.

Rectoglandulina torrida (Cushman) Loeblich and Tappan, 1955. Smithson Misc. Coll., 126 (3) p. 6; Barker, 1960, p. 128, pl. 61, figs. 20-22; Anderson, 1975, pl. 5, fig. 16. Cole and Ferguson, 1975, pl. 12, figs. 8,9.

Pseudonodosaria torrida (Cushman) Loeblich and Tappan, 1964, (2), p. C522-C523; LeRoy and Hodgkinson, 1975, pl. 8, fig. 8; Boltovskoy, 1980b, p. 354; Cole, 1981, p. 70, pl. 18, fig. 32; Milam and Anderson, 1981, pl. 6, fig. 5.

Distribution. P. cf. torrida appears only once in surface samples at 3985 m, as a single specimen. Another specimen was taken from a core sample.

Family Polymorphinidae d'Orbigny, 1839

Subfamily Polymorphininae d'Orbigny, 1839

Genus Pyrulina d'Orbigny, in de la Sagra, 1839

Pyrulina angusta (Egger)

Plate 8, figure 12

Guttulina praelonga Egger, 1857, p. 287, pl. 13, figs. 25-27.

Pyrulina angusta (Egger) Barker, 1960, p. 150, pl. 72, figs. 1-3.

Distribution. This species occurs in very small numbers in several samples from between 2205 m and 3500 m, and a single specimen was also seen in a core sample from 123-125 cm.

Pyrulina cylindroides (Roemer)

Plate 5, figure 4

Polymorphina cylindroides Roemer, 1838, p. 385, pl. 3, fig. 26.

Pyrulina cylindroides (Roemer) Barker, 1960, p. 150, pl. 72, figs. 5-6.

Distribution: *P. cylindroides* occurs in four surface samples from depths ranging from 2750 m - 3880 m, always in very small numbers. None were found in subsurface material.

Pyrulina fusiformis (Roemer)

Polymorphina fusiformis Roemer, 1838, p. 386, pl. 3, fig. 37.

Pyrulina fusiformis (Roemer) Barker, 1960, p. 148, pl. 71, figs. 17-19, pl. 72, fig. 4; Cole and Ferguson, 1975, pl. 12, fig. 4; Boltovskoy, 1980a, pl. 5, figs. 5a,b.

Distribution. Limited to one specimen found in a core sample from 7.5-9.5 cm.

Pyrulina sp.

Distribution. One specimen found at 1095-1057 cm in the piston core.

Family Glandulinidae Reuss, 1860

Subfamily Glandulininae Reuss, 1860

Genus *Laryngosigma* Loeblich and Tappan, 1953

Laryngosigma hyalascidia Loeblich and Tappan

Laryngosigma hyalascidia Loeblich and Tappan 1953. Smithson. Misc. Coll., vol. 121, (7), p. 83-84, pl. 15, figs.

6-8; Cole, 1981, p. 73-74, pl. 19, fig. 3.

Remarks. The specimens of *L. hyalascidia* encountered in this survey were not transparent as Cole (1981) mentions, but this may be due to a difference in preservation. Also, it is possible these specimens may represent small *Pseudopolymorphina novangliae* (Cushman).

Distribution. Rare, two specimens were seen in surface samples, one at 2487 m and the other at 2750 m. One or two specimens were also seen in the upper 1.5 m of the cores.

Subfamily *Oolininae* Loeblich and Tappan, 1961

Genus *Oolina* d'Orbigny, 1839

Oolina apiculata Reuss

Plate 5, figure 5

Oolina apiculata Reuss, 1851, Naturw. Aph. Wien, Bd. 4, Abth. 1, p. 22, pl. 2, fig. 1; Barker, 1960, p. 116, pl. 56, figs. 15-16; Vilks, 1969, p. 48, pl. 2, figs. 26a-b; Anderson, 1975, pl. 7, fig. 10; Ingle et al. 1980, p. 142.

Distribution. *O. apiculata* appears in 3 surface samples, the highest at 3050 m, the lowest at 3985 m, always in very small numbers. It is absent from the cores.

Oolina caudigera (Weisner)

Lagena (*Entosolenia*) *globosa* var. *caudigera* Weisner, 1931. Deuts. Sudpolar Exped. 1901-1903, vol. 20, p. 119, pl. 18, fig. 214.

Oolina caudigera (Weisner) Loeblich and Tappan, 1953, p. 67, pl. 13, figs. 1-3; Cole, 1981, p. 75, pl. 19, fig. 7.

Distribution. Very rare, appearing as single specimens in 2 surface samples (2750 m and 3050 m), and in several core samples.

Oolina globosa (Montagu)

Plate 5, figure 6

Fissurina globosa Bornemann, 1855, Deutsche Geol. Ges. Zeits. Bd. 7, Heft. 2, p. 317, pl. 12, fig. 4a,b.

Oolina globosa (Montagu) Parr, 1950. Brit. Austral. New Zealand Antarctic Res. Exped., 1929-1931. Reports, Ser. B, vol. 5, p. 6, p. 302; Barker, 1960, p. 114, pl. 56, figs. 1-3; Vilks, 1969, p. 48, pl. 2, fig. 27a-b; Anderson, 1975, pl. 7, fig 14; Ingle et al. 1980, p. 142.

Distribution. O. globosa appears in small numbers in several samples from 2205 m to 3543 m. It is absent from core material.

Oolina hexagona (Williamson)

Plate 8, figure 13

Entosolenia squamosa (Montagu) var. hexagona. Williamson, 1848, Ann. & Mag. Nat. Hist. ser. 2, vol. 1, p.20, pl. 2, fig. 23.

Oolina hexagona (Williamson) Parr, 1950. Brit. Austral., New Zealand Antarctic Res. Exped. 1929-31, Ser. B, vol. 5, no. 6, p. 304; Barker, 1960, p. 120, pl. 58, figs. 32-33; Vilks, 1969, p. 48, pl. 2, fig. 28; Anderson, 1975, pl. 7, fig. 15; Lagoe, 1977, p. 122, pl. 2, fig. 13; Ingle et al. 1980, p. 142; Milam and Anderson, 1981, pl. 6, fig. 3.

Distribution. This distinctive Oolinid occurs in 3 surface samples from between 2750 m and 2050 m depth, always as lone individuals. There are no occurrences in the cores.

Oolina longispina (Brady)

Lagena longispina Brady, 1884, Rept. Voy. Chall. vol. 9, p. 454, pl. LIX, figs. 13, 14; pl. LVI, figs. 33, 36.

Oolina longispina (Brady) Barker, 1960, p. 116, pl. 56, fig. 36. LeRoy and Hodgkinson, 1975, pl. 8, fig. 11

Distribution. Two specimens were seen in surface samples from 2500 m and 2750 m, and none were encountered in subsurface material.

Oolina spp.

Remarks. This designation includes a number of poorly preserved, anomalous, or indeterminate single-chambered forms which superficially resemble oolinids. It is possible that some may actually belong in *Fissurina* or *Lagena*.

Distribution. These forms occur in small numbers in most surface samples from depths between 2205 m and 3985 m.

Genus Fissurina Reuss, 1850

Fissurina alveolata (Brady)

Plate 5, figure 7; Plate 8, figure 14

Lagena alveolata Brady var. substriata Brady, 1884, Rept. Voy. Chall., vol. 9, pl. LX, fig. 34.

Fissurina alveolata (Brady) Barker, 1960, p. 126, pl. 60, figs. 30-32.

Distribution. This species is present in only two surface samples from 2995 m and 4925 m, as single specimens. Similar occurrences were seen in two core samples.

Fissurina annectens (Burrows and Holland)

Plate 8, figure 15

Lagena quadracostulata Burrows and Holland, 1895, Mono. Crag. Foram., pt. II, p. 203.

Fissurina annectens (Burrows and Holland) Barker, 1960, p. 122, pl. 59, fig. 7, 15; Anderson, 1975, pl. 6, fig. 2; Ingle et al., 1980, p. 134.

Distribution. F. annectens appears in some surface samples from depths between 2120 m and 3985 m, and single specimens are seen in three core samples.

Fissurina crebra (Mathes)

Lagena marginata Mathes, 1939, Paleontogr. vol. 90, Abt. A, p. 72.
Fissurina crebra (Mathes) Barker, 1960, p. 122, pl. 59, fig. 6; Anderson, 1975, pl. 6, fig. 5; Milam and Anderson, 1981, pl. 6, fig. 4.

Distribution. This species occurs in small numbers in some samples taken from between 2200 m and 3985 m, and one specimen was seen in a core sample.

Fissurina kerguelenensis Parr

Fissurina kerguelenensis Parr, 1950. Brit. Aust. New Zealand Antarctic Res. Exped., 1929-1931, Ser. B, vol. 5, no. 6, p. 305; Barker, 1960, p. 122, pl. 59, figs. 8-11; Anderson, 1975, pl. 6, fig. 8.

Distribution. This form appears in some samples from between 2000 m and 4046 m, never exceeding 1.0% of the total. A few specimens were seen in the top 4 meters of the cores.

Fissurina orbignyana Seguenza

Fissurina orbignyana Seguenza, 1862, p. 66, pl. 2, figs. 25-26. Barker, 1960, p. 124, pl. 59, figs. 18, 20, 26; Ingle et al. 1980, p. 136.

Distribution. This species occurs in small numbers in most surface samples from between 2200 m and 3985 m, but seems present most consistently at around 2500 m to 2995 m. Two specimens were seen in core

core samples from the upper two metres.

Fissurina seguenziana (Fornasini)

Plate 8, figure 16

Fissurina seguenziana Fornasini, 1886. Boll. Soc. Geol. Ital. vol. V, (1887), p. 350; Barker, 1960, p. 122, pl. 59, fig. 1.

Distribution. Very rare, a single specimen found in a surface sample from 3985 m, and one in the piston core at 802-804 cm.

Fissurina sulcata Seguenza

Plate 5, figure 8; Plate 8, figure 17

Fissurina sulcata Seguenza, 1862, p. 67, pl. 2, fig. 29.

Fissurina sulcata (Walker and Jacob) Barker, 1960, p. 127, pl. 60, figs. 35-37.

Distribution: This species is present in three surface samples from between 3880 m and 4046 m, always in very low concentrations. Four specimens were also seen in the uppermost metre of the cores.

Fissurina spp.

Remarks. This informal designation is given to a variety of indeterminate forms encountered in the study area which are too poorly preserved or too anomalous to be definitely assigned to one or another of the *Fissurina* species described above.

Distribution. Single specimens are seen in some surface samples and several core samples.

Genus *Parafissurina* Parr, 1947

Parafissurina tectulostoma Loeblich and Tappan

Plate 5, figure 9; Plate 8, figure 18

Parafissurina tectulostoma Loeblich and Tappan, 1953. Smithson, Mis. Coll. vol. 121, (7) p. 81, pl. 14, fig. 17; Vilks, 1969, p. 49, pl. 3, fig. 1a-b; Cole, 1981, p. 85, pl. 19, fig. 36.

Distribution. Small numbers of this species are seen is some samples from 2000 m to 3050 m, and a few specimens were seen in the upper 1.5 m of the cores.

Superfamily *Buliminacea* Jones, 1895

Family Turrilindae Cushman, 1927

Subfamily Turrilininae Cushman, 1927

Genus *Buliminella* Cushman, 1911

Buliminella elegantissima (d'Orbigny)

Bulimina elegantissima d'Orbigny 1839. Voy. dans l'Amèr. Mérid. Foram. vol. 5 (5), p. 51, pl. 7, figs. 13-14.

Buliminella elegantissima (d'Orbigny) Cushman and Parker, 1931. Proc. U.S. Nat. Mus. vol. 80, p. 13, pl. 3, figs. 12-13; Barker, 1960, p. 104, pl. 50, figs. 20-22; Anderson, 1975, pl. 7, fig. 18; Cole and Ferguson, 1975, pl. 6, figs. 8-9; Ingle et al. 1980, p. 131; Cole, 1981, p. 85-86, pl.

10, fig. 6; Blanc-Vernet, 1983, p. 504.

Distribution. Very rare, scattered individuals occur in several surface samples from a variety of depths, and a few more specimens were seen in core material.

Genus *Tosaia* Takayanagi, 1953

Tosaia hanzawai Takayanagi

Plate 5, figure 10; Plate 8, figure 19

Tosaia hanzawai Takayanagi 1953. Tohoku Univ. Inst. Geol. Paleon. Short Papers, no. 5, p. 30, pl. 40, fig. 7; Cole, 1981, p. 86-87, pl. 11, fig. 11.

Remarks. Except for its calcareous test, this species bears a very close resemblance to *Eggerella bradyi*, as previously noted. Well-preserved specimen exhibit a hyalinity which precludes mistaking them for the agglutinated form, but older, etched ones can be quite ambiguous.

Distribution. A fairly common form in the study material, *T. hanzawai* occurs in most surface samples down to 4046 m, sometimes exceeding 1.0 of the assemblage. It is also present in small numbers in the upper three metres of the cores.

Family Bolivinitidae Cushman, 1927

Genus *Bolivina* d'Orbigny, 1839

Bolivina aff. *earlandi* Parr

Plate 5, figures 11, 12

Bolivina earlandi Parr 1950. Brit. Austral. New Zealand Antarctic Res. Exped. Ser. B, vol. 9, no. 6, p. 339; Barker, 1960, p. 106, pl. 52, figs. 18-19.

Remarks. This relatively small species bears a resemblance to *B. earlandi* as pictured by Barker (1960), though its exact identification is uncertain. It is possible that this form may in fact merely represent well-preserved specimens of *Bolivina pseudopunctata*, which it certainly closely resembles. Its test is so thin and fragile that chambers tend to break off even when handled with the utmost care.

Distribution. Present in only one surface sample from 2996 m, it is quite common in core material, often composing 10% or more of foraminiferal assemblages. It is present in over 60% of all subsurface samples.

Bolivina cf. *inflata* Heron-Allen and Earland

Plate 5, figure 15

Bolivina inflata Heron-Allen and Earland 1913. Roy. Irish Acad. Proc. vol. 31 (3), p. 68, pl. 4, figs. 16-19; Cole, 1981, p. 87, pl. 11, fig. 14.

Distribution. This form is found only in small numbers in a few core samples.

Bolivina pseudoplicata Heron-Allen and Earland

Plate 9, figure 1

Bolivina pseudoplicata Heron-Allen and Earland 1930. Roy. Mic. Soc.

London Jour., ser. 3, p. 81, pl. 3, figs. 36-40; Feyling-Hanssen et al. 1971, Bull. Geol. Soc. Denmark, vol. 21, (3), p. 243, pl. 7, fig. 16, pl. 18, fig. 11; Cole and Ferguson, 1975, pl. 6, fig. 5.

Remarks. This rugose form is very small, and can easily be missed in a rich sample.

Distribution. Very rare, occurring in 4 surface samples from various depths, and occasional specimens were seen in a few core samples.

Bolivina pseudopunctata Högland

Plate 5, figure 16; Plate 9, figure 2

Bolivina pseudopunctata Höglund 1947. Zool. Bidr. Uppsala, Bd. 26, p. 273, pl. 24, fig. 5; pl. 32, figs. 23-24, text-figs. 280-281, 287; Cole and Ferguson, 1975, pl. 6, fig. 6; Cole, 1981, p. 87-88, pl. 11, fig. 12.

Distribution. *B. pseudopunctata* is quite rare in surface material, occuring in small numbers in a few samples from 3543 m to 4046 m. It is a common constituent, however, of core material, sometimes comprising over 10% of assemblages and reaching 27% at 651-653 cm.

Bolivina pygmaea Brady

Plate 5, figure 17

Bolivina pygmaea Brady 1881. Deutsch r.d.k. Akad. Wiss. Wien, vol. 43, p. 27; Barker, 1960, pl. 53, figs. 5-6; Ingle et al. 1980, p. 131; Cole, 1981, p. 88, pl. 19, fig. 37.

Distribution. Two specimens of this species were seen in a surface sample from 4046 m. It was not encountered in any subsurface material.

Bolivina striatula Cushman

Bolivina striatula Cushman 1922c. Carnegie Inst. Washington Publ. 311, p. 27, pl. 3, fig. 10; Höglund, 1947, Zool. Bidr. Uppsala, Bd. 26, pl. 24, fig. 4; Cole, 1981, p. 88, pl. 19, fig. 38.

Distribution. This species is very rare in the study area, occurring in very small numbers in 2 surface samples at 2120 m and 2750 m. It also appears in 2 core samples both near 750 cm.

Bolivina subaenariensis Cushman

Bolivina subaenariensis Cushman 1937. Cushman Lab. Foram. Res. Spec. Publ. 9, p. 156; Barker, 1960, p. 110, pl. 53, figs. 10,11; Rodriguez and Hooper, 1982b, p. 343; Williamson, 1983, p. 218, pl. 3, fig. 11.

Brizalina subaenariensis (Cushman) Barbieri and Medioli, 1969, p. 856, pl. 62, fig. 2a,b.

Distribution. This bolivinid is present only in small numbers in the lower parts of the piston core.

Bolivina subspinescens Cushman

Plate 9, figure 3

Bolivina subspinescens Cushman 1922a. U.S. Nat. Mus. Bull. 104, (3), p. 48, pl. 7, fig. 5; Barker, 1960, p. 108, pl. 52, figs. 24-25; Ingle et al., 1980, p. 131; Cole, 1981, p. 88; Williamson, 1983, p. 218, pl. 3, fig. 10.

Distribution. B. subspinescens occurs in only two surface samples, at 2000 m and 2200 m, never exceeding 1.0% of the total. A few specimens were also found in several core samples from below 250 cm.

Family Islandiellidae Loeblich and Tappan, 1964

Genus Islandiella Norvang, 1959

Islandiella norcrossi (Cushman)

Plate 6, figure 1; Plate 9, figure 4

Cassidulina norcrossi Cushman 1933b. Smiths, Misc. Coll. 89(9), p. 7, pl. 3, fig. 7; Lagoe, 1977, p. 127, pl. 5, fig. 17.

Islandiella norcrossi (Cushman) Norvang 1959. Vid. Medd. Dansk. Nat. Foren. 14, p. 32, pl. 7, figs. 8-13; pl. 8, fig. 14. Vilks, 1969, p. 49, pl. 3, figs. 4a-b; Feyling-Hanssen et al. 1971, Bull. Geol. Soc; Denmark, vol. 21, pts. 2-3, p. 248, pl. 8, figs. 1-2. Cole and Ferguson, 1975, pl. 9, fig. 3; Belanger and Streeter, 1980, p. 416; Cole, 1981, p. 89, pl. 19, figs. 40-41; Feyling-Hanssen, 1981, pl. 1, figs. 25-26; Rodriguez and Hooper, 1982b, p. 348.

Distribution. This well-documented form is not seen in surface samples in the study area, but is fairly widespread in core material, though rarely exceeding 5.0% of the total assemblage.

Family Eouvigerinidae Cushman, 1927

Genus *Stilostomella* Guppy, 1894

Stilostomella sp. cf. *antillea*

Plate 9, figure 5

Stilostomella antillea (Cushman) Barker, 1960, p. 158, pl. 76, figs. 9-10. LeRoy and Levinson, 1974, p. 9, pl. 5, fig. 5.

Remarks. This species appears to closely resemble *S. antillea* but not enough specimens were obtained to enable more specific identification.

Distribution. Only one specimen was collected from 400-402 cm in the piston core.

Family Buliminidae Jones, 1875

Subfamily Bulimininae Jones, 1875

Genus *Bulimina* d'Orbigny, 1826

Bulimina alazanensis Cushman

Plate 6, figure 2; Plate 9, figure 6

Bulimina alazanensis Cushman 1927b. Jour. Paleo., vol. 1, (2), p. 161, pl. 25, fig. 4; Barker, 1960, p. 104, pl. 51, figs.

18,19; LeRoy and Hodgkinson, 1975, pl. 9, fig. 3; Cole, 1981, p. 89, pl. 19, fig. 42.

Distribution. Only two specimens of this type were seen, one in a surface sample from 2750 m, and the other from 20-22 cm in the piston core.

Bulimina gibba Fornasini

Bulimina gibba Fornasini 1902. Mem. Reale Acc. Sci. Inst. Bologna, Sers. V, vol. 9, p. 377; Barker, 1960, p. 102, pl. 50, figs. 1-4; Anderson, 1975, pl. 7, fig. 23; Belanger and Streeter, 1980, p. 416-417; Feyling-Hanssen, 1981, pl. 1, figs. 13-16.

Distribution. *B. gibba* appears in very small numbers in two widely scattered surface samples, at 2120 m and 3500 m. It is very rare in subsurface material.

Bulimina notovata Chapman

Bulimina notovata Chapman 1941. Trans. Roy. Soc. South Australia, vol. 65, p. 166; Barker, 1960, p. 102, pl. 50, fig. 13.

Distribution. Only two specimens of this type were encountered in the study area, one in a surface sample at 2200 m, the other in a core sample.

Bulimina striata d'Orbigny

Plate 7, figure 7

Bulimina striata d'Orbigny, 1826, Ann. Sci. Nat. vol. 7, p. 269, Barker, 1960, p. 104, pl. 51, figs. 10-11; Williamson, 1983, p. 220-221, pl. 3, fig. 14.

Distribution. One of the more common species in the upper range of samples, this form is seen in all samples taken from between 2000 m and 2750 m, and never in deeper ones. At 2000 m it comprises 5.0% of the total foraminiferal assemblage, lessening to trace levels at 2750 m. It is very rare in subsurface samples.

Genus *Globobulimina* Cushman, 1927

Globobulimina auriculata (Bailey)

Plate 6, figures 3,4

Bulimina auriculata Bailey, 1851, Smithson. Contr., vol. 2, p. 12, pl. 1, figs. 25-27; Ingle et al., 1981, p. 131.

Globobulimina auriculata (Bailey) Barbieri and Medioli, 1969, p. 857, pl. 64, figs. 1a-b; 2a-d; Rodriguez and Hooper, 1982b, p. 344; Williamson, 1983, p. 221, pl. 3, fig. 17.

Globobulimina sp. Miller and Lohmann, 1982, pl. 1, fig. 5 *non* fig. 8.

Remarks. This well-described species is unique enough in its appearance to make it difficult to confuse with any others. However, there have been several morphotypes of the species described, and for the purposes of this study, all have been included in this designation.

Distribution. The primary range of G. auriculata in surface samples is from 2000 m to 2995 m, where it sometimes comprises over 5% of the total benthic assemblage. Occasional appearances occur in lower depth ranges. The form appears in a few core samples, more commonly in the uppermost 1.5 m.

Family *Uvigerinidae* Haeckel, 1894

Genus *Uvigerina* d'Orbigny, 1826

Uvigerina asperula Czjzek

Plate 4, figure 2; Plate 9, figure 8

Uvigerina asperula Czjzek 1848. Nat. Abh. Wien., Osterr. Bd. 2, Abth. 1, p. 146, pl. 13, figs. 14-15; Barker, 1960, p. 156, pl. 75, figs. 6-9; Anderson, 1975, pl. 7, fig. 24; pl. 8, fig. 2; Cole, 1981, p. 91, pl. 11, fig. 7; Blanc-Vernet, 1983, p. 506.

Uvigerina peregrina asperula (Cushman) Ingle et al. 1981, p. 146.

Remarks. *U. asperula* appears in the study area in two separate morphotypes, a small form (150-300 μ in length with a somewhat hyaline appearance) and a larger type (400-800 μ in length with a relatively thicker and more rugged test. The two forms, possibly ecophenotypes, have somewhat different ranges of occurence in the study area.

Distribution. The smaller form of *U. asperula* appears in a few surface samples at 2500 m and 3985 m and in somewhat larger numbers (nearly 4.0%) at 4046 m. In core material, the smaller type is fairly common, often exceeding 5% of the assemblage, occasionally reaching 20%. The larger form is not seen in surface samples, appearing in only small numbers in several core samples, almost invariably in company with *U. peregrina*.

Uvigerina peregrina Cushman

Plate 6, figures 5, 6

Uvigerina peregrina Cushman 1923. U.S. Nat. Mus. Bull. 104, (4), p. 166, pl. 42, figs. 7-10; LeRoy and Levinson, 1974, p. 10, pl. 5, fig. 18; Lohmann, 1978, p. 26, pl. 4, figs. 14-15; Boltovskoy, 1980b, p. 355, pl. 2, figs. 31-32; Ingle et al. 1980, p. 146, pl. 3, fig. 6; pl. 5, figs. 14-15; Cole, 1981, p. 92, pl. 10, fig. 9; Feyling-Hanssen, 1981, pl. 1, figs. 7-8; Miller and Lohmann, 1982, pl. 1, figs. 11-12; Blanc-Vernet, 1983, p. 506, pl. 2, figs. 1-3; Williamson, 1983, p. 222, pl. 4, fig. 3.

Euuvigerina peregrina (Cushman) Barker, 1960, p. 154, pl. 74, figs. 11-12.

Remarks. As can be seen from the extensive synonymy list, this species is well known and has been well described and depicted many times. As discussed in earlier chapters, its role in providing keys to the Quaternary history of deep circulation in the North Atlantic ocean has been thoroughly documented.

Distribution. *U. peregrina* occurs in only three samples of surface sediments in the study area, ranging from 2487 m to 4046 m depth. Its greatest concentration is at the upper level, where it exceeds 5% of the total benthic assemblage. In subsurface material this is one of the more common species, in several cases accountng for more than 30% of the total benthic foraminifera, even in samples where the fauna is very sparse.

Uvigerina spinicostata Cushman & Jarvis

Plate 4, figure 3; Plate 9, figure 9

Uvigerina spinicostata Cushman and Jarvis 1929. Cushman Lab. Foram. Res. vol. 5 (1), no. 72, p. 12, pl. 3, figs. 9-10. LeRoy and Levinson, 1974, p. 10, pl. 5, fig. 14. LeRoy and Hodgkinson, 1975, pl. 9, fig. 6; Cole, 1981, p. 92, pl. 19, fig. 45.

Remarks. This species somewhat resembles *U. peregrina* except that in the uppermost whorl(s) of chambers, the longitudinal costae are broken up into irregular rows of spines. There may well be a gradation between *U. spinicostata* and *U. peregrina* to which it is certainly closely related.

Distribution. *U. spinicostata* is one of the most common forms in surface samples from the 2000 m to 2487 m depth range, often accounting for over 20% of the total benthic assemblage, especially at 2200 m and above. From 2500 m to 2750 m it is limited to less than 5% of the totals, and below that its appearance is sporadic and in small numbers. In core material this species is quite rare, occurring in small numbers in the upper 1.5 m, but only very occasionally below that.

Genus *Trifarina* Cushman, 1923

Trifarina angulosa (Williamson)

Plate 4, figure 1; Plate 9, figure 10

Uvigerina angulosa Williamson 1858. Rec. Foram. Great Britain, p. 67, pl. 5, fig. 140.

Angulogerina angulosa (Williamson) Höglund 1947. Zool. Bidr. Uppsala, Bd. 26, p. 283, pl. 23, fig. 8; text-figs. 305-308. Barker, 1960, p. 154, pl. 74, fig. 15-16; Feyling-Hanssen, 1981, pl. 1, fig. 10.

Trifarina angulosa (Williamson) Michelson 1967. Meddr. Dansk. Geol. Foren. 17, p. 227, pl. 2, fig. 13; Barbieri and Medioli, 1969, p. 857-858, pl. 65, figs. 1-5; Anderson, 1975, pl. 8, fig. 4; Belanger and Streeter, 1980, p. 417; Ingle et al., 1980, p. 144, pl. 3, figs. 1,4; Cole, 1981, p. 92, pl. 19, fig. 46; Blanc-Vernet, 1983, p. 506; Williamson, 1983, p. 222, pl. 4, fig. 1.

Remarks. This well-known species has been amply described in the existing literature. It is possible in the present study that a few specimens of the closely-related Trifarina fluens (Todd) are included in this designation.

Distribution. T. angulosa occurs in most samples from depths less than 3050 m, but only in small numbers, usually less than 1.0% of the total. In core material it is represented only by a few scattered specimens.

Superfamily Discorbacea Ehrenberg, 1938

Family Discorbidae Ehrenberg, 1838

Subfamily Discorbinae Ehrenberg, 1838

Genus Buccella Anderson, 1952

Buccella frigida (Cushman)

Pulvinulina frigida Cushman 1922b. Contr. Can. Biol. no. 9, p. 12.

Eponides frigida (Cushman) Cushman 1931. U.S. Nat. Mus. Bull. 104 (8), p. 45.

Buccella frigida (Cushman) Anderson 1952. Washington Acad. Sci. Jour. vol. 42 (5) p. 144, text-figs. 4-6; Loeblich and Tappan, 1953, p. 115, pl. 22, figs. 2-3; Barker, 1960, p. 216, pl. 105, figs. 8-9; Vilks, 1969, p. 49, pl. 3, figs. 7a-b; Cole and Ferguson, 1975, pl. 8, figs. 8-9; Lagoe, 1977, p. 126, pl. 4, figs. 3-4; Cole, 1981, p. 94, pl. 10, fig. 10.

Distribution. In the present study, B. frigida was limited to occasional appearances in core material below 800 cm, being totally absent in surface samples.

Genus Discopulvinulina bertheloti Hofker, 1951

Discopulvinulina bertheloti (d'Orbigny)

Rosalina bertheloti d'Orbigny 1839. In de la Sagra, "Hist. Phys. pol. nat. Cuba", vol. 8, p. 135, pl. 1, figs. 28-30.

Discorbis bertheloti (d'Orbigny) Cushman 1931. U.S. Nat. Mus. Bull. vol. 8, p. 16, pl. 3, fig. 2.

Discopulvinulina bertheloti (d'Orbigny) Barker, 1960. P. 184, pl. 89, figs. 11-12.

Cibicides bertheloti (d'Orbigny) Feyling-Hanssen 1964. Norges Geol. Unders. NR 225, p. 338, pl. 18, figs. 21-24; Cole, 1981, p. 103-104, pl. 12, fig. 7.

Distribution. This species was only encountered as single specimens in 4 core samples from various levels.

Genus Epistominella Husezima and Maruhasi 1944

Epistominella exigua (Brady)

Plate 4, figure 10; Plate 6, figures 8, 9; Plate 9, figures 11, 12

Pulvinulina exigua Brady 1884. Rep. Voy. Challenger, Zool. 9, p. 696, pl. 103, figs. 13-14.

Eponides exigua (Brady) Cushman 1931. U.S. Nat. Mus. Bull. 104(8), p. 44, pl. 10, figs. 1-2.

Epistominella exigua (Brady) Parker 1954. Bull. Mus. Comp. Zool. vol. 111 (10), p. 533, pl. 10, figs. 22-23; Barker, 1960, p. 212, pl. 103, figs. 13-14; Anderson, 1975, pl. 8, figs. 9a-b; Corliss, 1979, p. 7, pl. 2, figs. 7-9; Belanger and Streeter, 1980, p. 417; Boltovskoy, 1980a, pl. 3, figs. 13a-b; Ingle et al. 1980, p. 134, pl. 2, fig. 4; Cole, 1981, p. 95, pl. 11, fig. 2; Blanc-Vernet, 1983, p. 504-505.

Remarks. This is a relatively small, hyaline species which often exhibits a star-shaped pattern in its sutures when viewed optically. It is possible in the present study that some specimens of Epistominella vitrea, Parker (figured in Cole, 1981, p. 95, pl. 11, figs. 3-4) a closely related or synonymous form, have been counted under this heading.

Distribution. In surface samples from less than 3000 m water depth, E. exigua appears sporadically in very small numbers, but below that it is present more consistently and in slightly higher concentrations, comprising over 9% of the total benthic assemblage at 3985 m. This form is present in small numbers in several parts of the cores, occasionally reaching 5% or more of the total, especially in levels below 750 cm.

Epistominella takayanagii Iwasa

Epistominella takayanagii, Iwasa, 1955. Jour. Geol. Soc. Japan, vol. 61, p. 16, text-fig. 4.

Pseudoparrella takayanagii (Iwasa) Rodriguez and Hooper, 1982b, p. 348.

Distribution. The occurrence of this species in this survey is limited to core samples, where it occurs quite frequently, often composing 2-5% of the total benthic assemblage.

Epistominella umbonifera (Cushman)

Plate 6, figure 7; Plate 9, figures 13-16

Pulrinulinella umbonifera Cushman, 1933d, Contr. Cushman. Lab. Foram. Res. vol. 9, pt. 4, p. 90, pl. 9, fig. 9a-c.

Epistominella (?) _umbonifera_ (Cushman) Phleger et al. 1953. pl. 9, figs. 33-34.

"_Epistominella_" _umbonifera_ (Cushman) Lohmann, 1978, p. 2-6, pl. 3, figs. 1-6.

Nuttalides umbonifer (Cushman) Anderson, 1975, p. 88, pl. 8, fig. 14.

Epistominella umbonifera (Cushman) Corliss, 1979, p. 7, pl. 2, figs. 10-12. Corliss and Honjo, 1981, p. 359, pl. 3, figs. 1-15.

Remarks. This species, although known by many names, has been well documented and illustrated many times. In this study, the specimens of *E. umbonatus* encountered often exhibited a rough "sugary" appearances, making individual chambers difficult to distinguish. Its characteristic overall shape, however, makes it difficult to confuse with other forms.

Distribution. This form is absent from all surface samples taken from water depths less than 2750 m. Below that level, it becomes more and more common down to 3985 m where it constitutes more than 50% of the total benthic assemblage. Its numbers taper off again below this depth, falling to less than 20% of the total at 4925 m.

This is also a principal component of core assemblages to 150 cm depth, and is often the only component of the very sparse samples down to 260 m. Below this point, its occurrences are sporadic and limited to small numbers.

Genus *Stetsonia* Parker, 1954

Stetsonia minuta Parker

Stetsonia minuta F. Parker 1954. Bull. Mus. Comp. Zool. vol. 111, (10), p. 534, pl. 10, figs. 27-29; Cole, 1981, p. 97, pl. 19, figs. 56-57.

Distribution. This tiny form appears only occasionally in surface samples, at 2500 m, 2995 m and 3985 m, always in numbers less than 1.0% of the total. It is very rare in core material, seen only as single specimens in a few samples.

Subfamily Bagggininae Cushman, 1927

Genus *Valvulineria* Cushman, 1926

Valvulineria sp. cf. *arctica* Green

Plate 4, figures 11, 12; Plate 9, figures 17, 18

Valvulineria arctica Green 1958. U.S.A.F. Cambridge Res. Centre Geophysics Res. Paper 63, vol. 1, paper 6, p. 78, pl. 1, fig. 3. Vilks, 1969, p. 49, pl. 3, fig. 9a-c; Cole, 1981, p. 97-98, pl. 12, fig. 3.

Remarks. The form designated by this name in the present study is similar to *V. arctica* Green, but does not appear to be identical. However, it is obviously a closely related form and some specimens readily conform to that type.

Distribution. Absent in surface material, this species is very common in core samples below 260 cm, often exceeding 10% of the total benthic assemblages.

Superfamily Rotaliacea Ehrenberg 1839

Family Elphidiidae Galloway 1933

Subfamily Elphidiinae Galloway 1933

Genus *Elphidium* de Montfort 1808

Elphidium excavatum forma *clavata* Cushman

Plate 4, figure 5-7; Plate 7, figures 1-3; Plate 9, figures 19-22

Elphidium excavatum (Terquem) forma *clavata* Cushman. Feyling-Hanssen, 1972, 339-340, pl. 1, figs. 1-9; pl. 2, fig. 1-9; Poag et al., 1980, pl. 1, fig. 12; Feyling-Hanssen, 1981, pl. 2, figs. 20-21; Miller et al., 1982,

p. 124-128, pl. 1, fig. 5-8; pl. 2, fig. 3-8; pl. 3, fig. 3-8; pl. 4, fig. 1-6; pl. 5, fig. 4-8; pl.6, fig. 1-5; Williamson, 1983, p. 224, pl. 5, fig. 9

Remarks. This is an enigmatic species group, showing a great deal of ecophenotypic variation (Miller, 1982). The specimens encountered in this survey fall into two main ecophenotypes, one from the surface samples containing Assemblage 1 faunas, the other from core material below the 250 cm level.

The "surface" form is larger, very white and quite opaque. (See Plate 4, figs. 5-7; Plate 9, figs. 19 and 22). According to Miller (pers. comm., 1985), it is a deep-water ecophenotype common on the Scotian slope from 1000 m down.

The form found below 250 cm in the core is comparatively smaller, often translucent, and may exhibit a brownish stain. (See Plate 7, figs. 1-3; Plate 9, figs. 20 and 21). It appears to correspond very closely to the Elphidium excavatum forma clavata of late glacial faunas described by Vilks (1981).

Distribution. The larger "deep-water" form is the dominant member of all surface samples from depths less than 2750 m, and comprises over 50% of the benthic totals at 2000 m, 2205 m, and 2500 m. Below 2750 m its appearance is occasional and rarely does it constitute more than 2.0% of a fauna. It is also fairly common in the upper 100 cm of the cores, but its appearance is much more sporadic below that.

The "late glacial" form is not encountered in surface samples, but is very common in core material below 250 cm, often exceeding 10% of assemblages, and even larger proportions in some samples which contain only a few foraminifera.

Superfamily Globigerinacea Carpenter, Parker and Jones, 1862

Family Heterohelicidae Cushman, 1927

Subfamily Heterohelicinae Cushman, 1927

Genus *Heterohelix* Ehrenberg, 1843

Heterohelix cf. *americana* (Ehrenberg)

Plate 10, figures 1, 2

Textularia americana Ehrenberg 1843. Abh. K. Akad. Wiss. Berlin. Phys.-Math. Cl. Jahrg. 1841, pp. 336, 398, 429.

Heterohelix americana (Ehrenberg) Loeblich, 1951. Cushman Found. Foram. Res. Contr., vol. 2, pt. 3, p. 107; Loeblich and Tappan, 1964, fig. 523, 5a,b.

Remarks. Test very small, biserial, with 7-9 visible globular chambers. Last chamber somewhat inflated, and all densely covered with fine longitudinal costae which are usually only barely visible with a binocular microscope. Aperture is large, sutural and forms a semicircular arch. Microspheric forms are commonly planispiral in early stages.

Loeblich and Tappan (1964) give the stratigraphic range of this form as Maastrichtian, thus its appearance in this study material must be viewed as a result of reworking. It is the only Mesozoic reworked species to appear in these samples. Oddly, its preservation is usually quite good, as shown by the figured specimen.

Distribution. This species is present only below 290-292 cm in the piston core. It occurs in approximately 1/3 of all samples below this level, and sometimes comprises over 5% of the total assemblage, even in a few samples with very poor faunas.

Superfamily Orbitoidacea Schwager, 1876

Family Eponididae Hofker, 1951

Genus Eponides de Montfort, 1808

Eponides bradyi Earland

Eponides bradyi Earland 1934. Discovery Rep. vol. 10, p. 187, pl. 8, figs. 36-38; Cole, 1981, p. 102, pl. 11, fig. 5; Boltovskoy, 1980a, pl. 3, figs. 3a-b.

Distribution. This small form occurs in several surface samples from between 2200 m and 3985 m. In two locales it exceeds 3.0% of the total. It is also fairly common in subsurface material, often making up 2-3% of the total benthic assemblage.

Family Cibicididae Cushman 1927

Subfamily Planulininae Bermudez 1952

Genus Planulina d'Orbigny, 1826

Planulina wuellerstorfi (Schwager)

Plate 7, figure 4; Plate 10, figure 3

Anomalina wuellerstorfi Schwager 1866. Novara Exped., Geol. Theil., vol. 2, p. 258, pl. 7, figs. 105, 107.

Truncatulina wuellerstorfi (Schwager) Brady 1884. Rep. Voyage Challenger, Zool. (9), p. 662, pl. 93, fig. 9.

Planulina wuellerstorfi (Schwager) Cushman 1929a. Cushman Lab. Foram. Res. Contr. vol. 5, p. 104, pl. 15, figs. 1-2.

Barker, 1960, p. 192, pl. 93, fig. 9; Lagoe, 1977, p. 127, pl. 5, figs. 1-2; Lohmann, 1978, p. 26, pl. 2, figs. 1-4; Corliss, 1979, p. 7-8, pl. 2, figs. 13-16; Ingle et al. 1980, p. 142; Corliss and Honjo, 1981, p. 362, pl. 8, figs. 1-16; Williamson, 1983, p. 225, pl. 4, figs. 8-9.

Cibicidoides wuellerstorfi (Schwager) LeRoy and Levinson, 1974, p. 16, pl. 7, figs. 1-3.

Cibicides wuellerstorfi (Schwager) Belanger and Streeter, 1980, p. 417. Boltovskoy, 1980a, pl. 2, figs. 5-7; Blanc-Vernet, 1983, p. 504, pl. 1, figs. 4-5.

Remarks. This well-known form is represented by fairly typical specimens in this study. The brown staining reported by Cole (1981) was seen in only a very few individuals, the remainder being either perfectly white or, more rarely, translucent.

Distribution. This rather common form is found in most surface samples, but was most prevalent in depths between 2500 m and 4030 m. At 3880 m, *P. wuellerstorfi* makes up over 6.0% of the total benthic assemblages. In core material, however, it disappears rapidly with depth, and is absent below 150 cm.

Subfamily Cibicidinae Cushman, 1927

Genus *Cibicides* de Montfort, 1808

Cibicides lobatulus (Walker and Jacob)

Plate 4, figure 9; Plate 7, figure 5; Plate 10, figure 4

Nautilus lobatulus - Walker and Jacob 1798. In Adam's "Essays on the microscope", p. 642, pl. 14, fig. 36.

Cibicides lobatulus (Walker and Jacob) Cushman 1931. U.S. Nat. Mus. Bull. 104, vol. 8, p. 118K, pl. 21, fig. 3; Barker, 1960, p. 190, 192, pl. 92, fig. 10, pl. 93, figs. 1,4,5; Barbieri and Medioli, 1969, p. 860-861; Vilks, 1969, p. 50, pl. 3,figs. 17a-b; Anderson, 1975, pl. 10, fig. 4; Cole and Ferguson, 1975, pl. 8, figs. 5-6; Poag et al. 1980, pl. 1, figs. 10-11; Feyling-Hanssen, 1981, pl. 2, fig. 6; Miller and Lohmann, 1982, pl. 1, fig. 4; Rodriguez and Hooper 1982b, p. 343; Blanc-Vernet, 1983, p. 504; Williamson, 1983, p. 226, pl. 4, figs. 10-11.

Cibicidoides lobatulus (Walker and Jacob) LeRoy and Hodgkinson, 1975, pl. 9, figs. 22-23; Corliss, 1979, p. 10, pl. 3, figs. 7-9.

Cibicides cf. lobatulus (Walker and Jacob) Belanger and Streeter, 1980, p. 417; Milam and Anderson, 1981, pl. 9, fig. 4.

Cibicides sp. Cole, 1981, p. 105, pl. 11, figs. 9-10.

Remarks. One of the most well-known of all benthic foraminifera largely because of its nearly cosmopolitan abundance in shelf and nearshore areas, this form is nevertheless also an important component of the benthic assemblages of the present survey.

C. lobatulus appears in two fairly distinct morphotypes on the lower Scotian slope and rise; the "typical" fairly large form familiar to many workers, and a smaller, more irregular form similar or identical to Cole's (1981) "*Cibicides* sp." listed above. It is the author's opinion that the small form is more common in sediments which have few or no clastic particles large enough for this normally attached form to properly adhere to. Evidence for this contention comes from the observation that the spiral side of the small form is much less likely to be as smooth and regular as in the case of a "typical" larger specimen.

Distribution. The "small" form of *C. lobatulus* is found in small numbers in most surface samples. At 3880 m it comprises over 6.0% of the total, and at 4046 m, 5.0%. It tends to be somewhat less widespread above 2750 m.In the cores the small form occurs in most levels in fairly small numbers.

The larger, "typical" form occurs in small numbers in a few surface samples from between 2995 m and 3985 m, and in only very small numbers in a few of the uppermost core samples.

Cibicides robertsonianus (Brady)

Plate 7, figure 6; Plate 10, figure 5

Planorbulina (Truncatulina) robertsoniana Brady 1881. Quart. Jour. Micr. Sci. No. 8, vol. 21, p. 65.

Cibicides robertsonianius (Brady) Cushman 1931. U.S. Nat. Mus. Bull. 104, vol. 8, p. 121, pl. 23, fig. 6; Barker, 1960, p. 196, pl. 95, fig. 4; Cole, 1981, p. 104-105, pl. 12, fig. 5; Blanc-Vernet, 1983, p. 504.

Cibicidoides robertsonianus (Brady) LeRoy and Levinson, 1974, p. 16, pl. 8, figs. 10-11; LeRoy and Hodgkinson, 1975, pl. 9, figs. 19-20; Ingle et al. 1980, p. 132, pl. 9, fig. 10.

Distribution. Found in most surface samples from the 2750 m to 4046 m depth range, this form is most common (3.5%) at 4030 m. Small numbers of this species also occur in a few near-surface core samples.

Superfamily Cassidulinacea d'Orbigny, 1839

Family Caucasinidae N.K. Bykova, 1959

Subfamily Fursenkoininae Loeblich and Tappan, 1961

Genus *Fursenkoina* Loeblich and Tappan, 1964

Fursenkoina concava (Höglund)

Plate 7, figures 7, 8; Plate 10, figures 6, 7

Virgulina concava Höglund 1947. Zool. Bidr. Uppsala, Bd. 26, p. 257, pl. 23, figs. 3-4; pl. 32, figs. 4-7; text-figs. 273-275.

Stainforthia concava (Höglund) Loeblich and Tappan 1964, p. C561; Cole, 1981, p. 91, pl. 9, fig. 5; Williamson, 1983, p. 221-222, pl. 3, fig. 18.

Remarks. In the study area this important form conforms quite closely to the descriptions and illustrations given for it in the above cited literature.

Distribution. One of the most common species from surface samples, it is not seen deeper than 4046 m. It is most prevalent in the 2000-2500 m range, often exceeding 5% of the benthic total. At one of the 2500 m samples, it accounts for nearly 20% of the total. Also common in core material, this form occasionally comprises 10% or more of assemblages, but is usually seen in somewhat smaller numbers. This species may be similar to _F. fusiformis_ of other authors (i.e. Scott et al., 1984).

Fursenkoina fusiformis (Williamson)

Plate 4, figure 4; Plate 5, figures 13, 14

Bulimina pupoides fusiformis Williamson 1858. Rec. foram. Great Brit., p. 63, pl. 5, figs. 129-130.

Bulimina fusiformis Williamson Höglund 1947. Zool. Bidr. Uppsala, Bd. 26, p. 232, pl. 20, fig. 3, text-figs. 219-233.

Fursenkoina fusiformis (Williamson) Loeblich and Tappan, 1964, p. C732-C733; Anderson, 1975, pl. 10, fig. 11; Poag et al. 1980, pl. 1, figs. 7-8; Cole, 1981, p. 105-106, pl. 14, fig. 1; Milam and Anderson, 1981, pl. 9, fig. 6; Williamson, 1983, p. 226-227, pl. 5, fig. 1.

Virgulina fusiformis (Williamson) Feyling-Hanssen, 1964, Norges. Geol. Unders., Nr. 225, p. 307, pl. 14, figs. 15-18.

Cassidella fusiformis (Williamson) Lagoe, 1977, p. 127, pl. 4, fig. 5.

Distribution. _F. fusiformis_ occurs at scattered localities from 2000-3985 m depth, always as less than 1.0% of the total benthic fauna. This species is present in small numbers at various depths in the cores.

Genus *Virgulina* d'Orbigny, 1826

Virgulina subdepressa Brady

Virgulina subdepressa Brady. Barker, 1960, p. 106, pl. 52, figs. 14-17.

Distribution. Quite rare; occurring as only two specimens in a surface sample from 2500 m, and a few individuals in several core samples from various levels.

Family Cassidulinidae d'Orbigny 1839

Genus *Cassidulina* d'Orbigny 1826

Cassidulina laevigata d'Orbigny

Plate 10, figure 9

Cassidulina laevigata d'Orbigny 1826. Ann. Sci. Nat. ser. 1, vol. 7, p. 282, pl. 15, figs. 4-5; Anderson, 1975, pl. 10, fig. 13; Boltovskoy, 1980b, p. 348; Feyling-Hanssen, 1981, pl. 1, figs 19-21; Rodriguez et al., 1980, p. 50,54.

Cassidulina laevigata carinata Silvestri. Ingle et al. 1981, p. 131, pl. 6, figs. 5-8.

Cassidulina neocarinata Thalmann. Williamson, 1983, p. 230-231, pl. 5, fig. 17.

Distribution. *C. laevigata* appears in four surface samples from various depths, always in small numbers. In subsurface material, this form is fairly common, and may be present in numbers from <1% of the total to over 50% where it does appear.

Cassidulina reniforme Nørvang

Plate 4, figures 13, 14; Plate 10, figure 10

Cassidulina crassa reniforme Nørvang 1945. Zool. of Iceland, Foram., vol. 2(2), p. 41, text-figs. 6e-h.

Cassidulina islandica Nørvang. Loeblich and Tappan 1953. Smithson. Misc. Coll. 12, (7), p. 118, pl. 24, fig. 1, (non Nørvang).

Cassidulina crassa d'Orbigny. Nørvang 1958, Dansk. Mat. F.V. Medd., vol. 120, p. 36, pl. 9, figs. 24-25 only.

Cassidulina crassa minima Boltovskoy 1959. Rep. Argentina S. Mar. Serv. Hidr. nov. H1005, p. 100, pl. 13, fig. 12.

Cassidulina bradshawi Uchio 1960. Cushman Found. Foram. Res. Sp. Publ. 5, p. 68, pl. 9, figs. 11-12.

Cassilaminella subacuta Gudina 1966. Acad. U.S.S.R., Inst. Geol. and Geophys. p. 67, pl. 7, figs. 4-5; pl. 13, fig. 3.

Cassidulina subacuta (Gudina) Feyling-Hanssen 1976. Mar. Sed. Sp. Publ. 1 (B), p. 354, pl. 2, figs. 14-19.

Cassidulina reniforme Nørvang. Rodriguez, Hooper and Jones 1980. Jour. Foram. Res. vol. 10(1), p. 58, pl. 2, figs. 2,4,6; pl. 3, figs. 3,8,9,11,12; pl. 5, figs. 10-12. Sejrup and Guilbault, 1980, p. 79-81; figs. 2f-k. Cole, 1981, p. 106-107, pl. 11, fig. 13; Feyling-Hanssen, 1981, pl. 1, fig. 23.

Remarks. Many descriptions and illustrations of this form exist in the contemporary literature, as is obvious from the above lengthy synonymy.

Distribution. This species is very rare in surface material, appearing in only 3 samples, always in very small numbers. However, it is the single most common element in core material. In the upper 260 cm of the cores its numbers are fairly small, and is often absent. Below this level it becomes much more prevalent, often exceeding 50% of benthic foraminiferal assemblages. In those samples with very low foraminiferal content *C. reniforme* is often one of the few species present.

Family Nonionidae Schultze, 1854

Subfamily Chilostomellinae Brady, 1881

Genus *Chilostomella* Reuss *in* Czjzek, 1849

Chilostomella oolina Schwager

Plate 7, figure 9

Chilostomella oolina Schwager 1878. Boll. Uff. Geol. (R. Com. Geol. (Ital.) vol. 9, p. 257, pl. 1, fig. 16; Barker, 1960, p. 112, pl. 55, figs. 12, 14, 17-18; Ingle et al. 1980, p. 132, pl. 6, figs. 9-10; Cole, 1981, p. 108, pl. 19, fig. 65; Blanc-Vernet, 1983, p. 504.

Remarks. This distinctively ovoid form is difficult to confuse with any other species found in the study area.

Distribution. *C. oolina* is found in most surface samples from between 2120 m and 4046 m. Its numbers exceed 1.0% of the total only at 2750 m and 2996 m. It is preset in small numbers in only a few subsurface samples from various levels.

Subfamily Nonioninae Schultze, 1854

Genus *Nonion* de Montfort, 1808

Nonion barleeanum (Williamson)

Plate 10, figure 12

Nonionina barleeanum Williamson, 1858, p. 32, pl. 3, figs. 68, 69.

Nonion barleeanum (Williamson) Cushman and Henbest 1940. U.S. Geol. Surv. Prof. Paper 196-A, p. 9, fig. 13.

Melonis zaandamae (van Voorthuysen) Loeblich and Tappan 1953. Smithson. Misc. Coll. 12 (7), p. 87,pl. 16, figs. 11-12; Cole, 1981, p. 115-116, pl. 13, fig. 8.

Gavelinonion barleeanum (Williamson) Barker, 1960, p. 224, pl. 109, figs. 8-9.

Melonis barleeanum (Williamson) Corliss, 1979, p. 10, 12, pl. 5, figs. 7-8. Belanger and Streeter, 1980, p. 419; Ingle et al., 1980, p. 142, pl. 7, figs. 14-15; Blanc-Vernet, 1983, p. 505, pl. 2, figs. 12-13.

Remarks. Obviously many names exist for this form. I have chosen to retain Williamson's designation because of its seniority.

Distribution. This species occurs in most surface samples from between 2000 m and 4046 m. It appears to be most common from 2487 m to 3247 m, where it often exceeds 1.0% of the total benthic assemblage. At 3050 m it reaches 2.2%. It is also present in small numbers in many samples from the upper 1.5 m of the cores, but is much scarcer below that.

Nonion *depressulus* (Walker and Jacob)

Plate 10, figure 11

Nautilus *depressulus* Walker and Jacob 1798. *In* Adam's Essays on the Microscope, p. 641, pl. 14, fig. 33.

Nonionina *depressulus* (Walker and Jacob) Parker and Jones 1859. Ann. Mag. Nat. Hist., ser. 3, vol. 4, p. 339, 341.

Nonion *depressulus* (Walker and Jacob) MacFadyen 1940. Geol. Mag. vol. 77, p. 379-381; Barker, 1960, p. 224, pl. 109, figs. 6-7; Cole, 1981, pl. 13, figs. 4, 7.

Remarks. This species can be distinguished from most similar ones by its growth of small papillae near the umbilicus. Even so, one form it does closely resemble is *Haynesina* *orbiculare*, and it is possible that some specimens counted as *N.* *depressulus* may in fact be the other species.

Distribution. *N.* *depressulus* occurs in most surface samples from 2120 m down to 4030 m, but is most prevalent from 2400 m to 3050 m, where it often exceeds 1.0% or 2.0% of the totals. It is also present in small numbers in a few samples from the upper 1500 m of the cores.

Nonion *grateloupi* (d'Orbigny)

Plate 10, figure 13

Nonionina *grateloupi* d'Orbigny 1826. Ann. Sci. Nat. Paris, ser. 1, vol. 7, p. 294, no. 19.

Nonion *grateloupi* (d'Orbigny) Schnitker 1971. Tulane Studies in Geol. and Paleont., vol. 8, no. 4, p. 206, pl. 10, fig. 6; Cole, 1981, p. 108-109, pl. 14, fig. 3.

Florilus grateloupi (d'Orbigny) Boltovskoy, 1980b, p. 353.

Nonionella grateloupi (d'Orbigny) Ingle et al. 1980, p. 142.

Distribution. N. grateloupi occurs at scattered surface locations from between 2000 m to 3985 m depth, never exceeding 1.0% of the benthic totals. It is also present in small numbers in some levels of the cores, twice comprising over 5.0% of the total fauna.

Genus Astrononion Cushman and Edwards, 1937

Astrononion gallowayi Loeblich and Tappan

Astrononion gallowayi Loeblich and Tappan 1953. Smithson. Misc. Coll., vol. 121, no. 7, p. 90, pl. 17, figs. 4-7; Vilks, 1969, p. 51, pl. 3, fig. 19; Cole and Ferguson, 1975, pl. 6, figs. 14-15; Cole, 1981, p. 109, pl. 13, fig. 6; Feyling-Hanssen, 1981, pl. 2, fig. 14; Rodriguez and Hooper, 1982b, p. 343; Williamson, 1983, p. 227, pl. 4, fig. 12.

Remarks. With its characteristic pattern of umbilical chamberlets, this species is readily identifiable and difficult to confuse with others.

Distribution. Present in only very small numbers in a few core samples.

Genus Nonionella Cushman, 1926

Nonionella atlantica Cushman

Nonionella atlantica Cushman 1947. Contr. Cushman. Lab. Foram. Res. vol. 23, no. 4, p. 90, pl. 20, figs. 4-5; Parker, Phleger and Peirson, 1953, p. 11, pl. 3, figs. 30-31; Boltovskoy, 1980b, p. 354, pl. 2, figs. 13-14.

Distribution. This species occurs only as scattered individuals in one surface sample (3050 m), and a few core samples.

Nonionella turgida (Williamson)

Rotalina turgida Williamson 1858. Rec. Foram. Gt. Britain, p. 50, pl. 4, figs. 95-97.Nonionina turgida (Williamson) Brady 1884. Rep. Voy. Challenger, Zool. 9, p. 731, pl. 109, figs. 17-19.

Nonionella turgida (Williamson) Cushman 1930. U.S. Nat. Mus. Bull. 104, vol. 7, p. 15, pl. 6, figs. 1-4; Barker, 1960, p. 224, pl. 109, figs. 17-19; Boltovskoy, 1980b, p. 354, pl. 2, figs. 15-17; Williamson, 1983, p. 228, pl. 4, fig. 13.

Distribution. Limited to subsurface material, the occurrence of this form is quite sporadic, appearing in only a few levels, but at 747-749 cm it makes up over 10.0% of the total benthic assemblage.

Genus Nonionellina Voloshinova 1958

Nonionellina labradorica (Dawson)

Plate 10, figure 14

Nonionina labradorica Dawson 1860. Can. Nat. vol. 5, p. 191, fig. 4.

Nonion labradorica (Dawson) Cushman 1927a. Bull. Scripps. Inst. Oceanogr. Techn. ser. vol. 1, p. 148, pl. 2, figs. 7-8.

Nonionellina labradorica (Dawson) Voloshinova 1958. Mikrofauna SSR, Sb. 9, VNIGRI. Trudy, no. 115, p. 142;

Barbieri and Medioli, 1969, p. 861, pl. 62, figs. 4a-c; Vilks, 1969, p. 51, pl. 3, figs. 20a-b; Cole and Ferguson, 1975, pl. 6, figs. 12-13; Cole, 1981, p. 110, pl. 13, fig. 20; Williamson, 1983, p. 227-228, pl. 4, figs. 14-15.

Nonion labradoricum (Dawson) Feyling-Hansen, 1981, pl. 2, figs. 12-13.

Nonionella labradorica (Dawson) Rodriguez and Hooper 1982b, p. 348.

Remarks. This well-known form is readily distinguishable from other similar forms.

Distribution. *N. labradorica* appears in only one surface sample, at 4046 m, where it makes up 1.0% of the total benthic assemblage. It is, however, fairly widespread in core material, sometimes accounting for over 5.0% of the benthics.

Genus *Pullenia* Parker and Jones *in* Carpenter, Parker and Jones, 1862

Pullenia bulloides (d'Orbigny)

Plate 7, figure 10; Plate 10, figure 15

Nonionina bulloides d'Orbigny, 1826. Ann. Sci. Nat. Paris, ser. 1, vol. 7, p. 293, no. 2.

Pullenia bulloides (d'Orbigny) Cushman and Todd 1943. Contr. Cushman Lab. Foram. Res., vol. 19, p. 13, pl. 2, figs. 15-18; Barker, 1960, p. 174, pl. 84, figs. 12-13; Lohmann, 1978, p. 26, pl. 1, figs. 10-11; Corliss, 1979, p. 8, pl. 4, figs. 1-2; Belanger and Streeter, 1980, p. 418; Boltovskoy, 1980a, pl. 4, figs. 8a,b; Ingle et al. 1980, p. 142, pl. 5, fig. 7; Cole, 1981, p. 111, pl. 14, fig. 5; Blanc-Vernet, 1983, p. 506.

Remarks. The only other species that *P. bulloides* could possibly be confused with in the study material is *Melonis pompiliodes*, but even this resemblance is quite superficial, the former being more spherical, and lacking the large pores of the latter.

Distribution. *P. bulloides* enjoys a widespread distribution in surface material. It is absent below 4046 m, but from that point up to 2400 m, it often constitutes 2.0 or 3.0% of the benthic total. This species appears in many core samples, especially in the upper 500 cm. Often it comprises over 3.0% of the benthic foraminiferal total in core samples.

Pullenia osloensis Feyling-Hanssen

Pullenia osloensis Feyling-Hanssen 1954. Norsk. Geol. Tideskr. 33, p. 194, pl. 1, figs. 33-35; Anderson, 1975, pl. 11, figs. 9a-b; Corliss, 1979, p. 9, pl. 4, figs. 3-4; Boltovskoy, 1980a, pl. 5, fig. 4a-b; Boltovskoy, 1980b, p. 354, pl. 2, figs. 20-21; Cole, 1981, p. 111, pl. 13, fig. 9.

Distribution. *P. osloensis* appears fairly regularly in surface samples from 2200 m down to 4046 m. Its numbers often exceed 1.0% of the benthic total below 3050 m. It is also fairly common in core material, appearing in many samples but rarely exceeding 2.0% of the total.

Pullenia quinqueloba (Reuss)

Plate 4, figure 8; Plate 7, figure 11; Plate 10, figure 19

Nonionina quinqueloba Reuss, 1851. Zeitschr. deutsch. Geol. Ges., vol. 3, p. 71, pl. 5, fig. 31.

Pullenia quinqueloba (Reuss) Brady 1882. Proc. Roy. Soc. of Edinburgh, vol. 11, p. 712; LeRoy and Levinson, 1974, p. 14, pl. 7, fig. 9; LeRoy and Hodgkinson, 1975, pl. 9, fig. 11; Ingle et al. 1980, p. 142, pl. 5, fig. 8; Cole, 1981, p. 111-112, pl. 14, fig. 6; Blanc-Vernet, 1983, p. 506; Williamson, 1983, p. 228, pl. 4, fig. 16.

Pullenia subcarinata (d'Orbigny) Heron-Allen and Earland 1932. Discovery Repts. 4, Foram. (1), p. 403; Barker, 1960, p. 174, pl. 84, figs. 14-15; Anderson, 1975, pl. 11, fig. 11; Milam and Anderson, 1981, pl. 11, fig. 5.

Pullenia subcarinata quinqueloba (Reuss) Boltovskoy, 1980a, pl. 5, figs. 1a-b; Boltovskoy, 1980b, p. 354, pl. 2, figs. 22-23.

Distribution. *P. quinqueloba* is present in almost all surface samples down to 4495 m. It appears to be most common below 2750 m, exceeding 5% of the total at 3247 m. It is quite rare in the cores, occurring at several scattered levels in very small numbers.

Family Alabaminidae Hofker, 1951

Genus *Gyroidina* d'Orbigny, 1826

Gyroidina orbicularis d'Orbigny

Plate 10, figure 17

Rotalia (*Gyroidina*) *orbicularis* d'Orbigny 1826. Ann. Sci. Nat., ser. 1, vol. 7, p. 278.

Rotalia *orbicularis* d'Orbigny. Brady, 1864, Trans. Linn. Soc. London, vol. 24, p. 470, pl. 48, fig. 16.

Gyroidina *orbicularis* d'Orbigny. Barker, 1960, p. 238, pl. 115, fig. 6. LeRoy and Levinson, 1974, p. 14, pl. 7, figs. 14-16. Cole, 1981, p. 112, pl. 20, figs. 8-9.

Gyroidinoides *orbicularis* (d'Orbigny). Corliss, 1979, p. 9, pl. 5, figs. 1-3; Corliss and Honjo, 1981, p. 359-360, pl. 4, figs. 1-14.

Distribution. This relatively small gyroidinid occurs in very small numbers in surface samples from 2000 m to 2400 m and is absent from there down to 2996 m. From 2996 m to 3985 m it is present again, but in somewhat greater numbers, reaching over 4.0% of the total at 3985 m. It is very rare in subsurface material, seen only as an occasional specimen in a few samples from the upper 300 cm of the cores.

Gyroidina *soldanii* d'Orbigny

Plate 10, figure 22

Rotalia (*Gyroidina*) *soldanii* d'Orbigny 1826. Ann. Sci. Nat. vol. 7, p. 278.

Gyroidina *neosoldanii* Brotzen 1936. Sver. Geol. Unders. Anh., ser. C, no. 396, (Ärsh 30, no. 3) p. 158; Barker, 1960, p. 220, pl. 107, figs. 6-7.

Gyroidina *soldanii* *neosoldanii* Brotzen. LeRoy and Levinson, 1974, p. 14, pl. 9, figs. 3-5.

Gyroidina soldanii d'Orbigny. Todd, 1965, U.S. Nat. Mus. Bull. 161, no. 4, p. 19, pl. 6, fig. 4; Boltovskoy, 1980a, pl. 5, figs. 2a-b; Boltovskoy, 1980b, pl. 353, pl. 2, figs. 7-8; Ingle et al. 1980, p. 138, pl. 7, figs. 12-13; Cole, 1981, p. 112-113, pl. 14, fig. 7; Blanc-Vernet, 1983, p. 505; Williamson, 1983, pl. 5, figs. 5-6.

Gyroidinoides soldanii (d'Orbigny) Lohmann, 1978, p. 29, pl. 1, figs. 1-3. Corliss, 1979, p. 9, pl. 5, figs. 4-6; Corliss and Honjo, 1981, p. 360, pl. 5, figs. 1-14.

Remarks. This relatively large form has a well-illustrated very characteristic morphology which distinguishes it quite readiy from other similar forms. It is normally of a very white, porcellanous appearance in the study area.

Distribution. _G. soldanii_ occurs in almost all surface samples from 2000 m down to 3985 m. It reaches 5.5% of the benthic assemblage at 3050 m and is generally more common below 2750 m. Also seen, very rarely, in a few samples from the upper 3 m of the cores.

Gyroidina sp.

Plate 10, figure 18

Remarks. This species is very similar in appearance to _G. soldanii_, but is of a much smaller size. (It may represent a dwarfed form of _G. soldanii_).

Distribution. This form is not seen in surface samples, occurring only as scattered individuals in various levels of the cores.

Genus Oridorsalis Andersen 1961

Oridorsalis tenera (Brady)

Plate 10, figures 20, 21

Truncatulina tenera Brady, 1884. Rept. Voy. Chall., Zool. pt. 22, vol. 9, p. 665, pl. VC, fig. 11a-c.

Eponides tenera Brady. Barker, 1960, p. 146, pl. 95, fig. 11. Lagoe, 1977, p. 127, pl. 5, figs. 3,7,14.

Eponides tener (Brady) Vilks, 1969, p. 50, pl. 3, fig. 16a-b.

Oridorsalis tener (Brady) Anderson, 1975, pl. 11, figs. 13a-c; Lohmann, 1978, p. 26, pl. 4, figs. 5-7; Corliss, 1979, p. 9, pl. 4, figs. 10-15; Belanger and Streeter, 1980, p. 418; Ingle et al. 1980, p. 142, pl. 5, figs. 5-6; Corliss and Honjo, 1981, p. 362, pl. 7, figs. 1-12.

Remarks. This species can be distinguished from its close relative O. umbonatus by its sharper keel. The two species, however, appear to form end members of a continuum, so there are many specimens whose placement in one or the other of these designations is somewhat subjective.

Distribution. O. tener is very widespread in surface samples, occurring in most from 2000 m to 4046 m. It appears to be most prevalent between 2400 m and 3543 m, often exceeding 2.0% of the total benthics.

It is also present in very small numbers in most samples from the upper 150 cm of the cores, and only very rarely below that.

Oridorsalis umbonatus (Reuss)

Rotalina umbonata Reuss 1851, p. 75, pl. 5, figs. 35a-c.

Oridorsalis tener umbonatus (Reuss) LeRoy and Levinson, 1974, p. 14, 16, pl. 7, figs. 17-18.

Oridorsalis umbonatus (Reuss) Lohmann, 1978, p. 26, pl. 4, figs. 1-3. Boltovskoy 1980a, pl. 4, figs. 4a-b; Boltovskoy 1980b, p. 354, pl. 2, fig. 19; Blanc-Vernet, 1983, p. 505, pl. 2, fig. 11; Williamson, 1983, p. 229, pl. 5, figs. 3-4.

Distribution. O. umbonatus is present in scattered surface samples from above 2750 m in very small numbers. Below this level, it is more common, forming 5.0% of the total benthics at 3247 m. It is seen in small numbers only in the upper 150 cm of the cores.

Family Anomalinidae Cushman 1927

Subfamily Anomalininae Cushman 1927

Genus Melonis de Montfort 1808

Melonis pompilioides (Fichtel and Moll)

Plate 10, figure 16

Nautilus pompilioides - Fichtel and Moll 1798. Test. Micr. p. 31, pl. 2, figs. a-e.

Nonion pompilioides (Fichtel and Moll) Phleger and Parker, 1951. Geol. Soc. Amer. Mem. 46(2), p. 11, pl. 5, figs. 19-20.

Nonion (?) pompilioides (Fichtel and Moll) Barker, 1960, p. 224, pl. 109, figs. 10-11.

Nonionina pompilioides (Fichtel and Moll) Parker, Jones and Brady, 1865. Ann. Mag. Nat. Hist. ser. 3, vol. 16, p.

18, pl. 3, fig. 98.

Melonis etruscus de Montfort 1808. Conch. Syst. Class. Meth. Cog., tome 1, p. 66-67, text-figs.

Melonis pompilioides (Fichtel and Moll) Voloshinova 1958. Mikrofauna SSSR, VNIGRI, Sbornik 9, no. 115, p. 117-191; Lohmann, 1978, p. 29, pl. 1, figs. 12-13; Corliss, 1979, p. 12, pl. 5, figs. 9-10; Cole, 1981, p. 114-115, pl. 14, fig. 9; Ingle et al. 1980, p. 142, pl. 9, figs. 14-15; Blanc-Vernet, 1983, p. 505, pl. 2, fig. 14; Williamson, 1983, p. 230, pl. 5, fig. 8.

Remarks. Known by several names, this form is nevertheless fairly distinctive because of its very broad, subspherical shape and characteristic large pores. As mentioned above, it superficially resembles Pullenia bulloides but even a weathered, damaged specimen can still be usually properly identified.

Distribution. M. pompilioides occurs in most surface samples from 2400 m to 4046 m, but is most common below 2750 m, sometimes accounting for over 150 cm, it occurs only sporadically below that.

Superfamily Robertinacea Reuss, 1850

Family Ceratobuliminidae Cushman, 1927

Subfamily Epistomininae Wedekind, 1937

Genus Hoeglundina Brotzen, 1948

Hoeglundina elegans (d'Orbigny)

Plate 7, figure 12

Rotalia (*Turbinulina*) *elegans* d'Orbigny 1826. Ann. Sci. Nat. ser. 1, vol. 7, p. 276, no. 54.

Pulvinulina elegans (d'Orbigny) Brady 1884. Rep. Voy. Challenger, Zool. 9, p. 699, pl. 105, fig. 3-6.

Epistomina elegans (d'Orbigny) Cushman 1931. U.S. Nat. Mus. Bull. 104(8), p. 65, pl. 13, fig. 6.

Hoeglundina elegans (d'Orbigny) Parker, Phleger and Pierson 1953. Cushman Found. Foram. Res. Spec. Publ. 2, p. 43, pl. 9, figs. 24-25; Barker, 1960, p. 216, pl. 105, figs. 3-6; LeRoy and Levinson, 1974, p. 18, pl. 9, figs. 13-14; LeRoy and Hodgkinson, 1975, pl. 9, fig. 24; Lohmann, 1978, p. 29, pl. 4, figs. 10-12; Corliss, 1979, p. 12, pl. 5, figs. 11-13; Ingle et al. 1980, p. 138, pl. 2, fig. 11; Corliss and Honjo, 1981, p. 360, 362, pl. 6, figs. 1-15; Williamson, 1983, p. 231, pl. 5, figs. 11-12.

Höglundina elegans (d'Orbigny) Blanc-Vernet, 1983, p. 505.

Remarks. This large, carinate form is easily distinguished by its lenticular form in cross section and the pressure of its distinctive supplementary apertures positions just below the keel. Some specimens, especially in the surface material, are clear and hyaline, affording a very good view of the internal structures of the skeleton. Most, however are somewhat etched (presumably because of the aragonitic nature of the test) and as a result are an opaque white.

Distribution. *H. elegans* occurs in most surface samples from depths between 2200 and 4030 m. Between 2400 m and 3543 m it is one of the principle components of the very diverse Assemblage II, often comprising 5-10% of the total benthic fauna. At 3543 m it reaches 11.6% of the total. Below that point its numbers are very small or it is entirely absent.

This form does not occur at all in subsurface material. It is unclear whether this absence is the result of comparatively rapid dissolution of the aragonitic test of this form, or if conditions at the core site prior to the present had precluded the existence of this form there.

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PLATES

Plate 1

Optical Micrographs - Agglutinated Species

1. Placopsilinella aurantiaca on Globorotalia menardii from 81-016-01, x 64.
2. Rhabdammina cf. irregularis from 81-016-01 x 39.
3. Rhizammina indivisa from 81-016-01 x 30.
4. Dendrophyra arborescens from 81-016-03 x 41.
5. Reophax dentaliniformis from 81-016-05 x 54.
6. Cyclammina cancellata from 81-016-05 x 56.
7. Ammobaculites agglutinans from 81-016-05 x 76.
8. Ammoscalaria tenuimargo from 79-002-50 x 60.
9. Ammomarginulina foliacea from 81-016-01 x 88.
10. Trochammina ochracea (dorsal view) from 82-022-78p, 20-22 cm x 95.
11. Martinottiella communis from 81-016-03 x 132.


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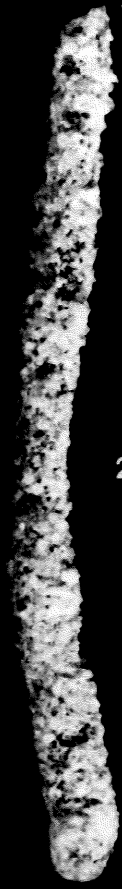
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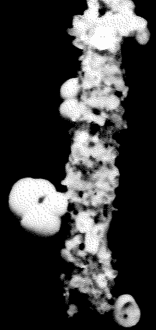
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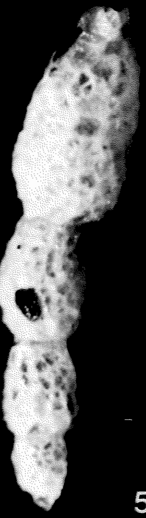
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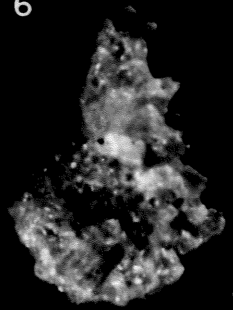
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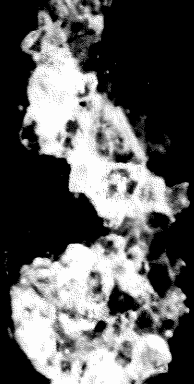
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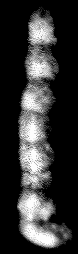
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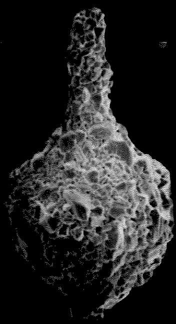
Plate 2

Scanning Electron Micrographs - Agglutinated Species

1. *Astrammina* sp. from 81-016-01, x 60.
2. *Rhabdammina linearis* from 81-016-01, x 31.
3,4. *Hyperammina elongata* from 81-016-01, x 18 (3), x 15 (4).
5. *Glomospira charoides* from 81-016-01, x 65.
6. *Tolypammina vagans* from 81-016-05, x 66.
7. *Hormosina globulifera* from 81-016-05, x 58.
8,9. *Reophax bacillaris* from 82-022-80, x 22 (8). 9 is an enlarged view of the same specimen, x 225.
10,11,12. *Saccammina difflugiformis* from 81-016-05, x 64 (10), x 45 (11), and x 47 (12).
13. *Reophax guttifer* from 81-016-03, x 98.
14. *Haplophragmoides bradyi* from 81-016-01, x 185.
15. *Haplophragmoides sphaeroloculum* from 81-016-01, x 155.
16. *Adercotryma glomerata* from 82-022-789, 7.5-9.5 cm., x 97.
17. *Cribrostomoides scitulum* from 81-016-02, x 33.
18. *Cribristomoides subglobosa* from 81-016-02, x 68.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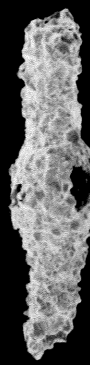
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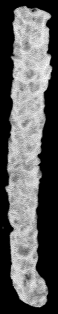
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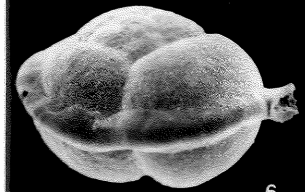
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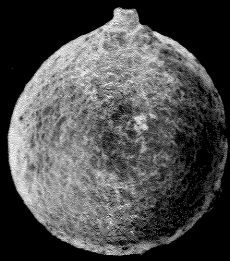
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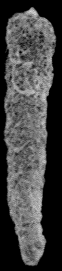
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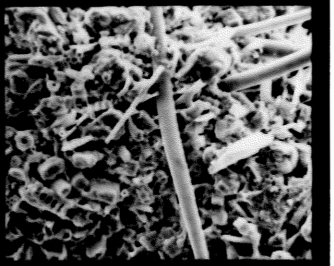
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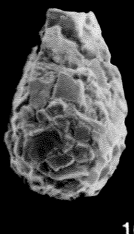
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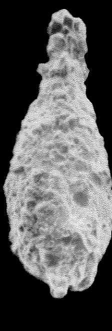
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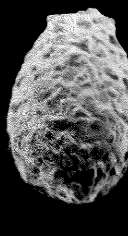
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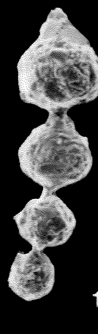
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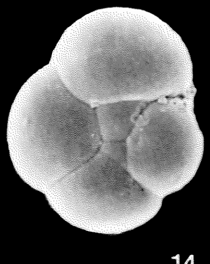
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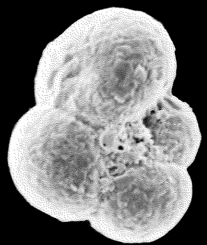
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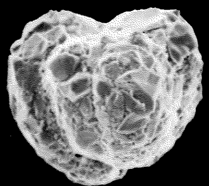
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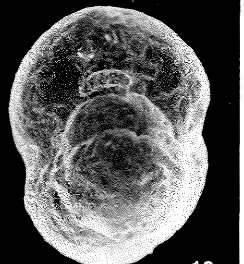
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Plate 3

Scanning Electron Micrograph - Agglutinated Species

1. *Cribrostomoides weisneri* from 81-016-01, x 120.
2. *Recurvoides contortus* from 81-016-01, x 97.
3. *Ammobaculites agglutinans* from 81-016-05, x 67.

4,5. *Spiroplectammina biformis* from 82-022-78p, 708-710 cm, both x 111.

6. *Textularia gracillima* from 82-022-78p, 290-292 cm, x 110.
7. *Siphotextularia catenata* from 81-016-02, x 136.
8. *Trochammina bullata* from 81-016-05, x 70. Side view.

9,10. *Trochammina malovensis* from 81-016-03, both x 65. 9, dorsal view; 10, side view, same specimen.

11. *Trochammina pusilla* from 81-016-01, x 340.

12,13. *Trochammina squamata* from 81-016-01, both x 91. 12, dorsal view; 13, ventral view, same specimen.

14. *Cystammina pauciloculata* from 81-016-05, x 82.
15. *Eggerella propinqua* from 81-016-01, x 39.
16. *Karreriella apicularis* from 81-016-05, x 152.
17. *Karreriella bradyi* from 81-016-01, x 38.
18. *Karreriella novanglia* from 81-016-05, x 24.
19. *Martinottiella nodulosa* from 81-016-02, x 78.


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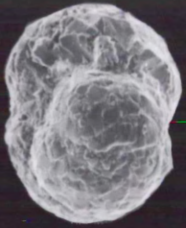
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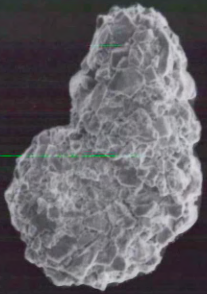
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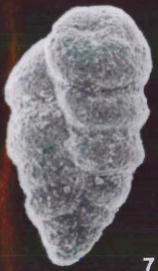
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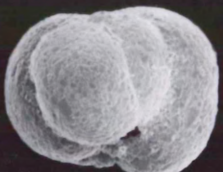
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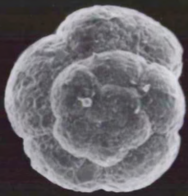
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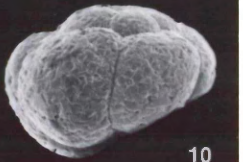
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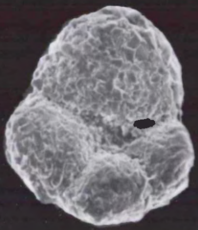
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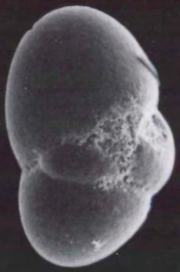
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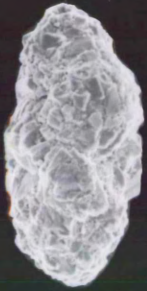
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Plate 4

Optical Micrographs - Calcareous Species

1\. *Trifarina angulosa* from 81-016-05, x 212.

2\. *Uvigerina asperula* from 82-022-788, 260-262 cm, x 153.

3\. *Uvigerina spinicostata* from 81-016-05, x 72.

4\. *Fursenkoina fusiformis* from 81-016-05, x 175.

5,6,7. *Elphidium excavatum* forma *clavata* from 81-016-05, all three x 69.

8\. *Pullenia quinqueloba* from 81-016-05, x 96.

9\. *Cibicides lobatulus* from 81-016-05, x 73. Dorsal view.

10\. *Epistominella exigua* from 81-016-05, x 150. The star-shaped pattern of the sutures is visible in this dorsal view.

11,12. *Valvulineria* sp. cf. *arctica* from 82-022-788, 420-422 cm, both x 103. Dorsal and ventral views of the same specimen.

13,14. *Cassidulina reniforme* from 81-016-05, both x 120. Dorsal and ventral views of two specimens.


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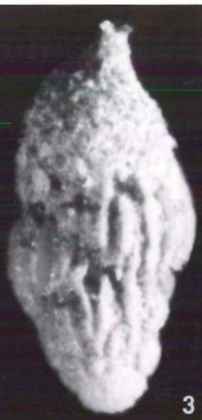
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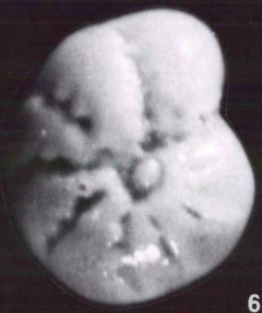
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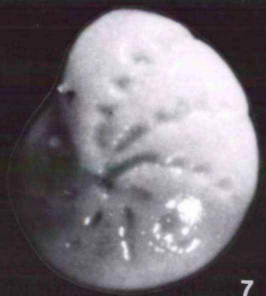
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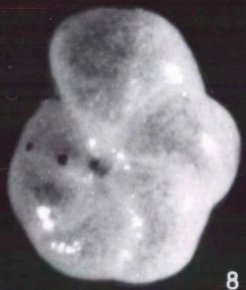
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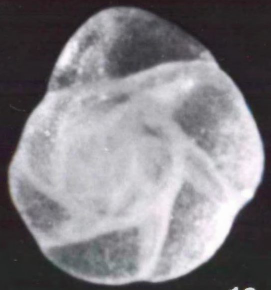
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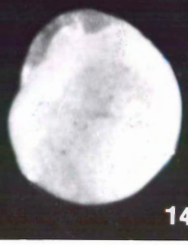
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Plate 5

Optical Micrographs - Calcareous Species

1. *Nodosaria albatrossi* from 81-016-06, x 39.

2. *Dentalina inornata bradyensis* from 81-016-02, x 80.

3. *Lagena gracilis* from 82-022-78G, 7.5-9.5 cm, x 144.

4. *Pyrulina cylindroides* from 81-016-02, x 61.

5. *Oolina apiculata* from 81-016-01, x 74. In this well-preserved specimen the entosolenian tube is clearly visible.

6. *Oolina globosa* from 81-016-04, x 96.

7. *Fissurina alveolata* from 81-016-05, x 90.

8. *Fissurina sulcata* from 81-016-01, x 100.

9. *Parafissurina tectulostoma* from 81-016-05, x 92.

10. *Tosaia hanzawai* from 81-016-01, x 116.

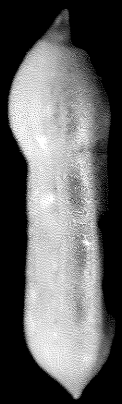
11,12. *Bolivina* aff. *earlandi* from 82-022-78G, 105-107 cm, both x 192.

13,14. *Fursenkoina fusiformis* from 81-016-01, both x 96.

15. *Bolivina* cf. *inflata* from 82-022-78G, 7.5-9.5 cm, x 93.

16. *Bolivina pseudopunctata* from 81-016-01, x 148.

17. *Bolivina pygmaea* from 82-022-78P, 0-2 cm, x 84.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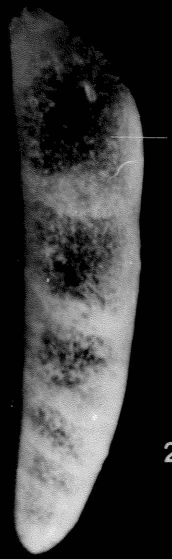
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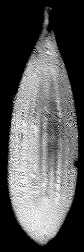
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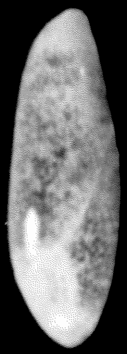
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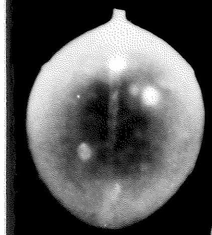
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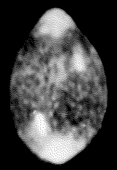
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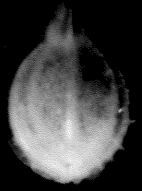
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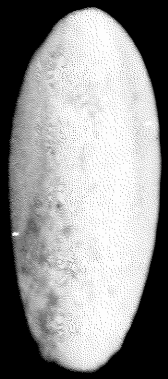
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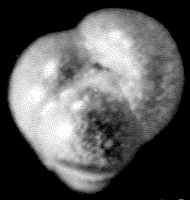
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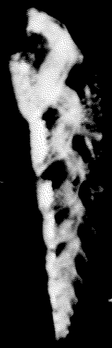
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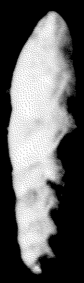
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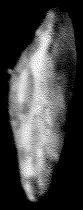
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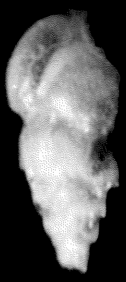
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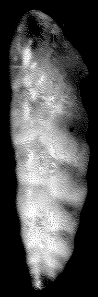
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Plate 6

Optical Micrographs - Calcareous Species

1. *Islandiella norcrossi* from 82-022-78G, 7.5-9.5 cm, x 110.

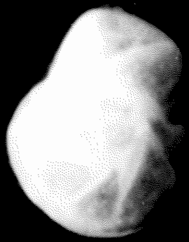
2. *Bulimina alazanensis* from 82-022-83B, x 90.

3,4. *Globobulimina auriculata* from 81-016-04, x 110 (3), x 84 (4). These two specimens exhibit some of the variation within this complex group.

5,6. *Uvigerina peregrina* from 82-022-78G, 105-107 cm, both x 74.

7. *Epistominella umbonifera* from 81-016-01, x 83. Ventral view.

8,9,10. *Epistominella exigua* 8 and 10 show ventral and dorsal views of two specimens from 82-022-78P, 260-262 cm, both x 91. 9 and 11 show ventral and dorsal views of two specimens from 81-016-01, both x 80.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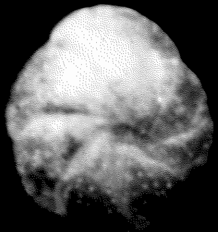
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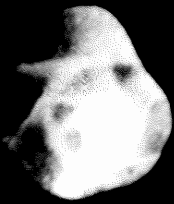
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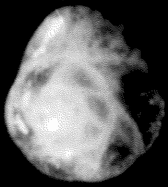
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Plate 7

Optical Micrographs - Calcareous Species

1,2,3. *Elphidium excavatum* forma *clavata* ("glacial" form) from 82-022-78G, 153-155 cm, all x 97.

4. *Planulina wuellerstorfi* from 81-016-03, x 86. Dorsal view.

5. *Cibicides lobatulus* from 82-022-78P, 340-342 cm, x 63. Ventral view.

6. *Cibicides robertsonianus* from 81-016-01, x 76. Ventral view.

7,8. *Fursenkoina concava* from 82-022-78P, 340-342 cm, both x 83.

9. *Chilostomella oolina* from 81-016-05, x 104.

10. *Pullenia bulloides* from 81-016-05, x 84.

11. *Pullenia quinqueloba* from 81-016-05, x 90.

12. *Hoeglundina elegans* from 81-016-05, x 73. Secondary apertures are visible around the periphery of this somewhat hyaline specimen in this ventral view.


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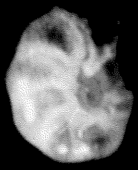
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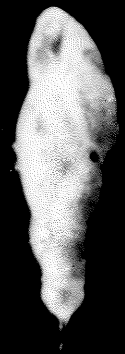
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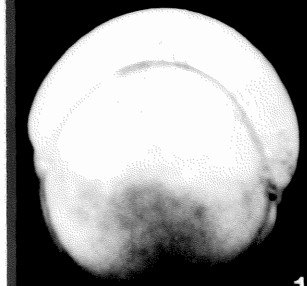
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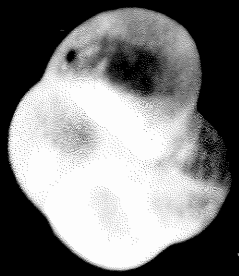
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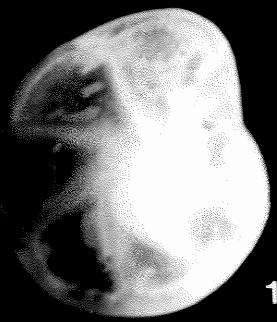
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Plate 8

Scanning Electron Micrographs - Calcareous Species

1. *Ophthalmidium pusilla* from 81-016-02, x 100.
2. *Pyrgo comata* from 81-016-06, x 66.
3. *Pyrgo murrhyna* from 81-016-01, x 51.
4. *Sigmoilopsis schlumbergeri* from 81-016-05, x 42.
5. *Triloculina tricarinata* from 81-016-01, x 100.
6. *Lagena elegantissima* from 81-016-01, x 152.
7. *Lagena gracilis* from 82-022-78G, 7.5-9.5 cm, x 92.
8. *Lagena hispidula* frpm 81-016-01, x 52.
9. *Lagena striata* from 81-016-06, x 83.
10. *Lenticulina angulata* from 81-016-05, x 67.
11. *Pseudonodosoria* cf. *torrida* from 81-016-01, x 99.
12. *Pyrulina angusta* from 81-016-03, x 68.
13. *Oolina hexagona* from 80-004-14, x 119.
14. *Fissurina alveolata* from 81-016-05, x 79.
15. *Fissurina annectens* from 81-016-01, x 95.
16. *Fissurina sequenziana* from 81-016-01, x 102.
17. *Fissurina sulcata* from 81-016-01, x 97.
18. *Parafissurina tectulostoma* from 81-016-05, x 55.
19. *Tosaia hanzawai* from 81-016-01, x 97.


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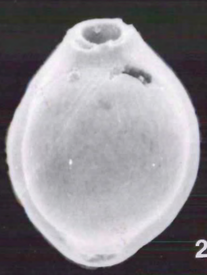
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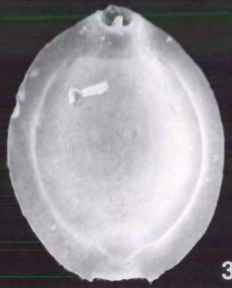
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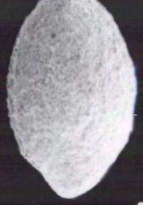
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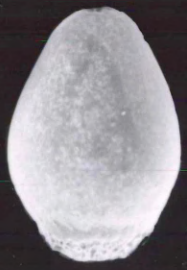
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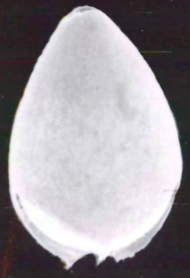
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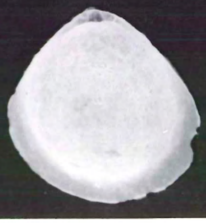
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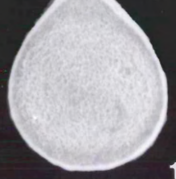
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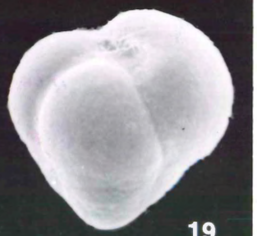
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Plate 9

Scanning Electron Micrographs - Calcareous Species

1. *Bolivina pseudoplicata* from 81-016-06, x 102.

2. *Bolivina pseudopunctata* from 81-016-01, x 78.

3. *Bolivina subspinescens* from 81-016-07, x 133.

4. *Islandiella norcrossi* from 82-022-78G, 7.5-9.5 cm, x 94.

5. *Stilostomella* cf. *antillea* from 82-022-78P, 400-402 cm, x 165.

6. *Bulimina alazanensis* from 82-022-83B, x 88.

7. *Bulimina striata* from 81-016-07, x 57.

8. *Uvigerina asperula* from, 81-016-01, x 83.

9. *Uvigerina spinicostata* from 81-016-06, x 52.

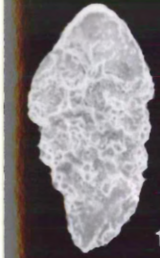
10. *Trifarina angulosa* from 81-016-07, x 125.

11,12. *Epistominella exigua* from 81-016-01, x 98. Ventral and dorsal views of different specimens. None of the internal structure is visible.

13,14, 15,16. *Epistominella umbonifera* from 81-016-01, all x 138. 13 and 16 are dorsal views of different specimens; 14 is a ventral view of another, and 15 is a side view of a fourth.

17,18 *Valvulineria* cf. *arctica* from 82-022-78G, 31-33 cm, x 269 (17) and x 328 (18). Dorsal and ventral views, respectively.

19,20, *Elphidium excavatum* forma *clavata* from 81-016-05 (19,22), and 82-022-78G, 153-155 cm (20,21). 19 and 22 are representative of the larger form found in surface material especially from Assemblage I. 20 and 21 show the smaller "glacial" form seen in some core material x 268 (19), x 175 (20), x 270 (21) and x 135 (22).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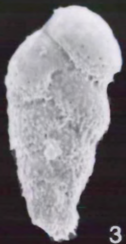
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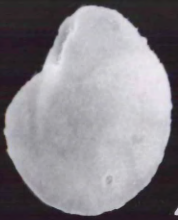
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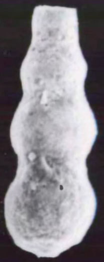
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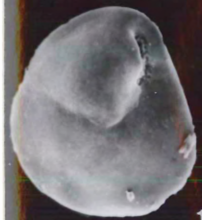
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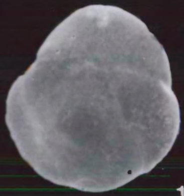
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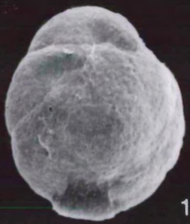
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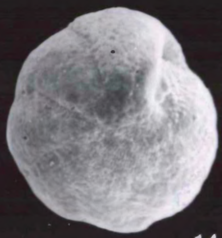
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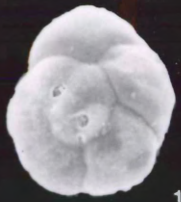
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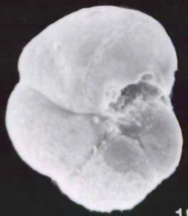
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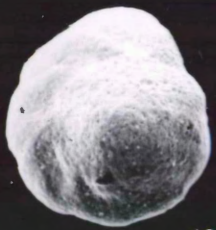
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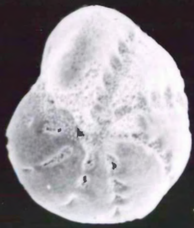
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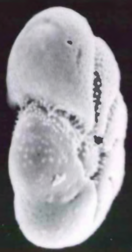
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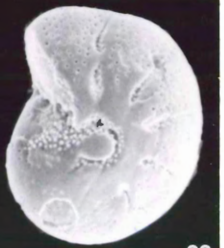
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Plate 10

Scanning Electron Micrographs - Calcareous Species

1,2. *Heterohelix* cf. *americana* from 82-022-78P, 300-302 cm, both x 210. Fig. 2 shows the large, arched aperture.

3. *Planulina wuellerstorfi* from 81-016-01, x 45. Ventral view.

4. *Cibicides lobatulus* from 81-016-01, x 75. Ventral view.

5. *Cibicides robertsonianus* from 82-022-79B, x 42. Dorsal view.

6,7. *Fursenkoina concava* from 79-002-51, both x 97.

8. *Fursenkoina fusiformis* from 81-016-01, x 139.

9. *Cassidulina laevigata* from 79-002-13, x 105. Ventral view.

10. *Cassidulina reniforme* from 80-004-65, x 153. Ventral view.

11. *Nonion depressulus* from 81-016-05, x 84.

12. *Nonion barleeanum* from 81-016-01, x 117.

13. *Nonion grateloupi* from, 81-016-01, x 95.

14. *Nonionellina labradorica* from 82-022-78G, 7.5-9.5 cm, x 93.

15. *Pullenia bulloides* from 79-002-52, x 131.

16. *Melonis pompilioides* from 81-016-01. x 95.

17. *Gyroidina orbicularis* from 81-016-01, x 82. Dorsal view.

18. *Gyroidina* sp. from 82-022-78G, 61-63 cm, x 90. Side view.

19. *Pullenia quinqueloba* from 81-016-01, x 87.

20,21. *Oridorsalis tenera* from 81-011-03, both x 97. Side view and dorsal view of two different specimens.

22. *Gyroidina soldani* from 81-016-01, x 61. Side view.


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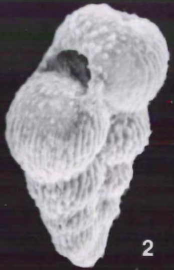
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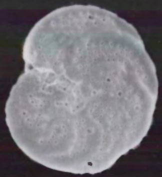
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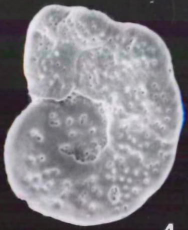
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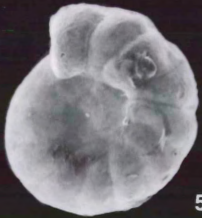
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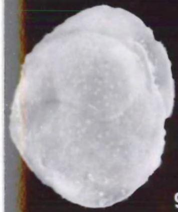
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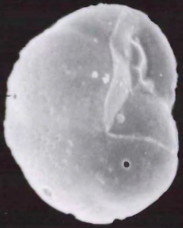
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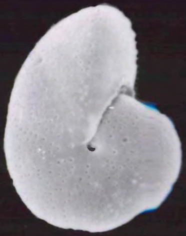
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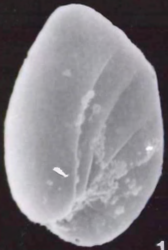
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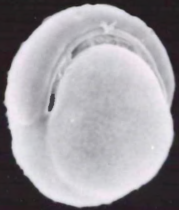
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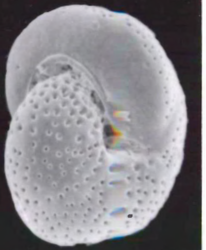
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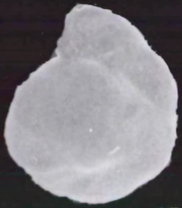
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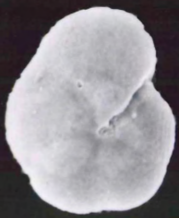
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SPECIES / DEPTH IN CORE (CM)	0-2	1-3G	7.5-9.5G	10-12	15-17G	20-22	20-22G	30-32	31-33G	40-42	41-43G	50-52	51-53G	60-62	61-63G	70-72	72.5-74.5G	78-80	85-87G	87-89	95-97G	101-103	105-107G	109-111	115-117G	120-122	123-125G	128-130G	130-132	139-141G
Total Benthics	772	3504	1624	888	292	332	153	33	142	276	38	132	112	306	136	45	28	146	61	12	492	2	111	10	12	0	9504	1576	2	1112
ADERCOTRYMA GLOMERATA			X					6	1					13		7	4	3			1						1	1		
ALVEOPHRAGMIUM RINGENS		X																									X			
AMMOBACULITES AGGLUTINANS	2	X	1			1															1		1				1			
AMMOMARGINULINA FOLIACEA	1		1																									2		
ASTACOLUS CREPIDULA																												X		X
ASTRAMMINA SP.		2	1																		1						1			
ASTRONONION GALLOWAYI																														X
ASTRORHIZA cf. CRASSATINA		X	X																											
BOLIVINA AFF. EARLANDI				2						2		5		11		7		7	3			1	19							14
BOLIVINA INFLATA			X					3		1																				
BOLIVINA PSEUDOPLICATA	X																											X		1
BOLIVINA PSEUDOPUNCTATA	1			4	2	4	18		9	1		1		5	3			10	15		X		3	50			X			10
BOLIVINA PYGMACEA	1																													
BOLIVINA STRIATULA																														
BOLIVINA SUBAENARIENSIS																														
BOLIVINA SUBSPINESCENS																														
BUCCELLA FRIGIDA																														
BULIMINA ALAZANENSIS						1																								
BULIMINA GIBBA																														1
BULIMINA NOTOVATA																														1
BULIMINA STRIATA					X																									
BULIMINELLA ELEGANTISSIMA																														
CASSIDULINA LAEVIGATA	2	X	1	1	4		4		1			5			3	2	4	8	6		2		4		50		X	2		8
CASSIDULINA RENIFORME	1	X	1	2	5		5		1	2		27	7	9	9	58	11	14	39	42	2		14					3		18
CHILOSTOMELLA OOLINA	X			1		1	1		3	1	5																			
CIBICIDES LOBATULUS	5	3	3	7	X	10	1				10		4	1							7	50	1				1	4		
CIBICIDES ROBERTSONIANUS		X	1				1																1							
CRIBROSTOMOIDES SCITULUM		1																												
CRIBROSTOMOIDES SUBGLOBOSA	X																				1									
CRIBROSTOMOIDES WEISNERI	X																													
CYCLAMMINA CANCELLATA		X																			X						X			
CYSTAMMINA PAUCILOCULATA																											X			
DENDROPHYRA ARBORESCENS																											X			
DENTALINA INORNATA BRADYENSIS	1	1				1				1				1	1								1							
DISCOPULVINULINA BERTHELOTI				X		1										4											[illegible]			
EGGERELLA SP.								3				3			3								1		8					
ELPHIDIUM EXCAVATUM FORMA CLAVATA	3		1	1	3	2	X	3	1	2		5		3		4		1	3		3	50					X	1		4
E. EXCAVATUM FORMA CLAVATA (glacial)												3				2		3												
EPISTOMINELLA EXIGUA	3	6	1	1	X	1		3					4		1					8	1						5	2		1
EPISTOMINELLA TAKAYANAGII				3		2	1					1	1	2				3			1						1	2		4
EPISTOMINELLA UMBONIFERA	41	53	36	44	35	46	9		1	19	5		52		1						35		26		42		51	39	100	
EPONIDES BRADYI					1		2		3					3	3			3	2					20			1	2		2
FISSURINA SPP. (all)	1	1	1	2		1									1				2		X						1	1		1
FURSENKOINA CONCAVA	1		X	X	3	1			3	4	11	1	1	5	4		11	14	2		1		3	20						2
GLOBOBULIMINA AURICULATA				1	1	1	12		4	1											2		1					X		X
GLOMOSPIRA CHAROIDES																							1							
GYROIDINA ORBICULARIS					1									1							1						1	2		1
GYROIDINA SOLDANI			X	1							5						3				X						1			
GYROIDINA SP.										1		1			1															
HAPLOPHRAGMOIDES BRADYI																														
HAPLOPHRAGMOIDES SPHAEROLOCULUM	1	2	1											5	2						1						1	1		
HETEROHELIX CF. AMERICANA																														
HYPERAMMINA ELONGATA	5	9	17	1	4																7						5	10		
ISLANDIELLA NORCROSSI			2	2	4	2	3	6	1		5	3		3	2				2		X						1	2		2
KARRERIELLA APICULARIS	X	X	X		X																		1				1			
KARRERIELLA BRADYI																					X									
KARRERIELLA NOVANGLIA				X																							X	X		
LAGENA SPP. (all)			X	X		2	2		6					1	1								1					X		
LARYNGOSIGMA HYALASCIDIA						1										2														
MARGINULINA OBESA		X		X		1															X		1							
MARTINOTTIELLA COMMUNIS																														
MARTINOTTIELLA NODULOSA			X		3																							X		
MELONIS POMPILIODES	3	X	2	3	2	3	2		1	1		1		2	3		11				3						1	1		X
MILIOLA SP.													1		1															
NODOSARIA ALBATROSSI										1																				
NONION BARLEEANUM	X	2	1	X			2		1	2	5				3						2						2	2		1
NONION DEPRESSULUS							1		4			5									X		4							1
NONION GRATELOUPI			X	1			15		3								4			8										11
NONIONELLA ATLANTICA			X				X							1									1							1
NONIONELLA TURGIDA				1			X																							1
NONIONELLINA LABRADORICA	1		X	1	2		2			1		3		5	1			4	2		8		1					2		5
OOLINA SPP. (all)									1						4			1									X			
OPHTHALMIDIUM PUSILLA				X																							X			
ORIDORSALIS TENERA	3	1	X	3	1	1	X		3	2			2	1			3	4			3						4	3		2
ORIDORSALIS UMBONATUS							X																							
PARAFISSURINA TECTULOSTOMA						1															X		1					1		
PLACOPSILINELLA AURANTIACA	X		1		X																X						1			
PLANULINA WUELLERSTORFI	1	1	3	X	5	2	X		2	1			4														3			X
PSEUDONODOSARIA cf. TORRIDA																							1							
PULLENIA BULLOIDES	1	X	X	1	1	3			7	4		3	2	3	12		29	4			2		1				X	X		1
PULLENIA OSLOENSIS	1			1	X	1			3	1					3				5		X		4				1	2		1
PULLENIA QUINQUELOBA	2			2	3		5		6	1											X						1	2		1
PYRGO COMATA																														
PYRGO MURRHYNA	1	1		1		1			1				2								2						2	3		
PYRGO SUBSPHAERICA		X		1		1											3													
PYRULINA ANGUSTA																											X			
PYRULINA FUSIFORMIS			1																											
PYRULINA SP. 1																														
QUINQUELOCULINA SP.																														
RECURVOIDES CONTORTUS	X	1	1		X																2						1	1		
REOPHAX BACILLARIS		X	X			1				1																	1			
REOPHAX DENTALINIFORMIS								3																						
REOPHAX DIFFLUGIFORMIS*1		1				2	X	39	2	23		8	5	9	7	2	4	8	2				2				1			1
REOPHAX FUSIFORMIS		X																												
REOPHAX GUTTIFER		X																									X			
REOPHAX SPP. FRAGMENTS	X	2	2																		2						1	X		
RHABDDAMMINA cf. IRREGULARIS			1																								X			
RHABDAMMINA LINEARIS																											1			
RHIZAMMINA cf. ALGAEFORMIS	1			1		1																					X			
SIPHOTEXTULARIA CATENATA					X																									
SPIROPLECTAMMINA BIFORMIS																														
STETSONIA MINUTA							1																							
STILOSTOMELLA SP. cf. ANTILLEA																														
TEXTULARIA GRACILLIMA																														
TOLYPAMMINA VAGANS	X		1			1																					1	X		
TOSAIA HANZAWAII	2	1	1	1	X		1			3		2	1								1		2				1	2		1
TRIFARINA ANGULOSA			1																								1	X		
TRILOCULINA OBLONGUM				X		1						1									X						X			
TRILOCULINA TRICARINATA		X		1					2	1		12	2	2	1			1		17				10			X			X
TROCHAMMINA MALOVENSIS		X																										X		
TROCHAMMINA OCHRACEA						1																								
TROCHAMMINA PUSILLA										1				5		4														
TROCHAMMINA SQUAMATA GR.		X																4									X	2		
UVIGERINA ASPERULA	4		1	1	4	1			4	2	53	5	4	3				1	3		1							X		X
UVIGERINA PEREGRINA	3			1				15		15		2		1		2							5					3		
UVIGERINA SPINICOSTATA	3	2	7	1	10	1	5	18	16	4		3	4	3	21		11	1	3		7		1				X			X
VALVULINERIA SP. cf. ARCTICA			X	X					6				4		6	4		5	3	25	X						X			
VIRGULINA FUSIFORMIS*2	1			X			1							1					8											1
VIRGULINA SUBDEPRESSA				1	X	X	2		4					1			3				X		1							2

SPECIES / DEPTH IN CORE (CM)	140-142	148-150G	150-152	153-155G	159-161G	160-162	170-172	182-184	189-191	202-204	210-212	219-221	230-232	240-242	250-252	260-262	270-272	280-282	290-292	300-302	310-312	320-322	330-332	340-342	350-352	360-362	370-372	380-382	390-392	400-402
Total Benthics	1	270	2	163	10	0	0	0	0	1	1	1	6	?2	?2	936	414	163	202	151	680	202	37	158	222	344	252	76	256	240
ADERCOTRYMA GLOMERATA																	X	1	X	3			3	1				1	5	3
ALVEOPHRAGMIUM RINGENS																														
AMMOBACULITES AGGLUTINANS																														
AMMOMARGINULINA FOLIACEA																														
ASTACOLUS CREPIDULA																			1											
ASTRAMMINA SP.		1																												
ASTRONONION GALLOWAYI																														
ASTRORHIZA cf. CRASSATINA																														
BOLIVINA AFF. EARLANDI		7		4													5	24	3	1	4	3		15	16	7	5	3	2	3
BOLIVINA INFLATA																												1	X	
BOLIVINA PSEUDOPLICATA																														
BOLIVINA PSEUDOPUNCTATA		2		3												3	11	8	4	2	2	10		5	7	5	6	5	4	3
BOLIVINA PYGMACEA																														
BOLIVINA STRIATULA																														
BOLIVINA SUBAENARIENSIS																					2						2			2
BOLIVINA SUBSPINESCENS				1													1		1											2
BUCCELLA FRIGIDA																														
BULIMINA ALAZANENSIS																														
BULIMINA GIBBA		1																	X	1										
BULIMINA NOTOVATA																														
BULIMINA STRIATA																					1									
BULIMINELLA ELEGANTISSIMA																													X	
CASSIDULINA LAEVIGATA		1															1	2	5		37	3					5			1
CASSIDULINA RENIFORME		11		4												13	20	23	21	9	7	28	30	5	5	37	29	32	18	28
CHILOSTOMELLA OOLINA		1																												
CIBICIDES LOBATULUS			50													2		1				1	5	1					X	1
CIBICIDES ROBERTSONIANUS																														
CRIBROSTOMOIDES SCITULUM																														
CRIBROSTOMOIDES SUBGLOBOSA				1																										
CRIBROSTOMOIDES WEISNERI																													X	
CYCLAMMINA CANCELLATA																														
CYSTAMMINA PAUCILOCULATA																														
DENDROPHYRA ARBORESCENS																														
DENTALINA INORNATA BRADYENSIS				2												1							3						1	
DISCOPULVINULINA BERTHELOTI																														
EGGERELLA SP.																		1	X	1										
ELPHIDIUM EXCAVATUM FORMA CLAVATA																					1	1			2					
E. EXCAVATUM FORMA CLAVATA (glacial)				3													2	2	13	3	15	6		1	3	14	5	4		7
EPISTOMINELLA EXIGUA		1		2	10											10	1	1	2											
EPISTOMINELLA TAKAYANAGII		2		1												1	1	2	2	3	4	2	5		4	9	5	5		3
EPISTOMINELLA UMBONIFERA	100	5	50	2	30						100	100	17				X			1	2		3	1	2					3
EPONIDES BRADYI		2		2						100						1	1	2	2	1		4			3	9	3	8	1	2
FISSURINA SPP. (all)		1														2	X			X	2								X	
FURSENKOINA CONCAVA		3		7												12	5	4	2	1		3	5	3	9	5	3	4	2	3
GLOBOBULIMINA AURICULATA																	X													
GLOMOSPIRA CHAROIDES																														
GYROIDINA ORBICULARIS																	1													
GYROIDINA SOLDANI																														
GYROIDINA SP.																1														
HAPLOPHRAGMOIDES BRADYI																														
HAPLOPHRAGMOIDES SPHAEROLOCULUM				19	10													2		10	1	2			4					
HETEROHELIX CF. AMERICANA																			1	1					2	5	3	8		3
HYPERAMMINA ELONGATA		2																												
ISLANDIELLA NORCROSSI																1	1	2	4		5		3				3			
KARRERIELLA APICULARIS					10													1		1										
KARRERIELLA BRADYI																														
KARRERIELLA NOVANGLIA																														
LAGENA SPP. (all)		1		X												1			X										X	
LARYNGOSIGMA HYALASCIDIA																														
MARGINULINA OBESA		1														X														
MARTINOTTIELLA COMMUNIS																			X											
MARTINOTTIELLA NODULOSA																		1												
MELONIS POMPILIODES		2		2												3	X	1		1				2					2	
MILIOLA SP.																														
NODOSARIA ALBATROSSI																														
NONION BARLEEANUM		1														1														
NONION DEPRESSULUS																														
NONION GRATELOUPI		4		2															1			2			1					3
NONIONELLA ATLANTICA																														
NONIONELLA TURGIDA																			1											
NONIONELLINA LABRADORICA		4		2												1	1				4	6		1	2		5	3	X	
OOLINA SPP. (all)																								1						
OPHTHALMIDIUM PUSILLA																														
ORIDORSALIS TENERA		1															1													
ORIDORSALIS UMBONATUS																														
PARAFISSURINA TECTULOSTOMA																														
PLACOPSILINELLA AURANTIACA																														
PLANULINA WUELLERSTORFI		1			10																									
PSEUDONODOSARIA cf. TORRIDA																														
PULLENIA BULLOIDES		8		2												8	1	1	1	4				13	4				5	2
PULLENIA OSLOENSIS		1																	1	1	2	1								2
PULLENIA QUINQUELOBA		1																												
PYRGO COMATA																														
PYRGO MURRHYNA																								1	1					
PYRGO SUBSPHAERICA																														
PYRULINA ANGUSTA																														
PYRULINA FUSIFORMIS																														
PYRULINA SP. 1																														
QUINQUELOCULINA SP.																														
RECURVOIDES CONTORTUS																				1					2					
REOPHAX BACILLARIS																														
REOPHAX DENTALINIFORMIS				15																									1	
REOPHAX DIFFLUGIFORMIS*1		3		1	10											3	1			1	1			1	4				1	
REOPHAX FUSIFORMIS																														
REOPHAX GUTTIFER																														
REOPHAX SPP. FRAGMENTS																						1								
RHABDDAMMINA cf. IRREGULARIS																														
RHABDAMMINA LINEARIS																														
RHIZAMMINA cf. ALGAEFORMIS		1																												
SIPHOTEXTULARIA CATENATA																	1	2	3	1					2		3	3	1	2
SPIROPLECTAMMINA BIFORMIS																														
STETSONIA MINUTA				2																										
STILOSTOMELLA SP. cf. ANTILLEA																														1
TEXTULARIA GRACILLIMA																			X											
TOLYPAMMINA VAGANS																														
TOSAIA HANZAWAII		1														2		1	X											
TRIFARINA ANGULOSA					10														X		1							1		
TRILOCULINA OBLONGUM		1		2																									X	
TRILOCULINA TRICARINATA		1		2												1									2				X	
TROCHAMMINA MALOVENSIS					10																	1								
TROCHAMMINA OCHRACEA																				1										
TROCHAMMINA PUSILLA																	1	2	X	1	2	1								
TROCHAMMINA SQUAMATA GR.																	X	1	X	2		1			3	2		1	5	2
UVIGERINA ASPERULA		7		2												16	6	4	3	9		3	8	9	8		6	4	10	4
UVIGERINA PEREGRINA		10		5												11	30	7	21	34	1	20	35	40	15	2	14	14	40	17
UVIGERINA SPINICOSTATA		10		5									83			6	X	1							2					
VALVULINERIA SP. cf. ARCTICA				3															X	2	5	1				5	3	3	2	3
VIRGULINA FUSIFORMIS*2																X	1	1	1											
VIRGULINA SUBDEPRESSA																	1	2		1										

SPECIES / DEPTH IN CORE (CM)	410-412	420-422	430-432	440-442	450-452	459-461	470-472	480-482	490-492	500-502	510-512	520-522	530-532	538-540	550-552	560-562	570-572	580-582	589-591	600-602	610-612	620-622	630-632	640-642	651-653	659-661	669-671	678-680	687-689	697-699
Total Benthics	496	282	1824	351	40	1	10	5	86	61	1292	15	14	420	8	28	72	181	13	16	6	7	0	2	41	20	119	1360	229	55
ADERCOTRYMA GLOMERATA	2	1	1	1	5				2	2			7	3	25	7	3	2									4	3	2	
ALVEOPHRAGMIUM RINGENS																														
AMMOBACULITES AGGLUTINANS																														
AMMOMARGINULINA FOLIACEA																														
ASTACOLUS CREPIDULA																														
ASTRAMMINA SP.																														
ASTRONONION GALLOWAYI																												X		
ASTRORHIZA cf. CRASSATINA																														
BOLIVINA AFF. EARLANDI	5	6	4	5					11	8	4			2	12	3		26							2		3	2	7	20
BOLIVINA INFLATA	1																													
BOLIVINA PSEUDOPLICATA																														
BOLIVINA PSEUDOPUNCTATA		9	5	12			10		2	5	4			16		3		4				14			27	25	8	3		
BOLIVINA PYGMACEA																														
BOLIVINA STRIATULA																														
BOLIVINA SUBAENARIENSIS	2		X							2	X			1													1	X	X	
BOLIVINA SUBSPINESCENS	1	1																												
BUCCELLA FRIGIDA																														
BULIMINA ALAZANENSIS																														
BULIMINA GIBBA	1	1																												
BULIMINA NOTOVATA																														
BULIMINA STRIATA																														
BULIMINELLA ELEGANTISSIMA																														
CASSIDULINA LAEVIGATA	2	1	15						2		14						7	3										1		2
CASSIDULINA RENIFORME	25	18	36	15	30		50	20	43	49	44	53	50	21		25	64	40	69	75	100	29		50	29	15	31	12	50	42
CHILOSTOMELLA OOLINA																														
CIBICIDES LOBATULUS		1		X						1				1				X								5	3	2		
CIBICIDES ROBERTSONIANUS																														
CRIBROSTOMOIDES SCITULUM																														
CRIBROSTOMOIDES SUBGLOBOSA		3		X																									1	
CRIBROSTOMOIDES WEISNERI																		X									2	X		
CYCLAMMINA CANCELLATA																														
CYSTAMMINA PAUCILOCULATA																														
DENDROPHYRA ARBORESCENS																														
DENTALINA INORNATA BRADYENSIS	X															3	1											X		
DISCOPULVINULINA BERTHELOTI																														
EGGERELLA SP.																														
ELPHIDIUM EXCAVATUM FORMA CLAVATA	X	1	1						2	2	1			1														1		
E. EXCAVATUM FORMA CLAVATA (glacial)	13	2	4		5						7		14	2		7				25		29		50	7	5	2	3	3	7
EPISTOMINELLA EXIGUA			2								1						1								5			X		
EPISTOMINELLA TAKAYANAGII	4	3	2	4				40		3	2		7	1													2	2		
EPISTOMINELLA UMBONIFERA		1		X			10					7			25												2	1		
EPONIDES BRADYI	2	2	3	2							2			2														3		5
FISSURINA SPP. (all)			1								X																		X	
FURSENKOINA CONCAVA	4	3	1	2			10			2	2		7	4	13	4		1									3	2		
GLOBOBULIMINA AURICULATA											X																	X		
GLOMOSPIRA CHAROIDES																														
GYROIDINA ORBICULARIS																														
GYROIDINA SOLDANI																														
GYROIDINA SP.				X																										
HAPLOPHRAGMOIDES BRADYI																														
HAPLOPHRAGMOIDES SPHAEROLOCULUM				1	2																							2	X	
HETEROHELIX CF. AMERICANA	4	4	1							5	2			1	25	14									5		5	1	2	
HYPERAMMINA ELONGATA																														
ISLANDIELLA NORCROSSI	2	2	4	1				20		1	2			2														1	1	
KARRERIELLA APICULARIS																												1		
KARRERIELLA BRADYI																														
KARRERIELLA NOVANGLIA																														
LAGENA SPP. (all)			1	1																								X		
LARYNGOSIGMA HYALASCIDIA																														
MARGINULINA OBESA																														
MARTINOTTIELLA COMMUNIS		1																												
MARTINOTTIELLA NODULOSA																														
MELONIS POMPILIODES		1		1														X										X		
MILIOLA SP.																														
NODOSARIA ALBATROSSI																														
NONION BARLEEANUM																							3							
NONION DEPRESSULUS																														
NONION GRATELOUPI		1	7	3					4		1																	1		
NONIONELLA ATLANTICA																														
NONIONELLA TURGIDA																												1		
NONIONELLINA LABRADORICA	2	1	4	3					4		3	20		1			3					14			2		4	1	1	2
OOLINA SPP. (all)	1		1	X												4														
OPHTHALMIDIUM PUSILLA																														
ORIDORSALIS TENERA				1					1		1																			
ORIDORSALIS UMBONATUS																														
PARAFISSURINA TECTULOSTOMA																														
PLACOPSILINELLA AURANTIACA																														
PLANULINA WUELLERSTORFI																														
PSEUDONODOSARIA cf. TORRIDA																														
PULLENIA BULLOIDES		4	X	1										1													3	1		
PULLENIA OSLOENSIS				1					7																			1	5	18
PULLENIA QUINQUELOBA				1					1	2																		X		
PYRGO COMATA																												X		
PYRGO MURRHYNA																														
PYRGO SUBSPHAERICA																														
PYRULINA ANGUSTA																														
PYRULINA FUSIFORMIS																														
PYRULINA SP. 1																														
QUINQUELOCULINA SP.																														
RECURVOIDES CONTORTUS				1	3	100																						1		
REOPHAX BACILLARIS																														
REOPHAX DENTALINIFORMIS																														
REOPHAX DIFFLUGIFORMIS*1				1														1										1	X	
REOPHAX FUSIFORMIS																														
REOPHAX GUTTIFER																														
REOPHAX SPP. FRAGMENTS																														
RHABDDAMMINA cf. IRREGULARIS																														
RHABDAMMINA LINEARIS																														
RHIZAMMINA cf. ALGAEFORMIS																														
SIPHOTEXTULARIA CATENATA	3		1	1							1																	1		
SPIROPLECTAMMINA BIFORMIS			X										7					X										1	6	2
STETSONIA MINUTA																												X		
STILOSTOMELLA SP. cf. ANTILLEA																														
TEXTULARIA GRACILLIMA																		1												
TOLYPAMMINA VAGANS																														
TOSAIA HANZAWAII																														
TRIFARINA ANGULOSA																											1			
TRILOCULINA OBLONGUM				1					1	2								1							2			X	X	
TRILOCULINA TRICARINATA	X		1	1					2		X					4		X							2		2	X	X	
TROCHAMMINA MALOVENSIS																														
TROCHAMMINA OCHRACEA				1														1										X		
TROCHAMMINA PUSILLA		1			8																						3			
TROCHAMMINA SQUAMATA GR.	2															4											2	3		
UVIGERINA ASPERULA	2	9	2	8	7				4	5	2	20	7	8		4	3								5			8	4	2
UVIGERINA PEREGRINA	11	14	2	25	40		10			2				28		11	18	6	8							45	1	24	1	
UVIGERINA SPINICOSTATA				X																										
VALVULINERIA SP. cf. ARCTICA	3	4		4			10	20	14	10	4			2		7		15	23			14			10	5	15	11	12	
VIRGULINA FUSIFORMIS*2	6	2		X							1			1				X							2				1	
VIRGULINA SUBDEPRESSA	1										1			1														1		

SPECIES / DEPTH IN CORE (CM)	708-710	718-720	728-730	738-740	747-749	758-760	771-773	783-785	792-794	802-804	812-814	822-824	832-834	840-842	853-855	870-872	885-887	903-905	919-921	931-933	946-948	960-962	974-976	985-987	995-997	1010-1012	1028-1030	1044-1046	1055-1057	1068-1070
Total Benthics	67	6	66	18	370	109	609	85	16	282	18	215	35	79	51	26	42	61	117	13	12	10	42	19	15	89	28	28	11	4
ADERCOTRYMA GLOMERATA					4	4	1				17	7		5		11							10							
ALVEOPHRAGMIUM RINGENS																														
AMMOBACULITES AGGLUTINANS																														
AMMOMARGINULINA FOLIACEA																														
ASTACOLUS CREPIDULA										3																				
ASTRAMMINA SP.																														
ASTRONONION GALLOWAYI						1				1																				
ASTRORHIZA cf. CRASSATINA																														
BOLIVINA AFF. EARLANDI	5			5	6	2	3	2		2		3	6	4		4	14	3	3		8		5				11			
BOLIVINA INFLATA					1							1																		
BOLIVINA PSEUDOPLICATA																														
BOLIVINA PSEUDOPUNCTATA	3			5	3	3	2	4		1		X		3						8				10						
BOLIVINA PYGMACEA																														
BOLIVINA STRIATULA							1			1																				
BOLIVINA SUBAENARIENSIS					1		X			1								2												
BOLIVINA SUBSPINESCENS					X		1																							
BUCCELLA FRIGIDA										1		1		5			2	3	3							1				
BULIMINA ALAZANENSIS																														
BULIMINA GIBBA																														
BULIMINA NOTOVATA																														
BULIMINA STRIATA					X																									
BULIMINELLA ELEGANTISSIMA																														
CASSIDULINA LAEVIGATA	1	17	2	6	1	3	2	6	6	5		1	3	1			2	74	2			10	2	11		1			9	
CASSIDULINA RENIFORME	10	33	26	44	18	53	39	46	56	34	66	25	29	34	63	31	64		50	54	58	90	26	42	67	54	43	61	46	25
CHILOSTOMELLA OOLINA																			3											
CIBICIDES LOBATULUS					1		1	1	6	X		X		1																
CIBICIDES ROBERTSONIANUS																														
CRIBROSTOMOIDES SCITULUM																														
CRIBROSTOMOIDES SUBGLOBOSA																														
CRIBROSTOMOIDES WEISNERI					X																									
CYCLAMMINA CANCELLATA																														
CYSTAMMINA PAUCILOCULATA																														
DENDROPHYRA ARBORESCENS																														
DENTALINA INORNATA BRADYENSIS					X			1															2							
DISCOPULVINULINA BERTHELOTI							X																							
EGGERELLA SP.																														
ELPHIDIUM EXCAVATUM FORMA CLAVATA	2	17	1	6	X							1							1	23										
E. EXCAVATUM FORMA CLAVATA (glacial)		33			3	2	2	5	13	11		2	6		8	4			2		17		5	21	7			4	18	
EPISTOMINELLA EXIGUA					1		1	9	6	2		1	6	8		23							14	5				21		
EPISTOMINELLA TAKAYANAGII			5		3	2	2	4		2	6	2	6																	
EPISTOMINELLA UMBONIFERA					2																									
EPONIDES BRADYI					1		X	2		1		1		5	4			3	3							2				
FISSURINA SPP. (all)					X		X			2			3										2							
FURSENKOINA CONCAVA	2						1			X	6	2				4														25
GLOBOBULIMINA AURICULATA					X		1			X																				
GLOMOSPIRA CHAROIDES																														
GYROIDINA ORBICULARIS																														
GYROIDINA SOLDANI																														
GYROIDINA SP.												X																		
HAPLOPHRAGMOIDES BRADYI					X																									
HAPLOPHRAGMOIDES SPHAEROLOCULUM							1					1																4		
HETEROHELIX CF. AMERICANA					X					1				1	2															
HYPERAMMINA ELONGATA																														
ISLANDIELLA NORCROSSI			3		1		1	4		4	6								2		8					2			9	
KARRERIELLA APICULARIS																														
KARRERIELLA BRADYI																														
KARRERIELLA NOVANGLIA																														
LAGENA SPP. (all)							X																							
LARYNGOSIGMA HYALASCIDIA																														
MARGINULINA OBESA																														
MARTINOTTIELLA COMMUNIS																														
MARTINOTTIELLA NODULOSA																														
MELONIS POMPILIODES																														
MILIOLA SP.																														
NODOSARIA ALBATROSSI																														
NONION BARLEEANUM																														
NONION DEPRESSULUS																														
NONION GRATELOUPI							1			2		1																		
NONIONELLA ATLANTICA										2																				
NONIONELLA TURGIDA					10																									
NONIONELLINA LABRADORICA						2	3			5		2		6			2	3	3						7					
OOLINA SPP. (all)										1		1																		
OPHTHALMIDIUM PUSILLA																														
ORIDORSALIS TENERA																														
ORIDORSALIS UMBONATUS																														
PARAFISSURINA TECTULOSTOMA																							2							
PLACOPSILINELLA AURANTIACA																														
PLANULINA WUELLERSTORFI																														
PSEUDONODOSARIA cf. TORRIDA																														
PULLENIA BULLOIDES			2																											
PULLENIA OSLOENSIS	6				2		2			3		2																		
PULLENIA QUINQUELOBA																														
PYRGO COMATA																														
PYRGO MURRHYNA																														
PYRGO SUBSPHAERICA							X																							
PYRULINA ANGUSTA																														
PYRULINA FUSIFORMIS																														
PYRULINA SP. 1																													9	
QUINQUELOCULINA SP.										1				1																
RECURVOIDES CONTORTUS																														
REOPHAX BACILLARIS																														
REOPHAX DENTALINIFORMIS																														
REOPHAX DIFFLUGIFORMIS*1																														
REOPHAX FUSIFORMIS																														
REOPHAX GUTTIFER																														
REOPHAX SPP. FRAGMENTS																														
RHABDDAMMINA cf. IRREGULARIS																														
RHABDAMMINA LINEARIS																														
RHIZAMMINA cf. ALGAEFORMIS																														
SIPHOTEXTULARIA CATENATA																														
SPIROPLECTAMMINA BIFORMIS	31		3		19	5	16					10	9	4	4								7			3				
STETSONIA MINUTA							X																							
STILOSTOMELLA SP. cf. ANTILLEA																														
TEXTULARIA GRACILLIMA					1																									
TOLYPAMMINA VAGANS																														
TOSAIA HANZAWAII																														
TRIFARINA ANGULOSA																														
TRILOCULINA OBLONGUM					1	2	1			1									3				5			1		4		
TRILOCULINA TRICARINATA	2				1		X												3				5				4			
TROCHAMMINA MALOVENSIS																														
TROCHAMMINA OCHRACEA			2		1					2																2				
TROCHAMMINA PUSILLA					1							1																		
TROCHAMMINA SQUAMATA GR.																														
UVIGERINA ASPERULA	8		24		3	2	X	4	13			3	11	4	8			3	1				5			1				
UVIGERINA PEREGRINA	10		21	28	11	4	X					12	23		10		2		9	15	8				13	28	36	7		50
UVIGERINA SPINICOSTATA																														
VALVULINERIA SP. cf. ARCTICA	21		12	6		16	16	13		10		18		18		23	12	8	14				10	11	7	3	7		9	
VIRGULINA FUSIFORMIS*2					X		1								2															
VIRGULINA SUBDEPRESSA												1																		

SPECIES / CORE NO.	79-002-13	79-002-50	80-004-65	79-002-51	79-002-12	79-002-52	82-022-84B	80-004-13	81-016-07	81-016-06	82-022-83B	81-016-05	82-022-82B	80-004-14	81-016-04	81-016-03	82-022-80B	81-016-02	81-016-01	82-022-79B	82-022-78g	82-022-78p	82-022-77B	82-022-76B
DEPTH (METRES)	2000	2000	2120	2200	2205	2400	2487	2500	2500	2750	2750	2995	2996	3050	3247	3500	3543	3880	3985	4030	4046	4046	4495	4925
Total Benthics	2700	3040	2562	1419	910	2165	2600	2584	4416	1148	3200	767	2208	1931	2376	11872	1864	163	6144	3184	3536	772	68	140
ADERCOTRYMA GLOMERATA															X					2				2
ALVEOPHRAGMIUM RINGENS										X	1	X							X		1		1	
AMMOBACULITES AGGLUTINANS			X				1				3	5	2	1	3	2	1	2			1	2	1	
AMMOMARGINULINA FOLIACEA												1	1			1	1	1	1	3		1		
AMMOSCALARIA TENUIMARGO		X																						
ASTACOLUS CREPIDULA																		1						
ASTRAMINA SP.									X			X			X			1		X	2			
ASTRORHIZA cf. CRASSATINA			1							1		2			2	9		1	1		1			
BOLIVINA AFF. EARLANDI													X											
BOLIVINA INFLATA																						X		
BOLIVINA PSEUDOPLICATA		X																				X		
BOLIVINA PSEUDOPUNCTATA				X						X							1		X			X		
BOLIVINA PYGMACEA																						X		
BOLIVINA STRIATULA			X							X														
BOLIVINA SUBSPINESCENS	X			X																				
BULIMINA ALAZANENSIS											X													
BULIMINA GIBBA			X													X								
BULIMINA NOTOVATA				X																				
BULIMINA STRIATA	1	4	2	2	2	4	1	2	X	1														
CASSIDULINA LAEVIGATA	X		X																		X	2		
CASSIDULINA RENIFORME			X																		X	1		
CHILOSTOMELLA OOLINA			X	X	X				1	2		1	2		X	X			1			X		
CIBICIDES LOBATULUS	X		X	1	X				1		1	2	2	1	2	3	4	6	3	1	3	5		
CIBICIDES ROBERTSONIANUS										1	1	1		1	X	1	X		2	3	X			
CRIBROSTOMOIDES SCITULUM			X	X			1				X	1	1	1	X	X	1	1			1			1
CRIBROSTOMOIDES SUBGLOBOSA	X						1			X	2	2	1		1	1	1	2		1		X		
CR!BROSTOMOIDES WEISNERI												1	1	1	1	1		1	2			X		
CYCLAMMINA CANCELLATA							X					X									X			
CYSTAMMINA PAUCILOCULATA			X	1			X	1		1	1	1		2	X				1				1	3
DENDROPHYRA ARBORESCENS	X	X					6				4		1			X								9
DENTALINA INORNATA BRADYENSIS				X				X		X	X	1			X	X		1			1	X		
EGGERELLA BRADYI									X	X		X												
EGGERELLA PROPINQUA											X	X												
ELPHIDIUM EXCAVATUM FORMA CLAVATA	69	44	38	39	81	40	19	58	35	21	X	2	X	1						1		3		
E. EXCAVATUM FORMA CLAVATA (glacial)																						2		
EPISTOMINELLA EXIGUA		X	X			X		X		X				2	5	1	1	4	9		5	3		1
EPISTOMINELLA UMBONIFERA			X		X					1	4	X	5		X	2	17	25	25	60	53	41	22	18
EPONIDES BRADYI				X			4	X						3	1	X		1	X					
FISSURINA SPP. (all)	X		X	1	X	1	X	1	2	2	X	1	1	2	X	1	2	1	3		1	X		1
FURSENKOINA CONCAVA	1	8	6	9	X	4	6	8	19	2	4	X	4	2	3	X		2	1			1		
GLOBOBULIMINA AURICULATA	1	2	7	2	1	1	2	1	X	1	2	1			1								3	
GLOMOSPIRA CHAROIDES		X	X	X	X			X		X	X	1			X	X		1	1					
GYROIDINA ORBICULARIS	X		X	X	X	2							2	3	2	1	1	1	4					
GYROIDINA SOLDANI		X	X	X	X	1			1	2	2	3	3	2	6	3	5	1	1					
HAPLOPHRAGMOIDES BRADYI												X			1	1			X					
HAPLOPHRAGMOIDES SPHAEROLOCULUM			X	X			1	X	1	X	4	1	1	1	X	1	5	2	1		2	1		
HOEGLUNDINA ELEGANS				1	X	8	4	1	3	9	8	6	9	3	7	3	12		1	X				
HORMOSINA GLOBULIFERA							1			1	X	1	1				X							
HYPERAMMINA ELONGATA	X			2			5		3	12	16	27	10	7	11	32	8	14	12	13	9	5		1
ISLANDIELLA NORCROSSI																						2		
KARRERIELLA APICULARIS			X								X	1	2	1	X	1			X	1	X	X		
KARRERIELLA BRADYI										1	1	2	1	1	1	X	1		X					
KARRERIELLA NOVANGLIA											X	X												
LAGENA SPP.		X	X	1	X	1	X	X		1		X	1	3	X				1					
LARYNGOSIGMA HYALASCIDIA							1				1													
LENTICULINA ANGULATA					X				X	X		1												
MARGINULINA OBESA																					X			
MARTINOTTIELLA COMMUNIS																X								
MARTINOTTIELLA NODOSA																		1						
MELONIS POMPILIODES						1	1		1	2	X	1	2	1	2	2		2	1		X	3		
NODOSARIA ALBATROSSI		X				X	X			X														
NONION BARLEEANUM		X		X		1	2		1	1	1	1	1	2	2	X			2	1	2	X		
NONION DEPRESSULUS			1	1	X	2	1	1	3	1	X	1	1	3			X			X				
NONIONELLA ATLANTICA														X										
NONIONELLINA LABRADORICA																						1		
NONION GRATELOUPI	X	X	X						1									1	X					
OOLINA SPP. (all)					X			X	X	2		X		2	1		1		1					
OPHTHALMIDIUM PUSILLA																		1						
ORIDORSALIS TENERA	1		1	1	1	2		2	3	2	4	1	6	4	7	3	3	1			1	1		
ORIDORSALIS UMBONATUS			X	1	X	1		1	1	1	1		3	2	4	1	1	1	1			2	4	
PARAFISSURINA TECTULOSTOMA	X			X	X	X	1				1	X		X										
PLACOPSILINELLA AURANTIACA				X							1	2		1	2	3			1			1		
PLANULINA WUELLERSTORFI		X		X				1	1	2	2	2	3	2	2	4	7	5	3	1	1	X	2	
PSAMMOSPHAERA PARVA																			X					
PSEUDONODOSARIA cf. TORRIDA			X																X					
PULLENIA BULLOIDES		X	X	X	1	3		X	1	1	4	X	2	2	1			3	2			1		
PULLENIA OSLOENSIS				X	X	X			X			X		1	1	X	1				X	1		
PULLENIA QUINQUELOBA	X	X	1	1	X	1	3		1	X	2	X	3	3	5	2	1	2	1			2		1
PYRGO COMATA										X														
PYRGO MURRHYNA	X				X	1				1	2	1	4			1	4	2	2	2	1	1	8	1
PYRGO SUBSPHAERICA						X	X												1		X			
PYRULINA ANGUSTA					X				X			X			1	X								
PYRULINA CYLINDROIDES											1			X	X			1						
RECURVOIDES CONTORTUS		X	X	X	X		2	X		1	3	3	1	2	3	2	3		2	2	1	X		
REOPHAX BACILLARIS										1	1	1	3	2	1	1	2	1	X	1	1			
REOPHAX DENTALINIFORMIS		1					1					1	X			X								
REOPHAX DIFFLUGIFORMIS*1	1	2	2	1	X	2	1	2	1	2	1	2	2	1	1	1	2	1	1		1		27	29
REOPHAX FUSIFORMIS	X		X	X				1	X	X		1			X						X			
REOPHAX GUTTIFER			1					X	X							X								
REOPHAX SPP. FRAGMENTS	X		2	X	X	1	2	1	X		1	1		2	3	1		1	1	3	2	X		
RHABDAMMINA cf. IRREGULARIS							4		6	1	5	2	4		1		3	1	2				2	
RHABDAMMINA LINEARIS				X			1				1	1			X		1		1					
RHABDAMMINA SCABRA	X	X	1	X			1	X	1	1	3	3	3	11	3	4	2	1	X			6	1	
RHIZAMMINA cf. ALGAEFORMIS												1										1		
RHIZAMMINA INDIVISA	4	12	7	9	1	6	13	9	X	1	3	2	4	9	1	1	5	2	1				6	24
SACCORHIZA RAMOSA					X							X												
SIGMOILOPSIS SCHLUMBERGERI	X			X		1	1	2	1	5	3	2	X	2	1	1	1							
SIPHOTEXTULARIA CATENATA													1		X			1						
SPIROPLECTAMMINA BIFORMIS															X	X								
STETSONIA MINUTA									1			X							X					
TECHNITELLA LEGUMEN																								1
TOLYPAMMINA VAGANS				1		X			X	2	5	3		6	2	3						X		
TOSAIA HANZAWAII	1	2		1	X	2		1			X	X			1	X		1	1		1	2		
TRIFARINA ANGULOSA		X	1	X	X	X			1	1			1	X										
TRILOCULINA OBLONGUM													1											
TRILOCULINA TRICARINATA	X		1	1		X	2		1	1	1		3		1	1		1	1		X			1
TROCHAMMINA BULLATA												X												
TROCHAMMINA MALOVENSIS						X				1	1	2		1		X	1			2	X		3	4
TROCHAMMINA OCHRACEA															1									
TROCHAMMINA PUSILLA															1	X			X					
TROCHAMMINA SQUAMATA GR.						X					1	X	1	2	1	2		1	1	3	1			3
UVIGERINA ASPERULA								X											X			4		
UVIGERINA PEREGRINA							5						X									3		
UVIGERINA SPINICOSTATA	19	25	21	21	9	6	6	4	5	2							X				2	3		
VIRGULINA FUSIFORMIS*2		X		X				X	2	X		X		X	X				X			X		
VIRGULINA SUBDEPRESSA									1															

GSC