QUATERNARY FORAMINIFERAL BIOSTRATIGRAPHY OF THREE SHALLOW GEOTECHNICAL BOREHOLES, BALMORAL, COHASSET AND PANUKE WELLSITES, WESTERN SABLE ISLAND BANK

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ABSTRACT

One hundred and twenty-three floated samples were analysed for Quaternary benthic and planktonic foraminifera and reworked (Cretaceous / Tertiary) foraminifera from three geotechnical boreholes on Sable Island Bank, Scotian Shelf; 37 from the Cohasset, 43 from the Balmoral and 43 from the Panuke well sites. Fifteen distinct assemblages have been recognized, all believed to be Quaternary in age and contained in Quaternary sediments. These 15 assemblages are: (1) E. excavatum - E. bartletti shelf fauna; (2) E. excavatum - I. helenae - C. teretis - reworked component; (3) E. albiumbilicatum - E. excavatum - reworked component; (4) E. excavatum - E. bartletti / albiumbilicatum; (5) E. excavatum - B. frigida - Brizalina spp. - reworked component; (6) low numbers; (7) E. excavatum - Epistominella spp. - Brizalina spp. - reworked component; (8) E. excavatum; (9) E. excavatum - C. reniforme - B. frigida - reworked component; (10) Epistominella spp. - E. excavatum - I. algida - reworked component; (11) E. excavatum - E. sandiegoensis - B. frigida - B. borealis; (12) E. excavatum - E. sandiegoensis - Quinqueloculina spp.; (13) Epistominella spp. - Brizalina spp. - reworked component; (14) reworked component; and (15) H. concentrica - C. subhaidingerii - reworked component.

Downhole in Balmoral the sequence is: assemblage 1 (0-17 m), assemblage 2 (17-28 m), assemblage 3 (28-29 m), assemblage 4 (29-33 m), assemblage 2 (33-38 m), assemblage 5 (38-40 m), assemblage 8 (40-41 m), assemblage 6 (41-44 m), assemblage 7 (44-46 m), assemblage 8 (46-47 m) and assemblage 6 (50-90 m).

Downhole in Cohasset the sequence is: assemblage 1 (3-16 m), assemblage 4 (16-19 m), assemblage 9 (19-20 m), assemblage 4 (20-25 m), assemblage 10 (25-26 m), assemblage 4 (26-30 m), assemblage 3 (30-33 m), assemblage 5 (33-35 m), assemblage 11 (35-40 m), assemblage 12 (40-43 m), assemblage 11 (43-44 m), assemblage 6 (44-67 m), assemblage 13 (72-73 m), assemblage 6 (81-85 m), assemblage 13 (87-90 m) and assemblage 6 (90-91 m).

Downhole in Panuke the sequence is: assemblage 2 (1-2 m), assemblage 1 (2-13 m), assemblage 2 (13-23 m), assemblage 4 (23-27 m), assemblage 3 (27-28 m), assemblage 5 (28-31 m), assemblage 4 (31-32 m), assemblage 11 (32-46 m), assemblage 12 (48-49 m), assemblage 8 (49-50 m), assemblage 14 (50-51 m), assemblage 13 (52-53 m), assemblage 14 (53-73 m), assemblage 15 (73-74 m), assemblage 14 (74-100 m) and assemblage 13 (100-101 m).

The faunal assemblages show strong correlation to seismo-stratigraphic events and distinct lithologic units. The trough and cross-bedded sands contain assemblages 1 and 4 and were formed in the last 10,000 years under modern marine conditions. The conformably bedded sand formed 10,000 to 11,000 YBP under heavy ice cover (assemblages 2, 4 and 9) attributed to the Younger Dryas event. The channel gravel member formed during the Late Wisconsinan low sea level stand (-110 m), 11,000 to 13,000 YBP (assemblages 2, 3, 4 and 10) in tidal channels and due to shelf sediment reworking during and after the transgression. The acoustic reflector R_1 is recognized in this unit. The upper stratified sand / fines formed in open marine shelf conditions, warmer than present day (assemblages 2, 4 and 5) from 13,000 - 28,000 YBP. The barren gravelly / sand formed during the late Mid-Wisconsinan low sea level stand (-98 m) from 28 - 32,000 YBP (assemblages 6, 7, 11 and 12) under conditions similar as the channel gravel member. The acoustic reflector R_2 is recognized within this unit. The lower stratified sand / fines were reworked (assemblages 6, 8, 11, 12 and 14) to

become barren (assemblage 6), due to subaerial exposure / ice cover during the Mid-Wisconsinan advance.

Quaternary sediments, stratigraphically underlying R_3 and the Scotian Shelf Drift, have been sampled. These sediments contain assemblages 6, 13, 14 and 15. These sediments have been identified as part of the Laurentian Formation. The formal designation of the Laurentian Formation has been modified to exclude the upper sediments previously designated to five Formations (Sable Island Sand and Gravel, La-Have Clay, Sambro Sand, Emerald Silt and Scotian Shelf Drift) by King (1970).

INTRODUCTION

The Scotian Shelf is characterized by central shelf basins and outer shelf banks. Studies of Quaternary paleo-oceanography have concentrated on basin sediments, which are as much as 250 m deep and contain a well-developed sequence of stratified, fine-grained sediments representative of the sequence of Late Quaternary depositional environments (King and Fader, 1986).

By contrast, little has been done on the outer banks. The most prominent of the outer banks are Sable Island Bank and Banquereau. They are as much as 100 km wide and fringe the shelf edge. The banks are demarcated by the 120 m isobath, have an average depth of 60 m and are emergent at Sable Island (Amos and Knoll, 1987). These outer banks are areas of erosion and the coarser texture makes it difficult, if not impossible, to sample using conventional piston coring techniques. Added to this is the notion that the upper sediments on the banks are the products of reworked glacial debris and thus represent a condensed and incomplete record of Late Quaternary sedimentation (Amos and Knoll, 1987).

The outer Scotian Shelf, particularly the area around Sable Island, has been an area of active petroleum exploration for the past 25 years. The surficial geology of the banks has been mapped acoustically by King (1967), King and MacLean (1970), MacLean and King (1971), Drapeau and King (1972), Jacques, McClelland Geosciences, inc. (1982), Boyd et al. (1988) and McLaren (1988). On the basis of seismic profiles, these authors proposed that the banks are underlain by a continuous layer of sand and gravel of Holocene age, formed by reworking of glacial and glaciomarine sediments.

Geotechnical sampling of the top 100 m of sediment was common, but it was rarely analyzed for stratigraphic characteristics. In 1983, a co-operative research effort between industry and government resulted in the correlation and interpretation of the Late Pleistocene-Holocene depositional environment on Banquereau (Amos and Knoll, 1987). This interpretation was based on regional and site-specific high resolution seismic profiles, multichannel seismic profiles, sub-bottom profiles and subsamples recovered from five boreholes. Miller and Scott (1984) studied the benthic foraminifera in two of these boreholes (at the Louisburg site) and Miller (1989) examined the foraminifera in selected intervals of two other boreholes (at the East and South Griffin sites). On Sable Island Bank, Scott et al. (1983), Ruffman et al. (1985) and Jacques, McClelland Geosciences, inc. (1985a) completed the early studies of Quaternary sea level changes and Quaternary micropaleontology.

A 152 m continuously sampled drillhole, completed for Dalhousie University under contract to Jacques, MacClelland Geosciences, Inc. (1985a) has been analyzed stratigraphically (McLaren and Boyd, 1987; Boyd et al., 1988; Scott et al., 1989). Quantitative micropaleontological data from this hole, however, is not available, as the foraminifera were only analyzed qualitatively (McLaren and Boyd, 1987; Boyd et al., 1988; Scott et al., 1989).

In 1985 and 1987, government and industry (Jacques, McClelland Geosciences, inc. and Petro-Canada Ltd.) embarked on another co-operative project; which resulted in government involvement in the drilling of industry boreholes at three sites on Sable Island Bank; the Cohasset, Como and Panuke well sites (Jacques, McClelland Geosciences, inc., 1985b, 1986, 1987a, 1987b). The G.S.C. contracted Marine G.E.O.S. to quantitatively analyze samples from these boreholes for foraminfera (Miller, 1987a, 1987b) and Amos and Miller (1990) utilized the results of these studies, plus additional

vibrocores and high resolution seismic reflection records to reconstruct the stratigraphy of the topmost 50 m of the sedimentary column of southwest Sable Island Bank.

In 1990 Lasmo N.S. Ltd. carried out an extensive borehole and in situ testing program on western Sable Island Bank. The Geological Survey of Canada was invited to participate in the sampling program in order to extend their data base and further resolve the age, depositional environment and engineering physical properties of the seismo-stratigraphic units (Christian and Zevenhuizen, 1990). The G.S.C. subsequently contracted Marine G.E.O.S. (DSS Contract No. 23420-10-M248/01-OSC) to quantitatively analyze samples from three of these boreholes at the Panuke, Balmoral and Cohasset well sites. This report is a compilation and interpretation of the foraminifera from these three boreholes.

PREVIOUS WORK

PRE-QUATERNARY GEOLOGY

The bedrock geology of the Scotian Shelf has been extensively studied, reported on and well summarized (King, 1980; King and Fader, 1986). Cretaceous rocks overlie Pennsylvanian and older rocks and form the bedrock beneath part of the Laurentian Channel and much of the shelf north of Sable Island (King and MacLean, 1976). Rocks of Cretaceous age have been dredged north of Sable Island and Sable Island Bank (King and MacLean, 1970; King et al., 1970). Tertiary strata unconformably overlie the Cretaceous rock and forms the bedrock underlying the outer Scotian Shelf. These strata thicken seaward. MacLean and King (1971) include in this unit all material overlying the Cretaceous strata and underlying recognizable Pleistocene deposits; and this may include early Pleistocene material. Oligocene and Miocene material have been found out-cropping in The Gully (Scotian Shelf) (Marlowe, 1965, 1969; Marlowe and Bartlett, 1967). There have been several cycles of erosion (some of which were subaerial) since deposition of the Cretaceous strata, particularly during the Late Cretaceous and Early Tertiary, causing deposition of Tertiary strata upon an eroded Cretaceous surface. Another period of subaerial erosion took place following deposition of Tertiary strata and prior to the onset of Pleistocene glaciation (MacLean and King, 1971). These erosional surfaces are a major controlling factor in the topography of the shelf today (MacLean and King, 1971).

QUATERNARY GEOLOGY

Seismo-stratigraphically the surficial geology (upper 150 m) of Sable Island Bank is characterized by an upper and lower unit separated by a prominent regional, gently southward dipping reflector (R_1) (Amos and Knoll, 1987; Amos and Miller, 1990; Christian and Zevenhuizen, 1990). Previously collected vibrocore and borehole sample data indicates that this is a sand unit that coarsens upwards in up to three distinct cycles. The lower unit has a smooth upper surface marked by the regional reflector R_1 (Amos and Knoll, 1987). This unit consists of well-defined, southward dipping, parallel reflectors, locally dissected by a series of complex, deep (>400 m) infilled incisions in places interpreted to represent a channel network (Boyd et al., 1988). The seismic character of these channels indicate a complex depositional history with possible multiple channel incision and depositional events (Christian and Zevenhuizen, 1990).

The upper unit was first mapped by King (1970) as the Sable Island Sand and Gravel Formation. James and Stanley (1968) considered these sediments to be relict material derived as glacial outwash during the Pleistocene era. King (1970) interpreted them to be post-glacial sands reworked from glacial deposits laid down during the Late Wisconsinan / Holocene transgression of the Scotian Shelf (King and Fader, 1986). McLaren (1988) subdivided the unit into five distinct facies; the upper two facies are interpreted to be of Holocene age, associated with Late Wisconsinan glacial deposition. Amos and Miller (1990) and Amos and Nadeau (1988) subdivided the upper unit into three members: the trough bedded sand, the cross-bedded sand and the conformably bedded sand on Sable Island Bank. The first two members are interpreted to have formed during post-transgressional, open (ice-free) water conditions during the Holocene. On Sable Island Bank, the conformably bedded sand is correlated with the Younger Dryas event (11,000 to 10,000 YBP) (Amos and Miller, 1990), described by

Mott et al. (1986). These units were correlated in age to those described by Amos and Knoll (1987) on Banquereau, with the base of R_1 attributed to the Late Wisconsinan transgressive lag of King (1970). Overall, the sequence on Banquereau was interpreted by Amos and Knoll (1987) to be associated with sand ridge genesis and so generally substantiated the conclusions of King (1970).

Disagreement over sea level low stands affects the interpretation placed on the origins of both the upper and lower units (Christian and Zevenhuizen, 1990). Scott et al. (1989), using foraminiferal and numerical modelling data of Quinlan and Beaumont (1981), infer a maximum low stand during the late Wisconsinan of -78 m. Amos and Miller (1990), using foraminiferal data and the well documented terraces and sedimentological characterisitics discussed by Fader (1989), places the maximum low stand at -110-120 m. Amos and Miller (1990) also discuss an earlier low stand at -98 m based predominantly on a sea level curve reconstructed from foraminiferal, grain shape, texture and seismo-stratigraphic data (Christian and Zevenhuizen, 1990).

The lower unit was mapped by King (1970) as the Emerald Silt Formation. It is a pro-glacial, Middle to Late Wisconsinan marine deposit (King and Fader, 1986), underlying Banquereau (Amos and Knoll, 1987) and Sable Island Bank (Amos and Miller, 1990). On Sable Island Bank Amos and Miller (1990), subdivided the Emerald Silt Formation into four members: the channel gravel, the upper stratified sand / fines, the barren gravelly / sand and the lower stratified sand / fines. The channel gravel is correlated with channel formation during the Late Wisconsinan low stand of sea level. It is capped by an overconsolidated clay layer deposited during transgression of the bank. The upper stratified sand / fines is characterized by open marine conditions at the top and nearshore conditions at the base. The barren gravelly / sand is a tidal channel deposit formed during the late Mid-Wisconsinan low stand of sea level of the Digby Stade (Grant and King, 1984). The lower stratified sand / fines is interpreted as glacio-marine in origin, deposited beneath an ice shelf (Brodzikowski and Van Loon, 1987).

On Banquereau, Amos and Knoll (1987) recognized the same four units, though the lower stratified sand / fines was recognized only acoustically beneath the maximum depth of sampling. The barren gravelly / sand member is traceable throughout Banquereau and is correlated with a Late Wisconsinan glacial advance and lowering of sea level ca. 28,000 to 32,000 YBP. The channel gravel and transgressive erosional surface separate the Emerald Silt Formation from the overlying Sable Island Sand and Gravel. Amos and Knoll (1987) consider it to have formed under fluvial conditions associated with the Late Pleistocene to Early Holocene subaerial exposure of Banquereau which took place ca. 8,000 to 16,000 YBP. Based on the foraminiferal content (Miller and Scott, 1984), the Emerald Silt Formation occurs at or very close to the surface on western Banquereau (at the Louisburg site). There is no accumulation of post-transgressive sediments.

There are conflicting views on the thickness, origin and designations of the Quaternary stratigraphic units on the Scotian Shelf. Subsequent to the work of King (1970), Jansa and Wade (1975) designated the Laurentian Formation as encompassing all Quaternary sediments on the Scotian Shelf; overlying the Banquereau Formation and including the glacial drift and stratified pro-glacial material of King (1970), but making no mention of reworked, post-transgressive sediments. Williams (1975) immediately fol-lowed this designation. Dinoflagellate evidence of Williams (1975) and stratigraphic evidence of L.F. Jansa (1988, personal communication to Amos and Miller, 1990) suggest that the majority of the sequence was deposited under non-marine conditions. Magnusson (1973) and Smith (1973), by contrast, interpreted it as marine in origin.

Wade and MacLean (1990), continue to use (sensu Jansa and Wade, 1975) the designation "Laurentian Formation" for all Quaternary sediments, making no mention of the units of King (1970). However, Hardy (1975), in her work on the Banquereau Formation, designates all material overlying the Banquereau to the formations of King (1970), with no mention of the Laurentian Formation. Piper (in Piper et al., 1990) also uses the terminology of King (1970), modified by King and Fader (1986). Hardy (1975) and Piper (in Piper et al., 1990) then, do not formally recognize any Quaternary sediments underlying the Scotian Shelf Drift. However, Hardy (1975) puts the top of the Banquereau Formation at 262 m, this contact was sampled in the Mobil C-67 well on Sable Island. Scott et al. (1989, p. 113), state that MacKinnon and Gradstein (unpublished data) have re-examined samples from C-67 for foraminifera and put the top of the Pliocene (and therefore the base of the Quaternary) at 220 m based on the first appearance of Astigerina guruchi. Consequently, there appears to be a zone of Quaternary sediments underlying the Scotian Shelf Drift and overlying the Banquereau Formation that have never been formally designated, named or described.

Boyd et al. (1988) and Scott et al. (1989) have concentrated their efforts on determining the origin of the deeply incised infilled channel complex. The presently proposed model amongst the various workers seems to be that these features form at or under margins of ice sheets (Boyd et al., 1988; Scott et al., 1989; Wingfield, 1990) by catastrophic meltwater discharge events (Christian and Zevenhuizen, 1990).

MICROPALEONTOLOGY

Detailed previous work on the micropaleontology of the Quaternary sediments will be outlined in the discussion, as it becomes pertinent to the comparison with the results of this study.

Until recently, it has been difficult to interpret the Quaternary foraminifera on the Scotian Shelf because little was known about modern assemblages living there today. Bartlett (1964) and Barbieri and Medioli (1969) carried out reconnaissance studies of total assemblages only on the inner and western portions of the shelf. Williamson (1982, 1983) and Williamson et al. (1984) completed a comprehensive study of both living and total assemblages to present day water masses. This modern data set now provides a data base to compare with fossil assemblages. Medioli et al. (1986) have studied the recent (surficial) distribution of foraminifera around Sable Island and on Sable Island Bank. The area west of the island, on the west bar, is virtually barren of foraminifera, probably due to oceanographic conditions.

Amos and Miller (1990) have provided the baseline study for this work. Miller (1987a, 1987b) examined 108 samples from the previously drilled boreholes at Cohasset (30 samples over 46 m), Como (29 samples over 37 m) and Panuke (49 samples over 61 m) for Quaternary benthic and planktonic and reworked (Cretaceous/Tertiary) foraminifera. Utilizing this data, Amos and Miller (1990) defined 9 assemblages (and 5 sub-assemblages) which showed strong correlation trends to lithologic changes and seismic events. Each assemblage is diagnostic of a distinct environment of deposition and is correlated with the stratigraphic members (Amos and Miller,1990; Figures 9, 10, 11). The assemblages are: (1) E. subarcticum - C. subhaidingerii, modern, low numbers, high energy, open marine bank; (2) E. excavatum - E. subarcticum, modern, low numbers, moderate energy, outer estuarine/inner shelf; (3) E. excavatum - C. reniforme - Epistominella spp. high numbers (QB), low diversity (3) or high diversity (3A), post-glacial / ice-influenced (high salinity), with a reworked component; (4) E. exca-

vatum - C. reniforme - I. helenae high numbers (QB) (4A) or low numbers (QB) (4B) post-glacial / ice-influenced (low salinity), with a reworked component; (5A) E. excavatum - C. reniforme - Epistominella spp. high numbers, temperate, shallow open marine, warm water component; (5B) barren of fauna; (6) E. excavatum - B. frigida or E. excavatum - Epistominella spp. low number (QB) (6A) or high numbers (QB) (6B) cold water, open (ice-free) marine, inner shelf / outer estuarine; (7) E. excavatum - C. reniforme - B. frigida - C. subhaidingerii high numbers, cold water, shallow open marine, with a reworked component; (8) E. excavatum low number, cold water glaciomarine, with a reworked component; (9) E. excavatum - E. subarcticum - G. wrightii low numbers or low diversity (9A) open marine / shallow bank to inner shelf.

Downhole these assemblages occur in the following sequence: Cohasset: assemblage 1 (0-12 m), assemblage 2 (12-18 m), assemblage 3A (18-28 m), assemblage 7 (28-33 m), assemblage 5A (33-44 m) and assemblage 8 (44-46 m). In the Como borehole the sequence is: assemblage 2 (0-13 m), assemblage 4A (13-20 m), assemblage 4B (20-25 m), assemblage 3 (25-31 m), assemblage 7 (31-35 m) and assemblage 9 (36 m). In the Panuke borehole the sequence is: assemblage 2 (0-9 m), assemblage 3A (9-11 m), assemblage 4B (11-19 m), assemblage 9 (19-24 m), assemblage 9A (24 m), assemblage 5A (24-29 m), assemblage 5B (29 m), assemblage 6A (29-46 m), assemblage 6B (46-54 m), assemblage 7 (54-60 m) and assemblage 8 (60 m).

The faunal assemblages show strong correlation to seismo-statigraphic and distinct lithologic units (Amos and Miller, 1990). The trough bedded and cross-bedded sand contain assemblages 1 and 2 and were formed in the last 10,000 years under modern marine conditions. The conformably bedded sand formed 10,000 - 11,000 YBP under heavy ice cover (assemblages 3, 3A, 4A and 4B) attributed to the Younger Dryas event. The channel gravel member formed during the Late Wisconsinan low sea level stand (-110 m), 11,000 - 13,000 YBP (assemblages 3, 7 and 9) in tidal channels and due to shelf sediment reworking during and after transgression. The acoustic reflector R_1 is recognized in this unit. The upper stratified sand / fines formed in open marine shelf conditions, warmer than present day (assemblage 5A), from 13,000 - 28,000 YBP. The barren gravelly / sand formed during the late Mid-Wisconsinan low sea level stand (-98 m) from 28,000 - 33,000 YBP (assemblages 6A and 9) under conditions similar to the deposition of the chanel gravel member. The lower stratified sand / fines were reworked (assemblages 6B, 7 and 8) and in some intervals became barren (assemblage 5B) due to subaerial exposure / ice cover / during the Mid-Wisconsinan advance.

Earlier studies completed on boreholes on Banquereau at Louisburg (Miller and Scott, 1984) and East and South Griffin (Miller, 1989), revealed similar assemblages but occurring in different sequences. Miller and Scott (1984) examined 21 samples over 42 m in BH4 and nine samples over 14 m in BH5 at Louisburg; and Miller (1989) looked at the intervals 19-47 m (7 samples) at East Griffin (BH7) and from 13-27 m (4 samples) at South Griffin (BH6). One new assemblage appeared at Louisburg, a bank fauna, assemblage 10, characterized by low numbers and dominated by Glabratella wrightii. At Louisburg (BH4) the sequence is: assemblage 5A (0-10 m), assemblage 5B (10-12 m), assemblage 8 (12-17 m), assemblage 10 (17-24 m) assemblage 6A (24-38 m) and assemblage 8 (38-42 m). In BH5 the sequence is: assemblage 5A (7-14 m). At East Griffin the sequence is: assemblage 5B (19-27 m), assemblage 3A (31-35 m) and assemblage 8 (35-47 m). At South Griffin the sequence is: assemblage 2 (13 m), assemblage 5A (13-17 m), assemblage 9 (17-21 m) and assemblage 7 (21-27 m). (However, this is based on only four samples.)

Assemblages 1 and 2 are absent at the Louisburg site on Banquereau (Miller and Scott, 1984), indicating that the Emerald Silt Formation is at or near the surface on Banquereau. There is no accumulation of post-transgressive sediments on western Banquereau. Though post-transgressive late glacial faunas (assemblages 3/3A or 4A/4B) are present stratigraphically straddling R_1 on Sable Island Bank (Amos and Miller, 1990), they are absent at both Louisburg boreholes and at South Griffin (Miller and Scott, 1984; Miller, 1989). These assemblages may be present directly underlying R_1 at East Griffin (Miller, 1989).

The barren interval, assemblage 5B, straddles R_2 in the Panuke and East Griffin boreholes. The regional reflector (R_2) is interpreted as the upper surface of the barren gravelly / sand member deposited during the Late Wisconsinan low stand of sea level 28,000-32,000 YBP (Amos and Miller, 1990).

Generally, the foraminiferal faunas reflect changes in sea level, water depth, temperature, salinity and meltwater influx.

BOREHOLE LOCATIONS

All three borehole locations are on western Sable Island Bank. One boring was drilled at the Balmoral drill site (B1) at 43° 51' 54.8" N and 60° 35' 46.8" W in 35 m of water. Two borings were drilled at the Cohasset drill site, though only boring one was studied; this boring (C1) was drilled at 43° 50' 58.1" N and 60° 37' 41.6" W in 43.6 m of water. Two borings were drilled at the Panuke drill site; P1 at 43° 48" 41.3" N and 60° 44' 01.8" W, P2 at 43° 48' 40.1"N and 60° 44' 00.0" W in 43.6 to 44.7 m of water.

METHODS

LABORATORY METHODS

Samples for biostratigraphic analysis were collected separately on site (Christian and Zevenhuizen, 1990). For a complete listing of all subsamples taken consult Christian and Zevenhuizen (1990). Micropaleontological subsamples were collected by A.G.C. personnel, placed in plastic vials and covered with a solution of sea water and $CaCl_2$ buffer (to balance the pH and prevent dissolution) and refrigerated at 4°C until processing. Samples were processed by A.G.C. personnel by wet sieving with 500 and 63 micron stainless steel sieves. The 63 - 500 micron fraction was retained and air dried, or dried overnight in a 30°C oven. Samples were supplied at this point. Original wet volumes / weights were not known but were estimated to be approximately 50 cc in size. All washed samples less than 50 cc in size were then subjected to a flotation procedure. A 50 cc portion was taken from those samples larger than 50 cc. Foraminifera were then concentrated by adding the sample to a 10:4 solution of bromoform and acetone (Gibson and Walker, 1967), which separated the foraminfera by flotation. The separation took place in about one minute after which the float was washed into filter paper, rinsed with acetone and dried.

ANALYTICAL METHODS AND IDENTIFICATION OF FORAMINIFERA

One hundred and twenty-three floated samples were analyzed for Quaternary benthic and planktonic foraminifera and reworked (Cretaceous / Tertiary) foraminifera; 37 samples from Cohasset, 43 from Balmoral, 43 from Panuke. Some samples (26 from Balmoral, 8 from Panuke) were dry sieved into two fractions (63 -125 microns, 125 - 500 microns) and each fraction split and picked by Atlantic Paleo. Services. The remaining samples were counted directly from the floats, without picking. Those samples containing abundant foraminifera were dry split with a microsplitter. Between 200-400 Quaternary benthic specimens (when present) and the accompanying Quaternary planktonic and reworked foraminifera were subsequently identified and counted. The faunal reference list is given in Appendix A. One major problem was encountered and that was in determining which component of the fauna (Quaternary or reworked) that many benthic genera belonged to. This became especially difficult in the 50-100 m interval in the Panuke borehole. Initially, all species were assumed to be Quaternary and identified by a Quaternary species name, except for those species known to have become extinct before the Quaternary. These extinct species were usually well known Cretaceous species and identified as such (ie. species of Heterohelix, Gumbelitrea, Gavelinella, Praebuliminia and Pyramidina). Consequently, the original assumption was made that all reworked material was Cretaceous in age. Genera that had not yet evolved in the Cretaceous were then taken to be Quaternary. However, in looking at the Quaternary assemblage, in some samples some discrepancies arose. Genera were appearing together that are not known to occur concurrently in modern environments. Generally they have different depth distributions. Invariably these samples contained a large "known" (i.e. Cretaceous) reworked component. The two most common deeper water genera appearing to be incongruous with their accompanying Quaternary fauna were the Gyroidina / Gyroidinoides and Uvigerina. Samples containing these two genera were re-examined and recounted to include these two groups within the reworked, rather than the Quaternary fauna. (This isn't strictly true for the Uviger-

iniids. At the base of Cohasset, Uvigerina is included in the indigenous, rather than the reworked fauna. However, these samples may be older than Pleistocene (see section on Interpretation). This also led to the conclusion that some of the reworked material is Tertiary in age. Deeper in the boreholes, distinct Tertiary species appeared (i.e. Caucasina elongata) which were attributed to the reworked fauna.

Rare specimens of Eponides were identified in some samples. Eponides is inconsistent with both the identified Quaternary fauna (based on its depth distribution) and the identified reworked fauna (based on its first appearance in the Eocene). Some specimens were present in samples with no other reworked component. As a result, Eponides was assigned to the Quaternary fauna.

In the 45-90 m interval, both Balmoral and Cohasset were largely barren of foraminifera. However, the Panuke borehole contained a poorly preserved fauna in the 50-100 m interval. Initially this fauna was believed to contain Quaternary and reworked components. The fauna determined to be Quaternary was inconsistent within itself and difficult to interpret. These samples (P2-15 through to P1-30) in this interval were re-examined and recounted with the new assumption that all specimens were reworked except for those which could be immediately and easily identified as "expected" Quaternary species. Due to the poor state of preservation, it was impossible to identify some specimens further than to the genera level. Some specimens of Cibicides in particular couldn't be identified to species level. Cibicides evolved in the Cretaceous; Cibicides is consistent with both the Quaternary fauna and the reworked component. Consequently, the specimens tentatively assigned to Cibicides couldn't be assigned to either the Quaternary or reworked fauna. They have been left as indeterminant.

Species are usually identified by the most common or frequently used name in the reference literature. Another problem occurring throughout the literature has been the custom to employ distinct names for species found in sediments of different ages, even if the specimens appear to be identical and therefore conspecific. The species of Hoeglundina is attributed to (Cretaceous) H. supracretacea (reworked fauna). It appears to be similar to, if not conspecific with, the Quaternary species H. elegans. For simplicity, the species of Uvigerina have been identified by their Quaternary names. This is not meant to imply that they are believed to be Quaternary in age.

Both Quaternary and Cretaceous names have been used to identify the species of Lenticulina. Almost all specimens of Lenticulina are attributed to the reworked fauna, except for an isolated specimen in the upper section of Cohasset.

Most reworked planktonic foraminifera are planispiral (i.e. Globigerinoides) and are easily distinguished from modern forms. Identification of Quaternary planktonic foraminifera was confirmed or corrected by either Dr. G. Vilks or Mr. B. Deonarine at A.G.C.

Representative specimens of all species (from the unpicked samples) were placed on key slides. Samples are curated at A.G.C., B.I.O. Dartmouth.

For each sample, the (sample) number, (sample) depth, size of the (sample) split, number of foraminifera in each category (QB, QP and reworked) counted, relative species abundances for the QB species, and actual counts of QP and reworked specimens by species, are listed on Tables 1 (Balmoral), 2 (Cohasset) and 3 (Panuke).

OBSERVATIONS

BALMORAL BOREHOLE:

Downhole in Balmoral the sequence is: assemblage 1 (0-17 m), assemblage 2 (17-28 m), assemblage 3 (28-29 m), assemblage 4 (29-33 m), assemblage 2 (33-38 m), assemblage 5 (38-40 m), assemblage 8 (40-41 m), assemblage 6 (41-44 m), assemblage 7 (44-46 m), assemblage 8 (46-47 m) and assemblage 6 (50-90 m).

Assemblage 1: E. excavatum - E. bartletti shelf fauna

Assemblage 1 occurs in samples B1-1 to B1-12, from 0-17 m. There are very low numbers (<23) of QB specimens. The dominant species is E. bartletti. Also present is E. excavatum and other cold water shelf species: C. subhaidingerii, C. reniforme and C. teretis. There are no QP specimens and no reworked specimens present.

Assemblage 2: E. excavatum - I. helenae - C. teretis - reworked component.

Assemblage 2 occurs two times in this borehole, in samples B1-13 to B1-19, from 17-28 m and samples B1-24 to B1-26, from 33-38 m. There are moderate to high numbers of QB specimens. The fauna is dominated by E. excavatum (37-67%). The sub-dominant species is I. helenae (1-30%). Also present are: C. teretis, B. frigida (2-6%), E. bartletti (1-8%) and Haynesina orbiculare (1.5-7%). Minor species occurrences include: C. reniforme, Cassidulina teretis, Cibicides spp., and Melonis barleeanum. There are almost no planktonics (QP) present except in the bottom two samples. There are low numbers of reworked specimens, increasing to very large numbers in sample B-18 (1344 specimens).

Assemblage 3: E. albiumbilicatum - E. excavatum - reworked component.

Assemblage 3 occurs in sample B1-20, at 28-29 m. There are very high numbers of very well preserved QB species. The fauna is dominated by E. albiumbilicatum (42%). Sub-dominant is E. excavatum (26%). Also present are B. frigida, C. reniforme, Cibicides spp., Epistominella spp., Fissurina spp., H. orbiculare, Miliolinella spp. and Oolina spp. The QP fauna is represented exclusively by N. pachyderma left and right coiled.

Assemblage 4: E. excavatum - E. bartletti / albiumbilicatum.

Assemblage 4 occurs in samples B1-21 to B1-23 from 29-33 m. There are moderate numbers of QB foraminfera (247-676 specimens). The assemblage is dominated by E. excavatum (55.5-64%). Sub-dominant species are C. subhaidingerii (3-4%), E. albiumbilicatum (4.5-9%), E. bartletti (5-8.5%), I. helenae (2.5-6%) and Q. seminula (5-8%). There are no QP specimens and very few reworked specimens present.

Assemblage 5: E. excavatum - B. frigida - Brizalina spp. - reworked component.

Assemblage 5 occurs in one sample (B1-27, 38-40 m). It is a high diversity QB fauna. In addition to E. excavatum, B. frigida, Cibicides spp. there is the first appearance of Brizalina spp. There are also cold water planktonics present and there is a very large reworked component.

SAMPLE NO.	B1-1	B1-2	B1-3	B1-4	B1-5	B1-6	B1-7	B1-8	B1-9	B1-10	B1-11	B1-12	B1-13	B1-14	B1-15	B1-16	B1-17	B1-18	B1-19	B1-20	B1-21	B1-22
DEPTH	0.32-	1.64-	3.19-	4.61-	6.15-	7.65-	9.00-	10.53-	12.07-	13.58-	15.10-	16.63-	18.05-	19.60-	21.10-	22.64-	24.10-	25.50-	27.00-	28.50-	30.23-	31.50-
	0.39	1.67	3.21	4.64	6.17	7.68	9.03	10.54	12.10	13.62	15.15	16.64	18.11	19.65	21.15	22.72	24.15	25.54	27.04	28.55	30.26	31.76
TOTAL NO. OF QUAT. BENTHICS	11	/	22	23	13	4	/	2	/	2	/	16	153	83	248	489	32	610	404	4632	247	331
SPLIT COUNTED	/	/	/	/	/	/	/	/	/	/	/	/	/	/		/	/	/	/	1/8	/	/
Eggerella advena	P																					
Silicosigmoilina groenlandica																						
Trochammina ochracea	D		P																			
Astacolus hyalacrulus																						
Astrononion hamadaense																		X	1.0			
Brizalina albatrossi																						
Brizalina lowmani																						
Brizalina mexicana																						
Brizalina spathulata																						
Brizalina subaenariensis																						
Buccella calida			P										X							2.0		
Buccella depressa																				X	X	
Buccella frigida														2.0	X	3.0		5.0	6.0	3.5	2.5	1.0
Buccella tenerrima													X					X				
Bulimina aculeata/marginata															X	X		2.0	X		X	
Bulimina affinis																						
Bulimina striata																						
Buliminella basicostata																						
Buliminella borealis																			X			
Cassidulina laevigata																						
Cassidulina reniforme			P					P					X	1.0	1.0	1.0	P	2.0	3.5	6.0	1.0	X
Cassidulina teretis				P									5.0		4.0	2.0		2.0				X
Cassidulina sp. A																						
Cibicides corpulentus													1.5		X			X	X		X	2.0
Cibicides floridanus				P										1.0			P	2.0		1.0		
Cibicides io												P	2.0		1.0	1.0				1.5	X	1.5
Cibicides lobatalus																			X			
Cibicides subhaidingerii			C			P						C	2.0	6.0	1.5	2.0	P	4.5	1.5	2.0	4.0	3.5
Cibicides umbonatus													1.5			2.5		1.0				
Cibicides wullerstorfi													X					X				
Dentalina guttifera																X						
Ehrenbergina trigona																						
Elphidium albiumbilicatum	P		P	P												1.0		1.5	3.5	42.0	4.5	6.0
Elphidium bartletti	P		D	D	P								7.0	5.0	3.0	3.0	C	2.0	2.5	5.0	5.0	8.5
Elphidium excavatum			C	C	D	C				P		C	44.5	43.0	48.0	57.0	D	64.0	66.0	26.0	64.0	60.0
E. excavatum galvestonensis														7.0	2.0							
E. excavatum gunteri													X									
Elphidium groenlandicum												D	2.5				P					
Elphidium subarcticum																				X		
Eoeponidella pulchella			P											1.0								
Epistomineila arctica																				1.0		
Epistominella sandiegoensis																		2.5	2.0	1.0	X	X
Epistominella takayanagii						P						P								1.5		
Eponides tumidulus																						
Fissurina annectans																				X		
Fissurina marginata																			X	X		
Fursenkoina fusiformis					P																	
Gavelinopsis praegeri																						
Glabratella lauriei																				1.0		
Glabratella wrightii										P								1.5	X		3.0	2.0
Globobulimina auriculata																			X			
Globobulimina pacifica													X									

Table 1a: Foraminiferal data, samples B1-1 to B1-22 (0-32 m), Balmoral borehole. Relative species abundance data for the Quaternary benthic species (rankings, i.e. D, C or P, given when the number of QB specimens < 75); total numbers given for the Quaternary planktonic and reworked species. X < 15.

SAMPLE NO.	B1-1	B1-2	B1-3	B1-4	B1-5	B1-6	B1-7	B1-8	B1-9	B1-10	B1-11	B1-12	B1-13	B1-14	B1-15	B1-16	B1-17	B1-18	B1-19	B1-20	B1-21	B1-22
Globocassidulina subglobosa																						
Guttulina gracilis																						
Hanzawaia asterizans																						
Hanzawaia concentrica								P														
Haynesina depressula																			X			
Haynesina germanica													X									
Haynesina incertum				P											X				X			
Haynesina orbiculare													7.0	6.0	5.5	6.0	C	4.0	5.0	5.5	1.5	1.0
Islandiella algida													2.0		2.0	2.0	P	1.0	1.0		X	X
Islandiella curvata																						
Islandiella helenae			P		C							P	20.5	28.0	30.0	16.0	C	4.0	1.0		6.0	3.0
Islandiella norcrossi															1.5	1.0						
Islandiella sublimbata																X						
Larynogsigma hyalascidia																				X		
Melonis barleeanum															X	X	P	X				
Miliolinella circularis																				X		
Miliolinella subrotunda				P	P															1.5		2.0
Noinionella basispinata																						
Nonionellina labradorica																			X	X		
Oolina borealis															X	X			X			
Oolina melo																			X			
Oolina striatopunctata																				X		
Oridosalis umbonatus																						
Quinqueloculina arctica	P																					
Quinqueloculina elongata																						
Quinqueloculina seminula					P										X	X			1.0	X	5.0	8.0
Quinqueloculina stalkeri																						
Rosalina globularis																						
Rosalina squamata																					1.0	X
Sigmoidella pacifica																				X		
Stainforthia compressa																						
Trifarina angulosa/fluens																X						
Troculina turbo																						
QUATERNARY PLANKTONICS																						
TOTAL NO./SAMPLE	/	/	/	1	1	/	/	/	/	/	/	/	2	/	1	8	/	14	19	96	/	/
Globigerina bulloides																1		1				
Globigerina quinqueloba																						
-right					1								1		1							
-left																						
Globigerinita glutinata																		1				
Neogloboquadrina atlantica													1									
Neogloboquadrina pachyderma																						
-right																		2	10	16		
-left				1												7		10	9	80		
REWORKED	1	/	/	/	1	1	/	/	2	/	1	6	87	52	159	173	27	1344	148	1408	1	1
ESTIMATED AGE - REW. FAUNA	K				K/T	K/T			K/T		K	K	K	K/T	K/T	K/T	K	K	K/T	K	K	K
Arenobulimina obesa											1				4	1	1					
Clavulinodes aspera																						
Dorothia bullata																						
Dorothia conula															1							
Marssonella oxycona																	1					
Plectina watersi																2						
Reussella spinulosa															1							
Spiroplectammina laevis																1						
Alabamina australis australis																1						

Table 1a: continued.

SAMPLE NO.	B1-1	B1-2	B1-3	B1-4	B1-5	B1-6	B1-7	B1-8	B1-9	B1-10	B1-11	B1-12	B1-13	B1-14	B1-15	B1-16	B1-17	B1-18	B1-19	B1-20	B1-21	B1-22
Alabamina sp. 2																1						
Allomorphina minuta																						
Anomalinoides harperi													4		3	6						
Anomalinoides stephensoni																	2					
Anomalinoides sp.																				32		
Bandyella greatvalleyensis																						
Bolivinita eleyi																1						
Bolivinoides decoratus australis																	1		1			
Bolivinoides decoratus delicatula																						
Brizalina cretosa																						
Brizalina incrassata													1		1	1			1	32		
Buliminella fabilis																1						
Cassidella tegulata																						
Caucasina elongata																						
Ceratobulimina contraria																		1				
Cibicides voltziana															1			1				
Dentalina basiplanata																						
Dentalina catenula																		8				
Dentalina confluens																						
Dentalina crinita																						
Dentalina fallax																						
Dentalina gracilis																						
Dentalina lorneiana																		8				
Dentalina luma																						
Dentalina megalopolitana															1							
Dentalina solvata																1						
Ellipsonodosaria alexanderi																						
Eouvigerina americana																			3	32		
Eouvigerina gracilis																						
Eouvigerina hispida																			4			
Gavelinella ammonoides																1		1				
Gavelinella clemintiana																						
Gavelinella henbesti													2									
Gavelinella kansasensis																						
Gavelinella monterelensis													4	18	45	26	7	23				
Gavelinella nelsoni													1									
Gavelinella pertusa														1	5	13		1				
Gavelinella rubiginosa														2		3		2				
Gavelinella sandidgei													10			3		1				
Gavelinella velascoensis													13		2	1						
Guttulina adherens																	1					
Gyroidinoides depressa															1							
Gyroidinoides diversus															5							
Gyroidinoides nitidus												1	1			2		2	3	32		
Hoeglundina supracretacea					1										2	5	1	14				
Kyphopyxa christeri																						
Lagena apiculata elliptica																		1				
Lenticulina formosa																1						
Lenticulina gibba													1			7						
Lenticulina muensteri														1	1							
Lenticulina oligostegius														1								
Lenticulina orbicularis													3									
Lenticulina peregrina																						
Lenticulina rotulata												2	13	6	21	27	10	14	1			
Lenticulina williamsoni																						
Loxostomoides cushmani																						
Marginulina austinana															3							
Marginulina cretacea														1								
Marginulina silicula														1		1						

Table 1a: continued.

SAMPLE NO.	B1-1	B1-2	B1-3	B1-4	B1-5	B1-6	B1-7	B1-8	B1-9	B1-10	B1-11	B1-12	B1-13	B1-14	B1-15	B1-16	B1-17	B1-18	B1-19	B1-20	B1-21	B1-22
Marginulina taylorana									2													
Marginulina texasensis																			1			
Melonis pompiloides																						
Neobulimina albertensis																1						
Neobulimina sp.																1						
Nodosarella texana																				32		
Nodosaria affinis																						
Nodosaria alternistriata															1							
Nonionella robusta													1									
Osangularia navarroana															1			9	1			
Pandaglandulina sp.																1						
Planulina spissocostata													7	3	2	4	1	1				
Planulina taylorensis															7							
Pleurostomella austinana																			1			
Pleurostomella velascoensis																						
Pleurostomella watersi															1							
Praebulimina carseyae														2	1							
Praebulimina kickapooensis																			4			
Praebulimina reussi													4	2	6	3		24	2	32		
Pseudouvigerina cretacea																						
Pseudouvigerina seligi																						
Pullenia coryelli																		1				
Pullenia jarvisi																		2	32			
Pyramidina referata														1	2	1			56			
Pyramidina rudita																			2			
Pyramidina triangularis																5			1			
Sigmoidella elegantissima															1							
Siphonina prima																1		1				
Stetsioina pommerana													2		3							
Stilostomella consobrina						1																
Stilostomella pseudoscripta														1								
Uvigerina bradyana																						
Uvigerina brunnensis																						
Uvigerina canariensis																			1			
Uvigerina cushmani																1						
Uvigerina hispido-costata														2	5	2			1			
Uvigerina peregrina														1	4	1						
Uvigerina schwageri																						
Valvulineria cretacea																						
Valvulineria umbilicatula															2							
Globorotalites michelinianus												1	15	6	15	38	2	8	8		1	
Globorotalites subconicus																						
Globotruncana sp.													3					1				
Gumbelitrea cretacea	1											1			4	2			24			
Heterohelix globulosa													1	1	4	4			4	96		
Heterohelix pulchra															1							
Planktonics (unidentified)												1	1	2	9	1		11	29	1088		1
COAL FRAGMENTS								--	-											---		
CO3 FRAGMENTS												-					-			-		-
DIATOMS																						
RADIOLARIANS																						
OSTRACODES																				-		

Table 1a: continued.

SAMPLE NO.	B1-23	B1-24	B1-25	B1-26	B1-27	B1-28	B1-29	B1-30	B1-32	B1-33	B1-34	B1-35	B1-36	B1-37	B1-38	B1-39	B1-40	B1-42	B1-45	B1-47	B1-50
DEPTH	33.00-	34.55	36.20-	37.50-	39.20	40.57-	42.05-	43.50-	45.10-	46.50-	50.05-	51.60-	53.00	54.55-	56.10-	57.60-	59.43	62.00-	71.72	77.34	90.00
	33.03	34.60	36.25	37.54	39.25	40.60	42.10	43.57	45.15	46.53	50.10	51.65		54.60	56.13	57.65		62.49			
TOTAL NO. OF QUAT. BENTHICS	676	1342	766	356	1376	709	15	11	6552	317	1	/	16	/	/	/	2	5	1	1	/
SPLIT COUNTED	1/2	1/2	1/2	1/2	1/4	/	/	/	1/8	/	/	/	/	/	/	/	/	/	/	/	/
Eggerella advena																					
Silicosigmoilina groenlandica					X																
Trochammina ochracea																					
Astacolus hyalacrulus					X																
Astrononion hamadaense			X																		
Brizalina albatrossi									1.0												
Brizalina lowmani									X												
Brizalina mexicana					X																
Brizalina spathulata									X												
Brizalina subaenariensis		2.0							1.0												
Buccella calida					1.5	X															
Buccella depressa																					
Buccella frigida	2.5	4.0	4.0	3.5	4.0	2.0		P	10.5	3.5	P										
Buccella tenerrima																					
Bulimina aculeata/marginata		X		1.5	1.0																
Bulimina affinis		X																			
Bulimina striata		X																			
Buliminella basicostata		X																			
Buliminella borealis		2.5	X						X	1.0											
Cassidulina laevigata					X																
Cassidulina reniforme	X		4.5	3.5	3.5	6.0			X	X			P					P			
Cassidulina teretis		4.0	2.0	10.0	1.0	X															
Cassidulina sp. A										X											
Cibicides corpulentus	6.0	5.0	2.5	6.0	4.0	X			1.5												
Cibicides floridanus			X	3.5		X															
Cibicides io	1.0		1.0	5.0	2.0				1.0											P	
Cibicides lobatalus																					
Cibicides subhaidingerii	3.0	4.0	6.0	4.5	6.5	2.0		C	3.0	2.0											
Cibicides umbonatus		4.5	4.5	5.0	4.5																
Cibicides wullerstorfi				X																	
Dentalina guttifera																					
Ehrenbergina trigona			X		1.0																
Elphidium albiumbilicatum	9.0	1.5		1.0	X	X			X												
Elphidium bartletti	8.5	3.0	2.5	4.5	2.5	1.0			3.5	1.0											
Elphidium excavatum	55.5	51.5	56.0	37.0	49.0	70.0	P	C	59.0	84.0			D				P	C			
E. excavatum galvestonensis							D														
E. excavatum gunteri																					
Elphidium groenlandicum						X															
Elphidium subarcticum																					
Eoeponidella pulchella																					
Epistominella arctica																					
Epistominella sandiegoensis		1.5	2.5	1.0	1.0				10.5												
Epistominella takayanagii				1.0	X	3.0		C	3.5	4.0			C								
Eponides tumidulus									X												
Fissurina annectans						X															
Fissurina marginata	X		X																		
Fursenkoina fusiformis		X																			
Gavelinopsis praegeri		X		1.0	X			P	2.0	X			P								
Glabratella lauriei						X															
Glabratella wrightii	1.5					X		C		X								P			
Globobulimina auriculata		X																			
Globobulimina pacifica			X		X																

Table 1b: Foraminiferal data, samples B1-23 to B1-50 (32-90 m), Balmoral borehole. Relative species abundance data for the Quaternary benthic species (rankings, i.e. D, C or P, given when the number of QB specimens < 75); total numbers for the Quaternary planktonic and reworked species. X < 1%.

SAMPLE NO.	B1-23	B1-24	B1-25	B1-26	B1-27	B1-28	B1-29	B1-30	B1-32	B1-33	B1-34	B1-35	B1-36	B1-37	B1-38	B1-39	B1-40	B1-42	B1-45	B1-47	B1-50
Globocassidulina subglobosa		X																			
Guttulina gracilis		X																			
Hanzawaia asterizans				1.5																	
Hanzawaia concentrica	X			1.0	X																
Haynesina depressula																					
Haynesina germanica						1.0															
Haynesina incertum																					
Haynesina orbiculare	1.5	1.5	4.5	2.0	2.0	4.5															
Islandiella algida	X	X	X	2.0	2.0	1.0															
Islandiella curvata		X																			
Islandiella helenae	2.5	3.5	4.5	5.0	7.0	5.5	C			1.0			P				P				
Islandiella norcrossi		2.0	X		X	X															
Islandiella sublimbata																					
Larynogsigma hyalascidia																					
Melonis barleeanum		4.0	1.0		2.0																
Miliolinella circularis	1.0																				
Miliolinella subrotunda						X				X											
Noinionella basispinata									1.0												
Nonionellina labradorica		X	X																P		
Oolina borealis	X																				
Oolina melo																					
Oolina striatopunctata																					
Oridosalis umbonatus			1.0																		
Quinqueloculina arctica																					
Quinqueloculina elongata		1.5																			
Quinqueloculina seminula	5.0					X			X												
Quinqueloculina stalkeri			X																		
Rosalina globularis				X	X																
Rosalina squamata																					
Sigmoidella pacifica		X																			
Stainforthia compressa		X																			
Trifarina angulosa/fluens					X																
Troculina turbo						X															
QUATERNARY PLANKTONICS																					
TOTAL NO./SAMPLE	/	10	16	2	32	4	/	/	320	2	/	/	/	/	/	/	/	/	/	/	/
Globigerina bulloides									8												
Globigerina quinqueloba																					
-right									8												
-left																					
Globigerinita glutinata									32												
Neogloboquadrina atlantica																					
Neogloboquadrina pachyderma																					
-right		4	2	2	24				128	1											
-left		6	14		8	4			144	1											
REWORKED	6	1624	675	508	1404	52	6	1	1424	11	/	/	1	/	3	/	/	2	/	/	/
ESTIMATED AGE - REW. FAUNA	K	K/T	K/T	K/T	K/T	K	K	K	K/T	K			K		K			K			
Arenobulimina obesa																					
Clavulinodes aspera					8																
Dorothia bullata		2			4																
Dorothia conula																					
Marssonella oxycona		4	4																		
Plectina watersi		2																			
Reussella spinulosa																					
Spiroplectammina laevis		20	12		4																
Alabamina australis australis																					

Table 1b: continued.

SAMPLE NO.	B1-23	B1-24	B1-25	B1-26	B1-27	B1-28	B1-29	B1-30	B1-32	B1-33	B1-34	B1-35	B1-36	B1-37	B1-38	B1-39	B1-40	B1-42	B1-45	B1-47	B1-50
Alabamina sp. 2				4																	
Allomorphina minuta		2																			
Anomalinoides harperi	2	4			4										1						
Anomalinoides stephensoni																					
Anomalinoides sp.																					
Bandyella greatvalleyensis		48			4																
Bolivinita eleyi																					
Bolivinoides decoratus australis		10	2		4																
Bolivinoides decoratus delicatula				2																	
Brizalina cretosa		16																			
Brizalina incrassata		34	12	2	20																
Buliminella fabilis		48																			
Cassidella tegulata		2																			
Caucasina elongata			2						32												
Ceratobulimina contraria		4		2	12																
Cibicides voltziana		2																			
Dentalina basiplanata			2		4																
Dentalina catenula					4																
Dentalina confluens		2																			
Dentalina crinita			2		4																
Dentalina fallax					4																
Dentalina gracilis			4	2																	
Dentalina lorneiana				2																	
Dentalina luma															1						
Dentalina megalopolitana																					
Dentalina solvata				4																	
Ellipsonodosaria alexanderi					4																
Eouvigerina americana		36	16		40																
Eouvigerina gracilis			4																		
Eouvigerina hispida																					
Gavelinella ammonoides			4																		
Gavelinella clementiana					12																
Gavelinella henbesti				4																	
Gavelinella kansasensis				2																	
Gavelinella monterelensis		40	108	38	176	4									1						
Gavelinella nelsoni																					
Gavelinella pertusa		28	2	4	20	4															
Gavelinella rubiginosa					4																
Gavelinella sandidgei		100	12	32	72				200												
Gavelinella velascoensis		2		24	4																
Guttulina adherens		4																			
Gyroidinoides depressa																					
Gyroidinoides diversus			12																		
Gyroidinoides nitidus		69	44	56	128				88	1											
Hoeglundina supracretacea		44	40	44	104		1		8	1											
Kyphopyxa christeri		2																			
Lagena apiculata elliptica																					
Lenticulina formosa																					
Lenticulina gibba		2																			
Lenticulina muensteri																					
Lenticulina oligostegius																					
Lenticulina orbicularis																					
Lenticulina peregrina				2	8																
Lenticulina rotulata	2	14	10	16	16	2	1	1													
Lenticulina williamsoni		2																			
Loxostomoides cushmani					12																
Marginulina austinana																					
Marginulina cretacea																					
Marginulina silicula																					

Table 1b: continued.

SAMPLE NO.	B1-23	B1-24	B1-25	B1-26	B1-27	B1-28	B1-29	B1-30	B1-32	B1-33	B1-34	B1-35	B1-36	B1-37	B1-38	B1-39	B1-40	B1-42	B1-45	B1-47	B1-50
Marginulina taylorana																					
Marginulina texasensis				2																	
Melonis pompiloides		2																			
Neobulimina albertensis																					
Neobulimina sp.																					
Nodosarella texana																					
Nodosaria affinis			4						8												
Nodosaria alternistriata																					
Nonionella robusta		4	2						80												
Osangularia navarroana		20	24		28																
Pandaglandulina sp.																					
Planulina spissocostata			30	2	8	4															
Planulina taylorensis																					
Pleurostomella austinana				6																	
Pleurostomella velascoensis					4																
Pleurostomella watersi																					
Praebulimina carseyae		68	12	8	44	1															
Praebulimina kickapooensis																					
Praebulimina reussi		120	58	54	80	8			32	1											
Pseudouvigerina cretacea				2																	
Pseudouvigerina seligi		6	2																		
Pullenia coryelli																					
Pullenia jarvisi		2		4																	
Pyramidina referata		160	52	22	96		2		256	6	1										
Pyramidina rudita																					
Pyramidina triangularis		22	18	16	28				32												
Sigmoidella elegantissima																					
Siphonina prima		8	14	2	16																
Stetsioina pommerana			6	1	16																
Stilostomella consobrina																					
Stilostomella pseudoscripta		2		2	4																
Uvigerina bradyana		1																			
Uvigerina brunnensis		1																			
Uvigerina canariensis		3																			
Uvigerina cushmani				2																	
Uvigerina hispido-costata		5		2	4				72	1											
Uvigerina peregrina			1		4																
Uvigerina schwageri		2			4																
Valvulineria cretacea		8																			
Valvulineria umbilicatula			2																		
Globorotalites michelinianus	2	82	58	36	76		2														
Globorotalites subconicus			2		20																
Globotruncana sp.		4		4																	
Gumbelitrea cretacea		112	8		20				384	1			1					1			
Heterohelix globulosa		200	24	24	108	8			96									1			
Heterohelix pulchra		2																			
Planktonics (unidentified)		182	68	82	180	21			136												
COAL FRAGMENTS	-	- - -				-										-		-			
CO3 FRAGMENTS	-					-							-								
DIATOMS																		-			-
RADIOLARIANS																		-			-
OSTRACODES		-					-														

Table 1b: continued.

Assemblage 8: E. excavatum.

Assemblage 8 occurs in samples B1-28 (40-41 m) and B1-33 (46-47 m). There are moderate to high numbers (317-709) of QB specimens. The assemblage is dominated by E. excavatum (70-84%). There are minor species occurrences of B. frigida (2.0-3.5%), E. takayanagii (3.0-4.0%) and C. subhaidingerii (2.0%). There are low numbers of QP and reworked specimens present.

Assemblage 6: Low numbers.

Samples B1-29 and B1-30 (41-44 m) and B1-34 to B1-40, (50-90 m) are almost barren of foraminifera. E. excavatum f. galvestonensis (?), B. frigida, C. subhaidingerii, E. takayanagii, G. wrightii, are all present. There are no QP specimens and very few reworked foraminifera.

Assemblage 7: E. excavatum - Epistominella spp. - Brizalina spp. - reworked component.

Assemblage 7 occurs in one sample, B1-32 (44-46 m). E. excavatum is dominant (59%); sub-dominant are: Epistominella spp. (14%) and B. frigida (10.5%). Brizalina spp. (3%) is also present. There are large numbers of QP specimens and a large reworked component showing evidence of extensive reworking.

COHASSET BOREHOLE:

Downhole in Cohasset the sequence is: assemblage 1 (3-16 m), assemblage 4 (16-19 m), assemblage 9 (19-20 m), assemblage 4 (20-25 m), assemblage 10 (25-26 m), assemblage 4 (26-30 m), assemblage 3 (30-33 m), assemblage 5 (33-35 m), assemblage 11 (35-40 m), assemblage 12 (40-43 m), assemblage 11 (43-44 m), assemblage 6 (44-67 m), assemblage 13 (72-73 m), assemblage 6 (81-85 m) assemblage 13 (87-90 m) and assemblage 6 (90-91 m).

Assemblage 1: E. excavatum - E. bartletti shelf fauna.

Assemblage 1 occurs in samples C1-3 to C1-11, from 3-16 m downhole. There are very few Quaternary benthic (QB) specimens present. The dominant species is Elphidium excavatum. Sub-dominant species are E. bartletti, B. frigida and I. helenae. There is one Quaternary planktonic (QP) specimen present, of Neogloboquadrina pachyderma left. There are a few reworked specimens present.

Assemblage 4: E. excavatum - E. bartletti / albiumbilicatum.

Assemblage 4 occurs three times in this borehole; in samples C1-12 and C1-13 from 16-19 m, in samples C1-15 to C1-18 from 20-25 m and in samples C1-20 to C1-21 from 26-30 m. Generally there are moderate (<100 specimens) numbers of QB foraminifera; all are very well preserved. The assemblage is dominated by E. excavatum (60%) and sub-dominant are: E. albiumbilicatum (4.5-15.5%), Cassidulina reniforme (7%), Bucella frigida (4-9%) and Epistominella sandiegoensis (1-3%). I. helenae is absent or present in numbers less than 3%. There are low numbers of QP and reworked specimens(<40) in this assemblage. QP specimens are all N. pachyderma.

SAMPLE NO.	C1-3	C1-6	C1-7	C1-9	C1-11	C1-12	C1-13	C1-14	C1-15	C1-18	C1-19	C1-20	C1-21	C1-23	C1-24	C1-25	C1-26	C1-27	C1-28
DEPTH	3.18-	3.73-	9.11-	12.00-	15.11-	16.50-	18.10-	19.68	21.13-	24.41-	25.56-	27.02-	28.74-	31.60-	33.14-	34.65-	36.03-	37.67-	39.14-
	3.20	3.77	9.14	12.04	15.15	16.78	18.20		21.15	24.45	25.63	27.05	28.77	31.65	33.22	34.70	36.05	37.83	39.16
TOTAL NO. OF QUAT. BENTHICS	1	6	5	19	14	193	374	2616	155	37	550	57	356	282	54	654	47	722	200
SPLIT COUNTED	/	/	/	/	/	/	/	1/8	/	/	5/8	/	/	/	/	/	/	/	/
Trochammina ochracea																			
Astrononion hamadaense							X	X											
Brizalina albatrossi																X	P		
Brizalina lanceolata																X		X	
Brizalina lowmani																X			
Brizalina mexicana																			
Brizalina pseudopunctata				P				X						1.0		X			
Brizalina spathulata									X				X			X	P		
Brizalina subaenariensis							X				1.0		X			X			
Buccella calida																			
Buccella depressa						X		X			X								
Buccella frigida	P		P		P	4.0	5.0	9.0	4.0	P	7.0	P	8.5	X		12.0	C	10.5	13.0
Buccella tenerrima																	P		
Bulimina aculeata/marginata						1.0	X	X		P	X					* X			
Bulimina striata								X											
Buliminella borealis								X			1.0					2.5	P	3.0	16.0
Cassidulina reniforme						7.0	9.0	17.0	7.0	P	5.5	P	14.0	2.0	P	2.0	C	2.0	1.0
Cassidulina teretis							1.0		X				X			X		X	
Cassidulina sp. A											2.0					X			
Cibicides corpulentus													X	14.0	P				
Cibicides floridanus								1.0											
Cibicides io								X	1.0		3.0								
Cibicides lobatalus							2.0												
Cibicides subhaidingerii				P		2.0	1.0				2.5		1.0		P	P			X
Cibicides umbonatus				P				X											
Cibicides wuellerstorfi														X					
Cyclogyra borealis											X								
Discorbis nitida						4.5	10.0	9.0	15.5		2.0			53.0	D	8.0			
Elphidium albiumbilicatum		P		P	P	8.5				P		P	5.0		P		C		1.0
Elphidium bartletti		P	D	D	D	56.0	59.5	38.0	46.5	D	25.5	D	55.0	6.5	P	64.0	D	58.5	51.0
Elphidium excavatum													X						
E. excavatum gunteri		P	P																
Elphidium groenlandicum							X							X	P				
Elphidium subarcticum								X				P	X						
Eoeponidella pulchella							X	1.5	3.0	P	9.5	P	2.5			3.5	C	17.0	13.0
Epistominella sandiegoensis											13.5								
Epistominella takayanagii											X					X			
Epistominella vitrea								X		P	3.0								
Eponides tumidulus																		X	
Esosyrinx curta								X											
Fissurina alveolata								X											
Fissurina annectans									X			P					P		
Fissurina marginata					P			1.0			X							X	1.0
Fursenkoina fusiformis											2.5					X			
Gavelinopsis praegeri													X						
Glabratella lauriei						X	X	3.5	7.0			P	1.0	X	P				1.0
Glabratella wrightii									X										
Globocassidulina subglobosa													X			X			
Hanzawaia concentrica								X										X	
Haynesina depressula		P						3.0	X										
Haynesina germanica		P			P	9.5	7.5	1.5	7.0	P	1.0	P	8.5			1.0	P		
Haynesina orbiculare																			

Table 2a: Foraminiferal data, samples C1-3 to C1-28 (3-40 m), Cohasset borehole. Relative species abundance data for the Quaternary benthic species (rankings, i.e. D, C or P, given when the number of QE specimens < 75); total numbers for the Quaternary planktonic and rework-species. X < 1%.

SAMPLE NO.	C1-3	C1-6	C1-7	C1-9	C1-11	C1-12	C1-13	C1-14	C1-15	C1-18	C1-19	C1-20	C1-21	C1-23	C1-24	C1-25	C1-26	C1-27	C1-28
Islandiella algida						1.5	1.5	1.0	2.0		11.0			1.0	P	X	P		
Islandiella helenae		P	P	P	P	2.5	1.5	2.0	X		3.5		X						
Islandiella norcrossi							1.0				2.0								
Lagena gracillima																X			
Lagena hispida								X											
Lagena laevis																		X	
Lagena semilineata							X						X						
Lenticulina gibba											X								
Melonis barleeanum									2.5					10.5	P			1.0	X
Miliolinella subrotunda																			X
Nonionella basispinata																			
Nonionella stella						1.5	X	1.5	X		1.0		X			1.0		X	
Nonionellina labradorica								X											
Oolina apiculeata								X	X										
Oolina borealis								X											
Oolina lineata								X											
Oolina melo											X								
Oridosalis umbonatus								X											
Parafissurina himatiostoma														X					
Pateoris hauerinoides														X				X	
Pyrgo elongata																			
Pyrgo williamsoni																			
Quinqueloculina agglutinata														5.0	P			X	
Quinqueloculina arctica														5.0				X	
Quinqueloculina elongata																			
Quinqueloculina seminula								X					X			X		3.5	
Quinqueloculina stalkeri											X			X					
Rosalina globularis											1.5	P	X			X		X	
Rosalina squamata													X						
Sigmoidella pacifica												P							1.0
Stainforthia concava								X			X	P				X		1.0	1.0
Stainforthia schreibersania																			
Stainforthia skagerakensis							X	X						X					
Trifarina angulosa/fluens																			
Tiriloculina trihedra																			
Uvigerina cnaarensis																			
Uvigerina flintii																			
Uvigerina peregrina																			
QUATERNARY PLANKTONICS																			
TOTAL NO./SAMPLE	/	/	/	/	1	3	2	272	/	3	34	8	10	1	2	79	14	32	4
Globigerina bulloides								8								3	1		
Globigerina quinqueloba																			
-right						1		8			1				1	3			
-left								16							1	1	1		
Globigerinita glutinata								8		1									1
Globigerinita uvula								40		1	11					8		9	2
Neogloboquadrina atlantica																			
Neogloboquadrina pachyderma																			
-right								56			9	3	5	1		38	6	9	
-left					1	2	2	136		1	12	5	5			26	6	14	1
REWORKED	/	/	2	11	5	21	24	2236	38	32	3410	19	39	/	/	52	5	2	/
ESTIMATED AGE			K	K/T	K	K	K	K/T	K	K	K	K	K			K/T	K/T	K	
Gaudryina stephensoni				1		K/T													
Spiroplectammina laevis																			
Astacolus dissonus																			
Bandyana greatvalleyensis								56			24								
Bolivinita eleyi											2								

Table 2a: continued.

SAMPLE NO.	C1-3	C1-6	C1-7	C1-9	C1-11	C1-12	C1-13	C1-14	C1-15	C1-18	C1-19	C1-20	C1-21	C1-23	C1-24	C1-25	C1-26	C1-27	C1-28
Bulimina arkadelphiana midwayensis																1			
Buliminella fabilis																2	1		
Caucasina elongata				1				40											
Chrysalogonium texanum								8											
Dentalina basiplanata																			
Dentalina confluens								8											
Dentalina crinita																			
Dentalina filiformis							1												
Dentalina lorneiana																			
Dentalina megalopolitana																			
Ellipsonodosaria alexanderi																			
Eouvigerina americana				1	1	1		120	2		49	2	5			1			
Eouvigerina excavata								32			5								
Eouvigerina gracilis								16											
Gavelinella sandidgei										1	1								
Gyroidinoides nitidus							1	88		1	22								
Hoeglundina supracretacea					1			16			4		1						
Lenticulina calcar																			
Lenticulina peregrina																			
Lenticulina rotulata																			
Lenticulina wiliamsoni																			
Marginulina bullata																			
Marginulina decorata					1														
Marginulina silicula																			
Nodosaria probiscidea																			
Nonionella robusta													1			9			
Osangularia navarroana											4								
Planulina spissocostata				1															
Pleurostomella watersi								56											
Praebulimina carseyae						1		40			12								
Praebulimina laevis/reussi				3		2	1	240	1	1	53					4			
Pseudoglandulina pygmaea																			
Pseudouvigerina seligi											4								
Pullenia coryelli								8											
Pullenia jarvisi						1						1							
Pyramidina referata					1	4	13	368	6	10	605	4	6			6		1	
Pyramidina triangularis									1		2								
Uvigerina asperula							1												
Uvigerina bradyana								8											
Uvigerina brunnensis																			
Uvigerina canariensis																			
Uvigerina cushmani																			
Uvigerina flintii								8					1						
Uvigerina hispido-costata																2			
Uvigerina peregrina						1													
Valvulineria umbilicatus																			
Globorotalites michelinianus								32		1	7								
Gumbelitrea cretacea						6		752	17	13	723	9	11			14	2	1	
Heterohelix globulosa						4		448	5	3	268	2	2			5	2		
Heterohelix pulchra											5		2						
Heterohelix striata								8											
Planktonics (unidentified)				4	1	1	4	760	6	2	341	1	10			8			
COAL FRAGMENTS	...											.	..			.	.	.	
CO3 FRAGMENTS				.					.						...				
DIATOMS						.													
RADIOLARIANS																			
OSTRACODES									.										

Table 2a: continued.

SAMPLE NO.	C1-29	C1-30	C1-31	C1-32	C1-33	C1-34	C1-35	C1-36	C1-37	C1-39	C1-41	C1-43	C1-44	C1-46	C1-49	C1-50	C1-51	C1-52
DEPTH	40.80-	42.30-	43.68-	45.10-	46.50-	48.00-	49.67-	51.26-	52.55-	55.70-	59.39-	63.84	66.80-	72.38-	81.73-	84.22-	87.62-	90.33-
	40.90	42.34	43.70	45.15	46.53	48.05	49.72	51.32	52.61	55.80	59.42		66.82	72.40	81.75	84.23	87.63	90.40
TOTAL NO. OF QUAT. BENTHICS	662	18400	145	/	46	1	/	1	4	/	5	1	/	207	2	3	1788	22
SPLIT COUNTED	1/2	1/32	/	/	/	/	/	/	/	/	/	/	/	/	/	/	1/4	/
Trochammina ochracea	X																	
Astrononion hamadaense																		
Brizalina albatrossi														15.0			9.0	
Brizalina lanceolata																	10.5	
Brizalina lowmani														7.0		P	4.0	
Brizalina mexicana														1.0				
Brizalina pseudopunctata																		
Brizalina spathulata					P									14.0			1.5	
Brizalina subaenariensis																	12.0	
Buccella calida		1.5																
Buccella depressa		X																
Buccella frigida	14.0	2.5	2.0		C													
Buccella tenerrima																		
Bulimina aculeata/marginata																		
Bulimina striata																		
Buliminella borealis		2.0	1.5		P									X	P	P	2.5	
Cassidulina reniforme	3.0	1.0												X			X	
Cassidulina teretis	X	X																
Cassidulina sp. A																		
Cibicides corpulentus																		
Cibicides floridanus																		
Cibicides io		X												2.5				
Cibicides lobatalus																		
Cibicides subhaidingerii	X		X											X				
Cibicides umbonatus																		
Cibicides wuellerstorfi		X																
Cyclogyra borealis																		
Discorbis nitida																		
Elphidium albiumbilicatum	1.5	2.0	1.5															
Elphidium bartletti		X			P			P	P									
Elphidium excavatum	71.0	73.0	63.5		D	P			D					2.5	P		2.5	
E. excavatum gunteri																		
Elphidium groenlandicum																		
Elphidium subarcticum		X																
Eoeponidella pulchella																		
Epistominella sandiegoensis	2.5	6.0	14.0		P							1.0		16.0		P	8.0	
Epistominella takayanagii		2.0																
Epistominella vitrea																		
Eponides tumidulus		X																
Esosyrinx curta																		
Fissurina alveolata																		
Fissurina annectans	X																1.0	
Fissurina marginata		X																
Fursenkoina fusiformis		X	4.0											1.5			X	
Gavelinopsis praegeri	X	X	X														4.0	
Glabratella lauriei																		
Glabratella wrightii																		
Globocassidulina subglobosa																		
Hanzawaia concentrica																	2 0	C
Haynesina depressula					P													
Haynesina germanica																	1 0	
Haynesina orbiculare																		

Table 2b: Foraminiferal data, samples C1-29 to C1-52 (40-91 m); Cohasset borehole. Relative species abundance data for the Quaternary benthic species (rankings, i.e. D, C or P given when the number of QB specimens < 75); total numbers for the Quaternary planktonic and reworked species. X < 1%.

SAMPLE NO.	C1-29	C1-30	C1-31	C1-32	C1-33	C1-34	C1-35	C1-36	C1-37	C1-39	C1-41	C1-43	C1-44	C1-46	C1-49	C1-50	C1-51	C1-52
Islandiella algida			X											1.5				
Islandiella helenae		X	X															
Islandiella norcrossi																		
Lagena gracillima																		
Lagena hispida																		
Lagena laevis	X		X														X	
Lagena semilineata		X																
Lenticulina gibba																		
Melonis barleeanum		X																
Miliolinella subrotunda	X	X	1.5															
Nonionella basispinata											D			7.0			40.0	C
Nonionella stella	X	1.5																
Nonionellina labradorica	X	1.5	4.0															
Oolina apiculeata																		
Oolina borealis																		
Oolina lineata																		
Oolina melo																		
Oridosalis umbonatus																		
Parafissurina himatiostoma																	X	
Pateoris hauerinoides																		
Pyrgo elongata																		
Pyrgo williamsoni		X																
Quinqueloculina agglutinata		X	X															
Quinqueloculina arctica		X																
Quinqueloculina elongata	1.0	X																
Quinqueloculina seminula	1.0	2.0	1.5															
Quinqueloculina stalkeri																		
Rosalina globularis																		
Rosalina squamata		X	X		P												X	
Sigmoidella pacifica																		
Stainforthia concava			X															
Stainforthia schreibersania		X															X	
Stainforthia skagerakensis		X	X															
Trifarina angulosa/fluens											P							
Tiriloculina trihedra			X															
Uvigerina cnaarensis																	1.0	
Uvigerina flintii														31.0			X	
Uvigerina peregrina																		C
QUATERNARY PLANKTONICS																		
TOTAL NO./SAMPLE	32	576	27	/	2	/	/	2	/	/	/	1	/	/	/	/	1298	/
Globigerina bulloides																	100	
Globigerina quinqueloba																		
-right	2	32	2														1	
-left		32	4															
Globigerinita glutinata		32															416	
Globigerinita uvula	8	160	9									1						
Neogloboquadrina atlantica																		
Neogloboquadrina pachyderma																		
-right	10	192	6		2			2									424	
-left	12	128	6														336	
REWORKED	2	/	/	/	1	1	/	/	/	/	/	8	/	206	1	3	236	20
ESTIMATED AGE	K/T				K	K						K/T		K/T	K	K/T	K/T	T
Gaudryina stephensoni																		
Spiroplectammina laevis																		
Astacolus dissonus																	4	
Bandyana greatvalleyensis																		
Bolivinita eleyi																		

Table 2b: continued.

SAMPLE NO.	C1-29	C1-30	C1-31	C1-32	C1-33	C1-34	C1-35	C1-36	C1-37	C1-39	C1-41	C1-43	C1-44	C1-46	C1-49	C1-50	C1-51	C1-52
Bulimina arkadelphiana midwayensis																	24	
Buliminella fabilis																	4	
Caucasina elongata												2		165			144	16
Chrysalogonium texanum																		
Dentalina basiplanata																		1
Dentalina confluens																		
Dentalina crinita														2				
Dentalina filiformis																		
Dentalina lorneiana														8				
Dentalina megalopolitana														1				
Ellipsonodosaria alexanderi																	4	
Eouvigerina americana																		
Eouvigerina excavata																		
Eouvigerina gracilis																		
Gavelinella sandidgei																		
Gyroidinoides nitidus														1			8	
Hoeglundina supracretacea																		
Lenticulina calcar												1						
Lenticulina peregrina																	20	
Lenticulina rotulata												1					8	
Lenticulina wiliamsoni														1				
Marginulina bullata														1				
Marginulina decorata														1				
Marginulina silicula														1				
Nodosaria probiscidea																		1
Nonionella robusta														5			8	2
Osangularia navarroana																		
Planulina spissocostata																		
Pleurostomella watersi																		
Praebulimina carseyae														2				
Praebulimina laevis/reussi															1			
Pseudoglandulina pygmaea																	4	
Pseudouvigerina seligi																		
Pullenia coryelli																		
Pullenia jarvisi																		
Pyramidina referata												1		5				
Pyramidina triangularis																		
Uvigerina asperula																		
Uvigerina bradyana																		
Uvigerina brunnensis																		D
Uvigerina canariensis																		D
Uvigerina cushmani	1																	
Uvigerina flintii																		
Uvigerina hispido-costata																		
Uvigerina peregrina																		C
Valvulineria umbilicatus																	12	
Globorotalites michelinianus																		
Gumbelitrea cretacea					1	1						1		4				
Heterohelix globulosa														3				
Heterohelix pulchra																		
Heterohelix striata																		
Planktonics (unidentified)												2		6		3		
COAL FRAGMENTS				•	•			•		•	•	•		•		•		•
CO3 FRAGMENTS															•	•		
DIATOMS							•									•		
RADIOLARIANS											•	•	•	• • •	•	•		
OSTRACODES			•															

Table 2b: continued.

Assemblage 9: E. excavatum - C. reniforme - B. frigida - reworked component.

Assemblage 9 occurs in sample C-14 (19-20 m). It is a high number - high diversity assemblage. The occurrence of E. excavatum has dropped to 38%. Secondary occurrences are C. reniforme (14%) and B. frigida (9%). There are many other species present with very minor occurrences: Bulimina spp., Buliminella borealis, Cibicides spp., Fissurina spp., Glabratella wrightii, Haynesina orbiculare, Islandiella spp. and Oolina spp. QP specimens are almost absent except for in sample C1-14 (272). In this sample the QP species present are N. pachyderma left and right coiled, Globigerina bulloides, G. quinqueloba, Globigerinita glutinata and G. uvula. There is a large number (2236) of reworked specimens in this sample.

Assemblage 10: Epistominella spp. - E. excavatum - I. algida - reworked component.

Assemblage 10 occurrs in C1-19 at 25-26 m. It is a high diversity - high number assemblage. E. excavatum (25.5%) and Epistominella spp. (E. takayanagii - E. sandiegoensis) (23%) are co-dominant. Secondary species include I. algida (11%) and B. frigida (7%). There are 34 QP specimens present and a very large reworked component.

Assemblage 3: E. albiumbilicatum - E. excavatum.

Assemblage 3 occurs in samples C1-23 and C1-24, from 30-33 m. It is dominated by E. albiumbilicatum (53%); sub-dominant species is Cibicides corpulentus (14%). Also present are C. reniforme, E. excavatum, Elphidium subarcticum, G. wrightii, Islandiella algida, Miliolinella subrotunda and Quinqueloculina elongata. There are almost no QP or reworked specimens present. All specimens are very well preserved. Sample C1-24 was composed almost entirely of shell fragments and foraminifera.

Assemblage 5: E. excavatum - B. frigida - Brizalina spp. - reworked component.

Assemblage 5 occurs in sample C1-25 at 33-35 m; specimens are very well preserved. It is dominated by E. excavatum (64%); sub-dominant are B. frigida (12%) and E. albiumbilicatum (8%). Also present are five species of Brizalina, C. corpulentus, E. sandiegoensis, Gavelinopsis praegeri, Hanzawaia concentrica, Quinqueloculina stalkeri, Rosalina squamata and Stainforthia concava. The QP fauna is dominated by N. pachyderma left and right coiled; also present are G. bulloides, G. quinqueloba and G. uvula. There are also some reworked specimens present.

Assemblage 11: E. excavatum - E. sandiegoensis - B. frigida - B. borealis.

Assemblage 11 occurs twice in this borehole, in samples C1-26 to C1-28 from 35-40 m and in sample C1-31 from 43-44 m. The fauna is dominated by E. excavatum (51-59%). Sub-dominant are E. sandiegoensis (13 -17%) and B. frigida (10-13%). Also present are B. borealis, C. reniforme, E. bartletti, F. fusiformis, Gavelinopsis praegeri, Miliolinella subrotunda, Nonionellina labradorica, Quinqueloculina spp. and Stainforthia spp. There are low numbers of QP present, dominated by N. pachyderma; and G. uvula and very few reworked specimens present.

Assemblage 12: E. excavatum - E. sandiegoensis - Quinqueloculina spp.

Assemblage 12 occurs in samples C1-29 and C1-30 (40-43 m). There are moderate numbers of QB specimens in sample C1-29. Sample C1-30 was entirely foraminifera and had very high numbers of benthic (18,400) and reworked specimens.

The fauna is dominated by E. excavatum (71-73%). Subdominant are B. frigida (2.5-14%), C. reniforme (1-3%) and E. sandiegoenis (2.5-6%). Of particular note is the occurrence of 4 species of Quinqueloculina, including Q. agglutinata. There are low numbers of QP specimens present in C1-29, higher numbers in C1-30.

Assemblage 6: barren.

Assemblage 6 occurs in samples C1-32 to C1-44 (44-67 m), in samples C1-49 and C1-50 (81-85 m) and at the base of the borehole in C1-52 (90-91 m). Essentially these samples are barren of foraminifera; those few specimens present show evidence of reworking. There are a few QP and reworked specimens present.

Assemblage 13: Epistominella spp. - Brizalina spp. - reworked component.

Assemblage 13 occurs in sample C1-46 at 72-73 m and in sample C1-51 at 87-90 m. Assemblage 13 is quite different than any other assemblage present in these boreholes. The co-dominant species group is four species of Brizalina (37%) and Uvigerina hispido-costata (31%). Secondary species include E. sandiegoensis (16%) and Nonionella basispinata (7%). There are no QP specimens present. There is a reworked component - the dominant reworked species is the Tertiary species Caucasina elongata.

PANUKE BOREHOLE:

Downhole in Panuke the sequence is: assemblage 2 (1-2 m), assemblage 1 (2-13 m), assemblage 2 (13-23 m), assemblage 4 (23-27 m), assemblage 3 (27-28 m), assemblage 5 (28-31 m), assemblage 4 (31-32 m), assemblage 11 (32-46 m), assemblage 12 (48-49 m), assemblage 8 (49-50 m), assemblage 14 (50-51 m), assemblage 13 (52-53 m), assemblage 14 (53-73 m), assemblage 15 (73-74 m), assemblage 14 (74-100 m) and assemblage 13 (100-101 m).

Assemblage 2: E. excavatum - I. helenae - C. teretis - reworked component.

Assemblage 2 occurs at the surface in sample P2-3 (1-2 m) and in samples P2-11 to P1-7, from 13-23 m. It is dominated by E. excavatum (59-69%). No species appears to be sub-dominant, though B. frigida, C. reniforme, C. teretis, E. bartletti, E. takayanagii, G. wrightii, H. orbiculare, I. helenae and R. squamata are consistently present. Few QP are present, all are N. pachyderma left. There are large numbers of reworked specimens present except in the surface sample.

Assemblage 1: E. excavatum - E. bartletti - shelf fauna

Assemblage 1 occurs in samples P2-3 to P2-10, from 3 to 13 m. This assemblage has very low to moderate numbers of QB foraminifera. The assemblage is dominated by E. excavatum (38-70%) and the sub-dominant species is I. helenae (15-21%). Also present are B. frigida, B. borealis, C. reniforme, Cibicides io, H. orbiculare and I. algida. There are no QP specimens present and there are a few reworked specimens present.

Assemblage 4: E. excavatum-E. bartletti / albiumbilicatum - shelf fauna.

Assemblage 4 occurs two times in this borehole; in samples P1-8 to P1-19 (23-26 m) and in P1-13 (32-33 m). There are moderate to high numbers of QB foraminifera. E. excavatum remains the dominant species (40-66%); E. albumbiliatum / bartletti (10.5-17%) and C. io (3-23%) are now the sub-dominant species.

SAMPLE NO.	P2-3	P2-5	P2-9	P2-10	P2-11	P2-12	P1-2	P1-5	P1-6	P1-7	P1-8
DEPTH	1.66-	4.65-	10.70-	12.00-	13.77-	15.13-	16.65-	19.61-	21.95-	22.80-	24.68-
	1.67	4.68	10.74	12.4	13.81	15.16	16.71	19.65	21.97	22.85	24.76
TOTAL NO. OF QUAT. BENTHICS	258	1	55	34	490	626	13792	13216	207	451	650
SPLIT COUNTED	/	/	/	/	1/2	1/2	1/32	1/16	/	/	1/2
Eggerella advena											
Trochammina ochracea	1.0									X	
Allomorphina fragilis						X					
Astrononion hamadaense							X	X			
Brizalina albatrossi											
Brizalina lanceolata											
Brizalina lowmani	X					X				X	
Brizalina pseudopunctata									X		
Brizalina spathulata											
Brizalina subaenariensis								1.5		X	
Buccella calida	X						1.0			1.0	1.0
Buccella depressa											X
Buccella frigida	X		P	P	2.0	3.5	5.0	2.0	5.0	5.0	6.0
Buccella tenerrima			P			X	X	X			
Bulimina aculeata/marginata	X						1.0	X		X	X
Bulimina striata											
Buliminella borealis	X						1.0		1.0	X	
Cassidulina reniforme	1.0					1.0	5.0	5.0	10.0	6.0	3.0
Cassidulina teretis								X			
Cassidulina sp. A						X					
Cibicides corpulentus	X						2.5			3.5	
Cibicides floridanus							X				
Cibicides grossa						X					
Cibicides io						X					
Cibicides lobatalus							X	X	X		
Cibicides mollis											
Cibicides robertsonianus	X					6.0					
Cibicides subhaidingerii	6.0				6.0	5.5		2.0	2.5	X	X
Cibicides umbonatus								1.5	1.0		
Cibicides wullerstorfi											
Dentalina baggi											
Discanomalina semipunctata											
Ehrenbergina pacifica											
Ehrenbergina trigona											
Elphidium albiumbilicatum						1.0	1.0	2.0		1.0	6.5
Elphidium bartletti	19.0		P	C	1.5	3.0	2.0	3.0	3.0	3.0	4.5
Elphidium excavatum	38.5		C	D	63.0	55.0	69.5	69.0	65.0	60.0	66.0
E. excavatum galvestonensis			P		2.0						
E. excavatum gunteri			P		2.0						
Elphidium groenlandicum	X					2.0				X	
Elphidium subarcticum											X
Eoeponidella pulchella										X	
Epistominella arctica											
Epistominella exigua								X			
Epistominella sandiegoensis									5.0	5.0	
Epistominella takayanagii					1.0	1.0	2.0	X	1.0	X	
Eponides bradyi											
Eponides tumidulus											
Fissurina annectans											
Fissurina cucurbitasema											
Fissurina marginata											
Fissurina quadrata											
Fissurina ventricosa										X	
Fursenkoina fusiformis											
Fursenkoina pontoni											
Gavelinopsis praegeri						X	X				
Gavelinopsis transluscens									X		
Glabratella lauriei											
Glabratella wrightii	X						1.5	X		1.5	4.0
Globobulimina pacifica											
Globocassidulina subglobosa								X			
Hanzawaia asterizans											
Hanzawaia concentrica											
Haynesina depressula											X
Haynesina germanica											
Haynesina orbiculare	4.0			P	3.0	7.0	2.0	3.0		2.0	4.0
Haynesina ustulatum										X	
Islandiella algida	3.0		P		1.0	1.0	1.0	1.0	X	2.0	

Table 3a: Foraminiferal data, samples P2-3 to P1-8 (1-25 m); Panuke borehole. Relative species abundance data for the Quaternary benthic species (rankings, i.e. D, C or P) given when the number of QB specimens < 75); total numbers for the Quaternary planktonic and reworked species. X < 1%.

SAMPLE NO.	P2-3	P2-5	P2-9	P2-10	P2-11	P2-12	P1-2	P1-5	P1-6	P1-7	P1-8
Islandiella helenae	21.0	P	D	P	17.5	15.5	3.5	7.5	1.5	5.5	
Islandiella norcrossi					X		X	X			
Lagena semilineata										X	
Larynogsigma hyalascidia						X					
Melonis barleeanum							X				
Miliolinella circularis											
Miliolinella subrotunda	1.5							X			X
Nonionella basisspinata											
Nonionellina labradorica								X	X	X	
Oolina borealis								X			
Oolina lineo-punctata	X										
Oolina melo											
Oolina striatopunctata											
Oridosalis umbonatus						X					
Patellina corrugata						X					
Pyrgo elongata											
Quinqueloculina agglutinata											
Quinqueloculina arctica											
Quiqueloculina elongata							X				X
Quinqueloculina seminula	3.0									X	X
Quinqueloculina stalkeri										X	
Rosalina globularis						X			X		
Rosalina squamata							X			X	X
Stainforthia concava			P								
Stainforthia mexicana											
Stainforthia schreibersania											
Trifarina angulosa/fluens	X					X	1.0	X			X
Triloculina trihedra											
Valvulineria laevigata											
QUATERNARY PLANKTONICS											
TOTAL NO. / SAMPLE	2	/	/	/	/	/	32	16	/	4	/
Globigerina bulloides											
Globigerina quinqueloba											
-right											
-left								16		2	
Globigerinita glutinata											
Globigerinita uvula											
Neogloboquadrina atlantica											
Neogloboquadrina dutertri											
Neogloboquadrina pachyderma											
-right											
-left	2						32			2	
INDETERMINANT											
Cibicides spp.					2						
REWORKED	4	1	13	12	216	414	1536	336	170	240	36
ESTIMATED AGE - REW. FAUNA	K/T	K	K/T	K/T	K/T	K/T	K	K	K/T	K	K
Arenobulimina obesa				1							
Clavulinoides aspera											
Dorothia bulleta											
Dorothia conula											
Dorothia refusa											
Eggerella mariae						2					
Gaudryina ellisorae											
Haplophragmoides eggeri											
Marssonella oxycona											
Nodellum velascoensis											
Plectina watersi						2					
Spiroplectammina laevis					2						
Spiroplectammina semicomplinata											
Textularia subconica											
Tritaxia pyramiditana											
Vernuilina muensteri											
Alabamina australis australis											
Alabamina sp. 1					2						
Alabamina sp. 2											
Allomorphina trochoides											
Amphicornya hirsuta						2					
Anomalinoides harperi					2						
Anomalinoides stephensoni											
Anomalinoides sp.											
Astacolus crepidulus											
Astacolus dissonus											

Table 3a: continued.

SAMPLE NO.	P2-3	P2-5	P2-9	P2-10	P2-11	P2-12	P1-2	P1-5	P1-6	P1-7	P1-8
Bandyana greatvalleyensis									1		2
Bolivinita eleyi										1	
Bolivinita planata											
Bolivinita selmenensis											
Bolivinoides culverensis											
Bolivinoides decoratus australis					6						
Bolivinoides decoratus delicatula						8					
Bolivinopsis papillata											
Brizalina cretosa											
Brizalina decurrens											
Brizalina incrassata						2				1	
Brizalina watersi								16			
Bulimina arkadelphiana midwayensis										1	
Bullminella fabilis											
Buliminoides chattonensis											
Caucasina elongata											
Ceratobulimina contraria											
Chrysalogonium cretaceum											
Dentalina alternata							32				
Dentalina basiplanata											
Dentalina catenula											
Dentalina consobrina											
Dentalina crinita											
Dentalina delicatula											
Dentalina fallax											
Dentalina gracilis									1		
Dentalina loreiana					2						
Dentalina luma											
Dentalina megalopolitana											
Dentalina solvata										1	
Ellipsonodosaria dentata-globrata					6	10	64		7	4	
Eouvigerina americana						2					
Eouvigerina austinana						2				2	
Eouvigerina excavata					2						
Eouvigerina gracilis										1	
Eouvigerina hispida											
Epistimina hechti											
Epistominella ripleyensis											
Eponides haidingerii											
Fissurina marginata											
Frondicularia dunbari											
Gavelinella ammonoides											
Gavelinella clementiana											
Gavelinella henbesti											
Gavelinella intermedia											
Gavellinella kansasensis									3		
Gavelinella monterelensis						2					
Gavelinella nelsoni											
Gavelinella pertusa						2					
Gavelinella rubiginosa						6		16	3	1	
Gavelinella sandidgei						2					
Gavelinella velascoensis					2	4					
Globulina lacrema											
Guttulina adherens											
Guttulina bartschi	1										
Guttulina regina											
Gyroidinoides depressus											
Gyroidinoides diversus											
Gyroidinoides girardanus									3	6	
Gryroidinoides nitidus								16	1		
Hoeglundina supracretacea											
Lagena acuticostata											
Lagena apiculata elliptica											
Lagena gracilis											
Lagena hispida											
Lagena substriata											
Lagena sulcata											
Lenticulina convergens			1								
Lenticulina denticulifera											
Lenticulina gibba											
Lenticulina muensteri											
Lenticulina nuda											
Lenticulina oligostegius											
Lenticulina orbicularis											
Lenticulina peregrina											
Lenticulina rotulata	1		9	1	14	16					
Lenticulina stephensoni											
Lenticulina sublaevis											

Table 3a: continued.

SAMPLE NO.	P2-3	P2-5	P2-9	P2-10	P2-11	P2-12	P1-2	P1-5	P1-6	P1-7	P1-8
Lenticulina williamsoni											
Loxostomum plaitum											
Marginulina cretacea											
Marginulina silicula						2					
Marginulina taylorana											
Marginulina texasensis											
Neobulimina albertensis											
Neobullmina canadiensis											
Neobulimina irregularis											
Neobulimina spinosa											
Neobulimina sp.											
Nodosarella texana											
Nodosaria affinis					2						
Nodosaria alternistriata											
Nodosaria flintii	1										
Nodosaria fusula				1							
Nodosaria navarroana											
Nodosaria obscura											
Nodosaria paupercula						2					
Nodosaria proboscidea	1		1			2					
Nonionella robusta											
Nonionella spissa											
Oolina globosa											
Osangularia navarroana					2	4	32				
Planulina dissona											
Planulina spissocostata						4			1		
Planulina taylorensis											
Pleurostomella austinana											
Pleurostomella subnodosa											
Pleurostomella watersi								16			
Praebulimina carseyae					4	22		16		2	
Praebulimina exigua									1		
Praebulimina kickapooensis									9		
Praebulimina laevis											
Praebulimina reussi				2	6	24	160		3	15	
Psuedopolymorphina incerta											
Pseudouvigerina cretacea									2		
Pseudsouvigerina plummerae											
Pseudouvigerina seligi						2		16		1	
Pullenia coryelli											
Pullenia jarvisi											
Pullenia minuta											
Pulvinulinella rippleyensis											
Pulvinulina texana											
Pyramidina referrata				1	30	98	352		40	61	8
Pyramidina rudita											
Pyramidina triangularis						2	32			2	
Pyrulina velascoensis											
Rotalina fimbriatula											
Rotalipora appenica											
Siphogeneroides plummeri											
Siphonina bradyana											
Siphonina prima						2					
Stetsioina pommerana								32			
Stilostomella consobrina											
Stilostomella pseudoscripta										1	
Uvigerina bradyana											
Uvigerina canariensis									1		
Uvigerina flintii											
Uvigerina hispidpo-costata					2						
Uvigerina peregrina				1	2						
Valvulineria allomorphinoides											
Valvulineria cretacea											
Valvulinaria infrequens											
Valvulineria umbilicatula											
Globorotalites michelinianus						2	32	48	3	4	
Globorotalites subconicus											
Globotruncana sp.											
Gumbelitrea cretacea			1	5	96	80	480		49	66	2
Heterohelix globulosa					22	36	256	96	23	30	
Heterohelix pulchra							32				
Heterohelix striata					2						
Planktonics (unidentified)		1	1		10	56	64	48	19	40	6
PLANT FRAGMENTS				*			***	*	*	*	
COAL FRAGMENTS											
CO3 FRAGMENTS											
DIATOMS											
RADIOLARIAMS											
OSTRACODES										*	

Table 3a: continued.

SAMPLE NO.	P1-9	P1-10	P1-12	P1-13	P1-14	P1-16	P1-18	P1-20	P1-22	P1-24	P1-25
DEPTH	25.81-25.84	27.12-27.17	30.02-30.04	31.65-31.68	33.18-33.20	36.55-36.60	39.18-39.21	42.10-42.18	45.34-45.52	48.50-48.58	49.85-49.94
TOTAL NO. OF QUAT. BENTHICS	1724	992	990	203	400	91	1392	560	800	632	1544
SPLIT COUNTED	1/4	3/8	1/2	/	3/4	/	1/4	1/2	1/2	1/2	1/4
Eggerella advena											
Trochammina ochracea											
Allomorphina fragilis				1.0			X				
Astrononion hamadaense			X								
Brizalina albatrossi											
Brizalina lanceolata		X	X								
Brizalina lowmani					X						
Brizalina pseudopunctata		X	X		1.0				1.0		
Brizalina spathulata											
Brizalina subaenariensis			X								
Buccella calida				X	1.0						
Buccella depressa	1.0										
Buccella frigida	X	1.5	3.0	X	12.5	4.0	9.0	3.0	6.0	4.5	8.5
Buccella tenerrima							X		4.0	1.0	
Bulimina aculeata/marginata			X								
Bulimina striata											
Buliminella borealis			X		8.0	3.0	8.0	5.0	X	1.5	X
Cassidulina reniforme	X	X	6.5	2.0	1.0	3.0		X	6.0	X	3.0
Cassidulina teretis									X		
Cassidulina sp. A											
Cibicides corpulentus								X			
Cibicides floridanus		X									
Cibicides grossa											
Cibicides io											1.0
Cibicides lobatalus											
Cibicides mollis											
Cibicides robertsonianus											
Cibicides subhaidingerii	2.5	8.5	2.5	23.5	X			X		X	
Cibicides umbonatus											
Cibicides wullerstorfi							X				
Dentalina baggi								X			
Discanomalina semipunctata											
Ehrenbergina pacifica											
Ehrenbergina trigona										X	
Elphidium albiumbilicatum	9.0	13.0	X	7.0	X	1.0	1.5				
Elphidium bartletti	7.0	17.5	2.5	10.0	2.0		2.0	1.0	X	X	X
Elphidium excavatum	54.0	38.5	68.5	39.5	42.0	38.5	48.0	38.0	54.0	68.5	73.5
E. excavatum galvestonensis	1.0										
E. excavatum gunteri											
Elphidium groenlandicum											
Elphidium subarcticum	X		X								
Eoeponidella pulchella	X	X		1.0					X		X
Epistominella arctica											
Epistominella exigua											
Epistominella sandiegoensis					9.5	15.5	10.5	42.0	4.5	14.0	4.0
Epistominella takayanagii	X		1.5	X	X						
Eponides bradyi											
Eponides tumidulus			X								
Fissurina annectans											
Fissurina cucurbitasema									X		X
Fissurina marginata		X			X						
Fissurina quadrata											
Fissurina ventricosa											X
Fursenkoina fusiformis					2.0	1.0	X	2.0		2.5	
Fursenkoina pontoni									3.5		X
Gavelinopsis praegeri		X					1.0	X	X	1.0	X
Gavelinopsis transluscens											
Glabratella lauriei	X	X	X						X		
Glabratella wrightii	1.0	6.5	1.5	2.0				3.0		X	
Globobulimina pacifica											
Globocassidulina subglobosa											
Hanzawaia asterizans											
Hanzawaia concentrica											
Haynesina depressula					X		X		1.0		1.0
Haynesina germanica											
Haynesina orbiculare	10.0	3.0	1.0	6.5						X	
Haynesina ustulatum											
Islandiella algida		1.0	1.0	1.5							

Table 3b: Foraminiferal data, samples P1-9 to P1-25 (25-50 m); Panuke borehole. Relative species abundance data for the Quaternary benthic species (rankings given when the number of QB specimens < 75); total numbers for the Quaternary planktonic and reworked species. X < 1%.

SAMPLE NO.	P1-9	P1-10	P1-12	P1-13	P1-14	P1-16	P1-18	P1-20	P1-22	P1-24	P1-25
Islandiella helenae	3.0	X	6.0	2.0		1.0	1.0		X		1.0
Islandiella norcrossi	X				X		X				X
Lagena semilineata											
Larynogsigma hyalascidia									X	X	
Melonis barleeanum		X							1.0		
Miliolinella circularis											
Miliolinella subrotunda	X	2.0	X				1.5		4.0	X	2.0
Nonionella basisspinata											
Nonionellina labradorica					X		1.0	1.5	X	X	X
Oolina borealis			X								
Oolina lineo-punctata											
Oolina melo											
Oolina striatopunctata											
Oridosalis umbonatus											
Patellina corrugata											
Pyrgo elongata							X		1.0	X	
Quinqueloculina agglutinata										X	X
Quinqueloculina arctica							X		X		
Quiqueloculina elongata			1.0		X				X	2.5	1.0
Quinqueloculina seminula	8.5	4.0		1.5			1.0		X	X	
Quinqueloculina stalkeri					12.0	33.0	11.0				X
Rosalina globularis		X	X								
Rosalina squamata		1.0	X	X			X	X	1.0		
Stainforthia concava			X		4.0		X	2.5		X	X
Stainforthia mexicana								2.0	3.5		X
Stainforthia schreibersania									3.0		2.0
Trifarina angulosa/fluens				X							
Triloculina trihedra									5.0		
Valvulineria laevigata											
QUATERNARY PLANKTONICS											
TOTAL NO. / SAMPLE	4	/	14	/	37	3	36	10	22	2	20
Globigerina bulloides					1						
Globigerina quinqueloba											
-right			2				12				
-left			4								
Globigerinita glutinata											
Globigerinita uvula					5		8	4	6		4
Neogloboquadrina atlantica											
Neogloboquadrina dutertri											
Neogloboquadrina pachyderma											
-right			6		4		4	2	2	2	4
-left	4		2		27	3	12	4	14		12
INDETERMINANT											
Cibicides spp.	4										
REWORKED	32	13	138	4	5	/	/	4	4	/	40
ESTIMATED AGE - REW. FAUNA	K/T	K	K/T	K	K			K	K		K
Arenobulimina obesa											
Clavulinoides aspera											
Dorothia bulleta											
Dorothia conula											
Dorothia refusa											
Eggerella mariae											
Gaudryina ellisorae											
Haplophragmoides eggeri											
Marssonella oxycona											
Nodellum velascoensis											
Plectina watersi											
Spiroplectammina laevis											
Spiroplectammina semicomplinata											
Textularia subconica											
Tritaxia pyramiditana											
Vernuilina muensteri											
Alabamina australis australis											
Alabamina sp. 1											
Alabamina sp. 2											
Allomorphina trochoides											
Amphicornya hirsuta											
Anomalinoides harperi											
Anomalinoides stephensoni											
Anomalinoides sp.											
Astacolus crepidulus											
Astacolus dissonus											

Table 3b: continued.

SAMPLE NO.	P1-9	P1-10	P1-12	P1-13	P1-14	P1-16	P1-18	P1-20	P1-22	P1-24	P1-25
Bandyana greatvalleyensis											
Bolivinita eleyi											
Bolivinita planata											
Bolivinita selmenensis											
Bolivinoides culverensis											
Bolivinoides decoratus australis											
Bolivinoides decoratus delicatula											
Bolivinopsis papillata											
Brizalina cretosa											
Brizalina decurrens											
Brizalina incrassata											
Brizalina watersi											
Bulimina arkadelphiana midwayensis											
Buliminella fabilis											
Buliminoides chattonensis											
Caucasina elongata	8										
Ceratobulimina contraria											
Chrysalogonium cretaceum											
Dentalina alternata											
Dentalina basiplanata											
Dentalina catenula											
Dentalina consobrina											
Dentalina crinita											
Dentalina delicatula											
Dentalina fallax											
Dentalina gracilis											
Dentalina loreiana											
Dentalina luma											
Dentalina megalopolitana											
Dentalina solvata											
Ellipsonodosaria dentata-globrata											
Eouvigerina americana			6								
Eouvigerina austinana											
Eouvigerina excavata			2								
Eouvigerina gracilis											
Eouvigerina hispida											
Epistimina hechti											
Epistominella ripleyensis											
Eponides haidingerii											
Fissurina marginata											
Frondicularia dunbari											
Gavelinella ammonoides											
Gavelinella clementiana											
Gavelinella henbesti											
Gavelinella intermedia											
Gavellinella kansasensis											
Gavelinella monterelensis											
Gavelinella nelsoni											
Gavelinella pertusa											
Gavelinella rubiginosa											8
Gavelinella sandidgei											
Gavelinella velascoensis											
Globulina lacrema											
Guttulina adherens											
Guttulina bartschi											
Guttulina regina											
Gyroidinoides depressus											
Gyroidinoides diversus											
Gyroidinoides girardanus											
Gryroidlnoides nitidus			2								
Hoeglundina supracretacea											
Lagena acuticostata											
Lagena apiculata elliptica											
Lagena gracilis											
Lagena hispida											
Lagena substriata											
Lagena sulcata											
Lenticulina convergens											
Lenticulina denticulifera											
Lenticulina gibba											
Lenticulina muensteri											
Lenticulina nuda											
Lenticulina oligostegius											
Lenticulina orbicularis											
Lenticulina peregrina											
Lenticulina rotulata			2								
Lenticulina stephensoni											
Lenticulina sublaevis											

Table 3b: continued.

SAMPLE NO.	P1-9	P1-10	P1-12	P1-13	P1-14	P1-16	P1-18	P1-20	P1-22	P1-24	P1-25
Lenticulina williamsoni											
Loxostomum plaitum											
Marginulina cretacea											
Marginulina silicula											
Marginulina taylorana											
Marginulina texasensis											
Neobulimina albertensis											
Neobulimina canadiensis											
Neobulimina irregularis											
Neobulimina spinosa											
Neobulimina sp.											
Nodosarella texana											
Nodosaria affinis											
Nodosaria alternistriata											
Nodosaria flintii											
Nodosaria fusula											
Nodosaria navarroana											
Nodosaria obscura											
Nodosaria paupercula											
Nodosaria proboscidea											
Nonionella robusta											
Nonionella spissa											
Oolina globosa											
Osangularia navarroana											
Planulina dissona											
Planulina spissocostata											
Planulina taylorensis											
Pleurostomella austinana											
Pleurostomella subnodosa			2								
Pleurostomella watersi											
Praebulimina carseyae											
Praebulimina exigua											
Praebulimina kickapooensis											
Praebulimina laevis											
Praebulimina reussi		3	14		3						
Psuedopolymorphina incerta											
Pseudouvigerina cretacea											
Pseudsouvigerina plummerae											
Pseudouvigerina seligi											
Pullenia coryelli											
Pullenia jarvisi											
Pullenia minuta											
Pulvinulinella rippleyensis											
Pulvinulina texana											
Pyramidina referrata		7	40	2	1			2			16
Pyramidina rudita											
Pyramidina triangularis			4								
Pyrulina velascoensis											
Rotalina fimbriatula											
Rotalipora appenica											
Siphogeneroides plummeri											
Siphonina bradyana											
Siphonina prima											
Stetsioina pommerana											
Stilostomella consobrina											
Stilostomella pseudoscripta											
Uvigerina bradyana											
Uvigerina canariensis											
Uvigerina flintii			2								
Uvigerina hispidpo-costata											
Uvigerina peregrina	4										
Valvulineria allomorphinoides											
Valvulineria cretacea											
Valvulinaria infrequens											
Valvulineria umbilicatula											
Globorotalites michelinianus	12		2								4
Globorotalites subconicus											
Globotruncana sp.											
Gumbelitrea cretacea			22					2	4		8
Heterohelix globulosa			22		1						4
Heterohelix pulchra											
Heterohelix striata											
Planktonics (unidentified)	4	3	18	2							
					• •						
PLANT FRAGMENTS	•								• •		
COAL FRAGMENTS	•	•		• •						•	
CO3 FRAGMENTS											
DIATOMS											
RADIOLARIAMS											
OSTRACODES		•				•	•			•	•

Table 3b: continued.

SAMPLE NO.	P2-13	P2-14	P2-15	P2-16	P2-17	P2-18	P2-19	P2-20	P2-21	P2-22	P2-23
DEPTH	50.70-50.72	52.04-52.07	53.78-53.79	55.02-55.08	56.53-56.54	59.50-59.56	59.70-59.73	61.35-61.38	64.05-64.08	67.00-67.04	70.17-70.2
TOTAL NO. OF QUAT. BENTHICS	7	138	2	21	33	19	7	2	21	10	23
SPLIT COUNTED	1/2	/	/	/	/	/	/	/	/	/	/
Eggerella advena											
Trochammina ochracea											
Allomorphina fragilis		2.0				P					
Astrononion hamadaense											
Brizalina albatrossi		4.5									P
Brizalina lanceolata											
Brizalina lowmani		7.0		P		C			P		
Brizalina pseudopunctata		2.0									
Brizalina spathulata	C	5.5			P			P			P
Brizalina subaenariensis		7.0			P					P	
Buccella calida											
Buccella depressa											
Buccella frigida	P	3.5			P	P		P	P	C	
Buccella tenerrima					C						
Bulimina aculeata/marginata		5.5			P				P	P	P
Bulimina striata											P
Buliminella borealis		2.0		P	P	P					P
Cassidulina reniforme				P		P		P			P
Cassidulina teretis											
Cassidulina sp. A											
Cibicides corpulentus											
Cibicides floridanus											P
Cibicides grossa									P		P
Cibicides io											
Cibicides lobatalus											
Cibicides mollis											
Cibicides robertsonianus											
Cibicides subhaidingerii									P		
Cibicides umbonatus											
Cibicides wullerstorfi		2.0									
Dentalina baggi											
Discanomalina semipunctata											
Ehrenbergina pacifica											
Ehrenbergina trigona											
Elphidium albiumbilicatum											
Elphidium bartletti		1.0									
Elphidium excavatum	C	14.0			D		P		C	C	P
E. excavatum galvestonensis											
E. excavatum gunteri											
Elphidium groenlandicum											
Elphidium subarcticum						P					
Eoeponidella pulchella											
Epistominella arctica											
Epistominella exigua											
Epistominella sandiegoensis		18.0	P	C	D	C			C		P
Epistominella takayanagii		1.0		P							
Eponides bradyi											
Eponides tumidulus		1.0		P							P
Fissurina annectans											
Fissurina cucurbitasema											
Fissurina marginata											
Fissurina quadrata											
Fissurina ventricosa									P		P
Fursenkoina fusiformis		1.0									
Fursenkoina pontoni											P
Gavelinopsis praegeri		3.0		P							
Gavelinopsis translucens		1.0									
Glabratella lauriei					P						P
Glabratella wrightii									P		
Globobulimina pacifica											
Globocassidulina subglobosa											
Hanzawaia asterizans					C	P		P			P
Hanzawaia concentrica											
Haynesina depressula											
Haynesina germanica		1.0									
Haynesina orbiculare											
Haynesina ustulatum											
Islandiella algida		6.5			P	P					

Table 3c: Foraminiferal data, samples P2-13 to P2-23 (50-71 m); Panuke borehole. Relative species abundance data for the Quaternary benthic species (rankings, i.e. D, C or P, given when the number of QB specimens < 75); total numbers for the Quaternary planktonic and reworked species. X < 1%.

SAMPLE NO.	P2-13	P2-14	P2-15	P2-16	P2-17	P2-18	P2-19	P2-20	P2-21	P2-22	P2-23
Islandiella helenae	P		P								P
Islandiella norcrossi		1.0									
Lagena semilineata											
Larynogsigma hyalascidia											
Melonis barleeanum	P										
Miliolinella circularis											
Miliolinella subrotunda											
Nonionella basisspinata											
Nonionellina labradorica						P					
Oolina borealis											
Oolina lineo-punctata											
Oolina melo											
Oolina striatopunctata											
Oridosalis umbonatus		1.0									
Patellina corrugata											
Pyrgo elongata											
Quinqueloculina agglutinata											
Quinqueloculina arctica											
Quiqueloculina elongata											
Quinqueloculina seminula											
Quinqueloculina stalkeri											
Rosalina globularis											
Rosalina squamata											
Stainforthia concava		3.5		P	P						
Stainforthia mexicana											
Stainforthia schreibersania		2.0									
Trifarina angulosa/fluens					P	P					
Triloculina trihedra											
Valvulineria laevigata											
QUATERNARY PLANKTONICS											
TOTAL NO. / SAMPLE	/	40	/	5	8	2	/	1	1	1	1
Globigerina bulloides						1			1		
Globigerina quinqueloba											
-right					2	1					
-left					2			1			
Globigerinita glutinata		8		1							
Globigerinita uvula					1						
Neogloboquadrina atlantica					1						
Neogloboquadrina dutertri											
Neogloboquadrina pachyderma											
-right		12		1							
-left		20		3	2					1	
INDETERMINANT											
Cibicides spp.	1	16			29	32		6	10	4	
REWORKED	27	1494	9	342	182	421	76	34	100	47	463
ESTIMATED AGE - REW. FAUNA	K	K/T	K	K/T	K/T	K/T	K/T	K/T	K/T	K/T	K/T
Arenobulimina obesa					1						
Clavulinoides aspera											
Dorothia bulleta											
Dorothia conula					1	2					
Dorothia refusa								1			
Eggerella mariae					1			1			
Gaudryina ellisorae											
Haplophragmoides eggeri											
Marssonella oxycona		1									
Nodellum velascoensis											
Plectina watersi					1						
Spiroplectammina laevis											
Spiroplectammina semicomplinata											
Textularia subconica											
Tritaxia pyramiditana											
Vernuilina muensteri											
Alabamina australis australis											
Alabamina sp. 1											
Alabamina sp. 2											
Allomorphina trochoides											
Amphicornya hirsuta											
Anomalinoides harperi											
Anomalinoides stephensoni											
Anomalinoides sp.											
Astacolus crepidulus											
Astacolus dissonus											

Table 3c: continued.

SAMPLE NO.	P2-13	P2-14	P2-15	P2-16	P2-17	P2-18	P2-19	P2-20	P2-21	P2-22	P2-23
Bandyana greatvalleyensis		15		3							
Bolivinita eleyi		2							1		
Bolivinita planata											
Bolivinita selmenensis						2					1
Bolivinoides culverensis											
Bolivinoides decoratus australis		1				1					
Bolivinoides decoratus delicatula											
Bolivinopsis papillata											
Brizalina cretosa											
Brizalina decurrens											
Brizalina incrassata		4	1	1	3	6			3	1	4
Brizalina watersi											
Bulimina arkadelphiana midwayensis											
Buliminella fabilis					1	2					
Buliminoides chattonensis											
Caucasina elongata		8		2		1					
Ceratobulimina contraria											
Chrysalogonium cretaceum											
Dentalina alternata											
Dentalina basiplanata											
Dentalina catenula											
Dentalina consobrina						1	1				
Dentalina crinita											
Dentalina delicatula											
Dentalina fallax		2						2			
Dentalina gracilis										1	
Dentalina loreiana								1			
Dentalina luma											
Dentalina megalopolitana											
Dentalina solvata											
Ellipsonodosaria dentata-globrata											
Eouvigerina americana		20		8		10			1		5
Eouvigerina austinana											
Eouvigerina excavata		27		7	16	11		1	6	1	45
Eouvigerina gracilis		2									1
Eouvigerina hispida		8		3							
Epistimina hechti											
Epistominella ripleyensis											
Eponides haidingerii					1						
Fissurina marginata											
Frondicularia dunbari											
Gavelinella ammonoides											
Gavelinella clementiana											
Gavelinella henbesti								1			
Gavelinella intermedia											
Gavellinella kansasensis											
Gavelinella monterelensis		4			3				4	5	3
Gavelinella nelsoni		1									
Gavelinella pertusa						1					
Gavelinella rubiginosa				1							
Gavelinella sandidgei		5	3	3	5	5	1	2	8		9
Gavelinella velascoensis					1	2					
Globulina lacrema											
Guttulina adherens					1						
Guttulina bartschi											
Guttulina regina											
Gyroidinoides depressus									1		
Gyroidinoides diversus											
Gyroidinoides girardanus											
Gryroidinoides nitidus		33	1	6	4	14	1	3	4	10	
Hoeglundina supracretacea		5	1	1	8	8	2	5	6	3	5
Lagena acuticostata		1									
Lagena apiculata elliptica											
Lagena gracilis					1						
Lagena hispida					1						
Lagena substriata		1									
Lagena sulcata											
Lenticulina convergens											
Lenticulina denticulifera					1						
Lenticulina gibba											
Lenticulina muensteri											
Lenticulina nuda											
Lenticulina oligostegius											
Lenticulina orbicularis											
Lenticulina peregrina											
Lenticulina rotulata		2	2		4	1		5	3		5
Lenticulina stephensoni											
Lenticulina sublaevis										1	

Table 3c: continued.

SAMPLE NO.	P2-13	P2-14	P2-15	P2-16	P2-17	P2-18	P2-19	P2-20	P2-21	P2-22	P2-23
Lenticulina williamsoni											
Loxostomum plaitum											
Marginulina cretacea											
Marginulina silicula					1	1					
Marginulina taylorana											
Marginulina texasensis											
Neobulimina albertensis				1		1					
Neobulimina canadiensis					1						
Neobulimina irregularis											
Neobulimina spinosa											
Neobulimina sp.											
Nodosarella texana											
Nodosaria affinis											
Nodosaria alternistriata											
Nodosaria flintii											
Nodosaria fusula											
Nodosaria navarroana											
Nodosaria obscura											
Nodosaria paupercula											
Nodosaria proboscidea											
Nonionella robusta		3		1	1	1					
Nonionella spissa											
Oolina globosa											
Osangularia navarroana		4	1			2	1		3		7
Planulina dissona											
Planulina spissocostata									1	1	
Planulina taylorensis											
Pleurostomella austinana											
Pleurostomella subnodosa											
Pleurostomella watersi											1
Praebulimina carseyae	1	32			3	5					4
Praebulimina exigua											
Praebulimina kickapooensis		1			1						
Praebulimina laevis				16							
Praebulimina reussi		57		12	8	10	4		3	3	15
Psuedopolymorphina incerta											
Pseudouvigerina cretacea											
Pseudsouvigerina plummerae											
Pseudouvigerina seligi											6
Pullenia coryelli						1				1	
Pullenia jarvisi									1		
Pullenia minuta		1									
Pulvinulinella rippleyensis		1									
Pulvinulina texana											
Pyramidina referrata	12	185		41	38	115	18	1	22	9	174
Pyramidina rudita				1							
Pyramidina triangularis	1	2		5	2	7			2		3
Pyrulina velascoensis											
Rotalina fimbriatula		1				2					
Rotalipora appenica											
Siphogeneroides plummeri											
Siphonina bradyana											
Siphonina prima					1			2	1		2
Stetsioina pommerana											
Stilostomella consobrina											
Stilostomella pseudoscripta									1		
Uvigerina bradyana					1						
Uvigerina canariensis											1
Uvigerina flintii											
Uvigerina hispidpo-costata		9		3				1	1		
Uvigerina peregrina		1			3		2				
Valvulineria allomorphinoides		1		1	1						
Valvulineria cretacea											
Valvulinaria infrequens											
Valvulineria umbilicatula											
Globorotalites michelinianus		2		7	3				2	1	5
Globorotalites subconicus											
Globotruncana sp.											
Gumbelitrea cretacea	6	298		63	23	66	20		8		78
Heterohelix globulosa	3	298		74	22	74	6	1	4	3	39
Heterohelix pulchra		10		1							
Heterohelix striata											
Planktonics (unidentified)	2	439		78	19	56	10	3	13	2	38
PLANT FRAGMENTS											
COAL FRAGMENTS		* * *									
CO3 FRAGMENTS											
DIATOMS			*								
RADIOLARIAMS											
OSTRACODES					*						

Table 3c: continued.

SAMPLE NO.	P2-24	P2-25	P2-26	P2-27	P2-28	P1-26	P1-27	P1-28	P1-29	P1-30
DEPTH	73.00-73.02	76.30-76.32	79.10-79.15	82.15-82.18	85.01-85.02	88.26-88.4	91.27-91.35	94.00-94.67	97.13-97.17	100.14-100.2
TOTAL NO. OF QUAT. BENTHICS	932	25	42	67	11	21	40	2	/	612
SPLIT COUNTED	1/4	/	/	/	/	/	/	/	/	1/2
Eggerella advena								P		
Trochammina ochracea										
Allomorphina fragilis										
Astrononion hamadaense										
Brizalina albatrossi		P			P					
Brizalina lanceolata										
Brizalina lowmani		D	D		P	P	P			18.0
Brizalina pseudopunctata										
Brizalina spathulata	X					P				1.0
Brizalina subaenariensis				P		P				7.5
Buccella calida										
Buccella depressa										
Buccella frigida	3.0			P						
Buccella tenerrima							P			
Bulimina aculeata/marginata			C	C	P					
Bulimina striata	1.0		P	P		P				
Buliminella borealis						P	C			20.0
Cassidulina reniforme										
Cassidulina teretis										
Cassidulina sp. A										
Cibicides corpulentus				P						2.0
Cibicides floridanus				P						
Cibicides grossa								P		
Cibicides io										
Cibicides lobatalus										
Cibicides mollis										
Cibicides robertsonianus										
Cibicides subhaidingerii	12.0			C						
Cibicides umbonatus				C						
Cibicides wullerstorfi							P			
Dentalina baggi										
Discanomalina semipunctata										
Ehrenbergina pacifica						P				
Ehrenbergina trigona										
Elphidium albiumbilicatum							P			
Elphidium bartletti										
Elphidium excavatum	1.0	P	C	C		P	P			X
E. excavatum galvestonensis										
E. excavatum gunteri										
Elphidium groenlandicum										
Elphidium subarcticum										
Eoeponidella pulchella				P						X
Epistominella arctica										
Epistominella exigua										
Epistominella sandiegoensis	X			C	P	P	P			27.0
Epistominella takayanagii										
Eponides bradyi	X									
Eponides tumidulus	1.0			P		P				
Fissurina annectans										
Fissurina cucurbitasema										X
Fissurina marginata										
Fissurina quadrata										X
Fissurina ventricosa										
Fursenkoina fusiformis						P	P			2.5
Fursenkoina pontoni										
Gavelinopsis praegeri					P	P	C			4.0
Gavelinopsis transluscens										
Glabratella lauriei										
Glabratella wrightii										
Globobulimina pacifica										
Globocassidulina subglobosa										
Hanzawaia asterizans										
Hanzawaia concentrica	81.0		P	D						X
Haynesina depressula										X
Haynesina germanica						P				X
Haynesina orbiculare		P								
Haynesina ustulatum										
Islandiella algida										

Table 3d: Foraminiferal data samples P2-24 to P1-30 (71-101 m); Panuke borehole. Relative species abundance data for the Quaternary benthic species (rankings, i.e. D, C or P given when the number of QB specimens ∠ 75); total numbers for the Quaternary planktonic and reworked species. X ∠ 1%.

SAMPLE NO.	P2-24	P2-25	P2-26	P2-27	P2-28	P1-26	P1-27	P1-28	P1-29	P1-30
Islandiella helenae						P				
Islandiella norcrossi										
Lagena semilineata										
Larynogsigma hyalascidia										
Melonis barleeanum						P				
Miliolinella circularis										
Miliolinella subrotunda										
Nonionella basisspinata				P	P					
Nonionellina labradorica							P			
Oolina borealis										
Oolina lineo-punctata										
Oolina melo										
Oolina striatopunctata										
Oridosalis umbonatus										
Patellina corrugata										
Pyrgo elongata										
Quinqueloculina agglutinata										
Quinqueloculina arctica										
Quiqueloculina elongata										
Quinqueloculina seminula										
Quinqueloculina stalkeri						P				
Rosalina globularis										
Rosalina squamata							P			1.0
Stainforthia concava										
Stainforthia mexicana										
Stainforthia schreibersania							C			10.5
Trifarina angulosa/fluens	X									
Triloculina trihedra										
Valvulineria laevigata										
QUATERNARY PLANKTONICS										
TOTAL NO. / SAMPLE	8	/	/	7	/	5	/	/	/	24
Globigerina bulloides				2						2
Globigerina quinqueloba										
-right										2
-left										
Globigerinita glutinata										
Globigerinita uvula										2
Neogloboquadrina atlantica										2
Neogloboquadrina dutertri										2
Neogloboquadrina pachyderma										
-right	8			5		3				6
-left										8
INDETERMINANT										
Cibicides spp.		72	124	105	125					
REWORKED	1228	763	1222	361	677	106	/	/	/	224
ESTIMATED AGE - REW. FAUNA	K/T	K/T	K/T	K/T	K/T	K/T				K/T
Arenobulimina obesa			2							
Clavulinoides aspera			12							
Dorothia bulleta			6	3	1					
Dorothia conula	12	3	8	1						
Dorothia refusa										
Eggerella mariae	4	1	4		1					
Gaudryina ellisorae			4							
Haplophragmoides eggeri			2							
Marssonella oxycona			4							
Nodellum velascoensis				1						
Plectina watersi		1	2	1	5					
Spiroplectammina laevis										
Spiroplectammina semicomplinata				2						16
Textularia subconica				1						
Tritaxia pyramiditana					1					
Vernuilina muensteri			8		5					
Alabamina australis australis										
Alabamina sp. 1						1				
Alabamina sp. 2										
Allomorphina trochoides				1	4					
Amphicornya hirsuta										
Anomalinoides harperi		3			4					
Anomalinoides stephensoni										
Anomalinoides sp.										
Astacolus crepidulus	4									
Astacolus dissonus		4	2							

Table 3d: continued.

SAMPLE NO.	P2-24	P2-25	P2-26	P2-27	P2-28	P1-26	P1-27	P1-28	P1-29	P1-30
Bandyana greatvalleyensis										
Bolivinita eleyi	4									
Bolivinita planata										
Bolivinita selmenensis										
Bolivinoides culverensis					3					
Bolivinoides decoratus australis	4									
Bolivinoides decoratus delicatula										
Bolivinopsis papillata										8
Brizalina cretosa					1					
Brizalina decurrens			2							
Brizalina incrassata	24	25	6	4	14	1				2
Brizalina watersi					4					
Bulimina arkadelphiana midwayensis		10			2					
Buliminella fabilis			8		2					
Buliminoides chattonensis										
Caucasina elongata		8	12		4	9				158
Ceratobulimina contraria		4			1					
Chrysalogonium cretaceum		1		1						
Dentalina alternata					2					
Dentalina basiplanata					4	1				
Dentalina catenula						1				
Dentalina consobrina				1						
Dentalina crinita			2							
Dentalina delicatula		1								
Dentalina fallax		1								
Dentalina gracilis			2							
Dentalina loreiana		1	4							
Dentalina luma										
Dentalina megalopolitana		1		1	2					
Dentalina solvata										
Ellipsonodosaria dentata-globrata										
Eouvigerina americana	24	16	10		82					
Eouvigerina austinana										
Eouvigerina excavata	92	12	42	5						
Eouvigerina gracilis										
Eouvigerina hispida										
Epistimina hechti					3					
Epistominella ripleyensis				1						
Eponides haidingerii										
Fissurina marginata			2							
Frondicularia dunbari										
Gavelinella ammonoides										
Gavelinella clementiana			10	6	8					
Gavelinella henbesti		2			6					
Gavelinella intermedia					4					
Gavellinella kansasensis		1								
Gavelinella monterelensis		80	72	4	25					
Gavelinella nelsoni										
Gavelinella pertusa			2	1	2					
Gavelinella rubiginosa		3	14		2	7				
Gavelinella sandidgei	4	120	160	31	42	4				22
Gavelinella velascoensis	16		6	7						
Globulina lacrema	4									2
Guttulina adherens				2						
Guttulina bartschi										
Guttulina regina										2
Gyroidinoides depressus		26	16	5	8					
Gyroidinoides diversus	64	12								
Gyroidinoides girardanus		9			10					
Gryroidinoides nitidus		50	24	10	44					
Hoeglundina supracretacea	16	63	156	27	36					
Lagena acuticostata										
Lagena apiculata elliptica										
Lagena gracilis										
Lagena hispida				1						
Lagena substriata										
Lagena sulcata				1						
Lenticulina convergens										
Lenticulina denticulifera		1								
Lenticulina gibba	8									
Lenticulina muensteri										
Lenticulina nuda						1				
Lenticulina oligostegius										
Lenticulina orbicularis										
Lenticulina peregrina										
Lenticulina rotulata		19	22	11	14	51				
Lenticulina stephensoni			2							
Lenticulina sublaevis		2	2	4						

Table 3d: continued.

SAMPLE NO.	P2-24	P2-25	P2-26	P2-27	P2-28	P1-26	P1-27	P1-28	P1-29	P1-30
Lenticulina williamsoni		1		3						
Loxostomum plaitum				1						
Marginulina cretacea		1	8							
Marginulina silicula				1	1					
Marginulina taylorana										
Marginulina texasensis			2	1	1					
Neobulimina albertensis					2	1				
Neobulimina canadiensis										
Neobulimina irregularis				2						
Neobulimina spinosa					1					
Neobulimina sp.										
Nodosarella texana				1						
Nodosaria affinis			2							
Nodosaria alternistriata				1						
Nodosaria flintii										
Nodosaria fusula										
Nodosaria navarroana			8							
Nodosaria obscura	4									
Nodosaria paupercula			8							
Nodosaria proboscidea										
Nonionella robusta		21	14	4	13	20				10
Nonionella spissa	4									
Oolina globosa			2							
Osangularia navarroana	4		10	2	9					
Planulina dissona				1						
Planulina spissocostata		12	4		1					2
Planulina taylorensis		1	8	11	8					
Pleurostomella austinana										
Pleurostomella subnodosa										
Pleurostomella watersi				1						
Praebulimina carseyae	12	5		1						
Praebulimina exigua	32									
Praebulimina kickapooensis	4	2	12							
Praebulimina laevis				4	13					
Praebulimina reussi	28	28	36	12	12					
Psuedopolymorphina incerta		2	2							
Pseudouvigerina cretacea					3					
Pseudsouvigerina plummerae				1						
Pseudouvigerina seligi	4	8	12	5	6					
Pullenia coryelli		1	2							
Pullenia jarvisi					4					
Pullenia minuta										
Pulvinulinella rippleyensis										
Pulvinulina texana		3								
Pyramidina referrata	152	17	90	22	56	1				
Pyramidina rudita				1						
Pyramidina triangularis	4	12	14		8					
Pyrulina velascoensis				1						
Rotalina fimbriatula										
Rotalipora appenica					2					
Siphogeneroides plummeri			2							
Siphonina bradyana										
Siphonina prima		4		2	5					
Stetsioina pommerana										
Stilostomella consobrina										
Stilostomella pseudoscripta										
Uvigerina bradyana						1				
Uvigerina canariensis		4	8							
Uvigerina flintii	8					1				
Uvigerina hispidpo-costata				2	2	1				
Uvigerina peregrina					2					
Valvulineria allomorphinoides		4	18	5	8					
Valvulineria cretacea										
Valvulinaria infrequens				2						
Valvulineria umbilicatula										
		1								
Globorotalites michelinianus	8		8	11	16					
Globorotalites subconicus										
Globotruncana sp.			6							
Gumbelitrea cretacea	432		48	12	54					
Heterohelix globulosa	168	34	98	15	82	2				
Heterohelix pulchra		1		2	3					
Heterohelix striata			2		4					
Planktonics (unidentified)	76	90	172	29	63					2
PLANT FRAGMENTS										
COAL FRAGMENTS							*			
CO3 FRAGMENTS										
DIATOMS										
RADIOLARIAMS										
OSTRACODES										

Table 3d: continued.

Assemblage 3: E. albiumbilicatum - E. excavatum - reworked component.

Assemblage 3 occurs in sample P1-10 (27-28 m). Co-dominant are E. excavatum (38.5%) and E. bartletti / albumbiliatum (30.5%). Also present are C. subhaidingerii (8.5%), G. wrightii (6.5%), H. orbiculare (3.0%), M. subrotunda (2.0%) and Q. seminula (4.0%). There are no QP specimens present and very few reworked specimens.

Assemblage 5: E. excavatum - B. frigida - Brizalina spp. - reworked component.

Assemblage 5 occurs in samples P1-12 at 30-31 m. It is dominated by E. excavatum (68.5%); subdominant are C. reniforme (6.5%), I. helenae (6.0%) and B. frigida, (3.0%) and three species of Brizalina. There are some reworked specimens present.

Assemblage 11: E. excavatum - Epistominella spp. - B. frigida - B. borealis.

Assemblage 11 occurs in samples P1-14 to P1-22 (32-46 m). There is a decrease in the occurrence of E. excavatum in some samples (38-54%) and two species become subdominant to dominant: E. sandiegoensis (4-42%) and Q. stalkeri (11-33%, in the upper three samples). Also present are B. frigida and B. borealis. There are QP specimens present, N. pachyderma (left and right coiled), G. bulloides, G. uvula and G. quinqueloba. There is a small reworked component (3-27 specimens / sample).

Assemblage 12: E. excavatum - E. sandiegoensis - Quinqueloculina spp.

Assemblage 12 occurs in sample P1-24 from 48-49 m. It is dominated by E. excavatum (68.5%); subdominant are E. sandiegoensis (4.5%) and B. frigida (4.5%). Also present are Quinqueloculina spp., in particular Q. agglutinata. There are low numbers of QP and reworked specimens present.

Assemblage 8: E. excavatum.

Assemblage 8 occurrs in sample P1-25 at 49-50 m. It is dominanted by E. excavatum (73.5%). Sub-dominant is B. frigida (8.5%). Also present are C. reniforme, E. takayanagii, M. subrotunda and Q. elongata. There are QP and reworked specimens present.

Assemblage 14: reworked component.

Assemblage 14 occurs in sample P2-13 (50-51 m), in the interval P2-15 to P2-23 (53-73 m) and in P2-25 to P1-29 from 74-100 m. There are very low numbers of QB foraminifera, all show evidence of extensive reworking. There is a very large reworked fauna; all specimens are etched, broken and yellowed; showing extensive reworking. There are a few QP specimens present.

Assemblage 13: Epistominella spp. - Brizalina spp. - B. borealis - reworked component.

Assemblage 13 occurs in sample P2-14 (52-53 m) and sample P1-30 (100-101 m). It is co-dominated by E. sandiegoensis (18-27%), Brizalina spp. (25-27%), B. borealis. (2-20%) and S. schreibersiana (2-10%). There are QP specimen present, all N. pachyderma (left and right coiled) in the upper sample; a varied fauna in the lower sample, including two specimens identified as N. atlantica (G. Vilks, pers. com.). Both samples contain large reworked components. In sample P1-30 the reworked fauna is dominated by the Tertiary species, C. elongata.

Assemblage 15: H. concentrica - C. subhaidingerii - reworked component.

Assemblage 15 occurs in sample P2-24 (73-74 m). It is strongly dominated by H. concentrica (73%). Sub-dominant is C. subhaidingerii (11%). Also present are Bulimina spp. (B. aculeata and B. striata) and B. frigida. There are QP specimens of N. pachyderma right and a large reworked component present.

DISCUSSION

ENVIRONMENTAL INTERPRETATION AND FORAMINIFERAL CORRELATION

Assemblage 1, the low number E. excavatum - E. bartletti assemblage, occurring in Balmoral from 0 -17 m, is interpreted as occurring in a modern, inner shelf / bank environment, constantly reworked and winnowed by currents, waves and storm events. This assemblage occurs in Cohasset (3-16 m) and in Panuke (2-13 m) and correlates with assemblages 1 (modern inner shelf / bank) and 2 (modern inner shelf / outer estuarine) of the previously studied Cohasset, Como and Panuke boreholes (Miller and Amos, 1990).

This assemblage does not correspond directly to the present day assemblages (or lack of) reported living on Sable Island Bank (Williamson, 1982, 1983; Williamson et al., 1984; Medioli et al.,1986). Williamson (1982, 1983) and Williamson et al. (1984) reported that surface samples from Sable Island Bank were virtually barren of foraminifera. Williamson (1983) and Williamson et al. (1984) also concluded, as a result of living-total foraminiferal distribution studies; that the presence of E. excavatum was largely relict and the tests had been transported. Williamson (1983) noted that the tests appeared ragged and worn, an observation also made in this study. Williamson et al. (1984) noted that continual sediment sorting and winnowing may account for the absence of foraminifera on Sable Island Bank. Medioli et al. (1986), using the Williamson studies as a baseline for comparison, have reported on samples collected from an area concentrated around Sable Island Bank. Generally, they found the unusually sparse and irregular distributions difficult to interpret. Samples which appear to have been collected in the vicinity of the Cohasset well site (Medioli et al., 1986, Figures 2 and 7) are either barren of foraminifera or dominated by the agglutinated species Adercotryma glomerata. Poag et al. (1980) reported E. subarcticum (E. subarcticum and E. alibiumbilicatum) as the dominant Elphidium species living in the northern part of the trough and basin of the New Jersey outer continental shelf. Poag et al. (1980) correlate this Elphidium fauna with the shallowest locations, which in turn correlate with the lowest salinity, lowest winter temperatures, coarsest sediment and maximum water turbulence.

Minor occurrences of other shelf species (B. frigida, C. reniforme, H. orbiculare, I. helenae, M. subrotunda and Quinqueloculina spp.) are probably both indigenous and relict. The specimen of C. teretis (assemblage 1, Balmoral) is interpreted as reworked.

Williamson (1983) has synthesized the bottom water hydrography on the continental margin and showed that all of Sable Island Bank is affected to a depth of 50 m by the water mass he named water mass no. 3, characterized by salinities of 33-34‰ and temperature of 4-8°C. The planktonic foraminifera present are either G. quinqueloba or N. pachyderma, characteristic of this water mass.

Assemblage 2 is the E. excavatum - I. helenae fauna occurring from 17-28 m and from 33-38 m in Balmoral. These high numbers of I. helenae (and consequently this fauna) are absent in the Cohasset borehole but present in the Panuke borehole at the surface and from 13 to 23 m. It correlates to assemblages 4A and 4B found in the 1987 boreholes (Amos and Miller, 1990), where it occurred from 13-19 m in Como and from 11-19 m in Panuke. Again, it was absent at the Cohasset site.

The high numbers of I. helenae indicate that this is probably an immediate postglacial / late glacial fauna. I. helenae is a co-dominant component of many immediate

post-glacial faunas (Miller et al., 1985; Scott et al., 1984; Vilks et al., 1974; Vilks and Rashid, 1976; Vilks, 1980). It is also a major component of modern outer deep estuarine assemblages (Schafer and Cole, 1978; Scott et al., 1980).

Cassidulina teretis appears in assemblages 2 and 4 in Balmoral (<1-5%) and also shows scattered minor occurrences in the same assemblages in Cohasset. In Panuke it is absent from assemblage 2 except for 1 specimen. It is also present in assemblage 11. C. teretis, originally described from the Pleistocene Gublik Formation in Alaska (Tappan, 1951), is associated with cold water in modern arctic environments (Vilks, 1969; Feyling-Hanssen and Buzas, 1976; Lagoe, 1977; Rodrigues et al., 1980). Mackensen and Hald (1988) report it as abundant on the Norweigan continental slope and conclude that it dominates living benthic foraminiferal assemblages in areas characterized by cold, relatively low salinity bottom water (NSDW). Mackensen and Hald (1988) show depth-latitude plots for C. teretis off northern Norway. These plots show: (1) an increase in abundance at depth with increasing latitude, and (2) an increase in abundance at latitude with depth. Mackensen and Hald (1988) conclude that the occurrence of C. teretis coincides with a northward decrease in bottom water summer temperatures from ca. 7°C to 4°C and winter temperatures from ca. 6°C to 3°C between 71°N and 72°N. In the area investigated by Mackensen and Hald (1988) C. teretis is restricted to the northern flanks of the Iceland - Faeroe Ridge, the Wyville-Thomson Ridge and the Norwegian continental slope, mainly from 500 to 1500 m water depths. Along the Norwegian continental margin C. teretis is dominant from water depths of 600-1500 m in the south and 1000-1600 m water depths in the north.

Mackensen and Hald (1988) have also discussed the stratigraphic distribution of C. teretis on the Norwegian continental shelf. They find C. teretis dominant (16-84%) in a unit believed deposited in open, cold shelf water. C. teretis also occurs in E. excavatum - C. reniforme assemblages (abundance 0-30%) believed to indicate near glacial conditions with rapid fluctuations in turbidity and salinity of bottom waters. It is present in what are interpreted to be a variety of glaciomarine paleo-environments. Feyling-Hanssen (1980a, 1980b) reports it characteristic of the C. teretis zone of the Clyde Foreland and zone G of the Qivituq Penninsula on Baffin Island; sections which would represent a transition unit between the Tertiary and Quaternary. Feyling-Hanssen et al. (1983) have also reported it from the Plio-Pleistocene Eodin Elv Formation in Greenland. Schnitker (1984, DSDP hole 552A, northeast Atlantic) found C. teretis abundance peaks exclusively during glacial episodes. Murray (1984) also correlates it to glacial episodes (DSDP holes 552 to 555). Scott (1987) reports "Islandiella teretis" downhole in DSDP holes 612 and 613, but this is of limited value because Scott (1987, p.328) includes C. teretis, I. helenae and I. norcrossi in this taxa.

At the Holocene-Pleistocene boundary on the continental shelf off Norway, cold glaciomarine waters are replaced by warmer, more saline waters of the Norwegian current. This boundary coincides with a decrease in the abundance of C. teretis. The early Holocene represents transitional paleo-environmental conditions with a high melt-water influx from 7,800 YBP to present; C. teretis has retreated down the continental slope or northward into western Barents Sea (Mackensen and Hald, 1988).

The presence of C. teretis (<1-5%), co-occurring with I. helenae, is interpreted as indicative of late glacial or post-glacial, near glacial conditions.

One specimen of Islandiella sublimbata (Cushman and Hughes) (= Islandiella limbata Cushman and Hughes and Islandiella inflata Gudina) appears in assemblage 2. Though one specimen has very limited value (if any), its appearance is interesting to note. Feyling-Hanssen (1990a) described an assemblage containing 32% Islandiella

inflata from raised Quaternary deposits in northeastern Greenland. Gudina (1966) considers I. inflata as an indicator of boreal-arctic conditions, usually occurring in high-diversity interglacial assemblages. Gudina (1966) reported it as common both in Eemian and Holsteinian deposits in the northern USSR. Feyling-Hanssen (1980a) remarks that this species has been reported from Eemian (Sangamonian) deposits at Bergen, Norway (Sejrup, 1978) and that he (Feyling-Hanssen), has observed rare specimens in Quaternary material from the North Sea and in a recent fauna off the northwest coast of Iceland.

On Baffin Island, arctic Canada, fossil foraminiferal assemblages with up to 19% I. inflata were found in the C. teretis zone (Upper Pliocene / lower most Pleistocene) and in the I. islandica zone (Pleistocene) of the Clyde Foreland (Feyling-Hanssen, 1976a); in zone G (Upper Pliocene / lower most Pleistocene) and in zones F and D (Pleistocene) of the Qivituq Peninsula (Feyling-Hanssen, 1980a). I. inflata also composes 21% of a sample collected 12 m above sea level on Broughton Island (Feyling-Hanssen, 1985); and shows affinity to samples from Cape Broughton (Feyling-Hanssen, 1976b), dated by radiocarbon at > 40,000 YBP. Feyling-Hanssen (1990a) believes it may be a distinct upper mid-Pleistocene marker.

In these boreholes, the presence of I. sublimbata is interpreted as reworked. The specimens of Cibicides spp. are consistent with both the Quaternary and reworked faunas. They have been included with the Quaternary fauna based on their state of preservation. Bulimina affinis, B. striata, and Buliminella basicostata may be part of the reworked fauna. This assemblage is also distinguished by its reworked (Cretaceous / Tertiary) benthic and planktonic foraminifera. In Balmoral, reworked specimens appear in sample B1-13 and increase steadily downhole. There are large numbers of reworked specimens in B1-18 and B1-20 in particular. There is a large reworked component in assemblages 3 (Balmoral), assemblage 4 (Balmoral), assemblage 6 (Balmoral), assemblage 8 (Cohasset), assemblage 9 (Cohasset), assemblage 13 (Cohasset, Panuke) and assemblage 14 (Panuke). The first peak of reworked foraminifera in Panuke also occurs in the uppermost "in situ" sample of the assemblage 2, P2-11 at 13 m (ignoring the sample at the surface, interpreted as reworked). The first peak of reworked foraminifera appears in Cohasset with assemblage C1-14 at 19-20 m. This same phenomena, high numbers of reworked foraminifera, was observed by Miller (1987a, 1987b) and Amos and Miller (1990) in specific intervals in all three previously studied Sable Island Bank boreholes. Scott and Medioli (1988) have found a late-glacial E. excavatum - C. reniforme fauna in piston cores from Emerald Basin; in the lower sections of these cores there was a reworked component (i.e. Praebulimina, Pyramidina, Heterohelix and Gumbelitrea). Miller and Scott (1984) noted this phenomena even earlier, though in much lower numbers on Banquereau. Scott and Medioli (1988) have noted from seismic records that the sediments containing these faunas (in Emerald Basin) in some instances directly overly glacial till; and they are of the opinion that these faunas were deposited as a result of glacial erosive activity which placed in suspension large amounts of Cretaceous / Tertiary material. The ice probably was not grounded here (on Sable Island Bank) as evidenced by the absence of till, but had been grounded at some point proximate to cause the reworking and redeposition of the Cretaceous faunas. Marlowe (1965,1969) and Marlowe and Bartlett (1967) have observed Oligocene to Miocene strata outcropping in the Gully; and King and MacLean (1970) and King et al. (1970) have dredged up rocks of Cretaceous age just north of Sable Island and on Sable Island Bank. The Cretaceous foraminifera are very well preserved

and probably have not been through more than one erosional cycle. These reworked Cretaceous sediments were probably deposited during the final "deglaciation event".

The occurrence of Cretaceous planktonic foraminifera in Pleistocene sediments is reported by Thomson (1983) as not unusual. Thomson (1983) reports specimens of Heterohelix, Hedbergella, Globotruncana and Eouvigerina in Pleistocene fluvio-lacustrine deposits in eastern Missouri. Thomson (1983) noted that these specimens are very well preserved and this leads Thomson to suggest that they were transported short distances before redeposition. Thomson (1983) suggests that the source rocks were either transported as erratics and deposited in glacial drift before further erosion and final deposition occurred; or glacial lobes transported blocks of source rock, deposited them as tills and local erosion during Wisconsinan time completed the break-down of the Cretaceous sediments.

Feyling-Hanssen (1971), Andersen (1971), Jorgensen (1971), Knudsen (1971a) and more recently Hald and Vorren (1987) have found Upper Cretaceous specimens reworked into Quaternary faunas. Scott (1987) also reported scattered occurrences of Gumbeltitrea sp. and Heterohelix sp. at both Sites 612 and 613 (DSDP Leg 95) but occurring more prominently at the base of Hole 613.

Assemblage 3 in sample B1-20 (Balmoral, 28-29 m) is the high number, high diversity E. alibiumbilicatum - E. excavatum fauna. Also present are Buccella spp., Cibicides spp., Cassidulina reniforme, Epistominella spp. and H. orbiculare. This assemblage also occurs in the 31-33 m interval of the Cohasset borehole, the 27-28 m interval in the Panuke borehole; and it probably correlates to assemblage 9A (E. excavatum - E. subarcticum [E. albiumbilicatum]) at the 24 m interval in the previously drilled (1987) Panuke borehole (Amos and Miller, 1990). This fauna is interpreted as present in a very shallow water / estuarine / quiet water (low wave energy) environment with hyposaline conditions.

Miller et al. (1982a) have found a fauna dominated by E. bartletti (including E. albiumbilicatum) in a Bedford Basin core. This fauna is late Holocene in age and the fauna is interpreted as from a marginal marine environment (sensu Scott et al., 1980). Scott et al. (1980) define a modern marginal marine assemblage zone (i.e. as in Chezzetcook Inlet) as marked by the appearance of several open ocean species and by the disappearance or reduction in relative abundance of certain estuarine (usually agglutinated) forms. The dominant species are Elphidium spp. and Haynesina orbiculare; open ocean forms include B. frigida, Cibicides lobatalus (=Cibicides spp.), Glabratella wrightii and Rosalina columbiensis (=R. globularis). In Restigouche estuary Cribrononion subarcticum (=E. albiumbilicatum) is a component of the modern deep bay association.

In Bedford Basin the marginal marine foraminiferal fauna is believed to represent a period of relative instability similar to that found in seaward sections of modern estuaries in Atlantic Canada. In Bedford Basin this fauna probably characterizes conditions prevailing as the water level slowly rose from a depth of 15-20 m lower than at present. It is believed (also based on dinocyst assemblages) that Bedford Basin contained turbid surface water of a deep salt wedge estuarine type during this period of sea level transgression. Lutze (1965) reports the species is common in recent boreal shallow and brackish water faunas. E. albiumbilicatum was originally described by Weiss (1954) from the interglacial Gardiners Clay, New York, where he describes it as common. Weiss (1954) interprets the environment of deposition as shallow, brackish water in a bay or lagoonal area protected by an offshore bar.

Knudsen (1978) found an E. albiumbilicatum zone in Late Quaternary marine deposits in northern Denmark. This zone is characterized by high frequencies of E. albiumbilicatum (up to 60%). E. excavatum is co-dominant and Cassidulina crassa (=C. reniforme) is also consistently present. Generally, this assemblage occurs in sandy sediments, probably indicative of shallower water, higher current velocity, rising temperatures and lower salinities than an E. excavatum assemblage. Radiocarbon dates of mollusc shells from sediments containing these faunas are latest Pleistocene (11,000-15,000 YBP). Knudsen (1978) correlates this fauna to the Bolling interstadial. Knudsen (1978) believes these sediments may represent a deep valley formed prior to the late-glacial transgression, either by the ice itself, or by meltwater streams during deglaciation.

Knudsen (1978, p. 25) noted both the difficulties in separating E. subarcticum and E. albiumbilicatum; and the presence of transitional forms. Knudsen (1977) had previously noted this phenomena. Knudsen (1978) suggests that they are some form of variants of one species; E. subarcticum representing the arctic form and E. albiumbilicatum the boreo-arctic and boreal form.

Assemblage 4 is an E. excavatum - E. bartletti / albiumbilicatum fauna occurring in Balmoral in sample B1-21 from 29-33 m. This fauna occurs three times in Cohasset; from 16-19, 20-25, and 26-30 m. Assemblages 9 and 10 are sandwiched within assemblage 4 in the Cohasset borehole. Assemblages 9 and 10 are high diversity, high number QB assemblages which may both represent preserved intervals, within the section of sediment. Assemblage 4 in Cohasset may be a reworked remnant of assemblage 9 and 10. The same phenomena is observed in the Panuke borehole. Assemblage 4 occurs twice in Panuke from 23-27 m and from 31-32 m. This fauna corresponds to assemblage 9 (21-23 m) in the previously drilled (1987) Panuke borehole (Amos and Miller, 1990). This fauna is interpreted as occurring in a cold outer estuarine / inner shelf environment.

In Cohasset assemblages 3 and 5 are sandwiched within assemblage 4. Assemblages 3 and 5 are high number high diversity QB faunas, 5 with a high number reworked component. Assemblages 4 in Panuke has higher QB numbers that in Balmoral and Cohasset. Assemblages 4 in Panuke may be a reworked remnant of assemblage 3 / 5.

Assemblage 5 is the high number E. excavatum - B. frigida - Brizalina spp. assemblage in Balmoral, in sample B1-27 (38-40 m). It also occurs in 1 sample in Cohasset, C1-25 at 32-35 m and 1 sample in Panuke, P1-12 at 28-31 m. It correlates to assemblage 5A in the previously studied (1987) Cohasset (34-43 m) and Panuke (25-29 m) boreholes (Amos and Miller, 1990). Assemblage 7 is the E. excavatum - Epistominella spp. - Brizalina spp. assemblage occurring in Balmoral, in sample B1-32 (44-46 m). It contains Epistominella spp. as the co-dominant group. Assemblage 7 is also present in the Banquereau boreholes; at Louisburg (Miller and Scott, 1984) and at South Griffin (Miller, 1989).

In Cohasset and Panuke, assemblage 5 is a transition fauna from the underlying assemblages (dominated by E. excavatum) and the overlying E. albiumbilicatum - E. excavatum assemblage. It probably indicates an increase in water temperature and an increase in salinity. There are up to 7 species of Brizalina present in the samples. If indigenous, these are indicative of warm, saline waters. Only 3 of these species (B. pseudopunctata, B. spathulata, B. subaenariensis) are found in modern environments along the Canadian continental margin, the other 4 (B. albatrossi, B. lanceolata, B. lowmani and B. mexicana) are found in the Gulf of Mexico (Phleger and Parker, 1951,

part 1; Poag, 1981). The specimens of E. excavatum show good preservation and varied ornamented morphology, indicative of warmer waters. There is a (relatively) high number of QP present, species indicative of slightly warmer or an influx of oceanic waters. Poag (1981) defines a Brizalina predominance area directly offshore of the Elphidium zone at approximately the 200 m water depth. However, there is also a large reworked component present. Included with the reworked component are reworked Tertiary specimens. It is plausible that these specimens of Brizalina spp. belong to the reworked component of the fauna. Their good state of preservation is evidence against this theory but it cannot be discounted. A noticeable Brizalina component does not appear again until 72 m.

Epistominella sandiegoensis (Uchio) and Epistominella takayanagii Iwasa have both been recognized in this assemblage. Both species were grouped as E. takayanagii in previous work (Miller and Scott, 1984; Miller 1987a, 1987b, 1989; Amos and Miller ,1990).

Epistominella sandiegoensis was first described by Uchio (1960) from the narrow continental shelf off California. E. sandiegoensis is eurybathic, found in low frequencies in nearshore and inner shelf areas and in high frequencies on the continental slope (particularly greater than 560 m). No information is given about water temperature or salinity.

E. takayanagii prefers shallow (inner shelf) water depths, slightly reduced salinities (32-33$^{o/oo}$, Leslie, 1965) calm, cold waters (Schafer and Cole, 1978) and a fine substrate. MacNeil (1986) has found a C. reniforme - E. takayanagii fauna at the base of a piston core from outer Notre Dame Bay, Northeast Newfoundland Shelf. Scott (1987) reports E. excavatum and E. takayanagii as the dominant (glacial) species at Site 613 (DSDP Leg 95; New Jersey transect), though deposited in 2400 m of water. He suggests that an E. excavatum - E. takayanagii fauna is a high salinity cold water counterpart of the sightly lower salinity more tolerant E. excavatum - C. reniforme fauna. European workers do not report Epistominella spp. in other than trace amounts in any Quaternary or Holocene environments.

Assemblage 6 is the near barren fauna occurring twice in Balmoral, in samples B1-29 and B1-30 (41-44 m) and B1-34 to B1-50 (50-90 m). It occurs in Cohasset in C1-32 to C1-44 (44 to 67 m), C1-49 to C1-50 (81-85 m) and at the base of the borehole in C1-52 (90-91 m). The corresponding assemblage in Panuke is assemblage 14, in samples P2-13 (50-51 m), P2-15 to P2-23 (53-73 m) and in P2-25 to P1-29 (74-100 m). Both assemblages are almost barren of QB fauna. Specimens present are broken and etched, indicating extensive reworking. In assemblage 6, there are low numbers of reworked specimens present. In contrast, assemblage 14 contains a very large and extensive badly broken, etched and yellowed reworked fauna. Assemblage 14 correlates to assemblage 5B in the 1987 drilled Panuke borehole (Amos and Miller, 1990). The near barren characteristic of assemblage 6 indicates subaerial exposure of this interval in Balmoral and Cohasset, but the sediments being reworked and redeposited must have been protected at Panuke to allow for preservation of the reworked specimens. The lack of Quaternary fauna, coupled with the very poor preservation suggests grounded or nearby grounded ice conditions rather than normal marine conditions.

Cibicides grossa (ten Dam and Reinhold) appears once in assemblage 2 and in this assemblage (assemblage14). In the North Sea basin, the last appearance datum (LAD) has been taken to be Late Pliocene (van Voorthuysen et al., 1972; Gregory and Bridge, 1979; King, 1983; Feyling-Hanssen, 1990b) and this LAD has been used, both

in the North Sea and on the continental shelf off Norway, as a marker horizon for the Pliocene / Pleistocene boundary in core sections (Feyling-Hanssen, 1980a; King, 1983). However, King (1989) has revised the LAD to the early Lower Pleistocene. Its pre-sence in this reworked zone implies that Late Pliocene or very early Pleistocene sed-iments have been reworked and redeposited in this stratigraphic interval along with older sediments.

Assemblage 8 is marked by an increase in the percent occurrence of E. excav-atum. It occurs in Balmoral twice, in B1-28 (40-41 m) and B1-33 (46-47 m) and once in Panuke (P1-25, 49-50 m); and correlates to assemblage 8 in the previously drilled (1987) Cohasset borehole (45 m) and assemblage 8 at the 60 m depth in the (1987) Panuke borehole (Amos and Miller, 1990). This low diversity fauna and its subdom-inant species are characteristic of cold polar waters, or a very shallow water depth.

Assemblages 9 and 10 occur only in Cohasset and are high number QB faunas with a high reworked component in assemblage 9. Due to their stratigraphic position they may be preserved intervals within this sediment; and consequently assemblage 4 may be the same fauna(s) in intervals that have been subject to greater reworking.

Assemblage 9 is a cold water continental shelf assemblage, found in C1-14 at 19-20 m, with cold shelf species A. hamadaense, B. aculeata, B. marginata, B. striata, Fissurina spp. Lagena sp., Oolina spp., Trifarina angulosa / fluens. It also has a high percentage of C. reniforme (17%). Assemblage 9 contains 11% I. algida. Both faunas have pristinely preserved, highly ornamented specimens of E. excavatum, indicative of shallow estuarine conditions.

Assemblage 9 contains a large reworked component which may be indicative of glacial activity. If indicative of glacial activity; the high state of preservation may be due to protection afforded by the extensive ice cover, or due to high sedimentation rates caused by an influx of ice rafted debris from melting ice / melt-water.

Assemblage 10 is the E. excavatum - Epistominella spp. - I. algida fauna occur-ring in 1 sample in Cohasset, sample C1-19 from 25-26 m. It correlates to the bottom of assemblage 3A (26.3 m) in the (1987) Cohasset borehole (Amos and Miller, 1990).

Williamson (1982, 1983) and Williamson et al. (1984) reported an assemblage completely dominated by I. islandica (=I. algida) (their assemblage 7) prevalent on isolated outer banks and isolated depressions on the Scotian Shelf, where it replaces a Cibicides assemblage (assemblage 2). Williamson et al. (1984) attribute this re-placement with conditions of higher salinity and increases in percent gravel. Sen Gupta (1971) found this assemblage on the sandy areas of the Tail of the Grand Banks and Vilks et al. (1982) report similar faunas in gravelly sandy muds on the Labrador Shelf.

I. algida has been reported as the dominant species in some zones of raised Quaternary deposits of the Clyde Foreland (Feyling-Hanssen, 1976a, 1976b), Brough-ton Island (Feyling-Hanssen,1976c) and the Qivituq Peninsula (Feyling-Hanssen, 1980a). In the Clyde Foreland Feyling-Hanssen (1980a) interprets its dominance - sub-dominance as an indicator of a high arctic environment (along with its accompany-ing species). The lowermost zone has been C_{14} dated at approximately 40,000 YBP.

Assemblage 11 occurs in Cohasset (C1-26 to C1-28, 35-40 m; and C1-31, 43-44 m) and Panuke (P1-14 to P1-22, 32-46 m), an E. excavatum fauna with B. frigida, B. borealis, Epistominella spp. and C. reniforme. It is indicative of an increase in water depth, decrease in temperature and increase in salinity from the underlying assemblage 12. The increase in water depth is probably due to rising sea level. It correlates to assemblage 6A and 6B in the previously drilled (1987) Panuke borehole

(Amos and Miller, 1990). The presence of QP specimens are also indicative of open water conditions.

Assemblage 12 occurs only in the Cohasset (C1-29 and C1-30, 40-43 m) and Panuke (P1-24, 48-49 m) boreholes. It is distinguished by the presence of Quinqueloculina, including Q. aggutinata. Specimens of E. excavatum are pristinely preserved and highly ornamented. This assemblage is indicative of shallow water with hyposaline to normal marine conditions. This assemblage lies directly above the main barren interval and in turn is directly overlain by a deeper water assemblage.

Assemblage 13 is markedly different from any other assemblage observed in these boreholes. It appears in Cohasset and Panuke; Cohasset, at the top (C1-46, 72-73 m) and near the bottom (C1-51, 87-90 m) of the barren interval and in Panuke near the top (P2-14, 52-53 m); of the barren interval and at the base of the borehole (P1-30, 100-101 m). Assemblage 5 in Balmoral only, occurs in the same stratigraphic position as assemblage 13 in Panuke, near the top of the barren interval. In this instance assemblage 5 in Balmoral probably correlates to assemblage 13 at 52-53 m in Panuke. The Epistominella present does appear to be E. sandiegoensis (up to 27%). The fauna also contains up to 37% Brizalina spp. and 31% Uvigerina hispido-costata.

Poag (1981) reports a Brizalina - Uvigerina predominance group at the shelf edge and on the upper continental slope across the mouth of the Gulf of Mexico. Assemblage 13 may indicate a period of warmer water when, previous to the buildup of Sable Island Bank, this area represented the shelf edge.

A species identified as Nonionella basispinata has been identified in assemblage 13. N. basispinata was reported by Bandy (1953) as a dominant species off California in the 0-50 m water depth range. Uchio (1960) reported it in San Diego Bay, Douglas and Heitman (1979) report in 50-200 m of water off Southern California and Quintero and Gardner (1987) place it in the middle shelf assemblage (50-90 m) off northern California. Quintero and Gardner (1987) note then N. basispinata exhibits a wide range of variation in test morphology including differences in degree of asymmetry and development of spinosity in the umbilical area; variations which Lankford and Phleger (1973) attribute to latitudinal environmental differences. Uchio (1960) couldn't distinguish N. basispinata from N. atlantica Cushman. Uchio suggested that N. atlantica was present in the San Diego area prior to the closing of the Isthmus of Panama, and N. basispinata developed after the closing; and concluded that N. basispinata is a subspecies of N. atlantica (which is a junior synomyn of N. basispinata). However N. basispinata in these boreholes is quite distinct from the species attributed to N. atlantica in modern Eastern Canada environments.

There is a noticeable reworked component in all samples of assemblabe 13. The samples attributed to this assemblage near the base in Cohasset and at the base of Panuke contain the very well preserved Tertiary Caucasina elongata as the dominant reworked form. This leads to the question as to which component, indigenous (Quaternary may not apply) or reworked the Brizalina spp. and U. hispido-costata may belong. This question can't be answered at this time. If the upper sample in Panuke (2-14) is a preserved remnant of this fauna, these species may be reworked in this assemblage at this upper level.

Assemblage 15 is markedly different than any other assemblages found in these boreholes. It occurs in Panuke only, in the 73-74 m interval (P1-24). It is distinguished by the sub-dominance of H. concentrica, in addition to E. excavatum and C. subhaidingerii. H. concentrica has been reported by Phleger and Parker (1951) and Poag (1981) as common in the Gulf of Mexico. It occurs there co-dominant with E. excavatum

on the inner shelf (100-200 m) in isolated areas (Poag, 1981). Phleger and Parker (1951, part 1) report it in water depths of 15 to 90 m. However, any of the species identified in this sample as Quaternary could, in fact, be part of the reworked component. This could be a preserved reworked remnant of an older assemblage. It is impossible at this time to determine exacty the status of these species in this sample.

CORRELATION TO THE LITHO- AND SEISMO-STRATIGRAPHIC INTERPRETATIONS

The stratigraphy of the upper 150 m of Sable Island Bank is discussed by Amos and Miller (1990) and Christian and Zevenhuizen (1990); and summarized in detail is the (earlier) 'Previous Work' section of this report.

To briefly review, the surficial sediments (upper 150 m) of Sable Island Bank and Banquereau subdivided into two formations by King (1970) and on Banquereau only into five members by Amos and Knoll (1987). Amos and Miller (1990) extended the 5 member subdivision to Sable Island Bank. The Sable Island Sand and Gravel Formation (upper formation) is divided into the tough bedded sand, cross-bedded sand, and conformably bedded sand. The (underlying) Emerald Silt Formation is subdivided into 4 members: the channel gravel; upper stratified sand / fines (USSF); barren gravelly / sand; and lower stratified sand / fines (LSSF). Two regional discontinuities are believed to be erosional surfaces attributed to two low stands of sea level (Amos and Miller, 1990).

Amos and Miller (1990) found foraminiferal faunas showing strong correlation to lithologic changes and seismic events. These observations are also made here. The thickness and position of each of the five members and R_1 and R_2 in the Panuke and Cohassset boreholes can be inferred from the lithologic logs of the boreholes given in Christian and Zevenhuizen (1990) and by extrapolation to the seismo-stratigraphic logs of Amos and Miller (1990).

At Cohasset, the trough bedded sand and cross-bedded sand occur above R_1 (0-19 m) and contain foraminiferal assemblages 1 and 4. Assemblage 1 is the low number modern bank QB fauna with a virtual absence of Quaternary planktonic and reworked foraminifera. The conformably bedded sand with its contained high number glaciomarine QB fauna and high number peak of reworked foraminifera (assemblages 9 and 4) is marked by a massive thin clay silt layer over fine sand from 19 to 22 m (Christian and Zevenhuizen,1990). In Cohasset R_1 is inferred to be at 22 m sb (sub-bottom), or 65 m bsl (below sea level), marked by a gravel layer (Christian and Zevenhuizen, 1990). Below R_1 are the four members of the Emerald Silt Formation. The channel gravel directly underlies R_1, from 22-33 m. This member is divided into a clay facies in the upper part and a sand facies at the lower part. The channel gravel contains foraminiferal assemblages 3, 4 and 10. It is consistent that the channel gravel unit would contain assemblage 3, the E. albiumbilicatum assemblage.

The upper stratified sand / fines are only a thin unit in the borehole, 2 m thick from 33-35 m. It contains its characteristic assemblage 5, marked by the presence of Bizalina. R_2 is inferred at 35 m, again coincident with a sharp faunal boundary. Underlying R_2 is the barren gravelly / sand (35 to 42 m), with assemblages 11 and 12. It is consistent that the shallow water / channel infill contain a very shallow water lagoonal fauna (assemblage 12). The lower stratified sand / fines begin at 42 m with its characteristic barren (assemblage 6) fauna. The base of this unit had not been previously sampled here. There is a dessication surface and change in lithology, but no change in fauna,

at 55 m. This horizon is believed to represent R_3 on the seismo-stratigraphy (Christian, 1992, pers. comm.). There appear on the lithologic logs to be changes in lithology at 71 m and 79 m. Assemblage 13 first appears at 72 m, but this is believed to be an erosional remnant due to the lack of planktonics in the fauna. Sample 51 (87-90 m) with its distinct planktonic faunas may be in situ and represent a preserved fauna of the Laurentian Formation. Amos and Miller (1990) state that the LSSF increases in thickness from 10 m north of Cohasset to 100 m in the southern most part of the (1987) study region. If the change in lithology at 55 m is the base of the LSSF, this infers a thickness of 16 m for this unit, and 35 m of the Laurentian Formation has been sampled. A C_{14} date of 36, 820 + 44 (Christian, 1992, pers. comm.) has been obtained on shell material at 85 m.

The Sable Island Sand and Gravel can be well correlated between the 1987 and 1990 Cohasset boreholes. The trough bedded sand and cross-bedded sand are 18 m thick in both boreholes and there is a thin unit of conformably bedded sand and its contained post-transgressive (above R_1) glacio-`marine foraminiferal faunas with a reworked component. In the 1987 borehole there was 7 m of 'Younger Dryas fauna' (assemblages 3A and 4B) (Amos and Miller, 1990); here, there is about 5 m. At this point, the occurrence and (if present) thickness of the units and their contained faunas becomes variable and difficult to correlate.

Seismo-stratigraphically, two units, D_1 and D_2 are recognized as occurring between the two acoustic reflectors (R_1 and R_2)(Amos and Miller, 1990). D_1 is characterized by channel like features seen on the air gun records as much as 10 m deep and 500 m wide. D_1 is a thin unit (3 m thick) except where the channels occur. D_1 and its channels are correlated to the channel gravel member and D_2 to the USSF. The first (1987 Cohasset borehole) was believed to have been drilled in such a channel, truncating R_2. The second (1990) borehole is believed not to be in one of these channels. Examination of the (1987) foraminiferal data suggests both a thick channel gravel member (9 m) and upper USSF member (10 m), the USSF is characterized by its Brizalina fauna. In contrast, the 1990 borehole contains a thick channel gravel member (11 m) and very thin (2 m) USSF member. It too may have been drilled in a channel, or conversely, neither may have been drilled in a channel (positioning errors).

In the 1987 borehole R_2 was believed to be missing and the base of the borehole bottomed in the LSSF member. However, the fauna at the base of the 1987 borehole correlates well with assemblage 8 (1990) believed to be in a thick barren / gravelly sand unit. In this work, the LSSF member was found to be barren of fauna. The 1987 drilled Cohasset borehole is now believed to bottom out in the barren gravelly / sand member, and may not have been drilled in a channel. This implies the presence of R_2, not truncated by a channel.

In the Panuke borehole, the trough bedded sand and cross-bedded sand occur to a depth of 6 and 10 m respectively (Amos and Miller, 1990). These 2 members contain foraminiferal assemblage 1. The conformably bedded sand occurs from 10 to 19 m, with R_1 inferred by an unconformity on the lithologic log at 19-20 m (Christian and Zevenhuizen, 1990). The conformably bedded sand contains foraminiferal assemblage 2 from 13-20 m; and therefore contains 7 m of'Younger Dryas' fauna.

The channel gravel member occurs from 19-29 m and contains assemblages 2, 4 and 3. Again it is consistent that the channel fill contains assemblage 3, the E. albiumbilicatum fauna.

The USSF member occurs from 29 to 32 m and contains assemblages 5 and 4. R_2 has been interpreted from the lithologic logs to occur at 32 m and the barren /

gravelly sand occurs from 32 to 42 m. It contains assemblage 11. The LSSF begin at 42 m and at the top contains assemblage 11 and the very shallow water assemblages 12 and 8. Underlying this interval it is largely barren of Quaternary foraminifera, but contains a reworked fauna (assemblage 14), which correlate to assemblage 6. The change in lithology appears to be at 52 m; based on the lithologic logs the dessication surface is believed to be here, described as "clay with sand inclusions and pebbles, over coarse sand" (Christian and Zevenhuizen, 1990). The appearance of assemblage 13 coincides with this change in lithology. There is also the presence of assemblage 15, which also may be a preserved pocket of assemblage 14, or reworked from an older assemblage. Christian and Zevenhuizen (1990) indicate a lithologic boundary at 71 m and another at 89 m but these boundaries are not marked by any change in fauna. The LSSF are 10 m thick at Panuke and the bottom 49 m of the Panuke borehole is the Laurentian Formation. Two C_{14} dates have been obtained from material from this unit. Christian (1992, pers. comm.) states that a date of 35,710 + 75 has been obtained from material from 75 m and a date of 50,850 + 1420 has been obtained from material at 102 m.

In comparison to the previously drilled (1987) Panuke borehole, the trough bedded and cross-bedded sand are both of similar thickness (10 m) and both contain sparce modern faunas (assemblage 3, here; assemblages 1 and 2, 1987). In both boreholes, the conformably bedded sand is 10 m thick; with 7 m (13-20 m) of glaciomarine fauna with the reworked component (assemblage 2) here; 9 m of the same fauna (assemblages 3A and 4B) in the 1987 hole. R_1 occurs at 19-20 m in this borehole, 19-20 m in the 1987 borehole. The channel gravel occurs from 19-29 m and contains low numbers of assemblage 2 here, which correlates to assemblages 9 and 9A in the 1987 borehole.

The thickness of the sediments, 12-13 m, remains consistent between the two regional discontinuities R_1 and R_2 in each borehole (19-31 m in the 1987 borehole, 19-32 m in this borehole). In the 1987 borehole, the USSF occurs from 24 to 31 m (7 m thick) and contains assemblage 5A. Where the channel gravel was interpreted to be 5 m thick and the USSF 7 m thick in the 1987 borehole; the channel gravel is interpreted as 10 m thick and the USSF as only 3 m thick in this borehole. This is probably due to the same channelling phenomena as was described for the 1987 Cohasset borehole.

R_2 is interpreted as occurring at 32 m in this borehole. The barren gravelly / sand appears to be 10 m thick, occurring from 32 to 42 m, containing assemblage 11. In the 1987 borehole, it appeared to be 15 m thick (31 to 46 m), containing assemblages 5B and 6A (Amos and Miller, 1990). The thickness of this unit is probably due to the channelling in the LSSF. Channels within this unit have been correlated with the barren / gravelly sand (Amos and Miller, 1990). The projected position of the 1987 borehole indicates it is sitting within one of the channels, part of an extensive channelling system at this site. The 1990 drilled borehole is also probably within one of these channels.

The next unit sampled in the (1987) Panuke borehole is the LSSF. It is now apparent that the base of this unit may have been sampled. The LSSF extend from 46 to 55 m of the 1987 Panuke borehole, and contains assemblages 6B and 7 (Amos and Miller, 1990). Assemblage 6B correlates to assemblage 11 here and 6 correlates to assemblage 14; it too contains larger numbers of reworked rather than Quaternary foraminifera. The 1990 borehole also contains shallow water assemblage 8 and 12. Assemblages 7 and 8 in the 1987 borehole may be in the Laurentian Formation and

must be in a preserved pocket of Quaternary fauna; they don't appear at this level in the 1990 borehole.

The Balmoral borehole can only be correlated to the lithologic logs of Christian and Zevenhuizen (1990). The trough bedded sand and cross-bedded sand appear to be quite thick, extending to a depth of 17 m. These contain foraminiferal assemblage 1. Assemblage 2 occurs from 18 to 28 m, this is inferred to be the conformably bedded sand. The Balmoral borehole contains 10 m of the 'Younger Dryas' fauna. R_1 appears in the lithologic logs to be at 28 m, near the base of assemblage 2 (Christian and Zevenhuizen, 1990). The channel gravel (clay facies) appears to be 9 m thick (26-35 m) with assemblages 2, 3, 4 and 2. The USSF occurs from 35 to 40 m, with assemblage 2 and its characteristic Brizalina spp. (assemblage 5) fauna. R_2 occurs at 40 m (Christian and Zevenhuizen, 1990). The upper section of the barren fauna (assemblage 6) occurs at 41-44 m and probably coincides with the barren gravelly / sand (40-46 m). This unit also contains assemblage 7. The LSSF begins at 46 m and extends to 60 m with assemblages 8 and 6 (in that order downhole). The Laurentian Formation (assem-blage 6) then extends from 60 m to the base (90 m) of the borehole. There is no faunal evidence to indicate that the Laurentian Formation has been sampled. Three C_{14} dates have been obtained from samples in the Laurentian Formation (Christian, 1992, pers. comm.): 30,580 + 280 from 74 m; 51,260 + 1440 from 84 m; and 37,860 + 510 from 97 m.

To summarize: faunal boundaries coincide with lithic- and seismo-stratigraphic boundaries. Faunas correlate to lithic units. Faunal boundaries coincide with R_1 and R_2. This summary (Figure 1) is shown below.

The upper-most sharp faunal boundary (top of assemblages 2 and 4) occurs at 18 m in Balmoral (53 m bsl), 16 m in Cohasset (59 m bsl) and 13 m in Panuke (57 m bsl), which is not quite as consistent as what was observed in the three 1987 drilled boreholes (52 m in Como, 55 m in Panuke, 56 m in Cohasset) but allowing for tidal variations and minor variations in seabed morphology, is very good. Scott (in Boyd et al., 1988; Scott et al., 1989) report a late glacial fauna accompanied by a large number of reworked (identified only as Tertiary / Cretaceous) forms at 56.3 m in the 1982 Sable borehole, which is also consistent with the observations made here. R_1, the acoustic

Lithic Member	**Assemblage**	**Borehole**
trough bedded sand	1 and 4	Cohasset
cross-bedded sand	1	Panuke
	1	Balmoral
conformably bedded sand	2	Panuke
	9 and 4	Cohasset
	2	Balmoral
	R_1	
channel gravel	3, 4 and 10	Cohasset
	2, 4, 3	Panuke
	3, 4, 2	Balmoral
upper stratified sand / fines	5 and 4	Panuke

	2 and 5	Balmoral
	5	Cohasset
	R_2	
barren gravelly / sand	11	Panuke
	11 and 12	Cohasset
	6 and 7	Balmoral
lower stratified sand / fines	11, 12, 8 and 14	Panuke
	11 and 6	Cohasset
	8 and 6	Balmoral
Laurentian Formation	6 and 13	Cohasset
	13, 14 and 15	Panuke
	6	Balmoral

Figure 1: Summary diagram of lithologic units and foraminiferal faunas for the Balmoral, Cohasset and Panuke boreholes.

regional discontinuity, is recognized at 28 m in Balmoral (63 m bsl), 22 m in Cohasset (65 m bsl) and 19 m Panuke (63 m bsl). This is quite consistent with the interpreted position of R_1 in the 1987 boreholes (61 m bsl in Cohasset, 65 m bsl in Como, 61 m bsl in Panuke). If R_1 is correctly placed and interpreted at 63 m the glacio-marine / immediate post-glacial QB fauna with the first peak of reworked foraminfera appears 10 m above R_1 in Balmoral (10 m thick), 5 m above R_1 in Cohasset (5 m thick) and 7 m above R_1 in Panuke (7 m thick). The presence of high numbers of well preserved Cretaceous forms is probably due to deposition of ice rafted detritus during the final 'deglaciation' event. Because the fauna occurs consistently above R_1, this late glacial fauna and causative deglacial activity post dates the latest marine transgres-sion. The hypothesis is that there was ice cover on Sable Island Bank as sea level rose around it.

R_2, the underlying acoustic regional discontinuity occurs at 40 m in Balmoral (75 m bsl) 35 m in Cohasset (78 m bsl) and 32 m in Panuke (70 m bsl). There is foraminiferal evidence that both the channel gravel and barren gravelly sand are thick units in all boreholes; indicative of channelling in both the USSF and LSSF; units in which R_1 and R_2 occur, as identified on the acoustic records. The USSF is a thinner unit than previously believed. The USSF contain a distinct 'warmer water' fauna with low but consistent numbers of warm water species of Brizalina. This occurs just above R_2 (72-75 m bsl). Scott (Boyd et al., 1988, Scott et al., 1989) also reported a warm water fauna at 67-68 m in the 1985 Sable borehole, which he interprets as an interglacial fauna.

The LSSF have been extensively sampled for the first time and for the most part, is barren of fauna in Balmoral and Cohasset. In Panuke, there is a poorly preserved reworked fauna with scattered occurrences of Quaternary fauna in the same interval. This large, barren (of Quaternary fauna) interval may be indicative of a third previously unknown period of lowered sea level. However, it may also be that these sediments were subaerially exposed and subject to channelling by the low sea level stand capped by R_2. The barren character of this interval in Cohasset and Balmoral may be due to subaerial exposure. Panuke was protected in some way from dissolution of the reworked fauna; possibly ice cover.

R_3, the accoustic regional discontinuity underlying the Emerald Silt, occurs at 60 m sb (97 m bsl) in Balmoral, at 55 m sb (99 m bsl) in Cohasset and at 52 m sb (97 m bsl) in Panuke. It was recognized at 55 m sb (98 m bsl) in the previously drilled (1987) Panuke borehole. Amos and Miller (1990) and Christian and Zevenhuizen (1990) noted dessication cracks and an erosional surface in the boreholes coinciding with these depths. Amos and Miller (1990) attributed this dessication surface to a low sea level stand during the latter part of the middle Wisconsinan.

The sediments underlying R_3 have been sampled for the first time. These were included by Jansa and Wade (1975) in the designation of the Laurentian Formation; but Jansa and Wade (1975) did not account for the five surfical formations, including the Sable Island Sand and Gravel and Emerald Silt Formation, previously designated and described by King (1970). These five formations of King (1970) are recognized here and the material stratigraphically underlying R_3 is assigned to the Laurentian Formation. The Laurentian Formation is here defined as all sediments underlying the Emerald Silt Formation (Scotian Shelf Drift) and overlying the Banquereau Formation. In these boreholes, it is described a hard, stiff (overconsolidated) clay. It does contain foraminifera, some of which is reworked, and therefore has a marine origin. Additional sampling may indicate that more than one distinct lithology is present and further subdivision into distinct units may be warrented.

Amos and Miller (1990) interpret the following events from the stratigraphic record and place a chronological framework on these events. The trough bedded sand formed over the past 6,000 years under modern marine conditions (assemblage 1). The cross-bedded sand formed between 10,000 and 6,000 YBP under cool, shallow marine conditions (assemblage 1). The conformably bedded sand is interpreted to have formed between 11,000 and 10,000 YBP under heavy ice cover (assemblage 2, 4 and 9). It was proposed by Amos and Miller (1990) to have been the result of the Younger Dryas event as described by Mott et al. (1986). The channel gravel is interpreted to have formed 11,000 - 13,000 YBP (assemblages 2, 3, 4 and 10); the result of nearshore, tidal channel infill and shallow quiescent marine sedimentation, at the end of the Late Wisconsin low stand of sea level (-100 m, 13,000 - 15,000 YBP). Amos and Miller (1990) correlate this to the Scotian Stade. The USSF must have formed in warm water marine conditions or contain a reworked foraminiferal fauna from an underlying unit deposited in warm water conditions (assemblage 2 and 5). If in situ, the USSF were deposited by rising sea level just after the earlier low sea level stand (R_2). This is correlated to the Scotian Interstade (Amos and Miller, 1990). The barren gravelly / sand was deposited during the late Mid-Wisconsinan low stand of sea level at 28,000 - 32,000 YBP. The channels are again interpreted as tidal / estuarine in origin (assemblages 6, 7, 11 and 12). These were infilled (assemblages 11 and 12) and covered during the subsequent marine transgression (assemblages 6 and 7). R_2 is correlated to the beginning of the Scotian Stade (oxygen - isotope stage 2) and the channelling correlated with the low sea level stand at the end of oxygen-isotope stage 3.

The LSSF is a pro-glacial marine deposit formed beneath an ice shelf during a Mid-Wisconsinan glacial advance. Panuke was probably ice covered much of the time (assemblages 8, 11, 12 and 14) but Cohasset and Balmoral were probably subaerially exposed (assemblages 6, 8 and 11). This unit is older than 32,000 YBP and correlates with stage 3 (Digby Stade). The upper part of the Laurentian Formation also appears to be a marine deposit (assemblages 13, 14 and 15 at Panuke; 6 at Balmoral; and 6 and 13 at Cohasset) with C_{14} dates of 30,000 to 54,000 YBP.

CONCLUSIONS

One hundred and twenty-three floated samples were analysed for Quaternary benthic and planktonic foraminifera and reworked (Cretaceous/Tertiary) foraminifera from three geotechnical boreholes on Sable Island Bank, Scotian Shelf; 37 from the Cohasset, 43 from the Balmoral and 43 from the Panuke well sites. Fifteen distinct assemblages have been recognized, all believed to be Quaternary in age and contained in Quaternary sediments. These 15 assemblages are: (1) E. excavatum - E. bartletti shelf fauna; (2) E. excavatum - I. helenae - C. teretis - reworked component; (3) E. albiumbilicatum - E. excavatum - reworked component; (4) E. excavatum - E. bartletti / albiumbilicatum; (5) E. excavatum - B. frigida - Brizalina spp. - reworked component; (6) low numbers; (7) E. excavatum - Epistominella spp. - Brizalina spp. - reworked component; (8) E. excavatum; (9) E. excavatum - C. reniforme - B. frigida - reworked component; (10) Epistominella spp. - E. excavatum - I. algida - reworked component; (11) E. excavatum - E. sandiegoensis - B. frigida - B. borealis; (12) E. excavatum - E. sandiegoensis - Quinqueloculina spp.; (13) Epistominella spp. - Brizalina spp. - reworked component; (14) reworked component; and (15) H. concentrica - C. subhaidingerii - reworked component.

Downhole in Balmoral the sequence is: assemblage 1 (0-17 m), assemblage 2 (17-28 m), assemblage 3 (28-29 m), assemblage 4 (29-33 m), assemblage 2 (33-38 m), assemblage 5 (38-40 m), assemblage 8 (40-41 m), assemblage 6 (41-44 m), assemblage 7 (44-46 m), assemblage 8 (46-47 m) and assemblage 6 (50-90 m).

Downhole in Cohasset the sequence is: assemblage 1 (3-16 m), assemblage 4 (16-19 m), assembage 9 (19-20 m), assemblage 4 (20-25 m), assemblage 10 (25-26 m), assemblage 4 (26-30 m), assemblage 3 (30-34 m), assemblage 5 (34-35 m), assemblage 11 (35-40 m), assemblage 12 (40-43 m), assemblage 11 (43-44 m), assemblage 6 (44-67 m), assemblage 13 (72-73 m), assem-blage 6 (81-85 m) and assemblage 13 (87-90 m) and assemblage 6 (90-91 m).

Downhole in Panuke, the sequence is: assemblage 2 (1-2 m), assemblage 1 (2-13 m), assemblage 2 (13-23 m), assemblage 4 (23-27 m), assemblage 3 (27-28 m), assemblage 5 (28-31 m), assemblage 4 (31-32 m), assemblage 11 (32-46 m), assemblage 12 (48-49 m), assemblage 8 (49-50 m), assemblage 14 (50-51 m), assemblage 13 (52-53 m), assemblage 14 (53-73 m) , assemblage 15 (73-74 m), assemblage 14 (74-100 m) and assemblage 13 (100-101 m).

The faunal assemblages show strong correlation to seismo-stratigraphic and distinct lithologic units. The trough and cross-bedded sands contain assemblages 1 and 4 and were formed in the last 10,000 years under modern marine conditions. The conformably bedded sand formed 10,000 to 11,000 YBP under heavy ice cover (assemblages 2, 4 and 9) attributed to the Younger Dryas event. The channel gravel member formed during the late Wisconsinan low sea level stand (-110 m), 11,000 to 13,000 YBP (assemblages 2, 3, 4 and 10) in tidal channels and due to shelf sediment reworking during and after the transgression. The acoustic reflector R_1 is recognized in this unit. The upper stratified sand / fines formed in open marine shelf conditions, warmer than present day (assemblages 2 and 5) from 13,000 - 28,000 YBP. The barren gravelly / sand formed during the late Mid-Wisconsinan low sea level stand (-98 m) from 28 - 32,000 YBP (assemblages 6, 7, 11 and 12) under conditions similar as the channel gravel member. The acoustic reflector R_2 is recognized within this unit. The lower stratified sand / fines were reworked to become barren in most intervals

(assemblages 6, 8, 11, 12 and 14), due to subaerial exposure / ice cover during the Mid-Wisconsinan advance.

The Laurentian Formation (assemblages 6, 13, 14, 15) has been sampled in all three boreholes.

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APPENDIX A

FAUNAL REFERENCE LIST

This is not a taxonomic report and lengthy synonymies will not be given here. However, it is important that an unambiguous concept of each species be conveyed to the reader; to that end the following references are given which contain an illustration and (in most cases) a synonymy of each species. Where the name of the species referred to is not the same as the one used in this report, the name in square brackets is the one used in the reference given.

The generic classification is in accordance with Loeblich and Tappan (1964) except for Haynesina (Banner and Culver, 1978) and Troculina (Loeblich and Tappan, 1988).

Species are listed alphabetically, first the agglutinated, then calcareous.

QUATERNARY BENTHONIC FORAMINIFERA

Eggerella advena Cushman. VILKS, 1989, p. 535-536, pl. 21-III, figs. 9-10.
Silicosigmoilina groenlandica Cushman. VILKS, 1989, p. 530, pl. 21-I, figs. 14-15.
Trochammina ochracea Williamson. VILKS, 1989, p. 535, pl. 21-III, figs. 4-6.

Allomorphina fragilis Hofker. KNUDSEN, 1971b, p. 250, pl. 8, figs. 7-9.
Astacolus hyalacrulus Loeblich and Tappan. SCHROEDER-ADAMS ET AL., 1990, p. 24, pl.5, fig. 12.
Astrononion hamadaense Asano. UJIIE ET AL., 1983, p. 61, pl. 9, figs. 10-11. (includes the junior synonym Astrononion gallowayi Loeblich and Tappan).
Brizalina albatrossi (Cushman). POAG, 1981, p. 44-45, pl. 23, fig. 5; pl. 24, figs. 5a-c.
Brizalina lanceolata (Parker). POAG, 1981, p.46, pl. 25, fig. 5; pl. 26, figs. 5a-c.
Brizalina lowmani (Phleger and Parker). POAG, 1981, p. 46, pl. 25, fig. 3; pl. 26, figs. 3a-c.
Brizalina mexicana (Cushman) [Brizalina subaenariensis mexicana (Cushman)]. POAG, 1981, p. 48, pl. 25, fig.1; pl. 26, figs. 1a-c.
Brizalina pseudopunctata (Hoeglund). MILLER ET AL., 1982a, p. 2364, pl. 2, fig. 21.
Brizalina spathulata (Williamson). SCOTT, 1987, p. 237, pl. 1, fig. 10.
Brizalina subaenariensis (Cushman). SCOTT, 1987, p. 327, pl. 1, fig. 11.
Buccella calida (Cushman and Cole) [Eponides frigidus (Cushman) var. calidus Cushman and Cole]. CUSHMAN, 1944, p. 34, pl. 4, figs. 19-20.
Buccella depressa. ANDERSEN, 1952, p. 145-146, pl. 1, figs. 7-8.
Buccella frigida (Cushman). MILLER ET AL., 1982a, p. 2364, pl. 3, figs. 9-10.
Buccella hannai [Eponides hannai]. PHLEGER and PARKER, 1951, part 2, p. 21, pl. 10, figs. 11a-14b.
Buccella tenerrima Bandy. KNUDSEN, 1971b, p. 254-255, pl. 8, figs. 15-17.
Bulimina affinis d'Orbigny. PHLEGER and PARKER, 1951, p. 15, pl. 7, figs. 21-22.
Bulimina aculeata / marginata d'Orbigny. POAG, 1981, p. 48-49, pl. 21, fig. 2; pl. 22, fig. 2.
Bulimina striata d'Orbigny. SCOTT, 1987, p. 327, pl. 1, fig. 4.
Buliminella basicostata Parr. BARKER, 1960, p. 102, pl. 50, figs. 23-24.
Buliminella borealis. HAYNES, 1973, p. 114-116, text-fig. 22:1-3.
Cassidulina laevigata (d'Orbigny) [Islandiella laevigata (d'Orbigny)]. POAG, 1981, p. 70, pl. 17, fig. 2; pl. 18, fig. 2.

Cassidulina reniforme Norvang. FEYLING-HANSSEN, 1990b, p. 22, pl. 4, figs. 4-9.
Cassidulina teretis Tappan. MACKENSEN and HALD, 1988, p. 17, pl. 1, figs. 8-15.
Cibicides corpulentus Phleger and Parker [Cibicidoides corpulentus (Phleger and Parker). POAG, 1981, p. 52-53, pl. 31, fig. 1; pl. 32, fig. 1.
Cibicides floridanus (Cushman) [Cibicidoides "floridanus" (Cushman) formae bathyalis and sublittoris]. POAG, 1981, p. 53-54, pl. 29, figs. 1-2; pl. 30, figs. 1-2.
Cibicides grossa ten Dam and Reinhold. FEYLING-HANSSEN, 1980a, p. 173, pl. V, figs. 1-6.
Cibicides io Cushman [Cibicidoides io (Cushman)]. POAG, 1981, p. 54, pl. 31, fig. 2; pl. 32, figs 2a-b.
Cibicides lobatalus (Walker and Jacob). FUNNEL, 1989, p. 566, pl. 12-1, figs. 4-6.
Cibicides robertsonianus (Brady) [Cibicidoides robertsonianus (Brady)]. POAG, 1981, p. 54-55, pl. 5, fig. 1; pl. 6, figs. 1a-b.
Cibicides subhaidingerii Parr. FUNNEL, 1989, p. 566, pl. 12.1, figs. 7-9.
Cibicides umbonatus Phleger and Parker [Cibicidoides umbonatus (Phleger and Parker)]. POAG, 1981, p. 55, pl. 31, fig. 4; pl. 32, figs.4a-b.
Cibicides wuellerstorfi (Schwager). SCOTT and VILKS, 1991, p. 30, pl. 2, figs. 13-14; pl. 4, figs. 14-15.
Cyclogyra borealis Cole (New species of Cyclogyrae). SCHROEDER-ADAMS ET AL., 1990, p. 24, pl. 5, figs. 3-4.
Dentalina baggi Galloway and Wissler. LOEBLICH and TAPPAN 1953, p. 54-55, pl. 9, figs. 10-15.
Dentalina guttifera d'Orbigny. BARKER, 1960, p. 130, pl. 62, figs. 10-12.
Discanomalina semipunctata (Bailey). MEDIOLI and SCOTT, 1978, p. 298-300, pls. 1, 2, 3.
Discorbis nitida (Williamson) [Discorbis cf. D. nitida (Williamson)]. PHLEGER and PARKER, 1951, part 2, p. 20, pl.10, figs. 8a-b.
Ehrenbergina pacifica Cushman. BARKER, 1960, p. 112, pl. 55, figs. 4, 6, 7.
Ehrenbergina trigona Goes. PHLEGER and PARKER, 1951, part 2, p. 28, pl. 15, fig. 1.
Elphidium albiumbilicatum (Weiss). FEYLING-HANSSEN, 1980a, p. 179, pl. VI, figs. 13-14.
Elphidium bartletti Cushman. FEYLING-HANSSEN, 1980a, p. 179, pl. VI, figs. 17-18.
Elphidium excavatum (Terquem) [Elphidium excavatum (Terquem) formae]. MILLER ET AL., 1982b, p. 116-144, pls. 1-6.
Elphidium groenlandicum Cushman [Elphidiella groenlandica Cushman]. LOEBLICH and TAPPAN, 1953, p. 106-107, pl. 19, figs. 13-14.
Elphidium incertum (Williamson). BUZAS, 1966, p. 592-593, pl. 73, figs. 1-6.
Elphidium subarcticum Cushman. FEYLING-HANSSEN, 1980a, p. 179, pl. VI, figs. 11-12.
Eoeponidella pulchella (Parker). VILKS, 1989, p. 540, pl. 21-IV, figs. 13-15.
Epistominella arctica Green [Stetsonia horvathi Green]. SCOTT, 1987, p. 328, pl. 2, figs. 1-2.
Epistominella exigua (Brady). SCOTT, 1987, p. 327, pl. 2, figs. 8-9.
Epistominella sandiegoensis. UCHIO, 1960, p. 68, pl. 9, figs. 6-7.
Epistominella takayanagii Iwasa. MILLER ET AL., 1982a, p. 2362, pl. 2, figs. 11-12.
Epistominella vitrea Parker. POAG, 1981, p. 63-64, pl. 5, fig. 3; pl. 6, fig. 3.
Eponides bradyi (Earland). BARKER, 1960, p. 196, pl. 95, figs. 9-10.
Eponides tumidulus (Brady). SCOTT and VILKS, 1991, p. 30, pl. 2, figs. 17-18; pl. 4, figs. 12-13.

Esosyrinx curta (Cushman and Ozawa). LOEBLICH and TAPPAN, 1953, p. 85, pl. 15, figs. 1-5.
Fissurina alveolata (Brady). BARKER, 1960, p. 127, pl. 60, figs. 30, 32.
Fissurina annectans Buchner. BARKER, 1960, p.122, pl. 59, figs. 7,15.
Fissurina cucurbitasaema Loeblich and Tappan. UJIE ET AL., 1983, p. 55, pl. 2, figs. 21-22.
Fissurina marginata (Walker and Boys). UJIE ET AL., 1983, p. 56, pl. 3, figs. 3-8.
Fissurina quadrata (Williamson). BARKER, 1960, p. 122, pl. 59, fig. 3.
Fissurina ventricosa (Wiesner). LOEBLICH and TAPPAN, 1953, p. 79, pl. 14, fig. 15.
Fursenkoina fusiformis (Williamson) [Virgulina fusiformis (Williamson)]. FEYLING-HANSSEN, 1964, p. 307, pl. 14, figs. 15-18.
Fursenkoina pontoni (Cushman). POAG, 1981, p. 66, pl. 33, fig. 5; pl. 34, figs. 5a-b.
Gavelinopsis praegeri (Heron-Allen and Earland). HANSEN and REVETS, 1992, p. 177, pl. 6, figs. 1-3, 7, 8.
Gavelinopsis transluscens (Phleger and Parker). SCOTT, 1987, p. 327, pl. 2, figs. 16-17.
Glabratella lauriei (Heron-Allen and Earland). SCHNITKER, 1971, p. 200, pl. 6, figs. 7a-c.
Glabratella wrightii (Brady). FEYLING-HANSSEN, 1990a, p. 104, pl. 2, figs. 6-8.
Globobulimina auriculata (Bailey). UJIE ET AL., 1983, p. 56, pl. 4, figs. 11-14.
Globobulimina pacifica Cushman. BARKER, 1960, p. 102, pl. 50, figs. 7-10.
Globocassidulina subglobosa (Brady). NOMURA, 1983, part 2, p. 20-22, pl. 2, figs. 8a-c; pl. 13, figs. 5-6.
Guttulina glacialis (Cushman and Ozawa). KNUDSEN, 1971b, p. 213-214, pl. 4, figs. 11-13.
Guttulina problema d'Orbigny. KNUDSEN, 1971b, p. 215, pl. 5, figs. 1-2.
Hanzawaia asterizans (Fichtel and Moll). HANSEN and ROEGL, 1980, p. 173-179, pl. 1, figs. 8-11, 13-15.
Hanzawaia concentrica (Cushman) [Hanzawaia concentrica (Cushman) forma typica] POAG, 1981, p. 67-68, pl. 39, fig. 2; pl. 40, fig. 2.
Haynesina depressula (Walker and Jacob). BANNER and CULVER, 1978, p. 200-201, pl. 10.
Haynesina germanica (Ehrenberg). SCHROEDER-ADAMS ET AL., 1990, p.34, pl. 8, figs.7-8.
Haynesina orbiculare (Brady). MILLER ET AL., 1982a, p.2362, pl. 2, fig. 7.
Haynesina ustulatum (Todd). GREGORY and BRIDGE, 1979, p. 70-71, pl. 1, figs. 1-6.
Islandiella algida (Cushman) [Islandiella islandica Norvang]. VILKS, 1989, p. 173, pl. 21-IV, figs. 1-2.
Islandiella curvata (Phleger and Parker). POAG, 1981, p. 69-70, pl.17, fig. 1; pl. 18, figs. 1a-b.
Islandiella helenae Feyling-Hanssen and Buzas. VILKS ET AL., 1982, p.226, pl. 1, fig. 14.
Islandiella norcrossi (Cushman). VILKS, 1989, p. 538, pl. 21-IV, figs. 5-6.
Islandiella sublimbata (Asano and Nakamura). NOMURA, 1983, part 2, p. 9-11, pl. 1, figs. 6a-8b. (Includes junior synonyms Islandiella inflata Gudina and Islandiella limbata Cushman and Hughes).
Lagena gracillima (Seguenza). UJIE ET AL., 1983, p. 54, pl. 2, fig. 2.
Lagena hispida Reuss. BARKER, 1960, p. 116, pl. 57, figs. 1-4.
Lagena laevis (Montagu). FEYLING-HANSSEN, 1964, p. 289, pl. 11, figs. 13-15.

Lagena semilineata Wright. FEYLING-HANSSEN, 1964, p. 291, pl. 12, fig. 2.
Laryngosigma hyalascidia Loeblich and Tappan. SCHROEDER-ADAMS ET AL., 1990, p. 34, pl. 4, figs. 11-12.
Lenticulina gibba (d'Orbigny). FEYLING-HANSSEN, 1964, p. 278, pl. 9, fig. 11.
Melonis barleeanum (Williamson) [Nonion barleeanum (Williamson)]. SCOTT and VILKS, 1991, p. 30, pl. 2, fig. 9; pl. 4, figs. 6-7.
Miliolinella circularis (Bornemann). POAG, 1981, p. 72, pl. 59, fig. 3; pl. 60, figs. 3a-b.
Miliolinella subrotunda (Montagu). FEYLING-HANSSEN, 1980b, p. 269-270, pl. 1, figs. 1-3.
Nonionella basispinata (Cushman and Moyer). QUINTERNO and GARDNER, 1987, p. 135, pl. 2. figs. 4-5, 7.
Nonionella stella Cushman and Moyer. UCHIO, 1960, p. 61, pl. 4, figs. 15-16.
Nonionellina labradorica (Dawson). VILKS, 1989, p. 545-546, pl. 21-IV, figs. 9-10.
Oolina apiculeata (Reuss). BARKER, 1960, p. 116, pl. 56, figs. 15-16.
Oolina borealis Loeblich and Tappan. FEYLING-HANSSEN, 1990a, p. 103, pl. 1, fig. 1.
Oolina lineata (Williamson). LOEBLICH and TAPPAN, 1953, p. 70, pl.13, figs. 11-13.
Oolina lineato-punctata (Heron-Allen and Earland). FEYLING-HANSSEN, 1964, p. 311, pl. 15, fig. 5.
Oolina melo d'Orbigny. UJIE ET AL., 1983, p. 55, pl. 2, fig. 15.
Oolina striatopunctata (Parker and Jones). UJIE ET AL., 1983, p. 55, pl. 2, figs. 17-18.
Oridosalis umbonatus (Reuss). VILKS, 1989, p. 546, pl. 21-IV, figs. 11-13.
Parafissurina himatiostoma. LOEBLICH and TAPPAN, 1953, p. 80, pl. 14, figs. 12-14.
Patellina corrugata (Williamson). SCHROEDER-ADAMS ET AL., 1990, p. 34, pl. 6, fig. 3.
Pateoris hauerinoides (Rhumbler). SCOTT ET AL., 1980, p. 228-231, pl. 3, figs. 6-8.
Pyrgo elongata d'Orbigny. BARKER, 1960, p. 4, pl. 2, fig. 9.
Pyrgo williamsoni (Silvestri). FEYLING-HANSSEN, 1964, p. 264, pl. 7, figs. 5-6.
Quinqueloculina agglutinata Cushman. VILKS, 1989, p. 536, pl. 21-III, fig. 11.
Quinqueloculina arctica Cushman. VILKS, 1989, p. 536, pl. 21-III, figs. 12-13.
Quinqueloculina elongata Natland. COLE, 1981, p. 50, pl. 8, fig. 7.
Quinqueloculina seminula (Linne). VILKS, 1989, p. 536, pl. 21-III, fig. 14.
Quinqueloculina stalkeri Loeblich and Tappan. FEYLING-HANSSEN, 1964, p. 252-253, pl. 4, figs. 13-18.
Rosalina globularis d'Orbigny). SCHNITKER, 1971, p. 210, pl. 6, figs. 1a-c.
Rosalina squamata [Discorbis squamata]. PARKER, 1952, p. 418, pl. 6, figs. 10-11.
Sigmoidella pacifica (Cushman and Ozawa). [Guttulina (Sigmoidella) pacifica (Cushman and Ozawa)]. BARKER, 1960, p. 150, pl. 72, figs. 14-15.
Stainforthia compressa (Bailey). POAG, 1981, p. 65, pl. 33, fig. 6; pl. 34, figs. 6a-b.
Stainforthia concava (Hoeglund). FEYLING-HANSSEN, 1964, p. 306, pl. 14, figs. 9-11.
Stainforthia mexicana (Cushman) [Fursenkoina mexicana Cushman]. POAG, 1981, p. 65-66, pl. 33, fig. 7; pl. 34, figs. 7a-b.
Stainforthia schreibersania (Czjzek). FEYLING-HANSSEN, 1964, p. 309-310, p. 14, figs.19-21.
Stainforthia skagerrakensis (Hoeglund). FEYLING-HANSSEN, 1964, p. 310, pl. 15, figs. 1-2.
Trifarina angulosa / fluens [Angulogerina angulosa (Williamson)] FEYLING-HANSSEN, 1964, p. 317-318, pl. 16, figs. 1-3; [Angulogerina fluens Todd] FEYLING-HANSSEN, 1964, p. 318, pl. 16, figs. 4-5.

Triloculina trihedra Loeblich and Tappan. VILKS, 1989, p. 537, pl. 21-III, figs. 15-16.
Troculina turbo (d'Orbigny). LOEBLICH and TAPPAN, 1988, p. 559-560, pl. 607, figs. 1-3.
Uvigerina hispido-costata Cushman and Todd. PHLEGER and PARKER, 1951, part 2, p. 18, pl. 8, figs. 17-21, 23.

QUATERNARY PLANKTONIC FORAMINIFERA

All references (except N. atlantica) are to SAITO ET AL., 1981.
Candeina nitida (d'Orbigny), p. 75, pl. 21.
Globigerina bulloides (d'Orbigny), p. 40, pl. 7, figs. 1a-d.
Globigerina quinqueloba Natland, (left and right coiled), p. 48, pl. 10.
Globigerinoides conglobatus (Brady), p. 56, pl. 14, figs. 1a-d.
Globigerinita glutinata (Egger), p. 17, pl. 22.
Globigerinita uvula (Natland), p. 81, pl. 24, figs. 3a-d.
Neogloboquadrina pachyderma (Ehrenberg) (left and right coiled), p. 106-108, pl. 34.
Globorotalia crassiformis (Galloway and Wissler), p. 129, pl. 43, figs. 2a-c.
Globorotalia truncatulinoides (d'Orbigny), p. 158, pl. 54, figs. 1a-c.

Neogloboquadrina atlantica (Globigerina atlantica). BERGGREN, 1972, p. 972-973, pl. 1, figs. 1-7.

REWORKED BENTHONIC FORAMINIFERA

Arenobulimina obesa (Reuss). McNEIL and CALDWELL, 1981, p. 183, pl. 15, figs. 1a-b, 2.
Clavulinoides aspera (Cushman). CUSHMAN, 1946, p. 38, pl. 9, figs. 24-30.
Dorothia bulleta (Carsey) [Dorothia cf. D. bulleta (Carsey)]. McNEIL and CALDWELL, 1981, p. 184-185, pl. 15, figs. 7a-b.
Dorothia conula (Reuss). CUSHMAN, 1946, p.44-45, pl. 12, figs. 12-14.
Dorothia refusa (Cushman). CUSHMAN, 1946, p. 46, pl. 13, figs. 1-4.
Eggerella mariae ten Dam. HART ET AL., 1989, p. 318, pl. 7.2, figs. 1-2.
Gaudryina ellisorae Cushman [Gaudryina (Pseudogaudryina) ellisorae Cushman]. CUSHMAN, 1946, p. 35-36, pl. 8, figs. 12-13.
Gaudryina stephensoni Cushman. McNEIL and CALDWELL, 1981, p. 178-179, pl. 14, figs. 13a-b, 14a-b.
Haplophragmoides eggeri Cushman. CUSHMAN, 1946, p. 20, pl. 2, figs. 9-10.
Marsonella oxycona (Reuss). CUSHMAN, 1946, p. 43-44, pl. 12, figs. 3-5.
Nodellum velascoense (Cushman). CUSHMAN, 1946, p. 17, pl. 1, figs. 28-31.
Plectina watersi Cushman. CUSHMAN,1946, p. 47, pl. 13, figs. 6-12.
Reusella spinulosa (Reuss). HERRICK, 1976, p. 143, pl. 11, fig. 57.
Spiroplectammina laevis (Roemer). NYONG and OLSSON, 1984, p. 450, pl. 1 fig. 18.
Spiroplectammina semicomplinata (Carsey). McNEIL and CALDWELL, 1981, p. 162, pl. 12, fig. 15.
Textularia subconica Franke. CUSHMAN, 1946, p. 30, pl. 6, figs. 21-22.
Tritaxia pyramiditana Reuss. HART ET AL., 1989, p. 320, pl. 7.3, figs. 2-3.
Verneuilina canadensis Cushman. McNEIL and CALDWELL, 1981, p. 175, pl. 14, fig. 3.
Verneuilina muensteri Reuss. HART ET AL., 1989, p. 320, pl. 7.3, figs.7-8.

Alabamina australis australis Belford. McNEIL and CALDWELL, 1981, p. 274, pl. 22, figs. 14a-c.
Alabamina sp. 1. McNEIL and CALDWELL, 1981, p. 274-275, pl. 22, figs. 15a-c.
Alabamina sp. 2. McNEIL and CALDWELL, 1981, p. 275, pl. 23, figs. 1a-c, 2a-c.
Allomorphina minuta Cushman. NYONG and OLSSON, 1984, p. 450, pl. 4, figs. 7-8.
Allomorphina trochoides (Reuss). NYONG and OLSSON, 1984, p. 450, pl. 4, figs. 15-16.
Amphicornya hirsuta (d'Orbigny). BARKER, 1960, p. 132, pl. 63, figs. 10-16.
Anomalinoides harperi (Sandidge). McNEIL and CALDWELL, 1981, p. 283-284, pl. 24, figs. 4a-c.
Anomalinoides stephensoni (Cushman) [Cibicides stephensoni Cushman]. CUSHMAN, 1946, p. 159, pl. 65, fig. 4.
Anomalinoides sp. McNEIL and CALDWELL, 1981, p. 284, pl. 24, figs. 3a-c.
Astacolus crepidulus (Fichtel and Moll). BARKER, 1960, p. 142, pl. 68, fig. 1.
Astacolus dissonus Plummer [Planularia dissonus (Plummer)]. CUSHMAN, 1946, p. 57, pl. 19, figs. 11-18.
Bandyana greatvalleyensis (Trujillo). McNEIL and CALDWELL, 1981, p. 270-271, pl. 22, fig. 10.
Bolivinita eleyi Cushman. CUSHMAN, 1946, p. 114, pl. 48, figs. 18-20.
Bolivinita planata Cushman. CUSHMAN, 1946, p. 114, pl. 48, figs. 21-22.
Bolivinita selmenesis Cushman. CUSHMAN, 1946, p. 114, pl. 49, figs. 1-2.
Bolivinoides culverensis Barr. HART ET AL., 1989, p. 322, pl. 7.4, figs. 10-11.
Bolivinoides decoratus australis Edgell. McNEIL and CALDWELL, 1981, p. 220-222, pl. 18, figs. 17a-b.
Bolivinoides decoratus delicatula Cushman [Bolivinoides decorata (Jones) var. delicatula Cushman]. CUSHMAN, 1946, p. 113, pl. 48, figs. 10-14.
Bolivinopsis papillata (Cushman). CUSHMAN, 1946, p. 102, pl. 44, fig. 9.
Brizalina cretosa (Cushman) [Bolivina cretosa Cushman]. CUSHMAN, 1946, p. 128, pl. 53, figs. 14-17.
Brizalina decurrens (Ehrenberg) [Bolivina decurrens (Ehrenberg)]. HART ET AL., 1989, p. 322, pl. 7.4, figs. 6-7.
Brizalina incrassata (Reuss) [Bolivina incrassata Reuss]. HART ET AL., 1989, p. 322, pl. 7.4, figs. 8-9.
Brizalina watersi (Cushman) [Bolivinoides watersi (Cushman)]. CUSHMAN, 1946, p. 128, pl. 53, fig. 18.
Bulimina arkadelphiana midwayensis Cushman and Parker. OLSSON, 1960, p. 231, pl. 5, fig. 9.
Buliminella fabilis (Cushman and Parker) [Buliminella cf. B. fabilis Cushman and Parker]. McNEIL and CALDWELL, 1981, p. 218, pl. 18, fig. 13.
Buliminoides chattonensis (Finlay). LOEBLICH and TAPPAN, 1964, p. C544, fig. 426:12.
Cassidella tegulata (Reuss). HART ET AL., 1989, p. 271-272, pl. 22, figs. 11-12.
Caucasina elongata (d'Orbigny). GRADSTEIN and ATGERBERG, 1982, p. 170, pl. 6, fig. 5.
Ceratobulimina contraria (Reuss). GRADSTEIN and ATGERBERG, 1982, p. 170, pl. 6, figs. 8-9.
Chrysalogonium cretaceum Cushman and Church. CUSHMAN, 1946, p. 75-76, pl. 27, fig. 13.

Chrysalogonium texanum Cushman. McNEIL and CALDWELL, 1981, p. 188, pl. 15, figs. 14a-b.
Dentalina alternata (Jones). CUSHMAN, 1946, p. 64-65, pl. 22, figs. 29-33.
Dentalina basiplanata Cushman. McNEIL and CALDWELL, 1981, p. 190-192, pl. 15, figs. 16-17.
Dentalina catenula Reuss [Dentalina cf. D. catenula Reuss]. McNEIL and CALDWELL, 1981, p. 193, pl. 15, fig. 19.
Dentalina confluens Reuss. CUSHMAN, 1946, p. 68-69, pl. 24, figs. 9-12.
Dentalina consobrina d'Orbigny [D. cf. consobrina d'Orbigny]. CUSHMAN, 1946, p. 69, pl. 24, figs. 23-27.
Dentalina crinita Plummer. CUSHMAN, 1946, p. 69, pl. 24, figs. 29-30.
Dentalina delicatula Cushman. CUSHMAN, 1946, p. 70, pl. 25, figs. 1-6.
Dentalina fallax Franke. CUSHMAN, 1946, p. 66, pl. 23, figs. 15-17.
Dentalina filiformis (d'Orbigny). BARKER, 1960, p. 132, pl. 63, figs. 3-5.
Dentalina gracilis d'Orbigny. CUSHMAN, 1946, p. 65, pl. 23, figs. 3-6.
Dentalina lorneiana d'Orbigny. CUSHMAN, 1946, p. 65-66, pl. 23, figs. 7-11.
Dentalina luma Belford [Dentalina cf. D. luma Belford]. McNEIL and CALDWELL, 1981, p. 193, pl. 15, fig. 20.
Dentalina megalopolitiana Reuss. CUSHMAN, 1946, p. 67, pl. 23, figs. 24-26.
Dentalina solvata (Cushman). NYONG and OLSSON, 1984, p. 451, pl. 5, figs. 17-18.
Ellipsonodosaria alexanderi Cushman. CUSHMAN, 1946, p. 135, pl. 56, figs. 12-15.
Ellipsonodoaria dentata-glabrata Cushman. CUSHMAN, 1946, p. 136, pl. 56, figs. 19-20.
Eouvigerina americana Cushman. CUSHMAN, 1946, p. 115, pl. 49, figs. 4-5.
Eouvigerina austinana Cushman. CUSHMAN, 1946, p. 116, pl. 49, fig. 9.
Eouvigerina excavata. CUSHMAN, 1940, p. 66, pl. 11, fig. 18.
Eouvigerina gracilis Cushman. CUSHMAN, 1946, p. 115, pl. 49, fig. 6.
Eouvigerina hispida Cushman. CUSHMAN, 1946, p. 115-116, pl. 49, figs. 7-8.
Epistomina hechti Bartenstein and Bolli. HART ET AL., 1989, p. 330, pl. 7.8, figs. 5-7.
Epistominella ripleyensis (Sandidge) (Pulvinulinella ripleyensis Sandidge]. CUSHMAN, 1946, p. 144, pl. 60, fig. 2.
Eponides haidingerii (d'Orbigny). CUSHMAN, 1946, p. 142, pl. 57, figs. 13-14.
Frondicularia dunbari Morrow. CUSHMAN, 1946, p. 86, pl. 34, figs. 1-2.
Gavelinella ammonoides (Reuss) [Anomalina ammonoides (Reuss)]. CUSHMAN, 1946, p. 154, pl. 63, figs. 10-11.
Gavelinella clementiana (d'Orbigny). HART ET AL., 1989, p. 336, pl. 7.11, figs. 1-3.
Gavelinella henbesti (Plummer). McNEIL and CALWELL, 1981, p. 284-285, pl. 24, figs. 5a-c, 6a-c.
Gavelinella intermedia (Berthelin). HART ET AL., 1989, p. 336, pl. 7.11, figs. 7-9.
Gavelinella kansasensis (Morrow). McNEIL and CALDWELL, 1981, p. 285-286, pl. 24, figs. 9a-c.
Gavelinella monterelensis (Marie). HART ET AL., 1989, p. 338, pl. 7.12, figs. 1-3.
Gavelinella nelsoni (Berry) [Anomalina nelsoni Berry]. CUSHMAN, 1946, p. 154, pl. 63, figs. 8-9.
Gavelinella pertusa Marrson. McNEIL and CALDWELL, 1981, p. 286-288, pl. 25, figs. 1a-c, 2a-c.
Gavelinella rubiginosa Cushman [Anomalina rubingosa Cushman]. CUSHMAN, 1946, p. 156, pl. 64, figs. 4-6.

Gavelinella sandidgei (Brotzen). McNEIL and CALDWELL, 1981, p. 288, pl. 27, figs. 7a-c, 8a-c.
Gavelinella taylorensis (Carsey) [Planulina taylorensis (Carsey)]. CUSHMAN, 1946, p. 158, pl. 64, figs. 14-15.
Gavelinella velascoensis (Cushman) [Anomalina velascoensis Cushman]. CUSHMAN, 1946, p. 156, pl. 64, fig. 7.
Globulina lacrima (Reuss). NYONG and OLSSON, 1984, p. 450, pl. 4, fig. 9.
Guttulina adherens (Olszewski). CUSHMAN, 1946, p. 96, pl. 40, figs. 8-10.
Guttulina bartschi CUSHMAN and OZAWA, 1930, p. 23-24, pl. 1, figs. 10a-c.
Guttulina regina (Brady, Parker and Jones). BARKER, 1960, p. 152, pl. 73, figs. 11-13.
Gyroidinioides depressus (Alth). [Gyroidinoides depressa (Alth)]. CUSHMAN, 1946, p. 139-140, pl.58, figs. 1-4.
Gyroidinoides diversus Brotzen. McNEIL and CALWELL, 1981, p. 279-280, pl. 23, figs. 7a-c, 8a-c.
Gyroidinoides girardanus (Reuss). McNEIL and CALDWELL, 1981, p. 280-281, pl. 24, figs. 1a-c.
Gyroidinoides nitidus (Reuss). McNEIL and CALDWELL, 1981, p. 281-283, pl. 24, figs. 2a-c.
Guttulina adherens (Olszewski). McNEIL and CALDWELL, 1981, p. 200, pl. 17, fig. 8.
Hoeglundina supracretacea (ten Dam). OLSSON, 1960, p. 37-38, pl. 6, figs. 10-12.
Kyphopyxa christneri (Carsey). NYONG and OLSSON, 1984, p. 450, pl. 1, fig. 17.
Lagena acuticostata Reuss. CUSHMAN, 1946, p. 94, pl. 39, figs. 14-15.
Lagena apiculata apiculata (Reuss). McNEIL and CALDWELL, 1981, p. 200, pl. 16, fig. 7.
Lagena apiculata elliptica (Reuss). McNEIL and CALDWELL, 1981, p. 200, pl. 16, fig. 8.
Lagena hispida Reuss. CUSHMAN, 1946, p. 93, pl. 39, fig. 13.
Lagena gracilis Williamson. BARKER, 1960, p. 119, pl. 58, figs. 22-24.
Lagena substriata (Williamson). UJIE ET AL., 1983, p. 54, pl. 2, fig. 5.
Lagena sulcata (Walker and Jacob). CUSHMAN, 1946, p. 94, pl. 39, figs. 18-21.
Lenticulina calcar (Linne). BARKER, 1960, p. 146, pl. 70, figs. 9-12.
Lenticulina convergens (Bornemann). BARKER, 1960, p. 144, pl. 69, fig. 7.
Lenticulina denticulifera (Cushman). BARKER, 1960, p. 152, pl. 73, figs. 11-13.
Lenticulina formosa (Cushman). BARKER, 1960, p. 146, pl. 70, figs. 13-15.
Lenticulina gibba (d'Orbigny). FEYLING-HANSSEN, 1964, p. 278, pl. 9, fig. 11.
Lenticulina muensteri (Roemer). McNEIL and CALDWELL, 1981, p. 202-203, pl. 16, figs. 13a-b.
Lenticulina nuda (Reuss). McNEIL and CALDWELL, 1981, p. 203, pl. 16, figs. 15a-b.
Lenticulina oligostegius (Reuss). CUSHMAN, 1946, p. 54, pl. 17, figs. 16-17.
Lenticulina orbicularis (d'Orbigny). BARKER, 1960, p. 144, pl. 69, fig. 17.
Lenticulina peregrina (Schwager). BARKER, 1960, p. 144, pl. 68, figs. 11-16.
Lenticulina rotulata (Lamarck). McNEIL and CALDWELL, 1981, p. 203, pl. 16, figs. 14a-b.
Lenticulina stephensoni (Reuss) [Robulus stephansoni (Reuss)]. CUSHMAN, 1946, p. 55, pl. 18, figs. 2-3.
Lenticulina sublaevis Morrow. McNEIL and CALDWELL, 1981, p. 204-205, pl. 16, figs. 16a-b.
Lenticulina williamsoni (Reuss) [Robulus williamsoni (Reuss)]. CUSHMAN, 1946, p. 54, pl. 18, figs. 2-3.

Loxostomum plaitum (Carsey). CUSHMAN, 1946, p. 130-131, pl. 54, figs. 10-14.
Loxostomoides cushmani (Wickenden). McNEIL and CALDWELL, 1981, p.230-231, pl. 18, figs. 18-19.
Marginulina austiniana Cushman. CUSHMAN, 1946, p. 59, pl. 20, figs. 5-10.
Marginulina bullata Reuss. CUSHMAN, 1946, p. 62, pl. 21, figs. 32-37.
Marginulina cretacea Cushman. CUSHMAN, 1946, p. 61, pl. 21, figs. 16-20, 39.
Marginulina decorata (Reuss) [Marginulina cf. M. decorata (Reuss)]. CUSHMAN, 1946, p. 63-64, pl. 21, fig. 41.
Marginulina silicula (Plummer). CUSHMAN, 1946, p. 61, pl. 21, figs. 42-45.
Marginulina taylorana Cushman. CUSHMAN, 1946, p. 61, pl. 21, figs. 11-15.
Marginulina texasensis Cushman. CUSHMAN, 1946, p. 61, pl. 21, figs. 21-29, 38, 40.
Melonis pompiloides (Fichtel and Moll) [Nonion pompiloides (Fichtel and Moll)]. BARKER, 1960, p. 224, pl. 109, figs. 10-11.
Neobulimina albertensis (Stelck and Wall). McNEIL and CALDWELL, 1981, p. 218-219, pl. 18, figs. 2-3.
Neobulimina canadiensis Cushman and Wickenden. CUSHMAN, 1946, p. 125, pl. 52, figs. 11-12.
Neobulimina irregularis Cushman and Parker. CUSHMAN, 1946, p. 125, pl. 52, fig. 14.
Neobulimina spinosa Cushman and Parker. CUSHMAN, 1946, p. 125-126, pl. 52, fig. 13.
Neobulimina sp. McNEIL and CALDWELL, 1981, p. 220, pl. 18, figs. 6-8.
Nodosarella texana Cushman. McNEIL and CALDWELL, 1981, p. 269, pl. 22, fig. 8.
Nodosaria affinis Reuss. CUSHMAN, 1946, p. 70-71, pl. 25, figs. 8-23.
Nodosaria aspera Reuss. McNEIL and CALDWELL, 1981, p. 186-187, pl. 15, fig. 10.
Nodosaria alternistriata Morrow. CUSHMAN, 1946, p. 71, pl. 26, figs. 3-4.
Nodosaria flintii Cushman. BARKER, 1960, p. 136, pl. 64, figs. 20-22.
Nodosaria fusula Reuss. CUSHMAN, 1946, p. 71, pl. 26, fig. 5.
Nodosaria navarroana Cushman. CUSHMAN, 1946, p. 73, pl. 26, figs. 23-24.
Nodosaria obscura Reuss. CUSHMAN, 1946, p. 73, pl. 26, figs. 15-16.
Nodosaria paupercula Reuss. CUSHMAN, 1946, p. 75, pl. 27, figs. 10-12.
Nodosaria probiscidea Reuss. McNEIL and CALDWELL, 1981, p. 187-188, pl. 15, fig. 12.
Nonionella robusta Plummer [Nonionella cf. N. robusta Plummer]. McBETH and SCHMIDT, 1973, p. 1058-1059, pl. 1, figs. 37-38.
Oolina globosa (Montagu). UJIE ET AL., 1983, p. 55, pl. 2, figs. 19-20.
Osangularia navarroana Cushman. McNEIL and CALDWELL, 1981, p. 275-277, pl. 23, figs. 6a-c.
Pandaglandulina sp. McNEIL and CALDWELL, 1981, p. 210, pl. 17, fig. 9.
Planulina spissocostata Cushman. CUSHMAN, 1946, p. 157, pl. 64, fig. 13.
Planulina taylorensis (Carsey). CUSHMAN, 1946, p. 158, pl. 64, figs. 14-15.
Plectina watersi Cushman. CUSHMAN,1946, p. 47, pl. 13, figs. 6-12.
Pleurostomella austinana Cushman. CUSHMAN, 1946, p. 131-132, pl. 54, figs. 19-21.
Pleurostomella subnodosa Reuss. CUSHMAN, 1946, p. 132, pl. 55, figs. 1-9.
Pleurostomella velascoensis Cushman. CUSHMAN, 1946, p.133, pl. 55, fig. 12.
Pleurostomella watersi Cushman. McNEIL and CALDWELL, 1981, p. 269, pl. 22, figs. 5-6b.
Praebulimina carseyae (Plummer). McNEIL and CALDWELL, 1981, p.222-223, pl. 18, fig. 9.

Praebulimina exigua (Cushman and Parker) [Bulimina exigua (Cushman and Parker)]. CUSHMAN, 1946, p. 122, pl. 51, fig. 18.
Praebulimina kickapooensis (Cole). McNEIL and CALDWELL, 1981, p. 223-225, pl. 18, figs. 10-11.
Praebulimina laevis (Beissel). HART ET AL., 1989, p. 356, pl. 7.21, figs. 1-2.
Praebulimina reussi (Morrow). McNEIL and CALDWELL, 1981, p. 225-226, pl. 18, fig. 12.
Pseudoglandulina pygmaea (Reuss). CUSHMAN, 1946, p. 76, pl. 27, figs. 27-28.
Pseudopolyuvigerina incerta (Egger). CUSHMAN, 1946, p. 97, pl. 41, fig. 1.
Pseudouvigerina cretacea Cushman. CUSHMAN, 1946, p. 117, pl. 49, figs. 17-20.
Pseudouvigerina plummerae Cushman. CUSHMAN, 1946, p. 116, pl. 49, figs. 14-16.
Pseudouvigerina seligi (Cushman). OLSSON, 1960, p. 30, pl. 4, fig. 23.
Pullenia coryelli White. CUSHMAN, 1946, p. 147, pl. 60, figs. 10-14.
Pullenia jarvisi Cushman. CUSHMAN, 1946, p. 147, pl. 60, fig. 12.
Pullenia minuta Cushman. CUSHMAN, 1946, p. 147, pl. 60, fig. 15.
Pulvinulinella rippleyensis Sandidge. CUSHMAN, 1946, p. 144, pl. 60, fig. 2.
Pulvinulinella texana Cushman. CUSHMAN, 1946, p. 143, pl. 59, figs. 8-9.
Pyramidina referrata (Jennings) [Bulimina referrata Jennings]. OLSSON, 1960, p. 32, pl. 5, figs. 3-4.
Pyramidina rudita (Cushman and Parker) [Bulimina rudita Cushman and Parker]. FRIZZEL, 1954, p. 116, pl. 17, figs. 6a-b.
Pyramidina triangularis (Cushman and Parker) [Bulimina triangularis Cushman and Parker]. FRIZZEL, 1954, p. 116, pl. 17, figs. 9a-b.
Rotalina fimbriatula Cushman and Hedberg. CUSHMAN, 1946, p. 142, pl. 58, fig. 12.
Rotalipora appenninica (Renz). HART ET AL., 1989, p. 360, pl. 7.22, figs. 9-11.
Siphomina prima Plummer. CUSHMAN, 1946, p. 142, pl. 59, figs. 3-5.
Stetsioina pommerana Brotzen. HART ET AL., 1989, p. 362, pl. 7.24, figs. 10-12.
Stilostomella consobrina (d'Orbigny). BARKER, 1960, p. 130, pl. 62, figs. 23-24.
Stilostomella pseudoscripta (Cushman). McNEIL and CALDWELL, 1981, p. 232-233, pl. 18, fig. 22.
Siphogeneroides plummeri (Cushman). CUSHMAN, 1946, p. 117, pl. 50, fig. 1.
Siphonina bradyana Cushman. BARKER, 1960, p. 198, pl. 96, fig. 8.
Sigmoidella elegantissima (Parker and Jones). BARKER, 1960, p. 150, pl. 72, figs. 12-13.
Uvigerina asperula Czjzek. SCOTT, 1987, p. 329, pl. 1, fig. 5.
Uvigerina bradyana Fornasini. BARKER, 1960, p. 156, pl. 74, figs. 24-26 (Includes junior synonym Uvigerina parvula (Cushman)).
Uvigerina brunnensis Karrer. BARKER, 1960, p. 156, pl. 75, figs. 4-5.
Uvigerina canarensis d'Orbigny. BARKER, 1960, p. 154, pl. 74, figs. 1-3.
Uvigerina cushmani Todd. BARKER, 1960, p. 154, pl. 74, figs. 4-7.
Uvigerina flintii Cushman. POAG, 1981, p. 86, pl. 27, fig. 5; pl. 28, figs. 5a-b.
Uvigerina hispido-costata Cushman and Todd. PHLEGER and PARKER, 1951, part 2, p. 18, pl. 8, figs. 17-21,23.
Uvigerina peregrina Cushman. PHLEGER and PARKER, 1951, part 2, p. 18, pl. 8, figs. 22, 24-26.
Uvigerina schwageri Brady. BARKER, 1960, p. 154, pl. 74, figs. 8-10.
Valvulineria allomorphoides (Reuss). OLSSON, 1960, p. 25, pl. 6, fig. 1
Valvulineria cretacea (Carsey). CUSHMAN, 1946, p. 138-139, pl. 57, fig. 8.
Valvulineria infrequens Morrow. CUSHMAN, 1946, p. 138, pl. 57, fig. 5

Valvulineria umbilicatula (d'Orbigny) [Valvulineria cf. V. umbilicatula]. CUSHMAN, 1946, p. 139, pl. 57, figs. 9-12.

REWORKED PLANKTONIC FORAMINIFERA

Globorotalites michelinianus (d'Orbigny). McNEIL and CALDWELL, 1981, p. 277-278, pl. 23, figs. 5a-c.

Globoratalites subconicus (Morrow). McNEIL and CALDWELL, 1981, p. 278-279, pl. 23, figs. 4a-c.

Gumbelitrea cretacea Cushman. SMITH and PESSAGNO, 1973, p. 15-16, pl. 1, figs. 1-8.

Heterohelix globulosa (Ehrenberg). McNEIL and CALDWELL, 1981, p. 234-239, pl. 19, figs. 1-2.

Heterohelix pulchra (Brotzen). McNEIL and CALDWELL, 1981, p. 239-241, pl. 19, fig. 3.

Heterohelix striata (Ehrenberg). McNEIL and CALDWELL, 1981, p. 241-243, pl. 19, fig. 4.