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# 2. PALEOENVIRONMENTAL SIGNIFICANCE OF LATE CRETACEOUS FORAMINIFERS FROM ODP SITE 1138 SAMPLES, A DREDGE AND *ELTANIN* CORE E54-7, KERGUELEN PLATEAU, INDIAN OCEAN[1]

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## ABSTRACT

Late Campanian and Maastrichtian benthic foraminifers are recorded from 12 samples from Ocean Drilling Program (ODP) Leg 183, Cores 183-1138A-52R through 63R (487.3–602.4 meters below seafloor), Kerguelen Plateau, Indian Ocean, and Danian benthics from one sample in the same section. The entire late Maastrichtian foraminifer fauna is noted from a dredge sample 220 km to the north. The structure of the fauna is compared with the Cenomanian–Turonian of the nearby *Eltanin* core E54-7. Faunas are reviewed in terms of planktonic percentage, composition, epifaunal/infaunal ratios, and dominance/diversity indices. The region was in the cool Austral Faunal Province through the Campanian–Maastrichtian and was probably warmer in the Cenomanian–Turonian. The ODP section is now 1600 meters below sea level and has subsided several hundred meters since deposition. Its fauna is dominated by epifaunal species suggesting little influence of upwelling. The dredge location has subsided little. Its fauna has a high infaunal content consistent with significant influence of upwelling near the plateau edge. The dominant benthic species remain constant through the ODP Cretaceous section, but subdominance changes, and the section is divided into three informal zones based on dominance/subdominance characteristics of the benthic fauna.

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[1] Quilty, P.G., 2002. Paleoenvironmental significance of Late Cretaceous foraminifers from ODP Site 1138 samples, a dredge and *Eltanin* core E54-7, Kerguelen Plateau, Indian Ocean. *In* Frey, F.A., Coffin, M.F., Wallace, P.J., and Quilty, P.G. (Eds.), *Proc. ODP, Sci. Results,* 183, 1–28 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/183_SR/VOLUME/CHAPTERS/003.PDF>. [Cited YYYY-MM-DD]

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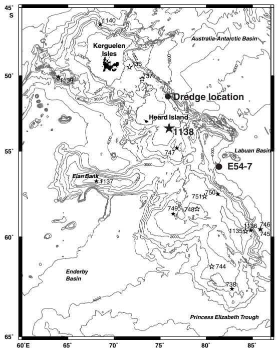
Brief taxonomic comments are made on several species and some are figured.

# INTRODUCTION

This paper documents Late Cretaceous benthic foraminifers from Ocean Drilling Program (ODP) Leg 183, Site 1138 (Cores 183-1138A-52R through 63R) (Fig. **F1**) and records the entire Late Cretaceous foraminifer fauna from a dredge sample taken 220 km to the north. In addition, it attempts to

1. Identify infaunal/epifaunal characteristics of the benthic species from these samples and the previously reported *Eltanin* core E54-7,
2. Use this information to reconstruct the environment in terms of water depth variation with time and possible changes in upwelling regime, and
3. Contribute to understanding effects of the tectonic evolution of Kerguelen Plateau during and since the Late Cretaceous.

**F1.** Locality map, p. 22.



The primary objective of ODP Leg 183 was the study of igneous basement of the region as part of a study of large igneous provinces (LIPs) (Coffin and Eldholm, 1994), and biostratigraphic studies were secondary (Shipboard Scientific Party, 2000). The prime objective for Site 1138 also was basement oriented—to establish the age of the youngest basalt and to compare that with results from Site 747. Sedimentary objectives were secondary and relate to sequence analysis, facies variation, and paleoceanographic history. The results reported here should be considered complementary to those of earlier ODP Legs 119 (Barron, Larsen, et al., 1989) and 120 (Schlich, Wise, et al., 1989) in the region.

Taxonomic notes are restricted to species that were not known previously from the Kerguelen Plateau or that warrant comment for some other reason.

## Sections and Age

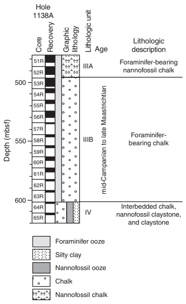
### ODP Section

Thirteen ODP samples were studied. They are listed as follows:

183-1138A-52R-1, 60–64 cm (basal Cenozoic); 487.3 meters below seafloor (mbsf);
183-1138A-52R-4, 122–126 cm (latest Cretaceous); 492.4 mbsf;
183-1138A-53R-4, 120–124 cm; 511.3 mbsf;
183-1138A-54R-1, 60–64 cm; 515.9 mbsf;
183-1138A-55R-1, 60–63 cm; 525.5 mbsf;
183-1138A-56R-1, 60–63 cm; 535.1 mbsf;
183-1138A-57R-1, 60–63 cm; 544.8 mbsf;
183-1138A-58R-1, 60–63 cm; 554.2 mbsf;
183-1138A-59R-1, 59–62 cm; 563.9 mbsf;
183-1138A-60R-1, 65–68 cm; 573.5 mbsf;
183-1138A-61R-1, 57–60 cm; 583.1 mbsf;
183-1138A-62R-1, 60–63 cm; 592.8 mbsf; and
183-1138A-63R-1, 61–64 cm; 602.4 mbsf.

The youngest sample studied is early Tertiary, and the Cretaceous/Tertiary boundary is placed at 183-1138A-52R-3, 127 cm (490.97 mbsf), where there is a change in color (Fig. F2). This boundary may equate to the contentious boundary at ODP Site 747 (Aubry and Berggren, 1989; Quilty, 1992c). It appears to be an unconformity, but its duration is unclear. The interval 265.9–601.8 mbsf has been assigned (Shipboard Scientific Party, 2000) to lithologic Unit III of "white to light gray and greenish gray foraminifer-bearing nannofossil chalk," which is further subdivided into Subunit IIIA on the basis of the presence of abundant calcareous nannofossils and Subunit IIIB on their virtual absence. Cores below Core 183-1138A-56R also contain black or gray chert nodules. Core recovery declined markedly from 50%–90% above this core to 15%–40% below. The boundary between these subunits is placed at the base of Core 183-1138A-52R at 496.4 mbsf; thus, the uppermost two samples examined here belong to Subunit IIIA. Deeper samples are from Subunit IIIB.

**F2.** Stratigraphic section encompassing Site 1138 samples studied, p. 23.



Interval 183-1138A-52R-1, 60–64 cm, is Paleocene and 52R-4, 122–126 cm, is Late Cretaceous. Samples 183-1138A-52R-CC and 183-1138A-53R-CC are late Maastrichtian in age, of the *Globigerinelloides subcarinatus* Subzone of the *Abathomphalus mayaroensis* Zone or *Cribrosphaerella daniae* Subzone of the *Nephrolithus frequens miniporus* Zone. It is likely that there is a disconformity within Core 183-1138A-54R, representing the *Biscutum magnum* Zone (Petrizzo, 2001).

Section 183-1138A-54R-CC is early Maastrichtian *Globotruncanella petaloidea* Subzone. Cores 183-1138A-55R and 56R have not been dated definitively, but the latter contains *Neocrepidolithus watkinsii,* consistent with a latest Campanian age. Cores 183-1138A-57R through 65R are late Campanian, *Biscutum coronum* Zone, *Aspidolithus parcus expansus* Subzone, or *Globigerinelloides impensus* Zone.

### Dredge Sample

Material from the dredge sample contains *A. mayaroensis* and is thus late Maastrichtian. It may be younger than any Cretaceous material recovered from Site 1138, but this is speculative.

### *Eltanin* Core E54-7

Kaharoeddin et al. (1973) and Quilty (1973) documented Cenomanian and Turonian calcareous nannofossils and foraminifers from this core. It is significant, as one of the few Cenomanian–Turonian deep-sea sections containing well-preserved calcareous microfossils. Although it is currently at 4304 m depth, it accumulated long before Broken Ridge separated from the original Kerguelen Plateau and was thus above the carbonate compensation depth (CCD), which was very dynamic during the mid-Cretaceous (Sliter, 1977). The current depth was achieved only after the late Eocene.

## PREVIOUS STUDIES

Quilty (1973) recorded the Cenomanian–Turonian planktonic foraminifers from *Eltanin* core E54-7. Benthic forms were not recorded except as a percentage of the fauna. He later (Quilty, 1984) described the benthic genus *Scheibnerova* from core E54-7 and the once-adjacent Exmouth Plateau. Huber (1991) described the Maastrichtian planktonic foraminifers and foraminiferal biostratigraphy around the Cretaceous/Tertiary (K/T) boundary from ODP Site 738 of Leg 119, but no results are available from studies of benthic or older planktonic foraminifers. Quilty documented Late Cretaceous planktonic and benthic foraminifers recovered during the drilling of ODP Leg 120 (Quilty, 1992b, 1992c) and summarized studies of Cretaceous foraminifers that had been conducted in the Indian Ocean Basin to that time (Quilty, 1992a).

## MATERIAL AND METHODS

ODP Site 1138A was drilled in January 1999 at 53°33.1′S, 75°58.5′E in the southern Indian Ocean in 1141.4 m water depth. The material studied is from Cores 183-1138A-52R through 63R (486.7–601.8 mbsf) and consists of the Campanian–Maastrichtian section and one sample from the overlying Danian. Planktonic foraminifers and calcareous nannofossils provide the age control (Petrizzo, 2001) employed in this paper, supported by several species and subspecies of the *Bolivinoides* complex. Material from Cretaceous sediments deeper in the section is the subject of Holbourn and Kuhnt (in press). These samples were taken by routine ODP rotary coring techniques.

While conducting fishing operations in the region, the fishing vessel *Petuna Explorer* accidentally recovered yellowish white weakly indurated chalk from the seafloor in 420 m depth at 51°25.3′S, 75°34.52′E, on 14 April 1997. This sample yields a very small residue from processing, indicating that it is a nannofossil/foraminifer ooze or chalk. Other components are very well preserved radiolarians and ostracodes. It contains a diverse, very well preserved foraminifer fauna. The planktonic fauna from this sample is recorded and analyzed for age and for faunal province relationship.

Core E54-7 was taken by *Eltanin* in 1972 at 55°52.78′S, 81°07.09′E in 4304 m water depth. Although the complete core was 5.27 m long, deeper parts of the core are highly disturbed and only the upper 2.12 m was studied in detail.

Samples were soaked in water with Calgon. The dredge and core E54-7 material disaggregated fully and easily with this process, perhaps reflecting a lack of overburden pressure at any stage in their history. Material from Site 1138 is much more compact, perhaps a result of higher, longer-term overburden pressure. The ODP material disaggregated only partially by this process and then was further crushed gently and reprocessed. This was generally successful, and the residues contain very little that has not disaggregated. Residues from all cores and localities are generally very small, reflecting the fact that the sediments are dominantly nannofossil oozes with a small foraminifer content. Site 1138 material, although entirely adequate for study, is not as well preserved as that from the dredge or the core E54-7 material.

Specimens figured on the plate are housed in the collections of the School of Earth Sciences, University of Tasmania (UTES), and the accession number in that collection is indicated on the figure explanation. The dredge sample is housed in the same collection as UTES147031.

Material studied is that coarser than 125 µm.

# DISCUSSION

Site 1138 and the location of the *Petuna Explorer* sample are in very different depositional settings. The former lies on the deeper (1141 m) flat surface of the plateau far from its margin, and the latter at only 420 m, close to the plateau margin and to the possible influence of upwelling from the east. The probable absence of the Antarctic Polar Frontal Zone at the time suggests that both locations were subject to the same oceanographic water masses and that differences are caused by differences in depth, nutrient supply, and degree of oxygenation.

Although from water depths typical of continental margin settings, the samples are from a submarine plateau, not usual open deep-sea ocean floor, and paleodepth analysis should be performed using oceanic faunal features. Traditional continental shelf faunal features are unlikely to be appropriate because of the oceanic setting, *probably* far from normal continental margin terrestrial nutrient supply; however, it is *possible,* even probable, that some of the nearby Kerguelen Plateau was emergent at this time and the continental margin model *may* have some validity.

Evidence of "moderately" shallow water depth comes from rapid changes in planktonic percentage and sporadic abundance of the continental shelf bivalve genus *Inoceramus.* Other studies on the Kerguelen Plateau (Royer and Coffin, 1992) indicate that the plateau did not sink to the modern setting until the Eocene, when the Southeast Indian Rise divided the previously unified plateau into two—Kerguelen Plateau and Broken Ridge.

## Planktonic Species in Dredge Sample and Core E54-7

The areal relationships of the three localities studied probably were much the same in the Cretaceous as now, and paleolatitudes at the time of deposition (Royer and Coffin, 1992) were probably much as they are now. The depth relationship has changed considerably since deposition. The dredge sample contains neither *Globotruncana* nor *Schackoina,* suggesting that the fauna can be assigned to the Austral Faunal Province of Sliter (1977), who defined this faunal province on the basis of a low diversity of species, many of which are components of this fauna. This fauna is a little less diverse than is typical of Sliter's Austral Faunal Province, and this may be due either to the analysis of a single sample or to the fact that faunas of the Faunal Province are less diverse with increasing paleolatitude. The foraminifer-based Austral Faunal Province has parallels in radiolarians and calcareous nannoplankton (Pessagno, 1975; Watkins, 1992)

Petrizzo (2001), following Premoli Silva and Sliter (1999) analyzed Late Cretaceous planktonic foraminifer faunas from Exmouth Plateau from ODP Leg 122 and categorized them in terms of r- or K-life strategies (MacArthur and Wilson, 1967). In addition to the two major groups (r-strategists include opportunistic species and K-strategists complex morphotypes), she identified a third group-r/K intermediate morphotypes. The latter group was further divided into those that are "closer to r-strategists" and "those closer to K-strategists." The approach taken by Petrizzo (2001) allows the faunal province concept to be quantified and, for comparison purposes, is followed here. The components of the dredge sample are

1. 14.5% r-strategists;
2. 64% intermediate morphotypes closer to r-strategists; and
3. 21.5% *Globigerinelloides multispina,* described by Petrizzo (2001) as cosmopolitan but an "important component of high latitude faunas."

There are no K-strategists in the main sample, and only a few (*A. mayaroensis*) of biostratigraphic value were identified in a supplementary sample. Coeval planktonic faunas at Site 747 also were allocated to the Austral Faunal Province.

Earlier, during the Turonian–Cenomanian, as evidenced from core E54-7, the planktonic fauna was much more diverse and conditions were probably considerably warmer (Quilty, 1973). The r-strategists dominate, but the diversity of K-strategists is much higher than in the Campanian–Maastrichtian.

## Benthic Faunas across the K/T Boundary at Site 1138

Very little change is evident in the benthic foraminifers from immediately above and below the K/T boundary at Site 1138, although it is not clear how much time separates the uppermost samples studied. Species composition and diversity indices are similar across the boundary, but dominance is a little lower above the transition than is typical of the section in the Cretaceous samples. There is no evidence of influence of carbonate dissolution, and all sediments formed and stayed above the CCD.

## Paleodepth Derived from Fauna

Faunas in the ODP section are dominated normally by *Stensioina beccariiformis* with *Osangularia cordieriana* and *Gyroidinoides quadratus* as subdominant or abundant. *Gavelinella* always is common. Sliter and Baker (1972), using principally the taxonomic units identified by Sliter (1968), attempted to define a series of bathymetric associations. Those species characteristic of shelf faunas are absent or present in very small numbers. Similarly, abyssal or lower-slope bathyal faunas are absent or very minor components. Their analysis suggests that the most similar foraminiferal faunal association recognizable at Site 1138 in the late Campanian–late Maastrichtian is middle- or upper-slope bathyal. The comparison is made a little difficult because *S. beccariiformis* was not in their species lists and because their material had a higher content of infaunal species such as *Praebulimina*. Van Morkhoven et al. (1986) studied only Cenozoic species but included *S. beccariiformis,* which they take to have been bathyal and abyssal. Thus, it seems that the ODP samples studied here are best taken to represent mid-bathyal environments in the 600- to 1000-m depth range in van Morkhoven et al.'s terms or 600–1200 m in the terms of Sliter and Baker (1972).

Planktonic percentages (percent of the fauna made up of planktonic species) are similar to modern outer continental shelf and slope proportions. They may indicate some deepening of the environment through the late Campanian from outer shelf depths to the mid-bathyal.

Quilty (1992b) conducted a similar analysis for the Cretaceous sections encountered at ODP Leg 120 Sites 747, 748, and 750. The Campanian section at Site 747 also was judged to be mid-bathyal and the Maastrichtian lower bathyal in a section that has a similar relationship to modern sea level as that at Site 1138. The faunas at Site 748 represent a very different, very shallow marine environment, equivalent to inner shelf conditions. The section at Site 748 is closer to modern sea level by several hundred meters than those at Site 747 or Site 1138, indicating that depth relationships between these sections have changed little. The situation at Site 750 was difficult to interpret because of poor recovery, highly lithified sediment, and poor preservation. It was suggested that the environment was upper bathyal by Maastrichtian times and shallower earlier.

### Dredge Sample

Because the sample collected by *Petuna Explorer* is a single specimen and yielded fewer benthic specimens, the statistics are not so reliable. It has a planktonic percentage of 90, consistent with an outer shelf–slope fauna. The dominance of *Praebulimina* suggests a shallower, mid-slope position and significant infauna. The absence of *Osangularia cordieriana* and reduced content of *Stensioina beccariiformis* are consistent with waters shallower than those of the ODP section.

### *Eltanin* Core E54-7

As with the ODP Site 1138 and dredge samples, *Osangularia* and *Gyroidinoides* are the dominant benthic genera, but there is a higher nodosariid content. This suggests a shallower depth, perhaps upper bathyal, roughly consistent with indications from the planktonic percentage figures.

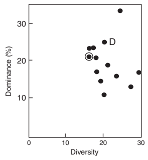
## Dominance/Diversity

### ODP Samples

Table **T1** is the range chart for species recovered in this study. It includes data on dominance and diversity as defined by Walton (1964) for recent shallow faunas in the Gulf of Mexico. Dominance is defined as the percentage of the benthic fauna constituted by the dominant species. Diversity is the number of species that constitute 95% of the benthic fauna. Figure **F3** is a plot of the figures for the samples studied. It is unrealistic to expect the foraminifers from Late Cretaceous pelagic carbonates to lie neatly on a curve generated from equivalents from modern continental shelf sediments, but the approach, in reality, produces some noteworthy results. Cretaceous plots are displaced to the lower dominance/lower diversity range, in contrast with any modern or mid-Tertiary plots recorded by Walton (1964) or Quilty (1972).

**T1.** Distribution of species, p. 25.

**F3.** Dominance/diversity relationships, p. 24.



A notable feature of the faunas is that in most samples there is a subdominant species that constitutes almost the same percentage as the dominant species. On Table **T1,** in many instances, the difference is so small that it is not obvious when the percentage is rounded to the nearest whole number. This feature may be responsible, in part, for reducing the dominance of the dominant species on Figure **F3.**

There are no noticeable clear trends in either dominance or diversity, indicating, in some contrast with planktonic percentage, that water depth changed little through the Late Cretaceous, and foraminifer trends relate little to changes in lithology. Throughout the section, *S. beccariiformis* is uniformly dominant or almost so, but the subdominant species change and several intervals can be differentiated. A tendency is for greater diversity of subdominance in the lower part of the section, perhaps reflecting shallower conditions indicated by the planktonic percentage figures. These changes with time reflect some environmental change and constitute a rough environmental basis for a zonation for purposes of comparison with other sections in the region.

Although there are no clear trends, there are clusters of dominance/diversity figures. Dominance of 21–23 and corresponding diversity of 16/17 is present in five samples, 11–15/19–27 in three, and 16–19/18–29 in four. The former group is present in two clusters of three and two and the latter in consecutive samples, and, thus, both groups appear to be systematic. The 16–19/18–29 group approximates (not perfectly) the *G. quadratus* Zone described below.

The lowest sample (183-1138A-63R-1, 61–64 cm) is dominated by *Stensioina* sp. 1 with *Gyroidinoides nitidus* and *S. beccariiformis* subdominant. As this is a single sample, it is not worth attributing to a separate zone.

The next four samples (183-1138A-62R-1, 60–63 cm, to 59R-1, 59–62 cm) are dominated by two or three species, including *S. beccariiformis* and *G. nitidus* with another species such as *Planulina rakauroana* or *G. quadratus*. Because of the important role of *G. quadratus,* this could be defined as the *G. quadratus* Zone.

Samples 183-1138A-58R-1, 60–63 cm, to 54R-1, 60–64 cm, are dominated by *S. beccariiformis,* and *O. cordieriana* is always important, but *G. quadratus* is subdominant in the lower three samples. On the basis of the regular important role of *O. cordieriana,* this could be defined as the *O. cordieriana* Zone.

In the upper three samples (183-1138A-53R-1, 120–124 cm, to 52R-1, 60–64 cm), *Gavelinella voltziana* is subdominant to *S. beccariiformis* and no other species make up a high percentage. On the basis of subdominance, this could be defined as the *G. voltziana* Zone.

### Dredge Sample

The dredge sample is different in many ways. *O. cordieriana* is absent and *S. beccariiformis* is much less important, whereas infaunal species are relatively more abundant. The differences in epifaunal species are consistent with shallower conditions at the dredge sample site.

### *Eltanin* Core E54-7

*Osangularia* routinely is dominant by a factor of two over *Gyroidinoides* in the epifaunal component of core E54-7, and other species are more sporadic and less abundant. These figures are consistent with a mid- to upper-bathyal depth in the scheme of Sliter and Baker (1972).

## Epifaunal/Infaunal Content

Thomas (1990) attempted an analysis of epifaunal/infaunal relationships for Cretaceous–Neogene benthic foraminifers from Maud Rise and Holbourn and Kuhnt (1998) from the continental margin Cretaceous off Africa in the equatorial Atlantic Ocean. The settings of Maud Rise and Kerguelen Plateau are similar in many ways. Both are atypical of "normal" oceanic settings because each is on a submarine plateau isolated from neighboring continents by a region of deep seafloor.

The criteria used for this discussion are identical to those used by Thomas (1990), with the exception that the fauna analyzed is that resting on a 125-µm sieve; Thomas (1990) used the fauna on the 63-µm sieve. Her Appendix 1 provides the basis, following Corliss and Chen (1988), for the identification of epifaunal (E), infaunal (I), and cylindrical (C) elements shown on Table T2. Despite the use of different sieve limits, the results seem comparable.

**T2.** Epifaunal/infaunal data from ODP Site 1138 and dredge sample locality, p. 26.

Epifaunal species (rounded trochospiral, planoconvex trochospiral, miliolids, and biconvex trochospiral morphotypes) routinely constitute 75%–85% of the benthic fauna from ODP samples, indicating that the ocean at the time was well oxygenated. The *Petuna Explorer* sample is different in having a much higher infaunal component (41% in contrast with 10%–20% in contemporaneous samples at Site 1138). Infaunal species (rounded planispiral, flattened ovoid, tapered and flattened tapered, spherical, and some unilocular morphotypes) regularly are dominant over the cylindrical group (uniserial lagenids such as *Nodosaria* and *Dentalina* in addition to *Pleurostomella* spp., *Nodosarella* spp., and *Stilostomella* spp.) but generally are in sympathy with the pattern indicated by Thomas. Following earlier authors, agglutinated species are excluded from the calculation. The differences are consistent with the dredge site being on the edge of Kerguelen Plateau and more influenced by upwelling as a source in increased nutrient supply from the east.

The contrast with the experience of Holbourn and Kuhnt (1998) is marked. Their faunas were dominated by the infaunal group, consistent with strong influence of upwelling in the continental margin setting.

Although somewhat older, it is worthwhile to comment on the epifaunal/infaunal features of the material from core E54-7, which is nearby and has not been analyzed this way before. As shown in Table T3, the numbers of benthic specimens in most samples are too small to be significant on their own, but summing the results for the entire core yields a result similar to that obtained from many individual samples. Core E54-7 samples are intermediate between the ODP Site 1138 and dredge samples in epifaunal and infaunal percentage and are generally higher than both in cylindrical content. This suggests a higher nutrient supply than available for foraminifers living at Site 1138 but lower than at the dredge locality. Planktonic percentages (Quilty, 1973) are consistently ~80%, similar to the 90% for the dredge sample. The agglutinated content of the core E54-7 samples is small and often nil. Other features noted above indicate an upper bathyal depth.

**T3.** Epifaunal/infaunal data, *Eltanin* core E54-7, p. 27.

## Faunal Affinities

The benthic faunas in the Campanian–Maastrichtian sections are very similar to coeval faunas in distant parts of the world. The similarity with those documented by Sliter (many papers over several oceans) is marked and suggests that during the Late Cretaceous, bathyal faunas were similar worldwide. The absence of certain groups, especially of *Globotruncana,* and low faunal diversity in the Cretaceous planktonic fauna indicate that the entire section belongs to the Austral Faunal Province of Sliter (1977).

## Tectonic Implications

Data from the dredge sample suggest that there was a significant infauna, and this is consistent with upwelling and enhanced nutrient supply, commonly associated with margins of positive marine features. Although based on a single sample, and thus speculative, it seems that some evidence for an eastern margin to Kerguelen Plateau exists for the late Maastrichtian. Foraminifer features for the earlier *Eltanin* core E54-

7 are consistent, but less developed, with this generalization. The Eocene separation of Kerguelen Plateau and Broken Ridge may have occurred along an earlier suture.

## CONCLUSIONS

Late Campanian and Maastrichtian benthic foraminifers are recorded from 12 samples collected from Leg 183 Hole 1138A in the southern Indian Ocean. In addition, benthic species are identified from the basal Paleocene in the same hole and both planktonic and benthic foraminifers from a dredge site some 220 km to the north. Age estimates are based on planktonic foraminifers and calcareous nannoplankton studies reported elsewhere.

All faunas accumulated on Kerguelen Plateau before its disintegration into Kerguelen Plateau (in the modern sense) and Broken Ridge. Conditions were fully marine in the Austral Faunal Province of Sliter (1977). Depth for the ODP site was mid-bathyal (600–1200 m), and the location was on the plateau surface—a considerable distance from its edge. The fauna is dominated by epifaunal species (75%–85%), indicating a high degree of oxygenation and lack of influence of upwelling. The dredge sample, in contrast, comes from mid-upper slope depths, with higher infaunal component (40%), suggesting lower oxygenation and greater influence of upwelling for a site near the plateau margin.

On the basis of dominance/subdominance characteristics of the benthic foraminiferid fauna, three informal zones are recognized:

1. Samples 183-1138A-62R-1, 60–63 cm, through 183-1138A-59R-1, 59–62 cm, are placed in the *G. quadratus* Zone;
2. Samples 58R-1, 60–63 cm, through 54R-1, 60–64 cm, in the *O. cordieriana* Zone; and
3. Samples 53R-1, 120–124 cm, through 52R-1, 60–64 cm, in the *G. voltziana* Zone.

Analyses of the foraminifers contained in *Eltanin* core E54-7 (Quilty, 1973) are included where appropriate. Taxonomic comments are made on several species.

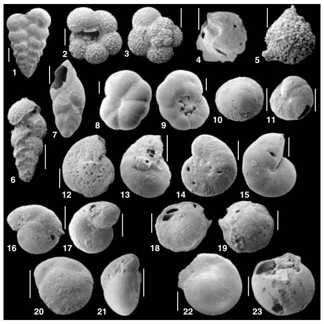
## TAXONOMIC COMMENTS

Except for planktonic species, the order of discussion of species follows that of genera in the classification of Loeblich and Tappan (1988). Categories higher than genus have not been employed. Species are divided into the few, for which comment is necessary, and the majority, for which no comment is needed. In the list of species for which no comment is made, arrangement is alphabetical by genus. Species illustrated are most of those for which comment is made. Most other species are illustrated in Belford (1960), Cushman (1946), Quilty (1992b, 1992c), or Sliter (1968, 1986).

### Planktonic Forms—Dredge Sample

***Heterohelix globulosa*** **(Ehrenberg) 1840**
(Pl. P1, fig. 1).
*Textilaria globulosa* Ehrenberg, 1840, p. 135, pl. 4, figs. 2b, 4b, 5b, 7b, 8b.

**P1.** Foraminifers, p. 28.



*Heterohelix globulosa* (Ehrenberg). Montanaro Gallitelli, 1957, p. 137, pl. 31, figs. 12–15.

**Remarks:** A large sample yields a population that includes all intermediates between *H. globulosa* sensu stricto to that figured with peripheral keels and probably identifiable as *Heterohelix globocarinata* (Cushman). Pessagno (1967) figured both and drew attention to the similarity.

### *Rugoglobigerina rugosa* (Plummer) 1927

(Pl. **P1,** figs. 2, 3)

*Globigerina rugosa* Plummer, 1927, p. 38, pl. 2, fig. 10.

*Rugoglobigerina rugosa* (Plummer); Bolli et al., 1957, p. 42, pl. 11, fig. 2.

**Remarks:** This is the most abundant species in the dredge sample. It has the characteristics of the species, but most specimens do not have meridionally arranged patterns on the chambers. Most are simply spinose, but the spinosity appears to be randomly distributed. Some specimens do have meridional rugosities, and thus at least two subspecies can be distinguished.

## Benthic Species

### *Spiroplectammina grzybowskii* Frizzell 1943

*Spiroplectoides clotho* (Grzybowski); Cushman and Jarvis, 1928, p. 101, pl. 14, figs. 13, 14.

*Spiroplectammina grzybowskii* Frizzell, 1943, p. 337, figs. 12a, 12b, 13; Belford, 1960, p. 7, pl. 1, figs. 4–6; Quilty, 1992b, p. 413, pl. 1, fig. 8.

**Remarks:** Two forms are recorded here. One is that normally placed in this species and has a tapered test. A few forms that could be allocated to *Spiroplectammina spectabilis,* which have an initial planispiral coil that is of the same width as the subsequent biserial portion of the test, have been included. It is possible that these form a microspheric/megalospheric relationship. This seems to be consistent with the concept of the species used by Belford (1960). Most specimens are fragmentary, and the specimen counts may have some errors as a result.

### *Gaudryina rugosa* d'Orbigny 1840

*Gaudryina rugosa* d'Orbigny, 1840, p. 44, pl. 4, fig. 21; Belford, 1960, p. 13, pl. 2, figs. 17–20.

**Remarks:** Very few specimens contain the biserial portion and without this, many individuals could be placed in other genera, especially *Verneulina*.

### *Dentalina basiplanata* Cushman 1938

*Dentalina basiplanata* Cushman, 1938, p. 38, pl. 6, figs. 6–8; Sliter, 1968, p. 57, pl. 5, figs. 8–11; Quilty, 1992b, p. 423, pl. 6, figs. 6–8.

**Remarks:** This species is recorded from most samples studied here. The category is used to include those species of *Dentalina* that are smooth with flush or only slightly depressed sutures. Most specimens are fragmentary, and thus the statistics may contain some errors. It is possible that this category also includes some specimens that would not be included if complete specimens were recovered.

### *Nodosaria affinis* Reuss 1845

*Nodosaria affinis* Reuss, 1845, p. 26, pl. 13, figs. 16a, b; Cushman, 1946, p. 70, pl. 25, figs. 8–23.

**Remarks:** This name is applied to a species that is present mostly as fragments that are straight, nodose, and with continuous costae. Statistics are based on counting fragments and assuming they are complete specimens. This is clearly erroneous to some extent. It is also possible that some specimens are incorrectly identified members of other costate species.

### *Lenticulina muensteri* (Roemer) 1839

(Pl. **P1,** fig. 4)

*Robulina münsteri* Roemer, 1839, p. 48, pl. 22, fig. 29.

*Lenticulina muensteri* (Roemer); Sliter, 1968, p. 66, pl. 7, figs. 9, 13; Huber, 1988, p. 197, fig. 32.3.

**Remarks:** The species identified here is present in several samples and has the basic characteristics of *L. muensteri* but consistently, the keel is produced into a distinct, thin, often ragged, flange.

### *Planularia* cf. *tricarinella* (Reuss) 1863

*Cristellaria tricarinella* Reuss, 1863, p. 68, pl. 7, figs. 9a, 9b.

*Planularia tricarinella* (Reuss); Cushman, 1946, p. 57, pl. 20, figs. 2, 3; Quilty, 1992b, p. 416, pl. 3, fig. 3.

**Remarks:** The specimen recovered from Sample 183-1138A-61R-1, 57–60 cm, is typical except in having only two keels and a papillate surface.

### *Ramulina* spp. (Pl. P1, fig. 5).

**Remarks:** This category is used to encompass fragments of species of the genus and only two could be placed in species—*Ramulina pseudoaculeata* (two samples) and *Ramulina* sp. A as used by Belford (1960).

### *Eouvigerina sculptura* McNeil and Caldwell 1981
(Pl. P1, fig. 6)

*Eouvigerina aculeata* Cushman, 1933, p. 62, pl. 7, figs. 8a, 8b.

*Eouvigerina sculptura* McNeil and Caldwell, 1981, p. 231, pl. 18, figs. 20, 21; Quilty, 1992b, p. 417, pl. 4, fig. 15.

**Remarks:** Typical members of this species were identified in the region by Quilty (1992b) but the material found here has some differences, even though given the same name. Specimens from Sample 183-1138A-52R-1, 122–126 cm, are hispid and with keels that are not as well developed as in those discussed by Quilty (1992b). Older material seems more typical. It seems possible that there is an evolutionary trend (or is it environmental?) to less-pronounced keels and higher hispidity with time.

### *Praebulimina reussi* (Morrow) 1934

*Bulimina ovulum* Reuss, 1845, p. 37, pl. 8, figs. 57a, 57b; pl. 13, figs. 73a, 73b.

*Bulimina reussi* Morrow, 1934, p. 195, pl. 29, fig. 12.

*Praebulimina reussi* (Morrow); Sliter, 1968, p. 85, pl. 12, figs. 1, 2.

**Remarks:** This species is interpreted somewhat liberally to allow inclusion of forms, quite abundant in some samples, that are almost globular, robust, with very polished surface. They are akin to *Praebulimina lajollaensis* Sliter, but the earlier whorls are clearly visible. The form has a great rate of increase in chamber size.

### *Coryphostoma minutissimum* (Cushman) 1938 (Pl. P1, fig. 7)

*Loxostoma minutissimum* Cushman, 1938, p. 45, pl. 7, fig. 19.

*Coryphostoma minutissimum* (Cushman). Sliter, 1986, p. 344.

*Loxostomum* sp. 2; Quilty, 1992b, p. 417, pl. 4, fig. 14.

**Remarks:** This species is characterized by a marked change in growth form after approximately half the adult test has formed. The change is from simple biserial chambers that increase slowly in height to a marked increase in chamber height. In one specimen, the midgrowth change is not evident.

### *Valvulineria nonionoides* (Bandy) 1951 (Pl. P1, figs. 8, 9)

*Valvulineria nonionoides* Bandy, 1951, p. 504, pl. 74, fig. 5.

*Gyroidina nonionoides* (Bandy); Sliter, 1968, p. 117, pl. 21, fig. 6.

**Remarks:** This highly characteristic species is present in the dredge sample. It is the form referred by Sliter (1968) to *Gyroidinoides nonionoides,* but it is not *Gyroidinoides* because, according to Sliter (1968), it has a granular wall. It lacks the normal flat dorsal surface and angled margin of *Gyroidinoides*. In addition, the apertural characteristics differ from those of forms consistent with the morphological definition of *Gyroidinoides*.

Although not referable to *Gyroidinoides,* it is not an easy matter to place it generically. Bandy's (1951) placement is followed here, even though *Valvulineria* is not expected in pre-Cenozoic rocks (Loeblich and Tappan, 1988). It differs from *Pseudogavelinella* in lacking thickened sutures and flattened sides. It has much in common with *Lingulogavelinella* but has an open ventral umbilicus; otherwise it is very similar.

### ***Neoeponides*** **sp. 1**

(Pl. P1, figs. 10, 11)

**Remarks:** A single unidentifiable specimen was recovered from Sample 183-1138A-55R-1, 60–63 cm. It is well preserved, small, and almost planoconvex. The dorsal surface is an evolute, smooth, high dome of four whorls, all of the same height with five to six chambers in the final whorl. Chambers are long and narrow; sutures are flush and straight but directed strongly posteriorly distally. The periphery is not keeled but strongly angled. The ventral surface is a very low dome, involute, lacking boss or umbilicus; sutures are slightly depressed and gently, posteriorly, distally curved. The proximal end of the chambers passes over the center of the test. Aperture is simple, a very low slit passing from under the proximal end of chamber, extending almost to the periphery. The wall is uniformly smooth and finely perforate. The identification is tentative because of the sample size and because *Neoeponides* is not to be expected in rocks of this age.

### ***Cibicides*** **sp. 1**

(Pl. P1, figs. 12, 13)

*Cibicidoides* sp. 5; Nomura, 1991, pl. 4, figs. 4a–4c.

**Remarks:** Nomura (1991) recorded, without taxonomic comment, a numbered series of species he placed in *Cibicidoides.* The species found here is very similar to his *Cibicidoides* sp. 5 in having a planoconvex, keeled test with flat dorsal side, which is more coarsely perforate (but not very coarsely perforate) in contrast with the convex, involute side which is smooth very finely perforate and has a central boss. The dorsal side may have weakly developed spiral grooves for a few chambers. The aperture sits astride the well-developed keel.

### ***Anomalinoides*** **sp.**

(Pl. P1, figs. 14, 15)

**Remarks:** The species recorded here is common in most samples. Populations are variable to the extent that individual specimens could be allocated to several different genera.

It is almost planispiral with a rounded margin and 9–12 chambers in the final whorl. The aperture is interiomarginal, with a slit running from the periphery to the umbilicus on the involute side. Here, it may terminate with or without umbilical flaps. It may join with the proximal ends of earlier apertures to form a continuous umbilical aperture, or it may not. The dorsal surface is coarsely perforate, but the ventral surface is smooth and lacks coarse pores.

Those specimens with a simple umbilical flap could be placed in *Valvulineria* or *Gavelinella.* The rounded periphery and general test form all prompt me to place the species in *Anomalinoides,* accepting that the variable characters of the aperture are features of the species.

Nomura (1991) recorded *Anomalinoides pseudoacuta* (Vasilenko), which has some similarities to this species, but the details are not clear and the aperture seems more restricted. Sliter's (1986) record of *Gavelinella nacatochensis* also is similar (perhaps the same species as figured by Nomura) but poses similar nomenclature problems. Cushman's (1946) reference to *Gyroidina depressa* seems to be of a more compressed species, but the fine details are not available for comparison. His *Valvulineria cretacea* is very similar to the species recorded here but has valvulinerian umbilical flaps. Sliter (1968) places *G. depressa* in *Gyroidinoides,* but the illustrations are something quite different from the species described by Cushman. Belford's (1960) discussion of *Valvulineria lenticula* is of a species with too few chambers and shows no signs of a coarsely perforate dorsal surface. North and Caldwell (1970) left in open nomenclature a species identified as *Anomalinoides* sp., and it is very similar but has a ventral umbilical boss.

### **Genus** ***GYROIDINOIDES*** **Brotzen 1942**

**Remarks:** As noted by Quilty (1992b), there remain questions about the concept of *Gyroidinoides*. For this study, the loose definition used earlier (including the suggestion that all Cretaceous gyroidinids should be included in *Gyroidinoides*) is employed but it contains significant unresolved anomalies, the chief one being whether, on a species-to-species basis, the wall consists of granular or radial calcite.

### *Gyroidinoides nitidus* (Reuss) 1845

*Rotalina nitida* Reuss, 1845, p. 35, pl. 8, fig. 52; pl. 12, fig. 20.
*Gyroidina nitida* (Reuss); Brotzen, 1936, p. 157, pl. 11, figs. 3a–3c.
*Gyroidinoides nitidus* (Reuss); Sliter, 1968, p. 121, pl. 22, figs. 10–15; Huber, 1988, p. 205, fig. 26, 5–6; Quilty, 1992b, p. 421, pl. 7, figs. 10, 11.

**Remarks:** This may include some forms that could be assigned to *Gyroidina globosa,* for example as identified by Belford (1960) and Cushman (1946).

### *Gyroidinoides quadratus* Cushman and Church 1929

*Gyroidina quadrata* Cushman and Church, 1929, p. 516, p. 41, figs. 7–9.
*Gyroidinoides quadratus* (Cushman and Church); Sliter, 1968, p. 121, pl. 22, figs. 8a–8c; Quilty 1992b, p. 421, pl. 7, figs. 16, 17.

**Remarks:** This is a common small species. The largest forms are identical to those illustrated by Sliter (1968) with depressed dorsal surface, but most are much smaller and have a central boss on the ventral side. This is surrounded by a depressed "moat," but the boss often stands above the general level of the dorsal surface. The characteristics of the species seem to be achieved only in the largest forms.

### *Gyroidinoides umbilicata* (Cushman) 1946 (Pl. P1, figs. 16, 17)

*Valvulineria umbilicata* Cushman, 1946, p. 139, pl. 57, figs. 9a–12c.

**Remarks:** The species has the main features of Cushman's (1946) concept of the species but is not as globose.

### *Alabamina australis australis* Belford 1960
(Pl. P1, figs. 20, 21)

*Alabamina australis australis* Belford, 1960, p. 84, pl. 23, figs. 13–20.

**Remarks:** Four specimens in Sample 183-1138A-52R-1, 122–126 cm, and five in the dredge sample are recorded here. They have very well defined dorsal sutures that are directed strongly posteriorly distally. There is no ventral boss. It is akin to *Gyroidinoides noda* (Belford) but has only five to six chambers in the final whorl. It is similar to *G. nitidus* but has strongly recurved dorsal intercameral sutures and its periphery is not as rounded as that of *G. nitidus*. The species is here taken to be *A. australis australis* Belford but the dorsal surface recorded here is more domed and evolute than for the holotype, although paratypes suggest that the degree of variation is encompassed within this species.

### *Gavelinella voltziana* (d'Orbigny) 1840
(Pl. P1, figs. 18, 19)

*Rotalina voltziana* d'Orbigny, 1840, p. 31, pl. 2, figs. 32–34.
*Cibicides voltziana* (d'Orbigny); Sliter, 1986, p. 344, pl. 8, figs. 6–8.
*Gavelinella* sp. 1; Quilty, 1992b, p. 422, pl. 8, figs. 22, 23.

**Remarks:** One of the most characteristic features of this species is the prominent boss on the ventral surface. The specimen figured by Quilty (1992b) was perhaps an extreme example, as it was a large specimen. Whereas most specimens are smaller, the boss is still prominent.

### *Gavelinella* sp.
(Pl. P1, figs. 22, 23)

**Remarks:** A single specimen is present in Sample 183-1138A-60R-1, 65–68 cm. It has some breakage but most features are visible and well preserved. It is unequally biconvex with high domed ventral and low domed dorsal surfaces. Ventral sutures are straight radial, flush, and there is a well-developed umbilical boss. Dorsal sutures are strongly recurved and flush but details in the center are not clear. The periphery is not keeled but strongly angled. Apertural details are not clear. The identification generically is tentative and it could also be assigned to *Gyroidinoides.*

## Species Recorded without Comment

Citation includes only the name and a reference to either the original description or to a paper containing justification of the name.

### Planktonic Species

*Abathomphalus mayaroensis* (Bolli); Bolli et al., 1957, p. 43, pl. 11, figs. 1a–1c.
*Globigerinelloides multispinatus* (Lalicker); Huber, 1990, p. 503, pl. 1, figs. 11, 12.
*Hedbergella holmdelensis* Olsson, 1964, p. 160, pl. 1, figs. 1, 2.
*Laeviheterohelix pulchra* (Brotzen); Nederbragt, 1991, p. 352, pl. 5, figs. 7a, 7b; pl. 6, figs. 1a–1c.

### Benthic Species

*Bolivina incrassata* Reuss, 1851, p. 29, pl. 5, fig. 13.
*Bolivinoides decoratus decorates* (Jones); Hiltermann, 1963, p. 207, pl. 3, fig. 15; pl. 4, figs. 8–14.
*Bolivinoides delicatulus delicatulus* Cushman; Hiltermann, 1963, pl. 1, figs. 1, 4–6, 10; pl. 2, fig. 19; pl. 3, fig. 1–2, 5–6, 10, 13–14, 16–18.
*Bolivinoides draco draco* (Marsson); Hiltermann and Koch, 1950, p. 598, fig. 1 (72, 73), figs. 2–4 (52–54 and 58–60), and fig. 5 (53 and 69, 70).
*Bulimina midwayensis* Cushman and Parker; Brotzen, 1948, p. 58, pl. 10, fig. 8.
*Dentalina aculeata* d'Orbigny, 1840, p. 13, pl. 1, fig. 2.
*Dentalina catenula* Reuss, 1860, p. 185, pl. 3, fig. 6.
*Dentalina consobrina* d'Orbigny, 1846, p. 46, pl. 2, figs. 1–3.
*Dentalina solvata* Cushman, 1938, p. 39, pl. 6, figs. 9–14.
*Dorothia* cf. *conicula* Belford, 1960, p. 20, pl. 5, figs. 8–13.
*Dorothia confraga* Belford, 1960, p. 20, pl. 5, figs. 1–7.
*Dorothia oxycona* (Reuss); Sliter, 1968, p. 50, pl. 3, fig. 13.
*Dorothia* sp. indet.
*Fissurina alveolata* (Brady); Parr, 1950, p. 307.
*Frondicularia* sp. C; Belford, 1960, p. 53, pl. 14, fig. 7.
*Gaudryina laevigata* Franke, 1914, p. 431, pl. 27, figs. 1, 2.
*Gaudryina pyramidata* Cushman; Graham and Clark, 1961, p. 109, fig. 2,1.
*Gaudryina* sp. indet.
*Gavelinella eriksdalensis* (Brotzen); Sliter, 1968, p. 123, pl. 23, fig. 6.
*Gavelinella excavates* (Brotzen); Quilty, 1992b, p. 423, pl. 8, figs. 4, 5.
*Gavelinella nacatochensis* (Cushman); Sliter, 1968, p. 124, pl. 23, figs. 4, 5.
*Gavelinella stephenson* (Cushman); Sliter, 1968, p. 125, pl. 23, fig. 3.
*Gavelinella velascoensis* (Cushman); Sliter, 1968, p. 125, pl. 23, fig. 9.
*Gavelinella whitei* (Martin); Sliter, 1968, p. 126, pl. 24, fig. 1.
*Globorotalites micheliniana* (d'Orbigny); Martin, 1964, p. 99, pl. 14, fig. 4.
*Globulina lacrimal* (Reuss); Cushman, 1946, p. 96, pl. 40, figs. 11, 12.
*Gyroidinoides cetacea* (Carsey) = *Gyroidina cetacea* (Carsey); Sliter, 1968, p. 117, pl. 21, figs. 7, 8.
*Gyroidinoides goudkoffi* (Trujillo); Sliter, 1968, p. 120, pl. 22, fig. 6.
*Gyroidinoides noda* (Belford); Quilty, 1992b, p. 423, pl. 7, figs. 12, 13.
*Guttulina communis* (d'Orbigny); Galloway and Wissler, 1927, p. 56.
*Guttulina trigonula* (Reuss); Cushman and Ozawa, 1930, p. 28, pl. 4, figs. 2a–2c.
*Heterolepa concinna* (Brotzen) = *Gyroidinoides concinna* (Brotzen); Quilty, 1992b, p. 420, pl. 6, figs. 29, 30.
*Heterolepa diversus* (Belford) = *Gyroidinoides diversus* (Belford); Quilty, 1992b, p. 420, pl. 6, figs. 31, 32.
*Heterolepa minuta* Sliter, 1968, p. 126, pl. 24, fig. 4.
*Lagena apiculate* (Reuss); Reuss, 1863, p. 318, pl. 1, figs. 4–8, 10, 11.
*Lagena semiinterrupta* Berry; Sliter, 1968, p. 64, pl. 6, figs. 19, 20.
*Lagena sulcata*? Walker and Jacob, 1798, p. 634, pl. 14, fig. 5.
*Lenticulina macrodisca* (Reuss) = *Robulus macrodiscus* (Reuss); Cushman and Jarvis, 1932, p. 23, pl. 7, fig. 3a, 3b.

*Lenticulina navicula* (d'Orbigny); Cushman and Jarvis, 1932, p. 24, pl. 7, figs. 5a, 5b.
*Lenticulina taylorensis* (Plummer); Sliter, 1968, p. 68, pl. 7, figs. 14, 15.
*Loxostomum eleyae* (Cushman); Loeblich and Tappan, 1964, p. C736, fig. 603, 2–5.
*Marginulina armata* Reuss, 1860, p. 65, pl. 7, fig. 7.
*Marginulina austinana* Cushman, 1937, p. 92, pl. 13, figs. 1–4.
*Marginulina basitorta* (Cushman) = *Dentalina basitorta* Cushman, 1938, p. 37, pl. 6, figs. 4, 5.
*Marginulina inconstantia* Cushman, 1938, p. 34, pl. 5, figs. 4–9.
*Marginulina jarvisi* Cushman, 1938, p. 35, pl. 5, figs. 17, 18.
*Marginulina navarroana* Cushman, 1937, p. 98, pl. 14, figs. 17, 18.
*Marginulina trinitatensis* Cushman, 1937, p. 99, pl. 14, fig. 16.
*Neoflabellina praereticulata* Hiltermann, 1952, p. 32, pl. 5.
*Nodosaria aspera* Reuss, 1845, p. 26, pl. 13, figs. 14, 15.
*Nodosaria limbata* d'Orbigny, 1840, p. 12, pl. 1, fig. 1.
*Nodosaria naumanni* Reuss, 1874, p. 82, pl. 20, fig. 11.
*Nodosaria prismatica* Reuss, 1860, p. 180, pl. 2, fig. 2.
*Nonionella robusta* Plummer, 1931, p. 175, pl. 14, fig. 12.
*Notoplanulina rakauroana* (Finlay); Malumian and Masiuk, 1976, p. 197, pl. 6, figs. 2a–2d.
*Nuttallinella coronula* (Belford); Belford, 1959, p. 20.
*Oolina globosa* (Montagu); Parr, 1950, p. 302.
*Osangularia cordieriana* (d'Orbigny); Martin, 1964, p. 102, pl. 15, fig. 2.
*Osangularia velascoensis* (Cushman); Quilty, 1992b, p. 424, pl. 6, figs. 17, 18.
*Pallaimorphina ruckerae* Tappan, 1957, p. 220, pl. 71, figs. 1–9.
*Pleurostomella nitida* Morrow, 1934, p. 196, pl. 30, figs. 22a, 22b.
*Pleurostomella subnodosa* Reuss, 1860, p. 204, pl. 8, fig. 2.
*Praebulimina aspera* (Cushman and Parker); Sliter, 1968, p. 83, pl. 11, figs. 11–13.
*Praebulimina carseyae* (Plummer); Hofker, 1957, p. 192, figs. 235–237.
*Praebulimina kickapooensis* (Cole); Hofker, 1957, p. 190, figs. 233, 234.
*Praebulimina lajollaensis* Sliter, 1968, p. 84, pl. 12, figs. 9, 10.
*Pullenia coryelli* White, 1929, p. 56, pl. 5, figs. 22a, 22b.
*Pullenia minuta* Cushman, 1936, p. 77, pl. 13, fig. 7.
*Pyramidina prolixa* (Cushman and Parker); Sliter, 1968, p. 86, pl. 12, figs. 7, 8.
*Pyramidina szajnochae* (Grzybowski); Sliter, 1968, p. 87, pl. 12, fig. 13.
*Pyramidina triangularis* (Cushman and Parker); Sliter, 1968, p. 87, pl. 12, fig. 11.
*Quadrimorphina allomorphinoides* (Reuss); Trujillo, 1960, p. 330, pl. 47, fig. 15.
*Ramulina pseudoaculeata* (Olsson); Sliter, 1968, p. 79, pl. 10, fig. 8.
*Ramulina* sp. A; Belford, 1960, p. 56, pl. 15, fig. 2.
*Reussella* sp. B; Belford, 1960, p. 57, pl. 15, fig. 3.
*Saracenaria triangularis* (d'Orbigny); Cushman, 1946, p. 58, pl. 28, figs. 1–3.
*Spiroplectammina laevis* (Roemer); Cushman, 1932, p. 87, pl. 11, fig. 2.
*Spiroplectammina spectabilis* (Grzybowski); von Hillebrandt, 1962, p. 32, pl. 2, figs. 26, 27.
*Stensioina beccariiformis* (White); van Morkhoven et al. 1986, p. 346, pl. 113A, figs. 1a–1c; pl. 113B, figs. 1a–2c; pl. 113C, figs. 1a–3b; pl. 113D, figs. 1a–4.
*Stilostomella alexanderi* (Cushman); Taylor, 1964, p. 583, pl. 82, fig. 8.

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# REFERENCES

Aubry, M.-P., and Berggren, W.A., 1989. Age of the upper volcaniclastic debris flow at Site 747: a special study. *In* Schlich, R., Wise, S.W., Jr., et al., *Proc. ODP, Init. Repts.,* 120: College Station, TX (Ocean Drilling Program), 57–72.

Bandy, O.L., 1951. Upper Cretaceous foraminifera from the Carlsbad area, San Diego County, California. *J. Paleontol.,* 25:488–513.

Barron, J., Larsen, B., et al., 1989. *Proc. ODP, Init. Repts.,* 119: College Station, TX (Ocean Drilling Program).

Belford, D.J., 1959. *Nuttallinella,* new name for *Nuttallina* Belford, 1958 (non *Nuttallina* Dall, 1871). *Contrib. Cushman Found. Foraminiferal Res.,* 10:20.

————, 1960. Upper Cretaceous foraminifera from the Toolonga Calcilutite and Gingin Chalk, Western Australia. *Bull.—Bur. Miner. Resour., Geol. Geophys. (Aust.),* 57:1–198.

Bolli, H.M., Loeblich, A.R., Jr., and Tappan, H., 1957. Planktonic foraminiferal families *Hantkeninidae, Orbulinidae, Globorotaliidae,* and *Globotruncanidae. Bull.—U.S. Nat. Mus.,* 215:3–50.

Brotzen, F., 1936. Foraminiferen aus dem Schwedischen untersten Senon von Eriksdal in Schonen. *Arsb. Sver. Geol. Unders., Ser. C,* 396:1–206.

————, 1948. The Swedish Paleocene and its foraminiferal fauna. *Arsb. Sver. Geol. Unders., Ser. C,* 493:1–140.

Coffin, M.F., and Eldholm, O., 1994. Large igneous provinces: crustal structure, dimensions, and external consequences. *Rev. Geophys.,* 32:1–36.

Corliss, B.H., and Chen, C., 1988. Morphotype patterns of Norwegian Sea deep-sea benthic foraminifera and ecological implications. *Geology,* 16:716–719.

Cushman, J.A., 1932. *Textularia* and related forms from the Cretaceous. *Contrib. Cushman Lab. Foraminiferal Res.,* 8:86–97.

————, 1933. New American Cretaceous foraminifera. *Contrib. Cushman Lab. Foraminiferal Res.,* 9:49–64.

————, 1936. Cretaceous foraminifera of the Family Chilostomellidae. *Contrib. Cushman Lab. Foraminiferal Res.,* 12:71–78.

————, 1937. Some notes on Cretaceous species of *Marginulina. Contrib. Cushman Lab. Foraminiferal Res.,* 13:91–99.

————, 1938. Additional new species of American Cretaceous foraminifera. *Contrib. Cushman Lab. Foraminiferal Res.,* 14:31–52.

————, 1946. Upper Cretaceous foraminifera of the Gulf Coastal region of the United States and adjacent areas. *Geol. Surv. Prof. Pap. U.S.,* 206:1–241.

Cushman, J.A., and Church, C.C., 1929. Some Upper Cretaceous foraminifera from near Coalinga, California. *Proc. Calif. Acad. Sci. Ser. 4,* 18:497–530.

Cushman, J.A., and Jarvis, P.W., 1928. Cretaceous foraminifera from Trinidad. *Contrib. Cushman Lab. Foraminiferal Res.,* 4:85–103.

Cushman, J.A., and Jarvis, P.W., 1932. Upper Cretaceous foraminifera from Trinidad. *Proc. U.S. Nat. Mus.,* 80:1–60.

Cushman, J.A., and Ozawa, Y., 1930. A monograph of the foraminiferal Family Polymorphinidae. *Proc. U.S. Nat. Mus.,* 77:1–195.

d'Orbigny, A., 1840. Memoire sur les Foraminiferes de la craie blanche du Bassin de Paris. *Mem. Soc. Geol. Fr.,* 4:1–51.

————, 1846. *Foraminifères Fossiles du Bassin Tertiaire de Vienne (Autriche):* Paris (Gide et Comp.).

Ehrenberg, C.G., 1840. Über die bildung der Kreidefelsen und des Kreidemergels durch ubsichtbare Organismen. *Abh. K. Preuss. Akad. Wiss. Berlin,* 1838:59–147.

Franke, A., 1914. Die Foraminiferen und Ostracoden des Emschers, besonders von Obereving und Derne nördlich Dortmund. *Zeits. Deutsch. Geol. Gesell.,* 66:428–443.

Frizzell, D.L., 1943. Upper Cretaceous foraminifera from northwestern Peru. *J. Paleontol.,* 17:331–353.

Galloway, J.J., and Wissler, S.G., 1927. Pleistocene foraminifera from the Lomita Quarry, Palos Verdes Hills, California. *J. Paleontol.,* 1:35–87.

Graham, J.J., and Clark, D.K., 1961. New evidence for the age of the "G-1 Zone" in the Upper Cretaceous of California. *Contrib. Cushman Lab. Foraminiferal Res.,* 12:107–114.

Hiltermann, H., 1952. Stratigraphische Fragen des Campan und Maastricht unter besonderer Berücksichtigung der Mikropaläontologie. *Jahrb. Geol.,* 67:47–66.

————, 1963. Zur Entwicklung der Benthos-Foraminifere Bolivinoides. *In* von Koenigswald, G.H.R., Emeis, J.D., Buning, W.L., and Wagner, C.W. (Eds.), *Evolutionary Trends in Foraminifera:* Amsterdam (Elsevier), 198–223.

Hiltermann, H., and Koch, W., 1950. Taxonomic und Vertikalverbreitung von *Bolivinoides*-Arten im Senon Nordwestdeutschlands. *Jahrb. Geol.,* 64:595–632.

Hofker, J., 1957. Foraminiferen der Oberkreide von Nordwestdeutschland und Holland. *Geol. Jahrb., Beih.,* 27:1–464.

Holbourn, A.E.L., and Kuhnt, W., 1998. Turonian–Santonian benthic foraminifer assemblages from Site 959D (Côte d'Ivoire-Ghana Transform Margin, equatorial Atlantic): indication of a Late Cretaceous oxygen minimum zone. *In* Mascle, J., Lohmann, G.P., and Moullade, M. (Eds.), *Proc. ODP, Sci. Results,* 159: College Station, TX (Ocean Drilling Program), 375–387.

Holbourn, A., and Kunht, W., in press. Cenomanian–Turonian palaeoceanographic change on the Kerguelen Plateau: a comparison with Northern Hemisphere records. *Cretaceous Res.*

Huber, B.T., 1988. Upper Campanian-Paleocene foraminifera from the James Ross Island region, Antarctic Peninsula. *In* Feldmann, R.M., and Woodburne, M.O. (Eds.), *Geology and Paleontology of Seymour Island, Antarctica*. Mem.—Geol. Soc. Am., 169:163–252.

————, 1990. Maestrichtian planktonic foraminifer biostratigraphy of the Maud Rise (Weddell Sea, Antarctica): ODP Leg 113 Holes 689B and 690C. *In* Barker, P.F., Kennett, J.P., et al., *Proc. ODP, Sci. Results,* 113: College Station, TX (Ocean Drilling Program), 489–513.

————, 1991. Maestrichtian planktonic foraminifer biostratigraphy and the Cretaceous/Tertiary boundary at Hole 738C, Kerguelen Plateau (southern Indian Ocean). *In* Barron, J., Larsen, B., et al., *Proc. ODP, Sci. Results,* 119: College Station, TX (Ocean Drilling Program), 451–466.

Kaharoeddin, F.A., Weaver, F.M., and Wise, S.W., Jr., 1973. Cretaceous and Paleogene cores from the Kerguelen Plateau, Southern Ocean. *Antarct. J. U.S.,* 8:297–298.

Loeblich, A.R., Jr., and Tappan, H., 1964. *Treatise on Invertebrate Paleontology* (Vol. 2): *Part C, Protista: Sarcodina, Chiefly "Thecamoebians" and Foraminiferida:* Boulder (Geol. Soc. Am.).

————, 1988. *Foraminiferal Genera and Their Classification:* New York (Van Nostrand Reinhold).

MacArthur, R.H., and Wilson, E.O., 1967. *The Theory of Island Biogeography:* (Princeton Univ. Press).

Malumian, N., and Masiuk, V., 1976. Foraminiferos de la Formaçion Cabeza de Leon (Cretacico Superior, Tierra del Fuego, rep. Argentina). *Rev. Asoc. Geol. Argent.,* 31:180–202.

Martin, L., 1964. Upper Cretaceous and Lower Tertiary Foraminifera from Fresno County, California. *Geol. Jahrb. Bundesanst,* 9:1–128.

McNeil, D.H., and Caldwell, W.G.E., 1981. Cretaceous rocks and their foraminifera in the Manitoba Escarpment. *Spec. Pap.—Geol. Assoc. Can.,* 21:1–439.

Montanaro Gallitelli, E., 1957. A revision of the foraminiferal Family Heterohelicidae. *Bull. U.S. Nat. Mus.,* 215:133–154.

Morrow, A.L., 1934. Foraminifera and ostracoda from the Upper Cretaceous of Kansas. *J. Paleontol.,* 8:186–205.

Nederbragt, A.J., 1991. Late Cretaceous biostratigraphy and development of Heterohelicidae planktic foraminifera. *Micropaleontology,* 37:329–372.

Nomura, R., 1991. Paleoceanography of upper Maestrichtian to Eocene benthic foraminiferal assemblages at Sites 752, 753, and 754, eastern Indian Ocean. *In* Weissel, J., Peirce, J., Taylor, E., Alt, J., et al., *Proc. ODP, Sci. Results,* 121: College Station, TX (Ocean Drilling Program), 3–30.

North, B.R., and Caldwell, W.G.E., 1970. Foraminifera from the Late Cretaceous Bearpaw Formation in the South Saskatchewan River Valley. *SRC Rep.,* 9:1–117.

Olsson, R., 1964. Late Cretaceous planktonic foraminifera from New Jersey and Delaware. *Micropaleontology,* 10:157–188.

Parr, W.J., 1950. Foraminifera. *Rep. B.A.N.Z. Antarc. Res. Exped.,* Ser. B, 5:233–392.

Pessagno, E.A., Jr., 1967. Upper Cretaceous planktonic foraminifera from the western Gulf Coastal Plain. *Palaeontograph. Am.,* 5:245–445.

————, 1975. Upper Cretaceous radiolaria from DSDP Site 275. *In* Kennett, J.P., Houtz, R.E., et al., *Init. Rep. DSDP,* 29: Washington (U.S. Govt. Printing Office), 1011–1029.

Petrizzo, M.R., 2001. Late Cretaceous planktonic foraminifera from the Kerguelen Plateau (ODP Leg 183): new data to improve the Southern Oceans biozonation. *Cretaceous Res.,* 22:829–855.

Plummer, H.J., 1927. Foraminifera of the Midway Formation in Texas. *Bull. Univ. Texas,* 2644:1–206.

————, 1931. Some Cretaceous foraminifera in Texas. *Bull. Univ. Texas,* 3101:109–236.

Premoli Silva, I., and Sliter, W.V., 1999. Cretaceous paleoceanography: evidence from planktonic foraminiferal evolution. *In* Barrera, E., and Johnson, C.C. (Eds.), *The Evolution of Cretaceous Ocean–Climatic System.* Spec. Pap.—Geol. Soc. Am., 332:301–328.

Quilty, P.G., 1972. The biostratigraphy of the Tasmanian marine Tertiary. *Pap. Proc. Royal Soc. Tasm.,* 106:25–44.

————, 1973. Cenomanian-Turonian and Neogene sediments from northeast of Kerguelen Ridge, Indian Ocean. *J. Geol. Soc. Aust.,* 20:361–371.

————, 1984. Cretaceous foraminiferids from Exmouth Plateau and Kerguelen Ridge, Indian Ocean. *Alcheringa,* 8:225–241.

————, 1992a. Data report: Studies into the paleontology of the Cretaceous of the Indian Ocean Basin. *In* Wise, S.W., Jr., Schlich, R., et al., *Proc. ODP, Sci. Results,* 120: College Station, TX (Ocean Drilling Program), 1079–1090.

————, 1992b. Upper Cretaceous benthic foraminifers and paleoenvironments, southern Kerguelen Plateau, Indian Ocean. *In* Wise, S.W., Jr., Schlich, R., et al., *Proc. ODP, Sci. Results,* 120: College Station, TX (Ocean Drilling Program), 393–443.

————, 1992c. Upper Cretaceous planktonic foraminifers and biostratigraphy, Leg 120, southern Kerguelen Plateau. *In* Wise, S.W., Jr., Schlich, R., et al., *Proc. ODP, Sci. Results,* 120: College Station, TX (Ocean Drilling Program), 371–392.

Reuss, A.E., 1845. *Die Versteinerungen der Böhmischen Kreideformation* (Vol. 1): Stuttgart (E. Schweizerbart).

————, 1851. Die Foraminiferen und Entomostraceen des Kreidemergels von Lemberg. *Naturwiss. Abh. Wein.,* 4:17–52.

————, 1860. Die Foraminiferen der Westphaelischen Kreideformation. *Sitzungsber. Kais. Akad. Wiss. Wien Math.-Naturwiss. Kl.,* 40:147–238.

————, 1863. Die Foraminiferen des norddeutschen Hils und Gault. *Sitzungsber. Kais. Akad. Wiss. Wien Math.-Naturwiss. Kl.,* 46:5–100.

————., 1874. Die Foraminiferen, Bryozoen und Ostracoden dees Pläners. *In* Geinitz, H.B., Das Elbthalgebirge in Sachsen; der mittlere und obere Quader. *Paläontographica Beitrage Naturges.* 20 Theil 2 Abt 4:73–127.

Roemer, F., 1839. *Die Versteinerungen des norddeutschen Oolithen-Gebirges:* Hannover (Hahn).

Royer, J.-Y., and Coffin, M.F., 1992. Jurassic to Eocene plate tectonic reconstructions in the Kerguelen Plateau region. *In* Wise, S.W., Jr., Schlich, R., et al., *Proc. ODP, Sci. Results,* 120: College Station, TX (Ocean Drilling Program), 917–928.

Schlich, R., Wise, S.W., Jr., et al., 1989. *Proc. ODP, Init. Repts.,* 120: College Station, TX (Ocean Drilling Program).

Shipboard Scientific Party, 2000. Leg 183 summary: Kerguelen Plateau-Broken Ridge—a large igneous province. *In* Coffin, M.F., Frey, F.A., Wallace, P.J., et al. *Proc. ODP, Init. Repts.,* 183: College Station, TX (Ocean Drilling Program, 1–101.

Sliter, W.V., 1968. Upper Cretaceous foraminifera from southern California and northwestern Baja California, Mexico. *Univ. Kansas Paleontol. Contrib., Pap.,* 49:1–141.

————, 1977. Cretaceous foraminifers from the southwestern Atlantic Ocean, Leg 36, Deep Sea Drilling Project. *In* Barker, P.F., Dalziel, I.W.D., et al., *Init. Repts. DSDP,* 36: Washington (U.S. Govt. Printing Office), 519–573.

————, 1986. Cretaceous redeposited benthic foraminifers from Deep Sea Drilling Project Site 585 in the East Mariana Basin, western equatorial Pacific and implications for the geologic history of the region. *In* Moberly, R., Schlanger, S.O., et al., *Init. Repts. DSDP,* 89: Washington (U.S. Govt. Printing Office), 327–361.

Sliter, W.V., and Baker, R.A., 1972. Cretaceous bathymetric distribution of benthic foraminifera. *J. Foraminiferal Res.,* 2:167–183.

Tappan, H., 1957. New Cretaceous index foraminifera from northern Alaska. *U.S. Nat. Mus., Bull.,* 215:201–222.

Taylor, D.J., 1964. Foraminifera and the stratigraphy of the western Victoria Cretaceous sediments. *Proc. R. Soc. Victoria,* 77:535–603.

Thomas, E., 1990. Late Cretaceous through Neogene deep-sea benthic foraminifers (Maud Rise, Weddell Sea, Antarctica). *In* Barker, P.F., Kennett, J.P., et al., *Proc. ODP, Sci. Results,* 113: College Station, TX (Ocean Drilling Program), 571–594.

Trujillo, E.F., 1960. Upper Cretaceous foraminifera from near Redding, Shasta County, California. *J. Paleontol.,* 34:290–346.

van Morkhoven, F.P.C.M., Berggren, W.A., and Edwards, A.S., 1986. *Cenozoic Cosmopolitan Deep-water Benthic Foraminifera.* Bull. Cent. Rech. Explor.—Prod. Elf-Aquitaine, 11.

von Hillebrandt, A., 1962. Das Paleozan und seine Foraminiferenfauna im Beckan von Reichenhall und Salzburg. *Abh. Bayer. Akad. Wiss., Math.-Naturw. Kl.,* 108:1–182.

Walker, G., and Jacob, E., 1798. *In* Adams, G. (Ed.), *Essays on the Microscope* (2nd ed.): London (Dillon and Keating).

Walton, W.R., 1964. Recent foraminiferal ecology and paleoecology. *In* Imbrie, J., and Newell, N.D. (Eds.), *Approaches to Paleoecology:* New York (Wiley), 151–237.

Watkins, D.K., 1992. Upper Cretaceous nannofossils from Leg 120, Kerguelen Plateau, Southern Ocean. *In* Wise, S.W., Jr., Schlich, R., et al., *Proc. ODP, Sci. Results,* 120: College Station, TX (Ocean Drilling Program), 343–370.

White, M.P., 1929. Some index foraminifera of the Tampico Embayment area of Mexico (Part 3). *J. Paleontol.,* 3:30–58.

**Figure F1.** Locality map.

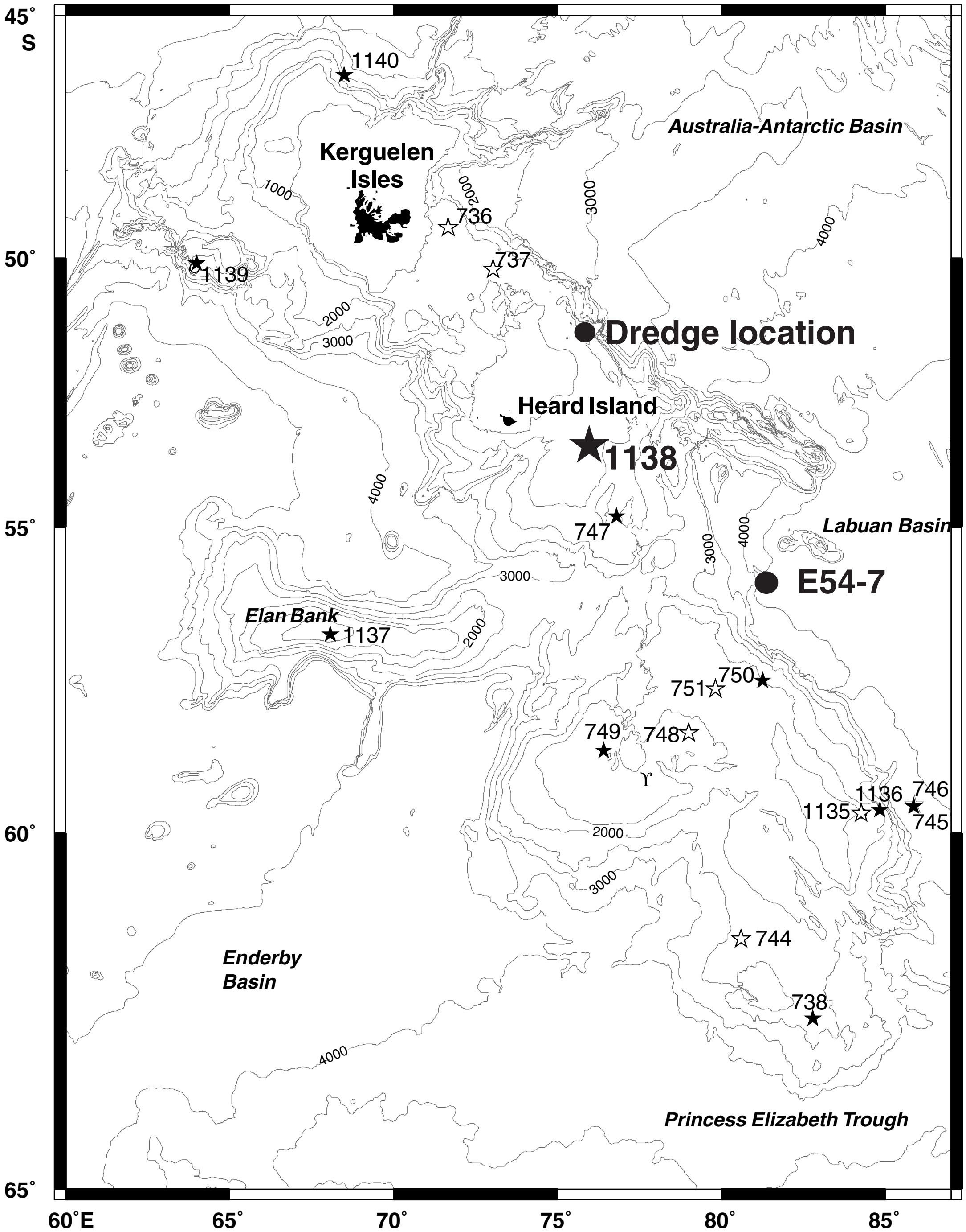

**Figure F2.** Stratigraphic section encompassing Site 1138 samples studied.

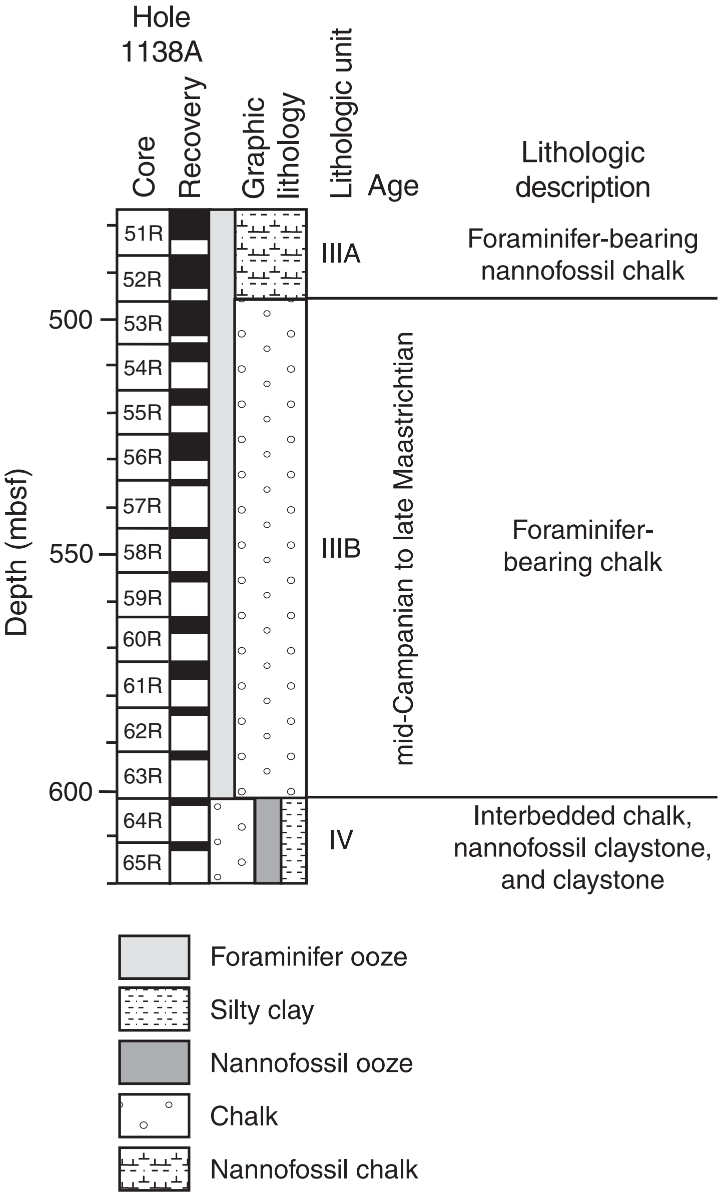

**Figure F3.** Dominance/diversity relationships for samples studied (D = dredge sample). Circled sample indicates two samples with same statistics.

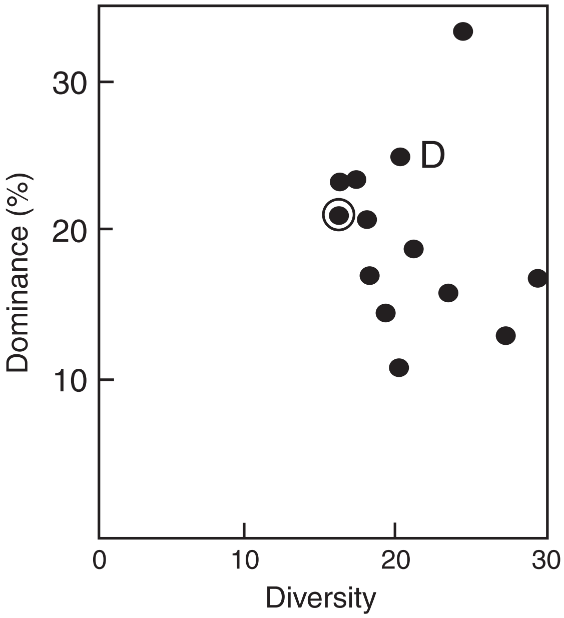

**Table T1.** Distribution of species. (This table is available in an **oversized format**).

**Table T2.** Epifaunal/infaunal data from ODP Site 1138 and dredge sample locality.

| Core, section, interval (cm): | Petuna Explorer | 183-1138A- | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 52R-1, 60–64 | 52R-4, 122–126 | 53R-4, 120-124 | 54R-1, 60–64 | 55R-1, 60–63 | 56R-1, 60–63 | 57R-1, 60–63 | 58R-1, 60–63 | 59R-1, 62 | 60R-1, 65–68 | 61R-1, 57–60 | 62R-1, 60–63 | 63R-1, 61–64 |
| Epifaunal (%): | 48 | 80 | 76 | 86 | 88 | 78 | 70 | 69 | 79 | 86 | 81 | 70 | 88 | 88 |
| Infaunal (%): | 41 | 12 | 17 | 9 | 6 | 19 | 21 | 24 | 11 | 11 | 15 | 24 | 6.5 | 11 |
| Cylindrical (%): | 10 | 8 | 7 | 5 | 6 | 3 | 8 | 7 | 10 | 3 | 4 | 6 | 5.5 | 1 |

**Table T3.** Epifaunal/infaunal data, *Eltanin* core E54-7.

| Depth (cm) | Epifaunal (%) | Infaunal (%) | Cylindrical (%) | Number of specimens |
|---|---|---|---|---|
| 21–22 | 33.3 | 27.3 | 39.4 | 33 |
| 31–32 | 50.0 | 30.0 | 20.0 | 40 |
| 41–42 | 46.7 | 13.3 | 40.0 | 15 |
| 51–52 | 63.6 | 18.2 | 18.2 | 11 |
| 61–62 | 58.1 | 29.0 | 12.9 | 31 |
| 71–72 | 46.1 | 30.8 | 23.1 | 13 |
| 81–82 | 75.0 | 18.8 | 6.2 | 32 |
| 91–92 | 42.8 | 28.6 | 28.6 | 7 |
| 101–102 | 60.7 | 25.0 | 14.3 | 56 |
| 111–112 | 68.0 | 14.0 | 18.0 | 50 |
| 121–122 | 69.6 | 21.7 | 8.7 | 23 |
| 131–132 | 75.0 | 25.0 | 0 | 8 |
| 141–142 | 61.8 | 25.4 | 12.8 | 55 |
| 151–152 | 38.9 | 44.4 | 16.7 | 18 |
| 161–162 | 72.8 | 13.6 | 13.6 | 22 |
| 171–172 | 60.0 | 30.0 | 10.0 | 20 |
| 181–182 | 64.9 | 27.0 | 8.1 | 37 |
| 201–202 | 74.1 | 24.7 | 1.2 | 89 |
| Avg/Tot | 61.6 | 24.5 | 14.0 | 560 |

**Plate P1.** **1.** *Heterohelix globulosa* (Ehrenberg) (dredge sample; UTES127736) 87×. **2, 3.** *Rugoglobigerina rugosa* (Plummer) (dredge sample; UTES127737) ventral and dorsal aspects, 100×. **4.** *Lenticulina muensteri* (Roemer) (183-1138A-55R-1, 60–63 cm; UTES127738) lateral aspect, 100×. **5.** *Ramulina pseudoaculeata* (Olsson) (183-1138A-63R-1, 61–64 cm; UTES127739), 100×. **6.** *Eouvigerina sculptura* McNeill and Caldwell (183-1138A-52R-4, 122–126 cm; UTES127740), 130×. **7.** *Coryphostoma minutissimum* (Cushman) (183-1138A-56R-1, 60–63 cm; UTES127741), 105×. **8, 9.** *Valvulineria nonionoides* (Bandy) (dredge sample; UTES127742) dorsal and ventral aspects, 70×. **10, 11.** *Neoeponides* sp. (183-1138A-55R-1, 60–63 cm; UTES127743) dorsal and ventral aspects, 150×. **12, 13.** *Cibicides* sp. 1 (183-1138A-55R-1, 60–63 cm; UTES127744) dorsal and ventral aspects, 125×. **14, 15.** *Anomalinoides* sp. (183-1138A-55R-1, 60–63 cm; UTES127745) dorsal and ventral aspects, 135×. **16, 17.** *Gyroidinoides umbilicata* (Cushman) (183-1138A-54R-1, 60–63 cm; UTES127746) dorsal and ventral aspects, 125×. **18, 19.** *Gavelinella voltziana* (d'Orbigny) (183-1138A-52R-4, 122–126 cm; UTES127747) dorsal and ventral aspects, 100×. **20, 21.** *Alabamina australis australis* Belford (183-1138A-52R-4, 120–124 cm; UTES127748) dorsal and ventral aspects, (20) 150×, (21) 110×. **22, 23.** *Gavelinella* sp. (183-1138A-60R-1, 65–68 cm; UTES127749) dorsal and ventral aspects, 105×. Scale bar represents 100 µm.