Maastrichtian Heterohelicidae (Planktonic Foraminifera) from the North West Atlantic

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ABSTRACT - Relative frequencies of heterohelicid species in the Maastrichtian of DSDP Site 605, DSDP Hole 111A and Imperial Oil/Amoco core hole C23 on the Grand Banks have been estimated to show temporal and geographic variation patterns in terms of Cretaceous faunal provinces. *Heterohelix globulosa* and *H. planata* dominate the shallow marine heterohelicid faunas of core hole C23. Together with *H. dentata* and *H. glabrans* they are the most common forms in the temperate faunas from Hole 111A. *Pseudoquernhelina* spp are common in the Tethyan faunas from Site 605 but are rare in Hole 111A. *Racemiquernhelina* spp and fully developed *Pseudotextularia* spp exclusively occur at Site 605. A distinct but unexplained faunal boundary within the Site 605 section involves frequency shifts of three “relatively cold” species, *H. dentata*, *H. glabrans* and *H. planata*. Dissolution effects, expressed in changes in the relative frequencies of *H. globulosa* and *Pseudotextularia elegans*, are present in several intervals across the section. *H. globulosa* is the most sensitive for dissolution. *Pst. elegans* is resistant, as are to a lesser extent, *Gublerina cuvieri*, *Pseudoquernhelina exculata*, *Psg. pulpehr-a*, and *Planoglohulinu ucerulinoide.s*.

INTRODUCTION

This study concerns the Upper Cretaceous planktonic foraminiferal family Heterohelicidae Cushman in Maastrichtian and some Upper Campanian sediments from the NW Atlantic. Many heterohelicid species show biostratigraphic potential, especially, but not only, the multiserial forms. Yet, relatively little attention has been paid to the heterohelicids, and their biostratigraphic and biogeographic distribution are not known in much detail. In this study, heterohelicid faunas from three NW Atlantic localities (Fig. 1), representing different faunal provinces, are compared. The upper Lower Maastrichtian and Upper Maastrichtian of DSDP Hole 111A represent a temperate environment (Nyong, 1984); the Upper Maastrichtian at DSDP Site 605 has a tropical fauna, with cold elements (Jansen and Kroon, 1987). The Upper Campanian/Lower Maastrichtian section of Imperial Oil/Amoco core hole C23 on the Grand Banks, South of Nova Scotia, represents shallow water deposits. Since there is little agreement on heterohelicid taxonomy, this study discusses the heterohelicid species concept in some detail.

The heterohelicids from DSDP Site 111 have been previously studied by Martin (1972) and Weiss (1983). Jansen and Kroon (1987) included heterohelicids in their study of the planktonic foraminifera of the Maastrichtian in DSDP Site 605. Nyong (1984) included Site 111 in his analysis of North Atlantic faunal provinces. However, these studies give qualitative or, at best, semi-quantitative results. While the results presented below agree with their general conclusions, the quantitative approach used here allows for a more detailed analysis of faunal changes. Heterohelicid species distributions were calculated from counts of some 300 specimens from the >125 μm size fraction of each sample. The percentage of benthic foraminifera was determined for each sample, to give an indication of the depth of deposition, and (or) dissolution effects. The percentage of heterohelicids within the planktonic association, and that of globotruncanids within the spirally coiled plankton give additional environmental information.

Planktonic and benthic foraminifera were qualitatively searched for biostratigraphic markers. The planktonic fo-
raminiferal biozonation follows that of Caron (1985). The 63-125μm size fraction was scanned for the presence of additional small sized Heterohelicid species. The material is filed in the micropalaeontological collection of the Geomarine Center of the Free University in Amsterdam.

RESULTS

Grand Banks

Grand Banks core hole C23 is one of a set of 25 holes drilled by Imperial Oil/Amoco in 1965. Sediment-ages between holes range from Paleozoic to Cenozoic. Hole C23 is the only one from which Upper Senonian sediments have been recovered; a 95m thick section of black to grey bioturbated clays is unconformably overlain by 250m of Eocene and younger sediments. Twelve samples from four 3m long cores, taken at approximately 25m intervals, were available for this study (Figure 2). They contain excellently preserved foraminiferal faunas that are rich in benthos (around 70%, Fig. 2), accompanied by low diversity plankton. At the present day, such a high percentage of benthic foraminifera is found on the middle shelf areas (Wright, 1977, Van Marle and others, 1987); the same shallow depth of deposition seems a probable estimate for the core hole C23 deposits.

Planktonic age-marker are absent. The presence of the benthic species Neofoellinina praereticulata Hilttermann and Bolivinoides draco miliaris Hilttermann and Koch give an upper Campanian to lower Maastrichtian age (Van Hinte, 1967, 1976; Koch, 1977). Because the C23 section is older than the other sections studied here, only the presence of any morphotype in common with the other localities can be used to give information about heterohelicids in shallow water deposits. The absence of any species may not only be due to the shallow depth of deposition, but also to differences in age.

The Grand Banks heterohelicid faunas are dominated by Heterohelix globulosa (Ehrenberg) and Heterohelix planata (Cushman), which together constitute 85-95% of the faunas (Fig. 2). Heterohelix dentata Stenestad, Heterohelix glabrans (Cushman), Heterohelix navarroensis Loeblich, Heterohelix pulchra (Brotzen), Pseudoguemhelina costulata (Cushman) and Pseudotextularia nutalli (Voorwijk) are present in low numbers.

DSDP Hole 111A

The Maastrichtian foramin-nanno chalk ooze of DSDP Hole 111A core 11 was deposited at an outer sublittoral to upper bathyal depth (van Hinte, 1972). The presence of Globotruncanana gansseri Bolli in the lower samples (11 cc to 11-2, 73-76 cm) gives an G. gansseri Zone age, the zonal marker Abathomphalus mayaroensis (Bolli) is present in the upper four samples, 11-2, 2-5cm to 11-1, 137-140cm. The section is unconformably overlain by lower Eocene sediments. The upper part of the A. mayaroensis Zone is missing. The 20 samples from the 8m thick section contain between 5 and 15% benthic foraminifera, with a peak of 30% in sample 111A-11-6, 143-147cm in the lower part of the

| Age | Sample | depth in m | cored intervals | SAMPLES |
|-----|--------|------------|-----------------|---------|
| 10  | 253    | 75-12      | 75-13           | 75-14   |
| 11  | 256    | 75-15      | 75-16           | 75-17   |
| 12  | 284    | 75-19      | 75-20           | 75-21   |
| 13  | 310    | 75-22      | 75-23           | 337     |

Fig. 2. Faunal composition of the Grand Banks samples. The frequencies of the heterohelicid species add up to 100%. Heavy lines denote rare presence (less than 2.5%) P = Plankton; B = Benthos; H = Heterohelicidae; G = spirally coiled plankton; Gt = Globotruncanana s.l.; H. = Heterohelix, Psg. = Pseudoguemhelina, Pst. = Pseudotextularia.
Maastrichtian Heterohelicidae (Planktonic Foraminifera)

Fig. 3. Faunal composition of Maastrichtian DSDP Hole 11A core 6 samples. The frequencies of the heterohelicid species add up to 100%. Heavy lines denote rare presence (less than 2.5%). P = Plankton; B = Benthos; H = Heterohelicidae; G = spirally coiled plankton; Gt = Globotruncanida s. l.; G = Gublerina; H = Heterohelix; Pl. = Planoglobulina; Psg. = Pseudoguembelina; Pst. = Pseudotextularia.

section (Fig. 3). While the relative frequencies of the heterohelids do not change much between samples, the number of globotruncanids relative to other coiled planktonics is more variable. The globotruncanid frequencies are high in the upper and lower samples; they are lowest in the middle part of the section, around 18%.

The planktonic foraminifera show signs of dissolution (dissolution holes, fragmentation) and it is possible that the shifts in the relative benthos- and globotruncanid-frequencies are the results of preferential dissolution, although not necessarily because of a rising CCD. The samples were washed onboard, during Leg 12, using a strong solvent, that may corrode samples, if they are left standing too long. The effects would be indistinguishable from primary dissolution in the lysocl ine.

As in the Grand Banks samples, H. globulosa and H. plan a ta form the bulk of the heterohelicid faunas, but at this Site they are accompanied by more species. Representatives of all Maastrichtian genera, except Racemiguembelina, are present, although mostly in low numbers. Pes sagno and Longoria (1972) reported the presence of Racemiguembelina powelli (=Racemiguembelina sp) in the A. mayaroensis zone of Hole 111A, but this species was not encountered during this study.

Apart from H. globulosa and H. planata, H. dentata and H. glabr ans are the most common species throughout the section. The higher relative frequencies of Planoglobulina acervulinoi d es (Egger) in the upper samples, 11-1, 137-140cm to 11-2, 2-5cm and of Planoglobulina riogr andensis (Martin) in sample 11cc coincide with higher relative frequencies of globotruncanids, and may be due to differential dissolution. The first occurrences of Pl. acervulinaoides, Planoglobulina multicamerata (de Klasz) and of Pseudotextularia intermedia de Klasz in the G. gunsseri Zone are in agreement with the ranges given for those species by Martin (1972), Masters (1977) and Weiss (1983).

The overall faunal composition in Hole 111A described here differs considerably from the results given by Weiss (1983), who studied a larger size fraction (>200μm) than here (>125μm). On a presence/absence basis, the differences between the two datasets are mainly taxonomic artifacts. However, in his >200μm size fraction, the heterohelids as a group are a rare part of the planktonic foraminiferal faunas, while here, in the >125μm size fraction, they constitute around 25%. Heterohelix spp. that form the bulk of the heterohelicid faunas are generally small-sized, and would only rarely be present in larger size fractions.

**DSDP Site 605**

At Site 605 DSDP drilled a 55m thick section in upper Maastrichtian grey foram-nanno oozes and marly oozes. Backtracking gives a bathyal depth of deposition of about 2.5km (Jansen and Kroon, 1987). The planktonic foraminifera give an upper G. gunsseri Zone (samples 71cc to 69-5, 60-62cm) and A. mayaroensis Zone age (samples 69-4, 60-62cm to 66-2, 28-30cm), based on the presence of the respec-
relative zonal markers. The *A. mayaroensis* Zone is complete in Site 605 as the K/T boundary is found in the interval around 66-1, 75cm (Smit and Van Kempen, 1987).

The 39 samples studied contain diverse planktonic foraminiferal faunas, with generally low numbers of benthic foraminifera (between 0.5% of the total foraminiferal faunas; Fig. 4). Three samples, 605-66-2, 28-30cm, 66-2, 59-61cm and 66-3, 59-61cm, clearly contain a higher amount of benthic foraminifera; the heterohelicid and globotruncanid frequencies are also higher than in other samples. These are thought to represent carbonate dissolution due to a rising CCD: the samples contain a much lower number of foraminiferal specimens than the others, and the relative frequencies of many species fluctuate drastically in this interval (Figs. 4 and 5). The frequencies of groups of foraminifera with heavy tests especially show a relative increase.

DSDP Site 605 has the most diverse heterohelicid fauna of the 3 sample sets. Yet, *H. globulosa* is the dominant form with relative frequencies that are approximately the same as in Hole 111 A and the Grand Banks samples. *H. planata* gave way to higher frequencies of other species (Fig. 5); *H. planata* is usually rare in the Site 605 samples. *Pseudoguembelina* spp and *Pseudotextularia* spp are more common than in the two northern localities. *Pseudotextularia* specimens with a fully developed, deep test are present. Additionally, *Pseudoguembelina* spp and *Racemiguembelina* spp were found in Site 605, though generally in low numbers. The ranges of *Racemiguembelina fructiosa* (Egger) and of *Racemiguembelina powelli* Smith and Pessagno coincide with that of the zonal marker *A. mayaroensis*.

Within the Site 605 sample set two faunal trends can be distinguished. The first is mostly expressed by the frequencies of *H. planata*, *H. dentata* and *H. glabrana*. *H. glabrana* and *H. planata* are consistently present to common, in the lower samples (71cc to 68-4, 60-62cm), but become rare in the upper samples (68-3, 60-62 to 66-2, 28-30cm). *H. dentata* shows an opposite trend; it is mainly confined to the upper samples. A second faunal trend is shown by changes in the relative frequencies of *H. globulosa* and, for the upper samples, *Pseudotextularia elegans* (Rzeheak).

A cluster analysis on the heterohelicid assemblages of Site 605 divides the samples into three main clusters (Fig. 6). One consists of those samples that contain a high amount of benthic foraminifera (Fig. 4), relatively rare *H. globulosa* and abundant *Pst. elegans*; 605-66-2, 28-30cm, 66-2, 59-61cm and 66-3, 59-61cm. The second boundary falls between samples 68-3, 60-62cm and 68-4, 60-62cm, dividing the lower samples with common *H. planata* and *H. glabrana*, and the upper samples with common *H. dentata*. The subclusters within the two main ones are again related to the *H. globulosa* and *Pst. elegans* frequencies (Fig. 6).

The two phenomena are apparently unrelated. The *H. globulosa* and *Pst. elegans* frequencies are constant across the interval in which *H. planata*, *H. dentata* and *H. glabrana* show their reversal. The independence also shows in the correlations between the frequency distributions of the various species found at Site 605 (Fig. 7). *H. globulosa* frequencies have no clearly positive correlation with any of the other species. *Pst. elegans* is part of a group of species that also includes *Pl. acervulinoidea*, *Pseudoguembelina excolata* (Cushman), *Pseudoguembelina palpebra* Brönnimann and Brown and *Pseudoguembelina* sp. This group shows the opposite of the *H. globulosa* trend, with which species it is negatively correlated. In the same manner *H. glabrana* and *H. planata* are negatively correlated with *H. dentata*, and to a lesser extent with *Planoglobulina carseyae* (Plummer).

Yet, the last four species are mostly uncorrelated to either *H. globulosa* and *Pst. elegans* frequencies (Fig. 6).

**DISCUSSION AND CONCLUSIONS**

Malinverno (1987) showed that of the Maastrichtian planktonic foraminiferal species, *H. globulosa* is the most susceptible to dissolution. Indeed, the lowest frequencies of *H. globulosa* (below 20%) and the highest of *Pst. elegans* (over 30%) are found in those samples that contain a high percentage of benthic foraminifera, and show effects of partial...
Maastrichtian Heterohelicidae (Planktonic Foraminifera).

Fig. 5. Maastrichtian heterohelicid faunal composition at DSDP Site 605 samples. The frequencies add up to 100%. Heavy lines denote presence of rare forms (less than 2.5%). 

- G. = Guhlerina
- H. = Heterohelix
- Pl. = Planoglobulina
- Psg. = Pseudoguemhelina
- Pst. = Pseudotextularia
- R. = Racemiguemhelina

Note faunal change between samples 68-3, 60-62 cm and 68-4, 60-62 cm.

The strongest dissolution is found in the uppermost part of the Site 605 section. There the relative proportion of benthic foraminifera increases as well. That the benthic foraminiferal content remains low in the other dissolution affected samples (Fig. 6) can be explained by assuming that dissolution effects are not strong enough to influence the P/B ratio much. Studies of Recent material show that indeed the faunal composition changes due to dissolution effects before a clear change in the Plankton/Benthos ratio can be noted (Troelstra, 1984).

It appears that Pst. elegans and, to a lesser extent, Psg. excolata, Psg. palpebra, G. cuvillieria, Pseudoguemhelina sp and Pl. acervulinoidea are dissolution resistant forms. Malmgren (1987) found that only Psg. palpebra is dissolution resistant, while Pst. elegans and Pl. acervulinoidea (=Planoglobulina brazoensis Martin in Malmgren's synonymy) showed no changes in frequency with increasing dissolution effects. The difference may be partly due to the fact that he did include the globotruncanids in his counts, while here the frequencies are measured relative to other heterohelicid forms only. The globotruncanids, with their heavy tests, would be dissolution resistant, and their relative increase might dampen the effects on the frequency changes of other, slightly less dissolution resistant forms. On the other hand, a differential initial faunal composition will cause different dissolution related frequency changes, since frequencies can only be measured relative to other species.

By analogy, it is likely that the changes in the Hole II11A heterohelicid faunas are also related to dissolution effects.
Fig. 6. Weighted Pair Group Average cluster analysis of DSDP Site 605 samples, based on a correlation matrix.

A- resulting dendrogram with shaded clusters; B - relative frequencies in stratigraphic order of the species that cause the main subdivision, and C - relative frequencies of species that give the subclusters (shadings as in A). *H. = Heterohelix; *Pst. = Pseudotextularia.

Explanation of Plate 1

bar = 100μm, unless otherwise indicated

Fig. 1 *Guhlerina acuta* De Klasz. Sample DSDP 111A-11-2, 2-5cm; a-edge view; b- side view.

Fig. 2 *Guhlerina cuvillieri* Kikoine. Sample DSDP 605-66-3, 124-126cm, a- oblique edge view, showing aperture between apertural flanges; b - oblique side view.

Fig. 3 Side view of *Guhlerina cuvillieri*. Sample DSDP 111A-11-6, top.

Fig. 4-6 *Heterohelix dentata* Stenestad. Sample DSDP 111A-11-6, top, 4a - edge view and 4b - side view of specimen with acute periphery and elongate chambers; 5, 6 - side views of specimens with reniform chambers.

Fig. 7 *Heterohelix dentata*. Sample C23 75-12. Specimen with a subacute periphery, an initial spiral coil and relict apertural flaps along the median suture; a - edge view; b - side view; c - detail of side view, showing that the depression is not an actual aperture, bar = 20μm.
190

diagonal. The correlation coefficients shown in the lower half are translated into symbols in the upper half of the matrix.

The same applies to the dissolution related subclustering of the samples (Fig. 6.) Since the species from groups la of the section.

uncorrelated to other species.

(2b) forms a fourth 'group'. The three other groups (3a-c) consist of species that do not show any definite trend, and are mostly uncorrelated to other species.

Fig. 7. Correlation matrix of DSDP Site 605 heterohelicid species, arranged to concentrate the positive correlations along the diagonal. The correlation coefficients shown in the lower half are translated into symbols in the upper half of the matrix.

Seven groups of species can be distinguished. Three have a high positive within group correlation (1a, 1b, 2a); H. globulosa (2b) forms a fourth 'group'. The three other groups (3a-c) consist of species that do not show any definite trend, and are mostly uncorrelated to other species.

1a and 1b are negatively correlated with each other, and correspond to the main faunal subdivision, while 2a and 2b represent the dissolution related subclustering of the samples (Fig. 6.) Since the species from groups 1a (H. dentata and Pl. caseyae) and 2a (Pl. elegans and other forms) are all mostly found in the upper part of the section, they are to some extent positively correlated. The same applies to 1b (H. glabrans and H. planata) and 2b (H. globulosa), that have their highest frequencies in the lower part of the section.

|     | 2a | 3a | 1a | 3b | 1b | 2b | 3c |
|-----|----|----|----|----|----|----|----|
| G. caseyae |    |    | +  |    | +  |    |    |
| Pl. caseyae |  +  |  +  |    |    |    |    |    |
| Pl. costata |    |    |    |    |    |    |    |
| H. dentata |    |    |    |    |    |  +  |    |
| H. elegans |    |    |    |    |    |  +  |    |
| H. glabrous |    |    |    |    |    |    |    |
| H. planata |    |    |    |    |    |    |    |
| H. globulosa |    |    |    |    |    |    |    |

Fig. 1 Heterohelix glabrans (Cushman). Sample DSDP 111A-11-2, top; a - edge view; b - side view.

Fig. 2 Side view of a Heterohelix glabrans specimen with an initial spiral coil. Sample DSDP 111A-11-3, 78-81cm.

Fig. 3 Heterohelix globulosa (Ehrenberg) with a long, slender test. Sample DSDP 605-70-2, 60-62cm; a - edge view; b - side view.

Fig. 4 Heterohelix globulosa with globular chambers. Sample C23 75-12, a - edge view; b - side view. Note thin costae, consisting of lined-out pastules.

Fig. 5 Heterohelix globulosa with an initial planispiral coil. Sample DSDP 605-69-3, 60-62cm; a - edge view, b - side view.

Fig. 6 Small-sized Heterohelix navarroensis Loeblich. Sample DSDP 605-69-5, 60-62cm; a - edge view; b - side view.

Fig. 7 Heterohelix navarroensis without an initial spiral coil. Sample C23 75-12, a - edge view, b - side view.

Fig. 8 Side view of a Heterohelix planata (Cushman) specimen with a bi-apertured terminal chamber. Sample DSDP 111A-11-3, top.
Maastrichtian Heterohelicidae (Planktonic Foraminifera)
either primary or due to laboratory preparation methods. The foraminifera there do show outward signs of dissolution: fragmentation, dissolution holes. Furthermore, the faunal changes seem to result from an enrichment in heavier, and the presence-absence patterns of heavy tested forms in Dendata eleguns. Foraminifera there do show outward signs of dissolution: either primary or due to laboratory preparation methods. The H. glohulosa, H. pulchra appears as a slightly dissolution resistant form in Site 605; in fragmentation, dissolution holes. Furthermore, the faunal faunas are tropical, with cold elements (Jansen and Kroon, 1984), and the Site 605 sent a shallow marine environment. DSDP Hole 11A solution affected samples. The Grand Banks samples represent a shallow marine environment. DSDP Hole 11A represents temperate waters (Nyong, 1984), and the Site 605 faunas are tropical, with cold elements (Jansen and Kroon, 1987). The heterohelicid diversity supports their conclusions. Sliter (1976) concluded for the South Atlantic heterohelicids that H. globulosa, H. planata and H. dentata (=H. globulosa, H. pulchra and H. glabrans in his synonymy) have the widest geographic ranges. Those species would also occur in temperate (and austral) provinces. For the North Atlantic temperate faunas of Hole 11A, this can be confirmed. H. glabrans can be added to this list. Together, the four forms dominate the transitional faunas of Hole 11A (discounting the frequencies of Pl. acervulinoides, which is here considered to be dissolution related). H. globulosa and H. planata are also dominant in the shallow deposits from the Grand Banks, where H. glabrans and H. dentata are very rare. This may signify that the first two species were more tolerant of variable shelf conditions than the latter two, but it can also be explained by a difference in depth habitat. Boersma and Shackleton (1981) concluded that striate Heterohelix spp (including H. globulosa and H. planata) were surface dwellers, while the smooth heterohelicids (including H. dentata and H. glabrans ) lived deeper in the water column.

Other species show opposite geographic trends. The Pseudoguembelina spp are more common (or less rare) at Site 605 than at Site 111, concurring with their mostly tropical occurrences observed by Sliter (1976). Racemiguembelina spp are confined to Site 605. The biserial pseudotextularian forms appear to be mostly tropical as well. Pst. elegans is found at Site 605 only, while Pst. mutalli is present at Site 111, but only forms with a narrow test.

More than the other three “cold” forms, H. planata seems to be at home in the northern waters. This species shows a distinct decrease in the more southern Site 605, where the relative frequencies of H. dentata, H. glabrans and H. globulosa are in the same order of magnitude as at Site 111. While the higher diversity at Site 605 indicates a tropical environment, the presence of those “cold” water forms makes it difficult to relate the faunal change at Site 605 to specific oceanic processes. Abundant radiolaria in the Paleocene at Site 605 indicate cold, nutrient rich waters (Nederbragt and Van Hime, 1987), either surface waters from the Labrador Sea, or upwelling. Possibly, the same water circulation patterns already influenced the Maastrichtian faunas; it would explain the combination of cold and warm species. The decrease of H. planata might then be interpreted as a change in the upwelling regime, or as a warming event. Unfortunately, these hypotheses cannot be tested by stable isotope analysis. Most specimens are calcite filled, and the preservation of the faunas is too poor to give reliable results.

Representatives of the multiserial genera Planoglobulina and Guhlerina show approximately the same frequencies at both DSDP Sites. This indicates a relatively widespread geographic distribution. Since these multiserial forms have relatively short age ranges, it increases their value as biostratigraphic markers.

SYSTEMATIC NOTES

A short discussion is given, when appropriate, of important morphologic features of the heterohelicid species encountered during this study. Some less well known species are described in more detail. The descriptive terminology for the heterohelicid tests is shown in figure 8. The patterns of multiserial growth that can be encountered in the heterohelicid genera are described in detail in Nederbragt, 1989. Only the most important synonymies are discussed.

**Explanation of Plate 3**

bar = 100µm, unless otherwise stated

Fig. 1 Heterohelix planata. Sample C23 75-18; a - edge view; b - side view.
Fig. 2 Side view of Heterohelix planata. Sample DSDP 111A-11-2, top.
Fig. 3 Side view of Heterohelix pulchra (Brotzen). Sample C23 75-18.
Fig. 4 Heterohelix pulchra with chambers extending nearly toward the opposite edge; note rim of broken off last chamber, that curves down along the periphery; Sample C23 75-18; a - edge view; b - side view.
Fig. 5 Heterohelix punctulata (Cushman) with bi-apertured chamber, only rims remain of the broken of multiserial set. Sample DSDP 111A-11-2, top, a - edge view; b - side view.
Fig. 6 Side view of Heterohelix punctulata specimen with a rapidly flaring juvenile test and subgobular adult chambers. Sample DSDP 111A-11-2, top.
Fig. 7 Heterohelix punctulata with accessory apertures. Sample DSDP 605-71, CC, a - edge view, b - side view, c - detail of accessory aperture. bar = 20µm.
Maastrichtian Heterohelicidae (Planktonic Foraminifera)
Superfamily Globigerinacea Delage and Herouard, 1896
Family Heterohelicidae Cushman, 1927
Subfamily Heterohelicinae Cushman, 1927
Genus Guhlerina Kikoine, 1948: 26.
Type species Guhlerina cuvillieri Kikoine, 1948
Guhlerina acuta De Klasz, 1953
(Pl. 1, fig. 1)

1953b Guhlerina acuta De Klasz: 246, 247, pl. 8, figs. 3a, b; 1953b Guhlerina acuta robusta De Klasz: 247, pl. 8, figs. 4, 5; 1953 Guhlerina hedbergi Brönnimann and Brown: 155

Remarks. The more heavily ornamented G. acuta robusta is here regarded as a junior synonym of G. acuta. Smith and Pessagno (1973) described G. acuta as a juvenile form of G. acuta robusta. However, the holotypes of both forms show multiserial growth, indicating that both are adult. The difference in ornamentation is here considered to be pheno-

Distribution. Throughout the DSDP Hole 111A and Site 605 section, but always in low numbers.

Guhlerina cuvillieri Kikoine, 1948
(Pl. 1, figs. 2, 3)

1948 Guhlerina cuvillieri Kikoine: 26, pl. 2, figs. 10a c; 1953b Guhlerina cuvillieri Kikoine; De Klasz, 245, 246, pl. 8, figs. 1a, b.

Remarks. Here, the emendation of G. cuvillieri as given by de Klasz (1953b) is followed. In the material studied here multiserial growth is absent, only biserial specimens have been found.

Distribution. Very rare in Hole 111A. At Site 605 confined to the upper part of the section.

Genus Heterohelix Ehrenberg, 1843
Type species: Spiroplectula americana Ehrenberg, 1844.
Heterohelix dentata Stenestad, 1968
(Pl. 1, figs. 4-7)

1968 Heterohelix dentata Stenestad: 67, 68, pl. 1, figs. 3-6, 8, 9; pl. 2, figs. 1-3.

Description. Test biserial, or with an initial spiral coil, wall microperforate, smooth. Periphery acute to subacute, chambers elongate in side view, straight to reinform. Aperture bordered by distinct flanges.

Remarks. The morphotype described above has variously been recorded as H. glabrans (Sliter, 1976; Weiss, 1983) or as H. pulchra (Masters, 1977; Jansen and Kroon, 1987). It differs from H. glabrans in its more reinform chambers, and from H. pulchra in its more acute periphery and smaller apertural flanges. These differences appear to be consistent, and sufficient to distinguish H. dentata as a separate species. Its occurrence in our Maastrichtian samples agrees with the range given by Stenestad (1969).

Smith and Pessagno (1973) described the presence of “accessory apertures” in Heterohelix glabrans (Cushman). The same structures were encountered both in H. glabrans and in H. dentata (Pl. 1, fig. 7). However, they are not true apertures, but relict exposures of the apertural flaps of preceding chambers.

Distribution. Rare in core hole C23, rare in the lower part but common in the upper part of the Maastrichtian of Site 605. A common species in Hole 111A, and therefore thought to be tolerant to colder waters.

Heterohelix glabrun (Cushman, 1938)
(Pl. 2, figs. 1, 2)

1938 Guembelina glabrun Cushman: 15, pl. 3, figs 1, 2.

Distribution. Rare in core hole C23; rare in the upper part but common in the lower part of the Maastrichtian section at Site 605. A common species in Hole 111A and therefore thought to be tolerant to colder waters.

Heterohelix globulosa (Ehrenberg, 1840)
(Pl. 2, figs. 3-5)

1840 Textularia globulosa Ehrenberg: 135, pl. 4, figs. 2β, 4β, 5β, 7β, 8β;
1840 Textularia striata Ehrenberg: 135, pl. 4, figs 1α-3α, 9α.

Explanation of Plate 4
bar = 100µm

Fig. 1 Heterohelix sp. with bi-apertured terminal chamber. Sample DSDP 605-67-3, 44-46cm; a - edge view; b - side view.
Fig. 2 Heterohelix sp. with reinform chambers. Sample DSDP 605-69-5, 60-62cm; a - edge view; b - side view.
Fig. 3 Heterohelix sp. Sample 66-3, 28-30cm; a - edge view; b - side view.
Fig. 4 Planoglobulina acervulinoidea (Egger). Sample DSDP 605-70-2, 60-62cm; a - edge view, b - side view.
Fig. 5 Planoglobulina acervulinoidea. Sample DSDP 605-70-3, 60-62cm; a - edge view; b - side view; note asymmetric test and apertural flanges along chambers of the last multiserial set.
Fig. 6 Planoglobulina acervulinoidea. Sample DSDP 605-70-3, 60-62cm; note nearly flush sutures.
Maastrichtian Heterohelicidae (Planktonic Foraminifera)
Fig. 8. Descriptive terminology of the heterohelicid morphology.

A - side- and top view (=peripheral view) of a biserial test.

B - side-view of a flat multiserial test (Planoglobulina) showing multiserial chamber arrangement and positions of apertures. After building a first bi-apertured chamber (=progressive chamber, Van Hinte, 1965) a set of chambers is formed at each growth step, resulting in multiserial growth (harmonic growth of Van Hinte, 1965). The chambers of each set enclose all apertures of the preceding set; each set has a relapsed mono-apertured chamber, at alternating sides of the test. Two chambers may merge to form a tri-apertured one. The chambers of each set are numbered, counting from the progressive chamber.

C - side-view of a multiserial Guhlerina test. The pattern of multiserial growth is similar to B, except that the bi-apertured chambers are widely spaced and connected by extended apertural flanges (indicated by thin lines); the progressive chamber is shaded.

D - 2) side-view of a Racemiguemhelina test, in which the multiserial chambers have been traced assuming harmonic growth as in B; the progressive chamber is shaded; 1) top view of an ellipsoid specimen. For each single chamber in a flat multiserial form, a pair of chamberlets is formed connected by a bridge. The peripheral relapsed chamber remains single; 3) top view of a cone shaped specimen, in which all chambers of each set, including the relapsed chambers, are connected by one large structure (a sieve plate, Pessagno and Brown, 1969).

Explanation of Plate 5

bar - 100 µm

Fig. 1 Planoglobulina acervulinoides. Sample DSDP 605-70-3, 60-62 cm; note inflated chambers and deeply depressed sutures. Fig. 2. Planoglobulina acervulinoides, with deep test, and second set of multiserial chambers broken off. Sample DSDP 605-66-2, 59-61 cm; a - edge view; b - side view.

Fig. 3 Side view of Planoglobulina caseyae (Plummer). Sample DSDP 111A-11-2, top. Note rims of broken off multiserial chamber set.

Fig. 4 Planoglobulina caseyae with progressive chamber only. Sample DSDP 605-67-3, 44-46 cm; a - edge view; b - side view; note small, but distinct apertural flanges.

Fig. 5 Side view of a Planoglobulina caseyae specimen with one set of multiserial chambers. Sample DSDP 605-67-3, 44-46 cm.

Fig. 6 Planoglobulina multicamerata (De Klasz). Sample DSDP 605-69, CC; a - edge view; b - side view.

Fig. 7 Side view of Planoglobulina multicamerata. Sample DSDP 111A-11-3, 3-6 cm.
Remarks. *Heterohelix globulosa* specimens may have an initial coil (Pl. 2, fig. 5), or a bi-apertured terminal chamber. *Heterohelix striata* should differ from *H. globulosa* in having stronger costae; our material shows transitions from specimens with lined piles to lightly constate (Pl. 2, fig. 4) to specimens with more heavy continuous costae (Pl. 2, fig. 3). The differences are gradual, and interpreted to represent intraspecific variation.

**Distribution.** *H. globulosa* is the most abundant heterohelicid species in all three localities studied here.

*Heterohelix navarroensis* Loeblich, 1951
(Pl. 2, figs. 6, 7)

1951 *Heterohelix navarroensis* Loeblich: 107, 108, pl. 12, figs 1-3; text fig. 2.

Remarks. *H. navarroensis* is a small species, that is mostly confined to the 63-125μm size fraction. The larger specimens, found in the >125μm size fraction, resemble *H. navarroensis* in general morphology, but lack the spiral coil (Plate 2, fig. 7). Such forms differ from *H. planata* in having a less rapidly flaring test. *H. navarroensis*, with or without initial coil, differs from *H. globulosa* in having more elongated chambers and larger apertural flanges.

**Distribution.** Rare in the >125μm size fraction of the samples from core hole C23 and Hole 605; not observed in Hole 111A.

*Heterohelix planata* (Cushman, 1938)
(Pl. 2, fig. 8; Pl. 3, figs. 1, 2)

1938 *Guembelina planata* Cushman: 12, 13, pl. 2, figs. 13, 14.

**Distribution.** Rare in Hole 605, abundant in core hole C23 and Hole 111A, therefore thought to have been tolerant to colder waters and variable conditions.

*Heterohelix pulchra* (Brotzen, 1936)
(Pl. 3, figs. 3, 4)

1936 *Guembelina pulchra* Brotzen: 121, pl. 9, figs. 3a, b (non 2a, b).

Remarks. The specimens here encountered have a smooth test, like the topotypes figured by Weiss (1983). Masters (1977) described *H. pulchra* as possessing poremounds, and Petters (1977) also figured a specimen with poremounds. Morphologically, the two types are identical, and are here considered to belong to the same species. The same difference in wall structure among specimens belonging to one species can be found in the Miocene planktonic foraminifer *Cassigerinella chipolensis* (Cushman and Ponton) (Saito and Biscaye, 1977).

**Distribution.** *H. pulchra* was encountered in core hole C23 sample 75-18 only.

*Heterohelix punctulata* (Cushman, 1938)
(Pl. 3, figs. 5-7)

1938 *Guembelina punctulata* Cushman: 13, pl. 2, figs. 15, 16;
1959 *Pseudotextularia echevarriai* Seiglie: 59, pl. 3, figs. 2-6.

Remarks. *H. punctulata* is often included in *Pseudoguembelina*, because of its accessory apertures. It is here included in *Heterohelix*, since its accessory apertures are not generally present, and, when present, lack the distinct lip that is characteristic of *Pseudoguembelina*. The multiserial forms here included in *H. punctulata* were described as *Pst. echevarriae* by Seiglie. Such forms resemble the biserial *H. punctulata* in general morphology; they are here regarded as gerontic individuals, comparable to the multiserial forms found in *H. globulosa* and *Pseudoguembelina palpebra* (Nederbragt, 1989).

**Distribution.** Throughout Hole 111A and Site 605, mostly rare. Multiserial forms were found in Hole 111A only.

*Heterohelix* sp
(Pl. 4, figs. 1-3)

Remarks. A variety of forms are here included in *Heterohelix* sp, that differ from other species in having relict apertural flanges visible along the median suture, and reinforce, costate chambers. A biapertured terminal chamber may be present.

**Distribution.** Rare to common at Site 605.

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**Explanation of Plate 6**

| Fig. 1 | Side view of *Planoglobulina riograndensis* (Martin) with widely flaring test. Sample DSDP 111A-11, cc. |
| Fig. 2 | *Planoglobulina riograndensis*. Sample DSDP 111A-11, CC; a - edge view, b - side view. |
| Fig. 3 | *Pseudoguembelina costulata* (Cushman). Sample DSDP 605-69-5, 60-62cm; a - edge view; b - side view. |
| Fig. 4 | *Pseudoguembelina costulata* with one accessory aperture. Sample DSDP 605-69-5, 60-62cm, a - edge view, b - side view. |
| Fig. 5 | Side view of *Pseudoguembelina costulata* without accessory apertures. Sample C23 75-15. |
| Fig. 6 | *Pseudoguembelina excolata* (Cushman). Sample DSDP 605-69-5, 60-62cm, a - edge view, b - side view. |
| Fig. 7 | Side view of *Pseudoguembelina excolata* without accessory apertures. Sample DSDP 111A-11, bottom. |
| Fig. 8 | Side view of *Pseudoguembelina kempensis* Esker. Sample DSDP 605-70-3, 60-62cm. |
Genus *Planoglobulina* Cushman, 1927
Type Species *Guemhelina acervulinooides* Egger, 1899

**Remarks.** Here the interpretation of *Planoglobulina* given by Martin (1972) and Smith (1978) is followed. *Planoglobulina multicamerata* (de Klasz) and *Planoglobulina riograndensis* (Martin) are variously included in the genus *Ventilabrella* Cushman (1972, Smith and Pessagno, 1973), or in *Planoglobulina* (Weiss, 1983). The type species of *Ventilabrella*, *Ventilabrella eggeri* Cushman, however, is a late Santonian to early Campanian species, that is phylogenetically unrelated to the Maastrichtian forms here under discussion: no multiserial heterohelicids are found in the upper Campanian (Weiss, 1983). While the phylogenetic relation of *Pl. multicamerata* and *Pl. riograndensis* with the genotypes *Pl. acervulinooides* is unclear, it is here considered preferable to include those two in the genus *Planoglobulina*.

*Planoglobulina acervulinooides* (Egger, 1899)
(Pl. 4, figs. 4-6; Pl. 5, figs. 1, 2)

1899 *Guembelina acervulinooides* Egger: 35, pl. 14, fig. 20 (non 14-18, 21, 22)
1972 *Planoglobulina acervulinooides* (Egger); Martin: 81, pl. 3, figs. 3-6
1972 *Planoglobulina brazoensis* Martin: 82, 83, pl. 3, fig. 7; pl. 4, fig. 1-2

**Remarks.** Martin (1972) assigned a neotype to *Pl. acervulinooides*, thereby stabilising the species concept. *Pl. brazoensis* should differ from *Pl. acervulinooides* in having more inflated chambers, narrower costae and less multiserial chamber sets. However, the holotype of *Pl. brazoensis* and the neotype of *Pl. acervulinooides* appear to be end members of a continuous morphologic series. Most specimens show a combination of the characteristics of the two morphotypes. Therefore, *Pl. brazoensis* is here regarded as a junior synonym.

**Distribution and Range.** Rare to common in the Maastrichtian of the upper part of Hole 111A and throughout Hole 605. It ranges from the middle part of the *G. gansseri* Zone to top of the *A. mayaroensis* Zone.

*Planoglobulina riograndensis* (Martin, 1972)
(Pl. 6, figs. 1, 2)

1972 *Ventilabrella riograndensis* Martin: 88, 89, pl. 2, figs. 1-4.

**Remarks.** According to Martin (1972) *Planoglobulina manuelensis* (Martin) would be present in Hole 111A. *Pl. manuelensis* is characterised by heavy vermicular ornamentation and a subcircular test-shape. *Pl. riograndensis* has thin vermicular ornamentation, while both its biserial and individual multiserial chambers are globular. Some specimens found here in Hole 111A, core 6, have indeed a widely flaring test. However, their ornamentation is the same as that of *Pl. riograndensis*, in which species these forms are therefore included.

**Distribution and Range.** Rare to common in the lower part of the *G. gansseri* Zone of Hole 111A.

Genus *Pseudoguernhelina* Brönnimann and Brown, 1953
Type species: *Guembelina excoluta* Cushman, 1926.

*Pseudoguernhelina costulata* (Cushman, 1938)
(Pl. 6, figs. 3-5)

**Explanation of Plate 7**

bar = 100µm

Fig. 1 *Pseudoguernhelina kempensis*. Sample DSDP 111A-11-1, bottom; a - edge view; b - side view.

Fig. 2 *Pseudoguernhelina palpebra* Brönnimann and Brown with thin costae and slightly cornute shaped terminal chamber. Sample DSDP 111A-11-2, top; a - edge view; b - side view.

Fig. 3 Side view of *Pseudoguernhelina palpebra* with coarse, discontinuous costae. Sample DSDP 111A-11-1, bottom.

Fig. 4 Side view of *Pseudoguernhelina palpebra* with last two chambers cornute-shaped. Sample DSDP 605-66-6, CC.

Fig. 5 Multiserial *Pseudoguernhelina* sp. Sample DSDP 605-66-2, 124-128; a - edge view, b - side view.

Fig. 6 Side view of *Pseudoguernhelina* sp. with biserial test and flush sutures, covered by thin, discontinuous costae. Sample DSDP 605-66-2, 28-30cm.

Fig. 7 *Pseudotextularia elegans* (Rzehak). Sample DSDP 605-66-6, CC; a - edge view; b - side view.

Fig. 8 *Pseudotextularia elegans* with test that is wider than deep. Sample DSDP 605-66-6, CC; a - edge view; b - side view.
Maastrichtian Heterohelicidae (Planktonic Foraminifera)
1938  *Guembelina costulata* Cushman: 16, 17, pl. 3, figs. 7-9.

**Distribution.** Rare in Hole 111A and core hole C23; more common at Site 605.

*Pseudoguembelina exolata* (Cushman, 1926)  
(Pl. 6, figs. 6, 7)

1926  *Guembelina exolata* Cushman: 20, pl. 2, fig. 9.

**Distribution.** Rare in DSDP Hole 111A; more common in Hole 605.

*Pseudoguembelina kempensis* Esker, 1968  
(Pl. 6, fig. 8; Pl. 7, fig. 1)

1968  *Pseudoguembelina kempensis* Esker: 168, text figs. 1-5.

**Remarks.** *Pseudoguembelina kempensis* should be characterised by its distinctly acute periphery (Smith and Pessagno, 1973; Weiss, 1983). The specimens found here have only an indistinctly acute periphery along the first few chambers of the test. The difference is interpreted to represent intraspecific variation that might be environmentally controlled.

**Distribution.** Rare in DSDP Hole 111A; more common at Site 605.

*Pseudoguembelina palpebra* Brönnimann and Brown 1953  
(Pl. 7, figs. 2-4)

1953  *Pseudoguembelina palpebra* Brönnimann and Brown: 155, text figs. 9, 10;
1959  *Pseudoguembelina cornuta* Seiglie: 60, 61, pl. 4, figs. 1-7;
1976  *Pseudoguembelina polypeleura* Masters: 319, pl. 1, fig. 9.

**Remarks.** *Psg. cornuta* should differ from *Psg. palpebra* in having a cornute-shaped last chamber. *Psg. palpebra* can also have a subquadrat terminal chamber, or a bi-apertured one. *Psg. polypeleura* has been described as having thinner costae. These differences are here regarded as intraspecific variation.

1983  *Pseudoguembelina* sp., Weiss: 58, 59, pl. 7, figs. 8, 9.

**Remarks.** This form shows the onset of multiserial growth, while accessory apertures are absent. It is included in *Pseudoguembelina* because of its morphologic resemblances to the *Psg. palpebra* specimens with a bi-apertured terminal chamber.

**Distribution.** Rare in the uppermost part of the *A. mayaroensis* Zone at Site 605.

**Genus Pseudotextularia** Rzehak, 1891

**Type species:** *Cuneolina elegans* Rzehak, 1891

**Pseudotextularia elegans** (Rzehak, 1891)  
(Pl. 7, figs. 7, 8)

1891  *Cuneolina elegans* Rzehak: 4;
1948  *Guembelina striata* var. *deformis* Kikoine: 20, pl. 1, figs. 8a - c;
1981  *Pseudotextularia elegans* (Rzehak); Nash: 72 - 74, pl. 1, fig. 1 - 7, text fig. 2.

**Remarks.** *Pseudotextularia elegans* is here regarded as a species with a bi-convex test and coarse, continuous costae. The name *Pst. elegans* has been alternately used for this morphotype (Master, 1977; Nash, 1981,) or for the thinly costate, bi-concave variety (Smith and Pessagno, 1973; Weiss, 1983). Nash (1981) found that Rzehak's typematerial mostly contains the bi-convex morphotypes, and selected such a form as a neotype for *Cuneolina elegans* (=*Pst. elegans*), thereby stabilising the species concept. Kikoine gave the name *Guembelina striata* var *deformis* to the same bi-convex, coarsely costate pseudotextularian form.

**Distribution.** Common throughout the Site 605 section; enriched in the upper samples, due to differential dissolution.

*Pseudotextularia intermedia* De Klasz, 1953.

(Pl. 8, fig. 1)

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**Explanation of Plate 8**

| Fig. | Description |
|------|-------------|
| 1    | *Pseudotextularia intermedia* De Klasz. Sample DSDP 605-68-6, 60-62cm; a - edge view; b - top view. |
| 2    | *Pseudotextularia nuttalli* (Voorwijk) Sample DSDP 605-70, CC; a - edge view; b - side view. |
| 3    | *Pseudotextularia nuttalli*. Sample DSDP 111A-11-2, top; a - edge view, b - side view. |
| 4    | *Racemiguembelina fruticosa* (Egger). Sample DSDP 605-67-3, 44-46cm; a - side view; b - top view, showing sieve plate. |
| 5    | *Racemiguembelina powelli* Smith and Pessagno, with 4 sets of multiserial chambers. Sample DSDP 605-69-2, 60-62cm; a - top view, note short bridge and irregular placement of the terminal chamber set; b - side view. |
| 6    | *Racemiguembelina powelli* with 2 full sets of multiserial chambers, the third is partly broken off. Sample DSDP 605-69-4, 60-62cm, a - top view, note short, costate bridges; b - side view. |
Maastrichtian Heterohelicidae (Planktonic Foraminifera)
1953a *Pseudotextularia intermedia* De Klasz: 231 - 232, pl. 5, figs. 2a - c.

**Distribution and Range.** Rare throughout the Maastrichtian of Hole 605, and the upper part of Hole 111A. It ranges from the middle part of the G. gansseri Zone to top of the A. mayaroensis Zone.

*Pseudotextularia nuttalli* (Voorwijk, 1937)
(Pl. 8, figs. 2, 3)

1937 *Guembelina nuttalli* Voorwijk: 192, pl. 2, figs. 1-9; 1937 *Guembelina plummerae* Loetterle: 33, 34, pl. 5, figs. 1, 2; 1969 *Pseudotextularia cushmani* Brown: 55, 56, pl. 2, figs. 2, 3; pl. 3, fig. 4; 1973 *Pseudotextularia elegans* (Rzehak); Smith and Pessagno: 30 -32, pl. 9, figs. 5-15; pl. 10, figs. 2-6; 1976 *Pseudotextularia browni* Masters (nom. nov.): 321, pl. 1, figs. 10-12.

**Description.** Test biserial, bi-concave in edge-view. An initial planispiral coil is sometimes present. Chambers much deeper than wide. Surface finely costate; aperture a wide, low arc.

**Remarks.** Since the name *Pst. elegans* is here reserved for the coarsely costate form, another name must be found for the above described morphotype. *Guembelina nuttalli* Voorwijk is the next oldest available name. Voorwijk’s material is stored in the micropalaeontological collection of the Rijksuniversiteit Utrecht, the Netherlands. Here, the specimen he depicted in figure 4 (Voorwijk, 1937) is designated as a lectotype. The nine specimens he figured are all in one slide (D12267), together with another 21 specimens, of which unpublished drawings were made. All specimens, except one, are finely costate, and are bi-concave in edge view. The main variation is in the shape of the two ultimate chambers, ranging from subglobular to elongate, subrectangular in edge view. Half of his figured specimens can be reliably identified, among them the specimen of figure 4, that is here redrawn (fig. 9)

![Fig. 9. Redrawing of A) side view and B) edge view of specimen, corresponding to figure 4 of Voorwijk, 1937, herein designated as lectotype for Guembelina nuttalli; scale bar = 100 μm](image)

The figured specimens, including the lectotype, may come from Voorwijk’s locality 80, as marked on the slide. However, both the original type description and the collection register mention that the drawn specimens are from various localities. Additional slides, with other locality numbers, are present. However, it is here considered preferable to choose a figured specimen as lectotype, even though its locality could be uncertain.

*Guembelina nuttalli* was published in February 1937; *Guembelina plummerae* Loetterle, a comparable form, was published later in the same year. The difference in strength of costae, described for *Pseudotextularia cushmani* Brown, is here considered insufficient to distinguish a separate species. Master published *Pseudotextularia browni* as a new name for *G. plummerae*, that in his synonymy is a subjective secondary homonym of *Ventilabrella plummerae* Sandidge 1932 (=*Pseudotextularia caseyae* according to Masters).

**Distribution.** Common throughout the Maastrichtian at Sites 605 and 111; the specimens in Hole 111A, on the average, have a less deep test than the specimens from Site 605.

Genus *Racemiguemhelina* Montanaro Gallitelli, 1957
Type species *Guembelina fructicosa* Egger, 1899
*Racemiguemhelina fructicosa* (Egger, 1899)
(Pl. 8, fig. 4)

1899 *Guembelina fructicosa* Egger: 35, pl. 14, figs. 8, 9, 24 (non figs. 25, 26).

**Distribution and Range.** Rare at Site 605, throughout the A. mayaroensis Zone.

*Racemiguemhelina powelli* Smith and Pessagno, 1973
(Pl. 8, figs. 5, 6)

1973 *Racemiguemhelina powelli* Smith and Pessagno: 35-37, pl. 11, figs. 4-12.

**Remarks.** According to Smith and Pessagno (1973) *R. powelli* would differ from *R. fructicosa* in having less multiserial chambers, and in possessing bridges instead of sieve-plate. They imply that all forms with bridges should be included in *R. powelli*. As discussed by Nederbragt (1989), *Racemiguemhelina* specimens may still posses pairs of chambers connected by a microperforate bridge, while resembling *R. fructicosa* in all other aspects. Here, *R. powelli* is restricted to those forms with bridges that are not well developed, and have the same wall structure as the actual chambers.

**Distribution and Range.** Here found at Site 605 only, rare throughout the A. mayaroensis Zone.

**ACKNOWLEDGEMENTS**

I am grateful J.E. van Hinte and S. R. Troelstra for their many suggestions and valuable advice. DSDP Sites 111 and 605 were sampled by J. E. van Hinte during DSDP Legs 12 and 93; thanks are due to Imperial Oil (Calgary, Canada) for permitting him to participate in DSDP Leg 12 and to sample.
and publish on Grand Banks core hole C23.

**Manuscript received September 1988**

**Revised manuscript accepted July 1989**

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