8. CRETACEOUS TO PALEOGENE BENTHIC FORAMINIFERS FROM THE IBERIA ABYSSAL PLAIN

Wolfgang Kuhnt and Eric S. Collins

ABSTRACT

Cretaceous and Paleogene benthic foraminifers from Leg 149 Holes 897C, 897D, 899B, and 900A were examined to complete biostratigraphic information for sediments deposited below the calcite compensation depth (CCD) and to obtain paleoecologic information on the depositional environment of these sites. Main results are that (1) the red abyssal claystones comparable to the NW Atlantic Plantagenet formation are mainly restricted to the Paleocene and Eocene at the sites studied; (2) Upper Cretaceous sediments are missing; the period from the Albian to Maastrichtian is comprised of a major hiatus; and (3) Lower Cretaceous sediments encountered at Site 897D contain small-sized neritic Aptian benthic foraminifers, which may have been redeposited from the Iberia shelf. The species composition and biostratigraphic succession of Paleogene deep-water agglutinated foraminifers of the Iberia Abyssal Plain exhibits striking similarities to faunas from deep-water sections in the Western Mediterranean and Alpine Tethyan Basins including the Gibraltar Seaway.

INTRODUCTION

Paleontologic information on Cretaceous and Paleogene abyssal claystones that were deposited close to or below the CCD is largely restricted to deep water agglutinated foraminifers (DWAF) and particularly to agglutinated forms using organic cement. There have been several attempts to develop supra-regional zonations using DWAF. The first reliable zonation was developed by Geroch and Nowak (1984) for the Polish External Carpathians. Initial DWAF zonations for the Atlantic Ocean were developed by Moullade et al. (1988) for the Cretaceous and by Kaminski (1988) for the Paleogene. A rough attempt to calibrate DWAF zonations to magnetostratigraphy was made using material from the Tethyan Cretaceous standard magnetic polarity section at Gubbio (Kuhnt, 1990). Recent biostratigraphic work on DWAF includes material dating from the Cretaceous from various localities within the Western Tethys and the North Atlantic, including DSDP Hole 398D (Vigo Seamount) and from the Paleogene from the Gibraltar Seaway (Kuhnt et al., 1992; Kaminski et al., in press). Using this biostratigraphic framework, even the sparse and poorly preserved agglutinated fauna from Iberia Abyssal Plain ODP Sites 897, 899, and 900 (Fig. 1) can be assigned with confidence at least to stages within the Cretaceous and Paleogene.

Additionally, the species composition of the preserved benthic assemblages discriminates autochthonous abyssal assemblages from redeposited assemblages in the light carbonate-rich layers, which we interpret as fine-grained turbidites transporting material from shelf and slope environments into the basin. The composition of the autochthonous assemblages is used to provide some rough paleobathymetric estimates, based mainly on the different solubilities of certain groups of benthic foraminifers with respect to the lysocline and CCD.

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Table 1. Distribution of autochthonous benthic foraminifers in the Cretaceous and Paleogene of Hole 897C.

<table>
<thead>
<tr>
<th>Core, section:</th>
<th>lower Eocene</th>
<th>Paleocene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample volume (cm³):</td>
<td>10 10 11 15 11 11 10 13 10 15 13 14</td>
<td>12</td>
</tr>
<tr>
<td>Ammodiscus sp. (rough)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Aschemocella carpathica, incl. fragments</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Aschemocella grandis</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Dendrophyxa exsulsa</td>
<td>10 11 23 26 1 1 1 2 3</td>
<td></td>
</tr>
<tr>
<td>Glomospira choanoides</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Glomospira gordiates</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Glomospira irregularis</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Haplocyphragmogone walteri</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hormosina crassa</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hyperammina sp. fragments</td>
<td>2 1 1 1 1 3</td>
<td></td>
</tr>
<tr>
<td>Karrerula eniformis</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Paratrophamminonidae cf. corpulentus</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Paratrophamminonidae oblongis</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Paratrophamminonidae spp., incl. fragments</td>
<td>1 15 6 14 5 3</td>
<td>1</td>
</tr>
<tr>
<td>Plectoporexoides sp.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Praeasymmedia sp.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Recurvoides spp.</td>
<td>1 5 5 1 4 1 1 1 3 1</td>
<td></td>
</tr>
<tr>
<td>Rhabdamminia fragments</td>
<td>1 1 2</td>
<td>18 31 35 43 6 4 17</td>
</tr>
<tr>
<td>Rhizolites epigona</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subrephax scalaris fragments</td>
<td>2 4 5</td>
<td>3 1</td>
</tr>
<tr>
<td>Subrephax splendida</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Trochammina aliiformis</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Trochammina sp. (coarse)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Trochammina sp. (small)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>tubular aggl. fragments</td>
<td>1 6</td>
<td>19 42 7 20 8 1</td>
</tr>
<tr>
<td>indet. aggl. fragments</td>
<td>5 1</td>
<td>16 2 30 4 7 4</td>
</tr>
<tr>
<td>ichthyoliths</td>
<td>22 17 22 8 18 12 13 29 21 23 33 5 5</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Distribution of autochthonous benthic foraminifers in the Cretaceous Paleogene of Hole 897D.

| Core, section: | M.E. 2R-2 2R-CC 3R-4 3R-4 3R-CC 4R-1 4R-1 4R-2 4R-2 4R-CC 5R-1 5R-2 5R-CC |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Interval (cm): | 48-50 48-50 | 18-20 18-20 | 54-56 54-56 | 118-120 118-120 | 30-32 30-32 | 80-82 80-82 | 28-30 28-30 | 93-95 93-95 |
| Sample volume (cm³): | 10 50 10 50 15 10 10 10 10 10 15 10 10 | 10 10 |
| Ammodiscus creticus | 28 | 3 52 16 2 36 8 4 6 1 |
| Dendrophyxa exsulsa | 11 | 3 52 16 2 36 8 4 6 1 |
| Glomospira choanoides | 1 | 1 1 1 1 1 1 |
| Glomospira gordiates | 1 | 1 1 1 1 1 1 |
| Glomospira irregularis | 1 | 1 1 1 1 1 1 |
| Glomospira serpens | 1 | 1 1 |
| Hormosina ovolitoides | 2 | 3 20 5 2 2 5 |
| Hyperammina sublitisenta | 1 |
| Karrerula conformis | 1 2 2 5 |
| Paratrophamminonidae | 5 2 9 2 2 5 1 |
| Recurvoides spp. | 5 2 9 2 2 5 1 |
| Remezesia varians | 1 |
| Reticulocephragmum amplexites | 58 |
| Rhabdamminia fragments | 21 1 7 25 1 1 7 3 |
| Saccammina cf. placenta | 1 |
| Spirophecammina mabaeaeringensis | 1 |
| tubular aggl. fragments | 22 2 5 5 10 4 |
| smooth tubular fragments | 2 |
| indet. aggl. fragments | 1 |
| Naturallides tenuipennis | 11 |
| Osangularia spp. | 5 |
| Bolivina | 79 42 |
| Uvigerina | 1 3 |
| rereacted Cretaceous foraminifers | xx |
| ichthyoliths | 171 23 22 5 31 12 |

METHODS

Samples of varying size (see Tables 1-4) were processed for study of benthic foraminifers. The samples were wet-sieved through a 63 µm (#230 mesh) screen and the residue was dried. Very consolidated samples were first boiled in water to help break them up before sieving. In all cases the complete residue was picked for benthic foraminifers. Data are reported only in numbers/sample because of the generally low numbers of benthic foraminifers. The number of ichthyoliths present in each sample is also reported.

BIOSTRATIGRAPHY

Aptian Neritic (Redeposited?) Assemblages

Aptian benthic foraminifers were encountered in Hole 897C, Cores 62R to 65R and in Hole 897D, Cores 6R to 10R. They consist of shallow-water forms such as Trocholina, Spirillina ex gr. minima, tiny gavelinellas, and small smooth-walled lenticalins. The assemblage composition closely resembles the type 1 assemblages of Guerin (1981), which characterize outer platform environments of the North Atlantic and Mesogean realm (Guerin, 1981). These shal-
low-water benthic foraminiferal assemblages encountered do not allow us to apply the zonations for Early Cretaceous deep-water benthic foraminifers of the North Atlantic and Western Tethys oceans developed by Moullade (1984) and Riegraf and Luterbacher (1989), because the marker species used by these authors are normally missing. An exception is Sample 897C-62R-4, 58-60 cm, where we observed the co-occurrence of *Dorothia ouachensis* and *Gavelinella flandrini*, which, according to the zonation of Moullade (1984), would correspond to a middle Aptian age.

### Albian to ?Maastrichtian Hiatus

In both Holes 897C and 897D typical brownish carbonate-free claystones corresponding to the Plantagenet formation of the western North Atlantic occur directly above Aptian sediments in Core 897C-62R, which corresponds to Core 897D-6R. However, even this section’s lowest samples (897C-61R-3, 135-137 cm, and 897D-5R-CC) contain a sparse agglutinated benthic foraminiferal fauna dominated by hyperamminids, and, additionally, they contain a number of ichthyoliths. The occurrence of fragments of large, thick-walled hyperammins or hormosins (*Hormosina ovuloides*) and the marker *Rzehakina epigona* in Sample 897C-61R-3, 135-137 cm are important characteristics of this assemblage. These forms normally characterize the uppermost Cretaceous and Paleocene part of the Plantagenet formation.
tion in the North Atlantic; they are generally absent from sediments older than Campanian.

### Paleocene Deep-water Agglutinated Foraminiferal Assemblages

Paleocene DWAF assemblages characterize Hole 897C, Cores 61R-3, 135-137 cm to 61R-5, 50-52 cm, Hole 897D, Cores 5R-CC to 4R-CC, 80-82 cm, and Hole 900A, Core 78R-2, 9-11 cm to 78R-1, 128-131 cm. Marker forms are *Hormosina ovulum* and *H. ovuloides*, which often occur as fragments and may then be included in *Hyperammina* (fragments) in the species distribution tables. The Paleocene assemblages are generally very poor, with low abundance and diversity. The position of the last occurrence of *H. ovuloides* with respect to the *Glomospira* biofacies agrees well with biostratigraphic data from ODP Site 647 in the Labrador Sea (Kaminski et al., 1989).

### Early Eocene Glomospira Event

In Holes 897C, 897D, and 900A a distinct faunal change is detectable in Samples 149-897C-60R-3, 30-35 cm, 149-897D-4R-2, 30-32 cm, and 149-900A-76R-2, 42-44 cm (Fig. 2). In all these samples various species of *Glomospira* (mainly *Glomospira charoides*) suddenly make up the most significant portion of the total benthic foraminiferal assemblage. This sudden increase in *Glomospira* is a widespread benthic foraminiferal event in the lower Eocene of the Western Tethys and North Atlantic (Kaminski, 1988).

Kaminski et al. (1989) recognized a *Glomospira* facies at the Ypresian/Lutetian (lower-middle Eocene) boundary at ODP Site 647 in the Southern Labrador Sea. Characteristic species of this assemblage consist of *Glomospira irregularis, Glomospira charoides, Ammodiscus cretaceus, Karrerulina coniformis, Trochamminoides spp.* and *Haplophragmoides walteri.* Similar assemblages have been found in the lower Eocene of the Moroccan flysch belt (Morgiel and Olszewska, 1982), and the Carpathians (Jurkiewicz, 1967; Morgiel and Olszewska, 1981, 1982). Winkler (1984) discovered a level with common *Glomospira* in the lower Eocene in the Schlierenflysch of the Alpine Flysch Zone of Switzerland. At Site 643 in the Norwegian Sea, the total range of *Glomospira* spp. is confined to the lower Eocene (Kaminski et al., 1990). Recently, a distinct *Glomospira* acme was observed within the Numidian Flysch nappes of the Gibraltar Seaway and correlated with the early Eocene (Kaminski et al., in press). In the Tellien Units in northern Morocco, there is a lower Eocene biosiliceous lithofacies, which may correlate with the *Glomospira* Event in the Numidian Flysch. Immediately above these biosiliceous sediments are middle Eocene claystones with *Reticulophragmgium amplectens* (Kuhnt, 1987). The *Glomospira* Event is consequently of biostratigraphic use in the North Atlantic and west-southwest.
ern Tethys, bearing in mind that it may be diachronous from east to west.

**Eocene Autochthonous DWAF and Redeposited Bolivina Assemblages**

The deep-water benthic foraminiferal marker species *Reticulophragmium amplectens* is encountered abundantly in Sample 149-897D-2R-2, 48-50 cm, in Cores 149-899B-13R and 14R, and Sample 149-900A-70R-2, 57-59 cm (Fig. 2).

Deep-water sediments containing large proportions of *Reticulophragmium amplectens* are typically referred to the middle Eocene in the Polish Carpathians. In Poland, its first occurrence was reported in the lower Eocene (Zone NP12) by Olszewska and Smagowicz (1977). Its total range in the Polish Carpathians was given as lower to upper Eocene by Morgiel and Olszewska (1981), and its partial range and optimum occurrence characterizes the middle Eocene *Cyclammina amplectens* Zone of Geroch and Nowak (1984). In the Austrian Alps, *R. amplectens* was reported from the lower to lower middle Eocene Buntmergelserie (Rögl et al., 1986). At Site 647 in the southern Labrador Sea, its first occurrence is in the upper part of Zone NP11, and the greatest abundance of *R. amplectens* in Hole 647A occurs in the middle Eocene. Also, in the Gibraltar Seaway, a middle Eocene biofacies with abundant *Reticulophragmium amplectens* directly overlies an early Eocene *Glomospira* biofacies (Kaminski et al., in press). This is exactly the pattern we observe in Hole 897D.

Redeposited benthic foraminiferal assemblages dominate in Hole 897C above Core 60R, in Hole 897D, Cores 1R to 3R, in Hole 899B, above Core 13R and in Hole 900A, from Core 76R throughout the entire Eocene (i.e., to Core 51R). Within these intervals a distinct alternation of predominant light, fine-grained, carbonate-rich turbiditic layers and darker brown, hemipelagic clay layers is observed. Because of the sampling strategy on board, most samples from this interval have been taken from the redeposited carbonate-rich layers. Consequently, our initial study of benthic foraminifers is based only on a few exceptional samples of the autochthonous hemipelagic material. The redeposited layers contain an abundant fauna of tiny (probably size-sorted) calcareous benthic foraminifers, which are dominated by bolivinids and occasionally contain uvigerinids and indeterminable small spiral rotaliids. As a result of the probable size sorting during transport, it is impossible to determine the original assemblage composition, and we only roughly checked these redeposited faunas. However, the dominance of small infaunal morphotypes such as bolivinids may indicate that these faunas originate from areas with substantial organic carbon flux rates at the outer shelf or upper slope.
Figure 2. Correlation of Holes 897C, 897D, 899B, and 900A using autochthonous benthic foraminifera. The last occurrence (LO) of the *Hormosina ovuloides* group corresponds to the Paleocene/Eocene boundary, the first occurrence (FO) of *Reticulophragmium amplectens* is regarded as the lower/middle Eocene boundary.
PALEOENVIRONMENT

The species composition of the agglutinated foraminiferal fauna of all hemipelagic Paleogene samples studied is comparable to coeval sub-CCD faunas within the Tethys and North Atlantic basins (Kuhnt and Kaminski, 1990). Only a few samples (e.g., 149-897D-2R-2, 48-50 cm and 149-899B-14R-CC) contain autochthonous calcareous benthic foraminifers. These samples document a depositional environment above the CCD but well below the lysocline for planktonic foraminifers. Little differences in taxonomic composition can be seen between the four sites studied. Only the genus Pararotochrinnminoides seems to be more abundant at the more distal Sites 897 and 899 than at Site 900, which is closer to the continent. Overall, the samples available, with their low abundance and poor preservation of most agglutinated foraminifers, do not allow discrimination of major differences in benthic biofacies within each site.

Rough paleobathymetry estimates for the individual holes follow.

**Hole 897C**

Hole 897C, Cores 60-61 (upper Paleocene to lower Eocene) were deposited below the CCD (deeper than 4200 m according to the CCD depth reconstruction in the Atlantic ocean by Jansa et al., 1979).

**Hole 897D**

Hole 897D, Cores 1R to 3R (middle Eocene) were deposited in a deep-water (abyssal) environment, but contain large numbers of reworked/redeposited shallow-water benthic foraminifers (e.g., bolivinids, uvigerinids) in most samples, undoubtedly samples from turbidite layers.

The best autochthonous fauna is observed in Sample 149-897D-2R-2, 48-50 cm, with the following common deep-water agglutinated foraminifers (ranked by abundance): (1) Reticulophragmium amplectens, (2) Rhabdammina fragments, (3) Glomospira charoides, and (4) Recurvoides sp. Calcareous forms are Nuttallides triumphi, osangulariis and a few compressed and corroded Eocene planktonic foraminifers. This fauna was recovered from a hemipelagic layer, indicating a depositional environment below the foraminifer lysocline and close to the CCD.

Sample 149-897D-3R-CC contains a poor deep-water agglutinated assemblage and rare reworked Cretaceous planktonic (including the late Albian marker Planomalina baxteri) and benthic foraminifers.

Hole 897D, Cores 4R and 5R (upper Paleocene to lower Eocene) contain abyssal agglutinated foraminiferal assemblages indicating deposition well below the CCD. Characteristic species are, in the order of their abundance: (1) Glomospira charoides, (2) Karrerulina coniformis and K. conversa, (3) Recurvoides sp., and (4) Rhabdammina fragments.

A major hiatus probably occurs between Cores 897D-5R and 897D-6R. Hole 897D, Cores 6R to 10R, contains calcareous benthic foraminiferal assemblages with large numbers of trocholinas and other calcareous benthic foraminifers, as well as abundant small planktonic foraminifers (Hedbergella spp.). These Aptian assemblages indicate shallow-water conditions (shelf to upper slope) but may be redeposited.

**Hole 899B**

Hole 899B, Cores 13R and 14R (lower to middle Eocene) contain exclusively agglutinated autochthonous foraminiferal assemblages, which indicate abyssal water depth well below the CCD (deeper than 4000-4500 m). Sedimentation above Core 13 mainly consists of calcareous turbidites; we only have samples from these intervals, which contain redeposited foraminifers.

**Hole 899A**

Hole 899A, Cores 70R-76R (Eocene) and 78R (Paleocene) contain autochthonous assemblages from hemipelagic claystones, that consist exclusively of agglutinated foraminifers indicating an abyssal depositional environment below CCD (deeper than ~4200 m).

Samples from the Eocene above Core 70 (Cores 52-70) were all from calcareous turbidites and the foraminifers were redeposited from shallower depths.

**COMPARISON TO ADJACENT AREAS**

In the abyssal central North Atlantic, Paleocene claystones are extremely poor in agglutinated foraminifers (Moullade et al., 1988; Kuhnt and Kaminski, 1990). Assemblages consist generally of a few long-ranging forms, which do not allow any biostratigraphic zonation. Close to the Paleocene/Eocene boundary there is a major change in lithology toward bioclastic sediments such as radiolarian oozes. Normal deep-sea claystones with diverse agglutinated foraminiferal assemblages are so far only known from marginal seas such as the North Sea (Charnock and Jones, 1990), the Labrador and Norwegian Seas (Kaminski et al. 1990), the Basque Basin (Hillebrandt, 1965; Kaminski, 1988), the Senegal Atlantic coastal basin (De Klasz et al., 1988), and Trinidad (Kaminski et al. 1988).

The Paleocene to Eocene benthic foraminiferal biostratigraphy of the North Sea region has been calibrated to the standard chronostратigraphy by the use of dinoflagellate zones (Charnock and Jones, 1990). Kaminski (1988) calibrated the stratigraphic ranges of DWAF to planktonic foraminifer zones in the Zumaya section of northern Spain. The DWAF biostratigraphy at Site 647 in the southern Labrador Sea is calibrated by the use of standard nannofossil zones (Kaminski, et al. 1989), but this record only extends upward from lower Eocene nannofossil Zone NP11. The biostratigraphy of DWAF in Trinidad was calibrated to the standard, low-latitude planktonic foraminiferzonation by Kaminski et al. (1988).

The Paleogene DWAF biostratigraphy for the western Tethys is based on the zonation of Geroch and Nowak (1984) from the Silesian flysch basin in Poland. Because these sediments are largely noncalcareous, direct calibration to the standard planktonic zones is not possible, and benthic foraminiferal assemblages were determined based largely on their superposition. However, the Geroch and Nowak zonation has proven useful in other Tethyan basins such as the Northern Apennines, Italy (Morloti and Kuhnt, 1992) and the Numidian Talaa Lakrah flysch basin, Morocco (Kaminski et al., in press).

Ranges of stratigraphically significant marker species of Paleogene deep-water agglutinated foraminifers are compiled in Figure 3. Because of the poor preservation and comparatively low-resolution sampling (see Tables 1-4), we are not yet able to give definite ranges for these marker species on the Iberia Abyssal Plain; however, the succession of their occurrences closely resembles Tethyan (i.e., Polish External Carpathian) zonations (Geroch and Nowak, 1984).

**CONCLUSION**

Cretaceous to Paleogene deep-water benthic foraminifers from ODP Sites 897, 899, and 900, Leg 149, Iberia Abyssal Plain show striking similarities in species composition and superposition of assemblages to Tethyan (Alpine Carpathian and Western Mediterranean) occurrences. Although in the present stage of our work no definition of zonal boundaries is possible, the occurrences of the marker species Gavelinella flandrini, Dorothia ouachensis (co-occurring in the Aptian), Rzehakina epigona and Hormoxina ovaloides (Paleocene), Karrerulina coniformis, Reophax elongatus, and Reticulophragmium amplectens (Eocene) allow an initial stratigraphic subdi-
vision of these intervals based on autochthonous microfossils from hemipelagic layers. More detailed samples of the hemipelagic claystones in Holes 899B and 900A will undoubtedly enable a more precise definition of benthic zonal boundaries and a calibration to planktonic data from the turbidite material. The similarities in taxonomic composition and stratigraphic succession of these benthic assemblages to Tethyan assemblages suggest a close deep-water mass connection to the Western Tethys, at least during the Paleogene, which most probably occurred through a widely opened Gibraltar Seaway between the North African and Iberian margins, with an outflow of Tethyan (saline?) deep water into the North Atlantic.

ACKNOWLEDGMENTS

We thank Drs. Michael A. Kaminski and Michel Moullade for their helpful discussion and for their reviews of the manuscript. Samples were prepared by Cloe Younger at Dalhousie University and Brigitte Salomon at the University of Kiel. Specimens were photographed using the Camscan 44 scanning electron microscope at Kiel; D. Lein and U. Schuldt are thanked for photographic work. WK's study of the biogeography of Cretaceous and Paleogene benthic foraminifers in the Equatorial and Central Atlantic is supported by the Deutsche Forschungsgemeinschaft (grant Ku 649/2-1).

REFERENCES


Figure 3. Ranges of selected Paleogene DWAF species from the Polish Carpathians (Geroch and Nowak, 1984), the Basque Basin of northern Spain (Kaminski, 1988), Trinidad (Kaminski et al., 1988), and the North Sea (Charnock and Jones, 1990). Calibration to planktonic zones applies only to Trinidad and Zumaya (modified from Kaminski et al., in press). Correlation to the observed occurrences of the marker species at Sites 897, 899, and 900 is mainly based on the observed superposition of the DWAF assemblages. The correlation is still tentative because of the comparatively low sampling resolution.
TAXONOMIC APPENDIX

Ammodiscus cretaceus (Reuss, 1845)
Operculina cretacea Reuss, 1845, p. 35, pl. 13, figs. 64, 65.
Ammodiscus cretaceus (Reuss) Krasheninnikov and Pflaumann, 1978, p. 569, pl. 2, fig. 7; Hemleben and Tröster, 1984, p. 517, pl. 1, fig. 17; Moullade et al., 1988, p. 363, pl. 1, fig. 7.

Ammodiscus spp.
Remarks: We lump fragments of planispirally coiled ammodiscids (Ammodiscus and outer whorls of Glomospirella) under this name.

Ammodiscus cf. pennyi Cushman and Jarvis, 1928
cf. Ammodiscus pennyi Cushman and Jarvis, 1928, p. 87, pl. 12, figs. 4-5
cf. Ammodiscus pennyi Cushman and Jarvis; Kaminski et al., 1988, p. 184-185, pl. 3, figs. 9-10.
Ammodiscus cf. pennyi Cushman and Jarvis; Kuhnt and Moullade, 1991, pl. 4, fig. B.
Remarks: Mainly fragments of ammodiscids with a rough surface and often slightly irregular planispiral coiling.

Ammodiscus cf. peruvianus Berry, 1928
Ammodiscus peruvianus Berry, 1928, p. 342, pl. 27.

Ammodiscus tenuissimus Grzybowski, 1898
Ammodiscus tenuissimus Grzybowski, 1898, p. 282, pl. 10, fig. 35.
Ammodiscus planus Loeblich; Kaminski et al., 1988, p. 185, pl. 3, fig. 13.
Ammodiscus tenuissimus Grzybowski; Kaminski and Geroch, 1993, p. 253, pl. 5, figs. 1-3b.
Aragonia velascoensis Cushman, 1925
(Pl. 2, Fig. 13)
Textularia velascoensis Cushman, 1925, p. 18, pl. 3, fig. 1.
Aragonia velascoensis (Cushman) Wicher, 1956, p. 107, pl. 13, figs. 9-14.
Aschemocella carpathica (Neagu, 1964)
Aschemonella carpathica Neagu, p. 1964, p. 582, text.-fig. 1/5-8, 2/2-4, 3/1-3, 4/166, pl. 27, fig. 1-3.
Aschemocella carpathica (Neagu) Kuhnt and Kaminski, 1990, p. 464, pl. 2, figs. a-c; Kuhnt and Moullade, 1991, pl. 1, fig. A.

Aschemocella grandis (Grzybowski, 1898)

Bolivina spp.
Remarks: Bolivinas are the most common elements in redeposited assemblages within the upper part of the Eocene sequence. We did not attempt to determine these forms at the species level.

Conotrochammina whangaia Finley, 1940
Conotrochammina whangaia Finley, 1940, p. 448, pl. 62, figs. 1-2.
Conotrochammina whangaia Finley; Kaminski et al., 1988, p. 193, pl. 7, figs. 19-20b.

Nothia excelsa (Grzybowski, 1898)
Dendrophrya excelsa Grzybowski, 1898, p. 272, pl. 10, figs. 1-4.

Dorohia ouachensis (Sigal, 1952)

Marssonella ouachensis. Sigal, 1952, p. 19, fig. 16.
Dorohia ouachensis (Sigal) Moullade, 1984, p. 448-450, pl. 7, fig. 11, pl. 9, figs. 1-11, pl. 10, figs. 1-9.
Remarks: We observed only one single specimen of this Hauterivia-Aptian stratigraphic marker in Sample 149-897C-62R-4, 58-60 cm.

Gaudryina spp.
Remarks: A few badly preserved specimens of this calcareous-cement-agglutinating genus have not been determined on the species level.

Glomospira charoides (Jones and Parker, 1860)
(Pl. 1, Figs. 1-2)
Trocchammina squamata Jones and Parker var. charoides Jones and Parker, 1860, p. 304.
Glomospira charoides (Jones and Parker) Berggren and Kaminski, 1990, pl. 1, fig. 1 (lectotype).

Glomospira gordalis (Jones and Parker, 1860)
Trocchammina squamata Jones and Parker var. gordalis Jones and Parker, 1860, p. 304.
Glomospira gordalis (Jones and Parker) Berggren and Kaminski, 1990, pl. 1, fig. 1 (lectotype).

Glomospira irregularis (Grzybowski, 1898)
Ammodiscus irregularis Grzybowski, 1898, p. 285, pl. 11, figs. 2, 3.
Glomospira irregularis (Grzybowski) Kaminski and Geroch, 1993, p. 256, pl. 6, figs. 1, 6-8.

Glomospira serpens (Grzybowski, 1898)
Ammodiscus serpens Grzybowski, 1898, p. 285, pl. 10, figs. 31-33.
Glomospira serpens (Grzybowski) Kaminski and Geroch, 1993, p. 256, pl. 6, figs. 2-5.

Haplophragmoides walteri (Grzybowski, 1898)
(Pl. 2, Fig. 6, 7)
Trocchammina walteri Grzybowski, 1898, p. 290, pl. 11, fig. 31.
Haplophragmoides walteri (Grzybowski) Kaminski and Geroch, 1993, p. 263, pl. 10, figs. 3-7.

Haplophragmoides spp.
Remarks: Small, compressed specimens of the genus Haplophragmoides that could not be determined on the species level.

Hormosina cf. crassa Geroch, 1966
(Pl. 1, Fig. 9)
cf. Hormosina ovalum crassa Geroch, 1966, p. 438, figs. 6 (19, 21-26), 7 (21-23).
Hormosina ovalum crassa Geroch; Hemleben and Tröster, 1984, p. 520, pl. 2, figs. 8, 9.
Hyperammina cf. dilata Grzybowski; Hemleben and Tröster, 1984, p. 520, pl. 1, fig. 11.
Hormosina crassa Geroch; Moullade et al., 1988, p. 365, pl. 2, fig. 4-6; Kuhnt, 1990, p. 314, pl. 2, fig. 5.
Hormosina cf. crassa Geroch; Kuhnt and Kaminski, 1990, p. 472, pl. 21, fig. 0

Hormosina ovaloides (Grzybowski, 1901)
(Pl. 1, Figs. 7, 8)
**Remarks:** We lumped smooth tubular fragments under this name.

**Remarks:** Small size and poor preservation of these forms allowed only in rare exceptions to tentatively assign them to the species Recurvoides cf. imperfectus Hanzlíková, Recurvoides nucleus (Grzybowski) and Recurvoides ex gr. gerochi Pflaumann.

**Remarks:** We included poorly preserved forms which superficially resemble **Recuvoides** in this species.

**Remarks:** We lumped poorly preserved specimens and fragments of **Paratrochamminoides** under this genus name.

**Remarks:** We did not determine individual species of this genus.

**Remarks:** We lumped poorly preserved specimens and fragments of this genus.
Saccammina complanata (Franke) Krasheninnikov, 1974, p. 644, pl. 7, figs. 10a-b.
Saccammina placenta (Grzybowski) Krasheninnikov and Pflaumann, 1977, p. 568, pl. 1, fig. 16.
Remarks: Differs from the true Saccammina placenta in its smaller size and more coarsely agglutinated wall.

Spiroplectammina subhaeringensis (Grzybowski, 1896)
(Pl. 2, Fig. 12)

Textularia subhaeringensis Grzybowski, 1896, p. 285, pl. 9, fig. 16.
Spiroplectammina subhaeringensis (Grzybowski) Hemleben and Tröster, 1984, p. 522, pl. 3, figs. 21-23.

Subreophax scalaris (Grzybowski, 1896)

Reophax guttifera Brady var. scalaris Grzybowski, 1896, p. 277, pl. 8, fig. 26.
Reophax scalaris Grzybowski; Hemleben and Tröster, 1984, p. 521, pl. 2, figs. 10-11.
Subreophax scalaris (Grzybowski) Kaminski et al., 1988, p. 187, pl. 2, figs. 16-17; Kuhnt, 1990, p. 326, pl. 3, figs. 4-5.

Subreophax splendidus (Grzybowski, 1898)
(Pl. 1, Fig. 5)

Reophax splendidus Grzybowski, 1898, p. 278, pl. 10, fig. 16.
Subreophax splendidus (Grzybowski) Kaminski and Geroch, 1993, p. 251, pl. 3, figs. 11-12.

Trochammina altiformis Cushman and Renz, 1946

Trochammina globigeriniformis (Parker and Jones) var. altiformis Cushman and Renz, 1946, p. 24, pl. 3, figs. 7-11.

Trochammina globigeriniformis altiformis Cushman and Renz; Krasheninnikov, 1974, p. 641, pl. 6, figs. 4a-c, 5a.

Trochammina altiformis Cushman and Renz; Moullade et al., 1988, p. 366-367, pl. 8, figs. 1-3.

Remarks: We lumped all compressed trochaminids under this name.

Trochamminoides dubius (Grzybowski, 1901)

Ammodiscus dubius Grzybowski, 1901, p. 274, pl. 8, figs. 12, 14.

Trochamminoides dubius (Grzybowski) Neagu, 1970, p. 38, pl. 2, fig. 20; Kaminski et al., 1988, p. 191, pl. 4, figs. 16-17; Kuhnt, 1990, p. 326, pl. 5, fig. 8.
Remarks: In the species charts we included this species in Trochamminoides spp.

Trochamminoides proteus (Karrer, 1866)

Trochammina proteus Karrer, 1866, pl. 1, fig. 8.

Trochamminoides proteus (Karrer) White, 1928b, p. 308, pl. 42, fig. 2; Samuel, 1977, p. 46-47, pl. 5, fig. 5a-b; Kaminski et al., 1988, p. 192, pl. 4, fig. 20; Kaminski and Geroch, 1993, p. 275, pl. 15, figs. 9-12.
Remarks: In the species charts we included this species in Trochamminoides spp.

Trochamminoides subcoronatus (Grzybowski, 1896)

Trochammina subcoronata Grzybowski, 1896, p. 283-284, pl. 9, fig. 3a-c.

Trochamminoides subcoronatus (Grzybowski) Kaminski et al., 1988, p. 192, pl. 4, fig. 19.
Remarks: In the species charts we included this species in Trochamminoides spp.

Uvigerina spp.

Remarks: First uvigerinids occur in redeposited assemblages within the upper part of the Eocene sequence. We did not attempt to determine these forms to the species level.