Whitmarsh, R.B., Sawyer, D.S., Klaus, A., and Masson, D.G. (Eds.), 1996
Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 149

8. CRETACEOUS TO PALEOGENE BENTHIC FORAMINIFERS FROM THE IBERIA ABYSSAL PLAIN[1]

Wolfgang Kuhnt[2] and Eric S. Collins[3]

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.

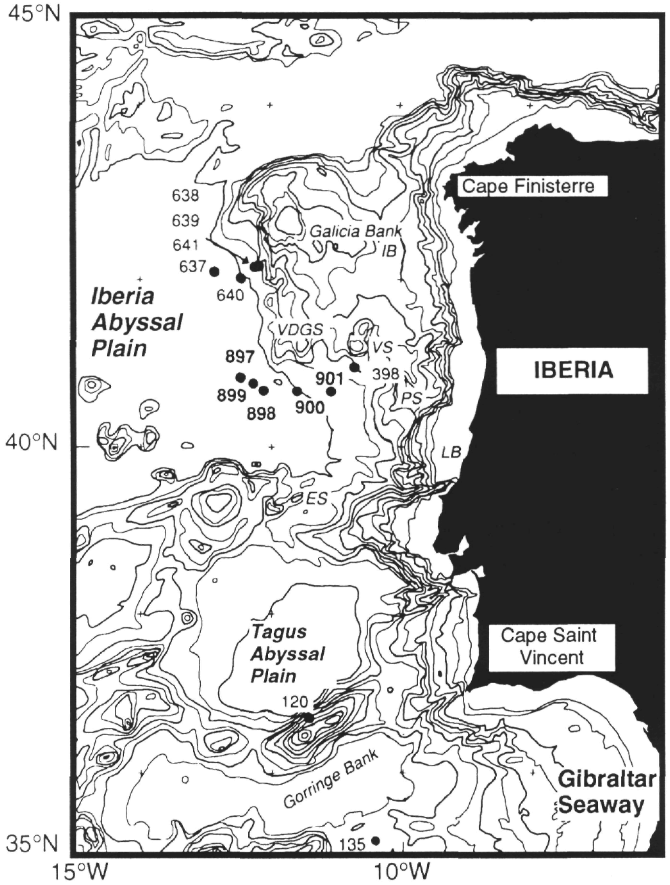

Figure 1. Location of Leg 149 sites and adjacent ODP and DSDP sites along the Iberia Margin. VDGS = Vasco da Gama Seamount; VS = Vigo Seamount; IB = Interior Basin; LB = Lusitanian Basin; ES = Estremadura Spur; PS = Porto Seamount.

---

[1] Whitmarsh, R.B., Sawyer, D.S., Klaus, A., and Masson, D.G. (Eds.), 1996. *Proc. ODP, Sci. Results,* 149: College Station, TX (Ocean Drilling Program).

[2] Geologisch-Palaontologisches Institut, Christian-Albrechts-Universitat, Olshausenstrasse 40, D-24118 Kiel, Federal Republic of Germany. wk@zaphod.gpi.uni-kiel.de

[3] Centre for Marine Geology, Dalhousie University, Halifax, Nova Scotia B3H 3J5, Canada.

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

	lower Eocene						Paleocene						
Core, section:	60R-1	60R-1	60R-2	60R-2	60R-3	60R-3	61R-1	61R-1	61R-2	61R-2	61R-3	61R-3	61R-3
Interval (cm):	41–43	125–127	43–45	116–118	33–35	60–62	50–52	113–115	47–49	129–131	1–3	68–70	135–137
Sample volume (cm^3):	10	10	11	15	11	11	10	13	10	15	13	14	12
Ammodiscus sp. (rough)								1					
Aschemocella carpathica, incl. fragments							2	20					
Aschemocella grandis								2					
Dendrophrya excelsa						1	2						
Glomospira charoides	10	11	23		26	1		1	2			3	
Glomospira gordialis							1				1		
Glomospira irregularis		1											
Haplophragmoides walteri					1	1							
Hormosina crassa	1												
Hyperammina sp. fragments							2	1		1	1	1	3
Karrerulina coniformis					1						1		
Paratrochamminoides cf. *corpulentus*								1					
Paratrochamminoides olszewskii				1									
Paratrochamminoides spp., incl. fragments					15	6	14	5	3		1		
Plectorecurvoides? sp.			1										
Praecystammina? sp.								1					
Recurvoides spp.	1	5	5		1	4	1	1	1	3	1		
Rhabdammina fragments	1	1	2		18	31	35	43	6	4	17		
Rzehakina epigona													1
Subreophax scalaris fragments				2	4	5		3		1			
Subreophax splendidus							1						
Trochammina altiformis					1								
Trochammina sp. (coarse)								4					
Trochammina sp. (small)													1
tubular aggl. fragments					1	6	19	42	7	20	8	1	
indet. aggl. fragments	5	1			16		2	30		4	7	4	
ichthyoliths	22	17	22	8	18	12	13	29	21	23	33	5	5

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

	M.E.	lower Eocene							Paleocene			
Core, section:	2R-2	2R-CC	3R-4	3-CC	4R-1	4R-1	4R-2	4R-2	4R-CC	5R-1	5R-2	5R-CC
Interval (cm):	48–50		18–20		54–56	118–120	30–32	80–82		28–30	93–95	
Sample volume (cm^3):	10	50	10	50	15	10	10	10	50	10	15	10
Ammodiscus cretaceus								1	4			
Dendrophrya excelsa				28			2					33
Glomospira charoides	11			3	52	16	36	8	4	6	1	
Glomospira gordialis					1	1	1	1	1			
Glomospira irregularis						4						
Glomospira serpens					1							
Hormosina ovuloides?									2		2	5
Hyperammina subdiscreta	2				3	20						
Karrerulina coniformis					5							
Paratrochamminoides						2			3			
Recurvoides spp.	5			2	29	3	2	5	1			
Remesella varians?	1											
Reticulophragmium amplectens	58											
Rhabdammina fragments	21			1	7	25	1		7	3		
Saccammina cf. *placenta*									1			
Spiroplectammina subhaeringensis		1										
tubular aggl. fragments					2				5			
indet. aggl. fragments	22				5		5		10			4
smooth tubular fragments								2				
Nuttallides truempyi	11											
Osangularia spp.	5											
Bolivina		79	42									
Uvigerina		1	3									
reworked 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 lenticulinas. 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-

Table 3. Distribution of autochthonous benthic foraminifers in the Cretaceous and Paleogene of Holes 899B.

	middle upper Eocene									
Core, section:	13R-2	13R-5	13R-5	13R-6	13R-6	13-CC	14R-1	14R-2	14R-2	14R-3
Interval (cm):	117-119	32–35	140–143	46–48	101–104		40–43	22–24	00–103	21–24
Sample volume (cm^3):	17			18		50		16		
Ammodiscus cf. *pennyi*							3			1
Ammodiscus sp.		1								
Ammolagena clavata		2								
Arenobulimina sp.										
Gaudryina sp.										
Glomospira charoides		17	14	4	4	33	4		2	1
Glomospira gordialis			1	1			4	2		
Glomospira irregularis		1			2	4			2	
Haplophragmoides walteri				1		7	2		1	
Haplophragmoides sp.						2				
Hyperammina subdiscreta						4				
Hyperammina fragments								2		
Karrerulina coniformis						2			2	
Paratrochamminoides		2	2		1	2	1		6	1
Recurvoides spp.		3	2			17			2	
Remesella varians										
Reophax elongatus		9	1		1	16	34		9	4
Reticulophragmium amplectens		3	6	1	1		5		1	5
Rhabdammina fragments		14	27	9	2	42	10	9	27	12
Subreophax scalaris		2			1					
indet. tubular aggl.		1		1	2	13				
indet aggl. fragments		40	23	51	10	166	14	30	25	39
autochthonous calcareous benthic foraminifera										
redeposited calcareous foraminifera	xx						x	xx		
radiolaria		x(?)	x(?)							
ichthyoliths		15	9		3		7		18	

Table 3 (continued).

	middle upper Eocene											
Core, section:	14R-4	14R-5	14R-6	14R-CC	15R-1	15R-1	15R-2	15R-2	15R-3	15R-3	15R-4	15R-4
Interval (cm):	30–33	40–43	9–12		40–43	120–124	40–43	120–124	40–43	120–124	61–64	97–100
Sample volume (cm^3):				50								
Ammodiscus cf. *pennyi*												
Ammodiscus sp.												
Ammolagena clavata												
Arenobulimina sp.									1			
Gaudryina sp.				1								
Glomospira charoides	20	11	12	33	6	1			4			
Glomospira gordialis			6									
Glomospira irregularis		1	2	1								
Haplophragmoides walteri				1						1(?)		
Haplophragmoides sp.		1		2								
Hyperammina subdiscreta												
Hyperammina fragments				18								
Karrerulina coniformis												
Paratrochamminoides		5	1	5	3	4			1	5	2	
Recurvoides spp.	1	4		2					1			
Remesella varians				3								
Reophax elongatus	6	19	24	14								
Reticulophragmium amplectens		3	8	1						18		
Rhabdammina fragments	23	78	15	53	2	9	3	4	3	17		
Subreophax scalaris			1									
indet. tubular aggl.												
indet aggl. fragments	21	45	19	113	10	4	14	3	34	1	3	
autochthonous calcareous benthic foraminifera				xx								
redeposited calcareous foraminifera												
radiolaria			x(?)									
ichthyoliths	6	11	9		4	25	10			8	1	2

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. At almost any other site in the North Atlantic and Western Pacific, this low-diversity agglutinated assemblage is typical of latest Maastrichtian and Paleocene assemblages (Moullade et al., 1988; Kuhnt and Moullade, 1991; Wightman and Kuhnt, 1992). The occurrence of fragments of large, thick-walled hyperammins or hormosins with smooth surfaces (*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 Forma-

Table 4. Distribution of autochthonous benthic foraminifers in the Cretaceous and Paleogene of Hole 900A.

	FO *Reticulophragmium amplectens*												
	middle upper Eocene											lower Eocene	
Core, section:	66R-1	66R-2	67R-2	67R-3	68R-1	68R-2	68R-3	69R-1	69R-2	70R-1	70R-2	70R-2	71R-1
Interval (cm):	43–46	43–46	110–113	14–17	40–43	113–116	125–128	84–87	83–86	69–72	57–59	93–96	60–63
Ammodiscus cretaceus													1
Ammodiscus cf. *pennyi*		1										4	
Ammodiscus cf. *peruvianus*													
Ammodiscus tenuissimus							1			1	5		
Ammosphaeroidina sp.									1	2			
Arenobulimina sp.													
Aschemocella carpathica													
Aschemocella grandis													
Conotrochammina whangaia													
Dendrophrya excelsa		1	3	1				1	4	6		1	6
Dorothia? sp.													
Glomospira charoides		4				5	2	1	5	3	44	6	5
Glomospira gordialis		5				7				3	7	4	
Glomospira irregularis		1							1	3			
Glomospira serpens								1	1			1	
Glomospirella sp.									1				
Haplophragmoides walteri								1	3	1(cf.)	1	3	
Haplophragmoides sp.										1			1
Hormosina ovulum-ovuloides													
Hormosina velascoensis													
Hyperammina laevigata													
Hyperammina subdiscreta													
Kalamopsis grzybowskii							1						
Karrerulina coniformis										12	3	2	7
Karrerulina conversa								1		5	3	2	1
Karrerulina horrida													
Lituotuba lituiformis										1			
Paratrochamminoides acervulatus													
Paratrochamminoides spp.								4	8	14		19	11
Recurvoides spp.		10			1	1	1	4	7	30	8	4	9
Reophax spp.												1	
Reticulophragmium amplectens	1(?)					2	3	22	4	1	2		
Rhabdammina fragments		49			8	51	9	12	24	5	58	82	7
Rhizammina fragments										5			
Saccammina placenta													
Saccammina sp.													
Subreophax scalaris										1(?)			
Subreophax pseudoscalaris												3	
Subreophax sp.													
Tolypammina? sp.													
Trochammina spp.													1
Verneuilinoides? sp.													
indet. aggl. fragments		12				1	1	2	4	10	20	4	8
Aragonia velascoensis (redeposited?)													
redeposited calcareous foraminifera				x									
radiolaria		c											
ichthyoliths		4		9	3	13	4	5	9	22		4	8

Note: c = common.

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-1, 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 *Reticulophragmium amplectens* (Kuhnt, 1987). The *Glomospira* Event is consequently of biostratigraphic use in the North Atlantic and west-

Table 4 (continued).

						Glomospira Event									
lower Eocene														Paleocene	
71R-2	72R-1	72R-2	73R-1	74R-1	74R-2	75R-1	75R-2	76R-2	76R-2	77R-1	77R-1	77R-2	77R-2	78R-1	78R-2
112–114	97–99	60–63	55–58	40–43	68–71	105–107	102–105	42–44	68–71	11–14	91–95	20–23	129–132	128–131	9–11
		1													
								2	1					4	
		1						1	1					3	
1			1				3								
1													4		
														1	
														1(?)	
								1							
		10							3			1	66	11	
														1	
		17			2	25	16	62	5	10	6	2	4	5	
		2		1		4		5	1	1				1	1
						3								5	
	2	1											3(?)		
														3	1
														2	2
														1	
		1													
								1							
		2													
		2			1			6							
	2	4			1	4		7	4					7	
							4								
												1			
		4			1		1	1	7			5	3	16	
	2	16		1	1	17	18	28	3	12	16	5		25	
													1		
		19	2		1	5	3	10		4	1	2		14	
														2	
														1	
														2	
									1	3		5			
												1			
		1													
									2						3
														1	
	1	13	2			8	9	9	9			5	15	8	4
															1
x	xx	xx	xx	x	x				x				x(?)		
		11			2		14		6	10		10	2	3	

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 647 A 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.

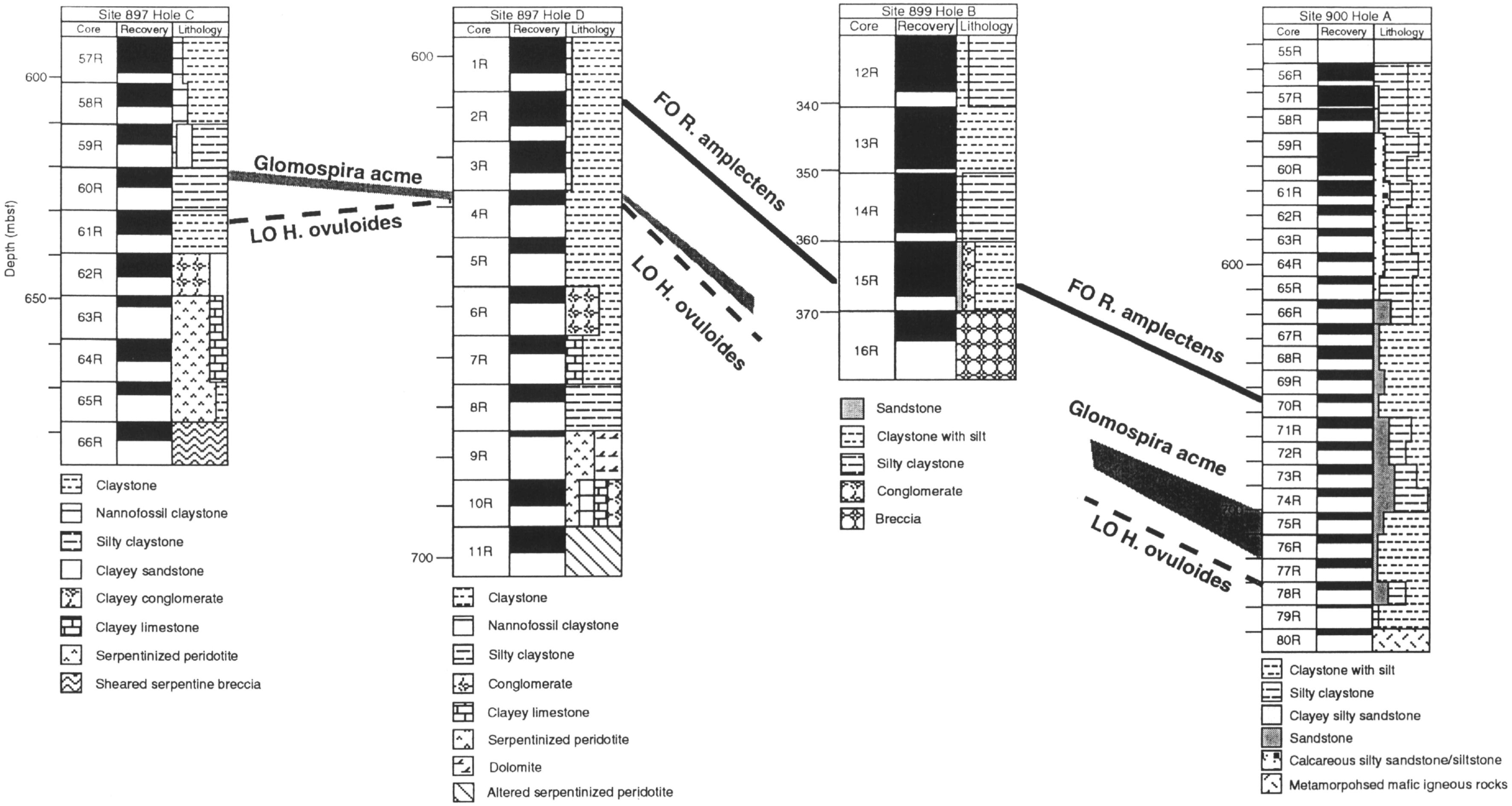

Figure 2. Correlation of Holes 897C, 897D, 899B, and 900A using autochthonous benthic foraminifera. The last occurrence (LO) of the *Hormosina ovuloides* group corresponds to the Paleocene/Eocene boundary, the first occurrence (FO) of *Reticulophragmium amplectens* is regarded as the lower/middle Eocene 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 *Paratrochamminoides* 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 truempyi,* osangulariids 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 buxtorfi*) 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) contains 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 900A

Hole 900A, Cores 70R-76R (Eocene) and 78R (Paleocene) contains 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 biosiliceous 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 chronostratigraphy 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 foraminifer zonation 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 (Morlotti 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 *Hormosina ovuloides* (Paleocene), *Karrerulina coniformis, Reophax elongatus,* and *Reticulophragmium amplectens* (Eocene) allow an initial stratigraphic subdivision 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 turbiditic 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

Berggren, W.A., and Kaminski, M.A., 1990. Abyssal agglutinates: back to basics. *In* Hemleben, C., Kaminski, M.A., Kuhnt, W., and Scott, D.B. (Eds.), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera.* NATO ASI Ser., Ser. C, 327:53-75.

Charnock, M.A., and Jones, R.W., 1990. Agglutinated foraminifera from the Palaeogene of the North Sea. *In* Hemleben, C., Kaminski, M.A., Kuhnt, W., and Scott, D.B. (Eds.), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera:* Dordrecht (Kluwer), 139-244.

De Klasz, I., De Klasz, S., and Ausseil-Badie, J., 1988. Etude systématique des foraminiferes du Danien de la Formation des Madeleines de Dakar (Sénégal). *Cah. Micropaleontol.,* 1987:29-112.

Geroch, S., and Kaminski, M.A., 1993. The morphology and systematics of *Nothia excelsa* (Grzybowski), a deep-water agglutinated foraminifera. *Ann. Soc. Pol. Geol.,* 62:255-265.

Geroch, S., and Nowak, W., 1984. Proposal of zonation for the late Tithonian-Eocene, based upon the arenaceous foraminifera from the outer Carpathians, Poland. *In* Oertli, H.J. (Ed.), *BENTHOS '83: 2nd Int. Symp. Benthic Foraminifera.* Bull. Cent. Rech. Explor.-Prod. Elf-Aquitaine, 6:225-239.

Gradstein, F.M., and Berggren, W.A., 1981. Flysch-type agglutinated foraminifera and the Maestrichtian to Paleogene history of the Labrador and North seas. *Mar. Micropaleontol.,* 6:211-269.

Guerin, S., 1981. Utilisation des foraminiferes planctiques et benthiques dans 1'étude des paleo-environements océaniques au Crétacé moyen: application au matériel des forages D.S.D.P. de 1'Atlantique nord et sud. Comparaison avec la Téthys [thèse]. Univ. de Nice.

Hillebrandt, A.V., 1965. Foraminiferen-Stratigraphie im Alttertiär von Zumaya (Provinz Guipuzcoa, N.W.-Spanien) und ein Vergleich mit anderen Tethys-Gebieten. *Abh. Bayer. Akad. Wiss., Math.-Naturwiss. Kl,* 123:1-62.

Jansa, L.F., Enos, P., Tucholke, B.E., Gradstein, F.M., and Sheridan, R.E., 1979. Mesozoic-cenozoic sedimentary formations of the North American Basin, western North Atlantic. *In* Talwani, M., Hay, W., and Ryan, W.B.F. (Eds.) *Deep Drilling Results in the Atlantic Ocean: Continental Margins and Paleoenvironment.* Am. Geophys. Union, Maurice Ewing Ser., 3:1-57.

Jurkiewicz, H., 1967. Foraminifers in the Sub-Menilitic Paleogene of the Polish Middle Carpathians. *Inst. Geol. Biul.,* 210:5-102.

Kaminski, M.A., 1988. Cenozoic deep-water agglutinated foraminifera in the North Atlantic [Ph.D. thesis]. Woods Hole Oceanogr. Inst./Mass. Inst. of Technol., Joint Program in Oceanogr.

Kaminski, M.A., and Geroch, S., 1993. A revision of foraminiferal species in the Grzybowski Collection. *In* Kaminski, M.A., Geroch, S., and Kaminski, D.G. (Eds.), *The Origins of Applied Micropaleontology: The School of Józef Grzybowski.* Grzybowski Found. Spec. Publ., 1:239-323.

Kaminski, M.A., Gradstein, F.M., and Berggren, W.A., 1989. Paleogene benthic foraminifer biostratigraphy and Paleoecology at Site 647, Southern Labrador Sea. *In* Srivastava, S.P., Arthur, M.A., Clement, B., et al., *Proc. ODP, Sci. Results,* 105: College Station, TX (Ocean Drilling Program), 705-730.

Kaminski, M.A., Gradstein, F.M., Berggren, W.A., Geroch, S., and Beckmann, J.P., 1988. Agglutinated foraminiferal assemblages from Trinidad: taxonomy, stratigraphy and paleobathymetry. *In* Gradstein, F.M., and Rögl, F. (Ed.), *Proc. 2nd Int. Workshop on Agglutinated Foraminifera.* Abh. Geol. Bundensanst. (Austria), 41:155-227.

Kaminski, M.A., Gradstein, F.M., Goll, R.M., and Greig, D., 1990. Biostratigraphy and Paleoecology of deep-water agglutinated foraminifera at ODP Site 643, Norwegian-Greenland Sea. *In* Hemleben, C., et al. (Eds.), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera:* Dordrecht (Kluwer Academic), 345-386.

Kaminski, M.A., Kuhnt, W., and Radley, J.D., in press. Paleocene-Eocene deep water agglutinated foraminifera from the Numidian Flysch (Rif, Northern Morocco). *J. Micropaleontol.*

Kuhnt, W., 1987. Biostratigraphie und Paläoenvironment der externen Kreideserien des westlichen Rif und Betikum—ein Ansatz zur Rekonstruktion der Kreide-Paläogeographie des Gibraltarbogens [Ph.D. dissert.]. Univ. of Tübingen.

————, 1990. Agglutinated foraminifera of western Mediterranean Upper Cretaceous pelagic limestones (Umbrian Apennines, Italy, and betic Cordillera, Southern Spain). *Micropaleontology,* 36:297-330.

Kuhnt, W., Geroch, S., Kaminski, M.A., Moullade, M., and Neagu, T., 1992. Upper Cretaceous abyssal claystones in the North Atlantic and Western Tethys: current status of biostratigraphical correlation using agglutinated foraminifers and palaeoceanographic events. *Cretaceous Res.,* 13:467-478.

Kuhnt, W., and Kaminski, M.A., 1990. Paleoecology of Late Cretaceous to Paleocene deep-water agglutinated foraminifera from the North Atlantic and western Tethys. *In* Hemleben, C., Kaminski, M.A., Kuhnt, W., and Scott, D.B. (Eds.), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera:* Dordrecht (Kluwer), 433-505.

Kuhnt, W., and Moullade, M., 1991. Quantitative analysis of upper Cretaceous abyssal agglutinated foraminiferal distribution in the North Atlantic-paleoceanographic implications. *Rev. Micropaleontol.,* 34:313-349.

Morgiel, J., and Olszewska, B., 1981. Biostratigraphy of the Polish External Carpathians based on agglutinated foraminifera. *Micropaleontology,* 27:1-30.

———, 1982. Uniformity of the Tethyan faunas from Cretaceous and Paleogene as shown by foraminifera from Morocco and Polish Flysch Carpathians. *Cah. Micropaleontol.,* 3:45-53.

Morlotti, E., and Kuhnt, W., 1992. Agglutinated deep-water foraminifera of the Eocene Monte Piano Formation (Northern Apennines, Italy). *J. Foraminiferal Res.,* 22:214-228.

Moullade, M., 1984. Interet des petits foraminiferes benthiques "profonds," pour la biostratigraphie et l'analyse des paleoenvironnements oceaniques Mésozoïques. *In* Oertli, H.J. (Ed.), *BENTHOS '83: Proc. 2nd Int. Symp. Benthic Foraminifera.* Bull. Cent. Rech. Expl.-Prod. Elf-Aquitaine, 6:429-464.

Moullade, M., Kuhnt, W., and Thurow, J., 1988. Agglutinated benthic foraminifers from Upper Cretaceous variegated clays of the North Atlantic Ocean (DSDP Leg 93 and ODP Leg 103). *In* Boillot, G., Winterer, E.L., et al., *Proc. ODP, Sci. Results,* 103: College Station, TX (Ocean Drilling Program), 349-377.

Olszewska, B., and Smagowicz, M., 1977. Porównanie podzialów biostratygraficznych górnej kredy i paleogenu jednostki dukielskiej na podstawie otwornic planktonicznych i nannoplantonu wapiennego', *Przeglad Geol.,* 7:359-363.

Riegraf, W., and Luterbacher, H., 1989. Benthonische Foraminiferen aus der Unterkreide des "Deep Sea Drilling Project" (Leg 1-79). *Geol. Rundsch.,* 78:1063-1120.

Rögl, F., Fuchs, R., Schnabel, W., Seifert, P., and Wagner, L., 1986. Excursion Guide to the 2nd IWAF Excursion in Austria 1986. In *Second Int. Workshop on Agglutinated Foraminifera, Abstracts, Program and Excursion Guide,* 60—92.

Wightman, W.G., and Kuhnt, W., 1992. Biostratigraphy and Paleoecology of Late Cretaceous abyssal agglutinated foraminifers from the western Pacific Ocean (Deep Sea Drilling Project Holes 196A and 198A and Ocean Drilling Program Holes 800A and 801 A). *In* Larson, R.L., Lancelot, Y., et al., *Proc. ODP, Sci. Results,* 129: College Station, TX (Ocean Drilling Program), 247-264.

Winkler, 1984. Rhabdammina-fauna: what relation to turbidites? Evidence from the Gurnigel-Schlieren Flysch. *In* Oertli, H.J. (Ed.), *BENTHOS '83, 2nd Int. Symp. Benthic Foraminifera.* Bull. Cent. Rech. Expl.-Prod. Elf-Aquitaine, 6:611-617.

Date of initial receipt: 7 December 1994
Date of acceptance: 14 August 1995
Ms 149SR-254

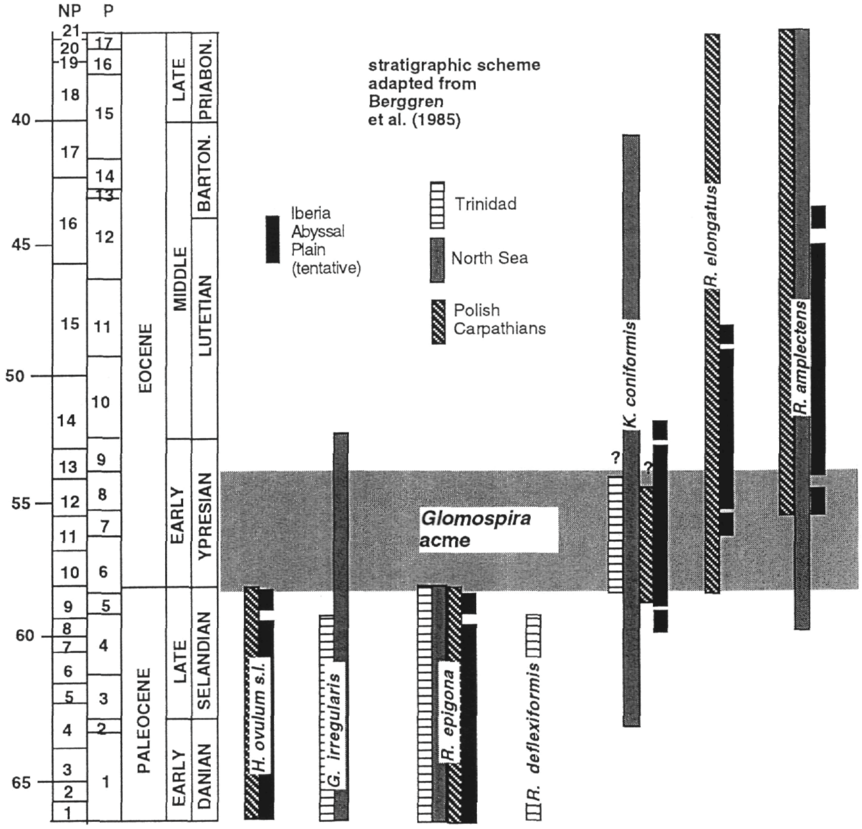

Figure 3. Ranges of selected Paleogene DWAF species from the Polish Carpathians (Geroch and Nowak, 1984), the Basque Basin of northern Spain (Kaminski, 1988), Trinidad (Kaminski et al., 1988), and the North Sea (Charnock and Jones, 1990). Calibration to planktonic zones applies only to Trinidad and Zumaya (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 peruvianus Berry; Gradstein and Berggren, 1981, p. 242-243, pl. 2, figs. 14, 15.

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-e; Kuhnt and Moullade, 1991, pl. 1, fig. A.

Aschemocella grandis (Grzybowski, 1898)

Reophax grandis Grzybowski, p. 1898, p. 277, pl. 10, figs. 13-15.

Aschemocella grandis (Grzybowski) Kuhnt and Kaminski, 1990, p. 464, pl. 2, figs. f-i; Kuhnt and Moullade, 1991, pl. 1, fig. B; Kaminski and Geroch, 1993, p. 249, pl. 2, figs. 8-10.

Bolivina spp.

Remarks: Bolivinids 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 (Grzybowki, 1898)

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

Nothia excelsa (Grzybowski) Geroch and Kaminski, 1993, p. 255-265.

Dorothia ouachensis (Sigal, 1952)

Marssonella ouachensis, Sigal, 1952, p. 19, fig. 16.

Dorothia 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)

Trochammina squamata Jones and Parker var. *charoides* Jones and Parker, 1860, p. 304.

Glomospira charoides (Jones and Parker) Berggren and Kaminski, 1990, pl. 1, fig. 2 (lectotype).

Glomospira glomerata (Grzybowski, 1898)

Ammodiscus glomeratus Grzybowski, 1898, p. 285, pl. 11, fig. 4.

Glomospira glomerata (Grzybowski) Kaminski and Geroch, 1993, p. 257, pi. 6, figs. 9-12.

Glomospira gordialis (Jones and Parker, 1860)

Trochammina squamata Jones and Parker var. *gordialis* Jones and Parker, 1860, p. 304.

Glomospira gordialis (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)

Trochammina 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 ovulum crassa* Geroch, 1966, p. 438, figs. 6 (19, 21-26), 7 (21-23).

Hormosina ovulum crassa Geroch; Hemleben and Tröster, 1984, p. 520, pl. 2, figs. 8, 9.

Hyperammina cf. *dilatata* 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. o

Hormosina ovuloides (Grzybowski, 1901)
(Pl. 1, Figs. 7, 8)

Reophax ovuloides Grzybowski, 1901, p. 268, pl. 7, fig. 3.
Hormosina ovuloides (Grzybowski, 1901) Kaminski et al., 1988, p. 186, pl. 2, figs. 3-4; Moullade et al., 1988, p. 365, pl. 2, figs. 7-8, 10; Kaminski and Geroch, 1993, p. 276, pl. 15, fig. 5a, b.

Hormosina ovulum (Grzybowski, 1896)

Reophax ovulum Grzybowski, 1896, p. 276, pl. 8, figs. 8, 9.
Hormosina ovulum (Grzybowski, 1896) Kaminski et al., 1988, p. 186, pl. 2, fig. 10; Moullade et al., 1988, p. 365, pl. 2, fig. 9.

Hyperammina subdiscreta (Grzybowski, 1896)

Rhabdammina subdiscreta Rzehak; Grzybowski, 1896, p. 275, pl. 8, figs. 5, 6.
Rhabdammina subdiscreta Grzybowski; Hemleben and Tröster, 1984, p. 522, pl. l, figs. 1,2.
Hyperammina subdiscreta (Grzybowski) Moullade et al., 1988, p. 365, pl. 2, fig. 1-3.

Hyperammina spp.

Remarks: We lumped smooth tubular fragments under this name.

Karrerulina coniformis (Grzybowski, 1898)
(Pl. 2, Fig. 4)

Gaudryina coniformis Grzybowski, 1898. p. 39 pl. 12, fig. 7
Karreriella coniformis (Grzybowski) Kaminski et al. 1988, p. 195, pl. 9, figs. 15-16.
Karrerulina coniformis (Grzybowski) Kaminski and Geroch, 1993, p. 269, pl. 13, figs. 1-4.

Karrerulina conversa (Grzybowski, 1901)
(Pl. 2, Fig. 2)

Gaudryina conversa Grzybowski, 1901, p. 285, pl. 7, figs. 15, 16.
Gerochammina conversa (Grzybowski) Kaminski and Geroch, 1993, p. 279, pl. 13, figs. 5-11.

Karrerulina horrida (Mjatliuk, 1970)
(Pl. 2, Fig. 3)

Karreriella horrida Mjatliuk, 1970, p. 114 - 115, pl. 5, fig. 9; pl. 33, figs. 15-16c.

Nuttallides truempyi Nuttall, 1930
(Pl. 2, Fig. 14)

Eponides truempyi Nuttall, 1930, p. 287, pl. 24, figs. 9, 13, 14.
Nuttallides truempyi Nuttall; Van Morkhoven et al., 1986, p. 288-295, pl. 96A, figs. 1-4, pl. 96B, figs. 1-3, pl. 96C, figs. 1-4, pl. 96D, figs. 1-2.

Osangularia spp.

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

Paratrochamminoides acervulatus (Grzybowski, 1896)

Trochammina acervulata Grzybowski, 1896, p. 284, pl. 9, fig. 4 a-c.

Paratrochamminoides cf. *corpulentus* Krasheninnikov, 1973
(Pl. 1, Fig. 11)

Paratrochamminoides corpulentus Krasheninnikov, 1973, p. 212, pl. 3, figs. 3a, b, c.
Paratrochamminoides conglobatus (Brady) Hemleben and Tröster, 1984, p. 520 pl. 3, fig. 9
Paratrochamminoides semipellucidus Krasheninnikov; Hemleben and Tröster, 1984, p. 520, pl. 3, figs. 12-14.
Paratrochamminoides sp. 2, Hemleben and Tröster, 1984, p. 521, pl. 3, fig. 18.
Paratrochamminoides corpulentus Krasheninnikov; Moullade et al., 1988, p. 365, pl. 3, figs. 8, 9.

Paratrochamminoides olszewskii (Grzybowski, 1898)
(Pl. 1, Fig. 10)

Trochammina olszewskii Grzybowski, 1898, p. 286, pl. 11, fig. 6.
Paratrochamminoides olszewskii (Grzybowski) Wightman and Kuhnt, 1992, p. 257, pl. 4, fig. 4.
Paratrochamminoides olszewskii (Grzybowski) Kaminski and Geroch, 1994, p. 257, pl. 7, figs. la-2b.

Paratrochamminoides spp.
(Pl. 1, Fig. 12)

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

Plectorecurvoides spp.
(Pl. 1, Fig. 3)

Remarks: Test biserial, in contrast to the uniserial *Recurvoides.* In many cases a differentiation between these two genera is not possible due to the bad preservation, which does not allow the single chambers to be distinguished, and thus makes identification tentative even to the generic level.

Praecystammina? cf. *globigerinaeformis* Krasheninnikov, 1973

Praecystammina? sp. cf. *globigerinaeformis* Krasheninnikov; Moullade et al., 1988, p. 366, pl. 7, fig. 5.

Recurvoides spp.
(Pl. 1, Fig. 4)

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

Reophax elongatus Grzybowski, 1898
(Pl. 2, Figs. 8, 9, 10, 11)

Reophax elongatus Grzybowski, 1898, p. 279, pl. 10, figs. 19-20; Kaminski and Geroch, 1993, p. 250, pl. 3, figs. 1-5.

Remesella varians (Glaessner, 1937)
(Pl. 2, Fig. 1)

Textulariella? *varians* Glaessner, 1937, p. 366-367, pl. 2, fig. 15.
Matanzia varians (Glaessner) Kaminski et al., 1988, p. 196, pl. 9, fig. 14, pl. 10, fig. 14.

Reticulophragmium amplectens (Grzybowski, 1898)
(Pl. 2, Fig. 5)

Cyclammina amplectens Grzybowski, 1898, p. 292, pl. 12, figs. 1-3.
Reticulophragmium amplectens (Grzybowski) Kaminski and Geroch, 1993, p. 266, pl. 11, figs. 5-7.

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

Rhabdammina cylindrica (Glaessner, 1937)

Rhabdammina cylindrica Glaessner, 1937, p. 354, pl. 1, fig. 1.

Rzehakina epigona (Rzehak, 1895)
(Pl. 1, Fig. 6)

Silicina epigona Rzehak, 1895, p. 214, pi. 6, fig. 1
Rzehakina epigona (Rzehak) Hiltermann, 1974, p. 36-56, pl. 5, figs. 1-44, pl. 6, figs. 1-35,39-41.
Rzehakina epigona epigona (Rzehak) Krasheninnikov and Pflaumann, 1977, p. 569, pl. 3, figs. 5a, b, 11.

Saccammina cf. placenta (Grzybowski, 1898)

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. *scalaria* Grzybowski, 1896, p. 277, pl. 8, fig. 26.

Reophax scalaris Grzybowski; Hemleben and Tröster, 1984, p. 521, pl. 2, figs. 10-11.

Subreophax scalaria (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 splendida 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.

Trochammina spp.

Remarks: We lumped all compressed trochamminids 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.

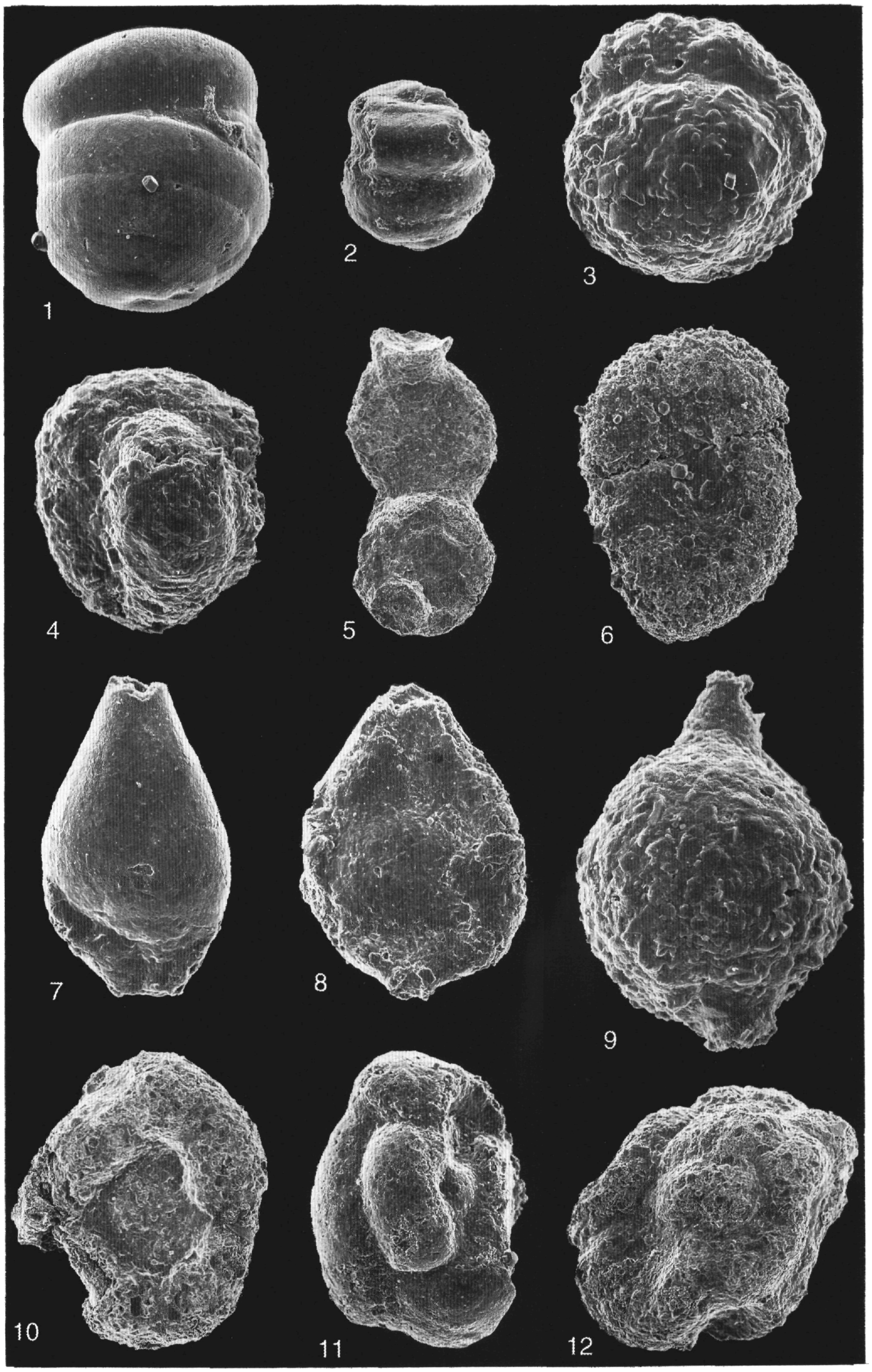

Plate 1. **1.** *Glomospira charoides,* Sample 149-897D-2R-2, 48-50 cm, large specimen of the middle Eocene, ×196; **2.** *Glomospira charoides,* Sample 149-897C-60R-3, 30-35 cm, small specimen of the Lower Eocene "*Glomospira*-Event" ×196; **3.** *Plectorecurvoides*? sp., Sample 149-897C-60R-2, 43-45 cm, ×160; **4.** *Recurvoides* sp., Sample 149-897D-4R-1, 54-56 cm, ×267; **5.** *Subreophax splendidus,* Sample 149-897C-61R-1, 50-52 cm, ×43; **6.** *Rzehakina epigona,* Sample 149-897C-61R-3, 135-137 cm, ×120; **7-8.** *Hormosina ovuloides,* Sample 149-900A-78R-2, 9-11 cm, ×187 (7), ×160 (8); **9.** *Hormosina crassa,* Sample 149-897C-60R-1, 41-43 cm, ×374; **10.** *Paratrochamminoides olszewskii,* Sample 149-897C-60R-2, 116-118 cm, ×64; **11.** *Paratrochamminoides corpulentus,* Sample 149-897C-61R-1, 113-115 cm, ×136; **12.** *Paratrochamminoides* sp., Sample 149-897C-61R-1, 50-52 cm, ×91.

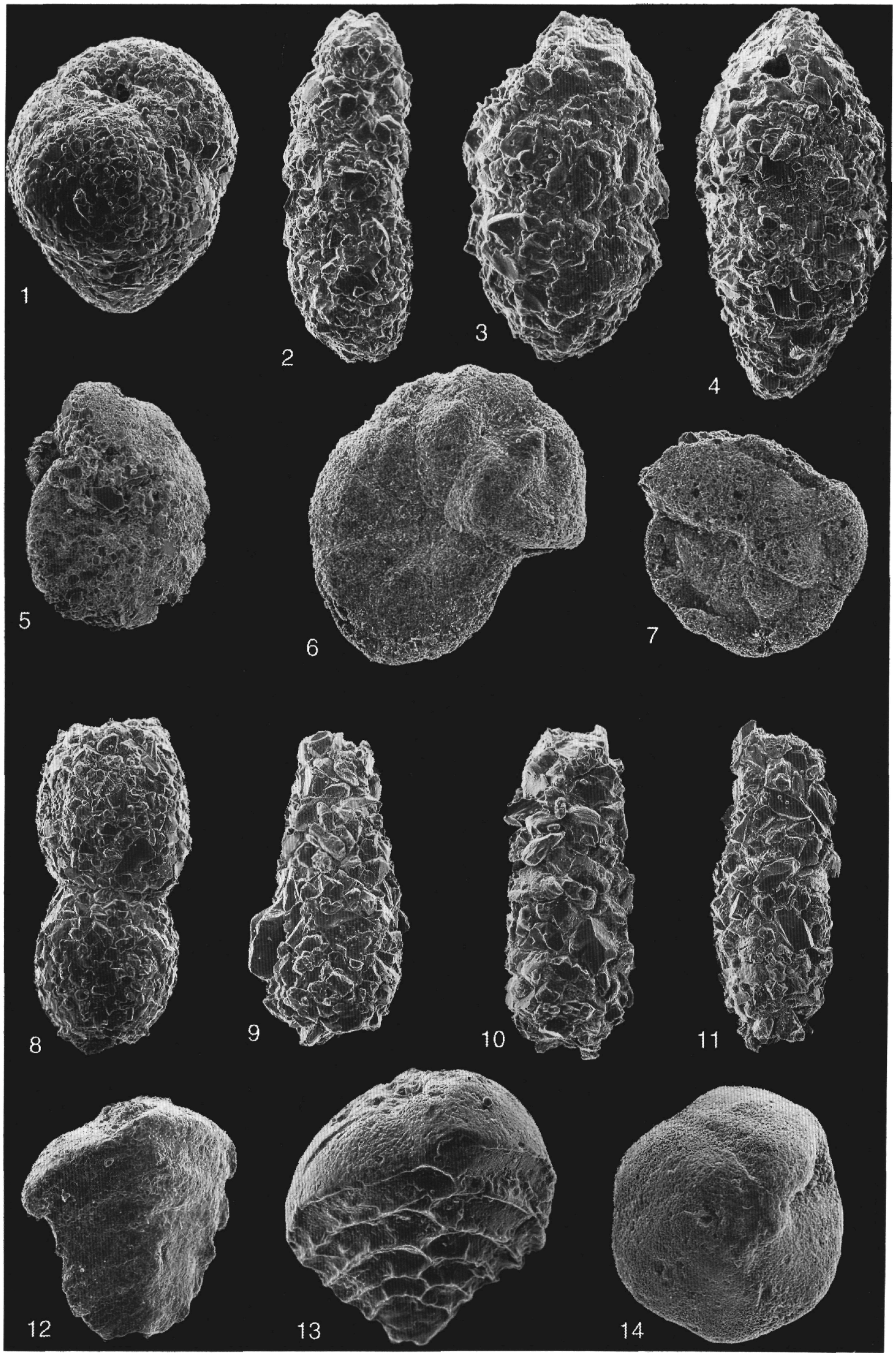

Plate 2. **1.** *Remesella varians,* Sample 149-899B-14CC, ×79; **2.** *Karrerulina conversa,* Sample 149-900A-70R-2, 57-59 cm, ×106; **3.** *Karrerulina horrida,* Sample 149-897D-4R-1, 54-56 cm; ×203; **4.** *Karrerulina coniformis,* Sample 149-900A-70R-2, 57-59 cm, ×79; **5.** *Reticulophragmium amplectens,* Sample 149-897D-2R-2, 48-50 cm, ×4; **6.** *Haplophragmoides walteri,* Sample 149-899B-13CC, ×139; **7.** *Haplophragmoides walteri,* Sample 149-897C-60R-3, 60-62 cm, ×79; **8.** *Reophax elongatus,* Sample 149-899B-14CC, ×58; **9-11.** *Reophax elongatus;* sample 149-899B-13CC, ×58 (9, 11), ×74 (10); **12.** *Spiroplectammina subhaeringensis,* Sample 149-897D-2R-2, 48-50 cm, ×79; **13.** *Aragonia velascoensis;* Sample 149-900A-78R-2, 9-11 cm, ×159; **14.** *Nuttallides truempyi,* Sample 149-897D-2R-2, 48-50 cm, ×159.