

### 13. 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 801A)<sup>1</sup>

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#### ABSTRACT

Abyssal agglutinated foraminifers allow biostratigraphic correlation of Upper Cretaceous brown zeolitic claystones in Deep Sea Drilling Project Holes 196A and 198A and Ocean Drilling Program Holes 800A and 801A. Three agglutinated foraminiferal zones subdivide the strata overlying the Campanian to Cenomanian cherts. The lower zone is characterized by *Hormosina gigantea*, which is a Campanian zonal marker in the North Atlantic Ocean and western Tethys. A major correlation level, which was observed in all holes studied, is based on the acme of evolute *Haplophragmoides* spp. This acme zone was observed in Sample 129-801A-6R-CC, about 9 m above the first occurrence of *H. gigantea* in Sample 129-801A-7R-1, 62–67 cm (approximately middle Campanian). The uppermost zone is characterized by dominant *Paratrochamminoides* spp. and in some instances common *Bolivinopsis parvissimus* (late Campanian to Maestrichtian). The available biostratigraphic data for the Upper Cretaceous of Sites 196, 198, 800, and 801 are correlated with the biochronologic framework of the North Atlantic, western Mediterranean, and Carpathians. Additionally, we use quantitative estimates of the diversity and abundance of agglutinated foraminiferal species to monitor general faunal trends with time in the western Pacific.

#### INTRODUCTION

Deep-water agglutinated foraminifers (DWAF) are often the only existing microfossils in Upper Cretaceous oceanic sediments deposited below the carbonate compensation depth (CCD). The biostratigraphic value of Late Cretaceous DWAF has often been neglected because the assemblage composition of this fossil group is extremely sensitive to environmental conditions. Different agglutinated assemblages and local ranges of DWAF may thus indicate changing environmental conditions rather than coeval biostratigraphic events. However, abyssal agglutinated foraminifers have been used successfully for biostratigraphic correlation of Upper Cretaceous successions on a local to basinwide scale. Krasheninnikov (1974) recognized two different assemblages of abyssal agglutinated foraminifers as useful in determining a stratigraphic succession in the Indian Ocean. Recent studies in the North Atlantic Ocean (Moullade et al., 1988; Kuhnt et al., 1989; Kuhnt and Moullade, 1991) and in the western Mediterranean realm (Kuhnt, 1990) have developed local biostratigraphic zonation of Late Cretaceous DWAF for these basins, which extended the zonation used in the Polish and Rumanian external Carpathians (Geroch and Nowak, 1984; Neagu, 1990; Kuhnt et al., in press).

The main objective of our study is to test the validity of using abyssal agglutinated foraminifers in interbasinal correlation. Material drilled at Ocean Drilling Program (ODP) Sites 800 and 801 supplements the incomplete data from Deep Sea Drilling Project (DSDP) Sites 196 and 198 (Krasheninnikov, 1973) in the eastern Pacific (Figs. 1 and 2). We give a taxonomic overview of 46 species of Late Cretaceous abyssal agglutinated foraminifers from the western Pacific, which completes the initial report from DSDP Sites 196 and 198 (Krasheninnikov, 1973). The evolution of the faunal diversity and density of the Late Cretaceous DWAF shows characteristic trends within the North Atlantic Ocean basin and the western Tethys (Kuhnt and Moullade, 1991). One of the objectives of our study is to compare

the quantitative trends observed in the North Atlantic to those of the western Pacific. This may help us to explore the potential of DWAF for documenting late Mesozoic paleoceanographic changes.

#### GEOLOGICAL SETTING

Holes 800A and 801A are located in the abyssal Pigafetta Basin in the far western part of the Pacific plate, between Japan and Australia and to the east of the Mariana Islands. They were drilled at 21°55.38'N, 152°19.3'E, and 18°38.568'N, 156°21.57'E, in 5686 and 5673 m water depth, respectively. The Pigafetta Basin is surrounded by several groups of islands, atolls, and guyots (Fig. 1) and is about 5680 m deep. Magnetic anomaly lineation mapping indicates that this part of the Pacific plate is underlain by the oldest known ocean crust, of Middle to Early Jurassic age. Accordingly, these sites had already undergone much subsidence during the Late Cretaceous, and Late Cretaceous water depths may have already exceeded 5000 m.

Sites 800 and 801 are characterized by the absence of a substantial accumulation of Cretaceous volcanogenic sediments and a low total sediment thickness over basement on the order of 450–550 m. Sedimentation rates for Upper Cretaceous sediments were about 5.1 m/m.y. at Site 800 and about 2.4 m/m.y. at Site 801.

Hole 196A was drilled on the abyssal floor east of the Izu-Bonin Trench (30°07.0'N, 148°34.5'E) in 6184 m water depth. Basement was not reached at Site 196, but judging from seismic reflection profiles, it is a few hundred meters below the total penetration of 623 m below seafloor (mbsf) and must be of Jurassic age (Heezen, MacGregor, et al., 1973). Hole 198A was drilled on the abyssal plain north of Marcus Island at 25°49.5'N, 154°35.0'E, in a water depth of 5848 m. Mechanical failure of the rig prevented the penetration of basement, which has been estimated to be Early Cretaceous or older (Heezen, MacGregor, et al., 1973).

#### MATERIALS AND METHODS

Two samples of 20 and 30 cm<sup>3</sup>, respectively, were removed from each core section (1.5 m) at approximately equal intervals and supplemented by shipboard samples of 10 and 40 cm<sup>3</sup> (core-catcher samples) from Holes 800A and 801A. The sediment samples were

<sup>1</sup> Larson, R. L., Lancelot, Y., et al., 1992. *Proc. ODP, Sci. Results*, 129: College Station, TX (Ocean Drilling Program).

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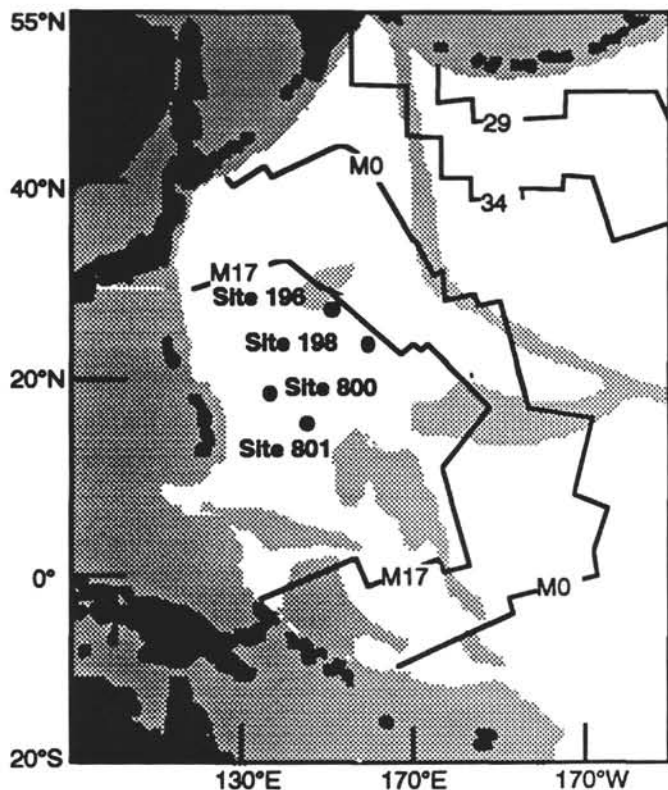


Figure 1. Location of DSDP Sites 196 and 198A and ODP Sites 800 and 801 (modified from Shipboard Scientific Party, 1990a, 1990b). Jagged contours represent magnetic lineations and unshaded areas represent normal Pacific oceanic crust. Shaded areas represent volcanic edifices with thickened crustal sections, as well as the younger areas beyond the Pacific subduction zones.

dried and weighed before processing for the quantitative calculation of faunal abundances. The samples were processed only with pure water or a water-Calgon solution and washed over a 63- $\mu$ m screen. All specimens of agglutinated foraminifers in the fraction larger than 63  $\mu$ m were completely picked and counted. Distribution charts were produced for each site (Tables 1–4). A problem for the quantitative treatment of abyssal agglutinated foraminiferal assemblages is the generally high abundance of fragmented tests. For this study larger fragments of multichambered *Haplophragmoides* and *Paratrochamminoides*, any single chamber of uniserial *Hormosina ovulum* or *H. gigantea*, and any fragment of tubular forms were counted as one individual.

### BIOSTRATIGRAPHY

Turonian-Santonian marker species (i.e., *Bulbobaculites lueckei-problematicus*, *Uvigerinamina jankoi*, and inflated involute *Haplophragmoides* of the *H. pseudokirki* group) are not found in agglutinated foraminiferal assemblages from the western Pacific Ocean. This time interval is represented by chert units that are generally barren of benthic foraminifers.

In Hole 801A four stratigraphically useful benthic events were observed immediately above the top of the chert units:

1. First occurrence of *Bolivinopsis parvissimus* and *Haplophragmoides multicamerus* Acme (maximum abundance within its range) (Sample 129-801A-6R-CC; middle Campanian).
2. First occurrence of *Hormosina ovulum gigantea* (Sample 129-801A-7R-1, 62–67 cm; lower-middle Campanian).

3. Acme of *Praecystammina globigerinaeformis* (Sample 129-801A-7R-1, 124–129 cm).

4. First occurrence of *Praecystammina globigerinaeformis* and *Hormosina* spp. (Sample 129-801A-7R-3, 80–85 cm).

The occurrence of the zonal marker *Hormosina ovulum gigantea*, typical of Campanian beds in the North Atlantic and the Alpine-Carpathian mountain chain in this succession enables a reasonable biostratigraphic correlation with the agglutinated foraminiferal zonations of the western Tethys (Geroch and Nowak, 1984; Moullade et al., 1988; Kuhn et al., in press) (Fig. 3).

The occurrence of a diverse, taxonomically distinct *Haplophragmoides multicamerus* acme assemblage was observed in all sites studied. This assemblage is characterized by the abundant evolute *Haplophragmoides* (e.g., *Haplophragmoides multicamerus*, *H. perplexicatus-constrictus*, *H. fraudulentus*, *H. biumbilicalis*) and, additionally, common *Praecystammina globigerinaeformis*, *Bolivinopsis parvissimus*, *Paratrochamminoides* spp., and forms of the *Hormosina ovulum* group. The consistent taxonomic composition of these high-diversity agglutinated foraminiferal assemblages provides evidence for a coeval benthic event, which enables correlation of the sites within the western Pacific basin.

### Age of *Haplophragmoides multicamerus* Acme Assemblages

The assemblages of the *Haplophragmoides multicamerus* Acme Zone in the western Pacific are characterized by the following biostratigraphically important forms:

1. Evolute *Haplophragmoides*: the evolutionary line of Late Cretaceous DWAF starts with involute forms (*H. gr. pseudokirki*) after the anoxic event at the Cenomanian/Turonian boundary, and pre-Campanian *Haplophragmoides* assemblages are generally still dominated by involute forms (e.g., *Haplophragmoides herbichi*). Assemblages dominated by evolute *Haplophragmoides* are common only since the middle Campanian in the North Atlantic basin.

2. Common/abundant *Paratrochamminoides*, which are characteristic for Campanian/Maestrichtian beds in the western Tethys.

3. *Bolivinopsis parvissimus*, which is restricted to the middle Campanian/Maestrichtian in the North Atlantic (e.g., Hole 543A, Hemleben and Troester, 1984; Site 386, Kuhn and Moullade, 1991).

4. The most reliable biostratigraphic markers are forms of the *Hormosina ovulum* group. The *Hormosina* populations of Holes 800A and 801A include *Hormosina gigantea*, which is a reliable marker species of lower Campanian to middle/upper Maestrichtian strata with a distinct acme in the middle Campanian in the North Atlantic and Alpine-Carpathian mountain chain (Geroch and Nowak, 1984; Moullade et al., 1988; Kuhn et al., in press).

In summary, we propose a middle Campanian age for the acme of *Haplophragmoides* in the western Pacific.

### CALIBRATION TO MAGNETOSTRATIGRAPHY

In Hole 800A the base of the early Campanian reversed interval 33R has been identified (Shipboard Scientific Party, 1990a) within Section 129-800A-7R-1, at about 50 mbsf. No reversed intervals have been identified in Core 129-800A-6R or higher. Thus, the top of the reversed interval 33R is between Sections 129-800A-7R-1 and 129-800A-6R-CC (i.e., between 40.3 and 50 mbsf). This is about 10.1 to 19.8 m below the marker depth of *Haplophragmoides multicamerus* acme, which we observed in samples 129-800A-5R-1, 15–20 cm, and 129-800A-5R-CC, at 30.05 and 30.35 mbsf, respectively.

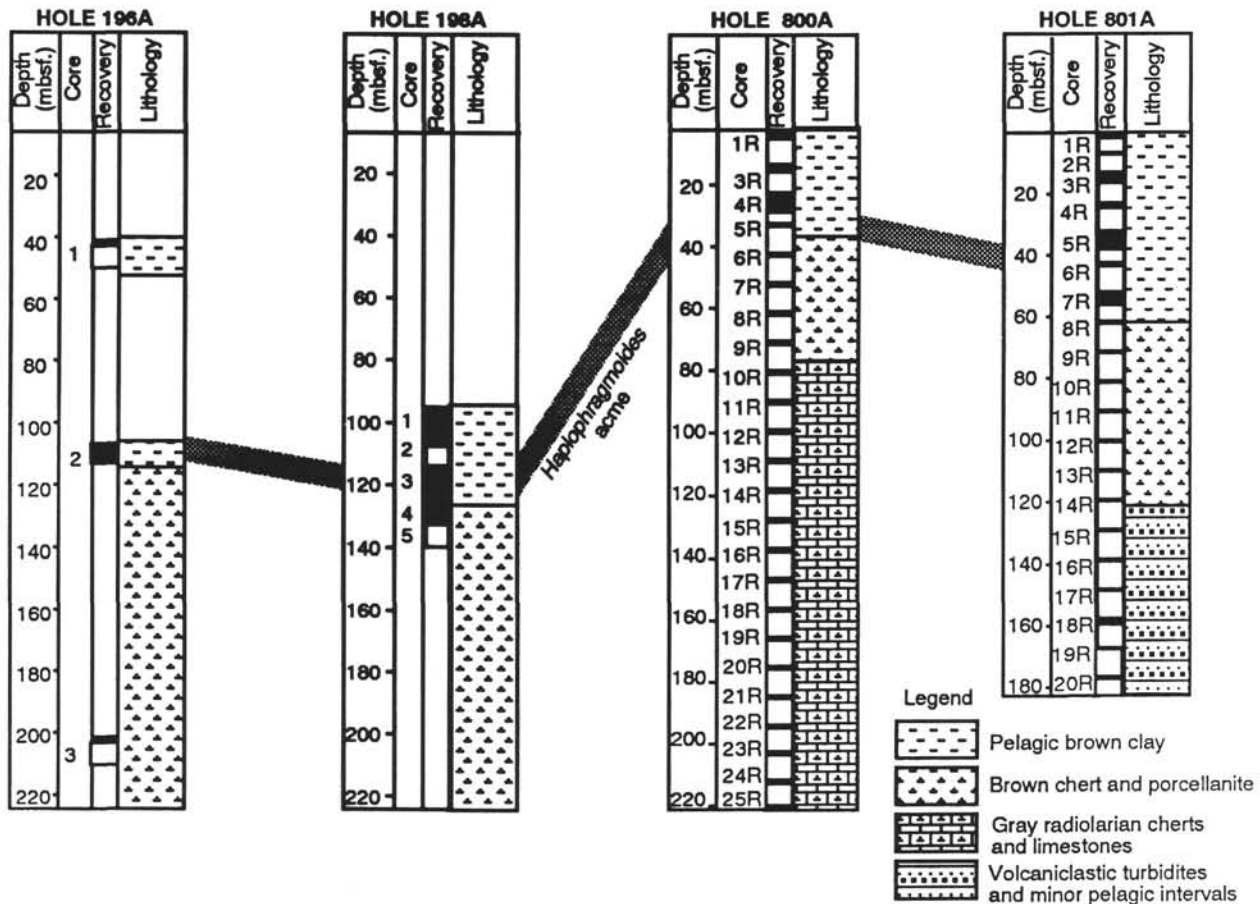


Figure 2. Core recovery and simplified lithology of the studied DSDP/ODP holes with the position of the evolute *Haplophragmoides* Acme correlation level.

In Hole 801A two reversed intervals above the mid-Cretaceous long normal zone are identified (Shipboard Scientific Party, 1990b). The lower of these two intervals is situated in Section 129-801A-7R-CC. The upper reversed interval is in Section 129-801A-7R-4, 30 cm, about only 15 cm above the lower reversed interval. The acme of *Hormosina gigantea*, which is a reliable biostratigraphic marker for Campanian strata in the North Atlantic Ocean, was observed in Sample 129-801A-7R-1, 62–67 cm. According to agglutinated foraminiferal biostratigraphy, both reversed intervals in Core 129-801A-7R may represent the reversed part of Chron 33. These reversed intervals are situated about 4.9 m below the acme of *Haplophragmoides multicamerus*, which we observed in Samples 129-801A-7R-1, 4–9 cm, and 129-801A-6R-CC.

Sedimentation rates for Upper Cretaceous sediments are about 5.1 m/m.y. at Hole 800A and about 2.4 m/m.y. at Site 801 (Shipboard Scientific Party, 1990b). This implies that the *Haplophragmoides multicamerus* Acme would be either about 2–4 m.y. younger (Hole 800A) or 2.1 m.y. (Hole 801A) younger than the top of the Chron 33R interval. This implies a consistent late middle Campanian age for the *Haplophragmoides multicamerus* Acme event.

## PALEOECOLOGY

### Quantitative Changes

A general trend is apparent in the foraminiferal diversity and density of the Late Cretaceous abyssal western Pacific (Figs. 4–7). A single, pronounced peak characterizes the evolution of species diver-

sity, which is reflected by foraminiferal density at all sites studied. Hole 196A (Fig. 4) has its maximum diversity and density in Section 196A-2-1. Diversity and density decline through Sections 20-196A-2-2 through 20-196A-2-4, and no foraminifers were recorded from deeper levels in this core. At Hole 198A (Fig. 5), foraminiferal diversity and density is lowest in Sections 20-198A-3-2 through 20-198A-3-4, but increases in Section 20-198A-3-5 through Sample 20-198A-4-2, 120–125 cm. Samples from greater depths, in Core 20-198A-4, did not contain any foraminifers. Density and diversity are low in samples from Core 129-800A-4R (Fig. 6), but reach a peak in Sample 129-800A-5R-1, 15–20 cm. In Sample 129-800A-5R-CC, density and diversity values are again low. Site 801 (Fig. 7) shows low values of diversity and density in samples from Core 129-801A-4R. In Core 129-801A-5R diversity is also low, but density shows a general increase down-section. Sample 129-801A-5R-5, 4–9 cm, has a sharp peak in density (about 35 specimens per gram of sediment), although diversity remains relatively low (5 species). This peak is due to the high abundance of tubular agglutinated forms of the *Rhizammina/Dendrophrya* complex. Diversity and density reach a peak in Sample 129-801A-7R-1, 4–9 cm.

### Assemblage Types

Foraminiferal assemblages of low diversity typically contain single or few species of such genera as *Rhizammina*, *Dendrophrya*, *Hormosina*, *Hyperammina*, *Glomospira*, and *Paratrochamminoides*, whereas the high-diversity assemblages are characterized by

Table 1. Distribution of Upper Cretaceous agglutinated benthic foraminifers, Hole 196A.

HOLE 196A	Core Section	2	2	2	2	2	2	2	2	2	2	2	2	
		1	1	1	2	2	3	4	4	5	5	6	6	CC
	Top (cm)	1	65	143	38	140	9	37	118	48	98	11	144	0
	Bottom (cm)	4	68	145	41	144	12	41	123	51	102	15	149	1
	Volume (cm <sup>3</sup> )	20	20	10	20	30	30	20	30	20	30	20	30	30
	Dry weight (g)	20	23	12	21	43	34	25	31	24	29	33	29	49
<i>Adercotryma</i> sp.					2									
<i>Ammodiscus tenuissimus</i>				1										
<i>Bolivinopsis parvissimus</i>		4												
<i>Buzasina pacifica</i>		4												
<i>Dendrophrya excelsa</i>		2*												
<i>Glomospira charoides</i>		1		1*		1								
<i>Glomospira gordialis</i>				1										
<i>Glomospira (Tolypammina?) irregularis</i>						1								
<i>Haplophragmoides biumbilicalis</i>		2												
<i>Haplophragmoides ex gr. perexplicatus-constrictus</i>		133	35	6		11			1					
<i>Haplophragmoides fraudulentus</i>		9	2											
<i>Haplophragmoides krasheninnikovi</i>			2											
<i>Haplophragmoides molestus</i>		1	1											
<i>Haplophragmoides multicamerus</i>		34	9	2		1								
<i>Hormosina crassa</i>		20*	6	2	4		2		3*					
<i>Hormosina ovulum</i>		2												
<i>Hyperammia</i> sp.			1*	1*	3*									
<i>Paratrochamminoides corpulentus</i>		5	13	13	11	4	3			4				
<i>Paratrochamminoides dubius</i>		4	2											
<i>Paratrochamminoides intricatus</i>		22*	6	2	3	1				1				
<i>Paratrochamminoides semipellucidus</i>		11*		3	6									
<i>Paratrochamminoides</i> sp.				6*						7*				
<i>Plectrocurvoides parvus</i>				1										
<i>Plectrocurvoides rotundus</i>		2	4	2	1	2	1							
<i>Praecystammina globigerinaeformis</i>		35	26	4		9	1			1				
<i>Pseudobolivina munda</i>		1												
<i>Rhizammina</i> sp.				12	1		5			2				
<i>Subreophax scalaris</i>					2									
indet.			2*	30*										
Total agglutinated foraminifers (excl. fragments)		237	107	50	28	30	12	0	9	0	0	0	0	0
Faunal density (specimens per gram sediment)		12	4.6	4.3	1.3	0.7	0.4	0	0.3	0	0	0	0	0
Diversity (number of species)		14	12	12	7	8	5	0	5	0	0	0	0	0

\* including fragments

*Bolivinopsis parvissimus*, *Buzasina pacifica*, *Pseudobolivina munda*, *Praecystammina globigerinaeformis*, and several species of *Paratrochamminoides* and *Haplophragmoides*. It is apparent that the lowest diversity assemblages are associated with biosiliceous sediments (e.g., with the radiolarian-rich sediments of Sections 129-801A-7R-3 and 129-801-7R-4), whereas the higher diversity assemblages are from residues with little or no biosiliceous components. Similar relationships were observed between foraminiferal biofacies and sediment type in the North Atlantic, in which the high- and low-diversity assemblages were termed "Biofacies A" and "Biofacies B," respectively (Kuhnt et al., 1989).

### Distribution of Faunal Groups

Three distinct groups of agglutinated foraminifers can be discriminated in our material according to their test morphology and from life positions and feeding habits (Jones and Charnock, 1985):

1. Tubular forms and ammodiscids—epifaunal suspension or detritus feeders.

2. Small, abyssal, thin-walled smooth multichambered morphotypes—inafaunal detrital/bacterial scavengers with the ability to survive under extreme oligotrophic conditions by such mechanisms as metabolizing protoplasm during resting phases or bacterial encystment (Gooday, 1990).

3. *Hyperammia*, *Hormosina*, and *Paratrochamminoides* group—probably infaunal detrital/bacterial scavengers and/or passive deposit-feeders.

*Glomospira charoides* and *Praecystammina globigerinaeformis* seem to occur within the latter two groups.

In the sections studied from the western Pacific group 2 is represented in larger numbers only during the short interval of the *Haplophragmoides multicamerus* Acme. Group 3 occurs immediately above the biosiliceous sedimentation in the lower Campanian, persists as a "background" fauna during the *H. multicamerus* Acme, and forms a major constituent of the low-diversity assemblages following the *H. multicamerus* Acme. Group 1, which is most dependent on a sufficient supply of detritic food particles from the ocean surface, dominates the assemblages above the *H. multicamerus* Acme (e.g., Core 129-801A-5R).

Table 2. Distribution of Upper Cretaceous agglutinated benthic foraminifers, Hole 198A.

HOLE 198A	Core Section	1	1	1	1	1	2	2	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	
	Top (cm)	73	74	91	69	72	96	82	24	125	18	135	20	119	35	113	20	130	28	113	20	120	47	0	105
	Bottom (cm)	76	78	95	73	76	100	86	28	130	22	140	25	124	39	117	24	135	32	118	24	125	51	5	110
	Volume (cm <sup>3</sup> )	30	30	30	30	30	30	20	30	20	30	20	30	20	30	20	30	20	30	20	30	30cc	20	20	30
	Dry weight (g)	21	26	43	39	38	32	32	29	21	34	28	33	29	33	32	37	32	33	35	33	37	46	41	
<i>Adercotryma</i> sp.																	1?		2						
<i>Ammodiscus cretaceus</i>											1														
<i>Bolivinopsis parvissimus</i>																						1			
<i>Glomospira charoides</i>																						6	2		
<i>Glomospira gordialis</i>																							1		
<i>Glomospira (Tolypammina?) irregularis</i>																						1			
<i>Glomospira serpens</i>																						1			
<i>Haplophragmoides biumbilicalis</i>																						4	3		
<i>Haplophragmoides fraudulentus</i>																						2	1	2	
<i>Haplophragmoides ex gr. herbichi</i>																							2	1	
<i>Haplophragmoides incredibilis</i>																							2		
<i>Haplophragmoides gr. perexplicatus-constrictus</i>																	5	3	1	10	6	25			
<i>Haplophragmoides multicamerus</i>																	2	1		3	4				
<i>Hormosina crassa</i>																	2	1		7	6	5			
<i>Hormosina ovulum</i>																	1			1	1	1			
<i>Hormosina/Hyperammina-fragments</i>																									
<i>Kalamopsis grzybowskii</i>											2	2	10	4	18	1	24	2	65	56	26				
<i>Paratrochamminoides corpulentus</i>																						2	2	10	
<i>Paratrochamminoides cubius</i>																						11	4		
<i>Paratrochamminoides intricatus</i>																						1	2	5	
<i>Paratrochamminoides semipellucidus</i>																								2	
<i>Paratrochamminoides sp. (fragments)</i>											3		8		5		10		70	33	43				
<i>Plectrocurvoides parvus/rotundus</i>																		1*		6	5	1			
<i>Praecystammina globigerinaeformis</i>																	1			1	3	2			
<i>Recurvoides sp. 198A</i>																	2			7	1	1			
<i>Rhizammina sp.</i>											8	20	1	25	2	5	2	5	2	45	12	20			
<i>Subreophax scalaris</i>																						1	1		
<i>Trochamminoides ex gr. proteus</i>																		1							
<i>Trochamminoides olszewskii</i>																	2			1					
<b>Radiolarian biofacies</b>																									
Total agglutinated foraminifers		0	0	0	0	0	0	0	0	0	11	23	3	43	6	28	20	48	7	265	155	155	0	0	0
Faunal density (specimens per gram sediment)		0	0	0	0	0	0	0	0	0	0.3	0.8	0.1	1.5	0.2	0.9	0.5	1.3	0.2	8.1	4.5	4.7	0	0	0
Diversity (number of species)		0	0	0	0	0	0	0	0	0	2	3	2	3	2	3	10	9	4	19	18	19	0	0	0

Table 3. Distribution of Upper Cretaceous agglutinated benthic foraminifers, Hole 800A.

HOLE 800A	Core Section Top (cm) Bottom (cm)	1R	2R	3R	4R	4R	4R	4R	4R	4R	4R	4R	4R	4R	5R	5R	
		CC	CC	CC	1	1	2	2	3	3	3	4	4	4	4	CC	1
	Volume (cm <sup>3</sup> )	40	40	40	20	30	20	30	10	30	10	20	10	30	40	30	40
	Dry weight (g)	44	44	44	35	41	20	25	11	35	11	40	11	42	44	47	44
<i>Ammodiscus cretaceus</i>					1*											1	2
<i>Aschemocella (?) -fragments</i>												17					
<i>Bolivina parvissima</i>						2				33					4	4	
<i>Buzasina pacifica</i>																3	
<i>Glomospira charoides</i>																15	
<i>Glomospira gordialis</i>						1		4									
<i>Glomospira (Tolypamina?) irregularis</i>													1		2	1	
<i>Glomospira serpens</i>													1				
<i>Haplophragmoides biumbilicalis</i>																10	
<i>Haplophragmoides decussatus</i>										1	2?						
<i>Haplophragmoides fraudulentus</i>															2	9	1
<i>Haplophragmoides gr. perexplicatus-constrictus</i>						4						2			21	120	47
<i>Haplophragmoides multicamerus</i>																11	14
<i>Haplophragmoides spp.</i>								1	1		10		1				
<i>Haplophragmoides-fragments</i>										4		7			10	38	
<i>Hormosina crassa</i>						1										8	
<i>Hormosina ovuloides</i>																1	7
<i>Hormosina ovulum gigantea</i>											1*						
<i>Hormosina ovulum ovulum</i>																17	2
<i>Hormosina/Hyperammina-fragments</i>					3	3	7	9		12	3	1		1		77	
<i>Kalamopsis grzybowskii</i>								1									
<i>Karrerulina cf. conversa</i>																	1
<i>Paratrochamminoides corpulentus</i>												2				52	
<i>Paratrochamminoides dubius</i>																14	
<i>Paratrochamminoides intricatus</i>										1							
<i>Paratrochamminoides semipellucidus</i>																4	
<i>Paratrochamminoides spp.</i>								1									9
<i>Paratrochamminoides-fragments</i>														38	8	90	6
<i>Plectrocurvoides parvus/rotundus</i>																	9
<i>Plectrocurvoides/Recurvoides-fragments</i>																	5
<i>Praecystammina globigerinaeformis</i>										1			1(?)		16	26	4
<i>Pseudobolivina munda</i>								1					1		1	1	1
<i>Rhizammina/Dendrophrya (?) sp.</i>					2	3	19	1		12	8	5		7	12	65	
<i>Subreophax scalaris</i>																9	
<i>Trochamminoides cf. proteus</i>																3*	
indet. aggl. fragments					8	5	27	2		46				12			
Total agglutinated foraminifers		0	0	0	13	11	63	16	5	75	58	70	4	28	156	508	88
Faunal density (specimens per gram sediment)		0	0	0	0.4	0.3	3.2	0.6	0.5	2.2	5.3	1.8	0.4	0.7	3.5	11	2
Diversity (number of species)		0	0	0	2	2	7	6	2	4	7	6	4	3	8	25	10

Note: For shipboard samples, we calculated 1 cm<sup>3</sup> = 1.1 g.

From these observations it seems that changes in surface productivity may have controlled the evolution of abyssal agglutinated foraminifers in the western Pacific basin during the Late Cretaceous. The enhanced productivity of siliceous plankton during the mid-Cretaceous was probably followed by a continuous decrease in surface productivity of siliceous plankton during the middle Campanian. The abyssal assemblages of the late middle Campanian to late Campanian *H. multicamerus* Acme Zone resemble benthic populations beneath oceanic oligotrophic gyres. The recurrence of suspension/detritus-feeding opportunists in the uppermost Cretaceous may indicate again the slightly increased productivity of the surface waters. A drastic decrease of agglutinated foraminifers was observed in the uppermost Maestrichtian or lower Paleogene. This trend parallels the trend observed by Moullade et al. (1988) in the North Atlantic. However, insufficient core recovery and lack of biostratigraphic

control do not allow a correlation of this observation to the Cretaceous/Paleogene boundary event.

#### COMPARISON TO THE EVOLUTION OF ABYSSAL AGGLUTINATED FORAMINIFERS IN THE NORTH ATLANTIC OCEAN

Diversity trends of Late Cretaceous abyssal agglutinated foraminifers were compared for DSDP Holes 398D and 386 in the North Atlantic and the western Pacific Holes 196A, 198A, 800A and 801A (Fig. 8). The diversity trends in North Atlantic sites are probably related to two Late Cretaceous biosiliceous events: the Cenomanian/Turonian boundary event (CTBE) and the early Campanian event (ECE) (Kuhnt et al., 1989). The diversity trends of the abyssal assemblages in the western Pacific also show low diversities in the



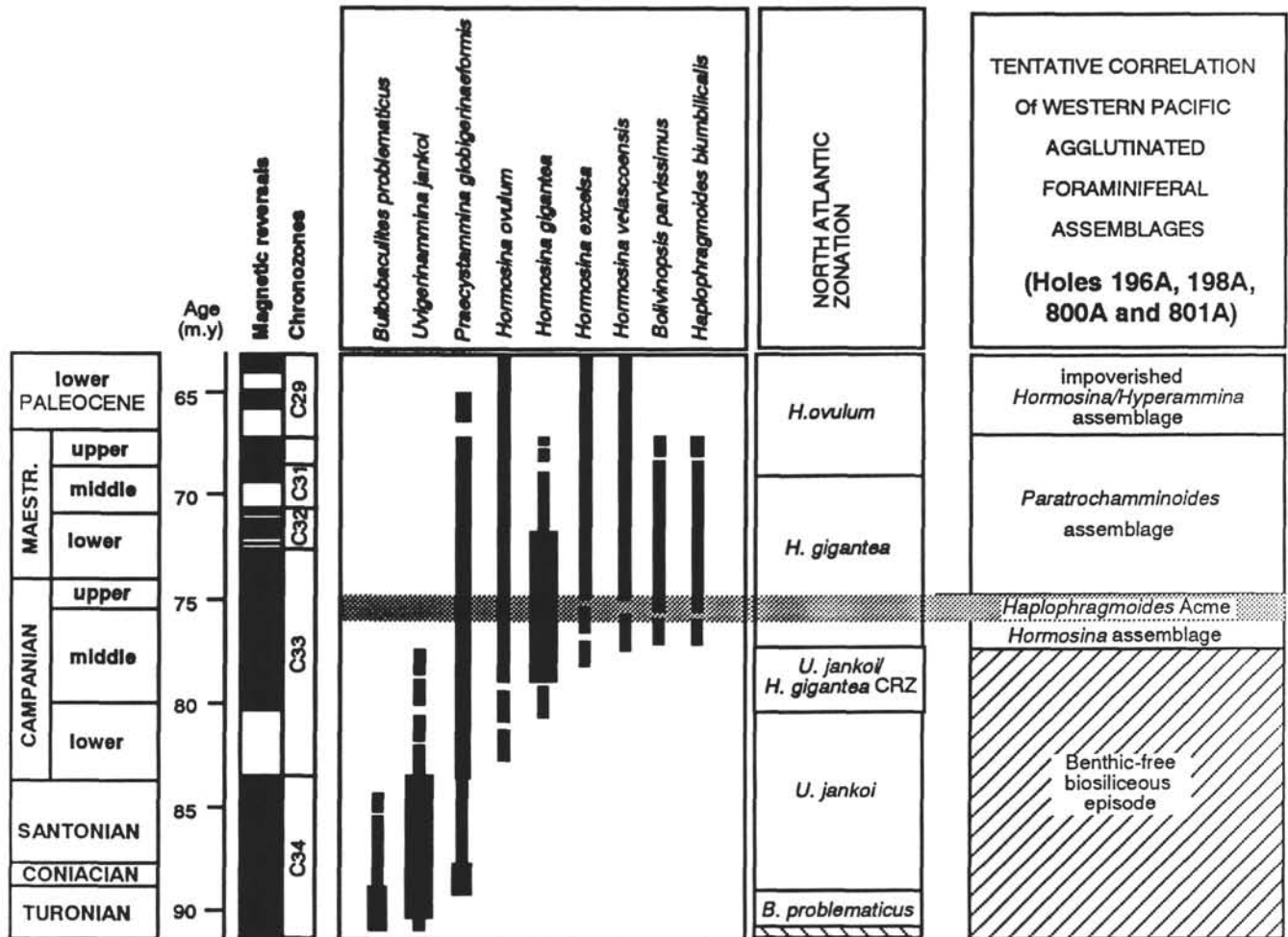


Figure 3. Biochronology of western Pacific foraminiferal assemblages as determined from the ranges of North Atlantic/western Tethyan marker species occurring in the assemblages.

lower Campanian at all sites. This appears to be related to the transition from biosiliceous to clay sedimentation. The higher diversity assemblages in the western Pacific during the *Haplophragmoides* spp. Acme characterize pelagic clays. The low diversities in the upper parts at Hole 800A and 801A occur probably in the Paleocene.

### CONCLUSIONS

The majority of the observed Upper Cretaceous DWAF are cosmopolitan species, which occur in the western Pacific, North Atlantic, and western Tethyan oceans. Several biostratigraphic markers (e.g., *Hormosina-Haplophragmoides* and *Paratrochamminoides* lineages) seem to have comparable stratigraphic ranges within these basins. However, differences in quantitative DWAF distribution in time between the North Atlantic and the western Pacific are obvious: the oldest typical abyssal assemblages are observed in the North Atlantic in the Turonian and those in the western Pacific are as late as late early Campanian. There is only one comparatively short-term episode of abundant and diversified DWAF in the middle Campanian of the western Pacific, whereas in the North Atlantic rich DWAF assemblages are common throughout the entire Upper Cretaceous, following the Cenomanian/Turonian boundary event. Mid-Cretaceous biosiliceous episodes, which were hostile to DWAF, have different intensities and durations. They cover the entire Turonian-lower Campanian interval in the western Pacific, whereas they are restricted to two short episodes at the Cenomanian/Turonian boundary and within the lower Campanian in the North Atlantic.

### ACKNOWLEDGMENTS

We are grateful to the Ocean Drilling Program for providing us with the sample material for this study. We especially appreciate the fast response to our additional post-cruise sample request for material from Sites 196 and 198. We thank W. A. Berggren and an anonymous reviewer for their comments on this manuscript. W. G. Wightman thanks the Ocean Drilling Program for inviting him to participate on Leg 129 aboard *JOIDES Resolution*. W. G. Wightman benefited from a NSERC Collaborative Special Project Grant awarded to F. M. Gradstein. W. Kuhnt was supported by a postdoctoral fellowship from the Killam Trust of Dalhousie University.

### TAXONOMIC NOTES

The alphabetic listing of species includes the original and present name of the species. Full synonymies/references are not given, although references to certain stratigraphically important species are provided.

*Adercotryma* sp.  
(Pl. 2, Fig. 5)

- ?*Trochammina gyroidinaeformis* Krasheninnikov, 1974, p. 641, pl. 5, figs. 7a-c, 8a-c, 9c.
- ?*Trochammina gyroidinaeformis* Krasheninnikov, Hemleben and Troester, 1984, p. 522, pl. 4, figs. 11-13.
- ?*Trochammina gyroidinaeformis* Krasheninnikov, Moullade et al., 1988, pl. 8, figs. 4-6.



*Ammodiscus cretaceus* (Reuss, 1845)  
(Pl. 1, Fig. 6)

*Operculina cretacea* Reuss, 1845, p. 35, pl. 13, figs. 64, 65.  
*Ammodiscus cretaceus* (Reuss), Hemleben and Troester, 1984, p. 517, pl. 1, fig. 17.  
*Ammodiscus cretaceus* (Reuss), Krasheninnikov and Pflaumann, 1978, p. 569, pl. 2, fig. 7.  
*Ammodiscus cretaceus* (Reuss), Moullade et al., 1988, p. 363, pl. 1, fig. 7.  
*Ammodiscus cretaceus* (Reuss), Kuhnt, 1990, pl. 1, figs. 2, 3.

*Ammodiscus tenuissimus* Grzybowski, 1898  
(Pl. 1, Fig. 7)

*Ammodiscus tenuissimus* Grzybowski, 1898, p. 282, pl. 10, fig. 35.  
*Ammodiscus planus* Loeblich, Kaminski et al., 1988, p. 185, pl. 3, fig. 13.  
*Ammodiscus planus* Loeblich, Kuhnt, 1990, pl. 1, fig. 5.

**Remarks.** We use this name for the small and thin-walled ammodiscids, which occur rarely in the material from the western Pacific. These forms agree well with the type material in the Grzybowski collection. The deep-sea forms differ from *A. planus* from the Turonian shallow-marine pepper shales in having fewer but slightly broader whorls.

*Aschemocella/Dendrophrya latissima* fragments  
(Pl. 1, Figs. 2, 3)

?*Aschemonella carpathica* Neagu, 1964, pp. 582-586, text-figs. 2.2-4, 3.1-3, 4.1-6.  
?*Aschemocella carpathica* (Neagu), Kuhnt and Kaminski, 1990, p. 464, pl. 2, figs. a-e.  
?*Dendrophrya latissima* Grzybowski, 1898, p. 17, pl. 10, fig. 8.  
?*Psammosiphonella anglesiaensis* (Crespin), Krasheninnikov and Pflaumann, 1977, p. 567, pl. 1, figs. 3-4.  
?*Dendrophrya latissima* Grzybowski, Kaminski et al., 1988, p. 182, pl. 1, fig. 6.

**Remarks.** The specimens occur as fragments of large, flattened agglutinated tests. The test wall is coarsely agglutinated from quartz, mica, and abundant cement. Some of the fragments allow recognition of an ovoid chamber outline. Fragments of two species, *Dendrophrya latissima* and *Aschemocella carepathica*, are probably included in this group.

*Bolivinopsis parvissimus* Krasheninnikov, 1973  
(Pl. 3, Fig. 11)

*Bolivinopsis parvissimus* Krasheninnikov, 1973, p. 210, pl. 2, figs. 8, 9.  
*Bolivinopsis parvissimus* Krasheninnikov, Hemleben and Troester, 1984, p. 517, pl. 4, fig. 1.

*Buzasina pacifica* (Krasheninnikov, 1973)  
(Pl. 1, Fig. 8)

*Labrospira pacifica* Krasheninnikov, 1973, p. 209, pl. 2, figs. 4a, b, 5a, b.  
*Labrospira pacifica* Krasheninnikov, Krasheninnikov, 1974, p. 637, pl. 3, figs. 1a, b, 2a, b.  
*Labrospira pacifica* Krasheninnikov, Gradstein and Berggren, 1981, p. 260, pl. 9, figs. 9, 10.  
*Labrospira pacifica* Krasheninnikov, Hemleben and Troester, 1984, p. 520, pl. 3, fig. 8.  
*Labrospira pacifica* Krasheninnikov, Moullade et al., 1988, p. 365, pl. 7, fig. 8.

**Remarks.** *Buzasina pacifica* differs from *B. inflata* (Krasheninnikov, 1974) in possessing less inflated chambers and in its more compressed outline. We assign these species to the genus *Buzasina*, in accordance with the usage in Loeblich and Tappan (1988).

*Glomospira charoides* (Jones and Parker, 1860)  
(Pl. 1, Fig. 9)

*Trochammina squamata* Jones and Parker var. *charoides* Jones and Parker, 1860, p. 304.  
*Glomospira charoides* (Jones and Parker), Kaminski et al., 1988, p. 185, pl. 3, figs. 14-15.

*Glomospira charoides* (Jones and Parker), Moullade et al., 1988, p. 363, pl. 1, fig. 6.

*Glomospira gordialis* (Jones and Parker, 1860)  
(Pl. 1, Fig. 10)

*Trochammina squamata* Jones and Parker var. *gordialis* Jones and Parker, 1860, p. 304.  
*Glomospira gordialis* (Jones and Parker), Hemleben and Troester, 1984, p. 518, pl. 1, fig. 20.  
*Glomospira gordialis* (Jones and Parker), Kaminski et al., 1988, p. 185, pl. 3, fig. 17.  
*Glomospira gordialis* (Jones and Parker), Moullade et al., 1988, p. 363, pl. 1, fig. 4.  
*Glomospira gordialis* (Jones and Parker), Kuhnt, 1990, pl. 1, figs. 9, 10.

*Glomospira (Tolypammina?) irregularis* (Grzybowski, 1898)  
(Pl. 1, Fig. 11)

*Ammodiscus irregularis* Grzybowski, 1898, p. 285, pl. 11, figs. 2, 3.  
*Glomospira? irregularis* (Grzybowski), Hemleben and Troester, 1984, p. 519, pl. 1, fig. 22.  
*Glomospira irregularis* (Grzybowski), Kaminski et al., 1988, p. 185, pl. 3, figs. 20-21.  
*Glomospira (Tolypammina?) irregularis* (Grzybowski), Kuhnt, 1990, pl. 1, fig. 12.

*Glomospira serpens* (Grzybowski, 1898)  
(Pl. 1, Fig. 12)

*Ammodiscus serpens* Grzybowski, 1898, p. 285, pl. 10, figs. 31-33.  
*Glomospira serpens* (Grzybowski), Hemleben and Troester, 1984, p. 519, pl. 1, fig. 23.  
*Glomospira serpens* (Grzybowski), Moullade et al., 1988, p. 363, pl. 1, fig. 2, 3.  
*Glomospira serpens* (Grzybowski), Kuhnt, submitted, pl. 1, fig. 4.

*Haplophragmoides biumbilicalis* Krasheninnikov, 1973  
(Pl. 2, Figs. 6-7)

*Haplophragmoides biumbilicalis* Krasheninnikov, 1973, p. 208, pl. 1, figs. 3a-b, 4.

**Remarks.** The umbilicus is narrow, but deep; the final whorl has a distinct shoulder bordering the umbilicus. It differs from *H. molestus* and *H. perexplotatus* by its more inflated test with a broadly rounded peripheral margin and by its deep, conical umbilicus.

*Haplophragmoides cf. concavus* (Chapman, 1892)  
(Pl. 2, Fig. 8)

*Trochammina concava* Chapman, 1892, p. 327, pl. 6, fig. 14a-b.  
*Haplophragmoides cf. concava* (Chapman), Geroch, 1960, p. 127, pl. 5, fig. 2.  
*Haplophragmoides cf. concavus* (Chapman), Moullade et al., 1988, p. 365, pl. 8, figs. 8, 9.

**Remarks.** The completely flattened, finely agglutinated tests have three to five chambers in the last whorl. It is comparable with *H. walteri* (Grzybowski) in its narrow compressed outline, but with fewer chambers in the last whorl and a lobulated periphery. In our material specimens of *H. cf. concavus* have a whitish coloration of the test, which differs from the other typically brown colored species of *Haplophragmoides*.

*Haplophragmoides decussatus* Krasheninnikov, 1973  
(Pl. 2, Fig. 9)

*Haplophragmoides decussatus* Krasheninnikov, 1973, pp. 208-209, pl. 2, fig. 3a, b.  
*Haplophragmoides decussatus* Krasheninnikov, Krasheninnikov, 1974, pl. 1, fig. 6a, b.

*Haplophragmoides fraudulentus* Krasheninnikov, 1973  
(Pl. 2, Figs. 10, 11)

*Haplophragmoides fraudulentus* Krasheninnikov, 1973, p. 207, pl. 1, fig. 9a, b.

- Haplophragmoides fraudulentus* Krasheninnikov, Krasheninnikov, 1974, p. 634, pl. 1, figs. 1a, b, 2a.  
*Haplophragmoides fraudulentus* Krasheninnikov, Hemleben and Troester, 1984, p. 519, pl. 2, figs. 19, 20.  
*Haplophragmoides fraudulentus* Krasheninnikov, Moullade et al., 1988, p. 365, pl. 5, fig. 7, 8.

**Remarks.** The test is small and evolute with a broad, shallow umbilicus. The last whorl has six to seven spherical chambers, separated by deep radial to slightly curved sutures.

*Haplophragmoides* ex gr. *herbichi* Neagu, 1968  
(Pl. 2, Fig. 12)

- Haplophragmoides herbichi* Neagu, 1968, p. 238, pl. 1, figs. 9–12.  
*Haplophragmoides bulloides* Beissel, Krasheninnikov, 1974, p. 636, pl. 1, figs. 9a, 9b, 10, and 11b.  
*Haplophragmoides bulloides* Beissel, Moullade et al., 1988, p. 363, pl. 6, fig. 3.  
*Haplophragmoides* cf. *herbichi* Neagu, Moullade et al., 1988, p. 365, pl. 6, figs. 1, 2.

**Remarks.** The tests are planispiral coiled and involute with 9–10 chambers in the last whorl. The peripheral margin is rounded and the radial sutures are completely flush (thus giving the test an appearance like a nautilus). A very narrow, deep umbilicus is present. The aperture is a narrow slit at the base of the final chamber. The species is rare in our material, but it occurs frequently in the Turonian to Santonian of the North Atlantic Ocean (Moullade et al., 1988; Kuhnt and Moullade, in press), in the Turonian/Coniacian of the Rumanian eastern Carpathians (Neagu, 1990), and in the Turonian/Santonian of the Indian Ocean (Krasheninnikov, 1974). Thus, it may represent an earlier stage in the evolution of Late Cretaceous abyssal *Haplophragmoides*. The few specimens we observed in Core 129-198A-4R are morphologically close to those from the Rumanian Eastern Carpathians and the Atlantic Ocean, however, the rare occurrence and the poor preservation of these specimens makes it preferable to place them in a *H. herbichi* group.

*Haplophragmoides incredibilis* Krasheninnikov, 1974  
(Pl. 2, Figs. 13–14.)

- Haplophragmoides incredibilis* Krasheninnikov, 1974, pl. 2, figs. 5a–c.

*Haplophragmoides krasheninnikovi* nomen novum  
(Pl. 2, Fig. 15; Pl. 3, Fig. 1)

- Haplophragmoides multiformis* Krasheninnikov, 1974, pl. 2, figs. 1a, b, 2a, b.

**Remarks.** The test is small to medium in size and strongly involute with four subtriangular or trapeziform chambers in the last whorl. The lateral outline is a somewhat elongate oval, and is slightly lobulate. It is restricted to the abyssal environment and rare in the material from the western Pacific.

This characteristic species was first described from the Indian Ocean as *Haplophragmoides multiformis* by Krasheninnikov (1974). Because this name is a junior homonym of *Haplophragmoides multiformis* Akimets, 1966, the name must be rejected under Article 59 of the International Code of Zoological Nomenclature (ICZN). As no junior synonym exists as a replacement name, we propose the new name *Haplophragmoides krasheninnikovi* after V. Krasheninnikov, who first described this form as a valid species.

*Haplophragmoides molestus* Krasheninnikov, 1973  
(Pl. 3, Fig. 2)

- Haplophragmoides molestus* Krasheninnikov, 1973, p. 208, pl. 1, fig. 8a, b.

**Remarks.** The test is involute, moderately compressed, with 5 to 6 chambers in the last whorl, increasing gradually in size as added. The umbilicus is narrow and flat, chambers are almost united in the center, and inner whorls are not observed. The wall is very finely agglutinated, siliceous, and glassy, with a smooth surface. It differs from *H. perexplicatus* in its narrow and flat umbilicus with inner whorls not visible. The species is very rare in our material and has been included in the *Haplophragmoides perexplicatus-constrictus* group in the range charts.

*Haplophragmoides multicamerus* Krasheninnikov, 1973  
(Pl. 3, Figs. 3–5)

- Haplophragmoides multicamerus* Krasheninnikov, 1973, p. 207, pl. 1, figs. 1a, b, 2a, b. Krasheninnikov, 1974, p. 635, pl. 1, fig. 4a, b. Moullade et al., 1988, p. 365, pl. 5, figs. 1, 2.

**Remarks.** The test is small and evolute, with a wide, but shallow, umbilicus; the last whorl consists of seven to 10 narrow chambers.

*Haplophragmoides* ex gr. *perexplicatus-constrictus* Krasheninnikov, 1973  
(Pl. 3, Figs. 6–8)

- Haplophragmoides perexplicatus* Krasheninnikov, 1973, p. 208, pl. 1, figs. 6a, b.  
*Haplophragmoides pervagatus* Krasheninnikov, 1973, p. 208, pl. 1, fig. 7a, b.  
*Haplophragmoides perexplicatus* Krasheninnikov, Krasheninnikov, 1974, p. 635, pl. 1, figs. 5a, b.  
*Haplophragmoides perexplicatus* Krasheninnikov, Moullade et al., 1988, p. 365, pl. 5, fig. 4–6.  
*Haplophragmoides constrictus* Krasheninnikov, 1973, pp. 207–208, pl. 1, figs. 5a, b.  
*Haplophragmoides constrictus* Krasheninnikov, Krasheninnikov, 1974, p. 635, pl. 1, figs. 3a, b.  
*Haplophragmoides constrictus* Krasheninnikov, Moullade et al., 1988, p. 365, pl. 4, figs. 7–9.

**Remarks.** *Haplophragmoides constrictus* differs from *H. perexplicatus* in its slightly more evolute aspect, a very slow increase of chamber height in the process of growth, a broader umbilicus, and the lack of an elongated final chamber protruding beyond the general contour of the test. In the rich material from the western Pacific Ocean we observed many intermediate stages between forms that correspond closely to the holotypes of *H. perexplicatus*, *H. pervagatus*, and *H. constrictus*. These forms may be morphologic end-members of a continuous morphologic lineage. Thus, we did not separate single species and placed all forms of this morphologic group in *Haplophragmoides* ex gr. *perexplicatus-constrictus*.

*Hormosina crassa* Geroch, 1966  
(Pl. 1, Figs. 15, 16)

- Hormosina ovulum crassa* Geroch, 1966, p. 438, figs. 6 (19, 21–26), 7 (21–23).  
*Hormosina ovulum crassa* Geroch, Hemleben and Troester, 1984, p. 520, pl. 2, figs. 8, 9.  
*Hyperammina* cf. *dilatata* Grzybowski, Hemleben and Troester, 1984, p. 520, pl. 1, fig. 11.  
*Hormosina crassa* Geroch, Moullade et al., 1988, p. 365, pl. 2, fig. 4–6.  
*Hormosina crassa* Geroch, Kuhnt, 1990, pl. 2, fig. 5.

**Remarks.** *Hormosina crassa* is more coarsely agglutinated than other species of the genus *Hormosina*. The chambers are ovoid to spherical in outline and have thick connections. Our specimens are generally represented by single chambered fragments.

*Hormosina ovuloides* (Grzybowski, 1901)  
(Pl. 2, Fig. 1)

- Reophax ovuloides* Grzybowski, 1901, p. 223, pl. 8, fig. 3.  
*Hormosina ovuloides* (Grzybowski), Hemleben and Troester, 1984, p. 520, pl. 2, fig. 6.  
*Hormosina ovulum* (Grzybowski), Moullade et al., 1988, p. 365, pl. 2, figs. 7–8.  
*Hormosina ovuloides* (Grzybowski), Moullade et al., 1988, p. 365, pl. 2, fig. 10.  
*Hormosina ovuloides* (Grzybowski), Kaminski et al., 1988, p. 186, pl. 2, figs. 3–4.

**Remarks.** This species has chambers that are more elongated and asymmetrical than those of *Hormosina ovulum*. The connections between the chambers are relatively broad. The wall is thick and finely agglutinated. Some of our specimens may be transitional forms to *H. excelsa*.

*Hormosina ovulum gigantea* Geroch, 1960  
(Pl. 1, Fig. 17)

- Hormosina ovulum* (Grzybowski) var. *gigantea* Geroch, 1960, p. 43, pl. 2, figs. 18–19.  
*Hormosina ovulum gigantea* Geroch, Geroch and Nowak, 1984, pl. 1, fig. 20; pl. 5, figs. 15–16.

*Hormosina gigantea* Geroch, Moullade et al., 1988, p. 365, pl. 2, fig. 11.  
*Hormosina ovulum gigantea* Geroch, Kuhnt and Kaminski, 1990, p. 474, pl. 1, figs. a–b.

**Remarks.** This species differs from *Hormosina ovulum* (Grzybowski) in the more globular outline of the chambers and larger size. In the western Pacific material, we observed both compressed (e.g., Sample 129-801A-5R-CC) and undeformed specimens (e.g., Sample 129-801A-7R-1, 62–67 cm). Because the compressed forms are found at shallower depth than the undeformed specimens within the same core, this feature is probably not related to differing burial histories. We assign this feature to different wall thicknesses due to differing environmental conditions (e.g., detrital food supply).

*Hormosina ovulum ovulum* (Grzybowski, 1898)  
 (Pl. 2, Fig. 2)

*Reophax ovulum* Grzybowski, 1896, p. 276, pl. 8, figs. 19–21.  
*Hormosina ovulum ovulum* (Grzybowski), Kuhnt and Kaminski, 1990, pp. 474–475, pl. 1, figs. c–e.

**Remarks.** This species differs from *Hormosina ovulum gigantea* in its smaller size (200–400 µm) and more elongated chambers. Although intermediate forms exist, *Hormosina ovulum ovulum* has a wider stratigraphic range, from the late Lower Cretaceous to the Paleocene (Geroch, 1960; Geroch and Nowak, 1984; Moullade et al., 1988).

*Hyperammina dilatata* Grzybowski, 1896  
 (Pl. 1, Fig. 4)

*Hyperammina dilatata* Rzehak, Grzybowski, 1896, pp. 274–275, pl. 8, fig. 17.  
*Hyperammina dilatata* Grzybowski, Kaminski et al., 1988, p. 184, pl. 2, figs. 1–2.

*Hyperammina elongata* Brady, 1884  
 (Pl. 1, Fig. 5)

*Hyperammina elongata* Brady, 1884, p. 257, pl. 23, figs. 4, 7–10.  
*Hyperammina* ex gr. *elongata* Brady, Hemleben and Troester, 1984, p. 520, pl. 1, figs. 12–13.  
*Hyperammina elongata* Brady, Kuhnt, 1988, pl. 4, fig. 3.

*Kalamopsis grzybowskii* (Dylazanka, 1923)  
 (Pl. 2, Fig. 3)

*Hyperammina grzybowskii* Dylazanka, 1923, pp. 65–66.  
*Kalamopsis grzybowskii* (Dylazanka), Hemleben and Troester, 1984, p. 550, pl. 2, figs. 3–5.  
*Kalamopsis grzybowskii* (Dylazanka), Kaminski et al., 1988, p. 187, pl. 1, figs. 18–20.

**Remarks.** Typical large specimens with a whitish colored wall are very rare in our material. Fragments of small brownish tubular forms with a smooth thin wall, and evidence of chamber separations are listed as *Kalamopsis* (?) fragments.

*Karrerulina* cf. *conversa* (Grzybowski, 1901)  
 (Pl. 4, Fig. 15)

*Gaudryina conversa* Grzybowski, 1901, p. 285, pl. 7, figs. 15, 16.  
*Plectina conversa* (Grzybowski), Krasheninnikov and Pflaumann, 1978, p. 569, pl. 3, figs. 4a, b.  
*Plectina* aff. *conversa* (Grzybowski), Hemleben and Troester, 1984, p. 521, pl. 4, fig. 24.  
*Karrerrella conversa* (Grzybowski), Kaminski et al., 1988, p. 196, pl. 9, figs. 17–18b.  
*Plectina conversa* (Grzybowski), Moullade et al., 1988, p. 365, pl. 9, figs. 1–3.

**Remarks.** This species occurs in our material as a single specimen with a broken end. The initial portion shows the typical features of the genus *Karrerulina*. Because the apertural part is broken, we are unable to decide whether this form may be included in the new genus *Gerochella* Neagu, 1990, which differs from *Karrerulina* mainly in possessing an apertural slit rather than a terminal aperture produced on an apertural neck.

*Lituotuba lituiformis* (Brady, 1879)  
 (Pl. 1, Fig. 14)

*Trochammina lituiformis* Brady, 1879, p. 59, pl. 5, fig. 16.  
*Lituotuba lituiformis* (Brady), Kaminski et al., 1988, p. 190, pl. 4, figs. 14–15.  
*Lituotuba lituiformis* (Brady), Kuhnt, 1990, pl. 1, figs. 17–18.

*Paratrochamminoides corpulentus* Krasheninnikov, 1973  
 (Pl. 3, Fig. 15; Pl. 4, Fig. 1)

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

**Remarks.** The test has an elliptical outline, and the chambers are elongated. Umbilical deepening is absent (in contrast to *P. semipellucidus*). The wall is very finely agglutinated, whitish, and smooth.

*Paratrochamminoides dubius* (Grzybowski, 1898)  
 (Pl. 4, Fig. 2)

*Ammodiscus dubius* Grzybowski, 1901, p. 274, pl. 8, figs. 12, 14.  
*Trochamminoides dubius* (Grzybowski), Kaminski et al., 1988, p. 191, pl. 4, figs. 16–17.

**Remarks.** This species has an irregular planispiral or streptospiral coil. The chambers are strongly elongated, with indistinct sutures. The wall is finely agglutinated with a smooth surface.

*Paratrochamminoides intricatus* Krasheninnikov, 1973  
 (Pl. 4, Fig. 3)

*Paratrochamminoides* (?) *intricatus* Krasheninnikov, 1973, p. 212, pl. 3, figs. 2a–c.  
*Paratrochamminoides intricatus* Krasheninnikov, Krasheninnikov, 1974, p. 638, pl. 4, figs. 2a–c.  
*Paratrochamminoides intricatus* Krasheninnikov, Hemleben and Troester, 1984, p. 520, pl. 3, figs. 10–11.

**Remarks.** The globular chambers gradually increase in size as added and are regularly coiled. This species commonly occurs as only fragments.

*Paratrochamminoides olszewskii* (Grzybowski, 1898)  
 (Pl. 4, Fig. 4)

*Trochammina olszewskii* Grzybowski, 1898, p. 286, pl. 11, fig. 6.  
*Trochamminoides olszewskii* Grzybowski, Neagu, 1962.  
*Paratrochamminoides* (?) *semipellucidus* Krasheninnikov, 1973, p. 212, pl. 3, figs. 4a, b, c.

**Remarks.** The test of this species has an irregular low trochospiral to almost planispiral coil, with elongated chambers. These forms have been assigned to *P. semipellucidus* by Krasheninnikov (1973). A comparison to type material of *P. olszewskii*, which is preserved in the Grzybowski collection of the Jagiellonian University (Krakow), shows an identical test morphology of these two forms. We regard the differences in wall structure (the forms from the Pacific Ocean are thin walled and extremely fine grained) as due to ecologic variability and/or a different diagenetic history, and regard *P. semipellucidus* Krasheninnikov as a junior synonym of *P. olszewskii* Grzybowski.

*Plectorecurvoides parvus* Krasheninnikov, 1973  
 (Pl. 4, Fig. 6)

*Plectorecurvoides parvus* Krasheninnikov, 1973, p. 210, pl. 2, figs. 6a, b, c, 7a, b, c.  
*Plectorecurvoides parvus* Krasheninnikov, 1974, p. 640, pl. 5, figs. 3a,b,c.

*Plectrocurvoides rotundus* Krasheninnikov, 1974  
(Pl. 4, Fig. 7)

*Plectrocurvoides rotundus* Krasheninnikov, 1974, p.641, pl. 5, figs. 4a, b, c, 5c, 6c.

**Remarks.** This species differs from *P. parvus* in its inflated spherical test with indistinct sutures. There are intermediate forms to *P. parvus*.

*Praecystamina globigerinaeformis* Krasheninnikov, 1973  
(Pl. 4, Figs. 8–10)

*Praecystamina globigerinaeformis* Krasheninnikov, 1973, p. 211, pl. 3, figs. 1a, b, c, 2.

*Praecystamina globigerinaeformis* Krasheninnikov, Hemleben and Troester, 1984, p. 521, pl. 4, fig. 8.

*Praecystamina globigerinaeformis* Krasheninnikov, Moullade et al., 1988, pp. 365–366, pl. 7, fig. 6.

*Pseudobolivina munda* Krasheninnikov, 1973  
(Pl. 4, Fig. 5)

*Pseudobolivina munda* Krasheninnikov, 1973, p. 210, pl. 2, figs. 10, 11.

*Pseudobolivina munda* Krasheninnikov, Hemleben and Troester, 1984, p. 521, pl. 4, fig. 3.

*Pseudobolivina munda* Krasheninnikov, Moullade et al., 1988, p. 366, pl. 9, figs. 9, 10.

*Pseudobolivina* cf. *munda* Krasheninnikov, Kuhnt, 1990, pl. 6, figs. 1–2.

*Recurvoides* sp. 1  
(Pl. 3, Figs. 9, 10)

**Remarks.** The small brownish forms have a chamber arrangement resembling *Recurvoides deflexiformis* Noth. The specimens are thin-walled with a smooth surface, similar to *Haplophragmoides multicamerus*.

*Rhizammina-Dendrophrya excelsa* group  
(Pl. 1, Figs. 1–2)

p.p. *Rhizammina indivisa* Brady, 1884, p. 277, pl. 29, figs. 5–7.

p.p. *Dendrophrya excelsa* Drzybowski, 1898, p. 272, pl. 10, figs. 1–4.

**Remarks.** We did not separate the strongly fragmented tubular forms in our material. According to the mode of agglutination, degree of compression, and width of the tube and curvature, at least two different morphotypes are represented within this group which may correspond to the species *Rhizammina indivisa* and *Dendrophrya excelsa*.

*Subreophax scalaris* (Grzybowski, 1896)  
(Pl. 2, Fig. 4)

*Reophax guttifer* Brady var. *scalaria* Grzybowski, 1896, p. 277, pl. 8, fig. 26.

*Reophax scalaris* Grzybowski, Hemleben and Troester, 1984, p. 521, pl. 2, figs. 10–11.

*Subreophax scalaria* (Grzybowski), Kaminski et al., in press, p. 187, pl. 2, figs. 16–17.

**Remarks.** The test consists of numerous disc-shaped, partially embracing chambers that gradually increase in size. The test is bent or curved.

*Trochammina* sp. 1. (?) ex gr. *globigeriniformis* (Parker and Jones, 1865)  
(Pl. 4, Figs. 11–14)

ex gr. *Lituola nautiloidea globigeriniformis* Parker and Jones, 1865, p. 407, pl. 15, figs. 46–47, pl. 17, figs. 96–98.

ex gr. *Trochammina globigeriniformis* Parker and Jones, Cushman, 1910, p. 124, text-figs. 193–194.

*Trochammina* ex gr. *globigeriniformis* Parker and Jones, Geroch, 1960, p. 134, pl. 7, fig. 2.

**Remarks.** We use the name in a broad sense and assign all small brownish Trochamminas with a four- or five-chambered test, a finely agglutinated wall, and a smooth surface to this group. Preservation of our material does not allow the observation of the apertural features. Our specimens differ from the similar

*T. lobulata* (Krasheninnikov, 1974) in possessing fewer chambers. It is rare in the material from the western Pacific.

*Trochamminoides proteus* (Karrer, 1866)  
(Pl. 3, Figs. 12, 13)

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

**Remarks.** This species is rare in our material and occurs only in fragments. We used the name *T. cf. proteus* in our range charts for these fragments of irregular planispiral tests with more or less rounded chambers.

*Trochamminoides septatus* (Grzybowski, 1898)  
(Pl. 3, Fig. 14)

*Ammodiscus septatus* Grzybowski, 1898, p. 283, pl. 11, fig. 1.

**Remarks.** This form has a planispirally coiled test. The chamber separations are indistinct and are indicated by constrictions of the test. Examination of the type material in the Grzybowski collection of the Jagiellonian University (Krakow), showed that *A. septatus* is a multichambered form and thus is placed in the genus *Trochamminoides*. The single specimen observed in our samples from the abyssal western Pacific, corresponds well to the type material.

*Turritelletta shoneana* (Siddall, 1878)  
(Pl. 1, Fig. 13)

*Trochammina shoneana* Siddall, 1878, p. 46, figs. 1, 2.

*Ammodiscus shoneanus* (Siddall), Brady, 1881, p. 335.

*Turritelletta shoneana* (Siddall), Barker, 1960, p. 78, pl. 38, figs. 17–19.

**Remarks.** This species has a tubular test with characteristic spiral coiling.

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Date of initial receipt: 30 May 1991

Date of acceptance: 17 March 1992

Ms 129B-148

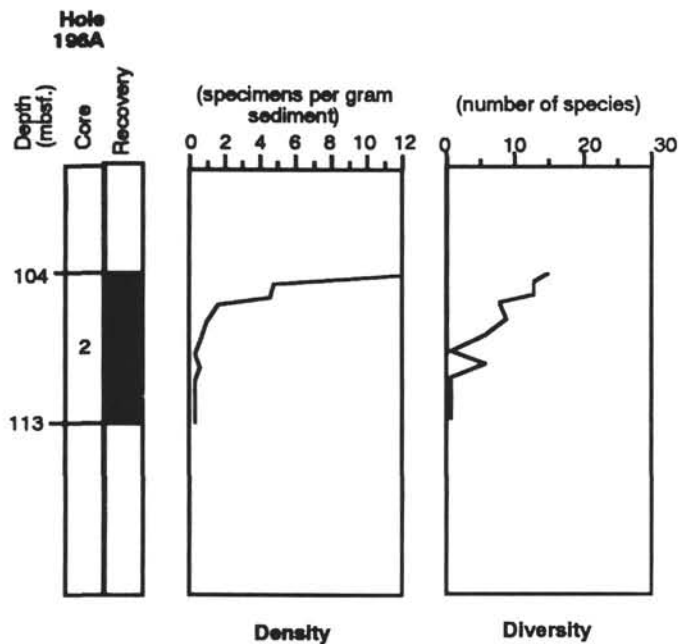


Figure 4. Foraminiferal diversity (number of species) and density (specimens per gram) in cores from Hole 196A.

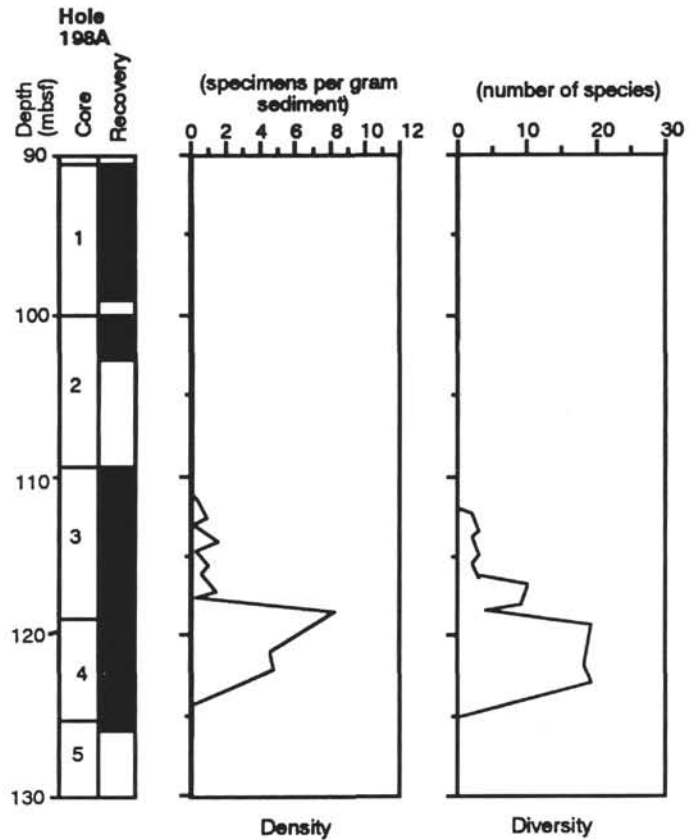


Figure 5. Foraminiferal diversity (number of species) and density (specimens per gram) in cores from Hole 198A.

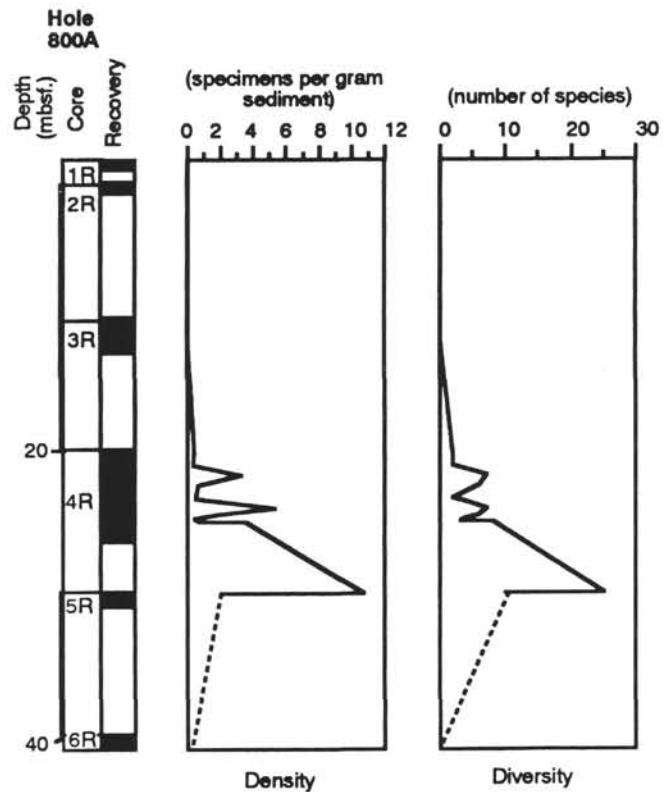


Figure 6. Foraminiferal diversity (number of species) and density (specimens per gram) in cores from Hole 800A.

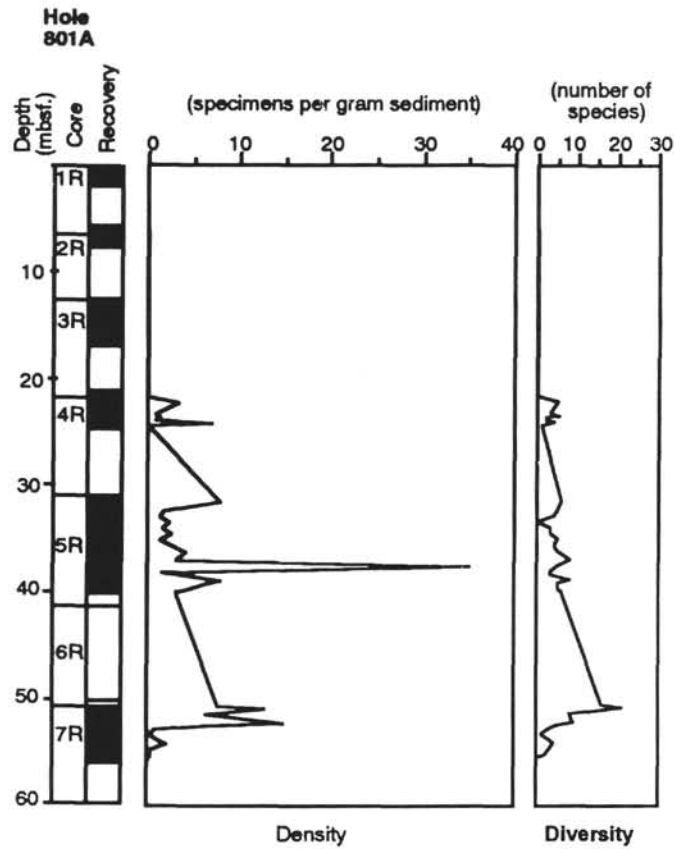


Figure 7. Foraminiferal diversity (number of species) and density (specimens per gram) in cores from Hole 801A.

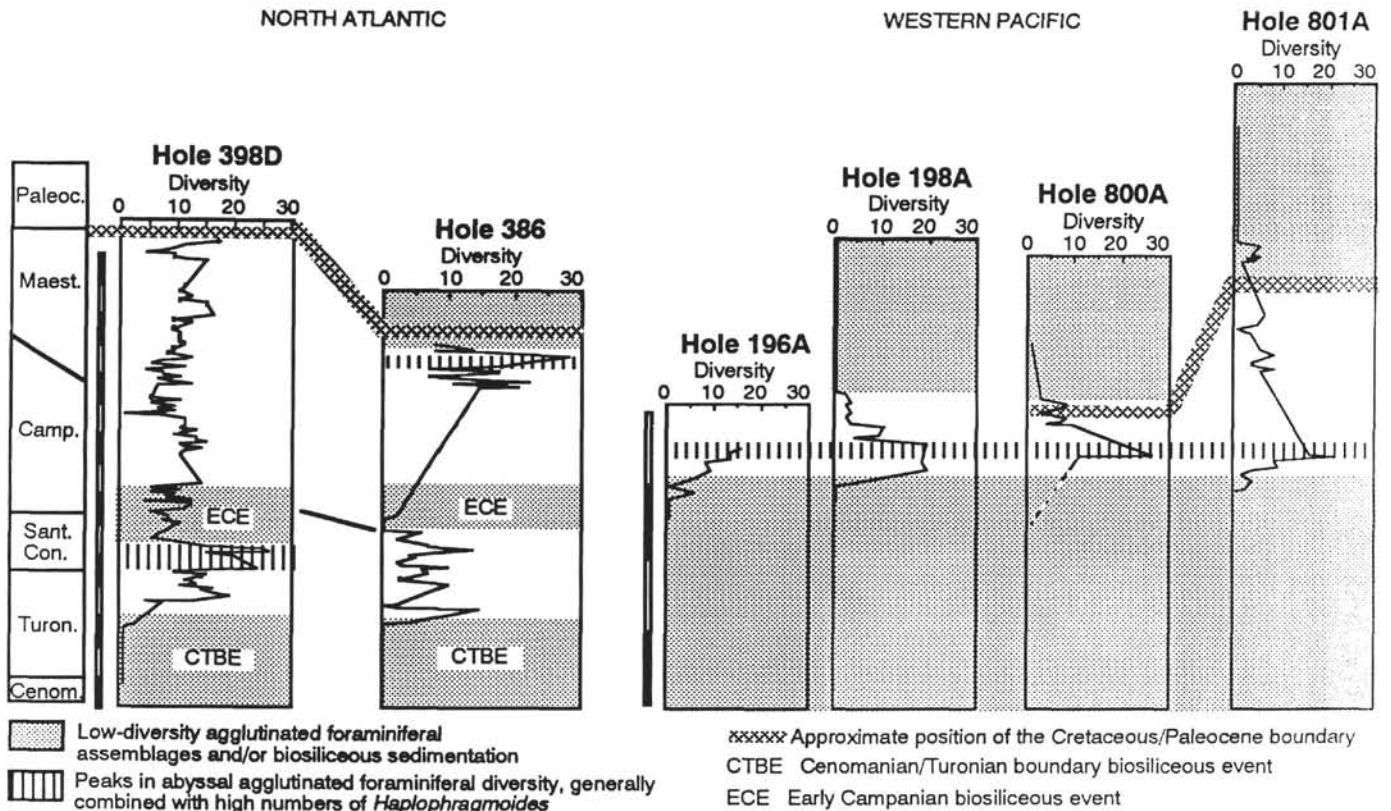


Figure 8. Comparison of the quantitative distribution of deep-water agglutinated foraminifera in the Upper Cretaceous of the western Pacific (Sites 196, 198, 800, and 801) and the North Atlantic (Sites 386 and 398).

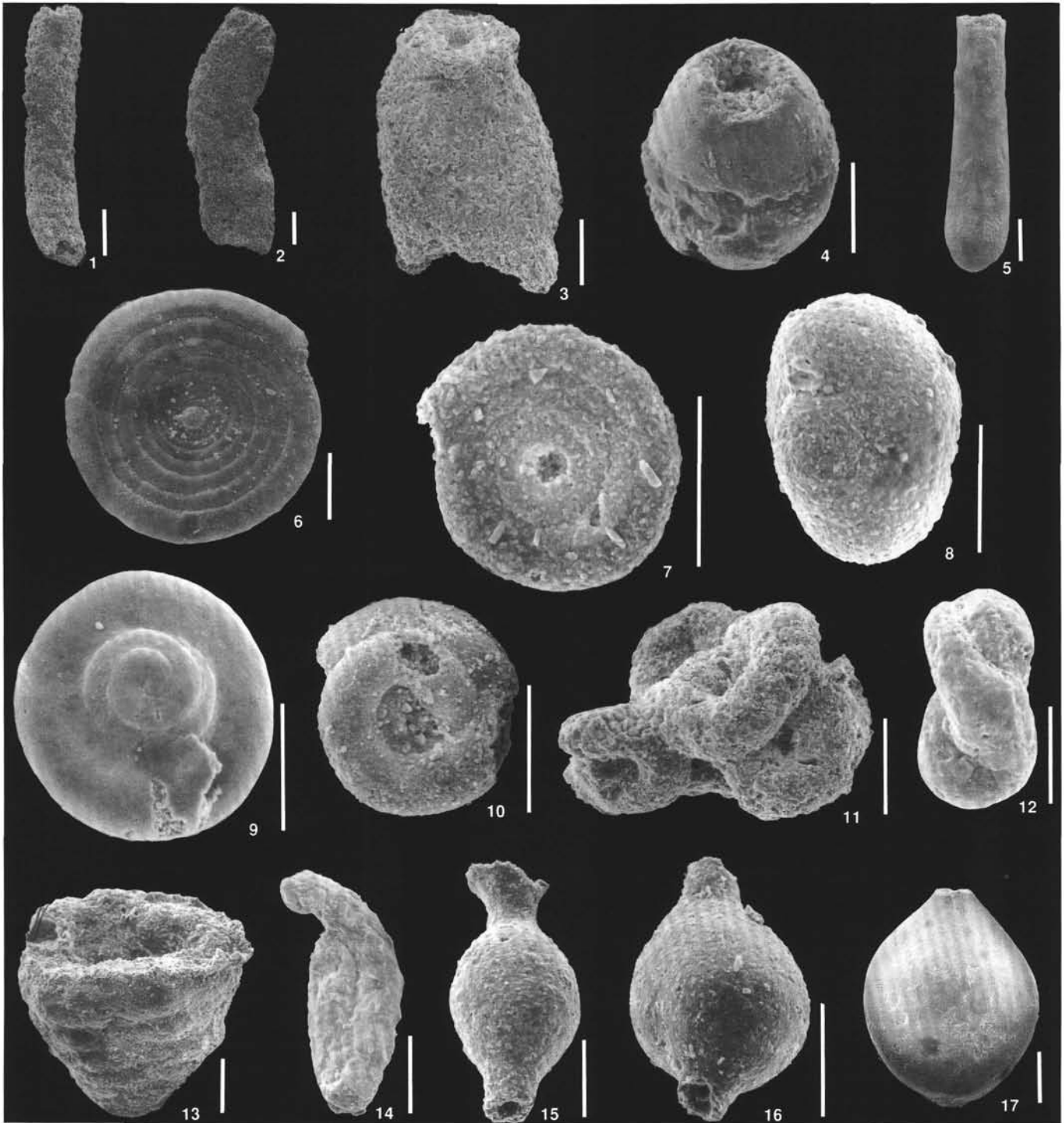


Plate 1. Scale bars = 100  $\mu$ m. **1.** *Rhizammina* sp., Sample 129-801A-5R-CC. **2.** *Dendrophrya* sp., Sample 129-801A-5R-CC. **3.** *Aschemocella*, sp., Sample 129-800A-4R-4, 5–10 cm. **4.** *Hyperammina dilatata*, Sample 129-801A-5R-CC. **5.** *Hyperammina elongata*, Sample 129-801A-7R-1, 124–129 cm. **6.** *Ammodiscus cretaceus*, Sample 129-800A-5R-CC. **7.** *Ammodiscus tenuissimus*, Sample 20-196-2-1, 143–145 cm. **8.** *Buzasina pacifica*, Sample 129-800A-5R-1, 15–20 cm. **9.** *Glomospira charoides*, Sample 129-801A-5R-1, 15–20 cm. **10.** *Glomospira gordialis*, Sample 129-801A-7R-1, 4–9 cm. **11.** *Glomospira irregularis*, Sample 129-800A-5R-1, 15–20 cm. **12.** *Glomospira serpens*, Sample 129-801A-5R-1, 83–87 cm. **13.** *Turritellella shoneana*, Sample 129-801A-5R-1, 117–120 cm. **14.** *Lituotuba lituiformis*, Sample 129-801A-4R-2, 32–34 cm. **15, 16.** *Hormosina crassa*, Sample 129-800A-5R-1, 15–20 cm. **17.** *Hormosina ovulum gigantea*, Sample 129-801A-4R-1, 62–67 cm.

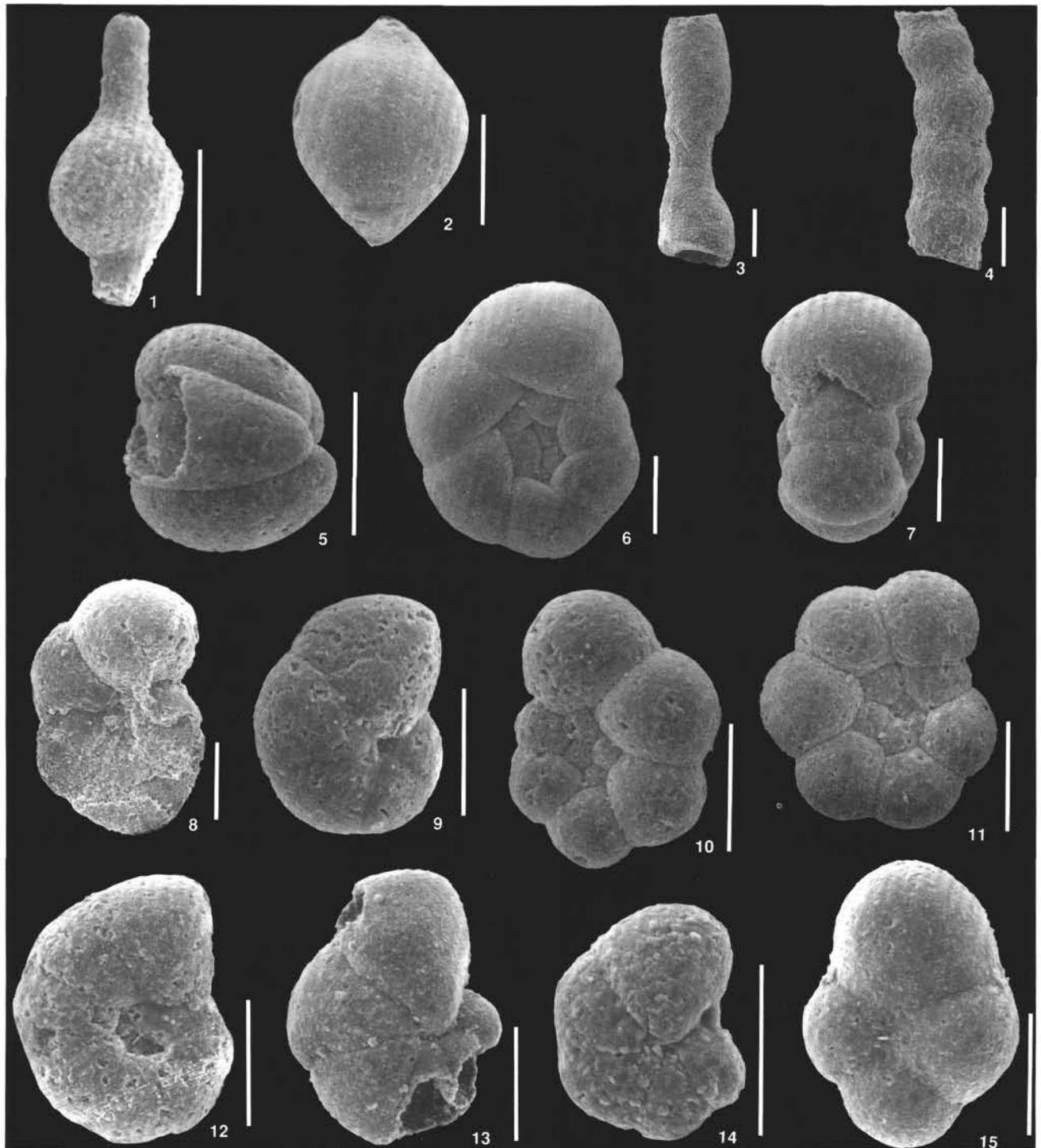


Plate 2. Scale bars = 100  $\mu$ m. 1. *Hormosina ovuloides*, Sample 129-800A-5R-CC. 2. *Hormosina ovulum ovulum*, Sample 129-800A-5R-CC. 3. *Kalamopsis gryzbowskii*, Sample 129-801A-6R-CC. 4. *Subreophax scalaris*, Sample 129-800A-5R-1, 15–20 cm. 5. *Adercotryma* sp. Sample 20-196A-2-1, 143–145 cm. 6, 7. *Haplophragmoides biumbilicalis*, Sample 129-800A-5R-1, 15–20 cm. 8. *Haplophragmoides* cf. *concavus*, Sample 129-801A-7R, 4–9 cm. 9. *Haplophragmoides decussatus*, Sample 129-800A-4R, 96–98 cm. 10, 11. *Haplophragmoides fraudulentus*, Sample 129-800A-5R-1, 15–20 cm. 12. *Haplophragmoides* ex gr. *herbichi*, Sample 20-198A-4-2, 20–24 cm. 13, 14. *Haplophragmoides incredibilis*, Sample 20-198A-4-2, 20–24 cm. 15. *Haplophragmoides krasheninnikov*, Sample 20-196A-2-1, 65–68 cm.



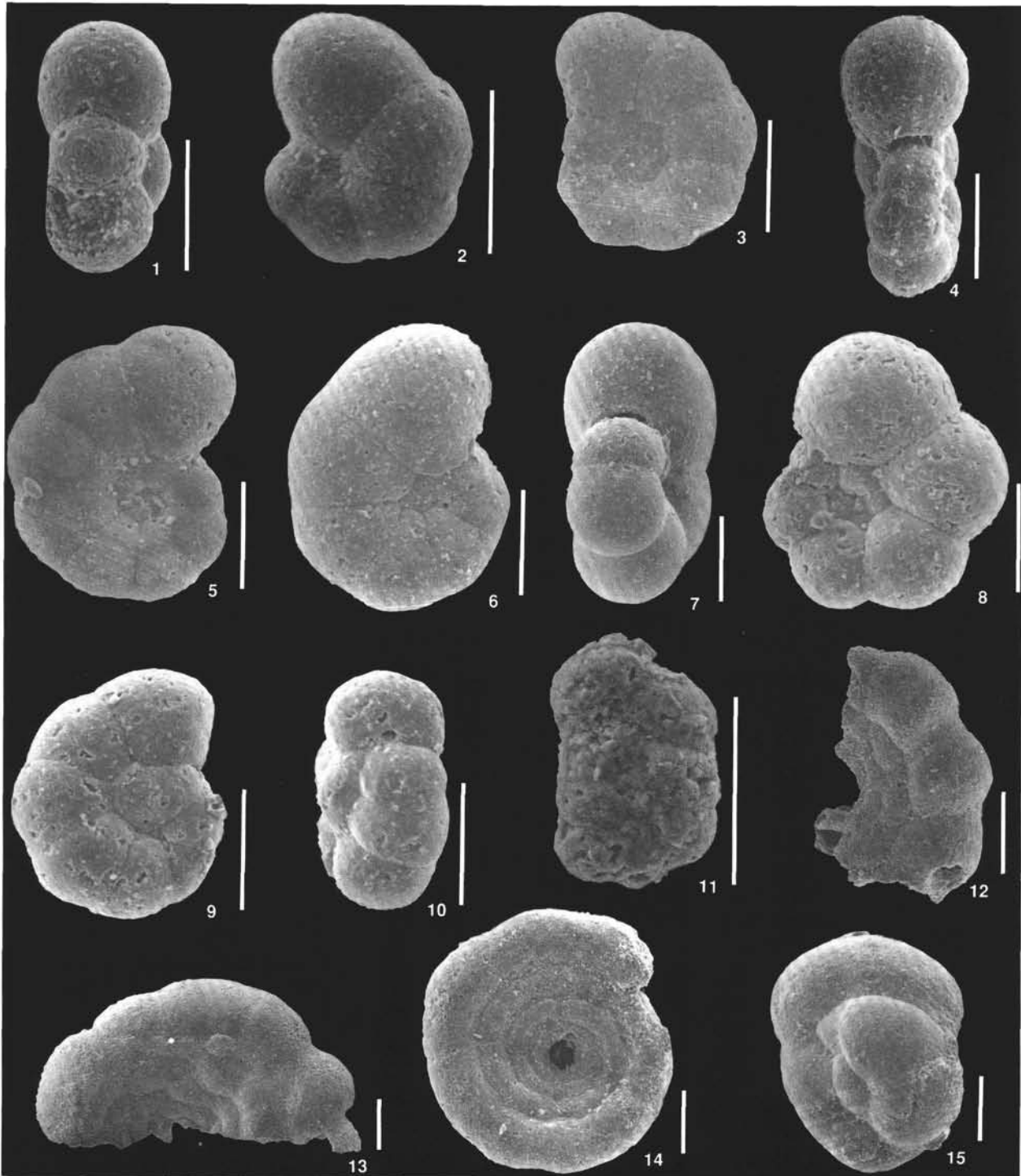


Plate 3. Scale bars = 100  $\mu\text{m}$ . **1.** *Haplophragmoides krasheninnikovi*, Sample 20-196A-2-1, 65–68 cm. **2.** *Haplophragmoides molestus*, Sample 20-196A-2-1, 1–4 cm. **3, 4, 5.** *Haplophragmoides multicamerus*, Sample 129-801A-6R-CC (3), Sample 129-800A-5R-CC (4, 5). **6, 7, 8.** *Haplophragmoides* ex gr. *perexplicatus-constrictus*, Sample 129-800A-5R-1, 15–20 cm. **9, 10.** *Recurvoides* sp., Sample 20-198A-3-6, 13–18 cm. **11.** *Bolivinopsis parvissimus*, Sample 129-800A-5-1, 83–87 cm. **12, 13.** *Trochamminoides proteus*, Sample 129-800A-5R-1, 15–20 cm. **14.** *Trochamminoides septatus*, Sample 129-801A-7R-1, 4–9 cm. **15.** *Paratrochamminoides corpulentus*, Sample 129-801A-7R-1, 4–9 cm.

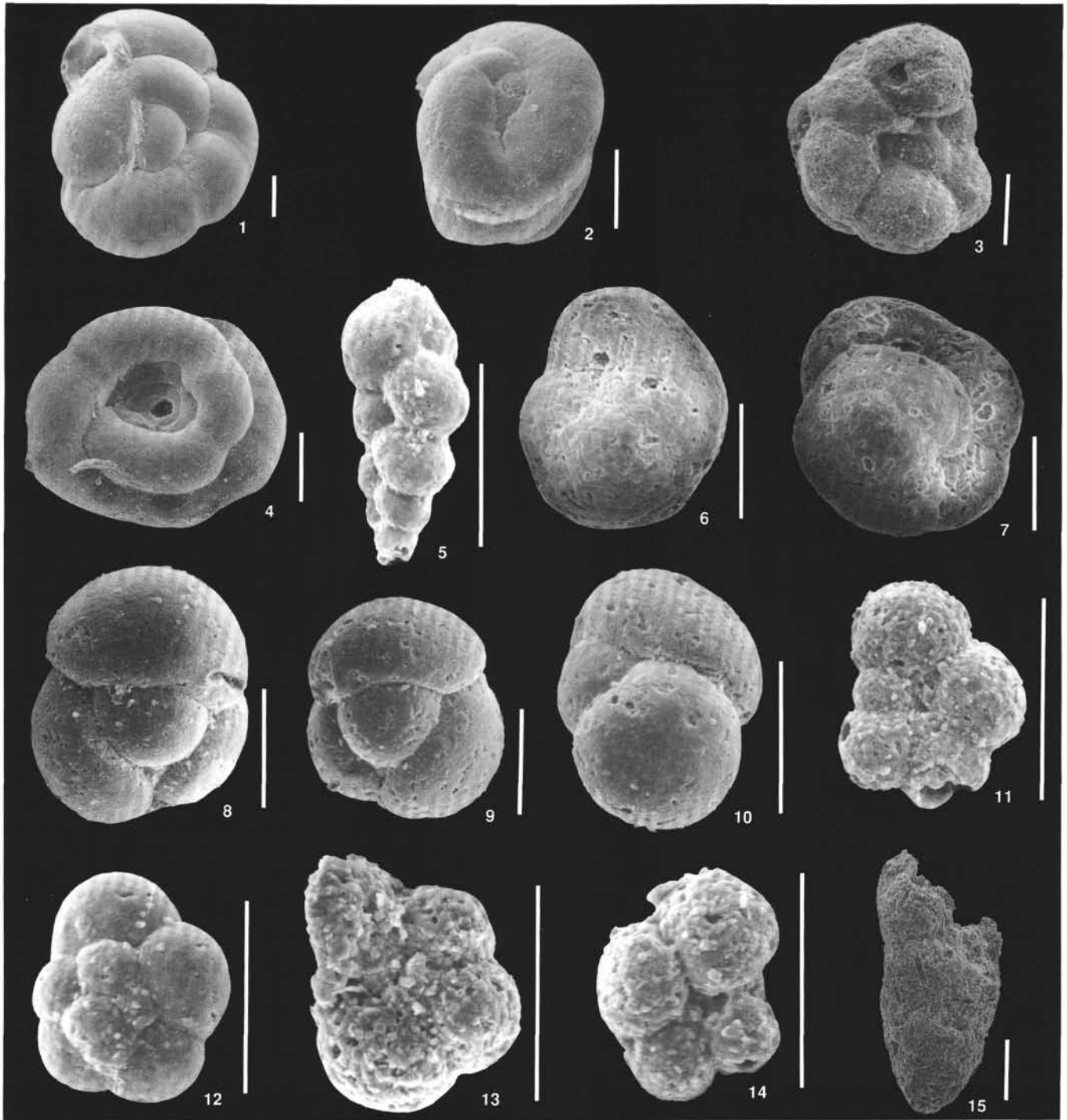


Plate 4. Scale bars = 100  $\mu$ m. 1. *Paratrochamminoides corpulentus*, Sample 20-198A-3-6, 113–118 cm. 2. *Paratrochamminoides dubius*, Sample 20-198A-3-6, 113–118 cm. 3. *Paratrochamminoides intricatus*, Sample 129-801A-7R-1, 4–9 cm. 4. *Paratrochamminoides olszewskii*, Sample 20-196A-2-1, 143–145 cm. 5. *Pseudobolivina munda*, Sample 129-800A-4R-4, 27–29 cm. 6. *Plectorecurvoides parvus*, Sample 20-196A-2-1, 143–145 cm. 7. *Plectorecurvoides rotundus*, Sample 20-196A-2-1, 143–145 cm. 8, 9, 10. *Praecystammina globigerinaeformis*, Sample 129-801A-7R-1, 124–129 cm. 11, 12, 13, 14. *Trochammina* sp. 1, Sample 129-801A-6R-CC (11, 12), Sample 129-801A-4R-2, 55–57 cm (13, 14). 15. *Karrerulina* sp., Sample 129-800A-5R-1, 15–20 cm.