

## 44. DATA REPORT: DISTRIBUTION OF PLEISTOCENE BENTHIC FORAMINIFERS FROM THE EASTERN EQUATORIAL ATLANTIC OCEAN<sup>1</sup>

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### ABSTRACT

Pleistocene benthic foraminifers recovered from four sites during Ocean Drilling Program Leg 159, located in the eastern equatorial Atlantic Ocean off the Côte d'Ivoire-Ghana, have been studied. Four different assemblages have been identified, each representing various depths and water masses.

### INTRODUCTION

For this study, four sites from the Ocean Drilling Program Leg 159, located on the Côte d'Ivoire-Ghana Transform Continental Margin in the eastern equatorial Atlantic Ocean, were examined (Fig. 1):

Site 959, located in 2100 m water depth on a small plateau that extends just north of the Côte d'Ivoire-Ghana marginal ridge on the southern shoulder of the deep Ivorian Basin;

Site 960, located 3 mi south of Site 959 in 2061 m water depth;

Site 961, located in 3303 m water depth at the bottom of the Côte d'Ivoire-Ghana marginal ridge; and

Site 962, located in 4650 m water depth on a small topographic bench southwest of the Côte d'Ivoire-Ghana marginal ridge's southern slope.

The uppermost parts of Sites 959, 960, and 961 (Shipboard Scientific Party, 1996a, 1996b, 1996c) are of Pleistocene age and consist of predominantly calcareous sediments with pyrite and organic matter. The uppermost part of Site 962 is of late Pleistocene age and consists of silty clays. It is located near the depth of the foraminifer lysocline. At Site 959, planktonic foraminifer data indicate an apparently continuous sequence from the middle Miocene M3 to the Holocene. Site 960 provides a nearly complete record of the Pliocene, but the Pleistocene sequence is disturbed. A discontinuous sequence from the Pleistocene to the upper Paleocene was identified at Site 961. At Site 962, a Holocene to late Pliocene assemblage is dominated by dissolution-resistant planktonic foraminifer taxa (Shipboard Scientific Party, 1996d).

We have studied the Pleistocene benthic foraminifers.

### METHODS AND MATERIALS

At Hole 959A, 13 Pleistocene samples have been examined: four from Hole 960C, three from Hole 961A—in which the Pleistocene sequence is very reduced—and 10 very poor or azoic samples from Hole 962B, which represents a deep sequence.

The samples were sieved on a 0.05-mm screen and counted to obtain about 150 specimens. For the least rich samples, foraminifers were extracted with CCl<sub>4</sub>.

The benthic foraminifers are listed in Table 1, and some of them are illustrated with SEM micrographs (Pl. 1).

### COMPOSITION OF THE ASSEMBLAGES

We have observed 90 species: three Textulariina, nine Miliolina and 80 Lagenina and Rotaliina. The most frequently encountered species at the four sites were (in alphabetical order)

*Bulimina rostrata*,  
*Cassidulina laevigata*,  
*Epistominella exigua*,  
*Fontbotia wuellerstorfi*,  
*Hoeglundina elegans*,  
*Melonis parkerae*,  
*Stilostomella adolphina*,  
*Uvigerina hispida*, and  
*Uvigerina peregrina*.

The most abundant species were

*Bulimina aculeata*,  
*Cassidulina laevigata*,  
*Epistominella exigua*,  
*Eponides tenera*,  
*Melonis parkerae*,  
*Uvigerina hispida*, and  
*Uvigerina peregrina*.

Overall, the most abundant species from the four sites was *Epistominella exigua*.

Rare species encountered, represented in only one or two sites, were

*Allomorphina trigona*,  
*Bolivina pseudoplicata*,  
*Bulimina aculeata*,  
*Bulimina clava*,  
*Bulimina exilis*,  
*Bulimina striata* subsp. *mexicana*,  
*Cancris oblongus*,  
*Cassidulina crassa*,  
*Cassidulinoides parkerianus*,  
*Ceratobulimina pacifica*,

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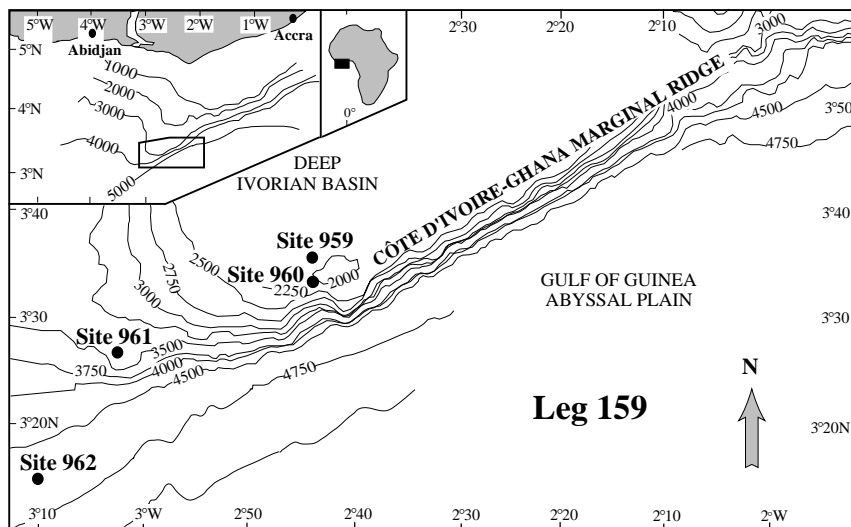


Figure 1. Locations of drilling sites on the Côte d'Ivoire-Ghana Transform Margin and surroundings (bathymetry is in meters), after Benkhelil et al. (1995).

*Cibicides robertsonianus*,  
*Dentalina guttifera*,  
*Dentalina intorta*,  
*Dentalina vertebralis*,  
*Eggerella bradyi*,  
*Fissurina alveolata*,  
*Fissurina lacunata*,  
*Karrerella bradyi*,  
*Lagena gracilis*,  
*Lagena striata*,  
*Lagena sulcata*,  
*Martinottiella communis*,  
*Nodosaria subsoluta*,  
*Oolina melo*,  
*Oolina williamsoni*,  
*Quinqueloculina venusta*,  
*Stomatorbina concentrica*, and  
*Uvigerina mediterranea*.

There is no obvious difference among Sites 959, 960, and 961. Site 962, however, is characterized by its very poor benthic foraminifer fauna: eight samples contain only 12 species.

## DISCUSSION

The Pleistocene microfaunas studied in the various sites are diversified both qualitatively and quantitatively. Several different associations are recognizable:

1. *Bulimina aculeata* assemblage. *B. aculeata* is predominant in Site 959 (as deep as 7.9 m). It is associated with *Bulimina marginata*, *Bulimina rostrata*, *Cassidulina laevigata*, *Fontbotia wuellerstorfi*, *Globocassidulina subglobosa*, *Melonis parkerae*, *Pyrgo murrhina*, *Sigmoilinita tenuis*, *Uvigerina ampullacea*, *U. hispida*, and *U. peregrina*.

According to Berggren and Haq (1976), *B. aculeata* is recorded from the lower to middle bathyal depth. Murray (1991) suggests that when *B. aculeata* and *B. marginata* are associated with the presence of *Globocassidulina subglobosa*, water is less cold. According to this author, *G. subglobosa* is characteristic of a salinity >35‰ (Mediterranean waters) and of a temperature of 4°–9°C.

2. *Cassidulina laevigata* and *Uvigerina peregrina* assemblage. *C. laevigata* is predominant at Sites 959 and 960. It is associated with *B. marginata*, *B. rostrata*, *F. wuellerstorfi*, *G. subglobosa*, *M. parkerae*, *Pullenia bulloides*, *Pyrgo murrhina*, and *U. hispida*.

This group is indicative of a rather large range of depths (Murray, 1991). Both species, *C. laevigata* and *U. peregrina*, are found together (Murray, 1991).

3. *Epistominella exigua* assemblage. It is most predominant at Site 959 (7.9 to 12.5 m depth), then in Hole 960C (as deep as 0.49 to 15.7 m), and at Site 961 (at 1.5 m depth). *E. exigua* is associated with *Heterolepa* sp., *Hoeglundina elegans*, *Cassidulina laevigata*, *Melonis parkerae*, *Stilostomella adolphina*, *Uvigerina hispida*, *U. peregrina*.

According to Murray (1991), this assemblage is indicative of a salinity lower than 35‰ and a temperature of 10°C; this assemblage is related to North East Atlantic Deep Water (Worthington 1976) and was observed by Schnitker (1974) and Weston and Murray (1984). *Epistominella exigua* is often found in the "fluffy layer" which represents the remains of phytoplankton blooms on the sediment surface (Goody, 1988 and Goody et al., 1992, in Struck, 1995; Murray, 1991)

4. *Eponides tenera* assemblage. It is predominant at Site 959 (from 11 to 18.5 m depth). *E. tenera* is associated with *Bulimina rostrata*, *Cassidulina laevigata*, *Cibicoides mundulus*, *Gyroidinoides soldanii*, *Melonis parkerae*, *Stilostomella adolphina*, *Uvigerina hispida*, and *U. peregrina*.

This assemblage is characteristic of cold waters and well known in the arctic seas (Murray, 1991).

*Epistominella exigua*, which is the most abundant species even at the foraminifer lysocline level, is a dissolution-resistant benthic species (Lévy et al., 1982). The scarcity of agglutinated specimens at depths down to 4650 m is very surprising. Agglutinated foraminifers are sometimes highly frequent in bathyal deposits (Brady, 1884; Lévy et al., 1982). On the contrary, Van Leeuwen (1989) noted the low and variable preservability of this group in the Angola basin.

Benthic foraminifers record, in their species composition, the properties of the water masses (Schnitker, 1980, Ruddiman and Jan-



Table 1 (continued).

Hole, bathymetry	959A; 2100 m												960C; 2061 m				961A; 3303 m			962B; 4650 m										
	1H-1	1H-2	1H-3	1H-4	1H-5	1H-6	2H-1	2H-2	2H-3	2H-4	2H-5	2H-6	2H-7	1H-1	1H-4	2H-3	2H-7	1R-1	1R-2	1R-2	1H-1	1H-2	1H-3	1H-4	1H-5	2H-1	2H-5	2H-6		
Interval (cm)	40-42	40-42	40-42	40-42	40-42	40-42	40-42	40-42	40-42	40-42	40-42	40-42	40-42	49-51	50-52	50-52	50-52	5-7	2-4	3-5	75-77	75-77	75-77	75-77	54-56	74-76	75-77	75-77		
Depth (mbsf)	0.40	1.90	3.40	4.90	6.40	7.90	9.50	11.00	12.50	14.00	15.50	17.00	18.50	0.49	5.00	9.70	15.70	0.05	1.52	1.53	0.75	2.25	3.75	5.25	6.54	8.24	14.25	15.75		
Age	Pleistocene												Pleistocene			Holocene			Pleistocene											
Nannofossils biozone	CN14a						CN13a						CN13b				CN15	CN14a	CN12a	CN15	CN13a	CN15	CN14b			CN14a				
<i>Globocassidulina subglobosa</i>	3	4		7					1	3	3	1	1							1	7									
<i>Gyroidina umbonata</i>				1	4														9											
<i>Gyroidinoides neosoldanii</i>							2		17	8	4								8	5	1	2								
<i>Heterolepa</i> sp.	5		2			16	7	1	6	2										2										
<i>Hoeglundina elegans</i>	3	2					1		3					5	10	11	53	3	2	2	1									
<i>Karreriella bradyi</i>																				1										
<i>Lagena gracilis</i>				1																1										
<i>Lagena hispidula</i>						1	1		3																					
<i>Lagena laevis</i>									1	1																				
<i>Lagena</i> sp.				1									1	1		1														
<i>Lagena striata</i>													1																	
<i>Lagena sulcata</i>	7	1				1												2												
<i>Lenticulina gibba</i>						1																								
<i>Martinottiella communis</i>						1																								
<i>Melonis parkerae</i>			14	17	15	17	9	1	4	7	6	6	7	10	4	3	16	7	6	5										
<i>Melonis pompilioides</i>						6	2										1													
<i>Nodosaria subsoluta</i>							1															1							2	
<i>Nodosaria vertebralis</i>											8																			
<i>Nonion</i> sp.								2									1	6												
<i>Oolina melo</i>	1																													
<i>Oolina</i> sp.																						1								
<i>Oolina williamsoni</i>				1																										
<i>Polymorphinidae</i>		1	3	1																										
<i>Pseudoepionides</i> sp.													4								1									
<i>Pullenia bulloides</i>		7	2	1	4		2	8	1		1	3	4								3									
<i>Pullenia quinqueloba</i>		3	2		1				2	2	1	1		1	1		2				3									
<i>Pyrgo depressa</i>			1							1				1																
<i>Pyrgo murrhina</i>	2	2	10	2	1	2	2			1	1			1		1														
<i>Pyrgo serrata</i>	1	1												1																
<i>Pyrgo</i> sp.														1																
<i>Quinqueloculina</i> sp.																1														
<i>Quinqueloculina venusta</i>																														
<i>Sigmoilinita tenuis</i>	3	3	2	1	1				1				1																	
<i>Sigmoilopsis schlumbergeri</i>	2																													
<i>Stilostomella</i>						1	6	16	10	8	12	7	6																	
<i>Stilostomella adolphina</i>																		13	21											
<i>Stilostomella consobrina</i>																	2													
<i>Stomatorbina concentrica</i>						3																								
<i>Uvigerina ampullacea</i>	2	1	8				4	3	5	1	16	18	15	15	7	14	13	13	10	9	2									
<i>Uvigerinahispida</i>	7	8	14		5	6																								
<i>Uvigerina mediterranea</i>													1	1																
<i>Uvigerina peregrina</i>	14	21	28	23	54	6	14	32	33	7	4	11	20	14	5	3	36	33	2	4									1	
Total sum	56	79	106	85	107	79	60	134	84	85	94	94	110	55	41	64	177	106	41	49	6	10	6	8	10	9	10	13		

ecek, 1989). All the species belong to the typical fauna of the slope of the Atlantic seaboard of Europe and Africa (Douglas and Woodruff, 1981; Murray, 1991). Moreover, the assemblage with *Globocassidulina subglobosa*, *Fontbotia wuellerstorfi*, *Hoeglundina elegans*, and *Uvigerina peregrina* is considered by Schnitker (1974) and Weston and Murray (1984) to be typical of the North Atlantic Deep Water (NADW). Schnitker (1980), in his study of the Quaternary deep-sea benthic foraminifers, the assemblage characterized by *F. wuellerstorfi* and *Epistominella exigua* occurs in samples from NADW, and the assemblage dominated by *U. peregrina* occurs in conjunction with relatively warm and saline water, which is in large part of Mediterranean origin.

## CONCLUSION

In spite of the quantitative homogeneity of the microfaunal assemblages, the quantitative analysis shows the existence of four main assemblages.

The first two assemblages, with *Bulimina aculeata*, *Cassidulina laevigata* and *Uvigerina peregrina*, characterize the deep-sea water masses of the ocean (Murray, 1991).

The *Epistominella exigua* assemblage is related to the NADW, suggesting a temperature  $>2^{\circ}\text{C}$  and a salinity of  $\sim 34^{\circ}9$ . This association is located in the lower part of Hole 959A (CN 14a and CN 13a).

The last assemblage, which contains *Eponides tenera*, confirms the cold character inferred from the previous association.

The upper part of Site 959 (CN 14a) shows a temperature greater than the one of the lower part, whereas Sites 960, 961, and 962 do not show any noticeable variations.

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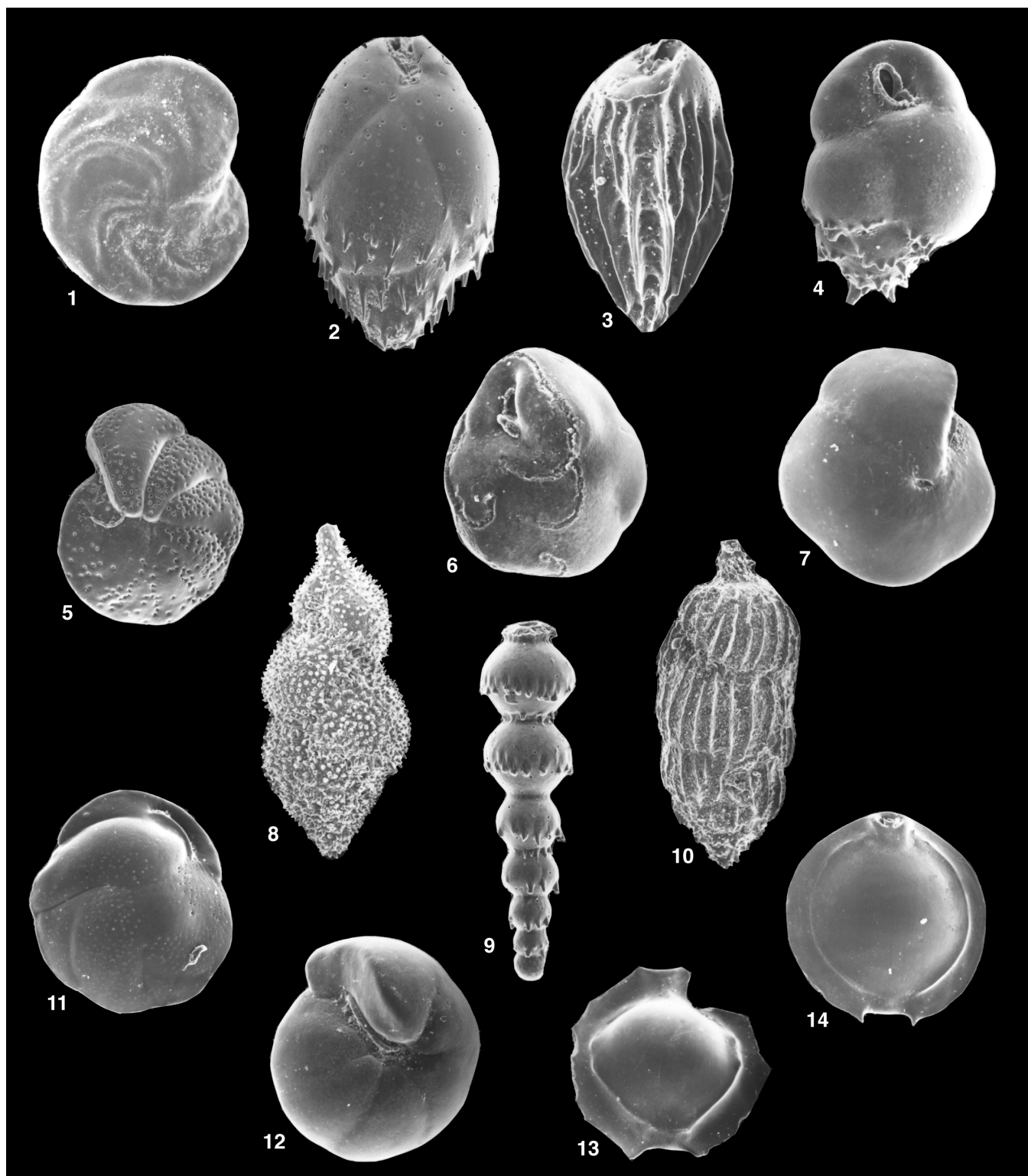


Plate 1. SEM pictures of benthic foraminifers. **1.** *Fontbotia wuellerstorfi* (Schwager), Sample 159-959A-1H-2, 40–42 cm, 80 $\times$ . **2.** *Bulimina aculeata* d'Orbigny, Sample 159-959A-1H-2, 40–42 cm, 90 $\times$ . **3.** *Bulimina rostrata* Brady, Sample 159-959A-1H-4, 40–42 cm, 115 $\times$ . **4.** *Bulimina marginata* d'Orbigny, Sample 159-959A-1H-4, 40–42 cm, 135 $\times$ . **5.** *Cibicides mundulus* (Brady), 159-959A-2H-4, 40–42 cm, 35 $\times$ . **6.** *Epistominella exigua* (Brady), 159-959A-2H-2, 40–42 cm, 185 $\times$ . **7.** *Epistominella tenera* (Brady), Sample 159-959A-2H-2, 40–42 cm, 90 $\times$ . **8.** *Uvigerina hispida* Schwager, Sample 159-959A-2H-2, 40–42 cm, 80 $\times$ . **9.** *Stilostomella adolphina* (d'Orbigny), Sample 159-959A-2H-2, 40–42 cm, 85 $\times$ . **10.** *Uvigerina peregrina* Cushman, Sample 159-959A-1H-5, 40–42 cm, 55 $\times$ . **11.** *Cassidulina laevigata* d'Orbigny, Sample 159-959A-1H-2, 40–42 cm, 110 $\times$ . **12.** *Gyroidinoides neosoldanii* (Brotzen), Sample 159-959A-2H-4, 40–42 cm, 100 $\times$ . **13.** *Pyrgo serrata* Bailey, Sample 159-959A-1H-3, 40–42 cm, 50 $\times$ . **14.** *Pyrgo murrhina* (Schwager), Sample 159-959A-1H-3, 40–42 cm, 50 $\times$ .