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28. LOWER CRETACEOUS BENTHIC FORAMINIFER ASSEMBLAGES, EQUATORIAL ATLANTIC: BIOSTRATIGRAPHIC, PALEOENVIRONMENTAL, AND PALEOBIOGEOGRAPHIC SIGNIFICANCE[1]

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ABSTRACT

Lower Cretaceous benthic foraminiferal assemblages from basal sedimentary sequences of Holes 959D, 962B, and 962D provide time constraints for the onset of marine sedimentation on the Côte d'Ivoire-Ghana Transform Margin and show that marine conditions were already established by late Aptian–early Albian near Hole 959D and by mid to late Albian near Hole 962D. The foraminiferal data suggest that older Aptian–Albian marine sequences were subsequently reworked into upper Albian–lowermost Cenomanian sediments within tectonically active sub-basins. Marked fluctuations in test size, abundance, and diversity reflect a pulsed sedimentation pattern with an overall high accumulation rate. Three main cycles of deposition are detected from overall changes in preservation, abundance and diversity, which are possibly related to major shifts in sediment provenance and/or supply. The composition of the benthic foraminiferal assemblages at Holes 959D and 962D indicates an outer shelf to upper bathyal setting and reflects a combination of Tethyan, South Atlantic, and local endemic faunal influences, pointing to restricted connections with the open ocean and Tethys during the late Albian and early Cenomanian. There is no evidence for bottom-water anoxia or severe dysoxia during the deposition of Cores 159-962D-16R through 37R. The high dissolution of planktonic tests and absence or scarcity of benthic foraminifers in the upper part of the sequence (Sections 159-962D-7R-1 through 13R-1 and 159-962B-8H-5 through 9H-6) indicate some later deterioration in bottom-water oxygenation.

INTRODUCTION

Except for some early investigations by de Klasz et al. (1960, 1961, 1963), de Klasz and Rérat (1962, 1963), Castelain et al. (1962), Fayose and de Klasz (1976), and Petters (1982, 1983), which focused on Upper Cretaceous foraminiferal assemblages from equatorial western Africa, very few studies have been published on Lower Cretaceous foraminifers from western African basins. De Klasz and du Chêne (1978) reported Albian–Cenomanian marine sequences, onshore and offshore, from Liberia to Nigeria, but did not include any foraminiferal data in their review. In a recent study, Saint-Marc and N'Da (in press) described upper Albian–Cenomanian marine sequences containing sparse planktonic and benthic foraminifers, from the base of an exploration well, drilled 15 km south-southwest off Abidjan in the Deep Ivorian Basin. The authors suggested that shallow marine incursions developed along the Côte d'Ivoire margin in the Albian to Cenomanian, during the early rifting stage of the Proto-South Atlantic.

During the drilling of Leg 159, thick basal Cretaceous sedimentary sequences were recovered at Holes 959D, 960A, and 962D, in more distal settings from the African continent, close to the continent/ocean boundary. Some of the sequences contain abundant planktonic and benthic foraminifers, which may provide further insight into the timing of continental separation (de Klasz, 1978; Moullade and Guérin, 1982; Moullade et al., 1993; Bonatti et al., 1996) and the early paleoceanographic evolution of the embryonic equatorial Atlantic. The main aims of this study are, therefore, to document the Lower Cretaceous benthic foraminiferal assemblages from Leg 159, and to use these data to constrain biostratigraphically the onset of marine sedimentation and to interpret the early paleoenvironments of the Côte d'Ivoire-Ghana Transform Margin.

LOCATION AND GEOLOGICAL SETTING

Figure 1 shows the location of all holes where Lower Cretaceous sediments were recovered during the drilling of Leg 159. Hole 959D is situated at 3°37.656′N, 2°44.149′W, in a water depth of 2090.7 m, on a small plateau close to the top of the Côte d'Ivoire-Ghana Marginal Ridge (CIGMR), which extends along the southern side of the Deep Ivorian Basin. Hole 960A was drilled close to the center of the ridge on the same plateau, 3 mi south of Hole 959D, at 3°35.025′N, 2°43.990′W, in a water depth of 2048.3 m. Holes 962B and 962D are located, respectively, at 3°15.063′N, 3°10.919′W, and 3°15.082′N, 3°10.898′W, and in water depths of 4637.0 and 4654.3 m, near the summit of a minor ridge extending southwest of the main CIGMR and north of the oceanic crust, which is covered by a thick sequence of undeformed sediments (Mascle, Lohmann, Clift, et al., 1996, chap. 8, fig. 3).

Comprehensive lithologic and sedimentological descriptions of Lower Cretaceous sedimentary sequences recovered from Holes 959D, 962B, and 962D can be found in Mascle, Lohmann, Clift, et al., 1996. The basal sediments at Holes 959D (lithologic Unit V), 962B (lithologic Unit II), and 962D (lithologic Unit III) were originally dated as late Albian on the basis of nannofossils and planktonic foraminifers, whereas the basal lithologic unit at Hole 960A (lithologic Unit V), which underlies sediments of Turonian-Coniacian age, remained undated (Mascle, Lohmann, Clift, et al., 1996). Mascle, Lohmann, Clift, et al. (1996) suggested that the basal sedimentary units from Holes 959D, 960A, and 962D were post-rift deposits and that strike faulting and uplifting of deepest sequences concurred with sedimentation. These basal sequences, therefore, reflect a complex paleotopography, marked by several fossil ridges, northward prograding sedimentary lenses deposited in developing half-grabens and distal fans along the steeper northern slopes of the CIGMR. According to Mascle, Lohmann, Clift, et al. (1996), the northward progradation of the sediments indicates that the terrigenous components were

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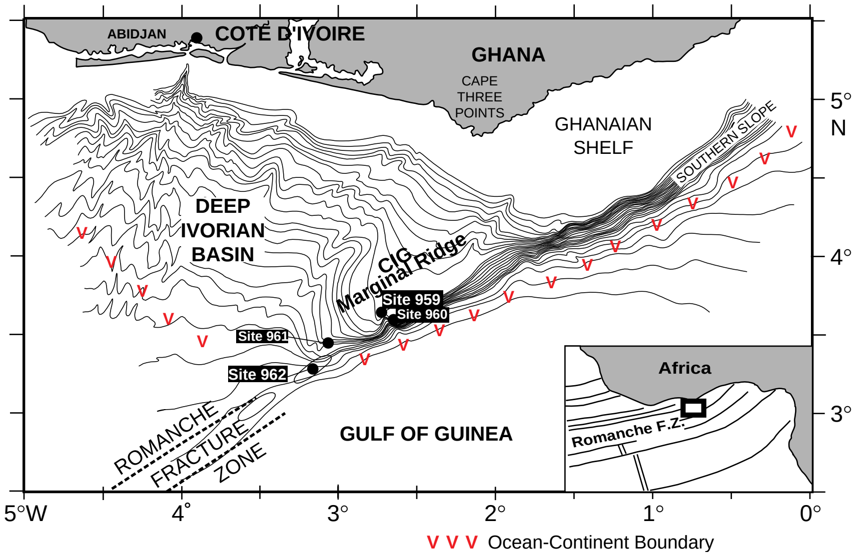

Figure 1. Locations of Sites 959–962.

mainly derived from the Brazilian Shelf, then located just south of the intracontinental transform margin.

METHODS

A total of 154 samples (approximately 20 cm^3) from the basal lithologic units of Holes 959D, 960A, 962B, and 962D were analyzed (Table 1). The samples were dried, weighed, soaked in distilled water, wet-sieved through a 63 µm screen, and the residue was dried. Very consolidated samples were first treated with a buffered 5% hydrogen peroxide solution to help break them up before sieving. In rare cases where this hydrogen peroxide treatment did not lead to complete disintegration of the clay, we soaked the dried sample in a concentrated anionic tenside solution (REWOQUAT of REWO Chemie, Steinau an der Strasse, Germany), that usually disintegrated even slightly silicified samples. Generally, the complete residue was picked for benthic foraminifers. In a few exceptional samples with extremely high faunal content, only splits of the samples were picked. Splitting was done with a standard Otto-splitter. Fragments of tubular species were counted as one individual; indeterminable fragments or extremely deformed specimens were picked, but not included in the counts. The foraminiferal slides are housed in the micropaleontology collections of the Geologisch-Paläontologisches Institut at the Christian Albrechts University in Kiel. Electron micrographs were made on a Camscan SEM at the Geologisch-Paläontologisches Institut at the Christian Albrechts University in Kiel. To clarify the biostratigraphic assignations made for each hole, a table was compiled from the literature that shows the stratigraphic ranges of relevant benthic and planktonic foraminiferal species (Fig. 2).

Table 1. Summary of samples studied from Holes 959D, 960A, 962B, and 962D.

Hole	Core sections	Lith. unit	Samples
959D	71R-1 to 78R-7	5	20
960A	37R-1 to 60R-2	5	23
962D	7R-1 to 37-CC	3	92
962B	7H-1 to 9H-6	2	19

BIOSTRATIGRAPHY

Hole 959D

The samples from the basal part of this hole are either barren or contain sparse assemblages of poorly preserved planktonic and benthic foraminifers. The presence of *Gavelinella flandrini* and *Hedbergella infracretacea* in Sample 159-959D-71R-1, 30–33 cm, points to a late Aptian or early Albian age for this assemblage (Fig. 2). However, some samples below this interval contain a few specimens of *Berthelina intermedia, Gavelinella* spp., *Bolivina* sp. 1, *?Spiroplectinella* sp. 1, *Heterohelix* sp. and *Schackoina* sp., which are also found to occur abundantly at Hole 962D, from Cores 159-962D-37R to 7R. A latest Albian-earliest Cenomanian age is suggested for these assemblages, by the presence of *Berthelina intermedia*, *Bolivina* sp. 1, *?Spiroplectinella* sp. 1, *Heterohelix* sp., and *Schackoina* sp. (Fig. 2).

Hole 960A

No benthic or planktonic foraminifers were recovered from the basal lithologic unit at this hole, except for a few downhole contaminants.

Hole 962D

Abundant, small benthic foraminifers as well as planktonic foraminifers, ostracodes, diatoms, and radiolarians are found only in the 63- to 125-µm fraction of most of the samples. Results are shown in Table 2. The assemblages are predominantly composed of calcareous taxa, but some samples also contain a small agglutinated component. The main calcareous genera are *Patellina*, *Trocholina*, *Berthelina, Gavelinella, Osangularia, Bolivina, Neobulimina, Laevidentalina, Frondicularia, Lingulina, Globulina*, and *Quinqueloculina.* Agglutinated genera consist mainly of some *?Spiroplectinella* and very rare tubular forms. Preservation varies considerably, and marked fluctuations in size, diversity, and abundance of benthic foraminiferal assemblages are observed throughout the sequence. Three main cycles are distinguished in the succession. From Cores 159-962D-9R through 13R, the preservation is consistently poor (planktonic foraminiferal tests are partially dissolved) and benthic foraminiferal diversity and abundance are low. No samples were available for study from Cores 159-962D-14R and 15R, which had extremely low recovery. From Cores 159-962D-16R through 20R, the preservation is mostly good and the benthic assemblages are abundant and diverse.

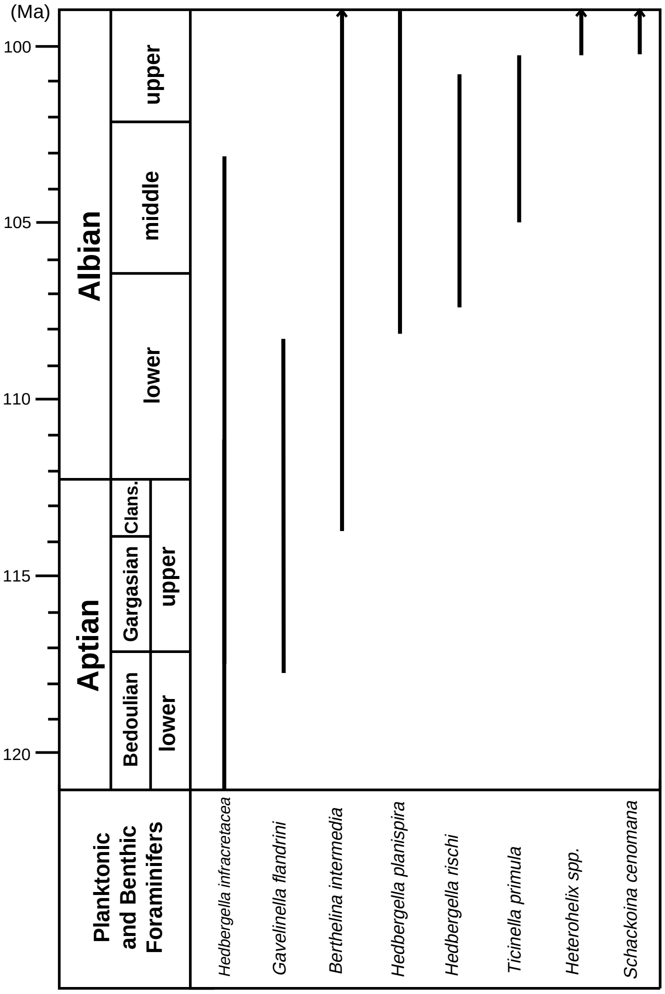

Figure 2. Stratigraphic ranges of age diagnostic planktonic and benthic foraminifers compiled from Moullade (1966, 1974), Robaszynski and Caron (1995). Time scale after Gradstein et al. (1994).

From Cores 159-962D-21R through 37R, the preservation, size, diversity, and abundance of benthic foraminiferal assemblages show great variability. Second-order fluctuations in abundance and diversity can also be detected within the three main cycles.

The foraminiferal biostratigraphy at Hole 962D is problematic, due to the absence of large keeled planktonic foraminifers. However, the co-occurrence of the planktonic foraminifers *Hedbergella delrioensis, Schackoina* sp., and *Heterohelix* sp. points to a latest Albian to earliest Cenomanian age for the sequence (Fig. 2). Planktonic assemblages of a slightly older age—including *Hedbergella rischi* with a late early Albian to late Albian range (Moullade, 1966, 1974), forms transitional to *Ticinella primula* (mid-Albian), *Hedbergella infracretacea* with a last appearance datum (LAD) end of mid-Albian (Moullade, 1966, 1974), and *Ticinella primula* with a mid-Albian to late Albian (early Vraconian) range (Moullade, 1966, 1974; Robaszynski and Caron, 1995)—are also intermittently recorded throughout the sequence, suggesting that the in situ sediment might periodically include allochthonous components derived from older stratigraphic units.

Few stratigraphically significant benthic foraminifers are found in the assemblages from Hole 962D. The genera *Spiroplectinella* and *Neobulimina* are not recorded in sediments older than late Albian in the literature. *Osangularia* is a typical Albian genus, rarely reported from older deposits (Guérin, 1981; Dailey, 1970; 1983; Haig, 1992; Crittenden and Price, 1990), although it does also occur in younger sediments. Some of the more common taxa at Hole 962D (*Bolivina* sp. 1, *?Spiroplectinella* sp.1, and *?Osangularia* sp. 2) were left in open nomenclature because they could not be matched with any described species in the literature. These taxa probably indicate some degree of endemism in the benthic foraminiferal assemblages of the basin during the Albian, and the stratigraphic potential of these endemic species remains to be investigated.

Hole 962B

A high level of dissolution is evident in most of the foraminiferal tests from this site. Planktonic foraminifers as internal molds, including *Hedbergella planispira* and *Hedbergella delrioensis,* were found in Sections 159-962B-8H-5 through 9H-6. Rare, benthic foraminifers, including some small gavelinellids and some *?Spiroplectinella*, which were found in abundance at Hole 962D, were recovered only in Section 159-962B-9H-4. These, together with small specimens of *Hedbergella planispira* and *Hedbergella delrioensis,* indicate a late Albian–earliest Cenomanian age for Section 159-962B-9H-4. Planktonic foraminifers in Sections 159-962B-8H-5 through 8H-CC are larger and with a more evolved morphology than in Sections 159-962B-9H-2 through 9H-6, suggesting a slightly younger Cenomanian? age for the upper interval. One well-preserved specimen of *Stilostomella* in Section 159-962B-8H-5, base, points to a Late Cretaceous age. The occurrence of numerous fish teeth in Sample 159-962B-8H-5 and in samples from two intervals, 159-962B-8H-4, 0–90 cm, and 8H-3, 140–150 cm, which also contain glauconite, indicates that accumulation rates were probably very slow, so that the concentration of the most resistant microfossils became enriched over a long time span. Cores 159-962B-7H and 8H are thus thought to represent condensed sequences, and hiatuses may have occurred during their deposition.

PALEOENVIRONMENTS

Hole 959D

The reversed stratigraphical position of the sparse foraminifers found in Hole 959D suggests that marine sediments of a late Aptian to early Albian age were being reworked into younger sediments of a late Albian to early Cenomanian age. Intermixing, or transport by sliding, may have occurred from a nearby uplifted source undergoing rapid erosion, following, for instance, an unroofing event on the tectonically active transform margin of separating plates.

Hole 960A

In Hole 960A the absence of foraminifers throughout the succession is in agreement with the paleoenvironmental interpretation of lacustrine sediments for lithologic Subunit VB and of brackish marine deposits for lithologic Subunit VA. Palynological evidence also supports this interpretation as spores and pollens are only recovered from lithologic Subunit VB, and rare, poorly preserved dinoflagellates from lithologic Subunit VA (Masure et al., Chap. 24, this volume; Oboh-Ikuenobe et al., Chap. 25, this volume).

Hole 962D

In Hole 962D, which is situated on a minor ridge extending southwest and in the prolongation of the main CIGMR, the abundant foraminiferal assemblages can be used to constrain both the timing of deposition and the paleobathymetry of the area. Marked fluctuations in test size, abundance, and diversity reflect a pulsed sedimentation pattern with an overall high accumulation rate during the late Albian–

Table 2. Benthic foraminiferal data for Hole 962D.

Core, section, interval (cm)	*Patellina subcretacea*	*Trocholina infragranulata*	*Spirillina minima*	*Berthelina intermedia*	*Gavelinella* spp—	*Osangularia* sp—1	*Osangularia* sp—2	*Globulina prisca*	*Oolina sulcata*	*Pyrulina cylindroides*	*Oolina* sp—	Miliolids	*Bolivina* sp—1	*Neobulimina albertensis*	*Frondicularia lamellata*	*Furkensoina viscida*	*Laevidentalina* spp—	*Laevidentalina linearis*	*Laevidentalina oligostegia*	*Lingulonodosaria nodosaria*	*Bolivina* sp—	?*Spiroplectinella* sp—1	*Globorotalites* sp—	*Gyroidinoides* cf— *nitidus*	*Astacolus calliopsis*	*Marginulinopsis striatocostata*	*Planularia complanata*	*Pseudonodosaria* sp.1	*Globulina* spp—	*Tristix acutangula*	*Lingulina* spp—	*Pyramidulina sceptrum*	*Lenticulina* spp—	*Saracenaria* sp—	*Laevidentalina debilis*	*Laevidentalina nana*	*Charltonina australis*	*Vaginulina petila*	*Berthelina* sp—	*Nothia latissima*	*Oolina* cf— *sulcata*	*Rhizammina* spp—	*Charltonina australis*	*Bolivina anambra*	Number of BF species	Number of BF specimens	Ostracodes	Diatoms	Radiolarians	Fish teeth	Preservation
7R-1, 40-44	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	1	—	—	P
9R-1, 18-22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	—	—	—	M
9R-1, 34-38	1	—	—	—	2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	3	5	—	—	C	—	G
9R-2, 37-41	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	—	C	—	P
9R-3, 111-115	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	—	—	—	VP
9R-4, 8-12	2	2	—	3	3	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	12	—	—	A	—	P
9R-5, 69-72	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	—	C	—	p
9R-5, 110-114	—	—	—	3	2	—	2	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	6	10	—	—	R	—	P
10R-2, 45-48	11	4	3	8	12	—	—	—	7	—	—	—	3	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	49	2	2	R	—	M
10R-2, 86-89	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	—	—	—	P
10R-CC, 15-17	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	—	—	C	—	VP
11R-1, 16-19	2	2	—	6	9	—	4	—	1	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	9	30	—	—	C	—	M
11R-CC, 4-7	15	—	—	12	25	—	3	2	3	—	—	—	13	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	74	2	—	R	—	P
12R-1, 22-24	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	R	—	VP
12R-1, 67-70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	2	—	A	1	P
12R-2, 11-14	6	3	—	5	52	—	5	—	6	—	—	2	9	—	3	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	92	9	—	A	—	M
12R-3, 19-22	4	1	—	3	27	—	1	—	5	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	43	—	1	C	1	M
12R-3, 100-103	4	5	—	2	12	—	1	—	1	—	1	—	—	—	—	—	1	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	29	—	—	C	—	P
12R-5, 34-37	6	4	3	3	25	—	2	—	—	—	1	—	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	56	15	—	C	—	M
12R-5, 44-47	—	—	—	—	4	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	5	1	1	R	—	P
12R-6, 49-52	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	R	—	P
13R-1, 26-30	—	2	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	4	—	—	—	—	VP
13R-1, 76-80	2	1	—	—	1	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	6	1	—	—	—	P
13R-1, 79-82	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	—	R	—	P
13R-1, 92-96	3	3	—	—	4	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	11	—	—	—	—	VP
13R-1, 110-114	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—	—	P
16R-1, 9-12	43	1	—	64	99	4	22	3	2	—	1	6	48	3	—	—	—	—	1	1	—	1	—	—	—	—	1	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18	304	10	—	C	—	G
16R-2, 83-86	16	3	—	24	61	—	13	1	1	—	—	—	14	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	12	137	19	—	C	—	G
16R-3, 73-76	29	16	1	95	74	9	55	—	3	—	3	3	50	6	2	1	1	—	1	1	—	—	—	—	1	—	—	—	1	—	3	—	2	—	—	—	—	—	—	—	—	—	—	—	21	357	5	—	C	—	G
18R-1, 64-69	61	4	1	85	88	9	46	2	3	—	3	24	2	1	1	—	—	—	—	—	—	3	—	—	—	—	—	—	4	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	17	338	11	—	C	—	G
18R-2, 30-35	16	11	—	9	35	1	19	2	—	—	—	1	17	2	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	12	115	7	—	C	—	M
18R-3, 10-15	31	15	1	108	55	4	32	2	—	—	—	3	32	3	2	—	1	1	1	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16	294	3	—	C	—	M
18R-4, 32-36	22	7	—	72	78	3	29	—	5	—	—	3	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	1	—	—	—	—	—	—	—	—	11	239	3	—	C	—	G
19R-2, 22-25	20	16	1	62	74	—	33	—	—	—	2	2	18	4	—	3	—	—	1	2	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	14	239	17	—	C	—	G
19R-CC, 0-3	5	3	1	37	88	—	21	—	1	1	—	5	33	—	2	—	1	—	1	2	—	—	—	—	—	1	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	17	205	3	—	C	—	M
20R-1, 28-33	7	1	—	2	50	—	6	2	—	—	—	—	14	2	1	1	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	88	—	—	C	—	M
20R-2, 46-50	4	4	—	1	29	—	5	—	—	—	1	—	3	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9	50	—	—	—	—	P
20R-3, 25-29	13	5	—	23	102	—	38	—	2	—	1	—	17	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	11	204	—	—	C	—	M
20R-3, 56-60	17	1	—	45	76	6	18	4	2	—	3	1	18	2	—	2	2	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	17	204	3	—	R	—	G
20R-4, 44-49	130	17	5	27	33	9	27	6	3	—	—	15	33	1	3	—	2	—	—	—	—	2	—	—	—	—	—	2	—	—	1	1	—	—	—	1	—	—	4	—	—	—	—	—	20	322	5	—	A	—	M
20R-4, 119-122	10	7	—	12	39	—	14	3	5	—	—	—	14	1	—	1	—	—	—	2	—	—	—	—	—	—	—	3	3	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	14	116	—	—	C	—	P
21R-2, 6-9	5	1	—	—	5	—	—	—	—	1	—	—	1	—	—	3	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	18	—	—	R	—	P
22R-1, 43-46	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	R	—	P
23R-1, 10-14	19	—	—	12	40	—	5	—	2	—	—	—	6	—	—	—	1	—	—	3	—	—	—	—	—	—	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	91	—	—	R	—	P
23R-1, 110-115	83	5	—	12	55	1	76	3	10	—	2	—	32	1	3	—	2	1	—	—	—	1	—	—	—	—	—	3	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	18	293	—	—	C	—	MP
23R-CC, 11-15	4	3	—	2	9	—	—	—	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	7	22	—	—	R	—	—
24R-1, 34-38	39	3	—	12	108	—	4	—	1	—	—	—	16	1	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	11	187	—	1	R	—	P
24R-2, 71-75	26	2	—	61	66	7	47	—	2	—	1	1	15	1	1	2	5	—	—	1	—	—	—	—	—	—	—	2	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	17	241	3	8	C	—	M
24R-2, 141-145	18	2	—	8	18	3	6	—	3	—	—	1	19	1	1	—	2	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	15	85	—	—	R	—	M
24R-3, 13-17	37	3	1	5	74	10	63	6	1	—	—	14	27	—	2	—	—	1	—	1	—	1	—	—	1	1	—	2	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	19	251	2	—	A	—	M
25R-1, 67-71	36	7	—	12	24	1	32	—	1	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	12	119	—	19	C	—	M
25R-CC	68	11	—	31	91	1	50	4	3	—	3	—	35	—	3	—	2	1	—	—	—	—	—	—	—	1	—	3	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	16	308	3	—	C	—	G
26R-2, 0-3	23	3	—	17	59	3	33	3	3	—	—	2	22	—	3	—	1	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13	174	1	—	R	—	M
26R-2, 4-7	13	1	—	9	14	—	9	—	—	—	—	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	8	56	—	—	—	—	M
27R-1, 24-29	48	5	—	21	50	4	53	—	2	—	3	1	10	—	—	2	4	—	2	1	1	—	—	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	17	210	2	3	C	—	G
27R-1, 96-99	15	2	—	—	2	—	—	—	—	—	—	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	27	1	—	—	—	P

Table 2 (continued).

Core, section, interval (cm)	*Patellina subcretacea*	*Trocholina infragranulata*	*Spirillina minima*	*Berthelina intermedia*	*Gavelinella* spp—	*Osangularia* sp— 1	*Osangularia* sp— 2	*Globulina prisca*	*Oolina sulcata*	*Pyrulina cylindroides*	*Oolina* sp—	Miliolids	*Bolivina* sp— 1	*Neobulimina albertensis*	*Frondicularia lamellatta*	*Furkensoina viscida*	*Laevidentalina* spp—	*Laevidentalina linearis*	*Laevidentalina oligostegia*	*Lingulonodosaria nodosaria*	*Bolivina* sp—	?*Spiroplectinella* sp— 1	*Globorotalites* sp—	*Gyroidinoides* cf— *nitidus*	*Astacolus calliopsis*	*Marginulinopsis striatocostata*	*Planularia complanata*	*Pseudonodosaria* sp.1	*Globulina* spp—	*Tristix acutangula*	*Lingulina* spp—	*Pyramidulina sceptrum*	*Lenticulina* spp—	*Saracenaria* sp—	*Laevidentalina debilis*	*Laevidentalina nana*	*Charltonina australis*	*Vaginulina petila*	*Berthelina* sp—	*Nothia latissima*	*Oolina* cf— *sulcata*	*Rhizammina* spp—	*Charltonina australis*	*Bolivina anambra*	Number of BF species	Number of BF specimens	Ostracodes	Diatoms	Radiolarians	Fish teeth	Preservation
27R-2, 58-61	48	4	—	26	43	3	11	—	4	1	—	—	5	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	146	—	41	C	—	M
28R-1, 26-30	4	—	—	6	12	—	4	—	—	—	—	—	2	1	—	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	31	—	5	C	—	M
28R-1, 92-96	53	9	5	29	92	12	50	—	4	—	—	21	9	7	5	—	3	—	—	1	—	13	—	—	1	1	1	3	—	1	1	—	1	—	—	2	—	1	—	—	—	1	—	—	24	325	—	—	R	—	G
28R-2, 49-51	7	2	—	2	16	—	2	—	—	1	—	—	1	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	10	35	—	—	A	—	M
28R-2, 67-70	15	2	—	4	31	—	2	1	—	—	—	—	1	4	—	1	1	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	64	—	—	R	—	M
29R-1, 60-63	22	2	—	18	54	5	26	—	3	—	—	7	4	3	—	6	3	—	—	—	—	8	—	5	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	15	167	—	—	C	—	M
30R-1, 80-82	3	—	—	5	6	—	—	—	1	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	17	—	2	—	—	P
30R-1, 93-97	19	5	—	24	95	12	39	—	—	—	—	1	14	9	5	—	1	—	—	—	—	2	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14	228	—	41	R	—	G
30R-1, 108-112	32	4	—	42	122	8	96	—	1	—	—	2	12	4	—	—	1	—	1	—	—	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13	341	—	6	—	—	G
30R-2, 52-55	32	—	1	29	70	7	47	—	2	1	—	4	9	8	1	—	—	—	—	1	—	5	—	—	—	—	—	1	1	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	18	221	—	1	C	—	M
31R-1, 10-14	8	—	—	1	8	—	10	1	—	—	—	—	5	—	—	3	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	37	—	—	R	—	P
31R-2, 16-19	21	2	—	9	17	1	5	—	1	—	—	2	16	—	1	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	77	—	1	C	—	M
31R-2, 36-39	13	—	—	3	7	—	5	—	—	—	—	—	2	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	31	—	—	—	—	P
31R-2, 75-78	—	—	—	1	11	1	4	—	1	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	20	—	—	C	—	P
33R-1, 33-35	3	—	—	—	5	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	12	—	—	—	—	P
33R-1, 58-60	21	13	3	1	19	1	5	3	—	—	—	—	23	1	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	94	—	—	C	—	M
33R-2, 16-19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	—	R	—	P
34R-1, 91-94	8	2	—	4	13	—	7	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	37	—	—	—	—	P
34R-1, 118-122	24	8	4	16	38	4	37	1	1	—	—	8	38	1	2	1	2	—	1	1	—	3	—	—	—	—	—	5	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	21	197	1	—	A	—	M
34R-3, 11-14	4	2	6	8	10	1	2	—	1	—	—	—	14	21	1	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13	72	—	—	A	—	M
34R-3, 43-46	22	1	—	16	23	—	20	—	1	—	—	4	16	1	4	—	2	—	—	1	2	—	8	—	—	—	2	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	16	125	3	—	A	—	M
35R-2, 4-7	6	—	—	1	11	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	31	—	—	R	—	M
35R-2, 107-111	5	—	—	2	10	—	11	—	1	—	—	—	5	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	35	—	1	R	—	P
35R-3, 18-21	2	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	3	—	2	—	—	P
35R-3, 87-91	142	20	2	29	67	1	38	3	4	—	1	—	—	2	3	—	2	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14	316	—	—	—	—	M
36R-1, 48-51	115	56	1	11	160	7	103	8	—	—	4	9	81	5	5	—	1	—	—	5	—	1	—	—	2	1	1	7	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	22	587	7	3	—	—	G
36R-1, 85-87	2	1	—	3	8	—	3	—	8	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	27	—	6	R	—	P
36R-2, 106-108	—	—	—	—	2	—	2	1	—	—	—	—	—	1	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	8	—	—	R	—	VP
36R-3, 34-37	7	1	—	5	14	—	17	—	—	—	—	—	3	2	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	50	—	—	R	—	P
36R-3, 98-101	8	2	4	4	25	2	13	—	—	—	—	3	5	1	1	—	1	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14	71	—	—	—	—	M
37R-1, 69-72	—	—	—	34	37	—	8	—	1	—	—	—	2	34	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	118	—	1	R	—	M
37R-2, 0-4	3	3	—	—	5	—	—	—	—	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	14	—	—	R	—	P
37R-2, 13-16	3	1	—	—	1	—	—	—	—	—	—	—	2	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	8	—	—	—	—	P
37R-2, 143-146	57	26	3	25	133	24	86	—	1	—	—	30	62	9	—	—	—	1	1	1	1	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	15	465	—	3	R	—	G
37R-4, 23-26	4	4	1	6	31	3	13	—	—	—	—	1	1	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	68	—	—	R	—	G
37R-CC	22	4	2	9	58	5	28	1	1	1	1	4	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13	153	—	—	R	—	M

Notes: R = rare, C = common, A = abundant, VP = very poor, P = poor, M = moderate, G = good. Shaded samples are barren.

earliest Cenomanian. Tectonic activity was probably the dominant control on sedimentation rates, and three main cycles of deposition can be detected from overall changes in the preservation, abundance, and diversity of the foraminiferal assemblages, possibly reflecting major shifts in sediment provenance and/or supply. Second-order fluctuations within the three main cycles may be related to variations in sediment accumulation rates, leading to intermittent episodes of dilution.

The foraminiferal assemblages from Hole 962D intermittently contain variable numbers of miliolids, patellinids, and trocholinids, which are characteristic of mid- or inner-shelf settings and some gavelinellids and nodosariids, which are more typical of outer shelf to upper bathyal environments (Eicher et al., 1974; Guérin, 1981; Moullade, 1984). The lack of deep-water agglutinated benthic foraminifers excludes a deeper bathyal environment. The composition of the assemblages indicates that some mixing might have occurred between autochthonous upper bathyal, outer shelf benthic foraminifers, and allochthonous forms originally living in inner- to middle-shelf settings. The intermittent occurrences of diatoms also suggest that at least part of the sediment was periodically redeposited from a proximal, shallower source.

There is no evidence for severe bottom-water dysoxia or anoxia between Cores 159-962D-16R and 37R, as benthic foraminiferal diversity is generally high, except in diluted intervals. The presence of diatoms and radiolarians in the assemblages may indicate enhanced surface-water productivity. However, as little is known about the ecology of these two groups (Thurow and Kuhnt, 1986; Thurow, 1988), such paleoenvironmental interpretation has to remain very speculative. The predominantly small and homogeneous size of benthic calcareous tests may be attributed to the granulometric sorting of allochthonous tests at a distal depositional setting above the carbonate compensation depth (CCD); this is also supported by the fact that only juvenile ostracodes are present in the assemblages. For autochthonous assemblages, the small size can also be attributed to somewhat dysoxic conditions at the seafloor, within a thick nepheloid layer, due to high accumulation rates of organic-rich sediment. From Cores 159-962D-13R through 7R, the high degree of dissolution of planktonic tests and the low abundance of benthic foraminifers suggest that conditions had become more dysoxic at the sediment/water interface during the deposition of the upper part of the sequence.

Hole 962B

The high level of dissolution of planktonic tests, the virtual absence of benthic foraminifers, and the abundance of radiolarians point to high productivity in surface waters and to severe dysoxia or anoxia at the sediment/water interface with corrosive bottom waters leading to the partial dissolution of planktonic tests. From Section 159-962B-9H-4 upward, several hiatuses may have occurred that may be related to the position of the hole on a topographic high, subjected to erosive submarine currents.

PALEOBIOGEOGRAPHY

The observed assemblages include an important number of cosmopolitan taxa; however, the presence of some taxa that could not be closely matched to the literature *(Bolivina* sp. 1, *?Spiroplectinella* sp.1, and *?Osangularia* sp. 2) and of *Bolivina anambra,* a typical "African" taxon, suggests that some degree of endemism is present and that circulation may have been restricted during the late Albian in the basin with limited connections to open ocean, and thus with the Tethys. Even a typical Tethyan form such as *Berthelina intermedia* was also found to be more asymmetrically evolute than morphotypes illustrated from Tethys (Malapris, 1965; Moullade, 1966; Revets, 1996). Most of the nodosariids in the assemblages from Leg 159 are typically found in Tethyan assemblages; however, the absence or rarity of some common Tethyan taxa (ornamented *Lenticulina,* palmate nodosariid morphotypes, and calcareous agglutinated forms such as *Protomarssonella)* may also indicate some faunal differentiation. The assemblages from Leg 159 lacked many of the species that typically occur among the "world-wide fauna" described by Riegraf and Luterbacher (1989) in their synthesis of Lower Cretaceous benthic foraminifers from DSDP Legs 1–79. The absence of some common genera listed by Riegraf and Luterbacher (1989) such as *Spiroplectammina, Pleurostomella, Pseudoclavulina,* and *Valvulineria* from our samples also points to restricted connections with the world's ocean. Overall, the distinctive composition of the Lower Cretaceous foraminiferal assemblages from Leg 159 reflects a combination of Tethyan, South Atlantic, and local, endemic faunal influences.

The lack of keeled planktonic foraminifers may support a cold water source from high southern latitudes. Alternatively, the absence of keeled bathypelagic planktonic foraminifers may be due to the lack of deep-water circulation between the open ocean and the embryonic South Atlantic in the late Albian or may be interpreted as an indication of shallow depths, leading to the exclusion of deeper subpelagic niches in the water column (Eicher, 1969; Leckie, 1987). This does not contradict observations of bathypelagic planktonic taxa (Moullade et al., 1993; Saint-Marc and N'Da, in press) in the Albian of the neighboring Gulf of Guinea, where open connections to the open sea were better established than in the Côte d'Ivoire-Ghana Transform Margin area, which was fragmented into tectonic sub-basins. The presence of microfossils as old as late Aptian or early Albian, even redeposited ones, demonstrates that marine sedimentation was occurring in the area at that time and strengthens earlier hypotheses by Förster (1978), Wiedmann and Neugebauer (1978), and Moullade and Guérin (1982) of an Early Cretaceous connection between Tethys and the South Atlantic, through the Central Atlantic.

CONCLUSION

This study extends our knowledge of Lower Cretaceous benthic foraminifers from the African Equatorial Margin and provides a data base for paleoceanographic interpretation and paleogeographic reconstructions. A summary of the biostratigraphy and paleoenvironmental interpretation based on benthic foraminiferal data from Hole 962D is presented in Figure 3. The foraminiferal data establish biostratigraphic constraints for the onset of marine sedimentation on the CIGMR and show that marine conditions already existed by the late Aptian–early Albian near Hole 959D and by mid- to late Albian near Hole 962D. The older marine sequences were subsequently reworked into younger sediments of a late Albian to earliest Cenomanian age at these two holes. The composition of the assemblages suggests mixing between autochthonous outer shelf to upper bathyal and allochthonous inner- to middle-shelf benthic foraminifers. Tectonic activity was probably the overriding control on sediment supply and accumulation rates, leading to a complex patchwork of sedimentary lenses and tectonic slices in developing half-grabens.

The distinctive composition of the benthic foraminiferal assemblages from Holes 959D, 962B, and 962D is characteristic of an outer shelf to upper bathyal setting. It also reflects a combination of Tethyan, South Atlantic, and local, endemic faunal influences, indicating that connections to the open ocean and to the Tethys probably remained restricted during the Albian and early Cenomanian, at least locally (i.e., on the CIGMR). In Hole 962D, there is no evidence for bottom-water anoxia or severe dysoxia between Cores 159-962D-16R and 37R, although the presence of radiolarians and the intermittent occurrence of diatoms point to high productivity in surface waters. A deterioration in bottom-water oxygenation appears to have occurred during the deposition of the upper part of the sequence from

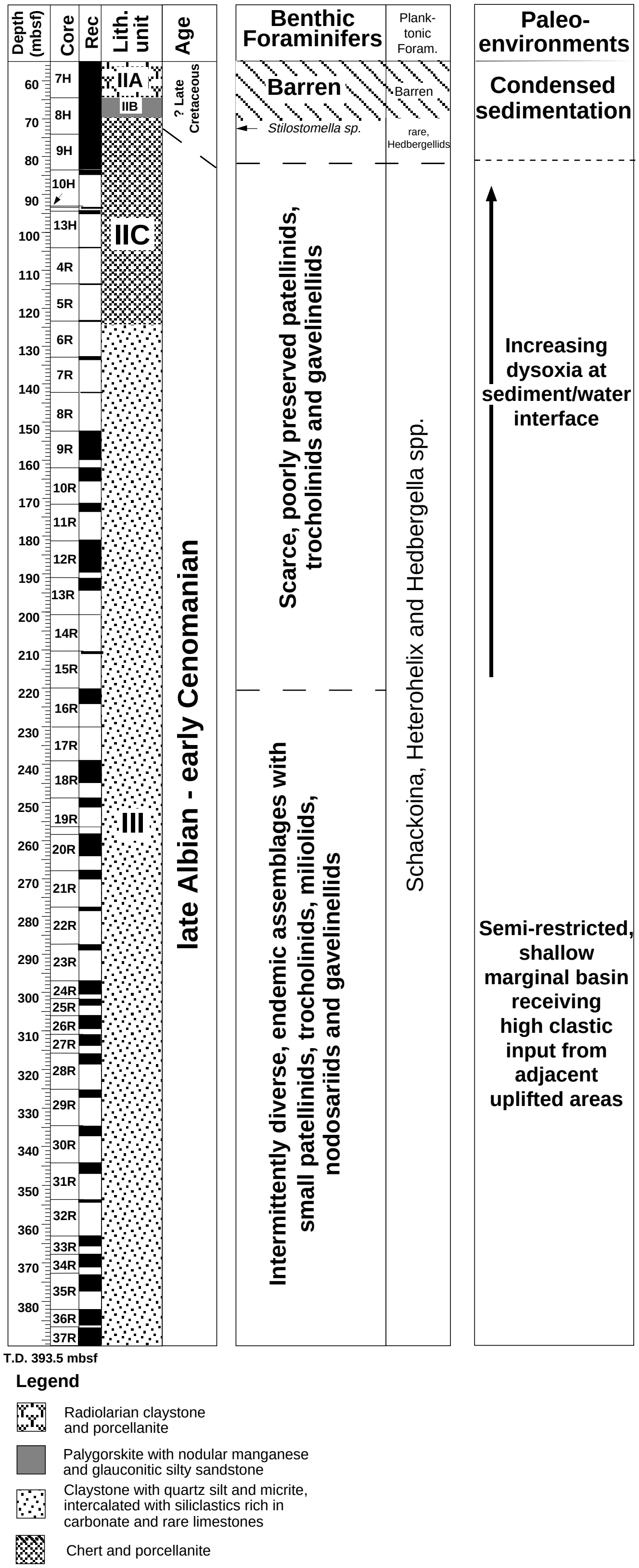

Figure 3. Benthic foraminiferal assemblages from Hole 962D: biostratigraphic and paleoenvironmental summary.

Holes 962D and 962B (Sections 159-962D-7R-1 through 13R-1 and 159-962B-8H-5 through 9H-6). From the Cenomanian onward, a period of nonsedimentation was probably related to the position of the hole on a topographic high along the margin of the Gulf of Guinea, subjected to erosive submarine currents.

SYSTEMATIC NOMENCLATURE

The benthic foraminiferal classification above the level of superfamily employed here follows the taxonomic classification of Loeblich and Tappan (1992). Below the level of superfamily, the classification of Loeblich and Tappan (1988) has been used with some exceptions, which mainly reflect the generic revision of Rotaliine families, proposed by Revets (1996). Open nomenclature has been used for taxa that do not closely match published descriptions.

Order ASTRORHIZIDA Lankester, 1885
Superfamily ASTRORHIZACEA, Brady, 1881
‘Family Rhabdamminidae Brady, 1884
Subfamily Rhabdammininae Brady, 1884
Genus ***Nothia*** Pflaumann, 1964

Nothia latissima (Grzybowski, 1898)
Plate 1, Figure 1

Dendrophrya latissima GRZYBOWSKI, 1898, p. 17, pl. 10, fig. 8.
Nothia latissima (Grzybowski) KAMINSKI and GEROCH, 1993, pl. 1, figs. 1, 14.

Description. A wide, flattened tube with a thin wall.

Range and Occurrence. Four fragments found in Sample 159-962D-20R-3, 56–60 cm. Commonly recorded in flysch-type assemblages (Kaminski and Geroch, 1993).

Genus ***Rhizammina*** Brady, 1879

Rhizammina spp.

Description. We included in this group all finely to medium agglutinated, flattened tubes.

Range and Occurrence. Very rare at all holes.

Order LITUOLIDA Lankester, 1885
Superfamily AMMODISCACEA Reuss, 1862
Family AMMODISCIDAE Reuss, 1862
Subfamily AMMOVERTELLININAE Saidova, 1981
Genus ***Glomospira*** Rzehak, 1885

Glomospira charoides (Jones and Parker, 1860)
Plate 1, Figure 5

Trochammina squamata var. *charoides* Jones and Parker, 1860, p. 304.
Glomospira charoides corona Cushman and Jarvis. Weidich, 1990, pl. 34, figs. 8, 9.

Description. Tubular test, coiling about a vertical axis, with four to five whorls in the outermost layer of coils. Aperture at open end of tube.

Range and Occurrence. A few specimens found in Sections 159-962B-8H-CC, 159-962B-8H-6, and 159-962B-8H-4.

Superfamily SPIROPLECTAMMINACEA Cushman, 1927
Family Spiroplectamminidae Cushman, 1927
Subfamily Spiroplectammininae Cushman, 1927
Genus ***Spiroplectinella*** Kisel’man, 1972

?*Spiroplectinella* sp. 1
Plate 1, Figures 2–4

Description. Elongate, flaring test, with lozenge-shaped cross section and small, initial planispiral whorl, followed by biserial stage. Low, broad chambers separated by thick, slightly raised sutures. Wall smoothly cemented with calcareous cement. Arched aperture at base of last chamber.

Remarks. Only tentatively assigned to the genus *Spiroplectinella,* as wall structure is unknown. Initial planispiral whorl is only present in microspheric specimens.

Range and Occurrence. Common in some samples in Hole 962D.

Order SPIRILLINIDA Gorbachik and Mantsurova, 1980
Suborder INVOLUTININA Hoenegger and Piller, 1977
Family Involutinidae Bütschli, 1880
Subfamily Involutininae Bütschli, 1880
Genus ***Trocholina*** Paalzow, 1922

Trocholina infragranulata Noth, 1951
Plate 1, Figures 9, 12

Trocholina infragranulata Noth, 1951, pl. 1, fig. 32.
Trocholina infragranulata Noth. Weidich, 1990, pl. 29, figs. 32, 34.
Trocholina infragranulata infragranulata Noth. Neagu, 1975, pl. 96, figs. 1–12, 25–26, 29–30.

Description. Low, conical, perforate test, evolute on dorsal side with all whorls of tubular second chamber visible. Large umbilicus with pillars surrounded by final whorl on ventral side. Aperture at open end of tube.

Range and Occurrence. Berriasian to early Aptian in the northern Alps (Weidich, 1990). Common in Hole 962D.

Suborder SPIRILLININA Hoenegger and Piller, 1975
Family Patellinidae Rhumbler, 1906
Subfamily Patellininae Rhumbler, 1906
Genus ***Patellina*** Williamson, 1858

Patellina subcretacea Cushman and Alexander, 1930
Plate 1, Figures 8, 11

Patellina subcretacea Cushman and Alexander, 1930, pl. 3, fig. 1a, b.
Patellina subcretacea Cushman and Alexander. Neagu, 1975, pl. 82, figs. 1–16; pl. 85, figs. 26–29. Basov and Krasheninnikov, 1983, pl. 4, fig. 2. BOLLI et al., 1994, pl. fig. 25.30–32.

Description. Conical, perforate test, evolute on spiral side with two chambers per whorl, separated by carinate, spiral sutures. Peripheral grooves, nodes and aperture distinct on ventral side of better preserved specimens.

Remarks. Tests from Hole 962D vary in height. Also close to *Patellina africana,* described from the middle-upper Albian of Zululand by Lambert and Scheibnerová (1974).

Range and Occurrence. Berriasian to Albian in Europe (Bartenstein and Brand, 1951; Magniez-Jannin, 1975; Neagu, 1975; Weidich, 1990), Hauterivian to Albian in Indian Ocean (Holbourn and Kaminski, 1997). Common in Hole 962D.

Family Spirillinidae Reuss and Fritsch, 1861
Genus ***Spirillina*** Ehrenberg, 1843

Spirillina minima Schacko, 1897
Plate 1, Figures 7, 10

Spirillina minima Schacko, 1897; pl. 1, fig. 4.
Spirillina minima Schacko. Bartenstein and Kovatcheva, 1982, pl. 4, figs. 38–39; pl. 5, figs. 43–44.

Description. Discoidal, perforate test with small proloculus and planispirally coiled, tubular second chamber. Aperture simple and terminal.

Range and Occurrence. Widely recorded from Lower Cretaceous sediments.

Order MILIOLIDA Lankester, 1885
Suborder MILIOLINA Delage and Hérouard, 1896
Superfamily MILIOLACEA Ehrenberg, 1839
Family Spiroloculinidae Wiesner, 1920
Genus ***Quinqueloculina*** d'Orbigny, 1926

***Quinqueloculina* sp.**
Plate 1, Figures 13, 14

Description. Ovate test, usually with five chambers (half coil in length) visible on the outside.

Order LAGENIDA Lankester, 1885
Superfamily ROBULOIDACEA Reuss, 1863
Family ICHTHYOLARIIDAE Loeblich and Tappan, 1988
Genus ***Lingulonodosaria*** A. Silvestri, 1903

Lingulonodosaria nodosaria (Reuss, 1863)
Plate 2, Figure 6

Lingulina nodosaria Reuss, 1863, pl. 5, fig. 12.
Lingulonodosaria nodosaria (Reuss). Scheibnerová, 1976, pl. 36, fig. 1.
Lingulonodosaria nodosaria (Reuss). Meyn and Vespermann, 1994, pl. 5, figs. 8–11; pl. 6, figs. 1–3.

Description. Rectilinear, uniserial test with broad chambers separated by straight, slightly depressed sutures, elliptical cross section and terminal slit aperture.

Range and Occurrence. Cosmopolitan in the Early Cretaceous.

Superfamily NODOSARIACEA Ehrenberg, 1836
Family Nodosariidae Ehrenberg, 1838
Subfamily Nodosariinae Ehrenberg, 1838
Genus ***Laevidentalina*** Loeblich and Tappan, 1988

Laevidentalina debilis (Berthelin, 1880)
Plate 2, Figure 11

Marginulina debilis Berthelin, 1880, pl. 3, fig. 28.
Lenticulina (Vaginulina) debilis (Berthelin). Moullade, 1984, pl. 3, fig. 13.

Description. Elongate, uniserial, narrow test with ventrally inflated chambers, separated by depressed, inclined sutures. Terminal, radiate aperture.

Range and Occurrence. Cosmopolitan in the Early Cretaceous.

Laevidentalina linearis (Roemer, 1841)

Nodosaria linearis Roemer, 1841, pl., 15, fig. 5.
Laevidentalina linearis (Roemer). Meyn and Vespermann, 1994, pl. 7, figs. 1–7.

Description. Elongate, curved, uniserial test with subcylindrical chambers separated by straight, depressed sutures. Terminal radiate aperture.

Range and Occurrence. Valanginian to Albian in northwestern Germany (Meyn and Vespermann, 1994).

Laevidentalina oligostegia (Reuss, 1845)
Plate 2, Figure 1

Nodosaria oligostegia Reuss, 1845, pl. 13, figs. 19–20.

*Dentalina oligostegia (*Reuss). Haig, 1982, pl. 1, figs. 8–10.

Description. Elongate, uniserial test with two or three ovate chambers, separated by markedly depressed sutures. Last chamber elongated towards a radiate aperture.

Range and Occurrence. Cosmopolitan in the Early Cretaceous.

Genus ***Pseudonodosaria*** Boomgaart, 1949

Pseudonodosaria sp. 1
Plate 2, Figure 2

Description. Elongate, uniserial, ovate test with overlapping chambers increasing rapidly in size. Last chamber inflated, much larger than previous ones. Aperture radiate and terminal.

Range and Occurrence. Common in Hole 962D.

Genus ***Pyramidulina*** Fornasini, 1894

Pyramidulina sceptrum (Reuss, 1863)
Plate 2, Figure 3

Nodosaria (Nodosaria) sceptrum Reuss, 1863, pl. 2, fig. 3.
Pyramidulina sceptrum (Reuss) Meyn and Vespermann, 1994, pl. 12, figs. 1–14; pl. 13, figs. 1–16; pl. 14, figs. 1–17.

Description. Elongate, uniserial test with inflated chambers, ornamented by fine, longitudinal costae and separated by depressed sutures. Aperture simple and terminal.

Remarks. Found mostly as fragments in Hole 962D.

Range and Occurrence. Cosmopolitan in the Early Cretaceous.

Subfamily Lingulininae Loeblich and Tappan, 1961
Genus ***Lingulina*** d'Orbigny, 1826

Lingulina spp.

Description. Elongate, compressed, uniserial tests with overlapping chambers and terminal slit aperture.

Subfamily Frondiculariinae Reuss, 1860
Genus ***Frondicularia*** Defrance, 1826

Frondicularia lamellata Tappan, 1940
Plate 2, Figure 5

Lingulina lamellata Tappan, 1940, pl. 16, fig. 19.
Frondicularia lamellata Tappan. Haig, 1982, pl. 3, figs. 25–29.

Description. Compressed, lanceolate test with low chambers, increasing irregularly in width, separated by arched, depressed sutures. Terminal slit-like aperture.

Range and Occurrence. Originally described from the Cenomanian of the Gulf Coast, U.S.A., by Tappan (1940), also recorded by Haig (1982) from the upper Albian of Queensland.

Genus ***Tristix*** Macfayden, 1941.

Tristix acutangula (Reuss, 1863)
Plate 2, Figure 4

Rhabdogonium acutangulum Reuss, 1863, pl. 4, fig. 14a, b.
Tristix acutangula (Reuss). Tronchetti and Grosheny, 1991, pl. 4, fig. 3. Meyn and Vespermann, 1994, pl. 20, figs. 8–13; pl. 21, figs. 1–4, 6–10; pl. 22, figs. 1, 2.

Description. Elongate, uniserial test, triangular in cross section with slightly concave lateral faces and low chambers separated by arched, depressed sutures. Terminal, circular aperture.

Range and Occurrence. Cosmopolitan in the Early Cretaceous according to Bartenstein and Bolli (1986).

Family Vaginulinidae Ehrenberg, 1838
Subfamily Lenticulininae Chapman, Parr and Collins, 1934
Genus ***Lenticulina*** Lamarck, 1804

Lenticulina spp.
Plate 2, Figure 7

Description. Involute, lenticuline tests with radiate, terminal aperture.

Range and Occurrence. Rare in Hole 962D.

Genus ***Marginulinopsis*** A. Silvestri, 1904

Marginulinopsis jonesi (Reuss, 1863)
Plate 2, Figure 8

Marginulina jonesi Reuss, 1863, pl. 5, fig. 19.
Marginulinopsis jonesi (Reuss) Meyn and Vespermann, 1994, pl. 31, figs. 5–8; pl. 31, figs. 1–14: pl. 33, figs. 1–14.

Description. Small, robust, elongate test, ornamented by thick, longitudinal ribs with three inflated chambers in the evolute portion. Radiate aperture at peripheral angle.

Range and Occurrence. One specimen found in Sample 159-959D-71R-1, 30–33 cm.

Marginulinopsis striatocostata (Reuss, 1863)
Plate 2, Figure 20

Marginulina striatocostata Reuss, 1863, pl. 6, fig. 2.
Marginulinopsis striatocostata (Reuss) Meyn and Vespermann, 1994, pl. 33, figs. 15–20; pl. 34, figs. 1–6.

Description. Elongate test ornamented by fine, longitudinal ribs, with three to four inflated chambers in the evolute portion, separated by depressed sutures. Radiate aperture at peripheral angle.

Range and Occurrence. Late Valanginian to middle Albian in northwestern Germany (Meyn and Vespermann, 1994). A few specimens found in Hole 962D.

Genus ***Saracenaria*** Defrance, 1824

Saracenaria sp.

Description. Elongate, triangular, finely striated test, with rounded ventral margins. Three chambers in the evolute portion are separated by slightly depressed, slanting sutures. Radiate, terminal aperture.

Range and Occurrence. One specimen found in Sample 159-962D-26R-2, 4–7 cm.

Subfamily Marginulininae Wedekind, 1937
Genus ***Astacolus*** de Montfort, 1808

Astacolus calliopsis (Reuss, 1863)
Plate 2, Figure 10

Marginulina calliopsis Reuss, 1863, pl. 5, fig. 16.
Astacolus calliopsis (Reuss). Bartenstein and Bolli, 1986, pl. 4, figs. 9, 10. Meyn and Vespermann, 1994, pl. 40, figs. 15, 16; pl. 41, figs. 1–15.

Description. Elongate, gently curved test with ventrally inflated chambers, separated by slightly depressed, inclined sutures. Radiate, terminal aperture.

Range and Occurrence. A cosmopolitan species in the Early Cretaceous.

Genus ***Planularia*** Defrance, 1826

Planularia complanata (Reuss, 1845)
Plate 2, Figures 12, 13

Cristellaria complanata Reuss, 1845, pl. 13, fig. 54a, b.
Planularia complanata (Reuss). Magniez-Jannin, 1975, pl. 9, figs. 26–38 and text fig. 83. Holbourn and Kaminski, 1995, pl. 13, figs. 4–6.

Description. Flattened "fan-shaped" test with low chambers separated by curved, limbate sutures. Radiate, terminal aperture.

Range and Occurrence. Cosmopolitan in the Early Cretaceous.

Genus ***Vaginulina*** d'Orbigny, 1826

Vaginulina petila (Eicher and Worstell, 1970)

Citharina petila Eicher and Worstell, 1970, pl. 2, figs. 20, 21.
Vaginulina petila (Eicher and Worstell). Haig, 1982, pl. 6, figs. 7–10. Holbourn and Kaminski, 1995, pl. 14, fig. 5.

Description. Elongate, curved test, ornamented by few fine, slanting costae. Ventrally inflated chambers, separated by inclined, depressed sutures. Last chamber elongated towards a terminal, radiate aperture.

Range and Occurrence. One specimen found in Sample 159-962D-28R-1, 92–96 cm.

Superfamily POLYMORPHINACEA d'Orbigny, 1839 (nom. transl. Grigelis, 1980)
Family POLYMORPHINIDAE d'Orbigny, 1839
Subfamily POLYMORPHININAE d'Orbigny, 1839
Genus ***Globulina*** d'Orbigny, 1839

Globulina prisca (Reuss, 1863)
Plate. 2, Figure 9

Polymorphina prisca Reuss, 1863, pl. 8, fig. 8.
Globulina prisca (Reuss). Bartenstein and Brand, 1951, pl. 10, fig. 286. Fowler and Braun, 1993, pl. 9, figs. 8–10.

Description. Elongate, ovate test with overlapping chambers arranged along three planes and separated by flush or slightly depressed sutures. Radiate, terminal aperture.

Range and Occurrence. Cosmopolitan in the Early Cretaceous.

Genus *Pyrulina* d'Orbigny, 1839

Pyrulina cylindroides (Roemer, 1838)

Polymorphina cylindroides Roemer, 1838, pl. 3, fig. 26a, b.
Pyrulina cylindroides (Roemer). Mcneil and Caldwell, 1981, pl. 17, fig. 16. Holbourn and Kaminski, 1995, pl. 15, fig. 10.

Description. Fusiform test with overlapping chambers separated by flush sutures. Radiate, terminal aperture.

Range and Occurrence. Cosmopolitan in the Early Cretaceous.

Family Ellipsolagenidae A. Silvestri, 1923
Subfamily Oolininae Loeblich and Tappan, 1961
Genus *Oolina* d'Orbigny, 1839

Oolina sulcata (Walker and Jacob, 1798)
Plate 2, Figures 14, 15

Serpula sulcata Walker and Jacob, 1798, pl. 14, fig. 5.
Lagena cf. *sulcata* (Walker and Jacob). Bartenstein and Brand, 1951, pl. 10, fig. 281.
Lagena sulcata (Walker and Jacob). Petters, 1982, pl. 5, fig. 33.

Description. Unilocular, globular test ornamented by longitudinal ribs. Simple, terminal aperture at the end of a short neck.

Range and Occurrence. Cosmopolitan in the Early Cretaceous.

Oolina cf. *sulcata* (Walker and Jacob, 1798)

Remarks. Differs from *O. sulcata* (Walker and Jacob) by having a less globular shape and fewer costae.

Order BULIMINACEA Fursenko, 1958
Superfamily BULIMINACEA Jones, 1875
Family BOLIVINITIDAE Cushman, 1927
Subfamily BOLIVINITINAE Cushman, 1927
Genus *Bolivina* d'Orbigny, 1839

Bolivina anambra Petters, 1982
Plate 2, Figures 16, 17

Bolivina anambra Petters, 1982, pl. 11, figs. 21, 22, 29.

Description. Small, elongate, biserial test with slightly lobulate periphery. Low chambers overlapping in central part of test are separated by curved, slightly depressed sutures. Narrow aperture on face of terminal chamber.

Range and Occurrence. Originally described by Petters (1982) from the lower Turonian of Nigeria. Six specimens found at the top of the studied sequence in Hole 962D (Sample 159-962D-9R-1, 34–38 cm).

Bolivina sp. 1
Plate 2, Figures 18, 19

Description. Elongate, flattened, biserial test with low chambers separated by slightly depressed, slanting sutures. Later chambers overlap markedly in central part of the test. Loop-shaped aperture bordered by a lip on face of terminal chamber.

Remarks. Toothplate indistinct in our specimens.

Range and Occurrence. Common in Hole 962D.

Subfamily FURSENKOININAE Loeblich and Tappan, 1961
Genus *Fursenkoina* Loeblich and Tappan, 1961

Fursenkoina viscida (Khan, 1950)

Virgiluna viscida Khan, 1950, pl. 2, figs. 3–5.
Cassidella viscida (Khan). Magniez-Jannin, 1975, pl. 15, figs. 12, 13. Weidich, 1990, pl. 49, figs. 5, 6.

Description. Elongate, narrow, biserial test, slightly twisted at the base. Chambers separated by curved, depressed sutures. Slit aperture on face of final chamber.

Remarks. Toothplate indistinct in our specimens due to poor preservation. An application to the ICZN to remove *Cassidella* in favor of *Fursenkoina* is pending (Revets, 1996).

Range and Occurrence. Middle to late Albian in Kent (Khan, 1950) and northern Alps (Weidich, 1990), late Albian in the Aube region of France (Magniez-Jannin, 1975). Rare in Hole 962D.

Superfamily TURRILINACEA Cushman, 1927
Family Turrilinidae Cushman, 1927
Genus *Neobulimina* Cushman and Wickenden, 1928

Neobulimina albertensis (Stelck and Wall, 1954)
Plate 3, Figure 1

Guembelitria cretacea albertensis Stelck and Wall, 1954, pl. 2, fig. 19.
Neobulimina albertensis (Stelck and Wall). McNeil and Caldwell, 1981, pl. 18, figs. 2, 3. Haig, 1982, pl. 9, figs. 10–20.

Description. Elongate test, initially triserial, becoming biserial. Subglobular chambers separated by depressed sutures. Loop-shaped aperture on face of terminal chamber.

Remarks. Toothplate indistinct in our specimens.

Range and Occurrence. Cenomanian-Coniacian in North America (McNeil and Caldwell, 1981), late early to late Albian in Queensland (Haig, 1982).

Superfamily STILOSTOMELLACEA Finlay, 1947
Family Stilostomellidae Finlay, 1947
Genus *Stilostomella* Guppy, 1894

Stilostomella sp.
Plate 3, Figure 8

Description. Rectilinear, uniserial test with subglobular chambers separated by constricted sutures. Wall hispid.

Range and Occurrence. One specimen found at the base of Section 159-962B-8H-5.

Order ROTALIIDA Lankester, 1885
Superfamily CHILOSTOMELLACEA Brady, 1881
Family ALABAMINIDAE Hofker, 1951
Genus *Charltonina* Bermúdez, 1952

Charltonina australis Scheibnerová, 1978

Charltonina australis Scheibnerová, 1978, pl. 5, figs. 2–5.
Charltonina australis Scheibnerová. Haig, 1992, pl. 3, figs. 12, 13.

Description. Trochospiral test with lobulate, carinate periphery. Chambers separated by slightly depressed sutures, strongly oblique on spiral side. Interiomarginal slit aperture.

Range and Occurrence. Aptian-Cenomanian in Indian Ocean (Holbourn and Kaminski, 1997). One poorly preserved specimen found in Sample 159-962D-16R-2, 83–86 cm.

Genus *Globorotalites* Brotzen, 1942

Globorotalites sp.

Description. Trochospiral test with flattened dorsal side and strongly convex umbilical side. Chambers separated by sutures, raised and limbate dorsally, gently curved and depressed ventrally. Interiomarginal slit aperture, extending to deep sulcus.

Genus ***Osangularia*** Brotzen, 1940

Osangularia sp. 1
Plate 3, Figures 2, 3.

Description. Trochospiral, planoconvex test with flattened ventral side. Twelve chambers in last whorl are separated by thick sutures, strongly curved dorsally. Interiomarginal, L-shaped slit aperture extends from umbilicus to periphery.

Range and Occurrence. Common in Hole 962D.

?*Osangularia* sp. 2
Plate 3, Figures 4, 5, 6.

Description. Trochospiral, asymmetrically biconvex to near planoconvex test with flattened ventral side. Seven chambers in last whorl surround umbilical boss and are separated by sutures, which are straight and markedly depressed ventrally, and curved dorsally. Interiomarginal slit aperture.

Remarks. Only tentatively assigned to the genus *Osangularia* on account of its atypical aperture (see Revets, 1996).

Range and Occurrence. Common in Hole 962D.

Family Gavelinellidae Hofker, 1956
Genus ***Berthelina*** Malapris, 1965

Berthelina intermedia (Berthelin, 1880)
Plate 3, Figures 9, 10, 14.

Anomalina intermedia Berthelin, 1880, pl. 4, fig. 14.
Berthelina intermedia (Berthelin). Haig and Lynch, 1993, pl. 4, figs. 26–28. Revets, 1996, pl. 8, figs. 1–4.

Description. Trochospiral test, slightly flattened on spiral side with rounded periphery and relict apertural flaps, partially covering the umbilicus. Chambers separated by curved, slightly depressed sutures. Interiomarginal aperture, bordered by lip.

Range and Occurrence. Widely recorded worldwide in Albian sediments. Common in Hole 962D.

Genus ***Gavelinella*** Brotzen, 1942

Gavelinella flandrini Moullade, 1960

Gavelinella flandrini Moullade, 1960, pl. 2, figs. 10–14. Moullade, 1984, pl. 6, figs. 1–3.

Description. Trochospiral, compressed test with rounded periphery. Chambers separated by depressed sutures. Interiomarginal aperture, bordered by a lip and partially covered by flaps extending into the umbilical area.

Range and Occurrence. One specimen found in Sample 159-959D-71R-1, 30–33 cm.

Gavelinella spp.
Plate 3, Figures 7, 11.

Description. We included in this group all small, trochospiral tests, evolute dorsallly and flattened, involute, ventrally with angled or subrounded periphery, open, depressed umbilicus and interiomarginal slit aperture bordered by a lip, extending from the umbilicus to the periphery.

Range and Occurrence. Common in Hole 962D.

Genus ***Gyroidinoides*** Brotzen, 1942

Gyroidinoides* cf. *nitidus (Reuss, 1845)
Plate 3, Figure 15.

Rotalina nitida Reuss, 1845, pl. 8, fig. 52, pl. 12, figs. 8, 20.
Gyroidinoides nitidus (Reuss). Basov and Krasheninnikov, 1983, pl. 9, figs. 2, 3.

Description. Trochospiral, subspherical test, with flattened spiral side and strongly convex umbilical side. Five or six chambers in last whorl separated by flush or slightly depressed sutures. Interiomarginal slit aperture close to the periphery.

Range and Occurrence. *Gyroidinoides nitidus* is typically a Late Cretaceous taxon, widely recorded from Upper Cretaceous sediments of Europe, North and South America (McNeil and Caldwell, 1981), Russia, and the Atlantic Ocean (Basov and Krasheninnikov, 1983). Rare in Hole 962D. Some large specimens found in Sample 159-962D-29R-1, 60−63 cm.

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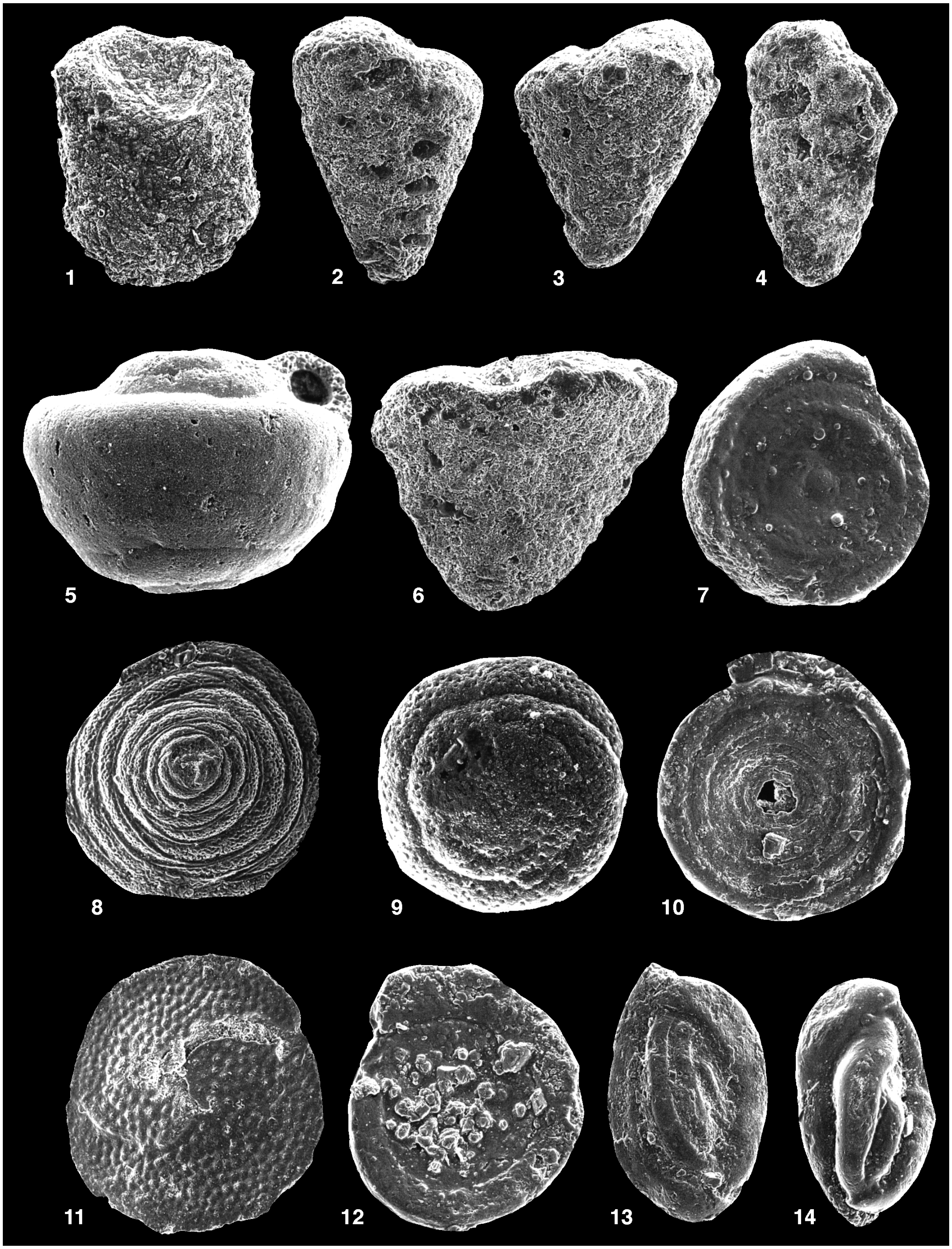

Plate 1. **1.** *Nothia latissima* (Grzybowski), 72×; Sample 159-962D-20R-3, 56–60 cm. **2.** *?Spiroplectinella* sp. 1, 183×; Sample 159-962D-30R-1, 93–97 cm. **3.** *?Spiroplectinella* sp. 1, 183×; Sample 159-962D-30R-2, 52–55 cm. **4.** *?Spiroplectinella* sp. 1; 165×, Sample 159-962D-37R-2, 143–146 cm. **5.** *Glomospira charoides* (Jones & Parker), 183×; Sample 159-962B-8H-CC, 1–4 cm. **6.** *?Spiroplectinella* sp.1, 165×; Sample 159-962D-28R-1, 92–96 cm. **7.** *Spirillina minima* Schacko, 190×; Sample 159-962D-37R-CC. **8.** *Patellina subcretacea* Cushman & Alexander, 200×; Sample 159-962D-20R-4, 44–49 cm. **9.** *Trocholina infragranulata* Noth, 240×; Sample 159-962D-20R-4, 119–122 cm. **10.** *Spirillina minima* Schacko, 195×; Sample 159-962D-20R-4, 44–49 cm. **11.** *Patellina subcretacea* Cushman & Alexander, 140×; Sample 159-962D-20R-4, 44–49 cm. **12.** *Trocholina infragranulata* Noth, 240×; Sample 159-962D-28R-1, 92–96 cm. **13.** *Quinqueloculina* sp., 130×; Sample 159-962D-24R-3, 13–17 cm. **14.** *Quinqueloculina* sp., 130×; Sample 159-962D-20R-4, 44–49 cm.

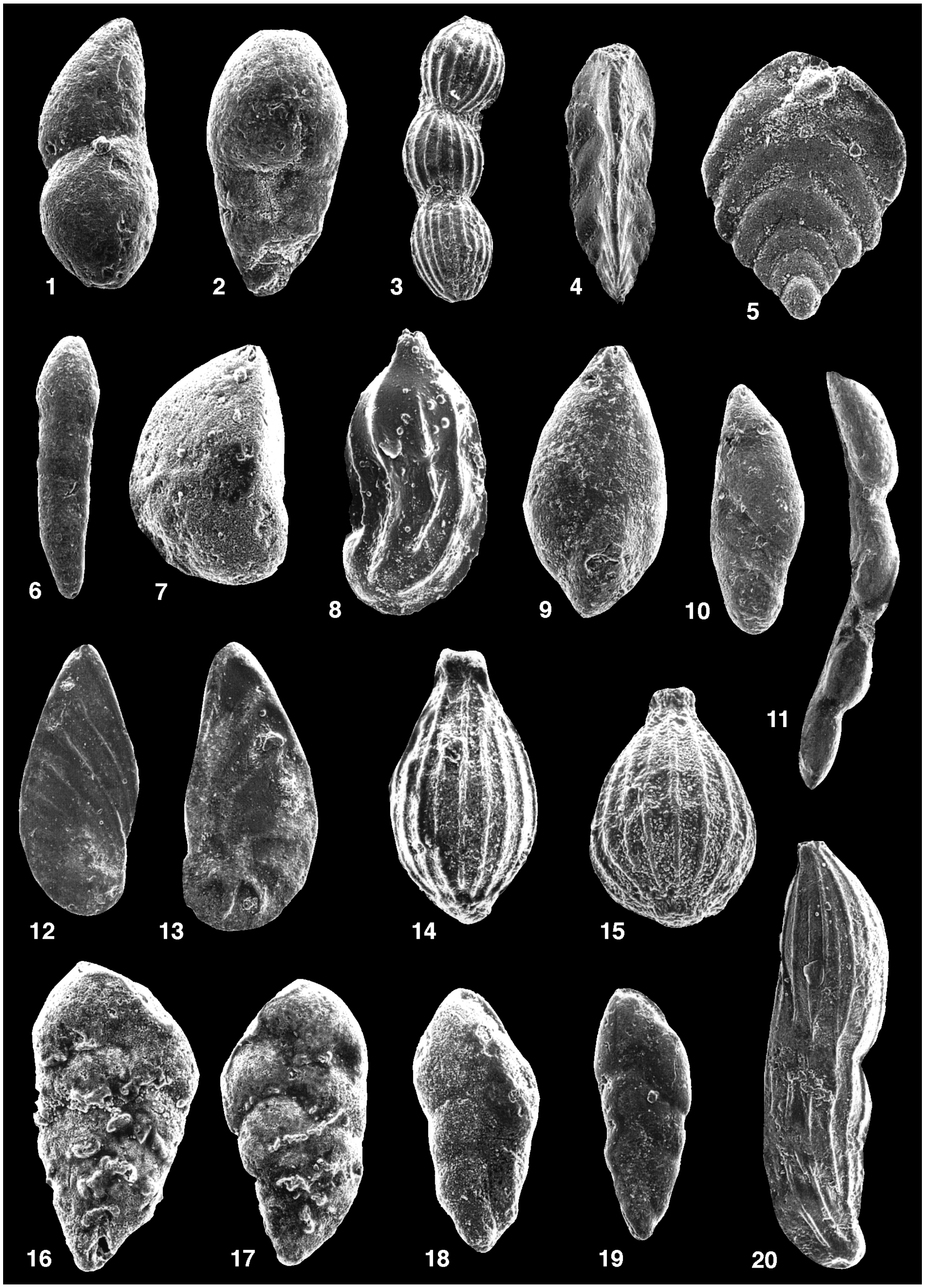

Plate 2. **1.** *Laevidentalina oligostegia* (Reuss), 165×; Sample 159-962D-34R-1, 118–122 cm. **2.** *Pseudonodosaria* sp. 1, 240×; Sample 159-962D-35R-3, 87–91 cm. **3.** *Pyramidulina sceptrum* (Reuss), 110×; Sample 159-962D-20R-4, 44–49 cm. **4.** *Tristix acutangula* (Reuss), 110×; Sample 159-962D-30R-1, 93–97 cm. **5.** *Frondicularia lamellata* Tappan, 130×; Sample 159-962D-12R-2, 11–14 cm. **6.** *Lingulonodosaria nodosaria* (Reuss), 130×; Sample 159-962D-36R-1, 48–51 cm. **7.** *Lenticulina* sp., 165×; Sample 159-962D-24R-1, 34–38 cm. **8.** *Marginulinopsis jonesi* (Reuss), 130×; Sample 159-959D-71R-1, 30–33 cm. **9.** *Globulina prisca* (Reuss), 195×; Sample 159-962D-20R-4, 44–49 cm. **10.** *Astacolus calliopsis* (Reuss), 100×; Sample 159-962D-28R-1, 92–96 cm. **11.** *Laevidentalina debilis* (Berthelin), 80×; Sample 159-962D-24R-2, 141–145 cm. **12.** *Planularia complanata* (Reuss), 80×; Sample 159-962D-28R-1, 92–96 cm. **13.** *Planularia complanata* (Reuss), 140×; Sample 159-962D-28R-2, 67–70 cm. **14.** *Oolina sulcata* (Walker & Jacob), 195×; Sample 159-962D-37R-2, 143–146 cm. **15.** *Oolina sulcata* (Walker & Jacob), 195×; Sample 159-962D-28R-1, 92–96 cm. **16.** *Bolivina anambra* Petters, 270×; Sample 159-962D-9R-1, 34–38 cm. **17.** *Bolivina anambra* Petters, 195×; Sample 159-962D-9R-1, 34–38 cm. **18.** *Bolivina* sp. 1, 145×; Sample 159-962D-18R-4, 32–36 cm. **19.** *Bolivina* sp. 1, 140×; Sample 159-962D-20R-4, 44–49 cm. **20.** *Marginulinopsis striatocostata* (Reuss), 110×; Sample 159-962D-24R-3, 13–17 cm.

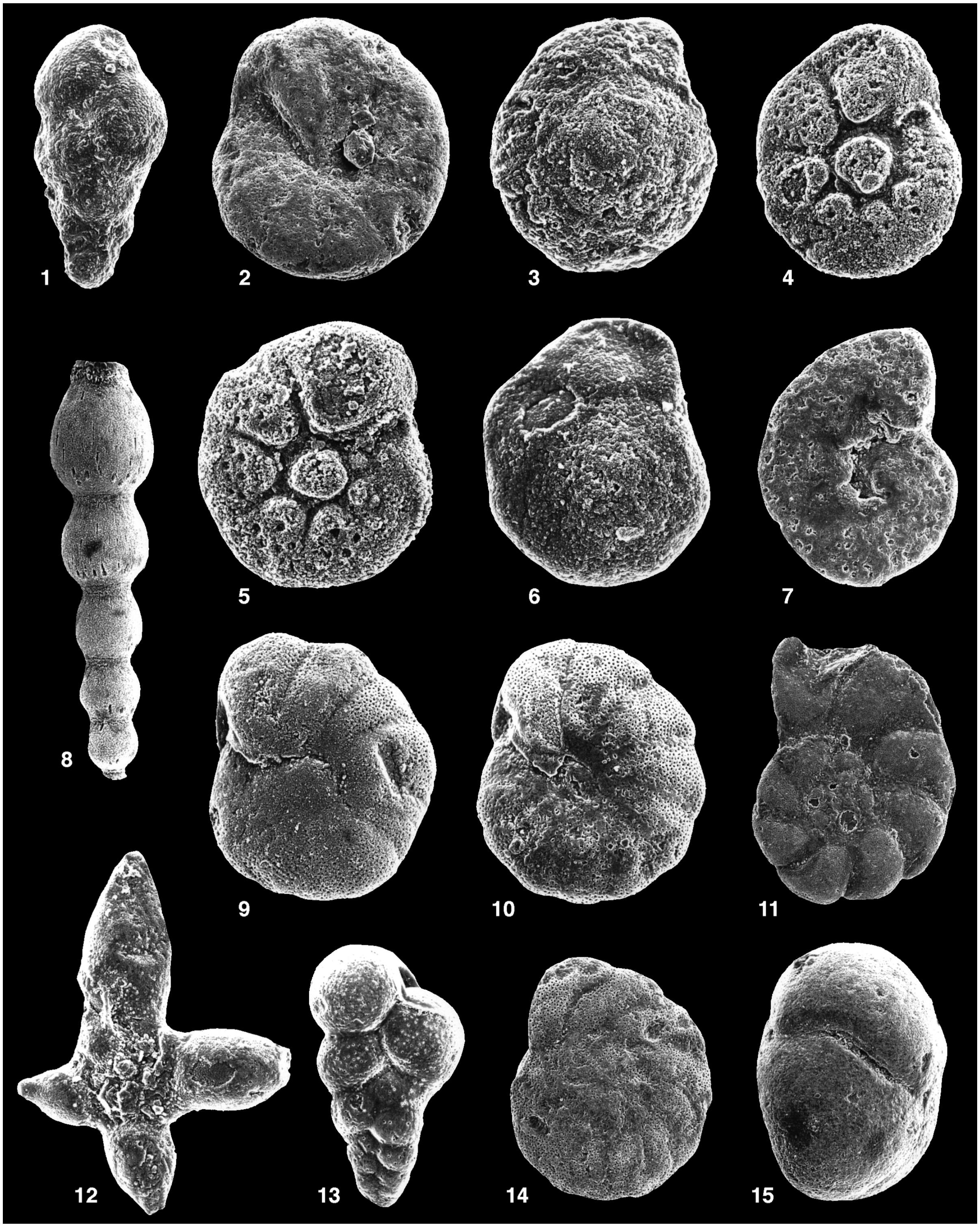

Plate 3**.** **1.** *Neobulimina albertensis* (Stelck & Wall), 180×; Sample 159-962D-34R-3, 11–14 cm. **2.** *Osangularia* sp. 1, 275×; Sample 159-962D-37R-2, 143–146 cm. **3.** *Osangularia* sp. 1, 250×; Sample 159-962D-20R-3, 56–60 cm. **4.** *Osangularia* sp. 2, 275×; Sample 159-962D-18R-3, 10–15 cm. **5.** *Osangularia* sp. 2, 290×; Sample 159-962D-16R-3, 73–76 cm. **6.** *Osangularia* sp. 2, 310×; Sample 159-962D-20R-4, 119–122 cm. **7.** *Gavelinella* sp., 290×; Sample 159-962D-18R-4, 32–36 cm. **8.** *Stilostomella* sp., 265×; Sample 159-962B-8H-5, bottom. **9.** *Berthelina intermedia* (Berthelin), 180×; Sample 159-962D-24R-2, 71–75 cm. **10.** *Berthelina intermedia* (Berthelin), 180×; Sample 159-962D-16R-1, 9–12 cm. **11.** *Gavelinella* sp., 130×; Sample 159-962D-20R-4, 44–49 cm. **12.** *Schackoina* sp., 265×; Sample 159-962D-23R-CC, 11–15 cm. **13.** *Heterohelix* sp., 175×; Sample 159-962D-9R-1, 34–38 cm. **14.** *Berthelina intermedia* (Berthelin). 130×; Sample 159-962D-19R-2, 22–25 cm. **15.** *Gyroidinoides* cf. *nitidus* (Reuss), 110×; Sample 159-962D-36R-3, 98–101 cm.