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33. MIDDLE EOCENE BENTHIC FORAMINIFERS FROM HOLES 960A AND 960C, CENTRAL ATLANTIC OCEAN[1]

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ABSTRACT

Benthic foraminifers of Eocene age from Holes 960A and 960C of the Ocean Drilling Program Leg 159 were examined. More than 70 species were isolated and identified. Very few fossiliferous samples are scattered in a sequence, which for the most part, is barren of calcareous microfossils. Based on the biostratigraphic analysis of their benthic foraminifer content, these fossiliferous samples are given a Bartonian age.

Despite some important intervals without any recovery, it appears that a long episode of strong carbonate dissolution was interrupted during Bartonian times by one or more sporadic and brief events of slight corrosion. We suggest that the samples were deposited in middle–lower bathyal environments at about 2 ± 1 km water depth, close to the lower limit of an oxygen minimum zone.

INTRODUCTION AND GEOGRAPHICAL SETTING

We examined benthic foraminifers from nine samples of Eocene age from Ocean Drilling Program Holes 960A and 960C, located on the top of the Marginal Ivorian Ridge (Fig. 1).

The analyzed samples were taken in a poorly recovered Paleogene sequence, truncated by an erosional event during the late Eocene and the Oligocene. According to the preliminary shipboard studies (Shipboard Scientific Party, 1996), the major part of the Paleogene section appears to be barren of calcareous microfossils and is dated Paleocene–Eocene by using sporadic and poorly preserved nannofossils (CP10 and CP12a–13) and planktonic foraminifers (P3/6 and P10–11).

MATERIALS AND METHODS

After drying, 10 to 20 cm^3 of each sample were disaggregated in paraffin oil for 24 hr and then washed using a thin trickle of water on nested sieves of 125-µm average mesh size.

This method permitted us to preserve the most delicate ornamental features of various microfossils, especially radiolarians.

Benthic foraminifers and other microfossils were identified (Fig. 2) and counted from the 125-µm size fraction. Percentages of planktonic foraminifers were also estimated (Fig. 3).

CHARACTERISTICS AND PRESERVATION OF THE ASSEMBLAGES

Samples 159-960A-14R-1, 39–42 cm, and 159-960C-17X-1, 112–114 cm, yielded a rich and well-diversified assemblage of benthic foraminifers.

More than 70 species were separated from the two samples (Fig. 2). Dominant taxa are represented by two genera: *Stilostomella* (Pl. 2, Figs. 10–13, and Pl. 3, Figs. 12–15) and *Bulimina* (Pl. 2, Figs. 1–6) and by two species: *Globocassidulina subglobosa* (Pl. 4, Figs. 17, 18) and *Oridorsalis umbonatus.* On the other hand, many species are represented by only one or a few specimens per sample.

We identified all microfossils, but because of their eventual scarcity and poor preservation, some of them have been left in open nomenclature. Two species appear to be new and one is described (*Pyramidina africana* n. sp., Pl. 3, Figs. 1–11).

In these two samples, benthic foraminifers are associated with planktonic foraminifers, numerous radiolarians, small echinid reticulated spines, and some ichthyoliths.

Other Eocene samples also contain ichthyoliths, siliceous sponge spicules, and sometimes numerous radiolarians (Samples 159-960A-15R-1, 114–116 cm, and 159-960C-15H-4, 113–115 cm), but foraminifers are absent or very scarce (one or few specimens per sample). All identified microfossils are listed in Figure 3.

The preservation of Samples 159-960A-14R-1, 39–42 cm, and 159-960C-17X-1, 112–114 cm, varies according to the species.

Benthic foraminifers show the following features: loss of surface smoothness (e.g., Nodosariidae), thinning of wall and fragility of test, etching of ornamentation (e.g., costae, *Rectuvigerina mexicana*; Pl. 2, Fig. 16), apertural details (*Chrysalogonium*; Pl. 1, Fig. 10), widening of pores (*Cibicidoides grimsdalei;* Pl. 4, Figs. 3, 4), breakage of rectilinear tests (*Chrysalogonium;* Pl. 1, Figs, 9–11, 13; *Stilostomella*; Pl. 2, Figs. 10–13, and Pl. 3, Figs. 12, 13) or of the last chamber(s) of coiled tests (*Cibicidoides grimsdalei;* Pl. 4, Figs. 3, 4), calcite overgrowths upon the test surface (sugary appearance) obscuring fine details (*Caucasina*? n? sp.; Pl. 4, Fig. 14), complete recrystallization, and pulverization of Miliolids tests.

Planktonic foraminifers are more etched than the benthic ones, and representatives of *Clavigerinella* are sometimes reduced to isolated chambers after the complete disappearance of the umbilical portion of the test (Pl. 4, Figs. 19, 20). Probably some (or numerous?) specimens were entirely dissolved. Thus, it is difficult to establish an accurate planktonic/benthic ratio. In Sample 159-960C-17X-1, 112–114 cm, this apparent ratio is about 35%. Benthic species dominance is proposed in Figure 3.

BIOSTRATIGRAPHIC REMARKS

Numerous species of Eocene benthic foraminifers present in Holes 960A and 960C have little stratigraphic significance. However, some of them have shorter ranges and are considered as good index fossils. Several taxa mentioned in Tjalsma and Lohmann

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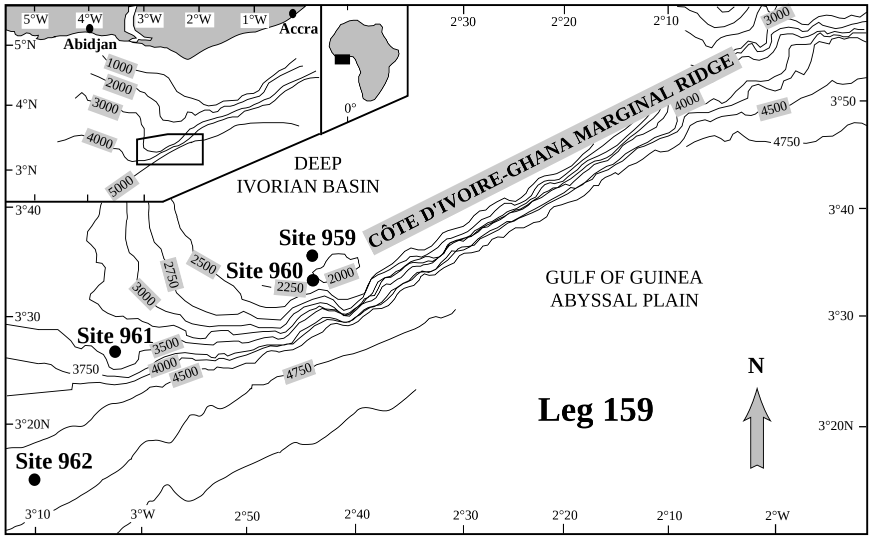

Hole (coordinates)	Core, section	Interval (cm)	Depth (mbsf)	Volume (cm^3)
960A	14R-1	39-42	117.29	20
	15R-1	71-74	127.31	20
	20R-1	97-99	175.47	10
3°34.979'N	21 R-1	11 13	184.21	10
2°44.009'W				
	15H-1	114-116	130.84	10
960C	15H-3	116-118	133.86	10
	15H-4	113-115	135.33	10
	17X-1	112-114	141.32	10
3°35.025'N	22X-1	66-68	189.26	10
2°43.990'W				

Figure 1. Location of Site 960 and depths of the nine analyzed samples.

(1983) and in van Morkhoven et al. (1986), and found in the analyzed samples, are listed in Figure 4.

Two of the species found in Sample 159-960A-14R-1, 39–42 cm, are of special interest. According to previous authors, the FAD (First Appearance Datum) of *Bulimina glomarchallengeri* (Pl. 2, Fig. 1) is in Zone P14, as well as the last occurrence of *Aragonia aragonensis* (Pl. 4, Figs. 7, 8). Thus the co-occurrence of these two species leads to confer a P14 age to the assemblage (i.e., the upper part of the middle Eocene and, more precisely, the Bartonian standard stage; Odin and Luterbacher, 1992; Berggren et al., 1995). Although the planktonic species were not studied in detail, remains of *Clavigerinella* gr. *eocanica* (Pl. 4, Figs. 19, 20), which have been found with the benthic foraminifers, are in agreement with the age proposed here. This age is quite different from that initially suggested (pp. 178–182) in Shipboard Scientific Party (1996).

The assemblage found in Sample 159-960C-17X-1, 112–114 cm, is consistent with a similar stratigraphic assignment, but could also be slightly older (possibly P13 or even P12) because some markers, especially, *Bulimina glomarchallengeri*, are absent.

Because of the lack of calcareous microfossils, an exact biostratigraphic dating of the other samples analyzed is not possible.

PALEOGEOGRAPHICAL DISTRIBUTION

It is hard to recognize the global extension of benthic foraminifers. Detailed taxonomic investigations (including search of synonymies) are always needed since most of the time one can suspect that a different name is used for the same species on every continent.

Scarce species of the Eocene assemblage found in Holes 960A and 960C are nearly worldwide in their distribution. For example, *Vaginulinopsis fragaria* is recorded in the Tethyan realm, at least from Ukraine to Mexico and California, and also far away toward the north: Orphan Knoll (Berggren and Aubert, 1976) and northwestern European basins (England, Netherlands, northern Germany) up to paleolatitudes of 35°–40°N.

The greater part of the identified species is common in and characteristic of the Tethyan realm. Well known in the deep basins of the Caribbean area since the classic publications of Cole (1927, 1928), Nuttall (1930), Cushman (1939), Cushman and Stainforth (1945), Cushman and Renz (1946, 1948), and Beckmann (1953), they have also often been described in Alpine bathyal Eocene paleoenvironments by European micropaleontologists, such as Reuss (1851) and

Foraminifers: * >5%; ▲ 1% to 5%; ● Scarce specimens

Microfossils	960A 14R 1	960A 15R 1	960A 20R 1	960A 21R 1	960C 15H 1	960C 15H 3	960C 15H 4	960C 17X 1	960C 22X 1
AMMODISCIDAE									
Psammosphaera eocenica CUSHMAN & STAINFORTH, 1951	▲							*	
ATAXOPHRAGMIIDAE									
Karreriella siphonella (REUSS, 1854).	▲							▲	
and its early stage "*Eggerella*" *palmerae* (COLE, 1927).	▲							▲	
Tritaxia havanensis (CUSHMAN & BERMUDEZ, 1937)	●								
TEXTULARIIDAE									
Spiroplectammina spectabilis (GRZYBOWSKI, 1898)	▲								
Vulvulina haeringensis (GUMBEL, 1868)								●	
MILIOLIDAE									
Spiroloculina ? sp. and others								●	
NODOSARIIDAE									
Astacolus sp.	●							●	
Chrysalogonium asperum CUSHMAN & STAINFORTH, 1945	▲							▲	
Chr. cf. *breviloculum* CUSHMAN & JARVIS, 1934	●								
Chr. laeve CUSHMAN & BERMUDEZ, 1936								●	
Chr. cf. *tenuiscostatum* CUSHMAN & BERMUDEZ, 1936								●	
Ch. vicksburgense TODD 1952	▲							▲	
Dentalina gr. *cooperensis* CUSHMAN, 1933	●							●	
D. guttifera d'ORBIGNY, 1846								▲	
D. pulchrella COLE, 1927.	●							●	
Lagena apiopleura LOEBLICH & TAPPAN, 1953								●	
L. crowleyi MARTIN, 1943	●							●	
L. gr. *gracilicosta* REUSS, 1863	●								
L. sulcata basisenta CUSHMAN & STAINFORTH, 1945								●	
Lenticulina spp..	▲							▲	
Marginulina pediformis BORNEMANN, 1855	▲							▲	
M. spp	▲							▲	
Nodosaria maximiliana GUMBEL, 1868	●							●	
Plectofrondicularia sp.								●	
Pseudonodosaria cf. *conica* (NEUGEBOREN, 1850)	●							●	
Vaginulinopsis fragaria (JONES, 1854)	●							●	
V. nummulitica (GUMBEL, 1868)	●							●	
POLYMORPHINIDAE									
Globulina inaequalis REUSS 1850	●							?	
Pyrulina gr. *cylindroides* (ROEMER, 1838)	●								
Ramulina sp..			?					●	

Figure 2. Distribution of microfossils in analyzed samples from Holes 960A and 960C.

Gümbel (1868). According to Hagn (1956) and other more recent publications, several synonymies were established:

Cibicidoides eocaenus (Gümbel, 1868) = *C. tuxpamensis* (Cole, 1928) = *C. perlucida* (Nuttall, 1932);
Hanzawaia ammophila (Gümbel, 1868) = *H. cushmani* (Nuttall, 1930); and
Osangularia pteromphalia (Gümbel, 1868) = *O. mexicana* (Cole, 1928).

Some others are suspected and proposed here in the taxonomic notes. Thus, the Eocene central Atlantic assemblage is present in the Tethyan realm as well (Proto Decima and Bolli, 1978; Clark and Wright, 1984; Bolli et al., 1994).

PALEOBATHYMETRY AND DISSOLUTION RATE

The high foraminifer absolute abundance and species diversity in the fossiliferous samples indicate benthic environments (normal salinity, high concentrations of dissolved carbon dioxide and oxygen, and abundant food resources) of an open sea with water renewal.

With only 35% of planktonic foraminifers, following the diagram of van Marle et al. (1987), the assemblages found in Samples 159-960A-14R-1, 39–42 cm, and 159-960C-17X-1, 112–114 cm, would be deposited no deeper than those in upper bathyal environments, with a water depth of 300–500 m or less. On the other hand, the benthic species that have been found in our samples are absent from the neritic and upper bathyal environments drilled by oil research companies in the neighboring Senegal, Ivory Coast, and Gabon margins (Brun, 1978). In addition, we observed in our samples a significant dissolution of foraminiferal tests, especially those of planktonic species. An indeterminate number of planktonic foraminifers probably disappeared. Thus, this assumption and direct observations do not allow us to take into account the planktonic/benthic ratio.

Publications of Tjalsma and Lohmann (1983) and van Morkhoven et al. (1986) about deep-water benthic foraminifers provide a list of some good paleobathymetric indices. According to the compilation shown in Figure 5, during middle Eocene times the seafloor on the top of the Ivorian Marginal Ridge was of a middle or lower bathyal type, at about 2 ± 1 km water depth.

This assumption is consistent with the provisional conclusions about the geologic history of the Ivorian Marginal Ridge (Shipboard Scientific Party, 1996). An Early Cretaceous preliminary uplift was followed in the Late Cretaceous (Santonian? Campanian?) by a slow subsidence, bringing the actual seafloor toward a 2 km depth.

Boss and Wilkinson (1991) suggest that in the Atlantic Ocean, during middle Eocene times, the average Calcite Compensation

Foraminifers: * > 5%; ▲ 1% to 5%; • Scarce specimens

Microfossils	960A 14R-1	960A 15R-1	960A 20R-1	960A 21R-1	960C 15H-1	960C 15H-3	960C 15H-4	960C 17X-1	960C 22X-1
BULIMINIDAE									
Bulimina glomarchallengeri TJALSMA & LOHMANN, 1983	•								
B. impendens PARKER & BERMUDEZ, 1937	▲							▲	
B. macilenta CUSHMAN & PARKER, 1939	*							▲	
B. semicostata NUTTALL, 1930	*							*	
B. trinitatensis CUSHMAN & JARVIS, 1928	▲							▲	
Fissurina cf. *orbignyana* SEGUENZA, 1862	•							•	
F. sp.	•							•	
Pyramidina africana n. sp.	*							▲	
Rectuvigerina mexicana (CUSHMAN, 1926)	▲							▲	
Stilostomella atlantisae (CUSHMAN, 1930)	*								
St. chileana (TODD & KNIKER, 1952)	•								
St. dentata-glabrata (CUSHMAN, 1936)	•								
St. gr. *jarvisi* (CUSHMAN, 1936)	▲	•						▲	
St. rohri (CUSHMAN & STAINFORTH, 1945)	•	•						•	
Turrilina robertsi HOWE & ELLIS, 1939	▲								
Uvigerina rippensis COLE, 1927	*								
U. spinosa BOERSMA, 1964	▲								
NONIONIDAE									
Florilus florinensis COLE, 1927	•							•	
Nonion havanense CUSHMAN & BERMUDEZ, 1937	*							▲	
Pullenia eocenica CUSHMAN & SIEGFUS, 1939	▲							▲	
P. quinqueloba (REUSS, 1851)	▲		•					•	
ROTALIFORMS									
Anomalinoides semicribrata (BECKMANN, 1953)	▲							▲	
A. spissiformis (CUSHMAN & STAINFORTH, 1945)	*							•	
Cibicidoides eocaenus (GUMBEL, 1868)	▲							▲	
C. grimsdalei (NUTTALL 1930)	▲							▲	
C. sp.*14* VAN MORKHOVEN & al,1986	▲								
Gyroidinoides girardana (REUSS, 1859)	▲							▲	
G. octocamerata (CUSHMAN & HANNA, 1927)	•							•	
Hanzawaia ammophila (GUMBEL, 1868)	▲								
Nuttallides truempyi (NUTTALL, 1930)	▲							*	
Oridorsalis umbonatus (REUSS, 1851)	*	•						*	
Osangularia pteromphalia (GUMBEL 1868)	▲							▲	
CASSIDULINIDAE									
Aragonia aragonensis (NUTTALL, 1930)	▲								
Caucasina ? n? sp.	▲							▲	
Ellipsoglandulina labiata (SCHWAGER, 1866)	▲							•	
E.? cf. *multicostata* (GALLOWAY & MORREY, 1929)	▲							•	
Globocassidulina subglobosa (BRADY, 1881)	*							*	
Nodosarella cf. *advena* CUSHMAN & SIEGFUS, 1939								•	
N. cf. *tuberosa* (GUMBEL, 1868)								•	
Pleurostomella brevis SCHWAGER, 1866	▲							•	
P. naranjoensis CUSHMAN & BERMUDEZ, 1937								•	
P. nuttalli CUSHMAN & SIEGFUS, 1939	•								
PLANKTONIC FORAMINIFERS	*	•			•			*	
RADIOLARIANS	*	*			•		*	▲	•
SILICEOUS SPONGES (spicules)						▲	▲		
ECHINIDS (remains)	•							▲	
ICHTHYOLITHS (teeths, vertebras, dermal scales)	▲	▲	▲	*	▲	▲	▲	*	•

Figure 2 (continued).

Depth (CCD) was as shallow as about 3.5 km. We assume that the depositional environment of Samples 159-960A-14R-1, 39–42 cm, and 159-960C-17X-1, 112–114 cm, and possibly of samples devoid of foraminifers, are situated above the CCD.

However, despite its relatively shallow depth, the top of the Ivorian Margin Ridge was characterized during Eocene times by a strong carbonate dissolution episode. This long episode was only interrupted by one or, more probably, a few short events of P14 age, during which the calcium carbonate was partially preserved.

This shallow dissolution might result from the permanent presence in this area of an oxygen minimum zone, with a lower depth of about 1500 m (cf. Ingle, 1980), close to the depositional environment of the samples studied.

In the Equatorial Atlantic Ocean area, the middle Eocene is known as a period of considerable instability (Oberhänsli et al., 1991). We interpret the sporadic levels with rich assemblages of foraminifers (and also of radiolarians) as short-term events of reduced oceanic productivity, probably initiated by fluctuations of equatorial upwellings.

CONCLUSION

Despite the importance of unrecovered intervals and of a limited sampling, the analysis of Eocene benthic foraminiferal assemblages from the marginal Ivorian Ridge permitted us to identify a long epi-

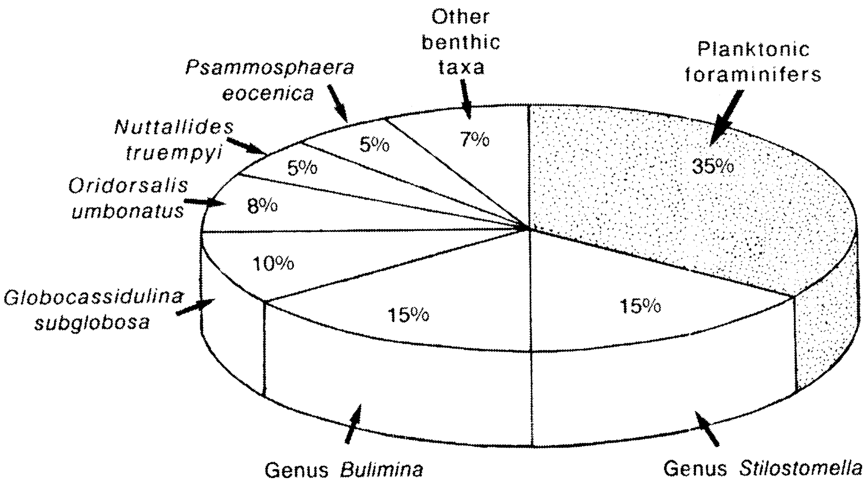

Figure 3. Approximate percentage composition of the foraminiferal association in Sample 159-960C-17X-1, 112–114 cm.

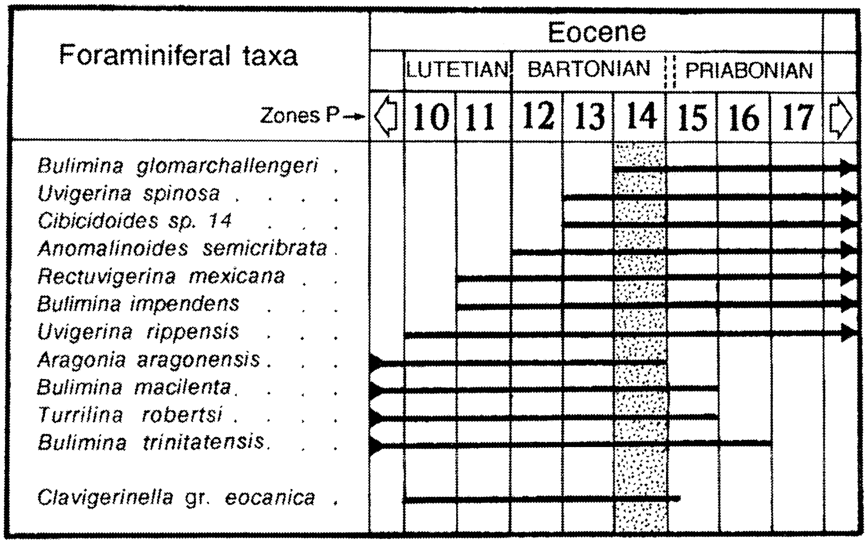

Figure 4. Stratigraphic range and correlation of some selected stratigraphic index foraminiferal species, chiefly according to Tjalsma and Lohmann (1983) and van Morkhoven et al. (1986). The joint occurrence of these species characterizes the P14 zone (stippled area).

sode of strong carbonate dissolution. The depositional environment is estimated to be of a middle or lower bathyal type (i.e., 2 ± 1 km water depth) close to that of the lower boundary of an oxygen minimum zone.

This long episode was interrupted during Bartonian times by one, or most probably, a few sporadic short event(s) of slighter dissolution, probably related to the fluctuations of the oceanic productivity, in relation to the regional pattern of upwellings.

TAXONOMIC NOTES

The benthic foraminiferal assemblage present in the middle Eocene samples of Holes 960A and 960C contains species that are already well known in the literature. Taxonomic references can be found in the Ellis and Messina Catalogue.

Thus, in the present paper, except the description of the new species, we have made only short taxonomic remarks about some species.

Karreriella siphonella (Reuss, 1851)
Plate 1, Figures 1–3

Gaudryina siphonella, Reuss, 1851, p. 78, pl. 5, figs. 40–42, (middle Oligocene from North Germany).

Aperture rounded or elliptical (not elongate) with a short tubular neck, situated toward the inner margin of the last formed chamber. *"Eggerella" palmerae* Cole, 1927, from the Eocene of Trinidad, is regarded to be the early stage of *K. siphonella.* This species has not been reported earlier from deep-water deposits.

Vulvulina haeringensis (Gümbel, 1868)
Plate 1, Figures 5–7

Venilina haeringensis, Gümbel, 1868, p. 71, pl. 2, figs. 84 bis a & b, ("Jüngste Nummulitenschichten" from Bavaria).
Vulvulina haeringensis (Gümbel, 1868) Hagn, 1956, p. 115, pl. 9, figs. 7–8.

Apex rounded. Sides nearly parallel. Sutures distinct, slightly raised and strongly curved backward.

It appeared difficult to distinguish *V. haeringensis* from the following:

Textilaria flabelliformis Gümbel, 1868 (Oligocene from Tirol);
Venilina nummulina Gümbel, 1868 (Oligocene from Tirol);
Vulvulina colei Cushman, 1932 (Eocene from Mexico); and
Vulvulina chirana Cushman and Stone, 1942 (late Eocene from Peru),

which are different by the more or less raised sutures and the number of uniserial chambers.

Vaginulinopsis fragaria (Gümbel, 1868)
Plate 1, Figure 8

Marginulina fragaria Gümbel, 1868, p. 57, pl. 1, fig. 58c (not 58a–b), ("Alteres Eocän Nummulitenmergel" from Bavaria).

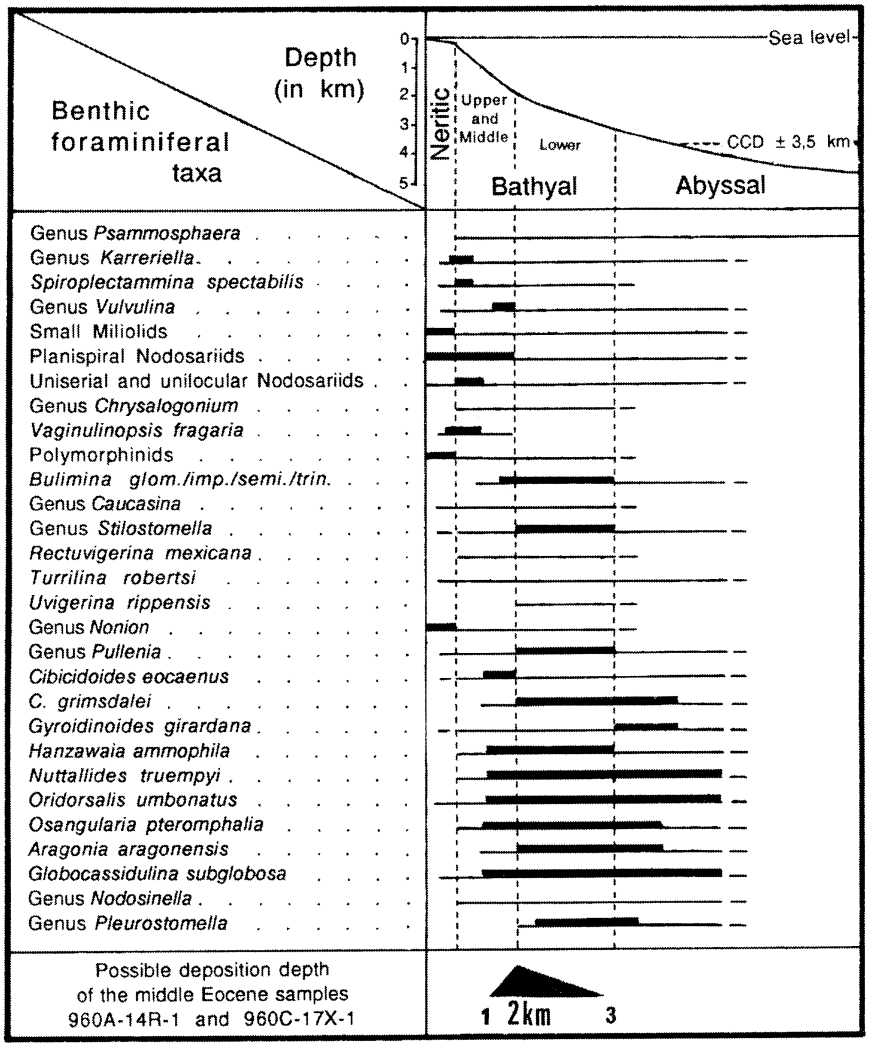

Figure 5. Paleobathymetric distribution of some selected benthic foraminifer taxa. Data are taken from numerous publications, including Boltovskoy and Wright (1976, p. 239), Resig (1976, p. 750), Tjalsma and Lohmann (1983), Boersma (1984), Van Morkhoven et al. (1986), and Murray (1991, p. 323).

Test large (more than 1.5 mm). Ornamentation of rows of rounded tubercles best developed on the coiled portion of the test and giving place to elongate costae on later chambers or even to depressions in extreme maturity. According to the author's estimates of the type specimens, the next Paleocene–Eocene species

Cristellaria subaculeata tuberculata Plummer, 1926, (Paleocene of Texas);
Cristellaria asperuliformis Nuttall, 1930, (early Eocene of Mexico);
Marginulina enbornensis Bowen, 1954, (Ypresian of London Basin); and
Marginulinopsis wetherellii sensu Murray, Curry, Haynes and King 1989, p. 522, pl. 10.7, figs. 10–11, (not *Marginulina wetherelli* Jones, 1854), (Ypresian from London basin)

seem similar to *V. fragaria*.

On other hand, this species appears to be related to, if not derived from, Cretaceous *"Marginulina" decorata* Reuss, 1855.

Chrysalogonium vicksburgense Todd, 1952
Plate 1, Figure 9

Chrysalogonium vicksburgense Todd, 1952, p. 13, pl. 2, figs. 13–15, (Oligocene from Mississippi).

This species has been generally and erroneously cited under the name *Nodosaria longiscata* (not d'Orbigny, 1846). *Ch. vicksburgense* appears to be related with the Paleocene *Ch. arkansasanum* Cushman and Todd, 1946.

Dentalina guttifera d'Orbigny, 1846
Plate 1, Figure 4

Dentalina guttifera d'Orbigny, 1846, p. 49, pl. 2, figs. 11–13, (Miocene from Vienna basin).
Nodosaria guttifera (d'Orbigny, 1846), Papp and Schmid, 1985, p. 30, pl. 13, figs. 1–6.
Dentalina soluta Reuss, 1851, from the Eocene of North Germany (see Kiesel, 1970, p. 226, pl. 8; fig. 4) is a synonym.

Lagena crowlei Martin, 1943
Plate 1, Figure 15

Lagena crowlei Martin, 1943, p., 108, pl. 5, figs. 5a–b, (Lodo formation California).

Test ornamented with nine longitudinal rows of 15 hollow cone-shaped tubules.
Lagena ciperensis Cushman and Stainforth, 1945, from the Oligocene Cipero formation from Trinidad is a synonym.

Pyramidina africana n. sp.
Plate 3, Figures 1–11

Holotype: Plate 3, Figures 1–2.
Paratypes: Plate 3, Figures 3–11.

Depository: The holotype and two paratypes in the Museum National d'Histoire Naturelle de Paris. The other paratypes are in the author's collection.

Type locality: Marginal Ivorian Ridge, central Atlantic Ocean: 3°34.979′N and 2°44.009′W.

Type sample: Section 159-960A-14R-1, 39–42 cm; Depth: 117.29 meters below seafloor (mbsf).

Type stratum: Upper part of middle Eocene (Bartonian), zone P14.

Diagnostic features: Test fusiform, broadest at the middle. Transverse section rounded and not carinated. Chambers broad, triserially and closely arranged. Sutures distinct and depressed. Wall smooth except at the basal part of chambers occupied by dense, cylindrical hollow pustulas. Aperture oval in outline, subterminal, bordered by a small collar, with more or less defined suture connecting aperture to the base of chamber.

Holotype: length: 0.275 mm; diameter: 0.150 mm.

Paratypes: length: 0.225 to 0.300 mm; diameter: 0.125 to 0.150 mm.

Affinities: By its transverse section outline and its apertural features the new species is intermediate between two genera: *Uvigerinella* Cushman, 1926, and *Pyramidina.* Brotzen, 1948. But, like the type-species of the last genus, *P. africana* had a test closely triserial without tendency to become biserial.

The new species is related to the Paleocene species *P. curvisuturata* (Brotzen, 1940) = *P. crassa* Brotzen, 1948, but it is different by its rounded transverse section, the pustulated wall and its apertural collar. Paleocene *P. europaea* (Cushman and Edwards, 1937) and Eocene *Angulogerina muralis* (Terquem, 1882) = *A. mauricensis* Howe, 1939 have chambers subtriangular in section with a pustulated wall and characteristic re-entrants of the basal suture.

Caucasina? n? sp.
Plate 4, Figures 12–16

Specimens in bad state of preservation with a dense coating of small calcite overgrowths upon the test surface (Pl. 4, Fig. 14). These specimens show an aperture, an elongate-oval, high loop at the inner margin of the last chamber at right angle to suture; sutures slightly depressed with some small (arched?) sutural openings; wall coarsely perforate.

They are tentatively regarded to belong to the genus *Caucasina* Khalilov, 1951 (Loeblich and Tappan, 1964).

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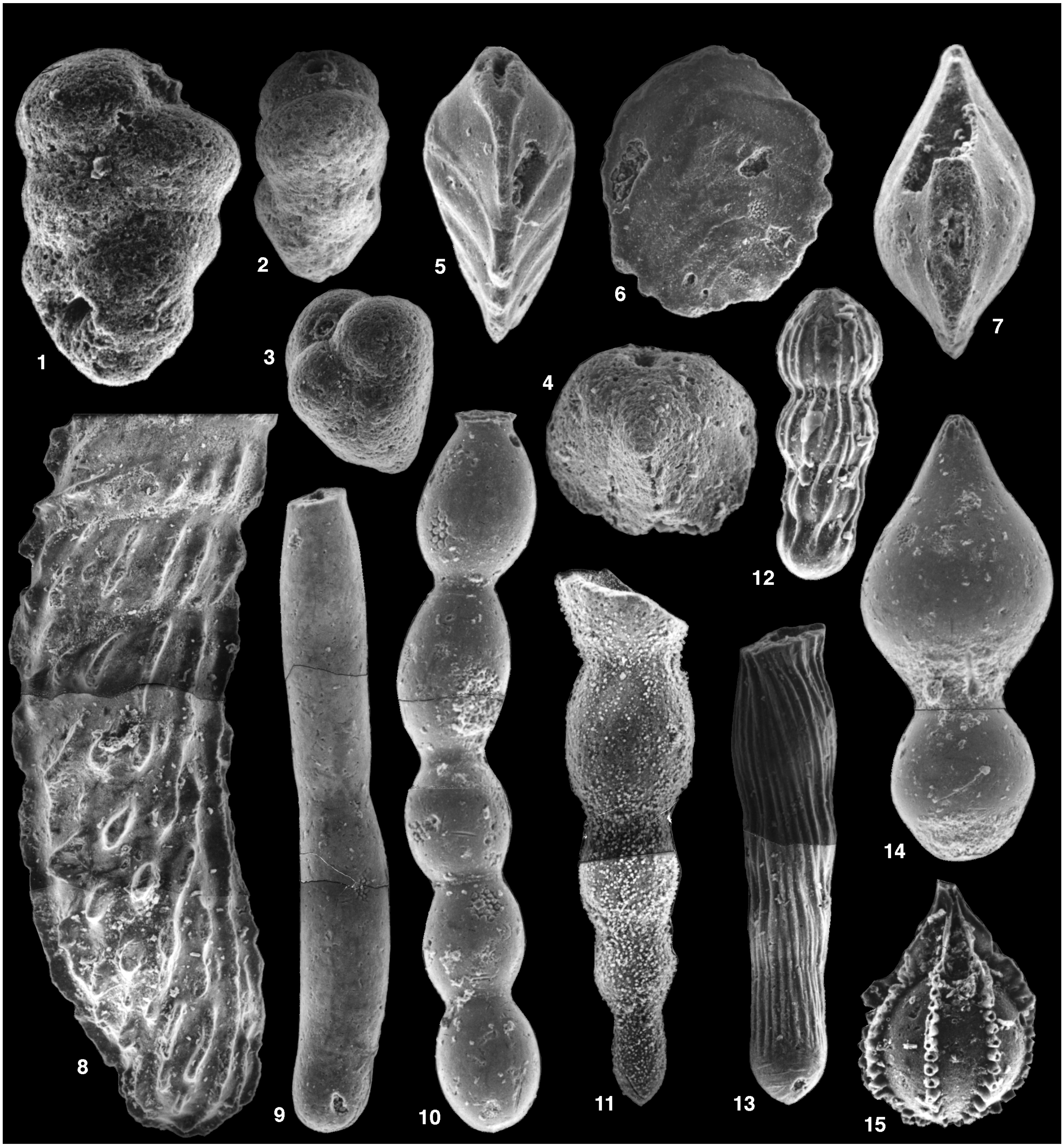

Plate 1. **1, 2.** *Karreriella siphonella;* Sample 159-960A-14R-1, 39–42 cm. 1: 120×. 2: 80×. **3.** "*Eggerella" palmerae;* Sample 159-960C-17X-1, 112–114 cm, 100×. **4.** *Tritaxia havanensis*; Sample 159-960A-14R-1, 39–42 cm, 80×. **5–7:** *Vulvulina haeringensis;* Sample 159-960C-17X-1, 112–114 cm. 5: oblique view, 65×. 6: 50×. 7: apertural view: 80×. **8.** *Vaginulinopsis fragaria*; Sample 159-960A-14R-1, 39–42 cm, 50×. **9.** *Chrysalogonium vicksburgense*; Sample 159-960A-14R-1, 39–42 cm, 60×. **10.** *Chrysalogonium laeve;* Sample 159-960C-17X-1, 112–114 cm, 60×. **11.** *Chrysalogonium asperum;* Sample 159-960A-14R-1, 39–42 cm, 60×. **12.** *Chrysalogonium* cf. *breviloculum*; Sample 159-960A-14R-1, 39–42 cm, 60×. **13.** *Chrysalogonium* cf. *tenuiscostatum;* Sample 159-960A-14R-1, 39–42 cm, 105×. **14.** *Dentalina guttifera;* Sample 159-960A-14R-1, 39–42 cm, 50×. **15.** *Lagena crowleii;* Sample 159-960A-14R-1, 39–42 cm, 130×.

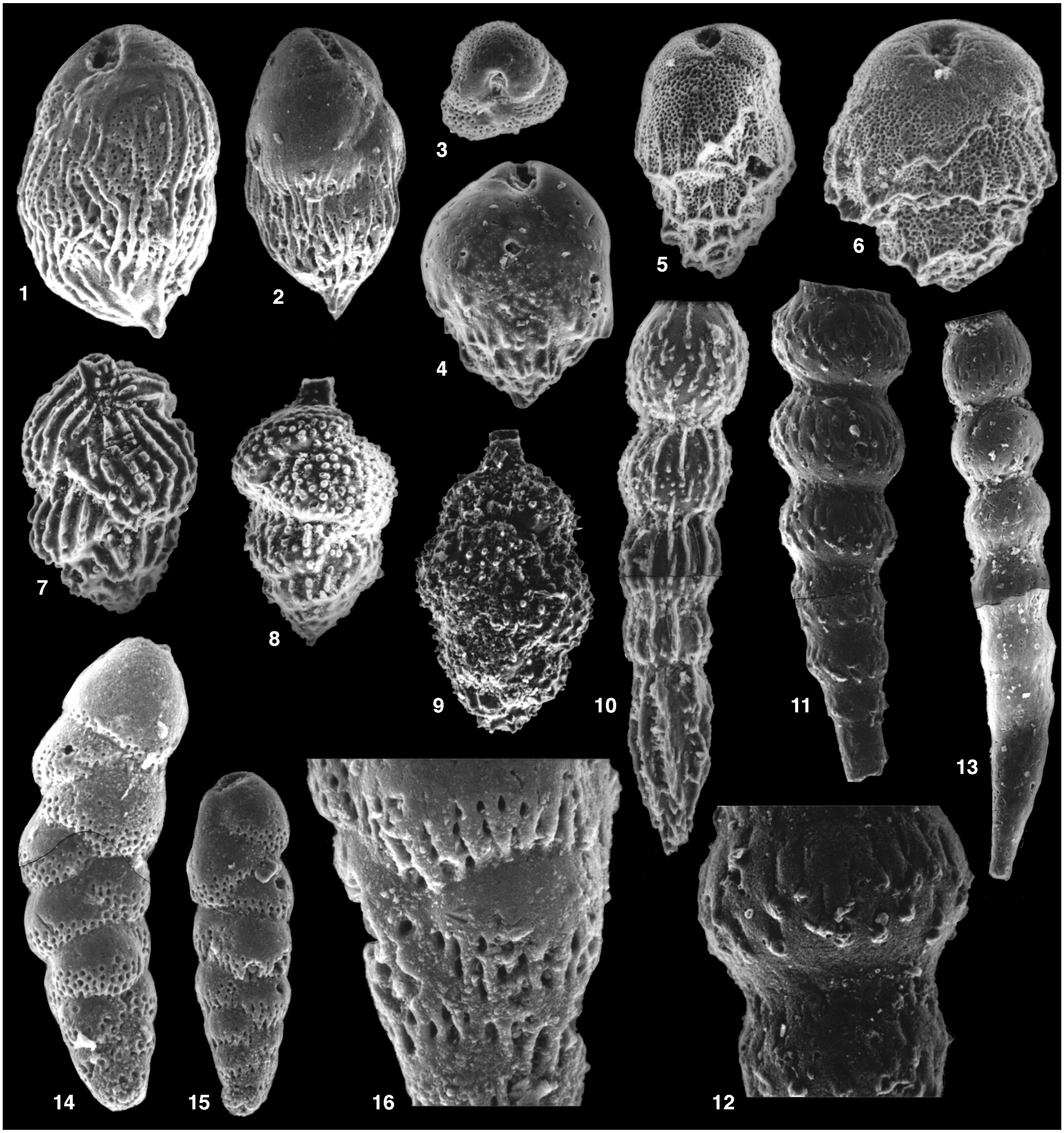

Plate 2. **1.** *Bulimina glomarchallengeri*; Sample 159-960A-14R-1, 39−42 cm, 170×. **2, 3.** *Bulimina semicostata*; 2: Sample 159-960C-17X-1, 112−114 cm, 75×. 3: Sample 159-960A-14R-1, 39−42 cm, 80×. **4.** *Bulimina macilenta;* Sample 159-960A-14R-1, 39−42 cm, 100×. **5.** *Bulimina trinidadensis*; Sample 159-960A-14R-1, 39−42 cm, 125×. **6.** *Bulimina impendens*; Sample 159-960C-17X-1, 112−114 cm, 110×. **7, 8.** *Uvigerina rippensis*; Sample 159-960A-14R-1, 39−42 cm. 7: 100×. 8: 75×. **9.** *Uvigerina spinosa;* Sample 159-960A-14R-1, 39−42 cm, 100×. **10.** *Stilostomella chileana*; Sample 159-960A-14R-1, 39−42 cm, 100×. **11–13.** *Stilostomella* gr. *jarvisi;* Sample 159-960A-14R-1, 39−42 cm. 11: 75×. 12: etched surface test, details of figure: 160×. 13: 50×. **14–16.** *Rectuvigerina mexicana;* Sample 159-960C-17R-1, 112−114 cm. 14: 160×. 15: 120×. 16: etched surface test: 370×.

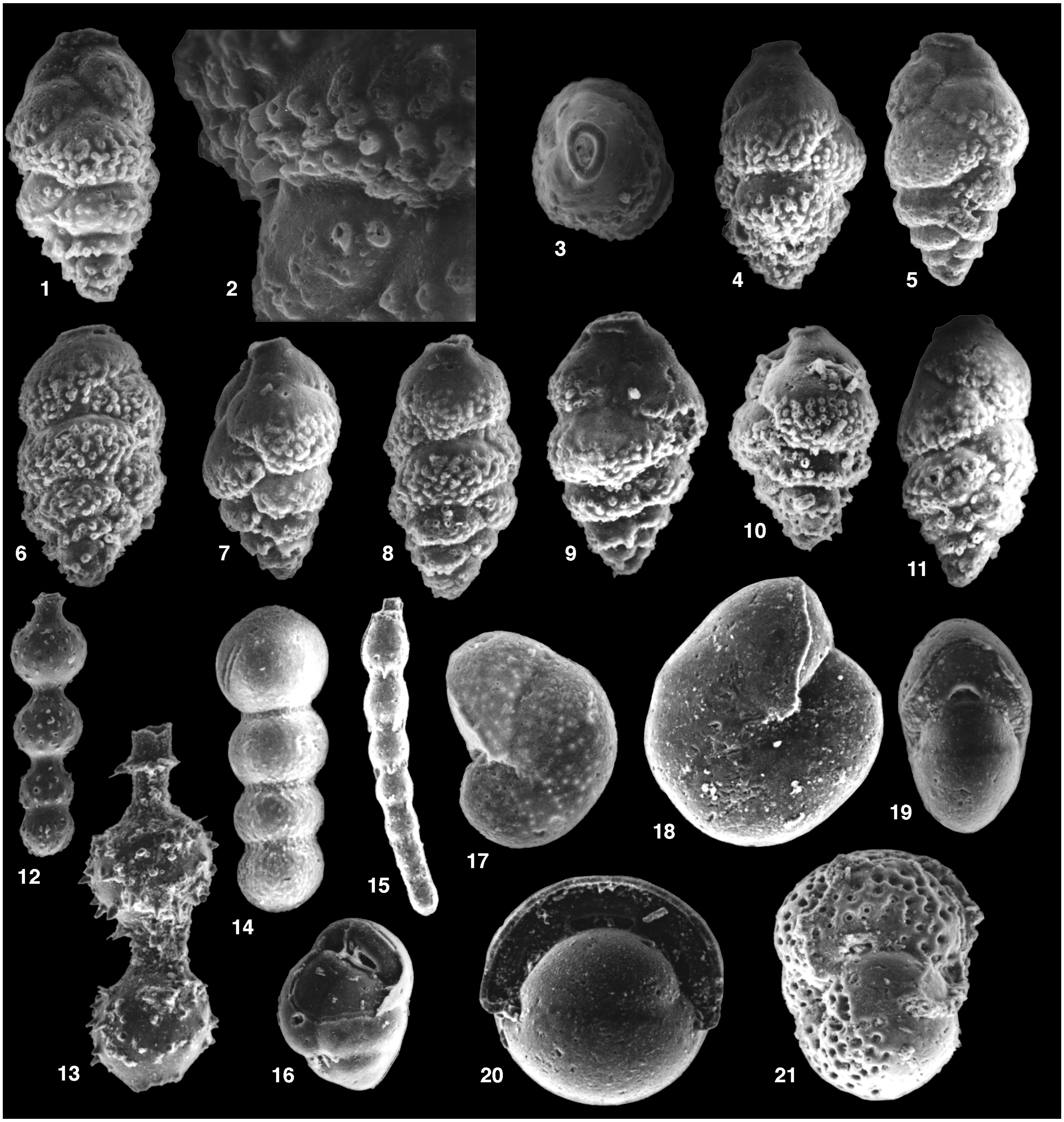

Plate 3. **1–11.** *Pyramidina africana* n. sp.; Sample 159-960A-14R-1, 39–42 cm. 1: holotype: 160×. 2: cylindrical hollow pustules of surface test, details of Figure 1, 500×. 3–11: paratypes, 160×. **12, 13.** *Stilostomella atlantisae*; 12: Sample 159-960A-14R-1, 39–42 cm, etched specimen, 55×. 13: Sample 159-960C-17X-1, 112–114 cm, well-preserved specimen, 150×. **14.** *Stilostomella rohri.*; Sample 159-960C-17X-1, 112–114 cm, 100×. **15.** *Stilostomella dentata-glabrata;* Sample 159-960A-14R-1, 39–42 cm, 80×. **16.** *Turrilina robertsi;* Sample 159-960A-14R-1, 39–42 cm, 80×. **17.** *Florilus florinensis*; Sample 159-960A-14R-1, 39–42 cm, 150×. **18, 19.** *Nonion havanense;* Sample 159-960A-14R-1, 39–42 cm, 18: lateral view, 120×. 19: edge view, 100×. **20.** *Pullenia eocenica;* Sample 159-960A-14R-1, 39–42 cm, edge view, 110×. **21.** *Anomalinoides semicribrata;* Sample 159-960A-14R-1, 39–42 cm, edge view, 100×.

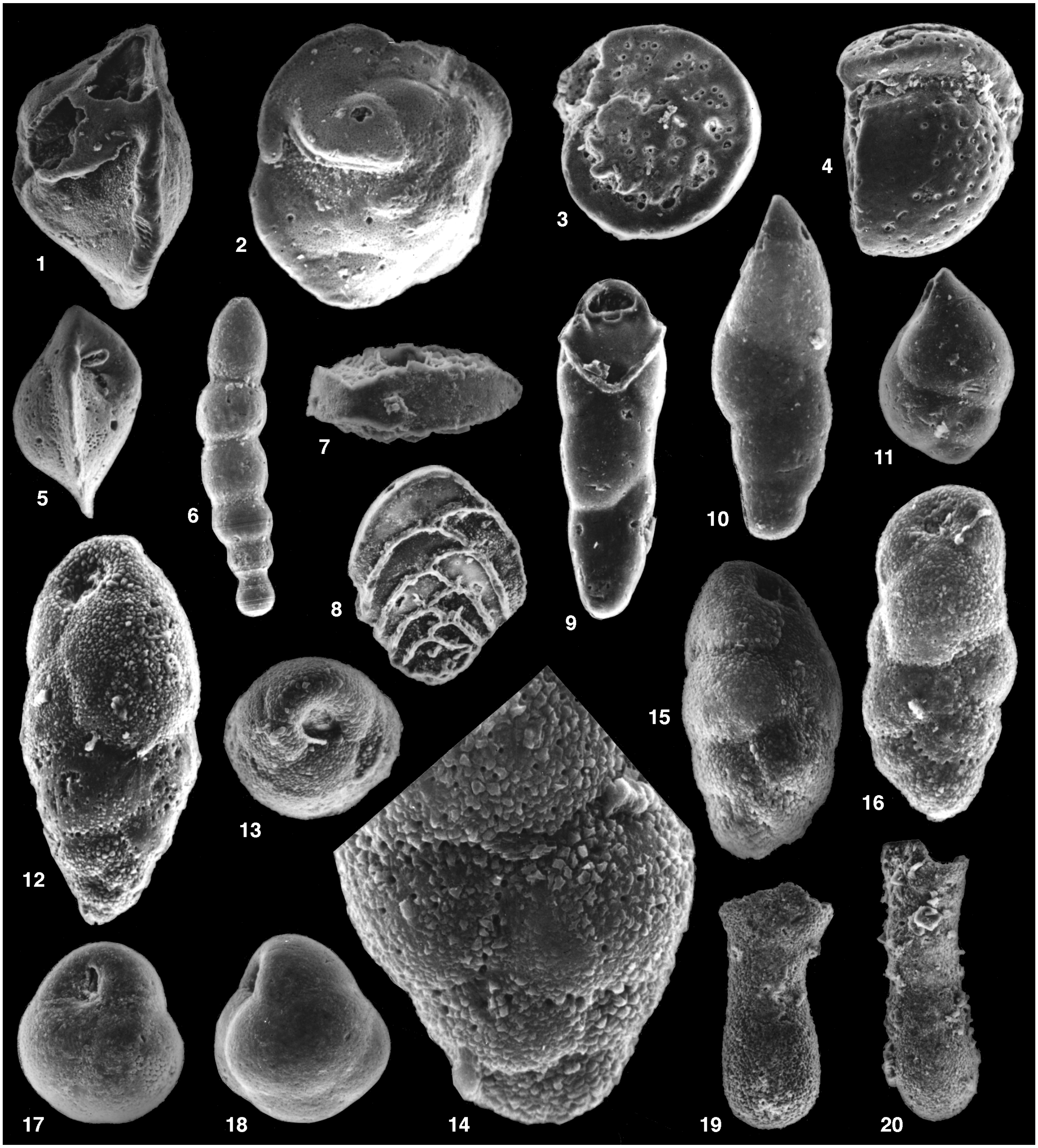

Plate 4. **1, 2.** *Nuttallides truempyii;* Sample 159-960C-17X-1, 112−114 cm. 1: edge view, 70×. 2: umbilical view, 75×. **3, 4.** *Cibicidoides grimsdalei*; Sample 159-960A-14R-1, 39−42 cm, 3: spiral view, 80×. 4: edge view, 100×. **5.** *Osangularia pteromphalia;* Sample 159-960A-14R-1, 39−42 cm, edge view, 80×. **6.** *Nodosarella* cf. *advena; S*ample 159-960C-17X-1, 112−114 cm, 65×. **7, 8.** *Aragonia aragonensis;* Sample 159-960A-14R-1, 39−42 cm. 7: edge view, 100×. 8: lateral view, 100×. **9.** *Pleurostomella nuttalli;* Sample 159-960A-14R-1, 39−42 cm, 180×. **10.** *Pleurostomella naranjoensis;* Sample 159-960C-17X-1, 112−114 cm, 180×. **11.** *Pleurostomella brevis;* Sample 159-960A-4R-1, 39−42 cm, 70×. **12−16.** *Caucasina* ? n? sp.; Sample 159-960A-14R-1, 29−42 cm. 12: 250×. 13: apertural view, 250×. 14: details of coated test surface, 600×; 15: 250×. **17, 18.** *Globocassidulina subglobosa;* Sample 159-960C-17X-1, 112−114 cm, 100×. **19, 20.** *Clavigerinella* gr. *eocanica;* Sample 159-960A-14R-1, 39−42 cm, isolated chambers, 100×.