

34. LATE CRETACEOUS AND PALEOCENE BENTHIC FORAMINIFERS FROM DEEP SEA DRILLING PROJECT SITE 516, RIO GRANDE RISE, WESTERN SOUTH ATLANTIC OCEAN¹

Donald H. Dailey, Cities Service Research, Tulsa, Oklahoma

ABSTRACT

Benthic foraminifers of the Coniacian-Santonian through the Paleocene were recovered from a continuous pelagic carbonate section from Hole 516F on the Rio Grande Rise. Sixty-five genera and 153 species have been identified, most of which have been reported from other localities. Bathyal depths are reflected in the benthic assemblages dominated by gavelinellids (*Gavelinella beccariiiformis*, *G. velascoensis*), *Nuttallides truempyi*, and various gyrogoninids and buliminids. Rapid subsidence during the Coniacian-Santonian from nearshore to upper to middle bathyal depths was followed by much reduced subsidence, with the Campanian-Paleocene interval accumulating at middle bathyal to lower bathyal depths.

A census study based on detailed sampling reveals major changes in benthic faunal composition at the Cretaceous/Tertiary boundary transition. It was a time of rapid turnover, with the extinctions of numerous species and the introduction of many new species. Overall, species diversity decreases about 20%, and approximately one-third of latest Maestrichtian species do not survive to the end of the Cretaceous. This shift indicates a significant environmental change in the deep sea, the precise nature of which is not apparent from the foraminifers or their enclosing sediments.

INTRODUCTION

Of the four sites drilled during Leg 72, Upper Cretaceous and Paleocene sediments were encountered only at Site 516. One of the objectives of this site was to investigate the early evolution of the Rio Grande Rise by drilling through the earliest deposited sediments and into the basement. Three previous attempts to reach the oldest sediments and basement, i.e., Leg 3, Sites 21 and 22 (Maxwell, Von Herzen, et al., 1970a, b), and Leg 39, Site 357 (Perch-Nielsen, Supko, et al., 1977), bottomed in Campanian, Oligocene, and Santonian sediments, respectively. Hole 516F, situated on the northeast flank of the Rio Grande Rise at 30°16.59'S, 35°17.11'W, at a water depth of 1313 m (Fig. 1), was successfully rotary-drilled with continuous coring from 169 to 1270.6 m. We encountered basement at 1252.6 m and, below the 900 m horizon, an essentially complete Upper Cretaceous (Coniacian/Santonian-Maestrichtian) through Paleocene succession with an intact Cretaceous/Tertiary boundary. This report records the Upper Cretaceous-Paleocene benthic foraminifers from this site.

The sedimentary section is predominantly a pelagic carbonate succession (Fig. 2). A high percentage of recovery was achieved, except for the lowermost 50 m, where, on the average, only about 35% of the penetrated section was retrieved. No significant hiatuses or sediment mixing could be recognized within this succession.

Age correlations are based on planktonic foraminifers, coccoliths, and magnetic reversals reported from Site 516 and described in separate chapters of this volume by Pujol, Weiss, and Hamilton and Suzyumov.

Data on the benthic fauna and the stratigraphic occurrences of species are given in Figures 3 through 5 and Appendix 1. Most of the common species are illustrated on Plates 1 through 10.

Sixty-five genera and 153 species have been identified. The foraminiferal fauna, in general, bears a close resemblance to deep-water faunas of distant regions. The Upper Cretaceous assemblages include species reported from California, the U.S. Gulf Coast, the Tampico Embayment of Mexico, and western and eastern Europe; those of the Paleocene have greatest affinities with faunas of the Tampico Embayment, Trinidad, Austria, and the Caucasus region of the Soviet Union. A preponderance of species in the Site 516 fauna have been recognized at other DSDP sites within the South Atlantic region. These include Sites 327, 329, and 330 of Leg 36, from the Falkland Plateau; Sites 355-358 of Leg 39, off southeast Brazil; and Sites 361, 363, and 364 of Leg 40, off southwest Africa. The reader is referred to Beckman (1972, 1978), Proto Decima and Bolli (1978), Sliter (1976, 1977a, b), Tjalsma (1976), and Tjalsma and Lohmann (in press) for more extensive commentaries on the affinities of South Atlantic Upper Cretaceous and Paleocene benthics with other reported contemporaneous faunas.

METHODS

Both freed specimens from disaggregated samples and thin sections cut from indurated limestone were used. However, only freed specimens were utilized in the sample census. The census is based on the study of 65 samples, 60 of 10-cm³ volume, and 5 of 5-cm³ volume from the Cretaceous/Tertiary boundary transition interval. Only specimens greater than 150 μm in diameter were examined. Numbers of benthic specimens per sample fluctuate from as few as 126 individuals to more than 2000; their abundance varies from an estimated 3 to 100% relative to the planktonic element. No relationship between lithology and abundance or diversity of species is apparent.

A slight majority of the assemblages consist of the 300 or more individuals necessary for a statistically valid representation of the fauna

¹ Barker, P. F., Carlson, R. L., Johnson, D. A., et al., *Init. Repts. DSDP*, 72: Washington (U.S. Govt. Printing Office).

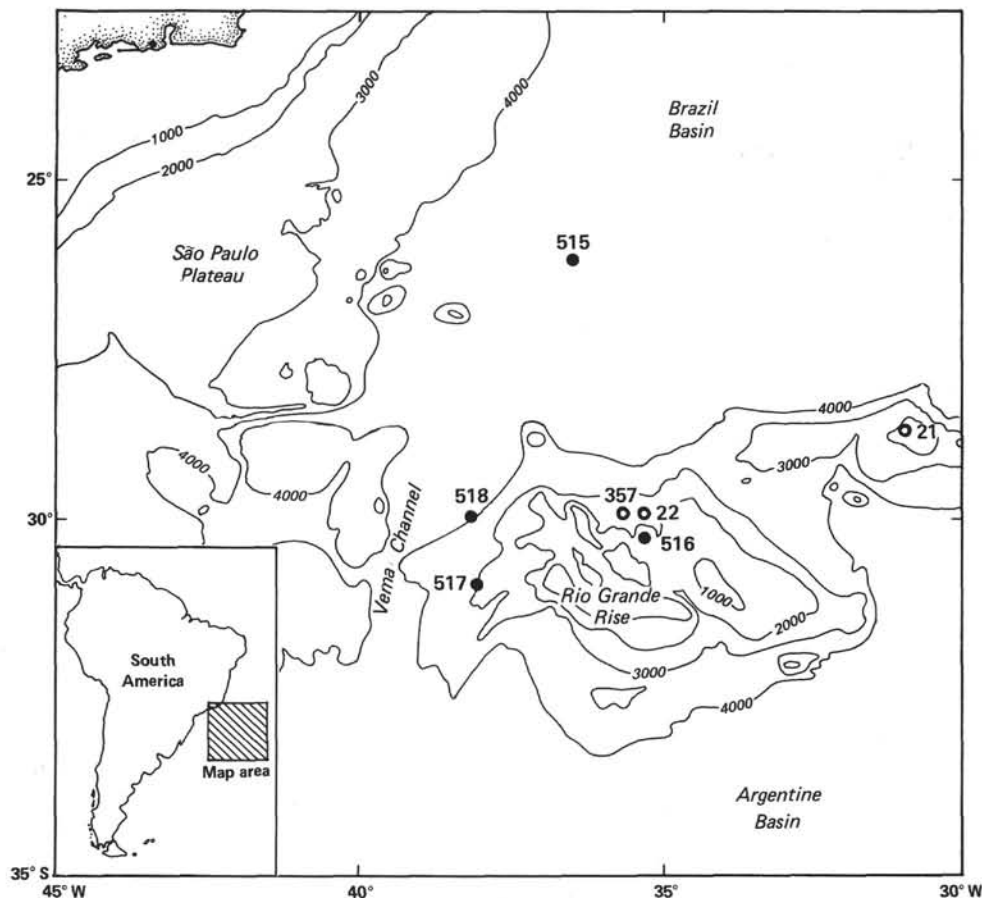


Figure 1. Location of Site 516 of Leg 72, Sites 21 and 22 of Leg 3, and Site 357 of Leg 39, on the Rio Grande Rise, off the eastern coast of South America. Depth contours are shown in meters.

(Douglas, 1973; Streeter, 1973). Fewer individuals occur in the remaining assemblages, indicating that the survey has under-represented the rarer species occurring in these samples and incompletely documented their stratigraphic ranges. The maximum number of individuals counted in any sample was approximately 600. The richer assemblages generally were reduced by splitting to a more convenient size.

ABUNDANCE AND PRESERVATION

Benthic foraminifers are common to abundant in all but the lowermost few meters of section (down to Core 516F-124, Section 1). Preservation is generally moderate but deteriorates below 1087 m (Core 516F-105) because of increasing recrystallization. Foraminifers could not be extracted from the highly recrystallized dolomitic limestone intervals between 1155 and 1172 m (Cores 516F-114 and 516F-115) or below 1203 m (Cores 516F-119 to 516F-125).

The number of benthic species per sample varies from 15 to 43, averaging 28 for the Cretaceous and 29 for the Paleocene, a degree of diversity much less than would be expected from comparison with well-preserved Recent and fossil deep-sea faunas. This, together with the common occurrence of numbers of broken and surface-damaged individuals, indicates some undetermined loss by selective dissolution.

Associated biogenic material includes *Inoceramus* shell fragments and prisms, abundant below 1150 m and usually present as high as 1080 m, and fecal pellets in

flood proportions between 1087 and 1225 m. Rare ostracodes and echinoderm spine fragments occur at a few horizons.

FORAMINIFERAL ASSEMBLAGES

Upper Cretaceous

Santonian-Maestrichtian benthic species were recovered above the 1200 m horizon. Cretaceous benthic assemblages are dominated by the Cassidulinacea; the genera *Gavelinella* and *Gyroidinoides* are especially prominent, together with fewer *Osangularia* and *Pullenia* (Fig. 3 and 4). Somewhat less important, both in abundance and variety, are the Discorbinacea represented by *Nuttallides* and *Nuttallinella*, and the Buliminacea, represented primarily by *Praebulimina*. The Nodosariacea occur in persistent but low numbers, whereas the agglutinated types, although occasionally numerous, develop little diversity. Least prominent are the Orbitoidacea represented by modest numbers of *Neoeponides*.

Especially conspicuous are several long-ranging cosmopolitan species that occur in both the Upper Cretaceous and Paleocene intervals. These include, among others: *Gavelinella beccariiiformis*, *G. hyphalus*, *G. velascoensis*, *Gyroidinoides globosus*, *Lenticulina macrodisca*, and *Nuttallides truempyi*. The most abundantly

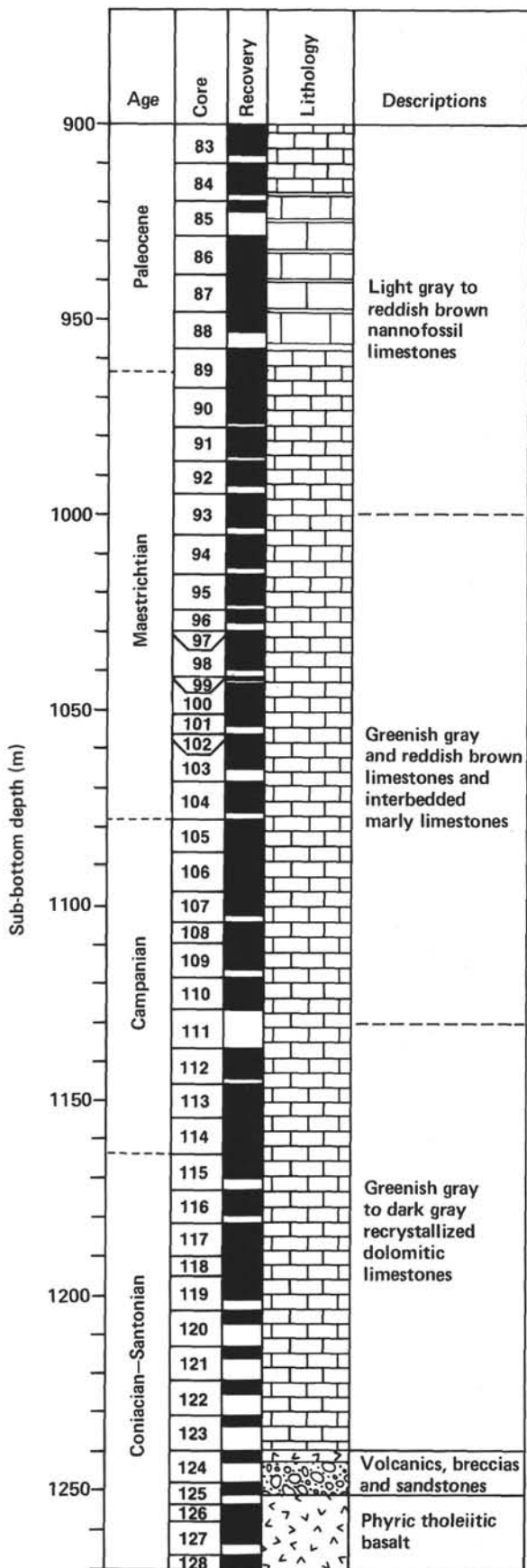


Figure 2. Upper Cretaceous-Paleocene stratigraphy of Hole 516F.

occurring species that are more or less confined to Cretaceous strata are: *Gavelinella stephensoni*, *Gyroidinoides beisseli*, *G. goudkoffi*, *G. nitidus*, *Nuttallinella florealis*, and *Praebulimina reussi*.

Santonian assemblages (Core 516F-116, Section 3 to Core 516F-119, Section 3) consist of a relatively low-diversity benthic element. *Bolivinooides strigillatus*, *Gyroidinoides praeglobosus*, and *Globorotalites multisepatus* appear to be restricted to this interval.

Campanian and Maestrichtian assemblages are characterized by increased species diversity over that of the Santonian fauna. Species diversity continues to increase until the late Maestrichtian, when a significant reduction in variety occurs and many characteristic Cretaceous species drop out. The majority of species make their first appearance in the Campanian, but none appear to be restricted to this age. Characteristic species of the Maestrichtian are *B. draco draco*, *Coryphostoma incrassata*, *Eouvigerina americana*, and *P. triangularis*.

Paleocene

Paleocene benthic assemblages compare closely with the underlying Cretaceous fauna at the suprageneric level but are otherwise distinguished by reduced diversity and by some turnover in genera and species. Assemblages are dominated by large populations of *Cibicidoides*, *Gavelinella*, and *Nuttallides*, together with fewer *Anomalinooides* and *Gyroidinoides*. Genera present only as accessory elements in the Cretaceous, such as *Oridorsalis* and *Pullenia*, occur in greater abundance. Approximately 67% of the species present in the upper Maestrichtian continue on into the Paleocene; the cosmopolitan types, in general, maintain their dominance.

Many new species first appear in the lowest Paleocene; the most prominent are *Anomalinooides welleri*, *Dorothia beloides*, *D. cubensis*, and *Bulimina trinitatensis* (which is confined to this interval). The remainder of the Paleocene, on the other hand, was a comparatively stable period. Some extinctions occurred but were compensated for by an equivalent number of first appearances. New species introduced at this time that immediately assumed a dominant position are *Cibicidoides pseudoperlucidus* and *B. velascoensis*.

The latest Paleocene was characterized by a sudden increase in extinctions. The genus *Bolivinooides*, together with the remaining species with origins in the Late Cretaceous (except *Nuttallides truempyi*, *Nonion havanense*, and *Oridorsalis umbonatus*), disappeared. The result was a low-diversity fauna dominated by these species and by *Cibicidoides*. A similar reduction has been documented in Trinidad (Beckman, 1960), Austria (Hillebrandt, 1962), and at several Atlantic Ocean DSDP sites (Tjalsma and Lohmann, in press).

PALEOBATHYMETRY

Depth of deposition interpretations have been inferred from the character of the benthic assemblages, planktonic/benthic ratios, and associated fossils and lithologic types. The marine benthic depth zones used in the following discussion are neritic (0-200 m), upper bathyal

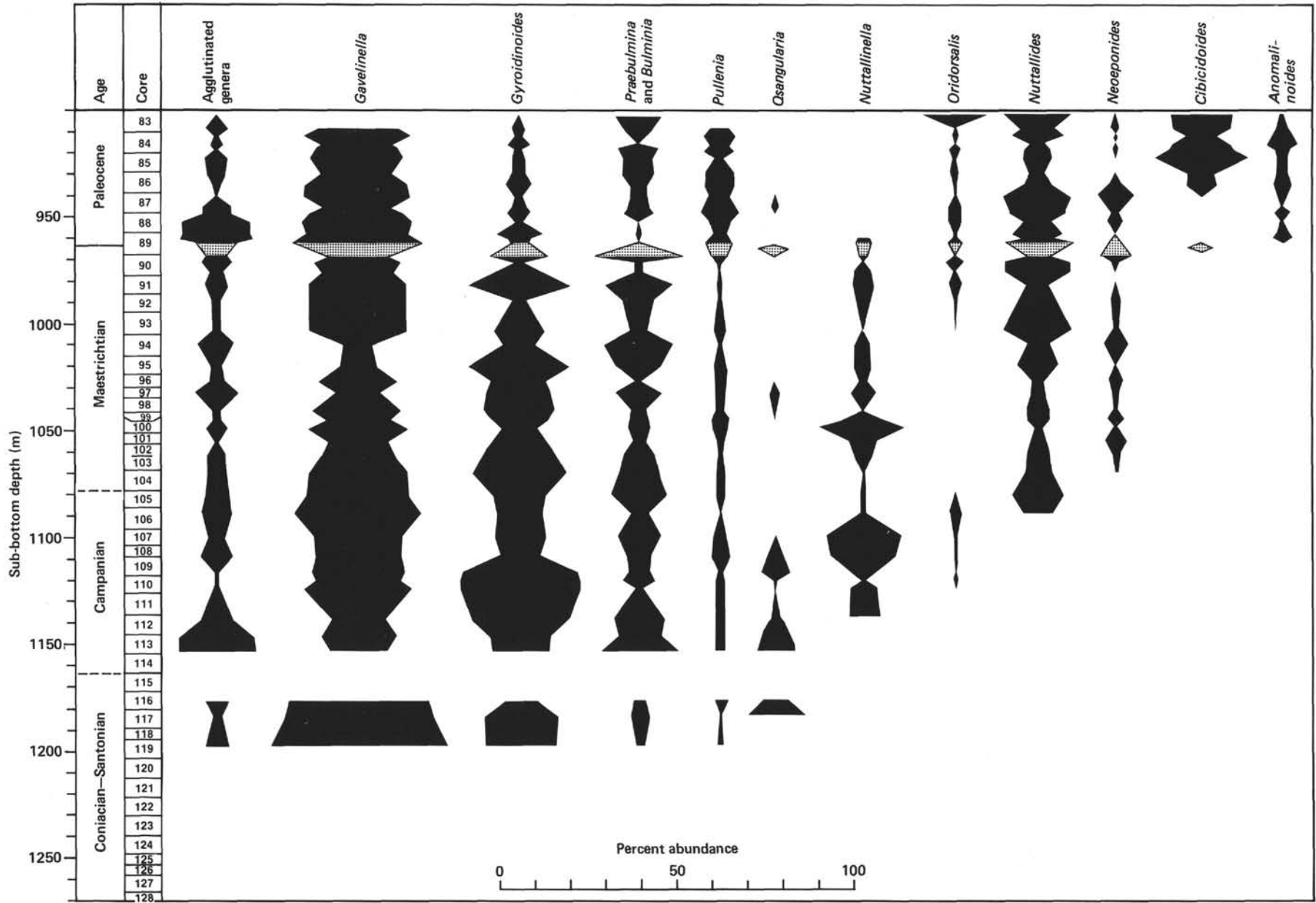


Figure 3. Frequency distribution of selected benthic foraminiferal taxa from Coniacian-Santonian to Paleocene of Hole 516F. See Figure 4 for distribution through stippled interval in Core 516F-89.

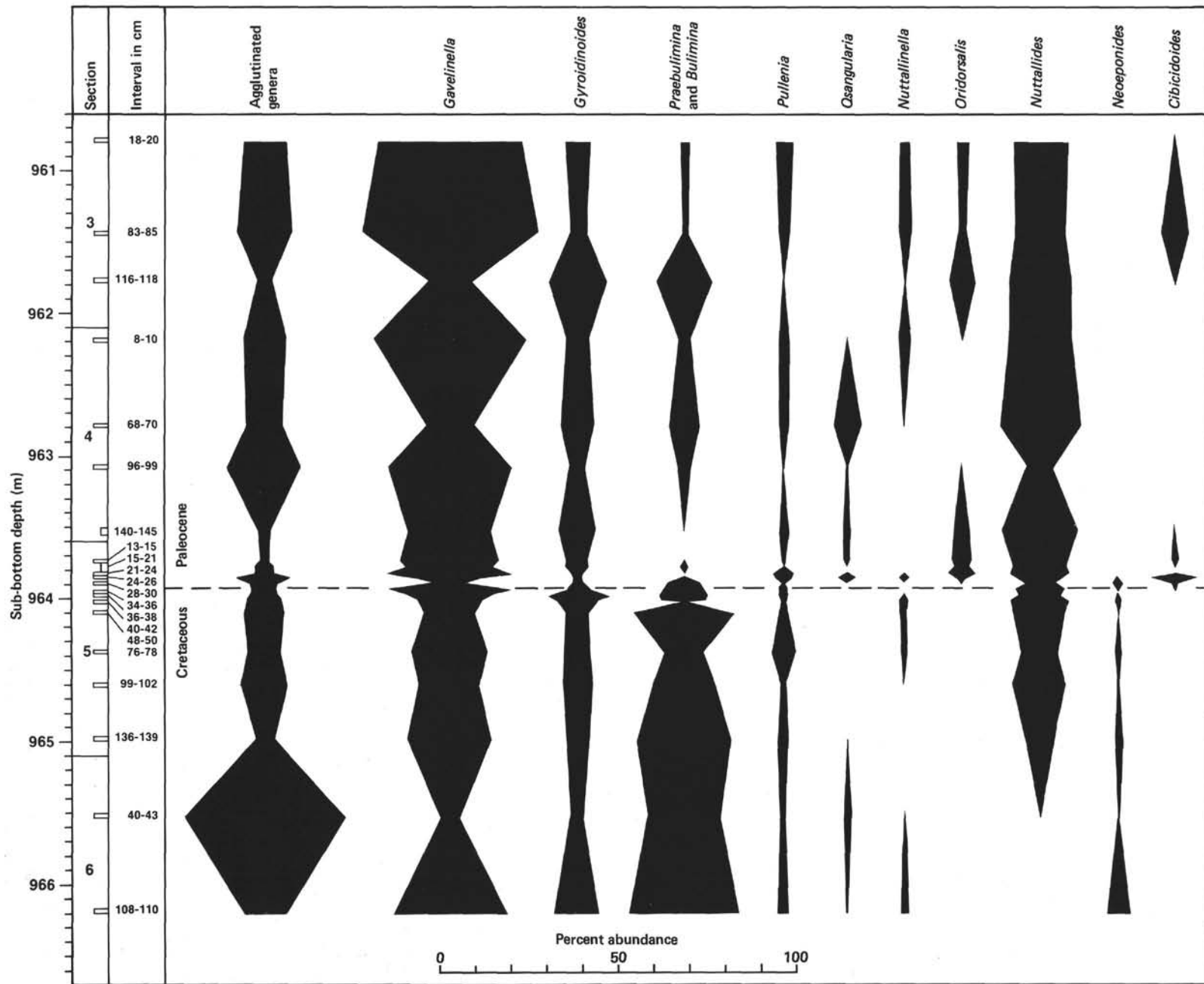


Figure 4. Frequency distribution of selected benthic foraminiferal taxa from Core 516F-89, 960.8–966.2 m, which spans the Cretaceous/Tertiary boundary.

(200-500 m), middle bathyal (500-1500 m), lower bathyal (1500-2500 m), and abyssal (> 2500 m).

Thin sections from several Coniacian-Santonian horizons below 1200 m (Cores 121-126 in Hole 516F) reveal planktonic foraminifers in Core 516F-124, Section 1 and benthics in Core 516F-126, Section 1. Milliman (this volume) reports carbonate sediment dominated by shallow water biogenic particles (coralline algae, benthic foraminifers, mega-invertebrate fragments), from fractures in the volcanic basement. He interpreted this deposit as having accumulated at shallow depths, possibly < 20 m. The stratigraphically lowest horizon examined for foraminifers (Sample 516F-125-2, 15-17 cm) includes rare indeterminate miliolids, ophthalmidiids?, and ostracodes in a well-washed and sorted skeletal grainstone. This material indicates a high-energy environment with water depths probably not deeper than 20 m.

A coarse-grained skeletal packstone layer in Core 516F 124, Section 1, consisting primarily of large *Inoceramus* shell fragments, calcispheres, and lesser amounts of coralline algae and pellets in a heavily iron-stained mud matrix, includes the following foraminifers: verneulinids, miliolids, indeterminate rotaliid types, and heterohelicid and globotruncanid planktonics. These data imply a more open marine-shelf sea environment.

Cores 516F-121 through 516F-123 show further deepening to outer neritic or shallow bathyal depths on the basis of alternating layers of claystone and fine-grained skeletal wackestone-packstone in a claystone matrix, in which radiolarians are abundant and *Inoceramus* prisms and shell fragments, ostracodes, and tiny heterohelicid and hedbergellid planktonic foraminifers are common.

The remainder of the Upper Cretaceous and Paleocene stratigraphic sequence is characterized by a well-developed foraminiferal fauna of bathyal character. Upper Cretaceous assemblages bear close resemblance to bathyal benthic successions of California (Sliter, 1968; Sliter and Baker, 1972) and the South Atlantic (Sliter, 1977).

The Santonian fauna (Cores 516F-116 to 516F-119) is characterized by a great abundance of the deep-water indicator *Gavelinella beccariiiformis*; also present in fewer numbers are *Globorotalites multiseptus*, *Gyroidinoides praeglobosus*, *Osangularia cordieriana*, and *Lenticulina muensteri*. This fauna represents upper to middle bathyal depths, and includes no shallower indicators. The abundant planktonic element (planktonic/benthic ratio 10:1) is in keeping with this interpretation (Fig. 5). Preservation ranges from moderate to poor. The modest faunal diversity (15-19 species) and high dominance of the durable Cassidulinacea seem to be the results of selective dissolution.

In the Campanian and Maestrichtian (Sample 516F-89-5, 30 cm through Sample 516F-113-6, 89-91 cm), benthic assemblages are more diverse and moderately well preserved. They contain large populations of *Gavelinella* (*G. beccariiiformis*, *G. velascoensis*), *Nuttallides truempyi*, *Praebulimina reussi*, and diverse gyroidinids and agglutinated species. The foraminiferal fauna develops a high planktonic/benthic ratio in the Maestrichti-

an, with the planktonic element making up 95% or more of the assemblages. Overall, this fauna is characteristic of middle bathyal to shallow lower bathyal depths.

Paleocene assemblages (Sample 516F-83-2, 28-30 cm through Sample 516F-89-5, 30 cm) compare closely with early Tertiary deep-sea faunas from the western North Atlantic and South Atlantic DSDP sites recently studied by Tjalsma and Lohmann (in press). The assemblages are dominated by a deep-water association of, among others, *Cibicidoides pseudoperlucidus*, *Gavelinella beccariiiformis*, and *Nuttallides truempyi*. Wide fluctuations in abundances, probably signifying ecologic instability in the shallower layers of the water column, characterize the earliest Paleocene planktonic element. Planktonic species are generally very abundant throughout the remainder of the Paleocene succession. The pelagic character of the fauna, together with the benthic deep-bathymetric indicators, indicate that, during the Paleocene, lower bathyal depths on the order of 1500-2000 m prevailed at Site 516.

Cretaceous/Tertiary Boundary

The stratigraphic section at Site 516 includes a continuous deposition sequence spanning the Cretaceous/Tertiary boundary. Well-preserved foraminifers are present throughout the boundary transition interval, providing the opportunity to study in detail the stratigraphic distribution of benthic species across this important time-stratigraphic horizon.

Two investigations into the distribution of benthic foraminifers across the boundary have been carried out. Both involved bathyal faunas recovered from incomplete sections that lack an intact boundary. Beckman (1960) showed that benthics occurring in the Upper Cretaceous Guayaguayare and Paleocene Lizard Springs formations in southern Trinidad change relatively little across the boundary; many relic species from the Cretaceous extend into the Paleocene. Webb (1973) determined a benthic extinction rate of 18% for the Trinidad Maestrichtian benthic fauna and, in addition, reported a benthic level of extinction of 54% for Upper Cretaceous taxa across the Cretaceous/Tertiary boundary at Site 208, Lord Howe Rise, Tasman Sea.

Upper Maestrichtian to lower Paleocene sediments of Site 516 consist of nannofossil limestone with some interbedded marly claystone. The Cretaceous/Tertiary transition between 963.7-964.2 m (Sample 516F-89-5, 10-50 cm) is characterized by a change at 35 cm from light gray to light reddish brown nannofossil limestone and by a sharp increase in interbedded dark gray mudstone. The mudstone occurs as angular to subhorizontal laminae and thin layers; some layers have developed minor rippling. Soft sediment deformation and minor intraformation fractures also are evident above the 25 cm horizon. Reworked Maestrichtian foraminifers occur through the transition interval above the 38 cm horizon. The most obviously displaced benthic species are indicated in the Appendix at the end of the chapter. Overall, these features suggest deposition in an unstable environment, with admixture of material from shallower horizons.

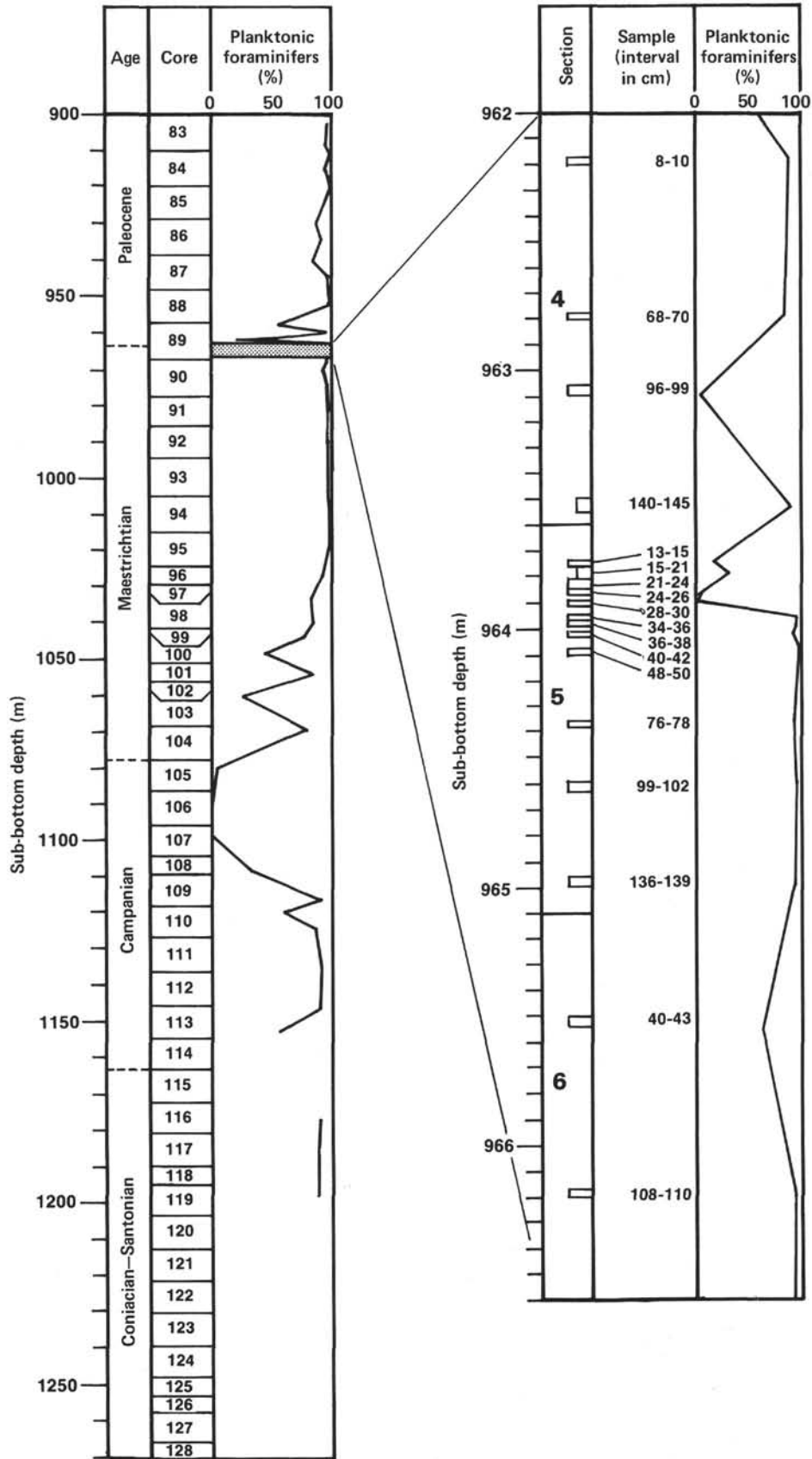


Figure 5. Planktonic foraminifers as a percent of the total foraminiferal fauna at Site 516. Column on right shows an expanded view of the planktonic foraminiferal abundance across the Cretaceous/Tertiary boundary.

The 28–30 cm horizon is characterized by an absence of bioturbation and by a foraminiferal assemblage (both autochthonous and displaced individuals) showing strong differential solution, which suggests a short episode of oxygen-minimum conditions or possibly close proximity to such a layer.

Boundary events occurring in the interval are: the first increase of iridium above background count at 34.5–36.5 cm, an iridium peak at 33.0–33.5 cm, the first occurrence of the Paleocene nannofossil indicator *Biantholithus sparsus* at 33.5 cm, and the probable base of the Paleogene planktonic foraminiferal Zone P1a at 29 cm. For the following discussion, the Cretaceous/Tertiary boundary is arbitrarily placed in the unsampled interval between 30 and 34 cm.

A shift in benthic foraminiferal faunal character occurred during the latest Maestrichtian and earliest Paleocene at Site 516. The change is substantial and almost exclusively at the species level. Compared to the planktonic groups that suffered abrupt mass extinction, the benthic foraminiferal turnover was comparatively moderate and occurred over a period of hundreds of thousands of years. Changes in the benthic fauna are evident through comparison of the number of local species extinctions and introduction of new species occurring in time intervals of 1 Ma and 0.5 Ma. Data pertaining to these faunal changes are summarized in Figure 6.

Most striking is the accelerated rate of last occurrences in the final 2 Ma of the Maestrichtian, when the incidence of disappearance increases 200% in each of the 66–67 Ma and 65–66 Ma intervals. A climax in extinctions is reached in the final 0.5 Ma. Partial compensation occurs in the last 1 Ma of the Maestrichtian with a four-fold increase in first appearances. On balance, however, it is a time of decreasing diversity. Thirty-three percent of the species present in the final 1 Ma and 28% of the species present in Site 516 in the final 0.5 Ma do not survive to the end of the Cretaceous. These include a few species (*Allomorphina trochoides*, *Ellipsoglandulina exponens*, and *Osangularia lens*) whose ranges extend well into the Paleocene in Trinidad and/or western Europe. Rapid replacement continues during the earliest 1 m.y. of the Paleocene, but the number of extinctions decline 63% to a total of 10. Again, most change occurs in the 0.5 Ma, after the end of the Cretaceous. A low rate of turnover is reestablished by about 63 Ma. The extinction rate may be estimated higher in the uppermost Maestrichtian and lower in lowest Paleocene if some apparent Cretaceous survivors above the boundary are actually interpreted as reworked individuals.

Benthic faunal change across the Cretaceous/Tertiary boundary in Hole 516F appears independent of the planktonic groups, although the peak of change more or less coincides with the planktonic mass extinction event. The substantial and progressive change in the benthics reflects important alteration of environmental conditions in the deep sea that developed during the closing phase of the Cretaceous. The nature of the change is not apparent from the benthic foraminifera nor from their enclosing sediments.

COMPARISON OF UPPER CRETACEOUS-PALEOCENE BENTHIC FORAMINIFERAL FAUNAS AT SITES 357 AND 516

In spite of the close proximity and great similarity of sediments in Sites 357 and 516, there are some differences. Sediments at both sites consist primarily of bioturbated nannofossil limestone; Site 357, however, shows much evidence of gravity-flow deposits, minor conglomerate, glauconite layers, and common transported foraminifera (Sliter, 1977b), and these sedimentary features are little developed at Site 516.

The thickness of Cretaceous sediments is comparable at both sites, but Paleocene strata at Site 357, are considerably thinner (i.e., 40 m versus 65 m at Site 516) because of two hiatuses. A short interval in the lower Paleocene equivalent to the planktonic Zone P1b and a much longer one in the upper Paleocene corresponding to planktonic Zones P5 and P6a (Boersma, 1977) are both missing. Both sites show a similar accumulation rate and a similar subsidence history of deepening from shallow bathyal depths in Coniacian–Santonian to lower bathyal depths in the Paleocene. Interpreted depths of deposition based on sub-bottom depths and foraminiferal assemblages indicate Site 357 was deeper than Site 516, possibly by as much as 300 m.

Cretaceous assemblages at both sites show similar preservation but those at Site 357 exhibit greater diversity. On the whole, the Cretaceous benthic fauna at both sites compare closely; there are only minor differences. Most notable are the agglutinated and nodosariid taxa that are common at Site 357 but are more limited in occurrence at Site 516.

Site 357 Paleocene assemblages from the collection of R. C. Tjalsma examined during this study consist of abundant individual specimens and show only nominal differences with coeval assemblages at Site 516. The degree of preservation is much higher at Site 357; this difference is probably caused by the preferential preservation at Site 516. The paucity of individual specimens previously attributed to the Site 357 Paleocene fauna (Boersma, 1977; Perch-Nielson, Supko et al., 1977) is not substantiated by our observations.

A dissolution episode characterized by some decrease in benthic diversity, and by the absence of the planktonic element observed in upper Campanian strata at Sites 356 and 357, is also developed in coexistent strata (Cores 516F-105 to 516F-108) at Site 516.

FAUNAL REFERENCE LIST²

- Alabamina creta* (Finlay) = *Pulvinulinella creta* Finlay, 1940, *R. Soc. N.Z. Trans. Proc.*, 69:643, pl. 66, figs. 187–192.
Allomorphina cretacea Reuss, 1851, *Haidinger's Naturwiss. Abh.*, 4:42, pl. 5, fig. 6.
Allomorphina minuta Cushman, 1936, *Contrib. Cushman Lab. Foraminiferal Res.*, 12:72, pl. 13, fig. 3.

² In accordance with common practice, most of the references pertaining to these species are listed *only* here. For references cited in the text, please see the reference list at the end of the chapter.

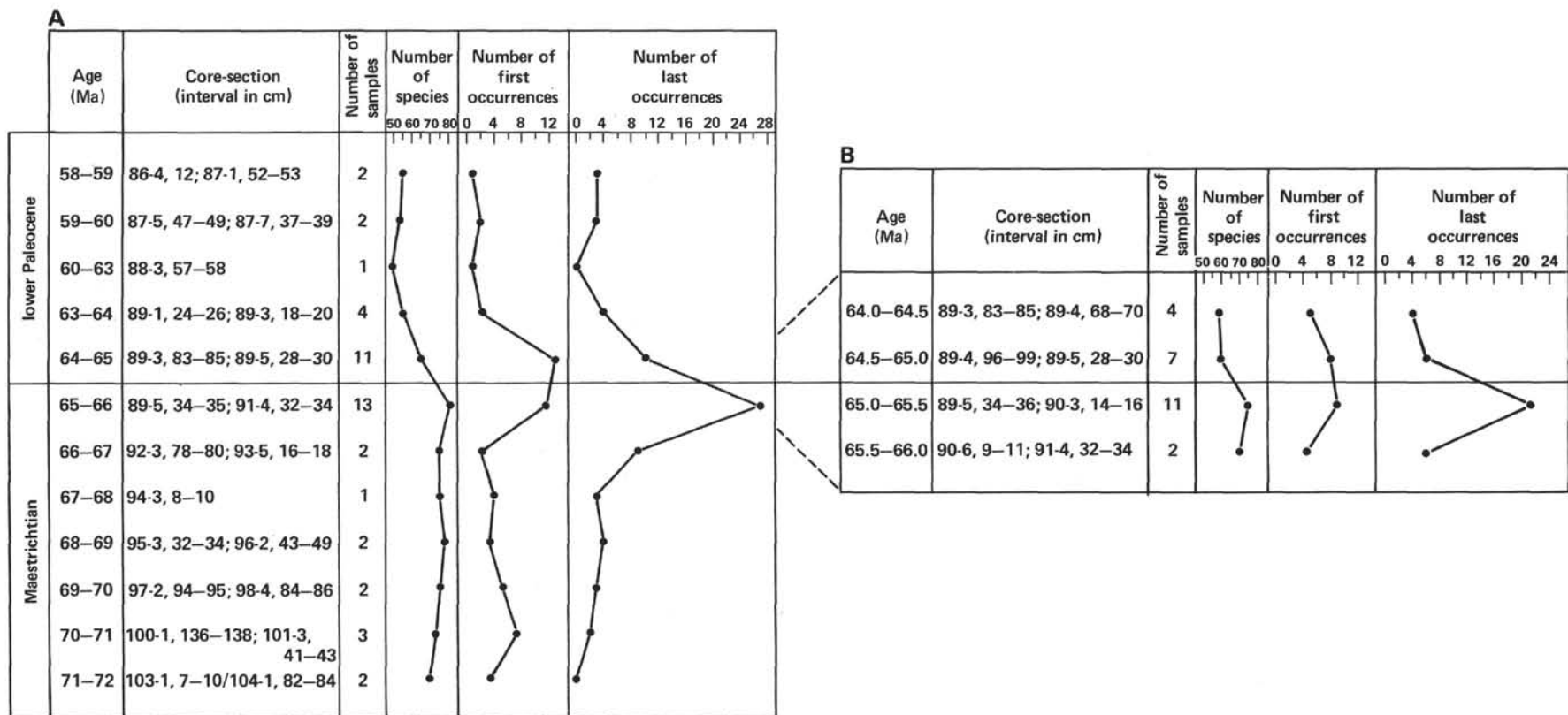


Figure 6. Maestrichtian-lower Paleocene benthic foraminiferal data at Hole 516F. Data are arranged in 1 Ma intervals (except for 60-63 Ma interval) in A and 0.5 Ma intervals in B. Age is based on magnetic polarity Events 25 to 33 and corresponds to the LaBrecque et al. (1977) magnetic reversal time scale. Species occurring only once have been omitted.

- Allomorphina trochoides* (Reuss) = *Globigerina trochoides* Reuss, 1845, *Die Versteinerungen der Böhmisches Kreideformation* (Pt. 1): Stuttgart (E. Schweizerbart), p. 36, pl. 12, fig. 22.
- Ammodiscus cretaceus* (Reuss) = *Operculina cretacea* Reuss, 1845, *Die Versteinerungen der Böhmisches Kreideformation* (Pt. 1): Stuttgart (E. Schweizerbart) p. 35, pl. 13, figs. 64–65.
- Anomalinoidea welleri* (Plummer) = *Truncatulina welleri* Plummer, 1927, *Univ. Tex. Bull.*, 2644:143, pl. 9, fig. 9.
- Aragonia semireticulata* (LeRoy) = *Bolivina semireticulata* LeRoy, 1953, *Geol. Soc. Amer., Mem.*, 24:20, pl. 8, fig. 26.
- Aragonia velascoensis* (Cushman) = *Textularia velascoensis* Cushman, 1925, *Contrib. Cushman Lab. Foraminiferal Res.*, 1:18, pl. 3, fig. 1. Some specimens at hand are distinguished by great thickness in transverse section, a characteristic of *A. ouezzanensis*, but otherwise are identical with Cushman's description and figure.
- Astacolus crepidulus* White, 1928, *J. Paleontol.*, 2:202, pl. 28, fig. 11.
- Astacolus gibbus* (d'Orbigny) = *Cristellaria gibba* d'Orbigny, 1839. Foraminifères. In de la Sagra, Ramon, *Histoire Physique, Politique, et Naturelle de l'île Cuba*: Paris (A. Bertrand), p. 40, pl. 7, figs. 20–21.
- Astacolus jarvisi* (Cushman) = *Marginulina jarvisi* Cushman, 1938, *Contrib. Cushman Lab. Foraminiferal Res.*, 14:35, pl. 5, figs. 17–18.
- Astacolus richteri* (Brotzen) = *Planularia richteri* Brotzen, 1936, *Arsb. Sver. Geol. Unders. Ser. C, No. 396*, Vol. 30(3), p. 59, pl. 3, fig. 3.
- Bandyella beckmanni* Proto Decima and Bolli, 1978, *Init. Rpts. DSDP*, 40 p. 790, pl. 3, fig. 12.
- Bandyella greatvalleyensis* (Trujillo) = *Pleurostomella greatvalleyensis* Trujillo, 1960, *J. Paleontol.*, 34:345 pl. 50, figs. 5–6.
- Bathysiphon* sp. The present specimens are fragmented and flattened small smoothly finished tubes.
- Bolivinoidea delicatulus* Cushman = *B. decorata* (Jones) var. *delicatulus* Cushman, 1927, *Contrib. Cushman Lab. Foraminiferal Res.*, 2:90, pl. 12, fig. 8.
- Bolivinoidea draco draco* (Marsson), Hilterman and Koch, 1950, *Geol. Jahrb.*, 64 (1943–1948):598; fig. 1, no. 72–73; figs. 2–4, no. 52–54, 58–60; fig. 5, no. 53, 69–70.
- Bolivinoidea draco miliaris* Hilterman and Koch, 1950, *Geol. Jahrb.* 64 (1943–1948):604; figs. 2–4, no. 26, 32–34, 39–41, 46–48; fig. 5, no. 39.
- Bolivinoidea granulatus* Hofker, 1957, *Geol. Jahrb. Beih.*, 27:250 text-figs. 303d–f, 307a–h, 310a–f.
- Bolivinoidea strigillatus* (Chapman) = *Bolivina strigillata* Chapman, 1892, *Geol. Soc. London Q.J.*, 48:515, pl. 15, fig. 10.
- Bulimina midwayensis* Cushman and Parker = *B. arkadelphiana* Cushman and Parker var. *midwayensis* Cushman and Parker, 1936, *Contrib. Cushman Lab. Foraminiferal Res.*, 12:42, pl. 7, figs. 9–10.
- Bulimina trinitatis* Cushman and Jarvis, 1928, *Contrib. Cushman Lab. Foraminiferal Res.*, 4:102, pl. 14, fig. 12.
- Bulimina tuxpamensis* Cole, 1928, *Am. Paleontol. Bull.*, 14:212, pl. 32, fig. 23.
- Bulimina velascoensis* (Cushman) = *Gaudryina velascoensis* Cushman, 1925, *Contrib. Cushman Lab. Foraminiferal Res.*, 1:20, pl. 3, fig. 7.
- Buliminella beaumonti* Cushman and Renz, 1946, *Cushman Lab. Foraminiferal Res. Spec. Publ.*, 18:36, pl. 6, fig. 7.
- Ceratobulimina perplexa* (Plummer) = *Rotalia perplexa* Plummer, 1927, *Univ. Tex. Bull.*, 2644:156, pl. 12, fig. 2.
- Cibicides excavatus* Brotzen, 1936, *Arsb. Sver. Geol. Unders., Ser. C, No. 396*, Vol. 30(3), p. 189, pl. 13, figs. 7–8.
- Cibicoides dayi* (White) = *Planulina dayi* White, 1928, *J. Paleontol.*, 2:300, pl. 41, fig. 3.
- Cibicoides pseudoperlucidus* (Bykova) = *Cibicides (Gemellides) pseudoperlucidus* Bykova, 1954, *Vses. Neft. Nauchno-Issled. Geologo, razved. Inst. Tr. (VNIGRI), N.S.*, 80:190, pl. 34, fig. 1.
- Coryphostoma incrassata* (Reuss) = *Bolivina incrassata* Reuss, 1851, *Haidinger's Naturwiss. Abh.*, 4:29, pl. 5, fig. 13.
- Coryphostoma limonense* (Cushman) = *Bolivina incrassata* var. *limonensis* Cushman, 1926, *Contrib. Cushman Lab. Foraminiferal Res.*, 2:19, pl. 2, fig. 2.
- Dentalina alternata* (Jones) = *Nodosaria zippei* Reuss var. *alternata* Jones, 1886, *Belfast Nat. Field Club Proc., N. Ser.* 1 (1884–1885), Appendix 9 (1886):330, pl. 27, fig. 10.
- Dentalina basiplanata* Cushman, 1938, *Contrib. Cushman Lab. Foraminiferal Res.*, 14:38, pl. 6, figs. 6–8.
- Dentalina catenula* Reuss, 1860, *K. Akad. Wiss. Wien Math.-Naturwiss. Kl. Sitzungsber.*, 40:185, pl. 3, fig. 6.
- Dentalina gracilis* d'Orbigny 1840, *Soc. Geol. Fr. Mem., Ser. 1*, 4:14, pl. 1, fig. 5.
- Dentalina legumen* Reuss, 1851, *Haidinger's Naturwiss. Abh.*, 4:10, pl. 1, fig. 14.
- Dentalina* spp. This category includes sparse numbers of unidentifiable individuals in our Paleocene samples assignable to *Dentalina*.
- Dorothia beloides* von Hillebrandt, 1962, *Bayer. Akad. Wiss. Math.-Naturwiss. Kl. Abh., N. S.*, 108:39, pl. 2, figs. 8–14; pl. 15, figs. 12–13.
- Dorothia bulletta* (Carsey) = *Gaudryina bulletta* Carsey, 1926, *Univ. Tex. Bull.*, 2612:28, pl. 4, fig. 4.
- Dorothia cubensis* (Cushman and Bermudez) = *Tritaxilina cubensis* Cushman and Bermudez, 1937, *Contrib. Cushman Lab. Foraminiferal Res.*, 13:7.
- Dorothia oxycona* (Reuss) = *Gaudryina oxycona* Reuss, 1860, *K. Akad. Wiss. Wien Math.-Naturwiss. Kl. Sitzungsber.*, 40:229, pl. 12, fig. 3.
- Dorothia pupa* (Reuss) = *Textularia pupa* Reuss, 1860, *K. Akad. Wiss. Wien Math.-Naturwiss. Kl. Sitzungsber.*, 40:232, pl. 13, fig. 4.
- Dorothia retusa* (Cushman) = *Gaudryina retusa* Cushman, 1926, *Am. Assoc. Pet. Geol. Bull.*, 10:588, pl. 16, fig. 10.
- Ellipsoglandulina exponens* (Brady) = *Ellipsodina exponens* Brady, 1892, In Jukes-Brown and Harrison, *Q.J. Geol. Soc. London*, 48:198.
- Ellipsoidella robusta* (Cushman) = *Nodosarella robusta* Cushman, 1943, *Contrib. Cushman Lab. Foraminiferal Res.*, 19:92, pl. 16, fig. 8.
- Ellipsopolymorphina velascoensis* (Cushman) = *Ellipsoglandulina velascoensis* Cushman, 1926, *Am. Assoc. Pet. Geol., Bull.*, 10:590, pl. 16, fig. 7.
- Eouvirgerina americana* Cushman, 1926, *Contrib. Cushman Lab. Foraminiferal Res.*, 2(1):4, pl. 1, fig. 1.
- Eouvirgerina excavata* Cushman, 1940, *Contrib. Cushman Lab. Foraminiferal Res.*, 16:66, pl. 11, fig. 18.
- Fissurina alata* Reuss, 1851, *Z. Dtsch. Geol. Ges.*, 3:58 pl. 3, fig. 1.
- Fissurina oblonga* Reuss, 1863, *K. Akad. Wiss. Wien Math.-Naturwiss. Kl. Sitzungsber.*, 46:339, pl. 7, fig. 89.
- Fissurina orbignyana* Sequenza, 1862, fide Ellis, B. F., and Messina, A. R., 1940, *Catalogue of Foraminifera*: New York (Mus. Nat. Hist. Spec. Publ.).
- Fronicularia jarvisi* Cushman, 1939, *Contrib. Cushman Lab. Foraminiferal Res.*, 15:91, pl. 16, fig. 6.
- Gaudryina aissana* Ten Dam and Sigal, 1950, *Contrib. Cushman Found. Foraminiferal Res.*, 1:31, pl. 2, fig. 2.
- Gaudryina laevigata* Franke, 1914, *Z. Dtsch. Geol. Ges.*, 66:431, pl. 27, figs. 1–2.
- Gaudryina pyramidata* Cushman = *G. laevigata* Franke var. *pyramidata* Cushman, 1926, *Am. Assoc. Pet. Geol. Bull.*, 10:587, pl. 16, fig. 8.
- Gavelinella beccariiiformis* (White) = *Rotalia beccariiiformis* White, 1928, *J. Paleontol.*, 2(4):287, pl. 39, fig. 32.
- Gavelinella costata* Brotzen of Hofker, 1957, *Geol. Jahrb. Beih.*, 27:288, text-fig. 341.
- Gavelinella danica* (Brotzen) = *Cibicides danica* Brotzen, 1940, *Arsb. Sver. geol. Unders. Ser. C, No. 435*, Vol. 34(5), p. 31, text-fig. 7:2. Specimens from Maestrichtian samples differ from Brotzen's description in their smaller size, more narrow cross-sectional width, and more gradually increasing size of ultimate whorl chambers.
- Gavelinella eriksdalensis* (Brotzen) = *Cibicides (Cibicoides) eriksdalensis* Brotzen, 1936, *Arsb. Sver. Geol. Unders., Ser. C, No. 396*, Vol. 30(3), p. 193, fig. 69, pl. 14, fig. 5.
- Gavelinella hyphalus* (Fisher) = *Anomalinoidea hyphalus* Fisher, 1969, *Palaeontology*, 12:197, text-fig. 3. A broad species concept has been applied here in which are included lowest Paleocene and upper Maestrichtian specimens differing from typical *G. hyphalus* in their more sharply rounded periphery and evolute dorsal side.
- Gavelinella monterelensis* (Marie) = *Anomalina monterelensis* Marie, 1941, *Mus. Nat. Hist. Nat. Mem., N.S.*, 12:243, pl. 37, fig. 342.
- Gavelinella nacatochensis* (Cushman) = *Planulina nacatochensis* Cushman, 1938, *Contrib. Cushman Lab. Foraminiferal Res.*, 14:50, pl. 8, fig. 9.

- Gavelinella stephensoni* (Cushman) = *Cibicides stephensoni* Cushman, 1938, *Contrib. Cushman Lab. Foraminiferal Res.*, 14:70, pl. 12, fig. 5.
- Gavelinella velascoensis* (Cushman) = *Anomalina velascoensis* Cushman, 1925, *Contrib. Cushman Lab. Foraminiferal Res.*, 1:21, pl. 3, fig. 3.
- Gavelinella* sp. A number of specimens recovered from lower Paleocene samples are characterized by their circular outline, subacute periphery, planoconvex to biconvex transverse section, numerous longer than high chambers that increase very gradually as added, and faintly curved sutures. In addition, most individuals develop a calcite plug on the umbilical side. It is possibly close to *Neorotalia* sp. of Said and Kenawy (1956, p. 153, pl. 6, fig. 13).
- Globorotalites conicus* (Carsey) = *Truncatulina refulgens* Montfort var. *conica* Carsey, 1926, *Univ. Tex. Bull.*, 2612:46, pl. 4, fig. 15.
- Globorotalites multiseptus* (Brotzen) = *Globorotalia multisepta* Brotzen 1936, *Arsb. Sver. Geol. Unders., Ser. C, No. 396*, Vol. 30(3), p. 161, pl. 11, figs. 6-7.
- Globulina lacrima* (Reuss) = *Polymorphina (Globulina) lacrima* Reuss, 1845, *Die Versteinerungen der Böhmisches Kreideformation* (Pt. 1): Stuttgart (E. Schweizerbart), p. 40, pl. 12, fig. 6, pl. 13, fig. 83.
- Globulina subsphaerica* (Berthelin) = *Polymorphina subsphaerica* Berthelin, 1880, *Soc. Geol. Fr. Mem., Ser. 3, 1(No. 5):58*, pl. 4, fig. 18.
- Glomospira corona* Cushman and Jarvis = *Glomospira charoides* (Jones and Parker) var. *corona* Cushman and Jarvis, 1928, *Contrib. Cushman Lab. Foraminiferal Res.*, 4:89, pl. 12, figs. 9-11.
- Glomospira gordialis* (Jones and Parker) = *Trochammina squamata* Jones and Parker, var. *gordialis* Jones and Parker, 1860, *Q.J. Geol. Soc. London*, 16:304.
- Guttulina caudata* d'Orbigny, 1826, *Ann. Sci. Nat. Hist. Paris, Ser. 1, 7:266*, no. 16; Fornasini, 1900, *Bol. Soc. Geol. Ital.*, 19:137, text-fig. 2.
- Guttulina communis* d'Orbigny 1826, *Ann. Sci. Nat. Paris, Ser. 1, 7:266* pl. 12, figs. 1-4.
- Gyroidinoides beisseli* (White) = *Gyroidina beisseli* White, 1928, *J. Paleontol.*, 2:291, pl. 39, fig. 7.
- Gyroidinoides depressus* (Alth) = *Rotalina depressa* Alth, 1850, *Haidinger's Naturwiss. Abh.*, 3:266, pl. 13, fig. 21.
- Gyroidinoides girardanus* (Reuss) = *Rotalina girardana* Reuss, 1851, *Z. Dtsch. Geol. Ges.*, 3:73, pl. 5, fig. 34.
- Gyroidinoides globosus* (Hagenow) = *Nonionina globosa* Hagenow, 1842, *Neues Jahrb. Min. Geogr. Geol. Petref.*, p. 574.
- Gyroidinoides goudkoffi* (Trujillo) = *Eponides goudkoffi* Trujillo, 1960, *J. Paleontol.*, 34:333, pl. 48, fig. 6.
- Gyroidinoides nitidus* (Reuss) = *Rotalina nitida* Reuss, 1845, *Die Versteinerungen der Bohmischen Kreideformation* (Pt. 1): Stuttgart, (E. Schweizerbart), p. 35, pl. 8, fig. 52, pl. 12, figs. 8, 20.
- Gyroidinoides octocameratus* (Cushman and Hanna) = *Gyroidina soldanii* d'Orbigny subspecies *octocamerata* Cushman and Hanna, 1927, *Calif. Acad. Sci. Proc. 4th Ser.*, 16:223, pl. 14, figs. 16-18.
- Gyroidinoides praeglobosus* (Brotzen) = *Gyroidina praeglobosa* Brotzen, 1936, *Arsb. Sver. Geol. Unders. Ser. C, No. 396*, Vol. 30(3), p. 159, pl. 11, fig. 4.
- Gyroidinoides quadratus* (Cushman and Church) = *Gyroidina quadrata* Cushman and Church, 1929, *Calif. Acad. Sci. Proc., Ser. 4*, 18:516, pl. 41, figs. 7-9. Rare individuals recovered from the Paleocene section differ from Cretaceous specimens in their less-oppressed and fewer whorls.
- Lagena gracilis* Williamson, 1848, *Ann. Mag. Nat. Hist. Ser. 2*, 1:13, pl. 1, fig. 5.
- Lagena hispida* Reuss, 1863, *K. Akad. Wiss. Wien Math.-Naturwiss. Kl. Sitzungsber.*, 40:335, pl. 6, figs. 77-79.
- Lagena sulcata* (Walker and Jacob) = *Serpula (Lagena) sulcata* Walker and Jacob, 1798, *In Kanmacher, F. Adams' Essays on the Microscope*: London (Dillon and Keating), p. 634, pl. 14, fig. 5.
- Lenticulina acuta* (Reuss) = *Cristellaria acuta* Reuss, 1860, *K. Akad. Wiss. Wien Math.-Naturwiss. Kl. Sitzungsber.*, 40:213, pl. 10, fig. 3.
- Lenticulina macrodisca* (Reuss) = *Cristellaria macrodisca* Reuss, 1862, *K. Akad. Wiss. Wien Math.-Naturwiss. Kl. Sitzungsber.*, 46:78, pl. 9, fig. 5.
- Lenticulina midwayensis* (Plummer) = *Robulus midwayensis* Plummer, 1927, *Univ. Tex. Bull.*, 2644:95, pl. 13, fig. 5.
- Lenticulina muensteri* (Roemer) = *Robulina münsteri* Roemer, 1839, *Die Versteinerungen des Norddeutschen Oolith-Gebirges, Ein Nachtrag*: Hannover (Hahn'schen Hofbuchhandlung), p. 48, pl. 22, fig. 29.
- Lenticulina velascoensis* White, 1928, *J. Paleontol.*, 2:199, pl. 28, fig. 8.
- Lenticulina whitei* Tjalsma and Lohmann n. sp., *Micropaleontology Spec. Publ.* 4 (in press). This species was originally reported from the Velasco Formation, eastern Mexico, as *L. gaultina* (Berthelin) by White (1928, p. 198, pl. 28, fig. 6).
- Lenticulina* spp. Few numbers of unidentifiable specimens occur in a minority of samples.
- Lingulina pygmaea* Reuss, 1875, *Palaeontographica, Beitr. Naturgesch.*, Vol. 20, Pt. 2 (1872-1875), Sec. 4, p. 90, pl. 2 (20), fig. 23.
- Loxostomum eleyi* (Cushman) = *Bolivinita eleyi* Cushman, 1927, *Contrib. Cushman Lab. Foraminiferal Res.*, 2:91, pl. 12, fig. 11.
- Marginulina armata* Reuss, 1860, *K. Akad. Wiss. Wien Math.-Naturwiss. Kl. Sitzungsber.*, 40:209, pl. 7, fig. 7.
- Marginulina austriana* Cushman, 1937, *Contrib. Cushman Lab. Foraminiferal Res.*, 13:92, pl. 13, figs. 1-4.
- Marginulina hamuloides* Brotzen, 1936, *Arsb. Sver. Geol. Unders. Ser. C, No. 396*, p. 68, pl. 10, figs. 10-11.
- Marginulina oligostegia* Perner, 1892, *Ceska Akad. Cis. Fr. Josefa, Prague: Paleontogr. Bohemiae*, 2(2):61, pl. 5, figs. 11-12.
- Marginulina siliqua* Cushman, 1938, *Contrib. Cushman Lab. Foraminiferal Res.*, 14: p. 35, pl. 5, figs. 15-16.
- Marginulinopsis texasensis* (Cushman) = *Marginulina texasensis* Cushman, 1938, *Contrib. Cushman Lab. Foraminiferal Res.*, 14:95.
- Neoepionides hillebrandti* Fisher, 1969, *Palaeontology*, 12:197. This species has been reported previously from eastern Mexico as *Rotalia* cf. *partschiana* (d'Orbigny) (White 1928, p. 288) and from Bavaria as *Eponides whitei* by Hillebrandt (1962, p. 106).
- Neoepionides lunata* (Brotzen) = *Eponides lunata* Brotzen, 1948, *Arsb. Sver. Geol. Unders., Ser. C, No. 493*, Vol. 42(2), p. 77, pl. 10, figs. 17-18.
- Neoflabellina semireticulata* (Cushman and Jarvis) = *Flabellina semireticulata* Cushman and Jarvis, 1928, *Contrib. Cushman Lab. Foraminiferal Res.*, 4(4):98, pl. 13, fig. 14.
- Nodosaria velascoensis* Cushman = *N. fontannesii* (Berthelin) var. *velascoensis* Cushman, 1926, *Am. Assoc. Pet. Geol. Bull.*, 10:594, pl. 18, fig. 12.
- Nonion havanense* Cushman and Bermudez, 1937, *Contrib. Cushman Lab. Foraminiferal Res.*, 13:19, pl. 2, figs. 13-14.
- Nonionella austinana* Cushman, 1933, *Contrib. Cushman Lab. Foraminiferal Res.*, 9:57, pl. 7, fig. 2.
- Nuttallides crassaformis* (Cushman and Siegfus) = *Astigerina crassaformis* Cushman and Siegfus, 1935, *Contrib. Cushman Lab. Foraminiferal Res.*, 11:94, pl. 14, fig. 10.
- Nuttallides truempyi* (Nuttall) = *Eponides truempyi* Nuttall, 1930, *J. Paleontol.*, 4:287, pl. 24, figs. 9, 13-14.
- Nuttallinella florealis* (White) = *Gyroidina florealis* White, 1928, *J. Paleontol.*, 2:293, pl. 40, fig. 3.
- Nuttallinella* sp. Fairly common at several lower Paleocene and uppermost Cretaceous horizons are rotaliform specimens, herein assigned to *Nuttallinella*, developing a strongly convex ventral side, flat to slightly convex dorsal side, two to two and one-half narrow whorls, and eight to nine chambers in the final whorl. *N. sp.* has affinities with the Marie species from the Late Cretaceous of the Paris Basin (described as *Eponides monterelensis* Marie, 1941) but is smaller and develops more chambers per whorl and a more or less smooth periphery.
- Oolina apiculata* Reuss, 1851, *Haidinger's Naturwiss. Abh.*, 4:22, pl. 2, fig. 1.
- Oolina delicata* Sliter, 1968, *Univ. Kansas Paleontol. Contrib. Serial no. 49* (Art. 7):80 pl. 10, figs. 21-22.
- Oolina morsei* (Kline) = *Entosolenia morsei* Kline, 1943, *Miss. Geol. Surv. Bull.*, 53:48, pl. 4, fig. 17.
- Oridorsalis biconvexus* (Marie) = *Eponides biconvexa* Marie, 1941, *Mus. Nat. Hist. Nat. Mém. Paris, N. S.*, 12(1):224, pl. 34, fig. 324.
- Oridorsalis umbonatus* (Reuss) = *Rotalina umbonata* Reuss, 1851, *Z. Dtsch. Geol. Ges.*, 3:75, pl. 5, fig. 35.
- Osangularia cordieriana* (d'Orbigny) = *Rotalina cordieriana* d'Orbigny, 1840, *Soc. Geol. Fr. Mem.*, 4(1):33, pl. 3, figs. 9-11.

- Osangularia lens* Brotzen, 1940, *Arsb. Sver. Geol. Unders., Ser. C*, No. 435, Vol. 34(5), p. 30, text-fig. 8, 1.
- Osangularia plummerae* Brotzen, 1940, *Arsb. Sver. Geol. Unders., Ser. C*, No. 435, Vol. 34(5), p. 30.
- Osangularia velascoensis* (Cushman) = *Truncatulina velascoensis* Cushman, 1925, *Contrib. Cushman Lab. Foraminiferal Res.*, 1:20, pl. 3, fig. 2.
- Planularia liebusi* Brotzen, 1936, *Arsb. Sver. Geol. Unders., Ser. C*, No. 396, Vol. 30(3), p. 60, pl. 4, figs. 5-6.
- Pleurostomella austinana* Cushman, 1933, *Contrib. Cushman Lab. Foraminiferal Res.*, 9:64, pl. 7, fig. 13.
- Pleurostomella subnodosa* Reuss, 1860, *K. Akad. Wiss. Wien Math.-Naturwiss. Kl. Sitzungsber.*, 40:204, pl. 8, fig. 2.
- Pleurostomella torta* Cushman, 1926, *Contrib. Cushman Lab. Foraminiferal Res.*, 2:18, pl. 2, fig. 7.
- Praebulimina carseyae* (Plummer) = *Buliminella carseyae* Plummer, 1931, *Univ. Tex. Bull.*, 3101:179, pl. 8, fig. 9.
- Praebulimina cushmani* (Sandidge) = *Buliminella cushmani* Sandidge, 1932, *J. Paleontol.*, 6:280, pl. 42, figs. 18-19.
- Praebulimina reussi* (Morrow) = *Bulimina reussi* Morrow, 1934, *J. Paleontol.*, 8:195, pl. 29, fig. 12.
- Praebulimina triangularis* (Cushman and Parker) = *Bulimina triangularis* Cushman and Parker, 1935, *Contrib. Cushman Lab. Foraminiferal Res.*, 11:97, pl. 15, fig. 4.
- Pseudonodosaria bistegia* (Olszewski) = *Cristellaria bistegia* Olszewski, 1875, *Spraw. Kom. Fiz. Akad. Umiej. Krakowie*, 9:115, pl. 1, fig. 9.
- Pseudonodosaria manifesta* (Reuss) = *Glandulina manifesta* Reuss, 1851, *Haidinger's Naturwiss. Abh.*, 4:22, pl. 1, fig. 4.
- Pseudouvierina plummerae* Cushman, 1927, *Contrib. Cushman Lab. Foraminiferal Res.*, 3:115, pl. 23, fig. 8.
- Pullenia coryelli* White, 1929, *J. Paleontol.*, 3:56, pl. 5, fig. 22.
- Pullenia cretacea* Cushman, 1936, *Contrib. Cushman Lab. Foraminiferal Res.*, 12:75, pl. 13, fig. 8.
- Pullenia jarvisi* Cushman, 1936, *Contrib. Cushman Lab. Foraminiferal Res.*, 12:77, pl. 13, fig. 6.
- Pullenia minuta* Cushman, 1936, *Contrib. Cushman Lab. Foraminiferal Res.*, 12:77, pl. 13, fig. 7.
- Pyramidina rudita* (Cushman and Parker) = *Bulimina rudita* Cushman and Parker, 1936, *Contrib. Cushman Lab. Foraminiferal Res.*, 12:45.
- Quadriformina allomorphinoides* (Reuss) = *Valvulina allomorphinoides* Reuss, 1860, *K. Akad. Wiss. Wien Math.-Naturwiss. Kl. Sitzungsber.*, 40:223, pl. 11, fig. 6.
- Reophax trinitatensis* (Cushman and Renz) = *Hormosina globulifera* Brady var. *trinitatensis* Cushman and Renz, 1946, *Cushman Lab. Foraminiferal Res. Spec. Publ.*, 18:14, pl. 1, figs. 15-19.
- Reussella szajnochae* (Grzybowski) = *Verneuilina szajnochae* Grzybowski, 1896, *Akad. Umiej. Krakowie Wyzd. Mat.-Przpr.*, Ser. 2, 10:287, pl. 9, fig. 19.
- Rhabdammina discreta* Brady, 1881, *Q.J. Microsc. Sci., N. S.*, 21:48.
- Saracenaria navicula* (d'Orbigny) = *Cristellaria navicula* d'Orbigny, 1840, *Soc. Geol. Fr. Mem.*, 4:27, pl. 2, figs. 19-20.
- Saracenaria triangularis* (d'Orbigny) = *Cristellaria triangularis* d'Orbigny, 1840, *Soc. Geol. Fr. Mem.*, 4(1):27, pl. 2, figs. 21-22.
- Spiroplectammina dentata* (Alth) = *Textularia dentata* Alth, 1850, *Haidinger's Naturwiss. Abh.*, 3:262, pl. 13, fig. 13.
- Spiroplectammina praelonga* (Reuss) = *Textularia praelonga* Reuss, 1845, *Die Versteinerungen der Bohmischen Kreideformation* (Pt. 1): Stuttgart (E. Schweizerbart), p. 39, pl. 12, fig. 14.
- Spiroplectammina sigmoidina* Lalicker, 1935, *Contrib. Cushman Lab. Foraminiferal Res.*, 11:7, pl. 1, figs. 10-11.
- Spiroplectammina spectabilis* (Grzybowski) = *Spiroplecta spectabilis* Grzybowski, 1896, *Akad. Umiej. Krakowie Wyzd. Mat.-Przpr.*, Ser. 2, 10:293, pl. 12, fig. 12.
- Spiroplectammina subhaeringensis* (Grzybowski) = *Textularia subhaeringensis* Grzybowski, 1896, *Akad. Umiej. Krakowie Wyzd. Mat.-Przpr.*, Ser. 2, 10:285, pl. 9, figs. 13, 16.
- Stensioeina pommerana* Brotzen, 1936, *Arsb. Sver. Geol. Unders., Ser. C*, No. 396, Vol. 30(3), p. 166.
- Stilostomella plummerae* (Cushman) = *Ellipsonodosaria plummerae* Cushman, 1940, *Contrib. Cushman Lab. Foraminiferal Res.*, 16(1):69, pl. 12, figs. 4-5.
- Stilostomella pseudoscripta* (Cushman) = *Ellipsonodosaria pseudoscripta* Cushman, 1937, *Contrib. Cushman Lab. Foraminiferal Res.*, 13:103, pl. 15, fig. 14.
- Tritaxia amorpha* (Cushman) = *Clavulina amorpha* Cushman, 1926, *Am. Assoc. Pet. Geol. Bull.*, 10:589 pl. 17, fig. 5.
- Tritaxia aspera* (Cushman) = *Clavulina trilatera* Cushman var. *aspera* Cushman 1926, *Am. Assoc. Pet. Geol., Bull.*, 10:589, pl. 17, fig. 3.
- Tritaxia globulifera* (ten Dam and Sigal) = *Pseudoclavulina globulifera* ten Dam and Sigal, 1950, *Contrib. Cushman Found. Foraminiferal Res.*, 1:32, pl. 2, figs. 5-7.
- Tritaxia trilatera* (Cushman) = *Clavulina trilatera* Cushman, 1926, *Am. Assoc. Pet. Geol., Bull.*, 10:588, pl. 17, fig. 2.
- Trochammina boehmi* Franke, 1928, *Abh. Preuss. Geol. Landesanst., N. S.*, 111:174, pl. 15, fig. 24.
- Vaginulina trilobata* (d'Orbigny) = *Marginulina trilobata* d'Orbigny, 1840, *Soc. Geol. Fr. Mem.*, 4:16, pl. 1, figs. 16-17.
- Valvulinaria lenticula* (Reuss) = *Rotalina lenticula* Reuss, 1845, *Die Versteinerungen der Bohmischen Kreideformation* (Pt. 1): Stuttgart (E. Schweizerbart), p. 35, pl. 12, figs. 17a-c.

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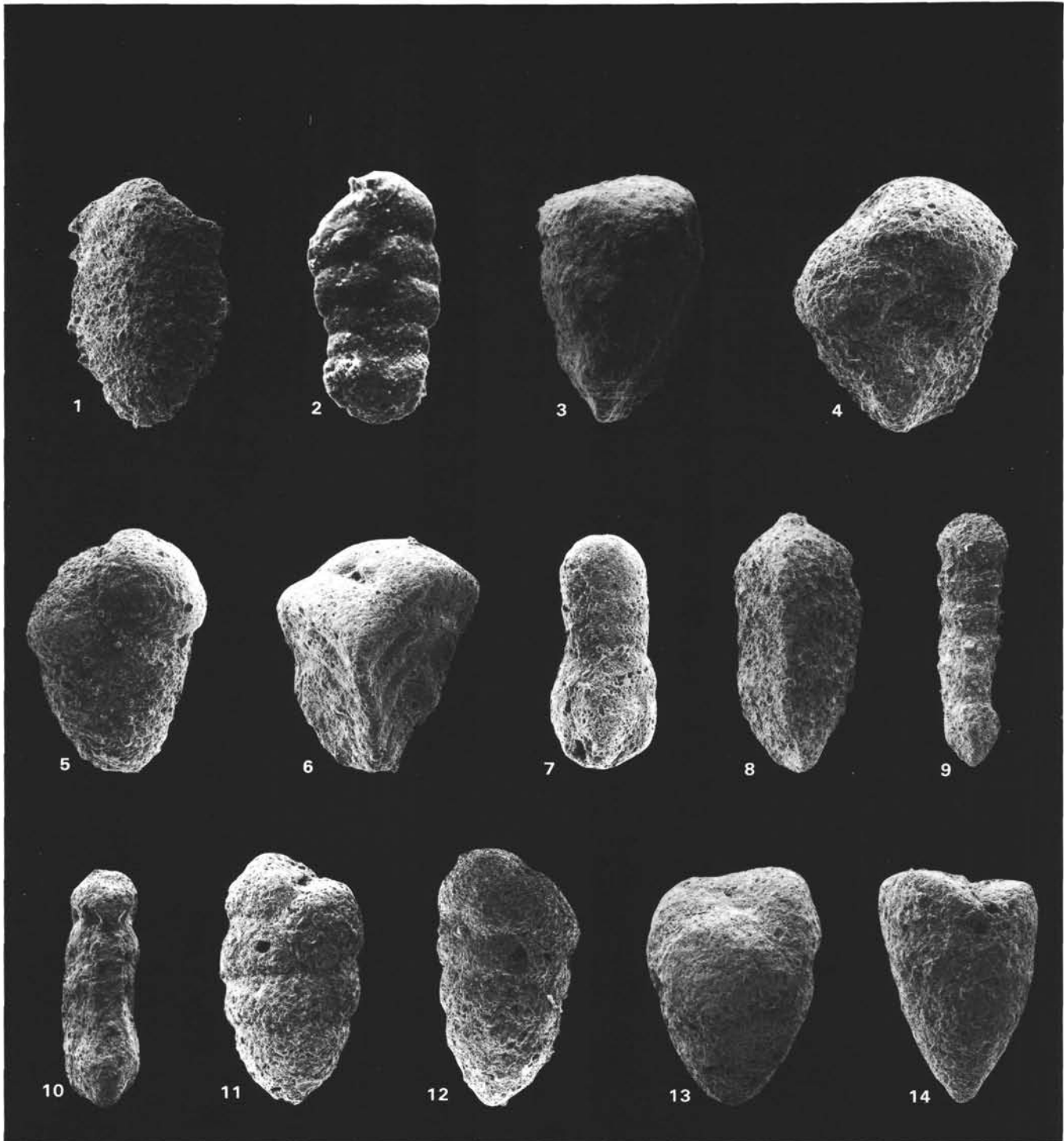


Plate 1. 1. *Spiroplectammina dentata* (Alth), Sample 516F-89-3, 83–85 cm, $\times 72$. 2. *S. spectabilis* (Grzybowski), Sample 516F-83-5, 24–26 cm, $\times 144$. 3. *Gaudryina aissana* ten Dam and Sigal, Sample 516F-89-1, 24–26 cm, $\times 54$. 4. *G. laevigata* Franke, Sample 516F-97-2, 94–95 cm, $\times 45$. 5. *G. pupa* (Reuss), Sample 516F-100-1, 136–138 cm, $\times 36$. 6. *G. pyramidata* Cushman, Sample 516F-89-2, 41–42 cm, $\times 162$. 7. *Triaxia amorpha* (Cushman), Sample 516F-107-2, 94–96 cm, $\times 48$. 8. *T. aspera* (Cushman), Sample 516F-89-6, 40–43 cm, $\times 54$. 9. *T. globulifera* (ten Dam and Sigal), Sample 516F-83-5, 24–26 cm, $\times 28$. 10. *T. trilatera* Cushman, Sample 516F-89-2, 119–121 cm, $\times 48$. 11. *Dorothyia belooides* von Hillebrandt, Sample 516F-83-5, 24–26 cm, $\times 60$. 12. *D. bulletta* (Carsey), Sample 516F-89-5, 136–139 cm, $\times 45$. 13. *D. cubensis* (Cushman and Bermudez), Sample 516F-83-5, 24–26 cm, $\times 48$. 14. *D. oxycona* (Reuss), Sample 516F-113-6, 89–91 cm, $\times 96$.



Plate 2. 1. *Nodosaria velascoensis* Cushman, Sample 516F-89-3, 18-20 cm, $\times 45$. 2. *Lenticulina macrodisca* (Reuss), Sample 516F-89-2, 119-121 cm, $\times 120$. 3. *Buliminella beaumonti* Cushman and Renz, Sample 516F-87-7, 37-39 cm, $\times 216$. 4. *Bolivinooides delicatulus* Cushman, Sample 516F-84-1, 28-29 cm, $\times 90$. 5-6, 11. Sample 516F-90-3, 14-16 cm, (5) *Praebulimina carseyae* (Plummer), $\times 120$, (6) *P. cushmani* (Sandidge), $\times 144$, (11) *Eouvigerina americana* Cushman, $\times 108$. 7. *P. reussi* (Morrow), Sample 516F-89-5, 99-102 cm, $\times 108$. 8. *Bolivinooides draco draco* (Marsson), Sample 516F-91-4, 32-34 cm, $\times 108$. 9. *B. draco miliaris* Hiltermann and Koch, Sample 516F-101-3, 41-43 cm, $\times 144$. 10. *B. granulatus* Hofker, Sample 516F-92-3, 78-80 cm, $\times 144$. 12. *Bulimina trinitatensis* Cushman and Jarvis, Sample 516F-89-3, 116-118 cm, $\times 132$. 13. *B. velascoensis* (Cushman), Sample 516F-84-5, 7-9 cm, $\times 96$. 14. *Reussella szajnochae* (Grzybowski), Sample 516F-97-2, 94-95 cm, $\times 96$.

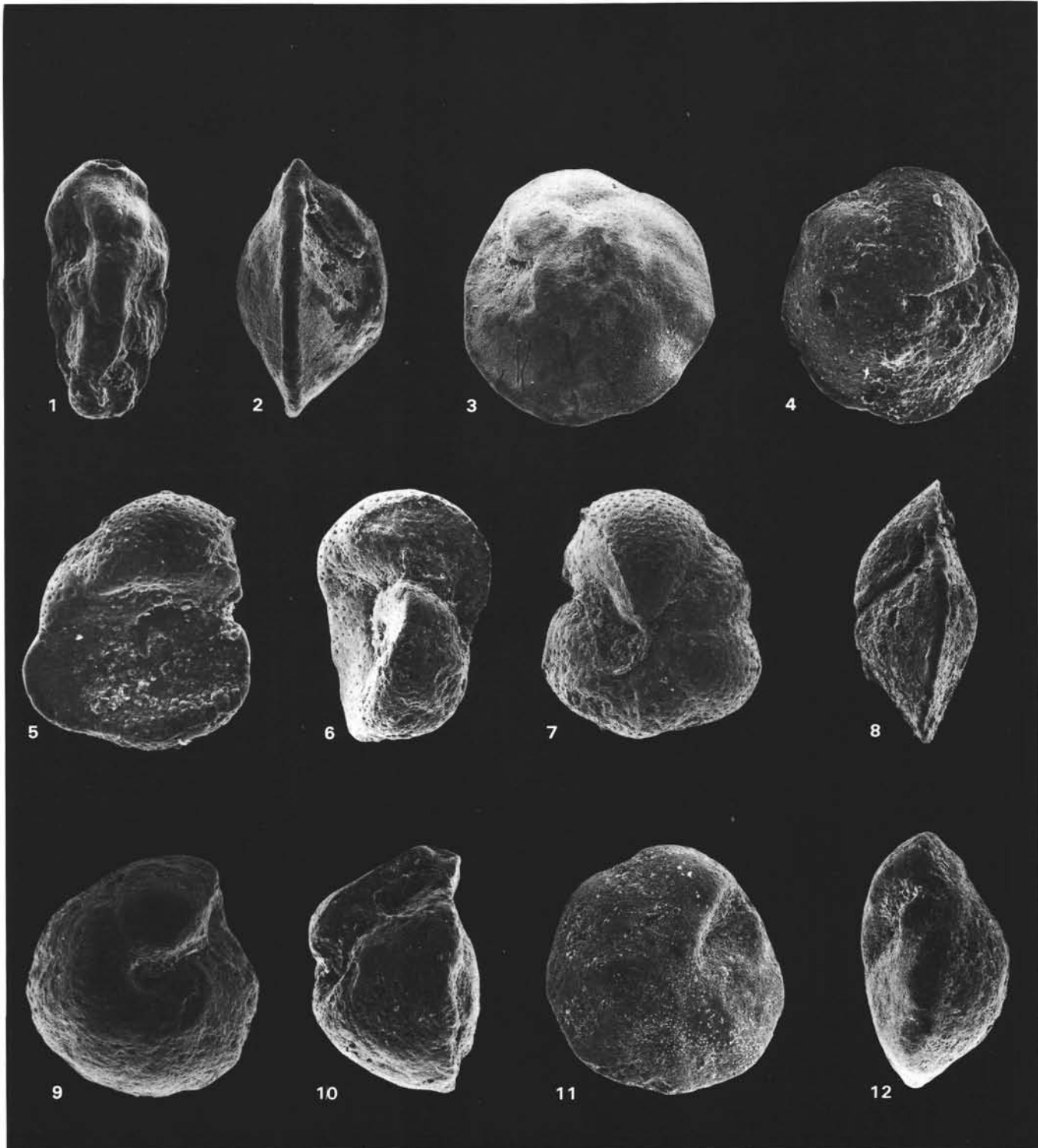


Plate 3. 1. *Pseudouvigerina plummerae* Cushman, Sample 516F-93-5, 16–18 cm, $\times 96$. 2–3. *Nuttallides truempyi* (Nuttall), Sample 516F-89-3, 18–20 cm, $\times 162$, (2) peripheral view, (3) umbilical view. 4, 8. *Nuttallinella florealis* (White), Sample 516F-107-2, 94–96 cm, $\times 78$, (4) umbilical view, (8) peripheral view. 5–7. *Cibicides excavatus* Brotzen, Sample 516F-110-2, 145–147 cm, $\times 144$, (5) umbilical view, (6) peripheral view, (7) spiral view. 9–10. *Nuttallinella* sp., Sample 516F-94-3, 8–10 cm, $\times 198$, (9) umbilical view, (10) peripheral view. 11–12. *Neoeponides hillebrandti* Fisher, Sample 516F-87-5, 47–49 cm, $\times 162$, (11) umbilical view, (12) peripheral view.

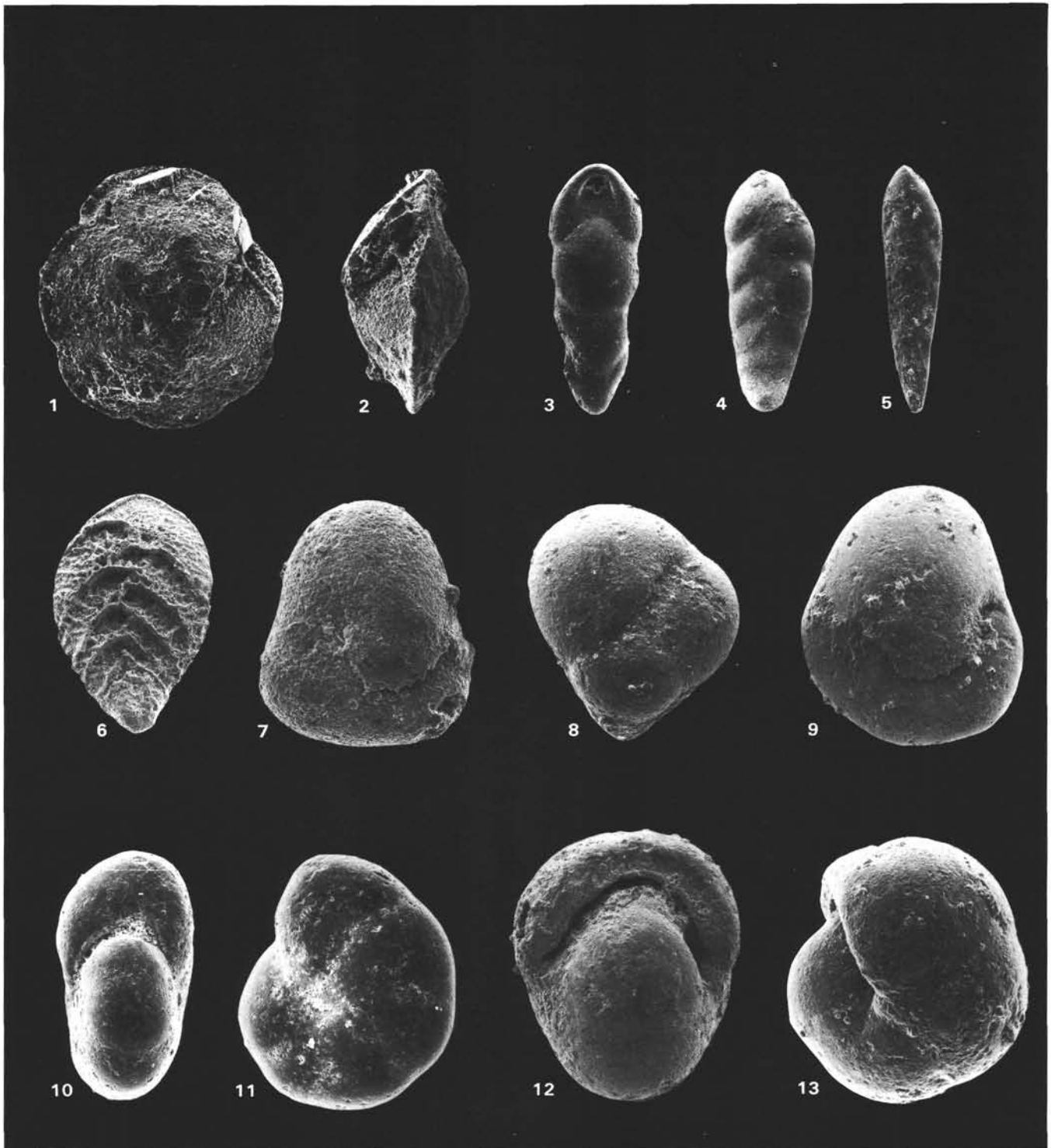


Plate 4. 1-2. *Neoeponides lunata* Brotzen, Sample 516F-87-1, 52-53 cm, $\times 144$, (1) umbilical view, (2) peripheral view. 3. *Pleurostomella subnodosa* Reuss, Sample 516F-107-2, 94-96 cm, $\times 48$. 4. *Coryphostoma incrassata* Reuss, Sample 516F-94-3, 8-10 cm, $\times 48$. 5. *Coryphostoma limonense* (Cushman), Sample 516F-89-2, 41-42 cm, $\times 72$. 6. *Aragonia velascoensis* (Cushman), Sample 516F-97-2, 94-95 cm, $\times 96$. 7. *Allo-morphina minuta* Cushman, Sample 516F-98-4, 84-86 cm, $\times 162$. 8. *A. trochoides* (Reuss), Sample 516F-110-2, 145-147 cm, $\times 132$. 9. *Quadriformina allomorphinoides* (Reuss), Sample 516F-89-5, 99-102 cm, $\times 90$. 10-11. *Nonion havanense* Cushman and Bermudez, Sample 516F-87-7, 37-39 cm, $\times 144$, (10) apertural view, (11) side view. 12-13. *Pullenia cretacea* Cushman, Sample 516F-108-2, 68-70 cm, $\times 120$, (12) apertural view, (13) side view.

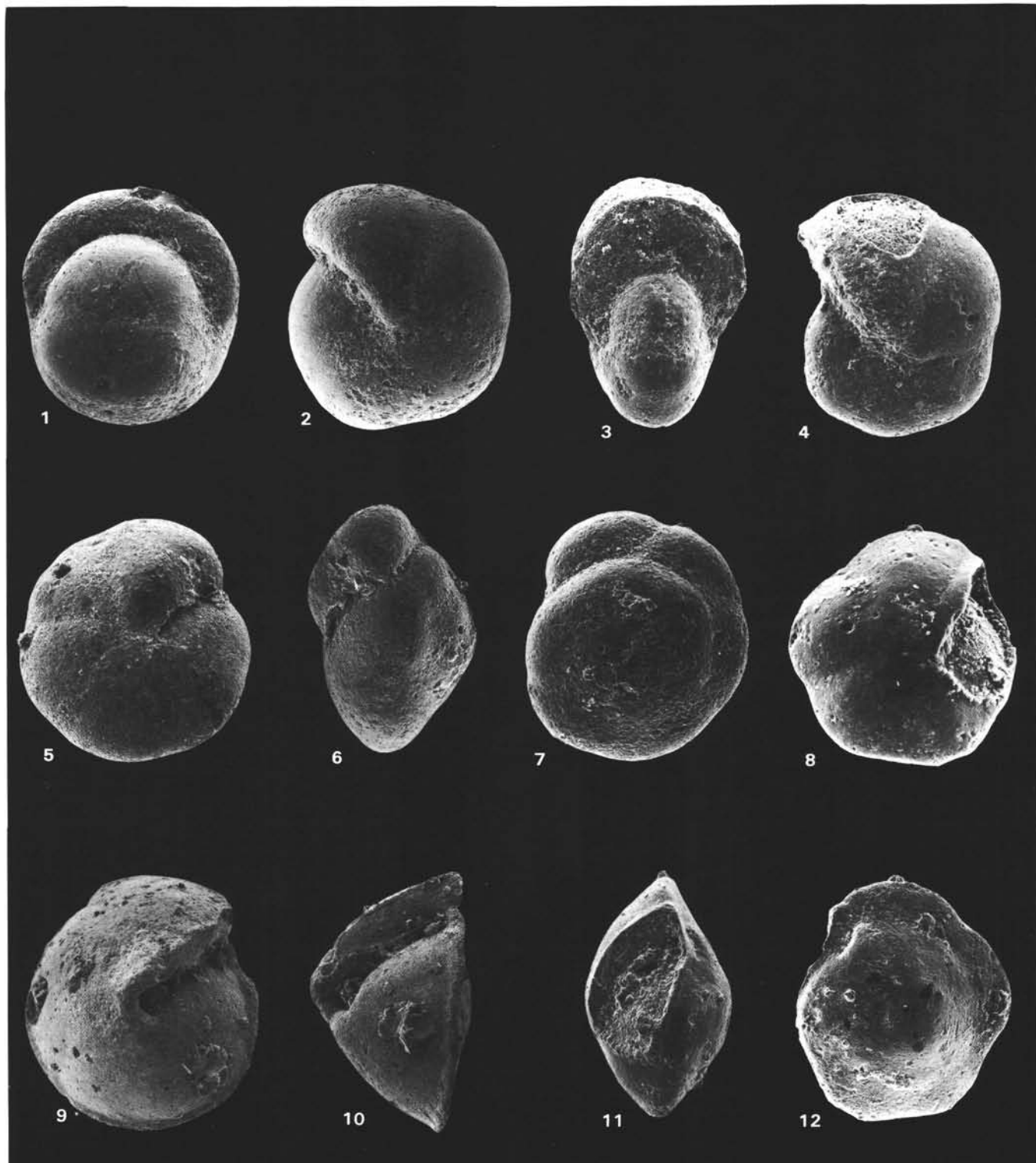


Plate 5. 1-2. *Pullenia coryelli* White, Sample 516F-87-5, 47-49 cm, $\times 120$, (1) apertural view, (2) side view. 3-4. *Pullenia jarvisi* Cushman, Sample 516F-89-4, 140-145 cm, $\times 180$, (3) apertural view, (4) side view. 5-7. *Alabamina creta* (Finlay), Sample 516F-90-6, 9-11 cm, $\times 180$, (5) umbilical view, (6) peripheral view, (7) spiral view. 8, 11-12. *Oridorsalis biconvexus* (Marie), Sample 516F-106-2, 3-5 cm, $\times 162$, (8) umbilical view, (11) peripheral view, (12) spiral view. 9-10. *Globorotalites conicus* (Carsey), Sample 516F-89-6, 40-43 cm, $\times 78$, (9) umbilical view, (10) peripheral view.

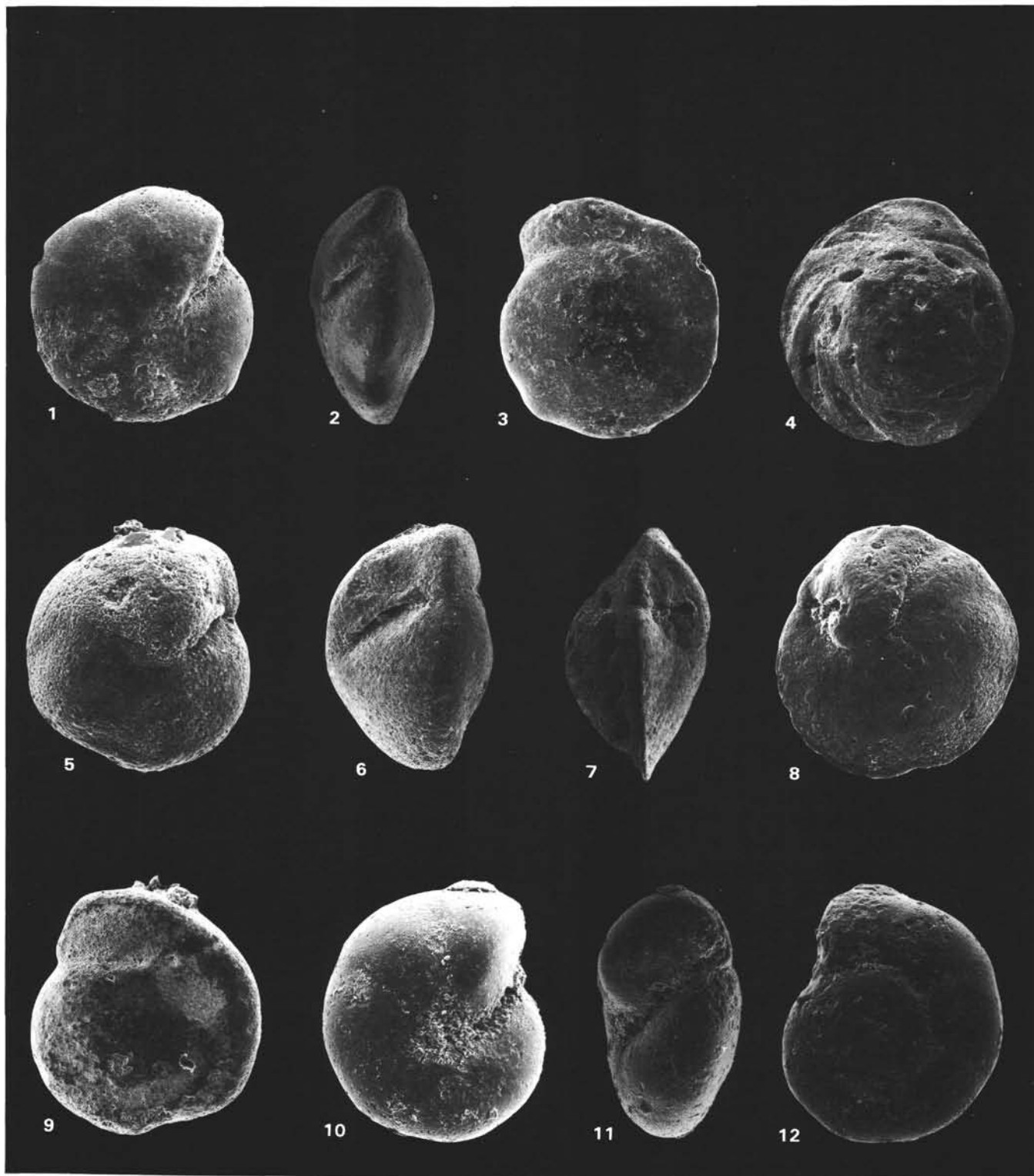


Plate 6. 1-3. *Oridorsalis umbonatus* (Reuss), Sample 516F-89-3, 83-85 cm, $\times 108$, (1) umbilical view, (2) peripheral view, (3) spiral view. 4, 7-8. *Osangularia cordieriana* (d'Orbigny), Sample 516F-97-2, 94-95 cm, $\times 78$, (4) spiral view, (7) umbilical view, (8) peripheral view. 5-6, 9. *Gyroidinoides beisseli* (White), Sample 516F-103-1, 7-10 cm, $\times 120$, (5) umbilical view, (6) peripheral view, (9) spiral view. 10-12. *Gyroidinoides depressus* (Alth), Sample 516F-88-3, 57-58 cm, $\times 144$, (10) umbilical view, (11) peripheral view, (12) spiral view.

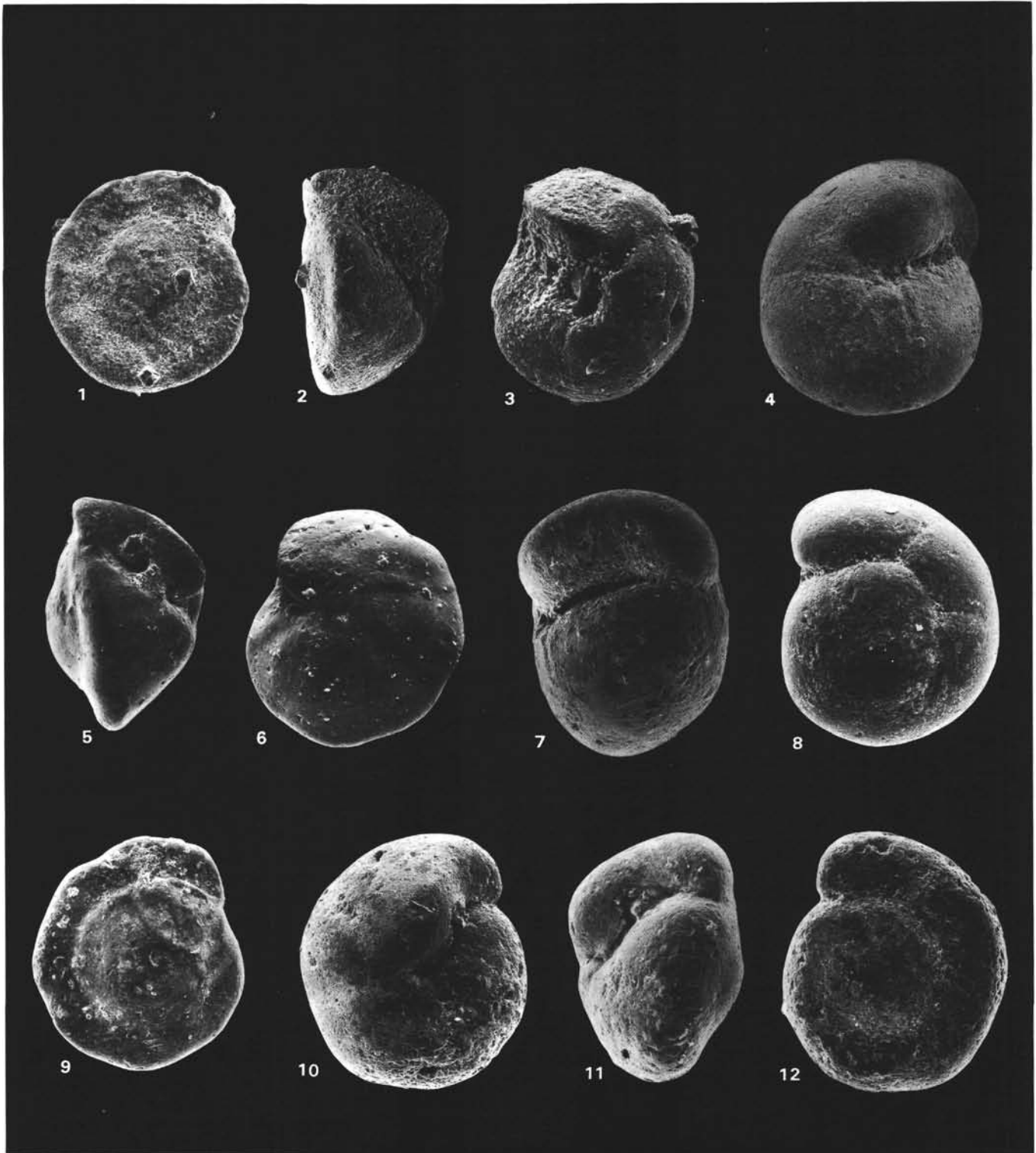


Plate 7. 1-3. *Gyroidinoides girardanus* (Reuss), Sample 516F-91-4, 32-34 cm, $\times 162$, (1) spiral view, (2) peripheral view, (3) umbilical view. 4, 7-8. *G. globosus* (Hagenow), Sample 516F-92-3, 78-80 cm, $\times 144$, (4) umbilical view, (7) peripheral view, (8) spiral view. 5-6, 9. *G. goudkoffi* (Trujillo), Sample 516F-106-2, 3-5 cm, $\times 108$, (5) peripheral view, (6) umbilical view, (9) spiral view. 10-12. *G. nitidus* (Reuss), Sample 516F-97-2, 94-55 cm, $\times 162$, (10) umbilical view, (11) peripheral view, (12) spiral view.

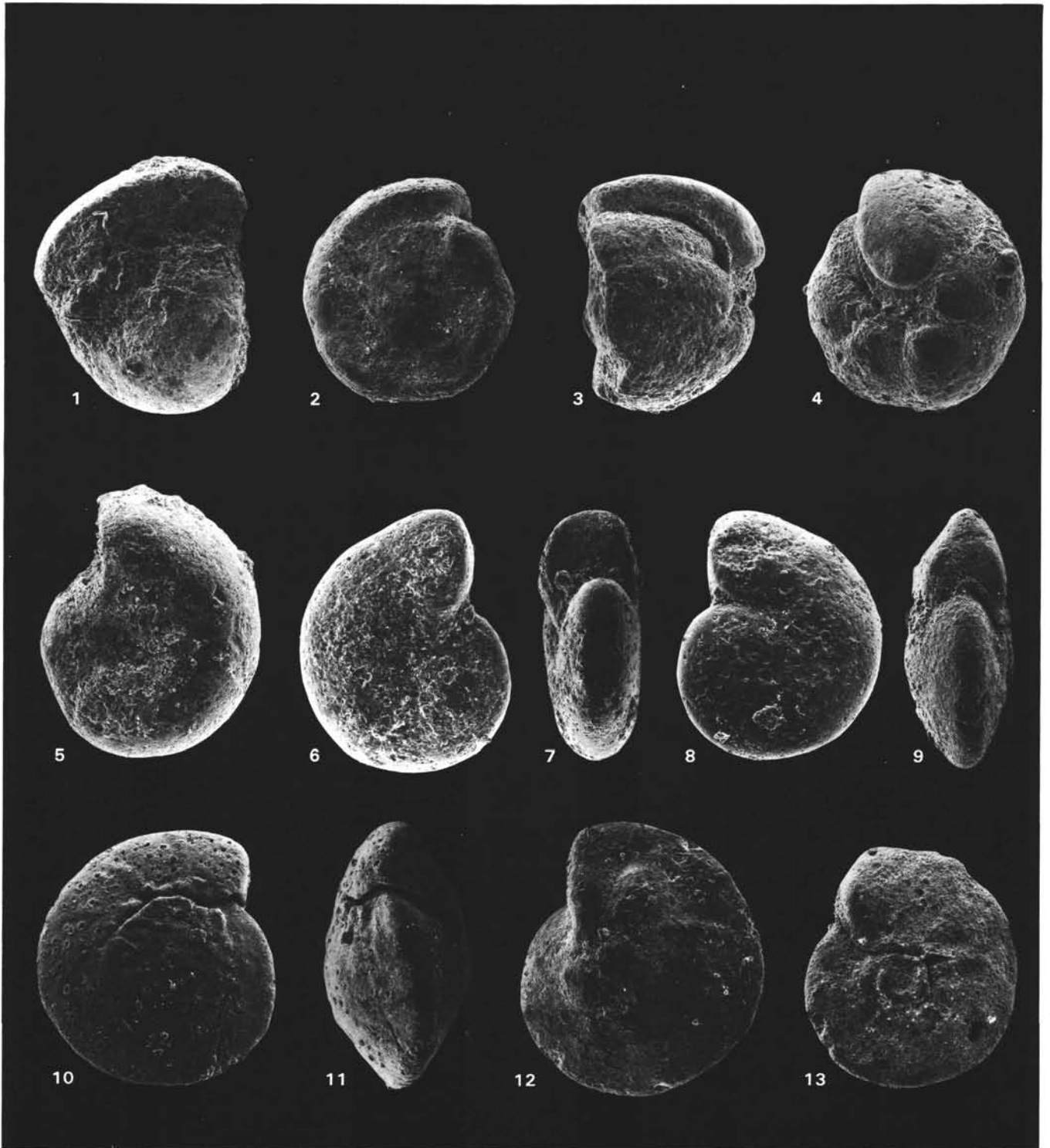


Plate 8. 1, 5. *Gyroidinoides praeglobosus* (Brotzen), Sample 516F-117-3, 20–22 cm, $\times 120$, (1) peripheral view, (5) spiral view. 2–4. *G. quadratus* (Cushman and Church), Sample 516F-97-2, 94–95 cm, $\times 108$, (2) spiral view, (3) peripheral view, (4) umbilical view. 6–8. *Anomalinooides welleri* (Plummer), Sample 516F-89-2, 41–42 cm, $\times 132$, (6) spiral view, (7) peripheral view, (8) umbilical view. 9, 13. *Gavelinella monterelensis* (Marie), Sample 516F-93-5, 16–18 cm, $\times 162$, (9) peripheral view, (13) umbilical view. 10–12. *Cibicoides pseudoperlucidus* (Bykova), Sample 516F-86-4, 9–12 cm, $\times 108$, (10) spiral view, (11) peripheral view, (12) umbilical view.

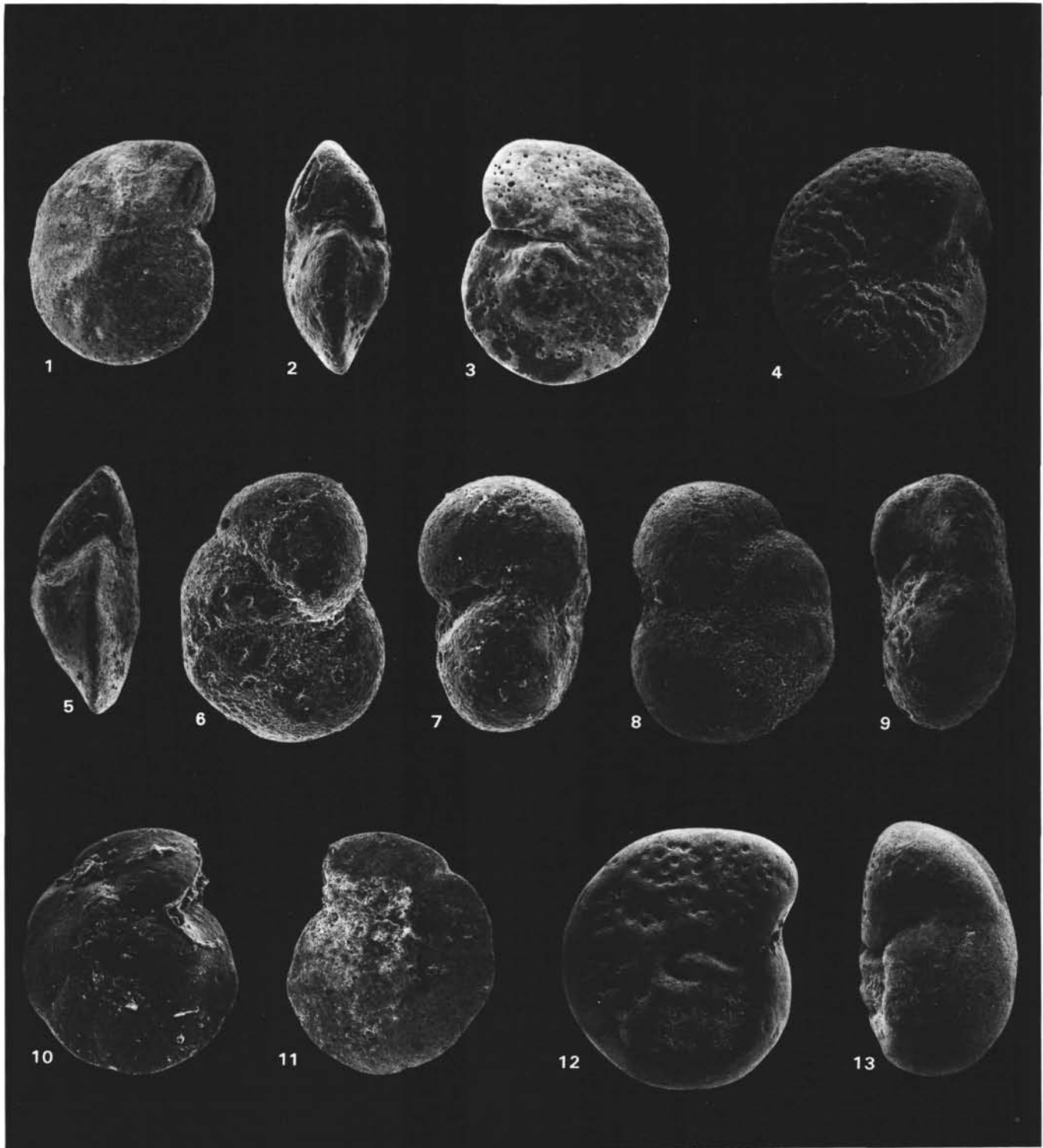


Plate 9. 1-3. *Cibicoides dayi* (White), Sample 516F-89-6, 40-43 cm, $\times 108$, (1) spiral view, (2) peripheral view, (3) umbilical view. 4, 9. *Gavelinella beccariiformis* (White), Sample 516F-88-3, 57-58 cm, $\times 96$, (4) umbilical view, (9) peripheral view. 5, 10-11. *G. eriksdalensis* (Brotzen), Sample 516F-89-6, 108-110 cm, $\times 78$, (5) peripheral view, (10) spiral view, (11) umbilical view. 6-8. *G. danica* Brotzen, Sample 516F-83-5, 24-26 cm, $\times 162$, (6) umbilical view, (7) peripheral view, (8) spiral view. 12-13. *G. velascoensis* (Cushman), Sample 516F-89-3, 18-20 cm, $\times 90$, (12) umbilical view, (13) peripheral view.

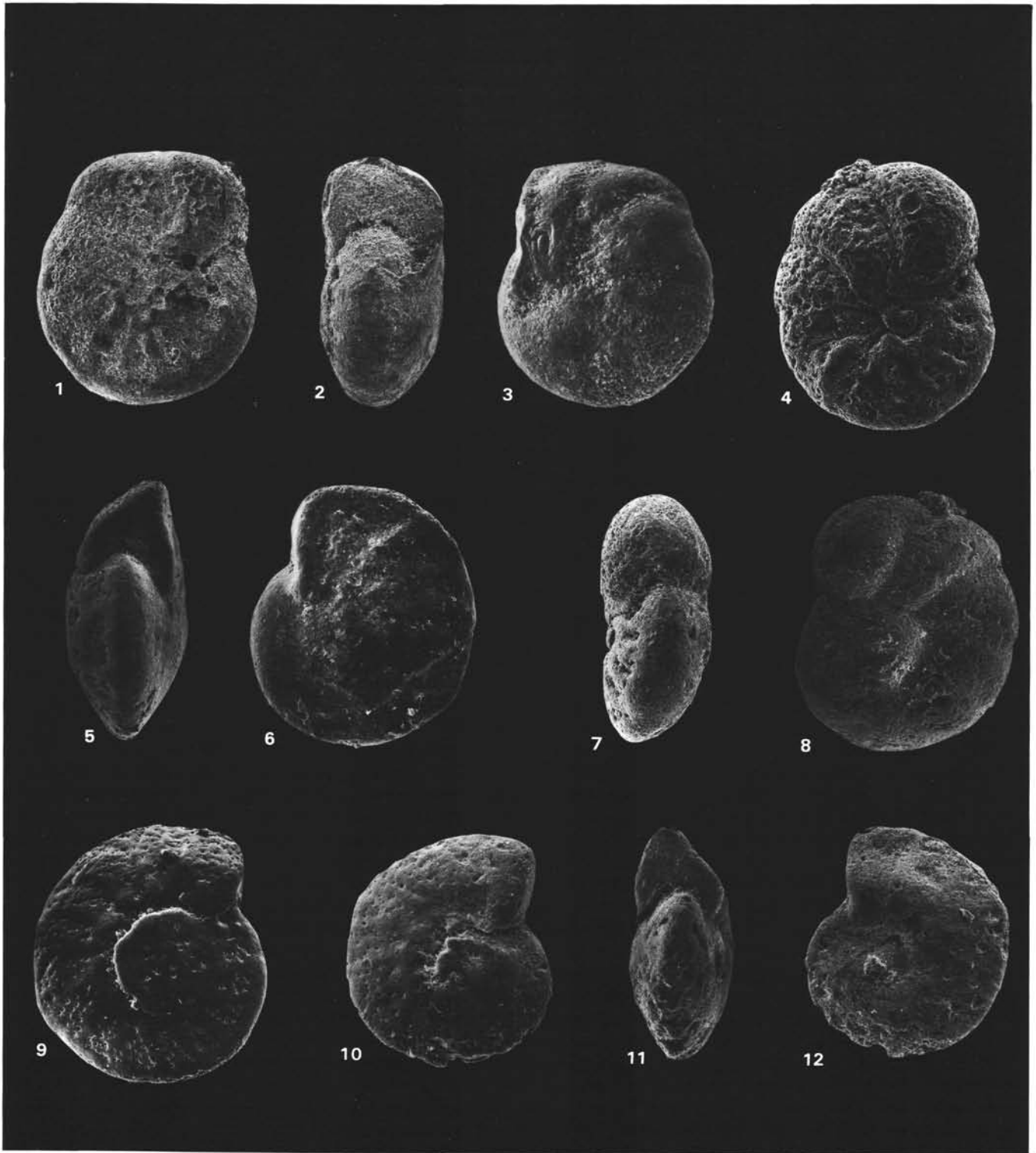


Plate 10. 1-3. *Gavelinella hyphalus* (Fisher), Sample 516F-85-2, 44-47 cm, $\times 78$, (1) umbilical view, (2) peripheral view, (3) spiral view. 4, 7-8. *G. nacatochensis* (Cushman), Sample 516F-109-5, 73-75 cm, $\times 132$, (4) umbilical view, (7) peripheral view, (8) spiral view. 5-6, 9. *G. stephensoni* (Cushman), Sample 516F-91-4, 32-34 cm, $\times 72$, (5) peripheral view, (6) spiral view, (9) umbilical view. 10-12. *G. sp.*, Sample 516F-89-2, 119-121 cm, $\times 132$, (10) umbilical view, (11) peripheral view, (12) spiral view.