9. MESOZOIC FORAMINIFERS AND DEEP-SEA BENTHIC ENVIRONMENTS FROM DEEP SEA DRILLING PROJECT SITES 415 AND 416, EASTERN NORTH ATLANTIC

William V. Sliter,[1] U.S. Geological Survey, Menlo Park, California

ABSTRACT

Mesozoic foraminifers recovered from DSDP Leg 50 Sites 415 and 416 in the Moroccan Basin of the eastern North Atlantic range in age from Late Jurassic to middle Cenomanian.

At Site 415, sediments range in age from late Albian to middle Cenomanian, as inferred from 19 species of planktonic foraminifers and selected benthic foraminifers. Assemblages are dominated by hedbergellids, whereas rotaliporids are few, and ticinellids are absent. Deposition took place beneath the calcite-compensation depth in a quiet, abyssal environment, at water depths of 3000 to 4000 meters. This environment received a regular influx of shallow-water material that decreased with time and was finally replaced by hemipelagic sediments.

Foraminifer assemblages of Site 416 range in age from Late Jurassic (Tithonian-Kimmeridgian) to early Cenomanian. The assemblages consist of 172 species of benthic foraminifers and three species of the planktonic genus *Hedbergella,* represented by seven specimens. During the Neocomian, shallow-water material was emplaced into a quiet, lower bathyal to abyssal environment beneath the calcite-compensation depth, at water depths of 2000 meters or more. As a result of this high rate of sedimentation, 35 of the 53 Mesozoic cores are Valanginian. Before and after the Neocomian, the rate of sedimentation was lesser. Foraminifers representative of slope environments are found throughout the Upper Jurassic and Neocomian; they are strongly similar to shelf assemblages and comprise nodosariids and simple, agglutinated species.

INTRODUCTION

Mesozoic foraminifers were recovered from Sites 415 and 416, drilled during DSDP Leg 50 in the eastern North Atlantic off the coast of Morocco (Figure 1). Both sites are on the lower continental slope, within the Moroccan Basin; Site 415 is near Agadir Canyon, and Site 416 is near Site 370 of Leg 41 (Table 1). The Late Jurassic to middle Cretaceous foraminifer faunas provide valuable biostratigraphic information and permit environmental reconstructions in a deep-water environment, although the faunas are, in general, of low diversity and abundance and are poorly preserved. The faunas and lithologies at both sites indicate deposition in a deep-sea environment below the calcite-compensation depth (CCD) that characteristically received regular influxes of distal turbidites. Consequently, foraminifer recovery was sporadic, and specimens generally are sorted hydrodynamically to a range between 63 and 149 μm. Because of differences in age and faunal content, foraminifers from Sites 415 and 416 are treated separately here. At Site 415, planktonic foraminifers are used for correlation, whereas at Site 416 the dominant benthic foraminifers form the basis for biostratigraphic interpretation.

The Mesozoic faunas allow close correlation with DSDP sites of earlier legs within the North Atlantic. Most notable among these are Sites 136 and 137 of Leg 14, off northwest Africa; Sites 367, 368, 369, and 370 of Leg 41; and Sites 101 and 105 of Leg 11, from the Blake-Bahama Abyssal Plain, in the northwestern Atlantic.

SITE 415

Site 415 was selected in an attempt to penetrate pre-Late Jurassic sediments close to a rifted continental margin; site selection was based on the results of Leg 41 (Site 370). Because drilling at Site 370 had reached a depth of 1,176 meters, Hole 415A, the principal hole of three drilled at Site 415, was discontinuously cored; cores were taken about every 70 meters to a sub-bottom depth of 1,079.5 meters. There were three successful re-entries (Table 1). Unstable hole conditions forced the abandonment of the site. The penultimate core, 415A-14, was highly fractured and calcite-veined mudstone that apparently was subject to continued and excessive caving. As a result, the foraminifer assemblages in the final two cores contain common down-hole contaminants.

[1] Present address: U.S. Geological Survey, National Center, Reston, Virginia, 22092.

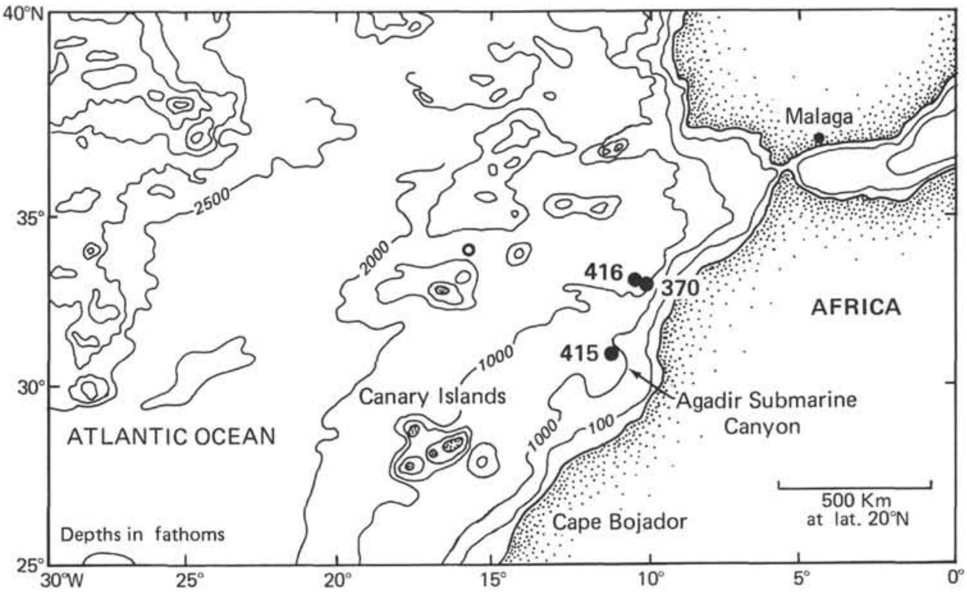


Figure 1. *Location of Sites 415 and 416 of Leg 50 and Site 370 of Leg 41, off the northwest coast of Africa.*

TABLE 1
General Data on Primary Holes of Leg 50

Hole	Latitude	Longitude	Water Depth (m)	Penetration (m)	Recovery Per Cent	Number of Cores in Mesozoic
415A	31°01.72'N	11°39.11'W	2794	1079.5	20	8
416A	32°50.18'N	10°48.06'W	4191	1624	47.3	52

Planktonic-species distributions form the primary basis for the following age determinations and correlations. The low-diversity fauna consists of nine genera and 19 species (Figure 2). Faunas are dominated by hedbergellids, numbers of specimens are low, and preservation is moderate to poor.

Planktonic-Foraminifer Zonation

The composite planktonic zonation used in this paper (Figure 3) is based on recent schemes by van Hinte (1976) and Premoli-Silva and Boersma (1977) for the South Atlantic and Sigal (in press) for the North Atlantic. The 19 species of Cretaceous planktonic foraminifers recognized from Site 415 represent four zones, from late Albian to middle Cenomanian. The reader is referred to the cited works for descriptions of the zones. The selected datum levels are based in part on Thierstein (1976) and Premoli-Silva and Boersma (1977).

Biostratigraphy of Hole 415A

Albian

Cores 415A-14 and 415A-15, greenish-black marlstone and olive-gray, calcareous claystone, are assigned to the upper-Albian *Rotalipora appenninica–Planomalina buxtorfi* Zone. The presence of *Rotalipora appenninica, Praeglobotruncana delrioensis, Schackoina cenomana, S. multispinata,* and *Guembelitria cenomana* and the absence of species of *Ticinella* are consistent with this assignment (Figures 2 and 3). Rare specimens of *Rotalipora evoluta, Clavihedbergella simplex,* and *Rotalipora cushmani* with this interval probably result from caving during drilling. The low-diversity benthic fauna (Appendix 1, faunal reference list; barren or nondiagnostic samples are listed in Appendix 2), with *Textularia foeda, Spiroplectinata complanata, Lenticulina gaultina, Vaginulina debilis, V. gaultina, Lingulina lamellata,* and *Gavelinella intermedia,* is compatible with an Albian assignment. Foraminifer abundance is low in this interval, preservation moderate to poor, and the effects of dissolution moderate.

Cenomanian

Core 415A-13, dark-greenish-gray mudstone to shale, is assigned to the early Cenomanian. The faunal assemblage is similar to that of the underlying cores, with the addition of *Rotalipora evoluta,* believed to be in place. Species of *Hedbergella* and *Globigerinelloides* are more abundant; preservation and dissolution effects remain about the same.

From Core 415A-12 through Sample 415A-8-2, 105–107 cm, the sediments belong to the early- to middle-Cenomanian *Rotalipora cushmani* Zone. Species that occur within this interval include *Rotalipora cushmani, R. evoluta, R. appenninica, Clavihedbergella simplex, Gubkinella graysonensis, Praeglobotruncana delrioensis,* and *P. stephani.* The section can be divided into three intervals based on the planktonic fauna.

Cores 415A-12 and 415A-11 and Sample 415A-10-CC, predominantly olive-gray, calcareous shale, contain the greatest abundance of *Rotalipora cushmani,* as well as common representatives of species of *Hedbergella* and *Globigerinelloides. Hedbergella* sp. cf. *H. delrioensis* makes its final appearance within this interval,

Age	Zone	Hole 415A Sample (interval in cm)	*Guembelitria cenomana*	*Hedbergella* sp. cf. *H. delrioensis*	*Rotalipora evoluta*	*Globigerinelloides bentonensis*	*Schackoina multispinata*	*Clavihedbergella simplex*	*Globigerinelloides caseyi*	*Praeglobotruncana delrioensis*	*Schackoina cenomana*	*Hedbergella simplicissima*	*Hedbergella planispira*	*Hedbergella delrioensis*	*Heterohexlix moremani*	*Hedbergella infracretacea*	*Rotalipora appeninnica*	*Gubkinella graysonensis*	*Rotalipora cushmani*	*Hedbergella* sp.	*Praeglobotruncana stephani*	Preservation	Dissolution Effects
Albian to Coniacian		415A-7-1, 15–17	Rare, agglutinated foraminifers only																			P	4
		7-1, 19-21	Rare, agglutinated foraminifers only																			P	4
		7,CC, 8-9										○										P	4
		7,CC, 11-13	No foraminifers																			P	4
		7,CC, 20-21	Rare, agglutinated foraminifers only																			P	4
		415A-8-1, 8-10	Rare, agglutinated foraminifers only																			P	4
		8-1, 89-91											○									P	4
		8-1, 128-138	Rare, agglutinated foraminifers only																			P	4
		8-2, 94-96											○	○								P	4
middle Cenomanian	*Rotalipora cushmani*	8-2, 105-107								○	○	◑	●	◑	○	◑		○				P	3
		8,CC, 9-11	No foraminifers																			P	4
		8,CC						○	○	○	○	◑	●	◑	○	◑		○				F	3
		415A-9-1, 14-16							○			⊙	●	◑		⊙		○				P	4
		9-1, 88-90						○	⊙			◑	●	●		◑						P	4
		9-1, 123-125					○		○	○	○	◑	●	●	○	◑		○				P	4
		9-2, 13-15				◑			⊙	○	○	⊙	●	●	○	○						P	3
		9-3, 81-83				◑			⊙			⊙	◑	●		○						P	4
		9-4, 25-27				⊙		○	⊙			◑	⊙	⊙		○						P	4
		9-5, 10-12			○			○	○		○	◑	●	●		◑		⊙				P	3
		9,CC, 10-12							⊙			⊙	⊙	⊙					○			P	4
		9,CC			○			○	○	○	○	⊙	◑	○	○	○	○				○	P	4
		415A-10-1, 22-24					○		○	○		○	⊙	○	○	○		○				P	3
		10-1, 31-33					○		○	○	○	○	⊙	○	○	○						P	4
		10-2, 15-18				○	○		○	○	○	○	○	○	○			○	○			P	4
		10-2, 54-56				○	○		⊙	○	○	○	◑	◑	◑							P	4
		10,CC, 2-4			○	○			○	⊙		⊙	⊙	⊙	○	○			○			P	3
		10,CC			⊙	⊙		○	○	○		◑	⊙	◑	○	○			⊙			P	3
		415A-11-1, 15-17				○			○			◑	◑	●		○						P	3
		11-2, 69-71			⊙	○		○	○	○		◑	⊙	◑	○	○	○		⊙			P	3
		11,CC, 13-15			○	◑	○		◑	○	○	●	⊙	◑		○				○		P	3
		11,CC			⊙	◑	○	○	◑	○	○	◑	⊙	◑			○		◑			P	3
		415A-12-1, 18-20		◑	○	⊙	○		⊙		○	●	◑	⊙			○					F	3
		12-1, 97-99		◑	○	◑	○		⊙		○	●	◑	◑		○						F	3
		12-2, 104-109		◑	◑	◑		○	◑	○	○	◑	●	●	○	⊙	○		◑			F	3
		12,CC		○	○	⊙	◑	○	⊙		⊙	◑	●	●	⊙	◑		○				P	3
early Cenomanian	*Rotalipora brotzeni*–*Rotalipora montsalvensis*	415A-13-1, 64-66		◑		●			●		○	●	●	○		○						F	3
		13-2, 80-82		⊙	○	⊙	○		⊙		○	●	◑	◑		○						F	3
		13,CC		◑	○	⊙	⊙		⊙		⊙	⊙	◑	◑	○	⊙						P	4
late Albian	*Rotalipora appenninica*–*Planomalina buxtorfi*	415A-14-1, 72-76		⊙	○	◑			⊙	○	○	⊙	◑	◑		⊙						F	3
		14-1, 96-100		○	○	⊙	○		⊙	⊙	○	⊙	◑	⊙		○			○			F	3
		14-1, 131-133	○	○	(?)	○			⊙	○	○	◑	●	⊙		⊙	○					P	3
		14,CC		○		⊙	○		○	○	○	⊙	◑	⊙	○	○	○					F	3
		415-15,CC	○	○	(?)	⊙	○	○	○	○	○	⊙	●	⊙	○		○					F	3

Abundance
● Abundant (> 50)
◑ Common (26-50)
⊙ Few (11-25)
○ Rare (1-10)

Preservation
F = Fair
P = Poor

Dissolution Effects
3 = Moderate etching and fragmentation
4 = Strong dissolution and fragmentation

Figure 2. *Distribution of Cretaceous planktonic foraminifers and foraminifer preservation at Site 415. Abundance (numbers of specimens) based on assemblage larger than 105 μm.*

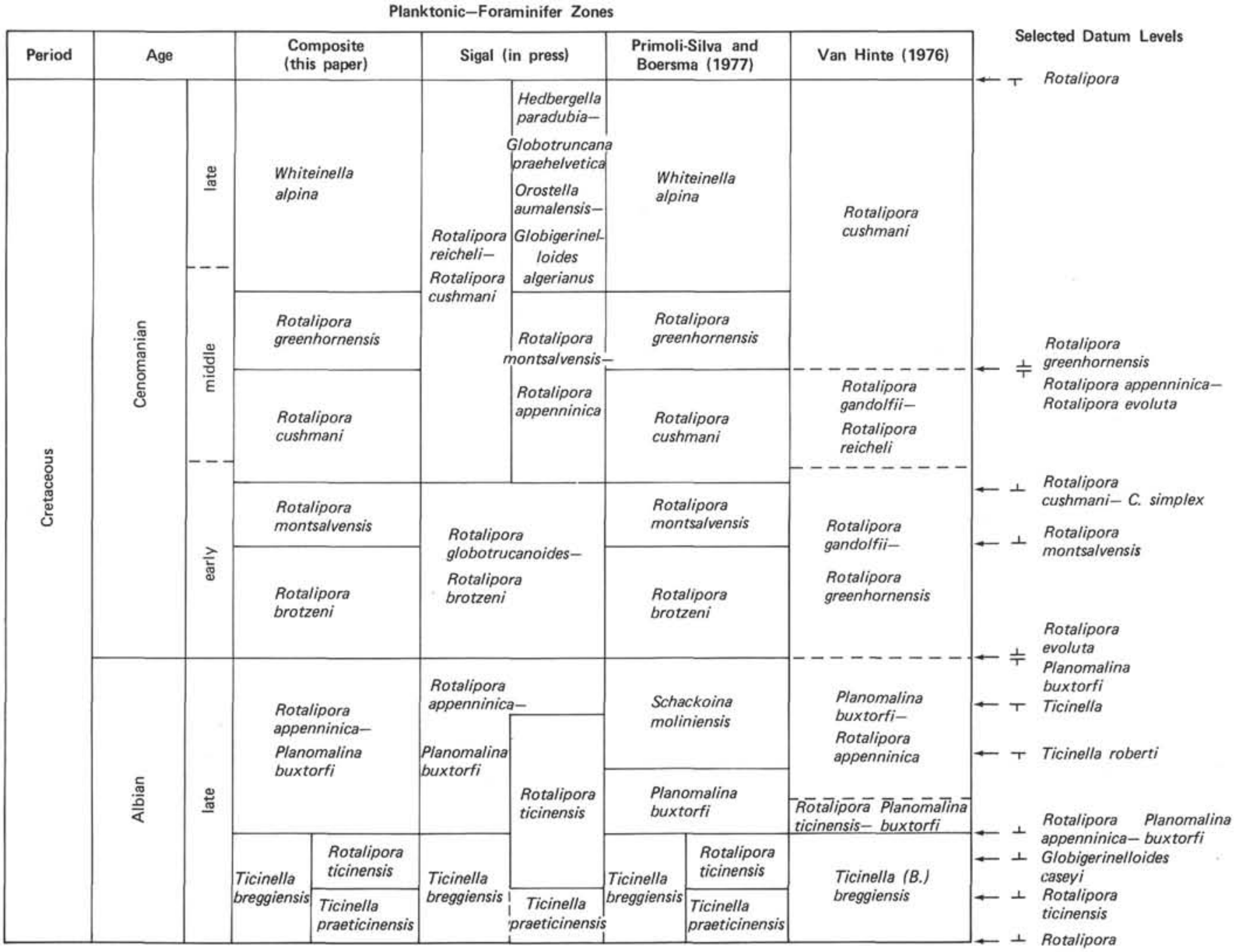


Figure 3. *Planktonic-foraminifer zones and selected datum levels. Datum levels in part after Moullade (1973), Porthault (1974), Thierstein (1976), and Premoli-Silva and Boersma (1977).*

which also includes the stratigraphically restricted specimens of *Hedbergella* sp. Preservation is poor to moderate, and the effects of dissolution are moderate.

The second interval (Core 10) contains a much reduced, poorly preserved fauna. The sediments are olive-gray, pyrite-bearing marlstone, with intervals of contorted stratification. Smaller specimens are relatively abundant, and there is a noticeable reduction in rotaliporids.

The third interval (Core 9) shows a renewed abundance of *Hedbergella* and *Globigerinelloides,* with rare specimens of *Rotalipora.* Sediments are dark-greenish-gray marlstone, and there is considerable evidence of disturbed bedding. The sporadic and repetitious nature of the fauna within these three intervals and the preservation patterns and presence of disturbed sediments suggest the effects of gravitational sliding and consequent increased dissolution in the more exposed or fractured intervals. Alternatively, changes in the corrosiveness of the bottom waters, fracturing of the strata associated with adjacent up-slope salt-dome emplacement, or vertical fluctuations of the CCD could produce similar results. On the basis of the faunal and lithologic patterns, the hypothesis of dissolution as a consequence of gravitational sliding is believed to be the most plausible.

Albian-Coniacian

The interval of Sample 415A-8-2, 94-96 cm through Core 415A-7 contains very few planktonic species and is characterized by strong carbonate dissolution and only rare, deep-water, agglutinated foraminifers. The rare specimens of *Hedbergella* indicate an age no younger than Coniacian. Sediments in Core 415A-7 consist of homogeneous olive-gray mudstone; Core 415A-8 is blue-green, calcareous mudstone to shale. Radiolarians within this interval show zeolitic alteration. The combination of strong carbonate dissolution, lowered sedimentation rates, and development of zeolites correlates these sediments with the dissolution facies or barren interval that characteristically extends from the upper Cenomanian to the middle Santonian in oceanic sediments (Sliter, 1976, 1977).

Paleoecology

Depositional Environment

Deposition of the Cretaceous sediments at Site 415 took place in a quiet, abyssal environment, at water depths of 3000 to 4000 meters, beneath the CCD. There was a regular influx of fine-grained, terrigenous sediment. Terrigenous sediments decrease upward to Cores 415A-7 and 415A-8, where they are replaced largely by hemipelagic sediments. Deposition of the terrigenous silts and clays took place by very distal resedimentation processes generated by traction flows or turbidity currents. These processes mixed biogenic material from shallow and intermediate water depths with resuspended autochthonous material. As a result, the recovery and preservation of the foraminifer assemblages at Site 415, and indeed of all the calcareous material, is strongly affected by the mode of sedimentation and the sediment type. The dominant lithology at Site 415 is calcareous or dolomitic shale or mudstone. Foraminifers and calcareous nannofossils contribute less than five per cent of the carbonate, the rest apparently being diagenetic carbonate. Bioturbation consists primarily in horizontal or nearly horizontal *Chrondites* burrows adjacent to the fine-grained sandstone or siltstone beds.

The foraminifer assemblages and biogenic components plotted in Figure 4 illustrate these changes. A deep-sea foraminifer assemblage is found throughout the sediments of Hole 415A; however, it is strongly diluted in Cores 415A-11 through 415A-15 by redeposited bathyal and neritic faunas. The autochthonous assemblage includes species of *Bathysiphon, Hyperammina, Hippocrepina, Lituotuba, Saccammina, Glomospira, Glomospirella, Ammodiscus, Recurvoides, Reophax, Ammobaculites, Gaudryina,* and *Trochammina.* These foraminifers are indicative of Cretaceous abyssal water depths of 3000 to 4000 meters (Sliter and Baker, 1972; Sliter, 1976, 1977).

The dominant neritic assemblage of Cores 415A-11 to 415A-15 is characterized by nodosariids, such as species of *Astacolus, Dentalina, Frondicularia, Lagena, Lenticulina, Nodosaria, Saracenaria, Vaginulina;* fistulose polymorphinids; large agglutinated species of *Dorothia, Tritaxia, Textularia,* and *Chofatella;* and miliolids that include species of *Quinqueloculina, Spiroloculina,* and *Nodobacularia*. This assemblage is indicative of water depths no greater than 400 to 500 meters. Also present in these cores are carbonaceous material, *Inoceramus* prisms, holothurian plates, echinoid spines, ostracodes, and rare calcisphaerulids, among other components. The calcareous material is better preserved, probably because of the buffering action of the greater carbonate content and the protection from corrosive bottom waters by rapid accumulation. Rare well-cemented calcarenite with shallow-water carbonate detritus is confined to this interval.

Cores 9 and 10 contain a dominant bathyal foraminifer component, as evidenced by species of *Praebulimina, Neobulimina, Stilostomella, Bolivina, Pleurostomella, Ellipsoidella, Allomorphina, Gavelinella, Gyroidinoides,* and *Osangularia*, among others. Both middle-bathyal (500–1500 m) and lower-bathyal (1500–2500 m) elements are present in the mixed assemblages; however, the assemblages are hydrodynamically sorted, and size distributions are skewed in favor of the smaller, lower-bathyal species. Neritic species make their final common appearance in Section 415A-9, CC. Fish debris, radiolarians, and diatoms increase and are accompanied by echinoid spines, ostracodes, and thin-shelled-bivalve fragments. *Inoceramus* prisms and miliolids become rare or disappear within this interval.

The abyssal assemblage becomes dominant in Cores 415A-7 and 415A-8, where it is accompanied by abundant fish debris and radiolarians. Radiolarians from Sample 415A-8-1, 8-10 cm to the top of Core 415A-7 are replaced by zeolites in this dissolution facies associated with the mid-Cretaceous hiatus.

The upward decrease in the terrigenous component is documented by the ratio of planktonic to benthic foraminifers and by the abundance of fragmented planktonic specimens (Figure 4). Planktonic species become relatively more abundant upward as the dilution by allochthonous benthic foraminifer lessens. Likewise, fragmentation of planktonic foraminifers increases upward as the protection offered by the terrigenous sediments lessens and the foraminifers are exposed to bottom waters for longer periods between flows.

Sample 415A-9, CC and samples from Core 415A-10 differ somewhat from adjacent samples in their foraminifer assemblage, biogenic content, and fossil preservation. These differences again may attest to gravity sliding within this interval.

Effect of Sedimentation

The effects of resedimentation and vertical sorting in the very distal turbidites of Site 415 are illustrated in Figure 5. Three examples are shown, two illustrating differences within turbidite cycles and one differences between marlstones differentiated by color within the upper unit of a turbidite cycle.

Samples 415A-10-2, 12-13 cm, 15-17 cm, and 17-18 cm record a single cycle, from a basal fine-grained sandstone to a greenish marlstone. Planktonic foraminifers are rare in the sandstone and overlying grayish-olive marlstone. Still, some evidence of sorting is seen in the restriction of the larger rotaliporids to the basal sandstone and the smaller species of *Schackoina* to the overlying grayish-olive marlstone. The mixed benthic assemblage in the sandstone consists of bathyal and neritic species that are found with abundant small, smooth and ornamented ostracodes (many with blackened carapaces), common echinoid spines, and rare miliolids, holothurian plates, and thin bivalve fragments. Pyrite is present as chamber fillings in planktonic foraminifers and as sporadic framboids.

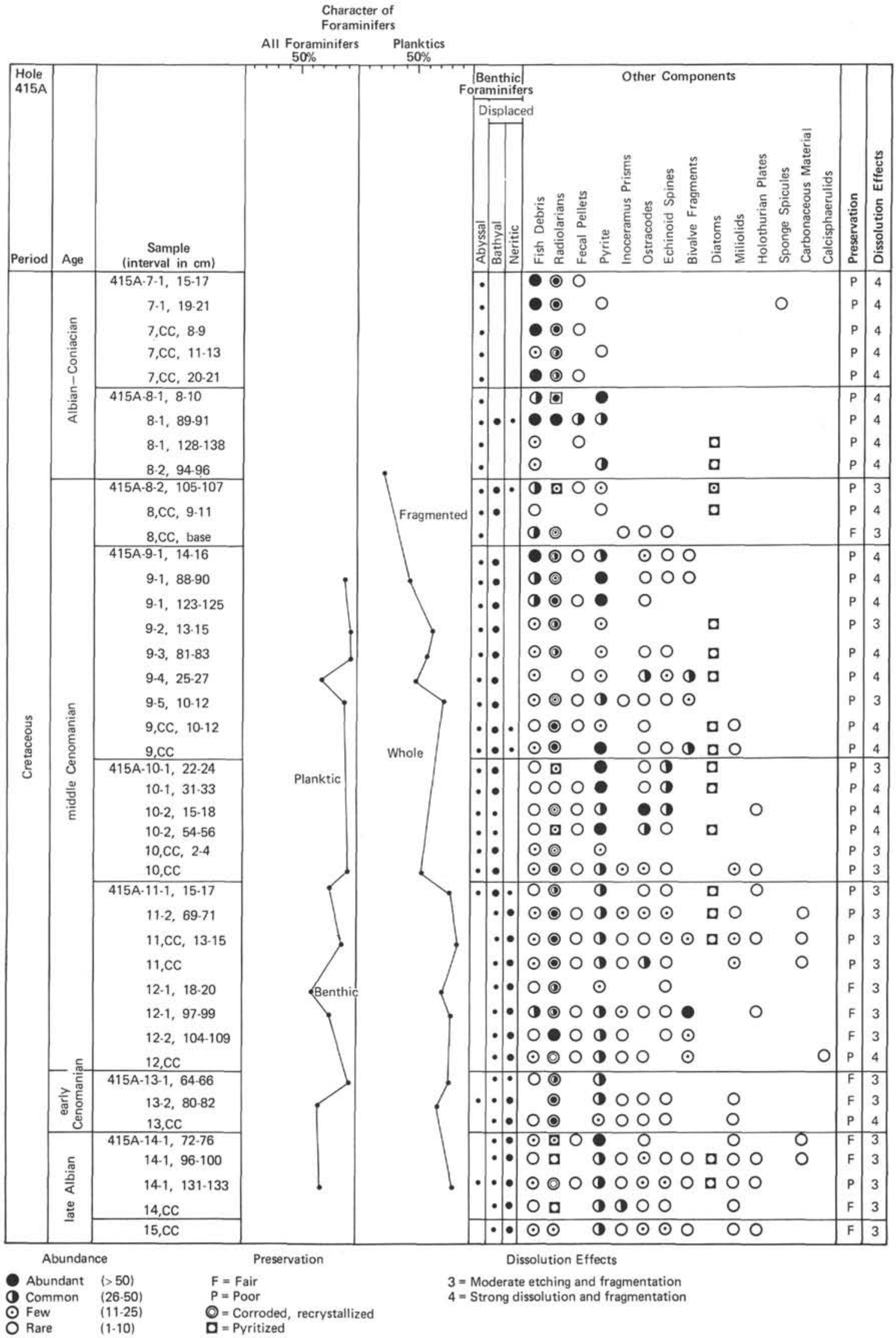


Figure 4. *Distribution and character of selected biogenic and lithologic components at Site 415. Relative abundance among benthic foraminifers of various depth zones shown by size of symbol. Relative abundance of benthic and planktonic foraminifers based on 300-specimen counts of fraction greater than 105 µm.*

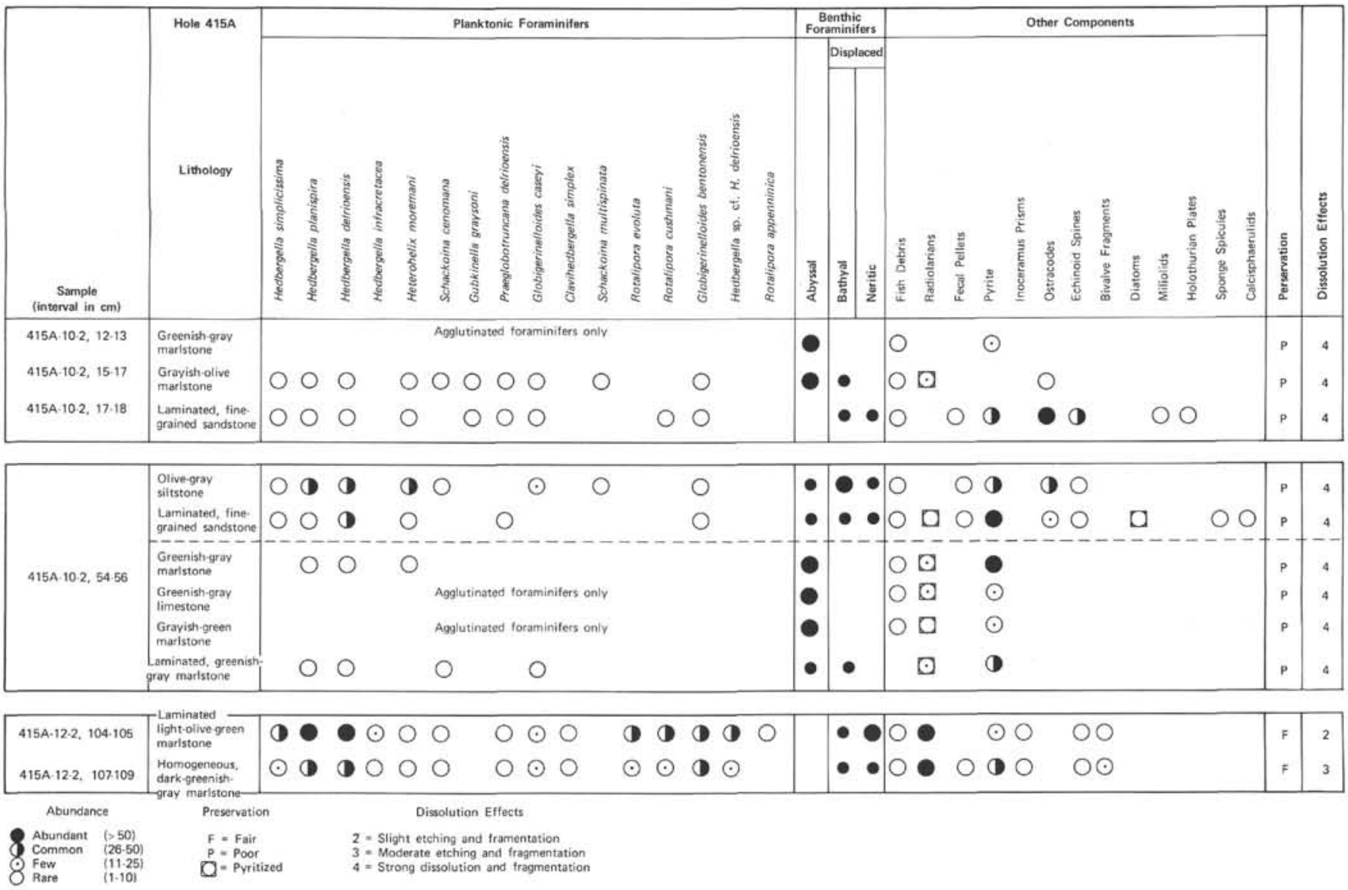


Figure 5. *Distribution of planktonic foraminifers and selected biogenic and lithologic components in separate units of turbidite cycles at Site 415. Planktonic-foraminifer abundance from assemblage greater than 105 μm; biogenic-component abundance from assemblage greater than 63 μm. Relative abundance of abyssal, bathyal, and neritic foraminifers shown by size of symbols. Dashed line represents boundary between turbidite cycles.*

An autochthonous, abyssal assemblage appears in the grayish-olive marlstone, together with bathyal species, pyritized radiolarians, fish debris, and rare ostracodes. The abyssal assemblage continues to the dissolution facies of the upper greenish-gray marlstone, where the planktonic foraminifers and other calcareous biogenic materials have been removed. Pyrite is present as framboids and sporadic fillings of agglutinated foraminifers.

Sample 415A-10-2, 54-56 cm contains the boundary (dashed in Figure 6) between two cycles. In the upper cycle, smaller species of *Hedbergella* and *Schackoina* are again more abundant in an olive-gray siltstone that overlies a laminated, fine-grained basal sandstone. The sandstone contains abyssal benthic foraminifers with bathyal and neritic species of moderately large size, together with pyritized radiolarians and diatoms, calcisphaerulids and sponge spicules. Pyrite is most abundant in foraminifers (89%); lesser amounts are present as framboids (10%) and pyritized radiolarians (1%). The overlying siltstone shows an increase in bathyal species and smooth ostracodes. Pyrite is distributed between foraminifers (70%) and framboids.

A laminated, greenish-gray marlstone at the base of the underlying cycle is nearly equivalent to the olive-gray siltstone of the upper cycle. A small, allochthonous, bathyal fauna is mixed with an abyssal foraminifer assemblage. Pyrite is found mostly as framboids (70%); the rest is distributed among pyritized radiolarians (20%), burrow fillings (7%), and foraminifers (3%). Overlying this is a grayish-green marlstone. Higher in the cycle, is a greenish-gray limestone, which presumably resulted from dissolution of pelagic carbonate from the underlying marlstones. In the limestone and immediately subjacent marlstone, pyrite is nearly evenly distributed between framboids and burrow fillings. The final unit, a greenish-gray marlstone, represents perennial sediment; it contains a meager planktonic fauna, abyssal benthic species, and fish debris. Pyrite is present as framboids (89%) and as fillings in agglutinated (10%) and planktonic (1%) foraminifers.

The third example, Samples 415A-12-2, 104-105 cm and 107-109 cm, shows faunal differences between a homogeneous, dark-greenish-gray marlstone and an overlying laminated, light-olive-green marlstone. Both units contain a moderately diverse planktonic fauna; however, the larger rotaliporids are more common in the laminated marlstone. The laminated marlstone also contains more and better-preserved neritic benthic fora-

Figure 6. *Location of previous DSDP sites (Legs 13, 14, 41) off northwest Africa that contain middle-Cretaceous foraminifers.*

minifers. Pyrite is similarly distributed in both units; it is found as fillings in foraminifers (60%), radiolarians (20%), and burrows (1%), and as framboids (19%).

In all three examples, the primary inprint of downslope bottom flows can be seen in the mixed assemblages of the sands and laminated siltstones and in the concentration of larger-sized and heavier biogenic debris in the basal units.

Faunal Comparisons

Foraminifers from Site 415 are comparable to those from Sites 136 and 137 of Leg 14 and Sites 367, 368, 369, and 370 of Leg 41, off northwest Africa (Figure 6). Of these assemblages, those from Site 370 reported by Pflaumann and Krasheninnikov (1978) are very similar; Site 370 is about 350 km northeast of Site 415, at a water depth of 4,216 meters. Cores 370-20 through 370-24 contain a late-Albian to early-Cenomanian fauna with *Rotalipora appenninica, Praeglobotruncana delrioensis, Hedbergella delrioensis, H. planispira, H. infracretacea, H. simplicissima,* and *H. simplex,* among other species. Cores 370-25 to 370-26 have a similar fauna, but lack species of *Rotalipora* and *Ticinella*. Pflaumann and Krasheninnikov attribute these cores to the upper-Albian *Rotalipora ticinensis* Zone. Cores 370-20 through 370-26 thereby correlate closely with Cores 415A-13 to 415A-15. In contrast, Albian sediments of Site 369, at a water depth of 1,760 meters, off Spanish Sahara, are older than those of Site 415, as indicated by such species as *Ticinella roberti, T. primula,* and *T. raynaudi,* together with *Rotalipora subticinensis.*

The poorly preserved, sporadic, planktonic fauna from Site 368, at a water depth of 3,367 meters, on the Cape Verde Rise, includes *Hedbergella delrioensis, H. planispira, H. simplicissima, Heterohelix* sp., and *Guembelitria* sp. and is assigned an Albian to Turonian age by Pflaumann and Krasheninnikov. Site 367, at a water depth of 4,748 meters, in the Cape Verde Basin, again contains faunas that span the Albian–Cenomanian boundary. Core 367-19 through Section 367-21-6 are Cenomanian, on the basis of *Hedbergella brittonensis, Heterohelix moremani,* and *Guembelitria harrisi.* This assemblage is followed in Cores 367-21 and 367-22 by an Albian assemblage that contains *Ticinella primula* and *T. raynaudi* and is therefore older than the basal sediments of Site 415.

There are strong similarities with faunas from Site 137 of Leg 14, described by Beckmann (1972). This site is at a water depth of 5,361 meters, in the Cape Verde–Madeira Abyssal Plain. The interval of Cores 137-8 through Section 137-12-1 contains a middle-Cenomanian fauna typified by *Rotalipora appenninica, R. brotzeni, R. cushmani, R. evoluta, R. greenhornensis, R. balernaensis,* and *R. reicheli.* Sections 137-12-1 through 137-15, CC include *Rotalipora evoluta, R. balernaensis,* and other species that indicate an early-Cenomanian age. Following an interval from Sections 137-16-1 through 137-16-3 which contains questionable *Rotalipora evoluta* and *Praeglobotruncana delrioensis,* the late Albian is recognized in the interval of Section 137-16-3 through sidewall core 137-1, on the basis of *Ticinella raynaudi digitalis, Rotalipora ticinensis, Planomalina buxtorfi, Hedbergella trocoidea, Globigerinelloides breggiensis,* and other species. This sequence, Cores 137-8 through 137-16-3, closely correlates with Cores 415A-8 through 415A-15.

Site 136 of Leg 14 lies north of Madeira in an area of abyssal hills, at a water depth of 4169 meters. A meager and questionable Albian fauna of *Hedbergella amabilis* (= *H. simplicissima*), *H. planispira,* and *Globigerinelloides tururensis* may be comparable to the fauna of the lower cores of Hole 415A.

Finally, Site 120 of Leg 13, at a water depth of 1711 meters, on Gorringe Bank, west of Portugal, contains an Albian fauna (Maync, 1973). The planktonic fauna is limited to a single specimen of *Hedbergella* cf. *H. infracretacea*; the varied benthic assemblage, however, indicates an age somewhat older than that of the basal sediments of Site 415.

SITE 416

Site 416 is in the Moroccan Basin about 2 km west of Site 370. This site was chosen primarily because it was known, after the earlier drilling on Leg 41, that pre-Late Jurassic rocks were within reach. Because Hole 370 had reached a depth of 1176 meters, there was no need at Site 416 for continuous coring above that level. The exact positions of Cores 416A-5 to 416A-9, taken in this discontinuously cored interval, are difficult to determine. This is especially true for Cores 416A-7 and 416A-8, where drilling proceeded with the core barrel in place until the barrel filled or became plugged. As a consequence, the material contained in these cores is a mixture of the sediments within the extended cored interval and cavings from stratigraphically higher units. Coring was continuous from Core 416A-9 to Core 416A-57, shortly after which bottom hole conditions deteriorated and drilling was terminated.

Benthic-species distributions form the basis for the following biostratigraphic determinations and correlations. The identified fauna consists in 54 genera and 172 species (Appendix 3). Of these species, only three of the planktonic genus *Hedbergella* were recovered, seven specimens in all. The remaining 171 species of benthic foraminifers are divided into 122 forms with calcareous tests, 44 agglutinated species, and 5 miliolids. Foraminifer distributions from 141 samples are shown in Table 2. An additional 86 samples examined that were either barren or contained only rare nondiagnostic specimens are listed in Appendix 2.

Biostratigraphy of Hole 416A

Tithonian–Kimmeridgian

Core 416A-51 through Section 416A-57-1 are reddish-brown mudstone with layers of greenish-gray, micritic limestone; these rocks are assigned a Kimmeridgian and Tithonian age. Of particular interest are the occurrences of *Bigenerina jurassica, Reophax helveticus, Epistomina uhligi, Textularia cordiformis, Trocholina conica,* and *Haplophragmoides haeusleri* (Figure 7, Appendix). Specimen preservation in this interval is poor, as it is for most of the samples from Hole 416A; hence, the possibility of reworking cannot be disregarded. Nevertheless, in view of the continuity of faunal distributions and the sporadic influx of the associated shallow-water biogenic material, the writer believes that Hole 416A penetrated Jurassic sediments within this interval. The foraminifers do not indicate the presence of sediments older than Late Jurassic, although the prominent "Blue" reflector, believed to be of Kimmeridgian-Oxfordian age, might lie close beneath the bottom core. The Jurassic-Cretaceous boundary is therefore drawn at the faunal break between Cores 416A-50 and 416A-51, in the knowledge that this placement may be too high by several cores.

Berriasian(?)

A narrow interval of reddish-brown mudstone and greenish-gray, micritic limestone represented by Cores 416A-49 and 416A-50 contains an overlap of species whose ranges include the Upper Jurassic and Lower Cretaceous and species whose ranges begin in the Lower Cretaceous. This assemblage includes *Haplophragmoides concavus, Dentalina communis, Vaginulinopsis matutina, Lagena oxystoma,* and *Pyrulina cylindroides.* A questionable Berriasian age is assigned to this mixed-assemblage interval.

Valanginian

The Valanginian assemblage begins with Core 416A-48 and extends upward through Core 416A-14. Sediments are predominantly terrigenous sandstone, siltstone, and mudstone, with some redeposited calcareous bioclastic material. Cycles of brownish terrigenous beds alternate with greenish-gray, carbonate-rich beds throughout this interval. However, greenish-gray micritic limestones are not found above Core 416A-36. Among the rocks penetrated in Hole 416A, this sequence of rapidly deposited sediments contains the greatest diversity of foraminifers; however, the numbers of specimens remain low, and preservation generally is poor. Of particular interest are the confinement to this interval of *Lenticulina busnardoi* and *Trocholina valdensis* and the first appearance here of species such as *Epistomina anterior, Saracenaria frankei, S. saxonica, Lenticulina ouachensis ouachensis, L. nodosa, Dorothia kummi, D. praehauteriviana, Vaginulina recta, Trocholina infragranulata,* and *Epistomina caracolla* (Figure 7).

Hauterivian

The Valanginian–Hauterivian boundary is placed between Cores 416A-13 and 416A-14, on the basis of the last appearance of *Lenticulina busnardoi,* the limited higher range of *Lagena hauteriviana hauteriviana,* and the first appearance of *Dorothia hauteriviana, Lenticulina ouachensis multicella,* and *Lagena hauteriviana cylindracea.* The Hauterivian assemblage extends from Cores 416A-9 through 416A-13. Sediments consist of cycles of greenish and brownish marlstone, with layers of grayish, fine-grained sandstone that become more common upward to Core 416A-9. Down-hole contamination is believed to be responsible for the presence of three poorly preserved specimens of the Barremian species *Gavelinella barremiana* in Core 12-3 (Figure 7, Appendix 3).

Hauterivian–Barremian(?)

Cores 416A-7 and 416A-8 are difficult to date, owing to problems of down-hole caving and limited core recovery. A Hauterivian to Barremian assemblage, with associated long-ranging species, characterizes this interval. Such species as *Marginulinopsis collignoni, Dorothia hauteriviana, Lenticulina eichenbergi, L. ouachensis multicella,* and *Vaginulinopsis reticulosa* indicate an age no younger than Barremian. Faunas remain sporadic and are characterized by rare, poorly preserved specimens. Sediments, too, resemble those of the underlying cores: cycles of greenish and brownish mudstone and some beds of fine sandstone and siltstone. Because of these similarities and the rare presence of such Barremian species as *Gavelinella barremiana* in Core 416A-8 and *Frondicularia didyma* in Core 416A-7, a questionable Hauterivian-Barremian age is assigned to these cores. However, the composition of the assemblage in-

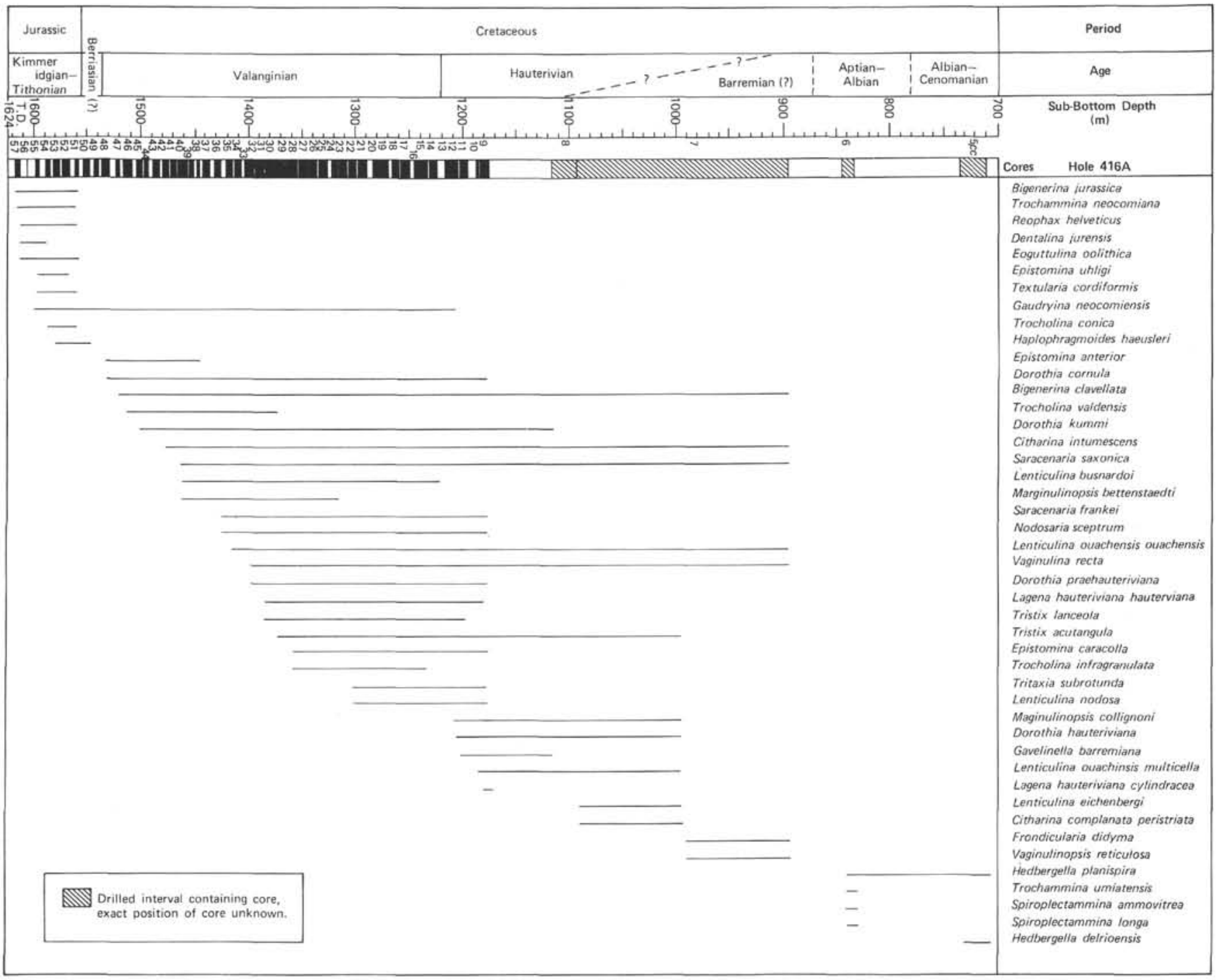


Figure 7. *Stratigraphic distribution of selected benthic species at Site 416.*

dicates that sediments of Barremian age are present within or just above the interval of Core 416A-7.

Aptian-Cenomanian

Core 416A-6 is assigned an Aptian-Albian age on the basis of the confinement to this interval of such species as *Trochammina umiatensis, Spiroplectammina ammovitrea,* and *S. longa.* Rare specimens of the planktonic species *Hedbergella planispira* signify an age no older than early Aptian. Sediments in Core 416A-6 are distinct from those below and consist predominantly of blue-green to olive-black, quartzose mudstone.

Foraminifers in Section 416A-5, CC are limited to six specimens of the planktonic species *Hedbergella delrioensis, H. planispira,* and *H. infracretacea;* these species indicate an Albian-Cenomanian age for this interval. Sediment in the core catcher consists of greenish-black to olive-black mudstone which contains deep-sea benthic foraminifers, fish debris, pyrite, and carbonaceous material. The biotic and lithologic association suggests a correlation of this interval with sediments at Site 415 which contain a similar association (Core 451A-7 and part of Core 415A-8). The correlation implies that Section 416A-5, CC falls within the mid-Cretaceous dissolution facies or barren interval that typically begins in the upper Cenomanian (Sliter, 1976, 1977).

Paleoecology

Depositional Environment

Mesozoic sediments at Site 416 were deposited in a quiet, abyssal environment beneath the CCD, analogous to that for Cretaceous sediments at Site 415. The influx of terrigenous and redeposited shallow-water material into this environment reached a maximum during the late Valanginian, then was reduced greatly during the Aptian-Cenomanian (Figure 8). Deposition of lithologic Unit VII (see site report, this volume) was controlled primarily by distal turbidites, whereas the rapid deposition of Unit VI, though distal, probably took place on the outer edge of a prograding deep-sea fan system. The terrigenous sediments wane in Unit VI and are replaced by hemipelagic sediments and extremely distal turbidites in Unit V that were deposited on an abyssal plain. A deep-sea association of abyssal foraminifers and fish debris continues throughout the Mesozoic; however, it is often diluted and mixed with redeposited material and is hydrodynamically sorted. No radiolarians, diatoms, or holothurian plates were found in the Mesozoic sediments of Hole 416A. Pyrite in Figure 8 indicates pyritized foraminifers, framboids, or rare crystals.

Jurassic sediments (Cores 416A-51 through 416A-57) are dominated by deep-sea foraminifers, with the continued presence of displaced species, fish debris, and carbonaceous material. *Inoceramus* prisms, echinoid fragments, bivalve fragments, calcisphaerulids, and calpionellids are rare, attesting to the distal nature of the turbidite sedimentation.

The Valanginian to Berriasian(?) part of Unit VII (Cores 416A-37 through 416A-50) is characterized by an alternation in the dominance of deep-sea and displaced foraminifers. Fish debris is present in nearly every sample; however, carbonaceous material is here sporadic; ostracodes are still present. *Inoceramus* prisms and echinoid spines increase in abundance, whereas bivalve fragments, miliolids, aptychi, and other components are rare.

The Valanginian interval of Unit VI (Cores 416A-15 through 416A-36) records an increase in the rate of accumulation and a corresponding influx in biogenic material (see site chapter, this volume, for accumulation rates). The magnitude of the change shown in Figure 8 is in part artificial, because the more fossiliferous basal sandstones of the turbidite cycle were sampled more commonly than the brownish mudstones containing the autochthonous deep-sea association. Nevertheless, differences in the biogenic content are apparent between samples from Units VI and VII when comparing samples of similar lithology. Displaced foraminifers now dominate the samples, together with fish debris, fecal pellets, calcisphaerulids, and carbonaceous material. Samples are also typified by *Inoceramus* prisms, echinoid spines, ostracodes, aptychi, miliolids, and glauconite. Calpionellids are sporadic as detrital particles, as are pyritized burrow fillings and *Chondrites*. This evidence of bioturbation is found in the laminated siltstones, fine sandstones, and brownish sandstones, but is not found in the calcareous sandstones.

Cores 416A-7 to 416A-14 of Unit VI record a decrease in shallow-water influence. Samples continue to be dominated by shallow-water foraminifers, fish debris, and carbonaceous material, whereas the other components are sporadic.

Unit V (Cores 416A-5 and 416A-6), of Albian–Cenomanian age, is distinct from the underlying units in its biogenic content. With the exception of Section 416A-6, CC, deep-sea foraminifers dominate the samples. The remaining components include fish debris, pyrite, carbonaceous material, and glauconite, with rare fecal pellets and sponge spicules. This association attests the results of hemipelagic sedimentation and a greatly lessened contribution by extremely distal turbidites.

Effects of Sedimentation

Resedimentation processes exerted a strong effect on the association of biogenic and lithologic components at Site 416, as at Site 415. Differences in these associations provide evidence of both the processes involved and the environmental distribution of the enclosed fauna and flora. Two examples are shown in Figure 9; one illustrating differences in components between two turbidite cycles, the other between adjacent samples in a single cycle differentiated primarily by grain size.

The coarse basal sandstone from Section 416A-9-3 contains shallow-water foraminifers associated with heavier debris, such as fish remains, fecal pellets, pyritized foraminifers and framboids, bivalve fragments, and aptychi. Included in this mixture is lighter debris, such as ostracodes, miliolids, and carbonaceous material, as well as elements of the autochthonous assemblage such as fish debris. Deep-sea foraminifers are no doubt present, but much diluted and extremely rare in the mixed association.

Deep-sea foraminifers appear in the overlying laminated siltstone along with more-buoyant debris, such as small *Inoceramus* prisms, ostracodes, carbonaceous material, calcisphaerulids, and large mica flakes. The deep fauna and lightweight material is even more obvious in the upper unit of the underlying turbidite cycle. Resedimentation processes, however, are still active, as evidenced by displaced foraminifers, fecal pellets, and ostracodes.

The second example, from Section 416A-28-4, contains a redeposited assemblage with few deep-sea elements. Still, the fine sandstone shows the expected concentration of more-buoyant elements, such as ostracodes, carbonaceous material, and calcisphaerulids.

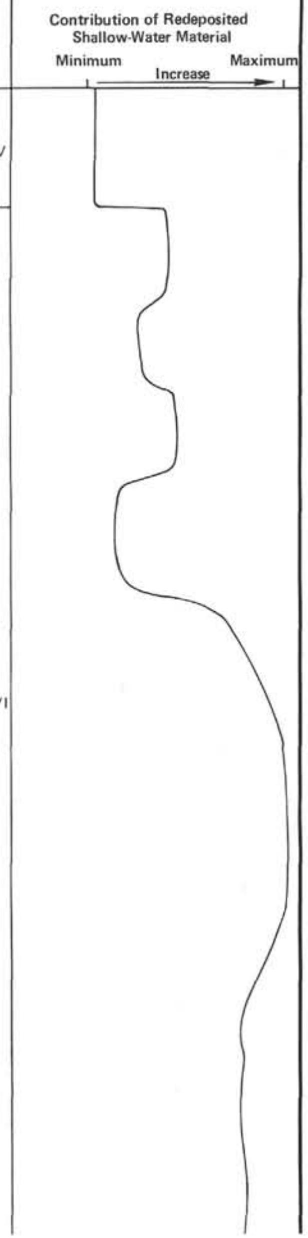
Faunal Comparisons

Jurassic sediments from Site 416 correlate in part with sediments from Hole 367 of Leg 41, drilled at a water depth of 4,748 meters, in the Cape Verde Basin; these sediments range in age from Oxfordian to Kimmeridgian, and possibly are also younger. Foraminifer assemblages described by Kuznetsova and Seibold (1978) show many similarities in content, abundance, and preservation; particularly significant are the dominance by the Spirillinacea, the composition of the agglutinated assemblage, and the diversity of the nodosariids. In contrast, radiolarians that were found in most samples at Site 367 are missing at Site 416.

A strong correlation is also made with the Valanginian at Sites 367 and 370. The fauna described from Sections 370-38, CC, through 370-51-2 by Kuznetsova (Kuznetsova and Seibold, 1978) is representative of the late Valanginian of Site 416 above Core 416-35. This correlation is based on the presence in both intervals of *Dorothia praehauteriviana, Lenticulina ouachensis,* and *L. nodosa,* among other species. Many similarities in composition, diversity, and preservation exist between these faunas.

At Site 120 of Leg 13 about 90 meters of Barremian to Albian sediments were recovered from Gorringe

Period	Age	Lithology	Preservation	Dissolution	Sample (interval in cm)	Deep-sea Foraminifers	Displaced Foraminifers	Fish Debris	Fecal Pellets	Pyrite	Inoceramus Prisms	Ostracodes	Echinoid Fragments	Bivalve Fragments	Aptychi	Miliolids	Sponge Spicules	Carbonaceous Material	Calcisphaerulids	Large Mica Flakes	Calpionellids	Glauconite	Lithologic Units
Cretaceous	Albian–Cenomanian	Greenish black mudstone	P	4	416-5,CC	•		◉		◉								●					
	Aptian–Albian	Olive green siltstone	P	4	416-61, 43-45	●		●		●								◑				○	Unit V
		Olive green mudstone	P	4	6-2, 55-57	●		●	○	●												○	
		Laminated olive green mudstone	P	4	6-3, 93-95	●		◉		●								●				○	
		Burrowed olive green mudstone	P	4	6-3, 136-138	●		◑		B●								○				○	
		Dark green mudstone	P	4	6-4, 24-26	●		◉		●							○	○				○	
		Dark green mudstone	P	4	6,CC		•	◉										○				◉	
	Hauterivian–Barremian (?)	Laminated brown mudstone	P	4	416-7-1, 49-51	•	•	◉	◑	◑	○		○					◑		◉		○	Unit VI
		Dark green fine sandstone	P	4	7-1, 119-121	●	•	◉	○	○		○						○					
		Laminated brown siltstone.	P	4	7-3, 33-35	•	●	◉	◉	B◉		○	○	○	○			○				○	
		Brown fine sandstone	P	4	7-3, 125-127		●	◉	◉			○	○					◉				○	
	Hauterivian	Laminated green siltstone	P	4	86, 145-147	•	●	◉		◑		○	○					◉	◑				
		Light green sandstone	P	4	9-3, 98-102	•	●	◑	◑	◑	○	○	○	◑	○	○		○	◑	○		○	
		Light green mudstone	P	4	9-5, 93-95	•	•	◉	○	◉								○	○				
		Light brown siltstone	P	4	10-1, 141-143	•	•	◉		◉													
		Laminated brown siltstone	P	4	10-2. 0-2	•		◉										○					
		Brown coarse sandstone	P	4	10-2, 71-72		•	◉	○	○			○		○			◉				○	
		Laminated brown siltstone	P	4	11-2, 110-112		•	◉		◑								○	○				
		Light green siltstone	P	4	11-5, 45-46		●	○	◉			○	○	○	○	○		◑	○				
		Laminated brown siltstone	P	4	11-6, 61-63		•	◉	○	B○	○	○		○	○			◑	○				
		Laminated brown siltstone	P	4	12-2, 144-146		●	◉	◑		○	○	○	○	○	○		◑	○	◉		○	
		Laminated brown mudstone	P	4	12-3, 17-19	•	●	◉		B◑		○						○					
		Laminated brown fine sandstone	P	4	12-4, 118-120	●	•	◑	○	B●		○										○	
		Laminated brown siltstone	P	4	12-5, 30-32		●	◉	◉	◉	○	○	○	○	○	○		○					
		Laminated brown siltstone	P	4	13-2, 118-120	•	●	◉		○													
	Valanginian	Brown siltstone	P	4	416-14-1, 69-71	●	•	◑	◉	◑													
		Light green siltstone	P	4	14-1, 119-120	•	●	○										●	○				
		Brown mudstone	P	4	14-2, 114-116	•	●	●	○	B●	○			○	○							○	
		Light green siltstone	P	4	14-2, 116-118	•	●	◉	○	B○		○		○	○			○				○	
		Brown fine sandstone	P	4	14-4, 51-53	●	•	◉		B◉			○										
		Light green siltstone	P	4	14-5, 137-139	●	•	●	◑	B○	○			○	○								
		Brown fine sandstone	P	4	15-1, 38-39	•	●	◑	◉		○	○	○	○	○				○			○	
		Laminated brown mudstone	P	4	15-5, 139-141		•	◑	◉		○	○	◉	○	○	○		○	○				
		Light green sandstone	P	4	15-6, 74-76		•	◉	◉		○			○	○			◑	○	◉			
		Brown mudstone	P	4	16-2, 66-68	•	•	●		B○		○		○	○			○					
		Laminated brown siltstone	P	4	17-3, 12-15		•	◑	◉	○		○	○	◉	○			○	○				
		Laminated brown mudstone	P	4	17,CC		•	◉	◉		○	○	○									◉	
		Laminated dark green siltstone	P	4	18-1, 66-68		•	◉	◉	◑		○			○	○		○	○				
		Graded brown siltstone	P	4	19-2, 111-113		•	●	○		○	○	○		○	○		◉		○		○	
		Laminated brown siltstone	P	4	20-1, 11-12		●	◉	○		○	○	○	○	○	○		○	○			○	
		Laminated gray siltstone	P	4	21-5, 117-119	•	●	◉	○	B◑		○			○			○	○				
		Light gray coarse sandstone	P	4	22-3, 108-109		●	◉	◉	○	◉	○	◉		◉	○		○	○			○	
		Light gray coarse sandstone	P	4	22-4, 119-121		●	◑	◉	○	○	○	○	○	○			◉	○			○	
		Laminated calcareous sandstone	P	4	23-5, 9-11		•	●	◑		○	○	○	○	○	○		○	○			○	
		Light gray coarse sandstone	P	4	23-5, 59-60		●	●	◑		◉	○	○	◉	○	○		◑	○	○		○	
		Light gray siltstone	P	4	24-3, 36-38		•	●	◉	○	◉	○	○	◉	○			◉	○	○		○	
		Light brown siltstone	P	4	25-1, 6-7		•	◉	○			○	○			○		○	◉			○	
		Laminated fine sandstone	P	4	25-3, 51-52	•	•	◑		B○	○	○	○									○	
		Laminated fine sandstone	P	4	25-4, 125-127	•	•	◉	○	B◉	○	○		○	○	○			○		○		
		Laminated calcareous sandstone	P	4	26-1, 36-38	•	●	◑	◉		◉	◉	○		○	○		○	○			○	
		Light green sandstone	P	4	26-4, 11-13	•	•	○			◉		○			○		◑					
		Light green fine sandstone	P	4	27-1, 44-46		•	◉	○			○						●		●			
		Light green coarse sandstone	P	4	27-4, 135-137		•	◉	○	○	○	○	○	○	○			○				○	
		Laminated light green sandstone	P	4	28-1, 17-19		•	◉	○	◉		○	○	○	○			◑	○				
		Light green fine sandstone	P	4	28-2, 0-2	•	•	◑	◉			○	○		○	○		◑	◑			○	
		Light green sandstone	P	4	28-4, 11-13		•	◉	◉	○		◉	○		○	○		○	◑			◑	
		Laminated brown mudstone	P	4	28-5, 123-125	•	•	◑	○	B○	○	○	○		○	○		◉					
		Laminated brown mudstone	P	4	28-6, 149-151	•	•	○				○				○		◑	◉				
		Laminated brown mudstone	P	4	28,CC	•	•	◑				○	○										
		Laminated green calcareous sandstone	P	4	29-3, 59-60		●	◉	○			○	○	○	○	○		○	◉		○	○	
		Burrowed brown mudstone	P	4	29-4, 26-28	•	•	◉		B◉	○	○	○			○			◑				
		Burrowed brown mudstone	P	4	29-5, 3-5	•	●	◉	○	B●	○								◉		○	○	
		Light green calcareous sandstone	P	4	29-6, 4-5	•	●	◉	○		○	○	○					○	◑			○	
		Light green calcareous sandstone	P	4	30-2, 58-60	•	•	◑	○			○		○	○	○		○	◑			○	
		Light green calcareous sandstone	P	4	30-3, 143-144		•	◑	○			○	○	○	○	○			◑		○	○	
		Light green calcareous sandstone	P	4	30-5, 36-38		•	◉	○			○	○		○	○						○	
		Light green sandy mudstone	P	4	31-1, 16-18		•	◉	○			○	○	○	○	○		○	◑			○	
		Light green calcareous sandstone	P	4	31-3, 7-9		●	◉	○			○	○	○	○	○			◑			○	
		Light green fine sandstone	P	4	31-4, 124-126	•	•	◉	○				○			○			●				
		Light green fine sandstone	P	4	31-5, 137-140	•	●	◉	○	B○		○	○	○	○	○			◑				
		Light green fine sandstone	P	4	31-6, 99-100	•	•	◑	○			○			○	○			●				
		Laminated gray green mudstone	P	4	32-3, 83-85	•	•	◑				○	○	○	○	○		○	◑				



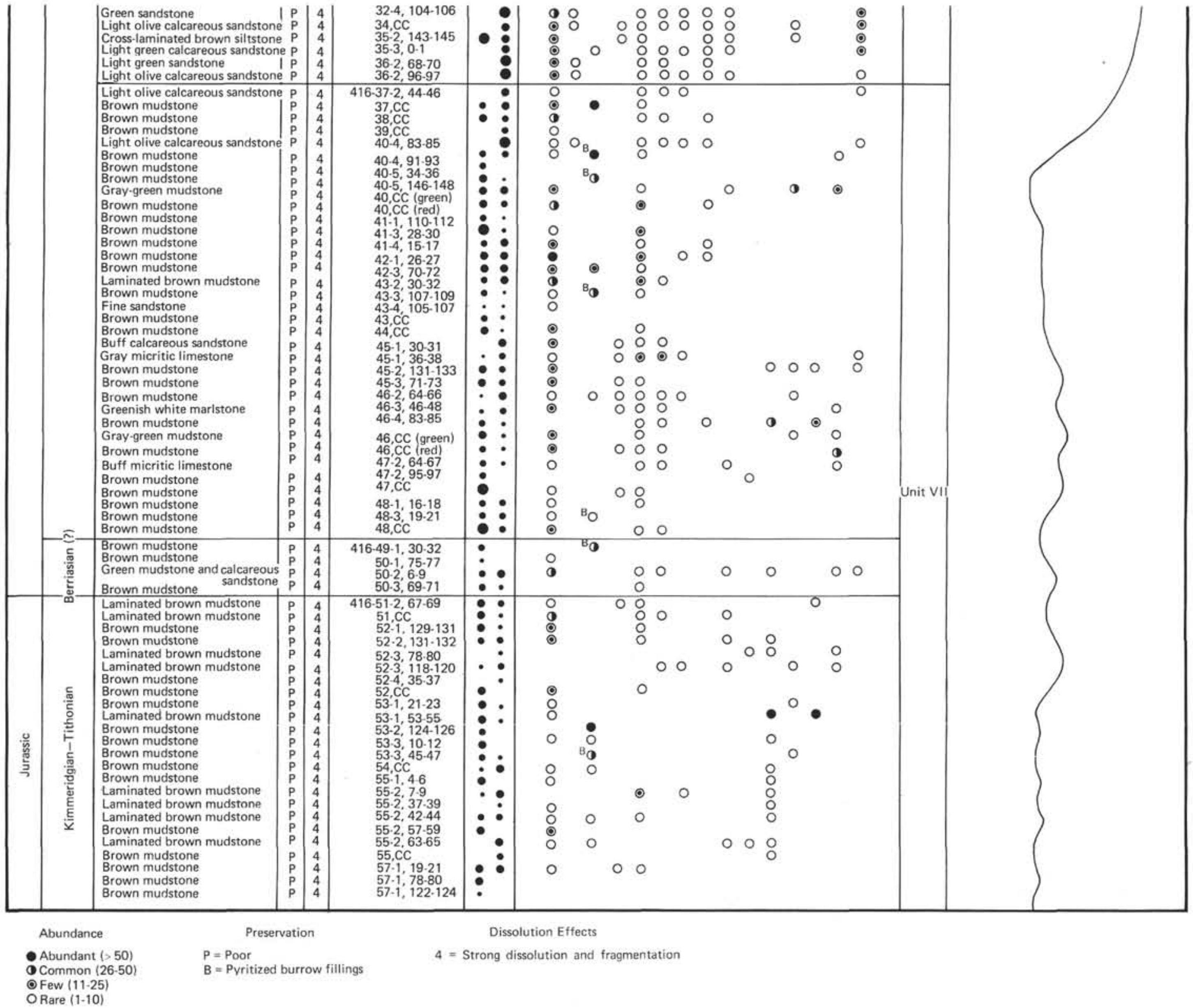


Figure 8. *Distribution of selected biogenic and lithologic components at Site 416. Relative abundance of deep-sea and displaced foraminifers shown by size of symbol. Abundance of other biogenic and lithologic components based on total assemblage greater than 63 µm.*

Hole 416A Lithology	Preservation	Dissolution	Sample (interval in cm)		Deep-Sea Foraminifers	Displaced Foraminifers	Other Components: Fish Debris	Fecal Pellets	Pyrite	Inoceramus Prisms	Ostracodes	Echinoid Fragments	Bivalve Fragments	Aptychi	Miliolids	Carbonaceous Material	Calcisphaerulids	Large Mica Flakes	Glauconite
Laminated brown siltstone	P	4	9-3	98-99	•	●	○	⊙	○	○	○	○		○		○	⊙	○	○
Brown coarse sandstone	P	4	9-3	99-100		●	⊙	◑	◑		○	○	◑	○	○	○			
Olive green mudstone	P	4	9-3	100-102	●	●	◑	○	B⊙		○					○	◑		
Light green fine sandstone	P	4	28-4	11-12		●	⊙	○			⊙	○				○	◑		⊙
Light green calcareous sandstone	P	4	28-4	12-13		●	⊙	⊙	○			○		○	○		○		◑

ABUNDANCE OF BIOGENIC AND LITHOLOGIC COMPONENTS

- ● Abundant (>50)
- ◑ Common (26-50)
- ⊙ Few (11-25)
- ○ Rare (1-10)

PRESERVATION

P = Poor
B = Pyritized burrow fillings

DISSOLUTION EFFECTS

4 = Strong dissolution and fragmentation

Figure 9. *Distribution of selected biogenic and lithologic components in separate units of turbidite cycles at Site 416. Relative abundance of deep-sea and displaced foraminifers shown by size of symbol. Abundance of other biogenic and lithologic components based on total assemblage greater than 63 μm. Dashed line represents boundary between turbidite cycles.*

Bank, off Portugal. Many of the foraminifers from this interval, described by Maync (1973) are found at Site 416. These faunal similarities indicate an approximate correlation between Cores 120-2 through 120-7 and Section 416A-5, CC through Core 416A-8. Although most of the species are long ranging or of uncertain stratigraphic value, the presence of *Lenticulina ouachensis ouachensis, L. ouachensis multicella, L. praegaultina, Marssonella hauteriviana (= Dorothia hauteriviana),* and *Hedbergella* sp. cf. *H. infracretacea* provides a broad stratigraphic framework within which to correlate.

In the western Atlantic, sediments penetrated in Holes 100, 101, and 105 of Leg 11 show close correspondence to those of Hole 416A, in both foraminifer assemblage and depositional environment. At Site 100, in the Blake-Bahama Abyssal Plain, several species from the Late Jurassic sequence described by Luterbacher (1972) correspond to species in the Hole 416A assemblage, notably *Bigenerina jurassica, Trocholina transversarii (= Trocholina conica),* and species of *Dentalina,* among others. The Site 100 section thus correlates in part with Cores 416A-51 through 416A-57 and possibly with sediment as young as Core 416A-49.

Neocomian sediments of Site 101, adjacent to Site 100, contain a low-diversity fauna that includes *Dorothia praehauteriviana.* This sequence correlates with the upper-Valanginian sediments of Site 416.

The most-complete correlations in the western Atlantic are made with sediments penetrated in Hole 105, on the Hatteras Abyssal Plain. Foraminifers described by Luterbacher (1972) range in age from Kimmeridgian–Oxfordian(?) to late Albian or early Cenomanian. Comparison of the faunal lists shows at least 27 species in common with the fauna of Hole 416, in addition to strong similarities in generic composition, foraminiferal abundance, and preservation. Species which are present in sediments of Holes 105 and 416 include *Reophax helveticus, Dentalina jurensis,* and *Brotzenia* sp. aff. *B. uhligi (= Epistomina uhligi)* in the Late Jurassic sequence; *Dorothia praehauteriviana, Lenticulina nodosa,* and *L. subalata* in the Valanginian; and *Lenticulina ouachensis ouachensis* and *L. ouachensis multicella* in beds referred to the upper Valanginian and Hauterivian in Hole 105.

Depositional environments of the western Atlantic sites are bathyal to deep bathyal, but probably not abyssal, according to Luterbacher (1972). The present study supports these earlier interpretations. Although it is difficult at this time to make exact comparisons between the western sites and Site 416, several differences do exist. Sediments from Jurassic and Neocomian sections of the western sites are richer in argillaceous limestone and calcareous mudstone. Radiolarians are present in most of the western samples, but are missing at Site 416. Foraminifer assemblages from the Jurassic of Hole 105 are enriched in miliolids and other shallow-water species. These differences may indicate somewhat shallower water depths for the western sites, although the evidence is far from conclusive. Upwelling along the eastern margin of the Atlantic off the African Coast during the Mesozoic, a not-improbable occurrence, presumably would raise the level of red-mudstone deposition to depths shallower than those at Site 105. In addition, the enrichment in shallow-water species at Site 105 could plausibly reflect the effectiveness of traction flows and bottom currents in compounding the hazards of paleoenvironmental interpretation.

BATHYMETRY OF JURASSIC AND EARLY CRETACEOUS FORAMINIFERS

Two foraminiferal assemblages are clearly distinguished in the Upper Jurassic and Neocomian sediments of Hole 416A: a deep-sea assemblage and a neritic assemblage. What remain to be defined are (1) the water depths of the deep-sea assemblage and (2) which foraminifers represent slope environments. Some preliminary answers to these questions can be made on the basis of present faunal distributions. The deep-sea assemblage is believed to represent lower-bathyal to abyssal water depths of 2000 meters or more. Several lines of evidence support this hypothesis: the relationship of the Site 416 fauna to other faunas, notably those of Leg 11; the lithology; and the tectonic history of the region since the opening of the North Atlantic. The strongest support, however, comes from the fauna itself and its similarity to assemblages in deep-sea middle-Cretaceous sediments such as those of Hole 415A. In these Albian and Cenomanian deposits, a distinct differentiation of shelf, slope, and deep-water assemblages provides a basis for interpretation of the bathymetric range of the deep-water assemblages. The foraminifers that constitute these deep-water assemblages are nearly identical generically — and often specifically to those from the Upper Jurassic and Lower Cretaceous at Site 416. The two assemblages contain such genera as *Bigenerina, Glomospira, Glomospirella, Haplophragmoides, Hippocrepina, Hyperammina, Rhizammina, Lituotuba, Psammosphaera, Recurvoides, Reophax, Saccammina,* and *Spiroplectammina.* On the basis of this correspondence, the bathymetric range of the Late Jurassic and Early Cretaceous assemblages is assumed to be similar to that of the middle Cretaceous.

Jurassic and Neocomian faunal assemblages of the continental slopes are more difficult to interpret. Certainly, neritic assemblages are well known from various latitudes, as noted for the Jurassic by Gordon (1970). These assemblages are rich in nodosariids, polymorphinids, epistominids, and miliolids such as *Ophthalmidium* and *Spiroloculina.* Agglutinated species are dominated by forms with simple walls in high latitudes and by those with complex internal structures in low latitudes. Slope fauna assemblages apparently were similar to those of shelf environments. It is this similarity, compounded by a lack of publication on foraminifers from slope environments of the Jurassic through the Neocomian, that remains the primary obstacle to interpretation. However, some information, such as the paper by Farinacci (1965) on bathyal foraminifers from Upper Jurassic marl and limestone of the central Apennines, does exist. This fauna is dominated by *Spirillina, Turrispirillina,* and *Lenticulina;* the remaining species belong to the Nodosariacea. Notably missing are agglutinated forms and species of *Frondicularia, Saracenaria,* and *Epistomina.*

At Site 416, foraminifers from slope environments are most apparent in the green siltstones of Neocomian age. These siltstones, which overlie sandstones at the bases of turbidite cycles, presumably represent a mixture of materials incorporated during sediment transport. The slope species are more easily observed, owing to the lack of dilution by coarser shelf debris that is associated with the sandstones. Elements of the slope assemblage are recognized by comparison of faunal distribution (Appendix 3) and lithology (Figure 8); faunal generalizations are made for each major lithology by identifying the dominant species in each sample and subsequently ranking them from most to least common according to lithology. Accordingly, the brown mudstones are dominated by *Hyperammina gaultina,* followed by *Trochammina quinqueloba, Glomospirella gaultina, Rhizammina indivisa, Haplophragmoides concavus, Dentalina communis,* and so on. For the coarse, commonly calcareous sandstones, the dominant species is *Spirillina minima,* followed by *S. tenuissima, Dentalina communis, Lenticulina muensteri, Ophthalmidium* spp., *Lenticulina subalata, Trocholina infragranulata,* and others. In contrast, the green siltstones are dominated by *Lenticulina muensteri, Spirillina tenuissima, Dentalina communis, Dorothia hauteriviana, Hyperammina gaultina,* and others. Because of these correlations, slope assemblages at Site 416 are believed to include such species as *Dentalina communis, Lenticulina subalata, L. praegaultina, L. muensteri, Astacolus incurvatus, Dorothia hauteriviana, D. kummi, D. filiformis, Textularia cordiformis, Spirillina tenuissima,* and *Pseudonodosaria humilis.* Of course, resedimentation processes have exerted a strong influence on the faunal composition of each lithology; nevertheless, some faunal differences, which are believed to reflect original environments of deposition, are apparent.

The low-diversity Jurassic and Neocomian slope faunas indicate weak stratification of the middle-depth waters in the North Atlantic, at least to the CCD. In fact, a well-defined slope assemblage does not appear until the middle Cretaceous with the evolution of such characteristic genera as *Globorotalites, Neobulimina, Eouvigerina, Pyramidina,* and *Quadrimorphina* (Sliter, 1972). It is believed that the middle-Cretaceous niche partitioning of slope environments was caused by intensified stratification of middle-depth waters. Certainly the geotectonic evolution of the North Atlantic exerted a strong influence on biotic evolution. Changes in the composition of foraminiferal assemblages from slope environments appear to have begun during the Barremian (between 120 and 115 Ma). By Aptian or Albian time (around 110 Ma), slope faunas were well defined. These faunal changes parallel several events that took place in the evolution of the North Atlantic. According to the reconstructions of Sclater and others (1977), the

North Atlantic was probably opened to surface flow from the Tethys Sea about 150 Ma. Exchange with the Pacific was likely, because the gap between the Bahamas platform and the Guinea nose is large. Whether this exchange involved shallow waters only or mid-depth and deep water must have depended on the configuration of the still poorly understood Caribbean island-arc system. By 110 Ma, both deep and shallow waters could have entered the North Atlantic from the Tethys Sea; however, deep flow from the Pacific is problematical. Between 110 and 95 Ma, it is likely that both deep and shallow waters entered from the Tethys Sea, but exchange with the Pacific is still problematical. Despite these uncertainties, changes that appear in the Barremian and Albian slope faunas reflect changes in middle-depth waters of the world's oceans at a time when exchange between the North Atlantic, the Tethys Sea, and the Pacific was established.

TAXONOMIC NOTES

Original designations of the species identified in samples from Leg 50 are listed in Appendix 1.

Rhizammina indivisa Brady
(Plate 1, Figure 1)

Fragments of *Rhizammina* are differentiated from those of *Hyperammina gaultina* ten Dam (Plate 1, Figures 4–6) by their larger size, coarser agglutinated material, and reduction in cement that produces a rougher surface. None of the fragments so identified have the bulbous proloculus that identifies the genus *Hyperammina.*

Glomospirella gaultina (Berthelin)
(Plate 1, Figures 11–13)

Glomospirella is distinguished from *Ammodiscus* by the initial irregular coil and later common overlapping coiling pattern. Specimens from the late-Valanginian samples of Site 416 sometimes develop a distinct neck and occasional nodes on the outer periphery, as shown in Figure 13. Although these specimens may prove to represent a distinct taxon, they are included here in the present species.

Reophax sp.

Several small, poorly preserved specimens with coarse wall material and indistinct sutures were found in Sample 416A-55-1, 4–6 cm. They most clearly resemble *Reophax multilocularis,* but differ in the lack of chamber differentiation as illustrated by Haeusler (1890). The specimens are 0.7 mm wide and up to 0.3 mm in length.

Ammobaculites euides Loeblich and Tappan
(Plate 2, Figures 10–12)

Considerable variation in test length–width ratios and prominence of the initial coil is found in intergrading populations at Site 416, as shown in Figures 10–12. Typically the species is recognized by the diameter of the initial coil, which generally is greater than in the rectilinear portion, by distinct sutures, and by a lobate periphery.

Ammobaculites irregularis (Gümbel)
(Plate 2, Figures 13–14)

Specimens referred to this variable species are characterized by a small initial coil, gradually flowing rectilinear portion of the test, indistinct sutures, and smooth to gently lobate periphery. The wall is finely agglutinated, and specimens are commonly compressed.

Spiroplectammina sp. cf. *S. obscura* Said and Barakat

A single poorly preserved specimen in Sample 416A-40-4, 83–85 cm is tentatively referred to this Cretaceous species. The test is broadly flaring, rounded in cross section, with indistinct chambers and initial coil. Length is 0.3 mm, width 0.2 mm.

Bigenerina clavellata Loeblich and Tappan
(Plate 3, Figures 6–7)

This species is recognized by the reduced initial, biserial portion of the test, and by globular chambers that increase rapidly in size, causing the rectilinear portion of the test to flare.

Bigenerina jurassica (Haeusler)
(Plate 3, Figures 8–10)

Jurassic specimens referred to this species agree closely with the original description of Haeusler (1890). Specimens show considerable variation in test dimensions, but differ from *Bigenerina clavellata* in the less-flaring test, less-globular chambers, and more distinct early, biserial portion of the test. Sides of elongate specimens are nearly parallel and tests are compressed and commonly deformed.

Dorothia hauteriviana (Moullade)
(Plate 4, Figure 19; Plate 5, Figures 1–4)

An elongate-conical test with flush sutures and flattened apertural face characterizes this species. Wall material in the present specimens is composed of coccolith debris, with minor amounts of silica, iron, and aluminum, as shown in Plate 5, Figure 2. An occasional specimen shows a rounded outline and slightly depressed sutures (Plate 5, Figure 4). For the present, these individuals are included in the present species.

Dorothia praehauteriviana Dieni and Massari
(Plate 5, Figures 7–9)

This species is differentiated from *Dorothia hauteriviana* by its less-tapered initial portion and less-flaring test. Sutures are slightly depressed, the periphery is gently lobate, and the apertural face is nearly horizontal. Thus, the species agrees closely with the original description of Dieni and Massari (1966). At Site 416, *D. praehauteriviana* ranges from the upper Valanginian to lower Hauterivian, where it overlaps with the Hauterivian–Barremian species *D. hauteriviana.*

Nodosaria sp. cf. *N. chapmani* Tappan
(Plate 5, Figure 19)

The illustrated specimen is referred to this species, although it differs somewhat in having less-elongate chambers and more-numerous longitudinal costae.

Astacolus incurvatus (Reuss)
(Plate 6, Figures 11–12)

Specimens with an elongate, compressed test, having a pointed or rounded initial portion of the test with elongate, narrow, oblique chambers are included in this species. Considerable variation is noted between the two specimens figured on Plate 6.

Dentalina nana Reuss
(Plate 7, Figures 5–6)

This is a variable species, as shown on Plate 7. The form shown in Figure 6 more closely typifies the species; it has a gradually tapering test and gradually enlarging chambers, of which the final one tends to become inflated.

Lenticulina praegaultina Bartenstein, Bettenstaedt, and Bolli
(Plate 10, Figures 5–7, 10)

Specimens referred to this species have a distinct keel, average 10 chambers in the last-formed whorl, and have flush to slightly raised sutures, as illustrated on Plate 10. The species typically ranges from the Hauterivian to the Barremian; however, specimens at Site 416 were found in upper-Valanginian and Hauterivian sediments.

Lenticulina subalata (Reuss)
(Plate 10, Figures 8–9, 11–16)

A number of aberrant specimens of this species were found in Sample 416A-22-3, 108–109 cm, as shown on Plate 10. The species is typically represented by specimens with raised sutures, seven to nine chambers, and an angled to keeled periphery.

Lenticulina sp. A
(Plate 11, Figures 6–8)

Two specimens from the upper Valanginian of Site 416 illustrated on Plate 11 have a globose test with a rounded periphery, four globular chambers in the final whorl, and slightly depressed sutures.

Lenticulina sp. B
(Plate 11, Figure 9)

Several specimens from the Hauterivian section of Site 416 have a compressed test, 10 to 11 chambers in the final whorl, and distinctly raised, limbate sutures between chambers.

Lenticulina sp. C
(Plate 11, Figures 10–11)

A single specimen from the Hauterivian of Site 416 with a compressed test, evolute coiling pattern, 10 chambers in the final whorl, and slightly depressed sutures somewhat resembles *Lenticulina* sp. 2 of Bartenstein, Battenstaedt, and Bolli (1957) from the Barremian of Trinidad.

Vaginulinopsis sp. A
(Plate 13, Figure 6)

A single poorly preserved specimen from the lower Valanginian at Site 416 has an elongate test with a triangular section, numerous chambers that increase gradually in size, and oblique, flush sutures.

Vaginulinopsis sp. B
(Plate 13, Figures 7–8)

Several typical specimens from the lower Valanginian of Site 416 are shown on Plate 13. The test is much compressed, with an initial coiled portion followed by chambers that increase in width more rapidly than in height, producing the characteristic shape with overhanging chambers.

Vaginulinopsis sp. C
(Plate 13, Figure 9)

This species is represented by a single poorly preserved specimen from the lower Valanginian of Site 416. The test is elongate and gently arcuate, with strongly oblique sutures and some evidence of longitudinal costae. These characteristics are similar to those of the specimen illustrated as *Vaginulina* sp. 3 by Bartenstein and Brand (1951).

Vaginulinopsis sp. D
(Plate 13, Figure 10)

A single specimen from the upper Valanginian of Site 416 has an arcuate test that is distinctly triangular in cross section, numerous chambers that increase gradually in size, and slightly depressed sutures.

Lingulina sp.
(Plate 13, Figure 16)

Several specimens of this species were found in the Valanginian of Site 416. These are conical, with a globular final chamber, indistinct sutures, and a terminal, elongate, slit-like aperture. These specimens appear to be related to the specimen illustrated by Bartenstein and Brand (1951) as *Lingulina* sp. 3.

Tristix lanceola Sliter, n. sp.
(Plate 14, Figures 10–18)

Test free, uniserial, flaring in outline, unevenly quadrate in section, so that width is greater than thickness. Chambers 7 to 8 arcuate, increasing gradually in height, final chamber commonly narrower than maximum width of test. Sutures distinct, slightly depressed, gently curved. Wall calcareous, finely perforate. Aperture terminal, consisting of an irregular series of small pores elongate in plane of compression.

Dimensions of holotype: Length 180 μm, width 120 μm. (Paratypes range from 165 to 180 μm in length.)

Locality: Holotype from DSDP Leg 50, Site 416, Sample 416A-17-3, 12–15 cm. Paratypes from Sample 416A-12-5, 30–35 cm., 416A-17-3, 12–15 cm., and 416A-30-3, 143–144 cm. Moroccan Basin, North Atlantic Ocean (lat. 32°50.18′ N., long. 10°48.06′W.).

Stratigraphic range: Upper Valanginian and lower Hauterivian.

Remarks: This small species of characteristic quadrate shape is a rare but consistent component of the Valanginian and Hauterivian sediments at Site 416. Morphologic variations are minor and consist of slight changes in the degree of test flare and shape of the final chamber.

Holotype (USNM 252178) and paratypes (USNM 252179, 252180, 252498) are deposited in the U.S. National Museum of Natural History, Washington, D.C.

Schackoina multispinata (Cushman and Wickenden)
(Plate 17, Figures 5–7, 9)

Specimens included here in *multispinata* include both the *bicornis* and *moliniensis* forms of Reichel (1948), as shown in Figures 7 and 9. These larger specimens were found at Site 415 in Section 415A -12, CC, to Core 415A-15, or from upper Albian to middle Cenomanian. They are included in the species because they intergrade with smaller specimens that correspond to the typical description (Figures 5 and 6).

Hedbergella sp. cf. *H. delrioensis* (Carsey)
(Plate 17, Figures 13–16)

Numerous specimens from Site 415, Cores 415A-12 to 415A-15 differ from the original concept of *Hedbergella delrioensis* and from the neotype selected by Longoria (1974) in having 5 to 7 chambers, less-globular chambers, a slightly convex to flattened spiral side, a smaller umbilicus, and a more spinose surface, as shown on Plate 17. They most closely resemble the *H.* sp. aff. *delrioensis* of Krasheninnikov (1974), from Albian sediments in the eastern Indian Ocean. The Leg 50 material may be related to *H. pseudotrocoidea* Michael from the Albian of Texas, but dissimilarities are apparent in the size of the final chamber, the amount of chamber inflation, and the compression of the test. Similar variations distinguish the specimens from the Aptian and Albian species *H. gorbachikae* Longoria.

Hedbergella sp.
(Plate 18, Figures 11–14)

Several specimens from Core 415A-11 are distinguished by their small tests, globular chambers that increase rapidly in size, small umbilicus, and unusual, oblique coiling pattern. The specimens are unrelated to other members of the population and are restricted to the middle-Cenomanian *Rotalipora cushmani* Zone.

Genus *Trocholina* Paalzow

Three species of *Trocholina* are recognized in the Leg 50 material. Jurassic specimens with transverse grooves of the ventral surface and few umbilical nodes are placed in *Trocholina conica* (Plate 20, Figures 13–14). This concept includes *Trocholina transversarii* Paalzow in synonymy, and the specimens are identical to those illustrated by Winter (1970). Early-Valanginian specimens with a flattened ventral surface, conical shape, and numerous umbilical nodes are referred to *Trocholina valdensis* (Plate 20, Figures 15–16; Plate 21, Figures 1–3). Late-Valanginian specimens are placed in *Trocholina infragranulata* (Plate 20, Figures 7–12). These specimens have more-numerous umbilical nodes, a less-conical shape, and a more-distinct final whorl on the ventral surface.

Epistomina anterior Bartenstein and Brand
(Plate 22, Figures 1–6)

The present specimens from the Valanginian of Site 416 agree with the original description. These differ from the Jurassic species *Epistomina uhligi* (Plate 22, Figures 11, 13–15) in having a more-angled periphery and being more evenly biconvex, with a more-prominent umbo on the umbilical side.

Epistomina sp.
(Plate 22, Figures 12, 16)

A single specimen from Sample 416A-40-5, 34–36 cm is referred to *Epistomina.* The plano-convex shape, carinate periphery, and raised sutures on the umbilical side are distinctive.

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PLATE 1

Figure 1	*Rhizammina indivisa* Brady. Sample 416A-51-1, 19-21 cm. Scale 150 μm.
Figures 2, 3	*Hippocrepina depressa* Vasicek. 2. Sample 416A-48, CC. Scale 100 μm. 3. Sample 416A-51, CC. Scale 50 μm.
Figures 4-6	*Hyperammina gaultina* ten Dam. 4, 5. Sample 416A-55-1, 4-6 cm. Scale 100 μm. 6. Sample 416A-55-2, 42-44 cm. Initial bulbous portion of test. Scale 30 μm.
Figure 7	*Saccammina lathrami* Tappan. Sample 416A-6-2, 55-57 cm. Scale 50 μm.
Figure 8	*Ammodiscus rotalarius* Loeblich and Tappan. Sample 416A-6-4, 24-26 cm. Scale 100 μm.
Figures 9, 10	*Glomospira variabilis* (Kübler and Swingli). Sample 416A-55-1, 4-6 cm. Scale 30 μm.
Figures 11-13	*Glomospirella gaultina* (Berthelin). Scale 60 μm. 11. Sample 416A-53-1, 21-23 cm. 12. Sample 416A-7-3, 33-35 cm. 13. Sample 416A-19-2, 111-113 cm. Typical of poorly preserved specimens from late Valanginian sequence of Site 416.
Figure 14	*Reophax guttifer* Brady. Sample 416A-22-32, 108-109 cm. Scale 100 μm.
Figures 15, 16	*Reophax helveticus* (Haeusler). 15. Sample 416A-55-1, 4-6 cm. Scale 50 μm. 16. Sample 416A-53-1, 21-23 cm. Scale 30 μm.
Figure 17	*Reophax horridus* (Schwager). Sample 416A-42-1, 26-27. Scale 100 μm.
Figure 18	*Reophax minuta* Tappan. Sample 416A-8-6, 146-147 cm. Scale 30 μm.
Figure 19	*Reophax multilocularis* Haeusler. Sample 416A-55-1, 4-6 cm. Scale 50 μm.
Figures 20, 21	*Reophax pilulifer* Brady. Scale 100 μm. 20. Sample 416A-11-1, 57-59 cm. 21. Sample 416A-48-3, 19-21 cm.
Figure 22	*Miliammina valdensis* Bartenstein and Brand. Sample 416A-47-2, 64-67 cm. Scale 60 μm.

PLATE 1

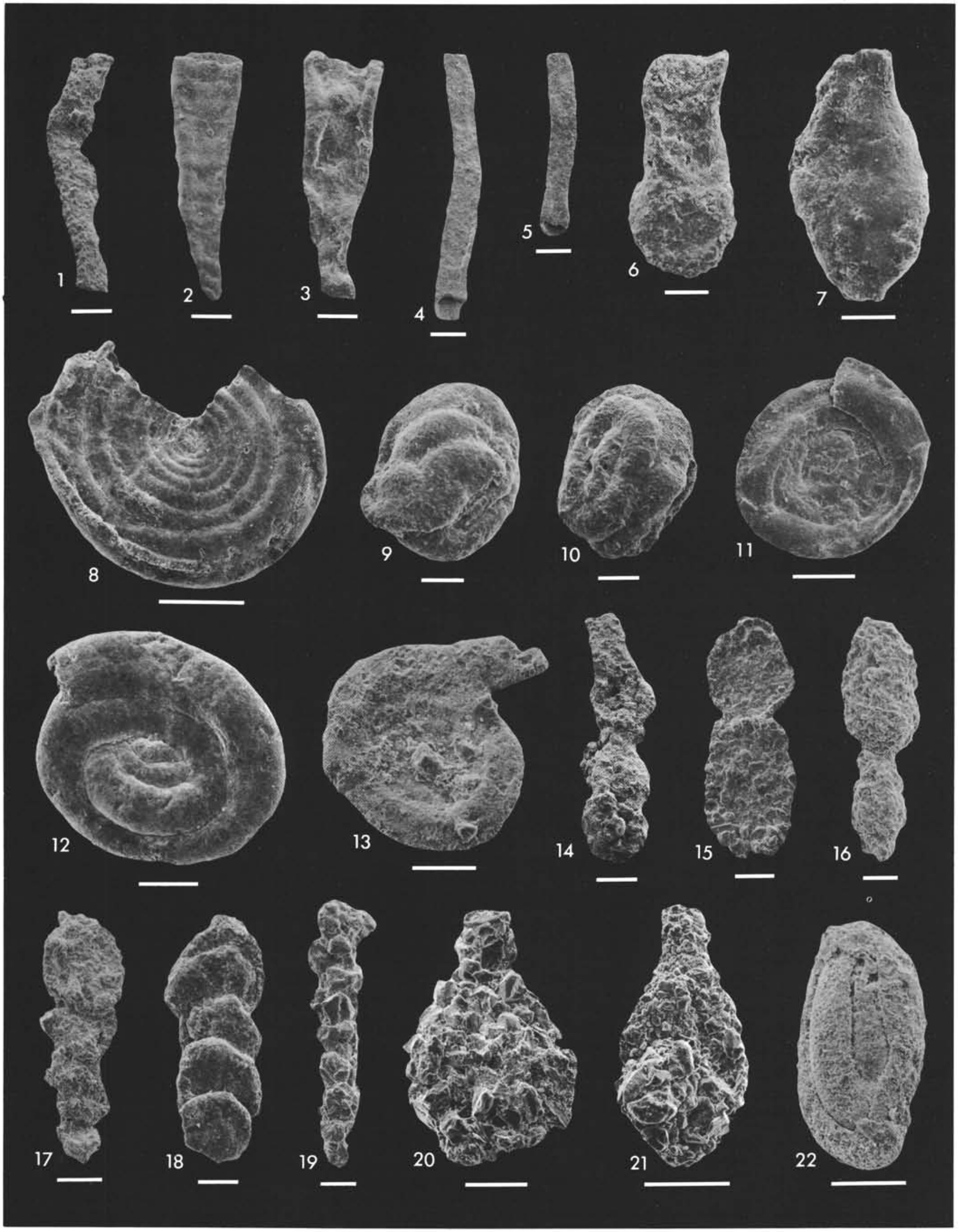

PLATE 2

Figures 1–3	*Haplophragmoides concavus* (Chapman). 1, 2. Side and peripheral view of same specimen. Sample 416A-41-4, 15–17 cm. Scale 100 μm. 3. Side view. Sample 416A-7-1, 119–121 cm. Scale 60 μm.
Figure 4	*Haplophragmoides haeusleri* Lloyd. Side view of distorted specimen. Sample 416A-53-3, 10–12 cm. Scale 100 μm.
Figures 5, 6	*Haplophragmoides nonioninoides* (Reuss). Sample 416A-6-4, 24–26 cm. Scale 100 μm. 5. Side view. 6. Peripheral view of same specimen.
Figures 7, 8	*Recurvoides imperfectus* (Hanzlikova). Scale 100 μm. 7. Side view showing areal aperture and bordering lip. Sample 416A-6-4, 24–26 cm. 8. Side view of distorted specimen. Sample 416-11-1, 57–59 cm.
Figure 9	*Ammobaculites* cf. *A. cuyleri* Tappan. Fragment of rectilinear portion of test. Sample 416A-6-2, 93–95 cm. Scale 100 μm.
Figures 10–12	*Ammobaculites euides* Loeblich and Tappan. Scale 100 μm. 10, 11. Sample 416A-11-1, 57–59 cm. 12. Sample 416A-12-5, 30–32 cm.
Figures 13, 14	*Ammobaculites irregularis* (Gümbel). Scale 100 μm. 13. Sample 416A-51, CC. 14. Sample 416A-52-3, 118–120 cm.
Figures 15, 16	*Ammobaculites suprajurassicus* (Schwager). Scale 30 μm. 15. Sample 416A-55-1, 4–6 cm. 16. Sample 416A-29-5, 3–5 cm.
Figures 17, 18	*Haplophragmium aequale* (Roemer). Side views. Sample 416A-53-2, 7–9 cm. Scale 100 μm.
Figures 19, 20	*Haplophragmium inconstans erectum* Bartenstein and Brand. 19. Side View. Sample 416A-47, CC. Scale 100 μm. 20. Side view. Sample 416A-55-1, 4–6 cm. Scale 60 μm.

PLATE 2

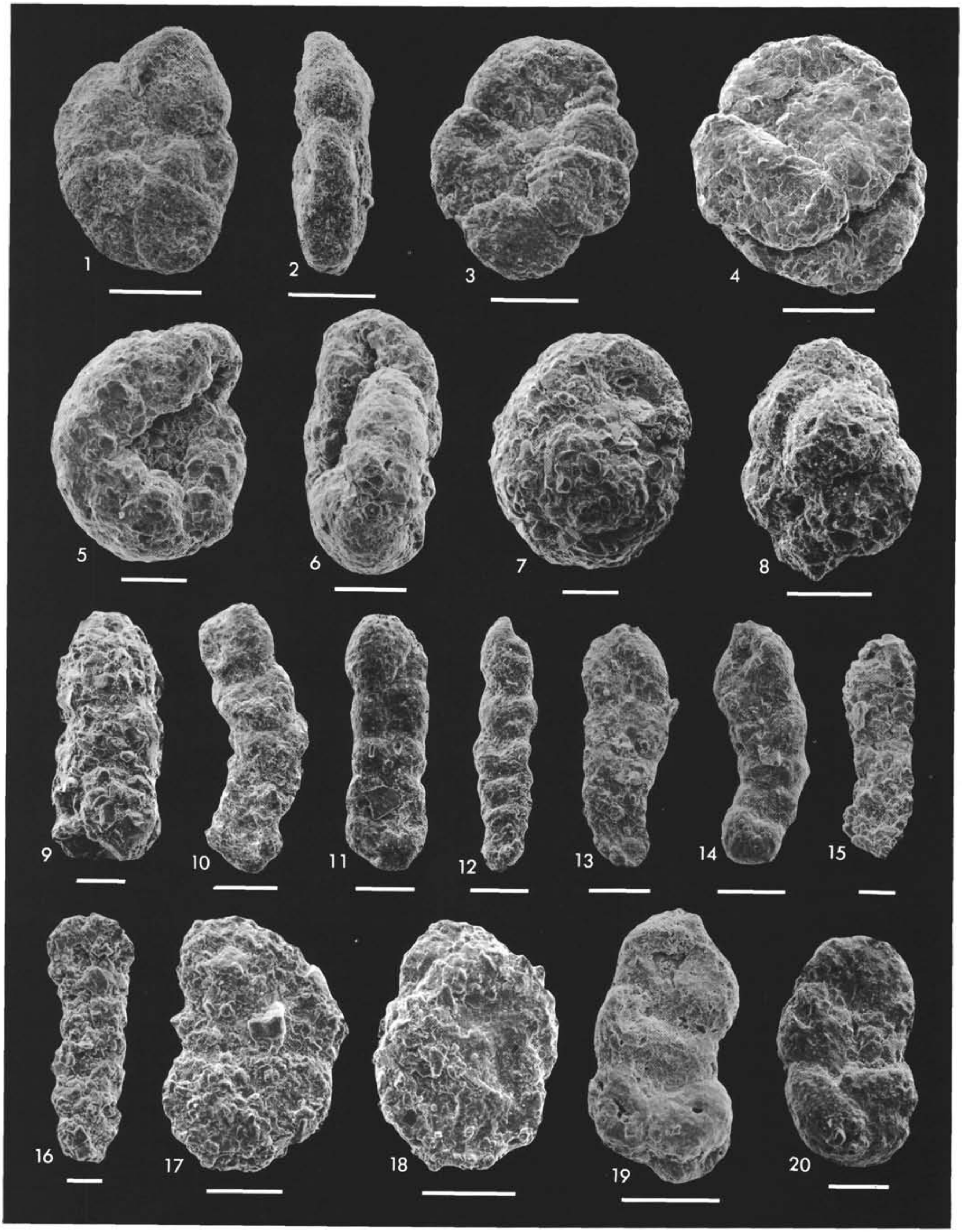

PLATE 3

Figures 1, 5	*Spiroplectammina ammovitrea* Tappan. Scale 60 μm. 1. Side view showing distinct initial coil. Sample 416A-6-2, 24-26 cm. 5. Fragment of rectilinear portion of test. Sample 416A-6-2, 93-95 cm.
Figure 2	*Spiroplectammina longa* Lalicker. Side view. Sample 416A-6-2, 55-57 cm. Scale 60 μm.
Figures 3, 4	*Textularia cordiformis* Schwager. Scale 60 μm. 3. Side view. Sample 416A-53-2, 7-9 cm. 4. Side view. Sample 416A-55-2, 42-44 cm.
Figures 6, 7	*Bigenerina clavellata* Loeblich and Tappan. 6. Side view. Sample 416A-47, CC. Scale 30 μm. 7. Side view. Sample 416A-42-1, 26-27 cm. Scale 50 μm.
Figures 8-10	*Bigenerina jurassica* (Haeusler). Sample 416A-55-1, 4-6 cm. 8. Side view. Scale 30 μm. 9. Side view. Scale 30 μm. 10. Side view of elongate specimen. Scale 50 μm.
Figures 11, 15	*Trochammina depressa* Lozo. Sample 416A-14-1, 69-71 cm. Scale 60 μm. 11. Spiral view. 15. Umbilical view.
Figures 12-14	*Trochammina neocomiana* Mjatliuk. Scale 60 μm. 12. Spiral view. Sample 416A-53-3, 10-12 cm. 13. Peripheral view, same specimen. 14. Spiral view. Sample 416A-53-3, 45-47 cm.
Figures 16-19	*Trochammina quinqueloba* Geroch. Scale 60 μm. 16. Umbilical view. Sample 416A-53-2, 124-126 cm. 17. Peripheral view. Sample 416A-53-2, 124-126 cm. 18. Spiral view. Sample 416A-35-2, 143-145 cm. 19. Umbilical view. Sample 416A-47, CC.

PLATE 3

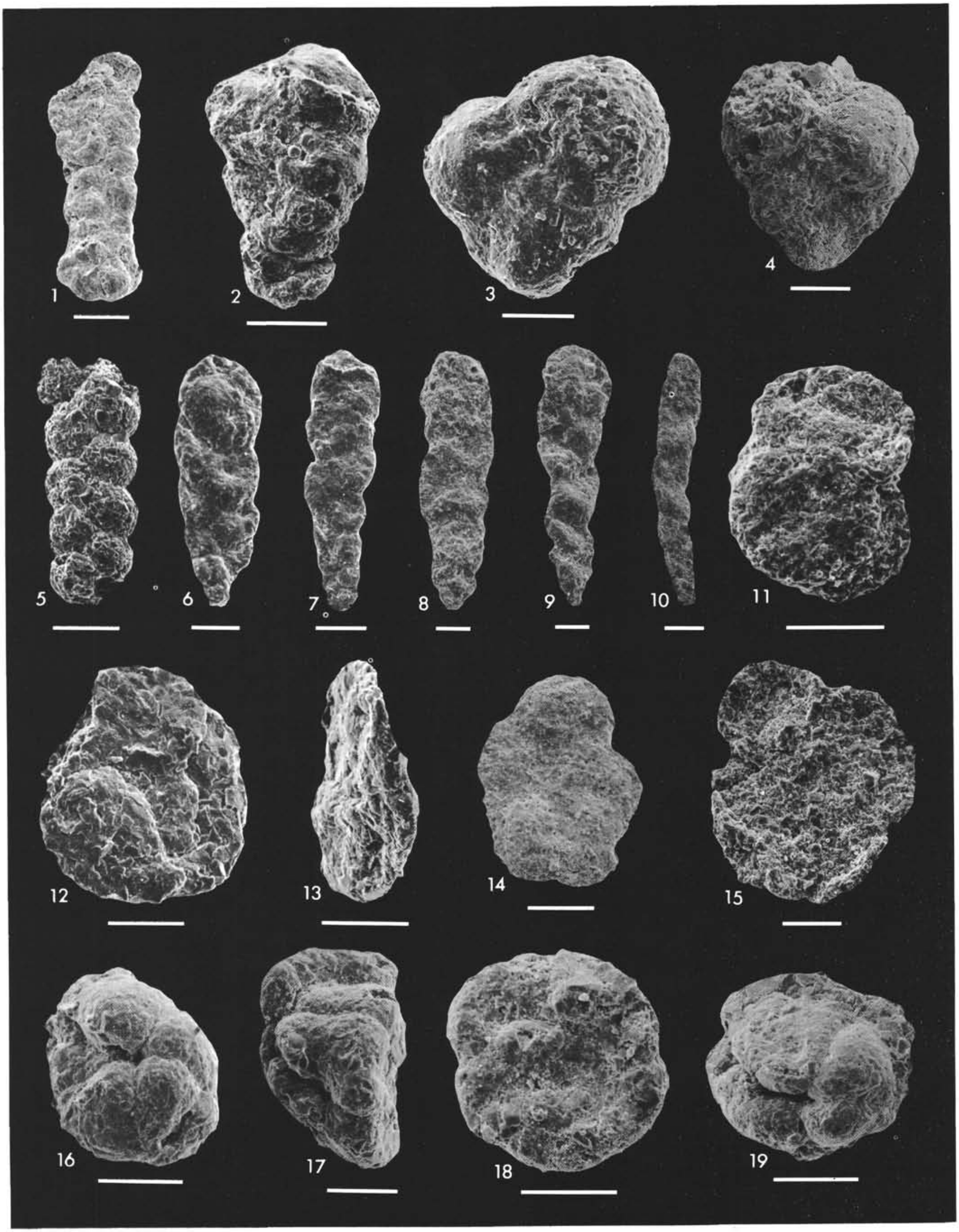

PLATE 4

Figures 1, 2, 6, 7	*Trochammina umiatensis* Tappan. Sample 416A-6-2, 24-26 cm. Scale 60 μm. 1. Spiral view. 2. Peripheral view. 6. Spiral view. 7. Umbilical view.
Figures 3-5	*Trochammina suprajurassica* Seibold. 3. Spiral view. Sample 416A-53-3, 10-12 cm. Scale 60 μm. 4. Peripheral view. Sample 416A-53-3, 10-12 cm. Scale 60 μm. 5. Spiral view. Sample 416A-55-1, 4-6 cm. Scale 50 μm.
Figure 8	*Gaudryina grandis* (Crespin). Sample 416A-47, CC. Scale 60 μm.
Figures 9-11	*Gaudryina neocomiensis* (Mjatliuk). 9. Sample 416A-55-2, 7-9 cm. Scale 30 μm. 10. Sample 416A-14-1, 69-71 cm. Scale 50 μm. 11. Sample 416A-53-3, 10-12. Scale 30 μm.
Figures 12-14	*Tritaxia subrotunda* ten Dam. Sample 416A-22-3, 108-109 cm. Scale 100 μm. 12. Triserial initial portion. 13. Triserial initial portion. 14. Test with portion of uniserial growth stage.
Figures 15-17	*Dorothia conula* (Reuss). Scale 100 υm. 15. Side view. Sample 416A-25-3, 51-52 cm. 16. Side view. Sample 416A-25-3, 51-52 cm. 17. Peripheral view. Sample 416A-12-5, 30-32.
Figure 18	*Dorothia filiformis* (Berthelin). Sample 416A-15-1, 38-39 cm. Scale 100 μm.
Figure 19	*Dorothia hauteriviana* (Moullade). Sample 416A-12-3, 17-19 cm. Scale 100 μm.

PLATE 4

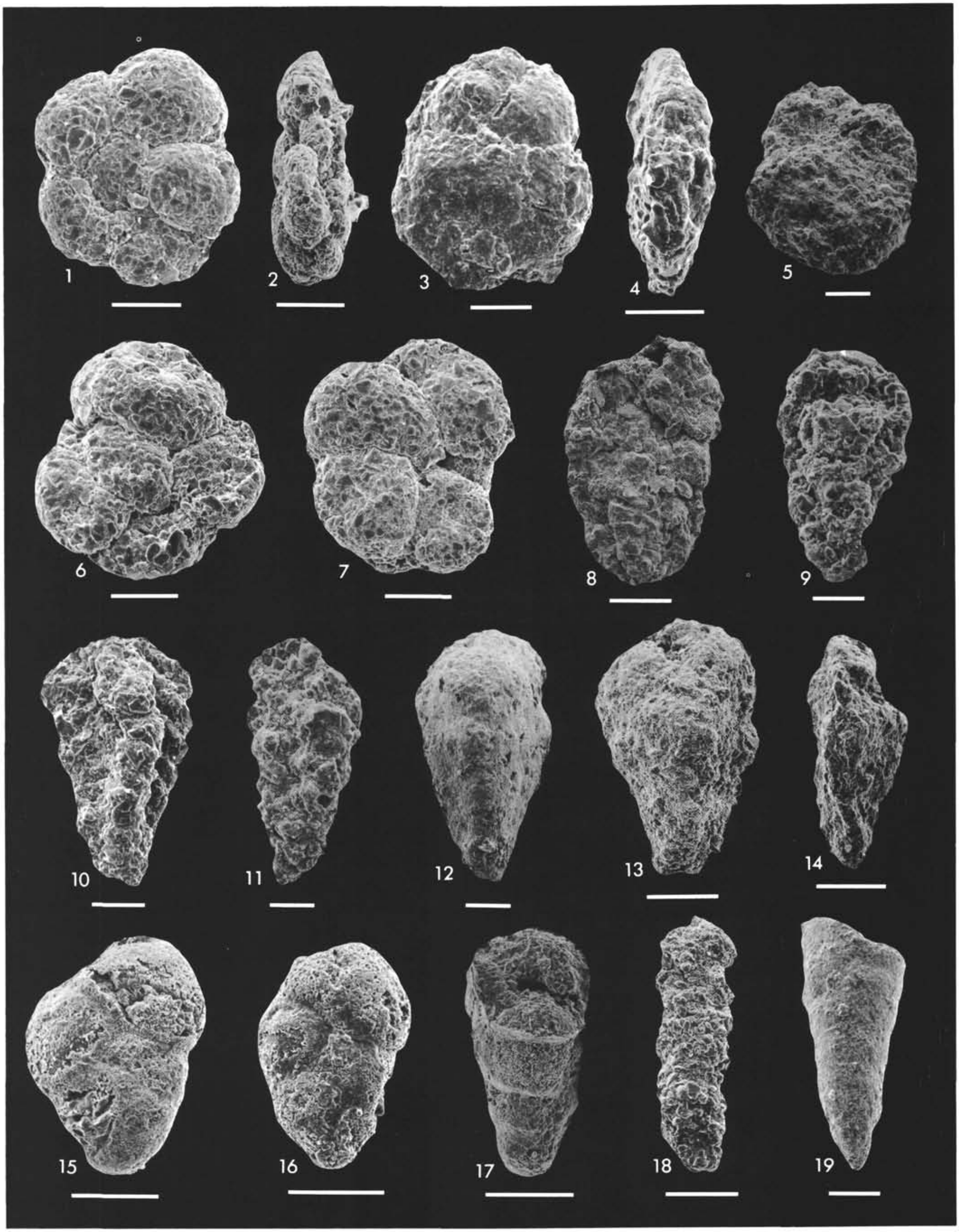

PLATE 5

Figures 1–4	*Dorothia hauteriviana* (Moullade). 1. Sample 416A-8-6, 146–147 cm. Scale 100 μm. 2. Energy-dispersive elemental X-ray spectrum of test surface of specimen in Figure 1. Note major Ca peak and minor Si, Fe, and Al peaks. 3. Enlargement of Figure 1, showing wall composed in part of corroded coccoliths. Scale 30 μm. 4. Sample 416A-9-3, 99–100 cm. Scale 100 μm.
Figures 5–6	*Dorothia kummi* (Zedler). 5. Sample 416A-32-4, 104–106 cm. Scale 60 μm. 6. Sample 416A-26-1, 36–38 cm. Scale 100 μm.
Figures 7–9	*Dorothia praehauteriviana* Dieni and Massari. Scale 100 μm. 7. Sample 416A-22-3, 108–109 cm. 8. Sample 416A-28-4, 11–13 cm. 9. Earliest representative of species at Site 416. Carbonate-filled chambers exposed in initial portion of test. Sample 416A-32-4, 104–106 cm.
Figures 10, 12	*Ophthalmidium* sp. cf. *O. carinatum* (Kubler and Zwingli). Scale 100 μm. 10. Sample 416A-9-3, 99–100 cm. 12. Sample 416A-26-1, 36–38 cm.
Figure 11	*Spiroloculina duestensis* Bartenstein and Brand. Sample 416A-26-1, 36–38 cm. Scale 100 μm.
Figure 13	*Massilina* sp. cf. *M. planoconvexa* Tappan. Sample 416A-22-3, 108–109 cm. Scale 100 μm.
Figures 14, 15	*Nodobacularia nodulosa* (Chapman). 14. Sample 416A-27-1, 44–46 cm. Scale 30 μm. 15. Sample 416A-19-2, 111–113 cm. Scale 100 μm.
Figure 16	*Triloculina meotica* Loeblich and Tappan. Sample 416A-22-3, 108–109 cm. Scale 100 μm.
Figures 17, 18	*Nodosaria* sp. cf. *N. aspera* Reuss. Scale 50 μm. 17. Sample 416A-15-1, 38–39 cm. 18. Sample 416A-22-3, 108–109 cm.
Figure 19	*Nodosaria* sp. cf. *N. chapmani* Tappan. Sample 416A-22-3, 108–109 cm. Scale 50 μm.
Figure 20	*Nodosaria obscura* Reuss. Sample 416A-36-2, 68–70 cm. Scale 50 μm.
Figure 21	*Nodosaria paupercula* Reuss. Sample 416A-15-1, 38–39 cm. Scale 50 μm.

PLATE 5

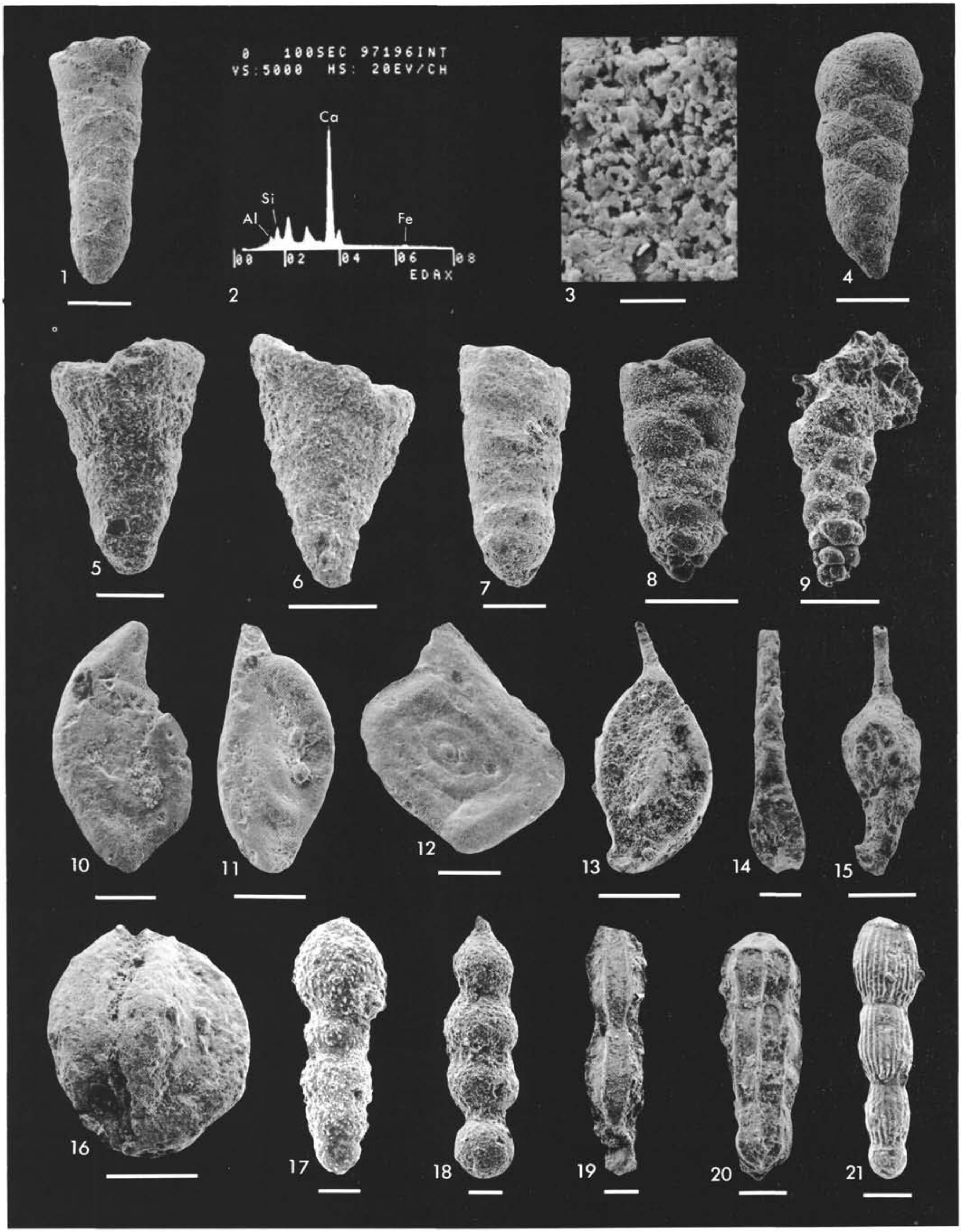
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PLATE 6

Figure 1	*Nodosaria prismatica* Reuss. Sample 416A-12-2, 144-146 cm. Scale 100 μm.
Figure 2	*Nodosaria sceptrum* Reuss. Sample 416A-31-1, 16-18 cm. Scale 100 μm.
Figure 3	*Nodosaria zippei* Reuss. Sample 416A-32-4, 104-106 cm. Scale 100 μm.
Figures 4, 5	*Astacolus calliopsis* (Reuss). Sample 416A-43-2, 30-33 cm. Scale 60 μm. 4. Side view. 5. Face view of same specimen.
Figures 6-8	*Astacolus crepidularis* (Roemer). Scale 100 μm. 6. Side view. Sample 416A-32-4, 104-106 cm. 7. Oblique peripheral view. Sample 416A-17, CC. 8. Side view. Sample 416A-7-3, 125-127 cm.
Figures 9, 10	*Astacolus gratus* (Reuss). Scale 100 μm. 9. Side view. Sample 416A-28-4, 11-13 cm. 10. Side view. Sample 416A-55-2, 42-44 cm.
Figures 11, 12	*Astacolus incurvatus* (Reuss). Scale 50 μm. 11. Side view. Sample 416A-43-2, 30-32 cm. 12. Side view of specimen with severely corroded test. Sample 416A-53-1, 21-23 cm.
Figures 13, 18	*Astacolus mutilatus* Espitalié and Sigal. Sample 416A-9-3, 100-102 cm. Scale 100 μm. 13. Side view. 18. Side view.
Figure 14	*Astacolus planiusculus* (Reuss). Side view. Sample 416A-32-4, 104-106 cm. Scale 100 μm.
Figure 15	*Citharina complanata peristriata* Tappan. Sample 416A-7-3, 125-127 cm. Scale 100 μm.
Figures 16, 17	*Citharina intumescens* (Reuss). Scale 100 μm. 16. Side view. Sample 416A-25-4, 125-127 cm. 17. Side view. Sample 416A-26-1, 36-8 cm.
Figures 19, 20	*Dentalina communis* d'Orbigny. Scale 100 μm. 19. Sample 416A-28-1, 17-19 cm. 20. Sample 416A-15-1, 38-39 cm.
Figures 21, 22	*Dentalina cylindroides* Reuss. Sample 416A-26-1, 36-38 cm. Scale 100 μm.
Figures 23, 24	*Dentalina distincta* Reuss. 23. Sample 416A-17-3, 12-15 cm. Scale 50 μm. 24. Sample 416A-12-5, 30-32 cm. Scale 100 μm.
Figure 25	*Dentalina ejuncida* Loeblich and Tappan. Corroded specimen. Sample 416A-54, CC. Scale 60 μm.

PLATE 6

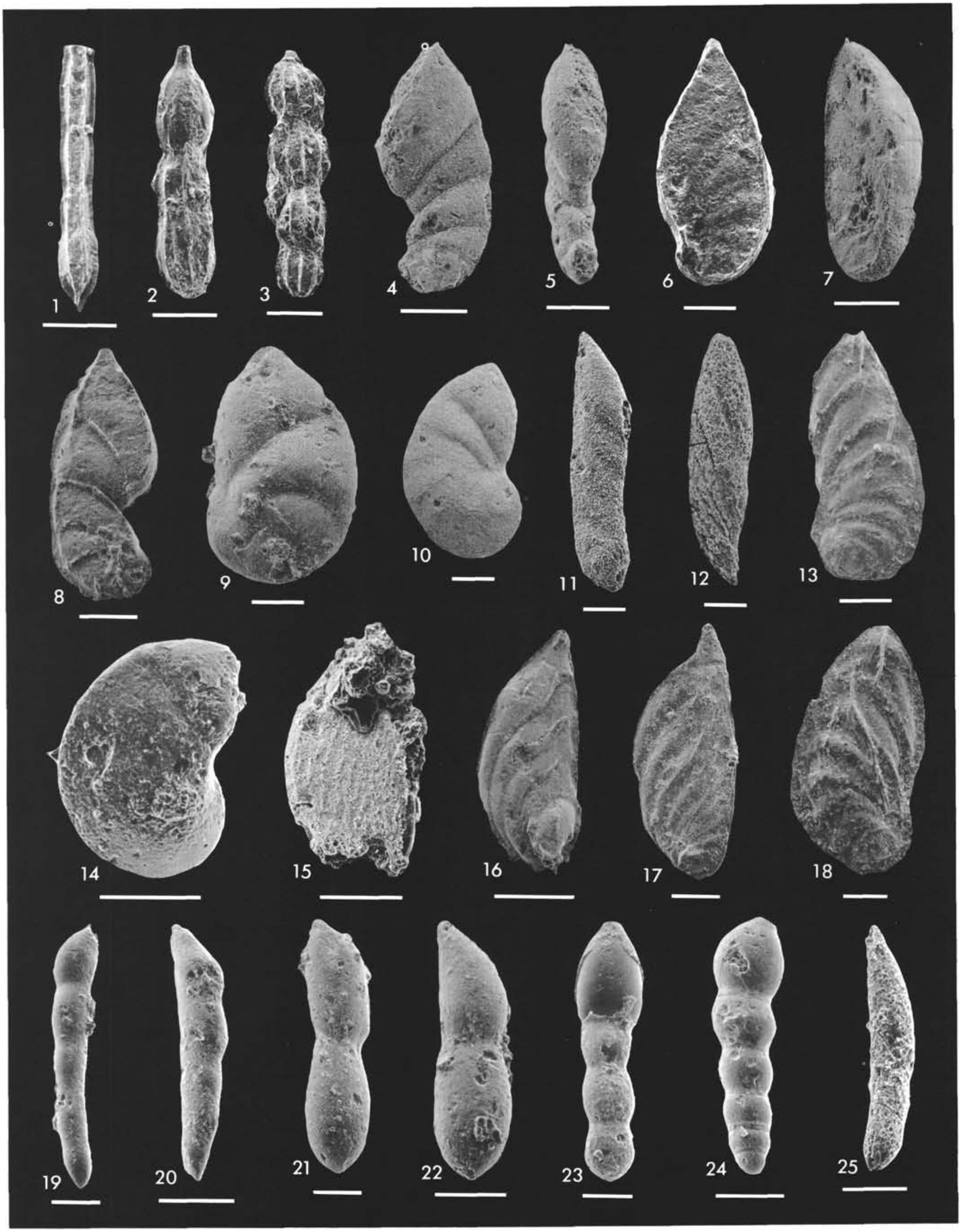


PLATE 7

Figure 1	*Dentalina gracilis* d'Orbigny. Sample 416A-15-1, 38-39 cm. Scale 50 μm.
Figure 2	*Dentalina guttifera* d'Orbigny. Sample 416A-22-3, 108-109 cm. Scale 100 μm.
Figure 3	*Dentalina jurensis* (Gümbel). Sample 416A-55-2, 7-9 cm. Sample 50 μm.
Figure 4	*Dentalina linearis* (Roemer). Sample 416A-46, CC. Scale 100 μm.
Figures 5, 6	*Dentalina nana* Reuss. Scale 50 μm. 5. Sample 416A-43-2, 30-32 cm. 6. Sample 416A-42-1, 26-27 cm.
Figure 7	*Dentalina pseudonana* ten Dam. Sample 416A-54, CC. Scale 50 μm.
Figure 8	*Dentalina soluta* Reuss. Sample 416A-17-3, 12-15 cm. Scale 100 μm.
Figure 9	*Dentalina torta* Terquem. Sample 416A-55-2, 42-44 cm. Scale 30 μm.
Figures 10, 11	*Dentalina varians* Terquem. Scale 100 μm. 10. Sample 416A-32-4, 104-106 cm. 11. Sample 416A-12-2, 144-146 cm.
Figures 12, 13	*Frondicularia didyma* Berthelin. Sample 416A-7-3, 33-35 cm. Scale 100 μm.
Figure 14	*Frondicularia hastata hastata* Roemer. Juvenile specimen. Sample 416A-23-5, 9-11 cm. Scale 100 μm.
Figures 15, 16	*Frondicularia intermittens* Reuss. Scale 100 μm. 15. Sample 416A-23-5, 59-60 cm. 16. Broken specimen showing surface ornamentation. Sample 416A-24-3, 36-38 cm.
Figures 17, 18	*Frondicularia inversa* Reuss. 17. Adult specimen. Sample 416A-26-1, 36-38 cm. Scale 300 μm. 18. Juvenile specimen. Sample 416A-28, CC. Scale 60 μm.
Figure 19	*Frondicularia joidesi* Maync. Sample 416A-14-2, 116-118 cm. Scale 150 μm.
Figure 20	*Frondicularia rehburgensis* Bartenstein and Brand. Sample 416A-32-4, 104-106 cm. Scale 100 μm.
Figure 21	*Lagena globosa* (Montagu). Sample 416A-14-1, 119-120 cm. Scale 30 μm.
Figure 22	*Frondicularia simplicissima* ten Dam. Sample 416A-11-5, 45-46 cm. Scale 50 μm.
Figure 23	*Frondicularia* sp. Sample 416A-25-4, 125-127 cm. Scale 100 μm.
Figure 24	*Kyphopyxa* sp. Sample 416A-29-6, 4-5 cm. Scale 60 μm.
Figures 25, 26	*Lagena hauteriviana cylindracea* Bartenstein and Brand. Sample 416A-9-3, 100-102 cm. Scale 100 μm.

PLATE 7

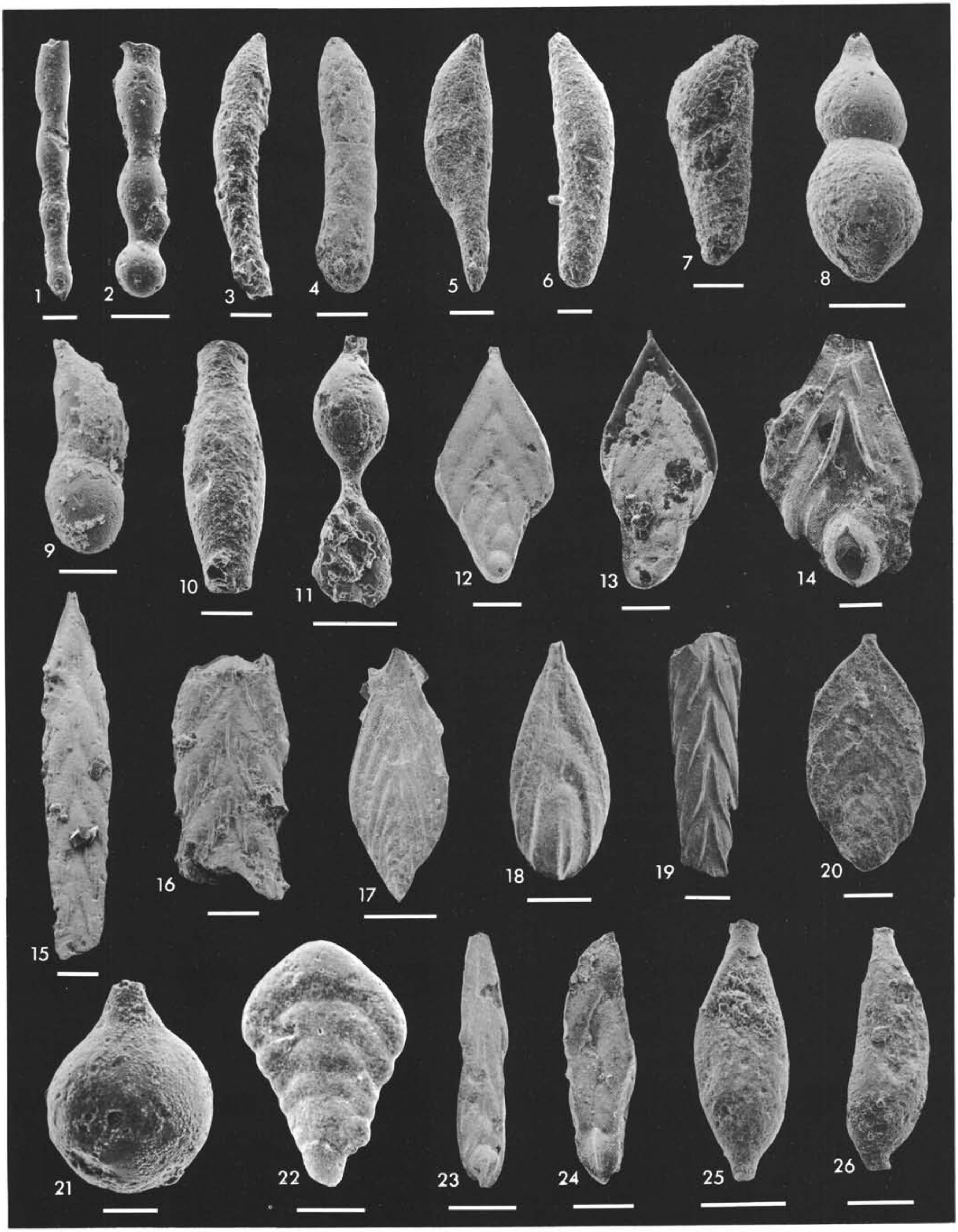


PLATE 8

Figures 1, 2	*Lagena hauteriviana hauteriviana* Bartenstein and Brand. 1. Sample 416A-12-5, 30-32 cm. Scale 50 μm. 2. Sample 416A-29-5, 3-5 cm. Scale 30 μm.
Figures 3, 4	*Lagena laevis* (Montagu). Scale 30 μm. 3. Sample 416A-30-3, 143-144 cm. 4. Rare specimen with initial spine. Sample 416A-26-4, 11-13 cm.
Figure 5	*Lagena* sp. cf. *L. meridionalis* Wiesner. Sample 416A-15-1, 38-39 cm. Scale 50 μm.
Figure 6	*Lagena ovata* (Terquem). Sample 416A-54, CC. Scale 30 μm.
Figure 7	*Lagena oxystoma* Reuss. Sample 416A-15-1, 38-39 cm. Scale 60 μm.
Figures 8-10	*Lagena sulcata* (Walker and Jacob). Scale 100 μm. 8. Sample 416A-31-3, 7-9 cm. 9. Sample 416A-27-4, 135-137 cm. 10. Sample 416A-23-5, 59-60 cm.
Figures 11-14	*Lagena sztejnae* Dieni and Massari. 11. Sample 416A-28-2, 0-2 cm. Scale 30 μm. 12. Sample 416A-43, CC. Scale 30 μm. 13. Sample 416A-20-2, 11-12 cm. Scale 50 μm. 14. Rare double specimen. Sample 416A-23-5, 59-60 cm. Scale 50 μm.
Figures 15-18	*Lenticulina busnardoi* Moullade. Scale 100 μm. 15. Side view. Sample 416A-28-4, 11-13 cm. 16. Side view. Sample 416A-38, CC. 17. Side view. Sample 416A-14-2, 116-118 cm. 18. Face view of same specimen.
Figures 19, 20	*Lenticulina eichenbergi* Bartenstein and Brand. Sample 416A-7-3, 33-35 cm. Scale 100 μm. 19. Side view of corroded juvenile specimen. 20. Face view of same specimen.
Figure 21	*Lenticulina guttata* (ten Dam). Side view. Sample 416A-9-3, 98-99 cm. Scale 100 μm.

PLATE 8

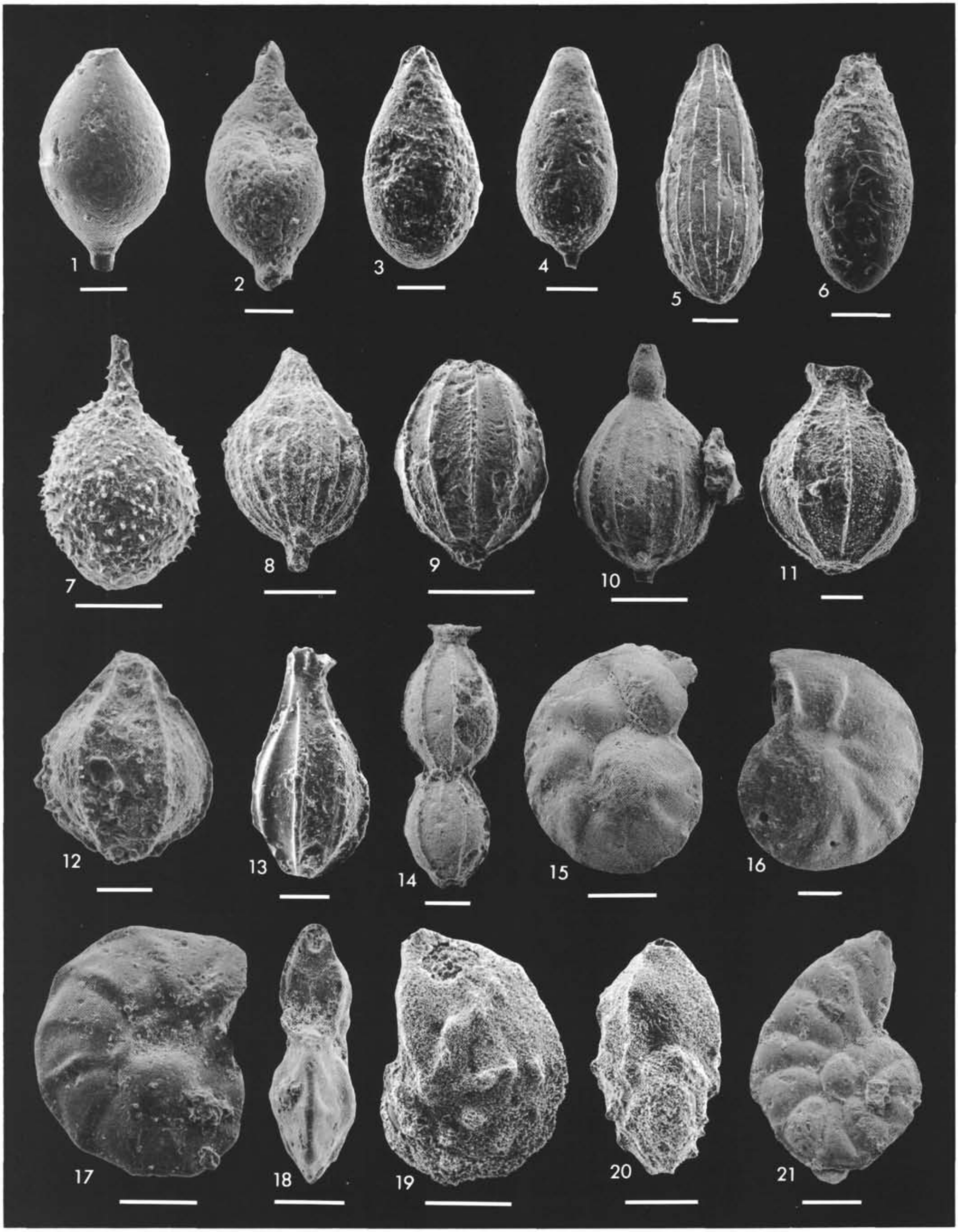


PLATE 9

Figures 1, 2	*Lenticulina guttata* (ten Dam). Sample 416A-15-1, 38-39 cm. Scale 100 μm. 1. Side view. 2. Side view of less-compressed specimen.
Figures 3, 4	*Lenticulina muensteri* (Roemer). Sample 416A-35-3, 0-1 cm. Scale 200 μm. 3. Side view. 4. Face view of same specimen.
Figures 5-8	*Lenticulina nodosa* (Reuss). Scale 100 μm. 5. Side view. Sample 416A-10-1, 141-143 cm. 6. Face view of same specimen. 7. Side view. Sample 416A-14-2, 116-118 cm. 8. Side view. Sample 416A-14-2, 116-118 cm.
Figures 9, 10	*Lenticulina ouachensis multicella* Bartenstein, Bettenstaedt, and Bolli. Sample 416A-9-3, 99-100 cm. 9. Side view. Scale 300 μm. 10. Side view. Scale 200 μm.
Figures 11-16	*Lenticulina ouachensis ouachensis* (Sigal). Sample 416A-9-3, 99-100 cm. Scale 100 μm. 11. Side view. 12. Face view of same specimen. 13. Side view. 14. Face view of same specimen. 15. Side view. 16. Face view of same specimen.

PLATE 9

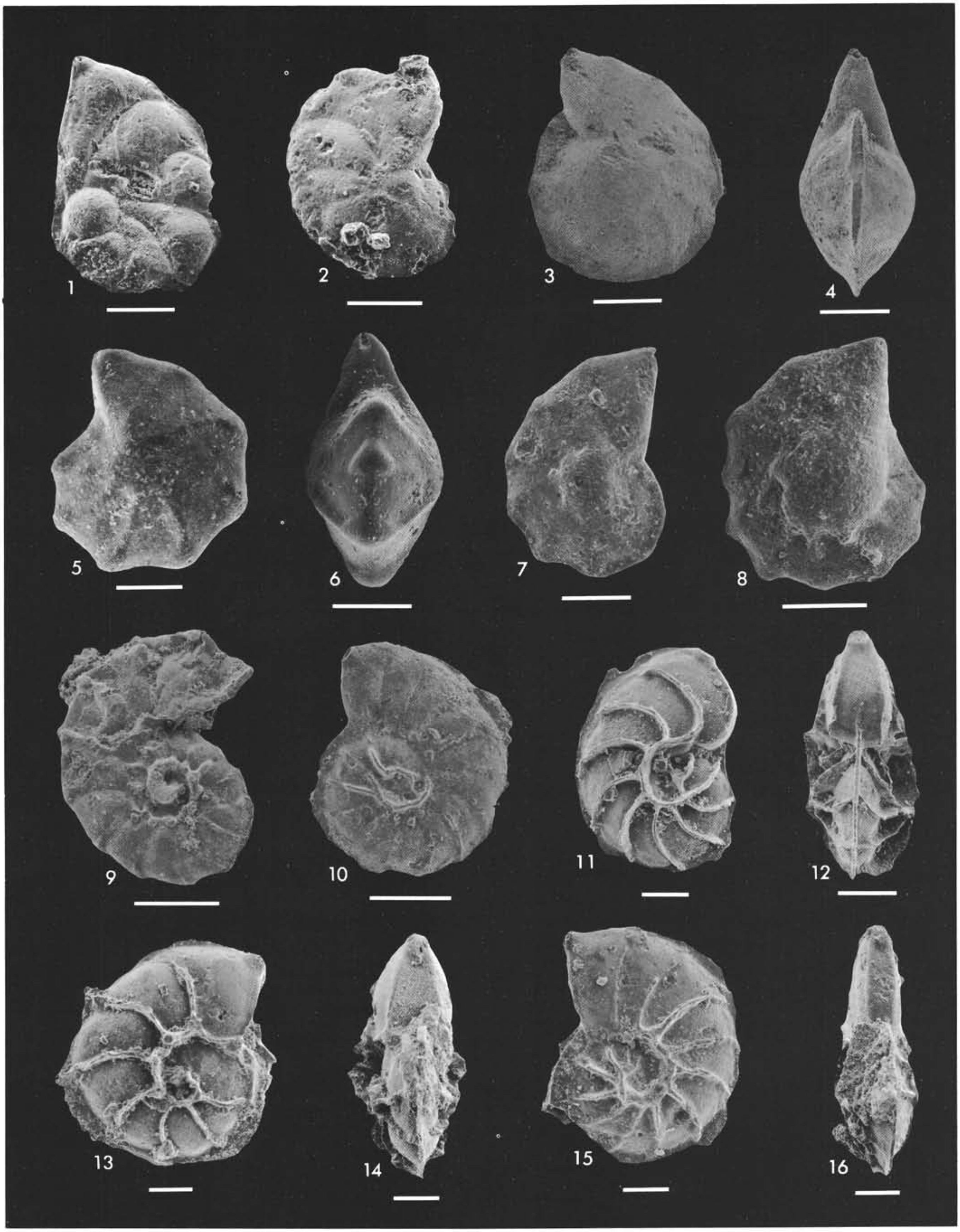


PLATE 10

Figures 1–4 *Lenticulina ouachensis ouachensis* (Sigal).
Sample 416A-12-5, 30–32 cm.
1. Side view. Scale 50 μm.
2. Face view of same specimen. Scale 50 μm.
3. Side view of aberrant specimen. Scale 100 μm.
4. Face view of same specimen. Scale 100 μm.

Figures 5–7, 10 *Lenticulina praegaultina* Bartenstein, Bettenstaedt, and Bolli.
Scale 100 μm.
5. Side view. Sample 416A-22-4, 119–121 cm.
10. Face view of same specimen.
6. Side view. Sample 416A-22-3, 108–109 cm.
7. Face view of same specimen.

Figures 8, 9, 11–16 *Lenticulina subalata* (Reuss).
8. Side view. Sample 416A-40-4, 83–85 cm. Scale 100 μm.
9. Side view. Sample 416A-23-5, 59–60 cm. Scale 100 μm.
11. Side view aberrant specimen. Sample 416A-22-3, 108–109 cm. Scale 100 μm.
12. Face view of same specimen. Scale 100 μm.
13. Side view of aberrant specimen. Sample 416A-22-3, 108–109 cm. Scale 200 μm.
14. Face view of same specimen. Scale 200 μm.
15. Side view of aberrant specimen. Specimen 416A-22-3, 108–109 cm. Scale 200 μm.
16. Face view of same specimen. Scale 200 μm.

Figures 17, 18 *Lenticulina subangulata* (Reuss).
17. Side view. Sample 416A-22-3, 108–109 cm. Scale 200 μm.
18. Side view of earliest specimen at Site 416. Sample 416A-43-2, 30–32 cm. Scale 60 μm.

PLATE 10

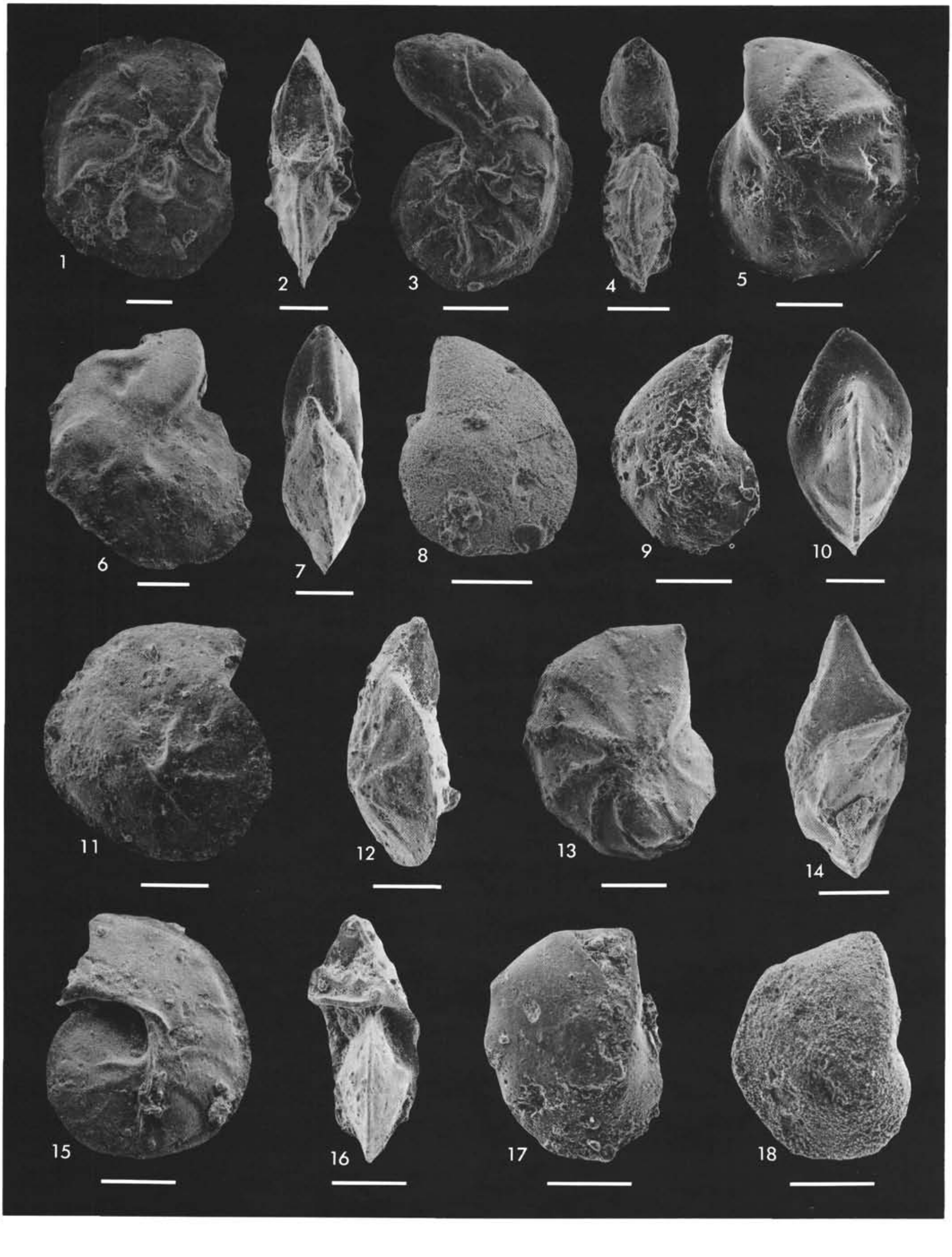


PLATE 11

Figures 1–5 *Lenticulina turgidula* (Reuss).
1. Side view. Sample 416A-15-1, 38-39 cm. Scale 100 μm.
2. Face view of same specimen. Scale 100 μm.
3. Side view. Sample 416A-12-5, 30-32 cm. Scale 100 μm.
4. Face view of same specimen. Scale 100 μm.
5. Side view of aberrant specimen. Sample 416A-14-2, 114-116 cm. Scale 60 μm.

Figures 6–8 *Lenticulina* sp. A.
Sample 416A-25-3, 51-52 cm. Scale 100 μm.
6. Side view.
7. Face view of same specimen.
8. Side view.

Figure 9 *Lenticulina* sp. B.
Sample 416A-12-5, 30-32 cm. Scale 100 μm.

Figures 10, 11 *Lenticulina* sp. C.
Sample 416A-9-3, 99-100 cm. Scale 100 μm.
10. Side view.
11. Face view of same specimen.

Figures 12, 13 *Marginulinopsis bettenstaedti* (Bartenstein and Brand).
Sample 416A-26-1, 36-38 cm. Scale 100 μm.
12. Side view.
13. Face view of same specimen.

Figures 14, 15 *Marginulinopsis cephalotes* (Reuss).
Sample 416A-12-5, 30-32 cm. Scale 100 μm.
14. Side view.
15. Side view.

Figures 16–18 *Marginulinopsis collignoni* (Espitalié and Sigal).
16. Side view. Sample 416A-11-6, 61-63 cm. Scale 30 μm.
17. Side view. Sample 416A-12-5, 30-32 cm. Scale 50 μm.
18. Face view of same specimen. Scale 50 μm.

PLATE 11

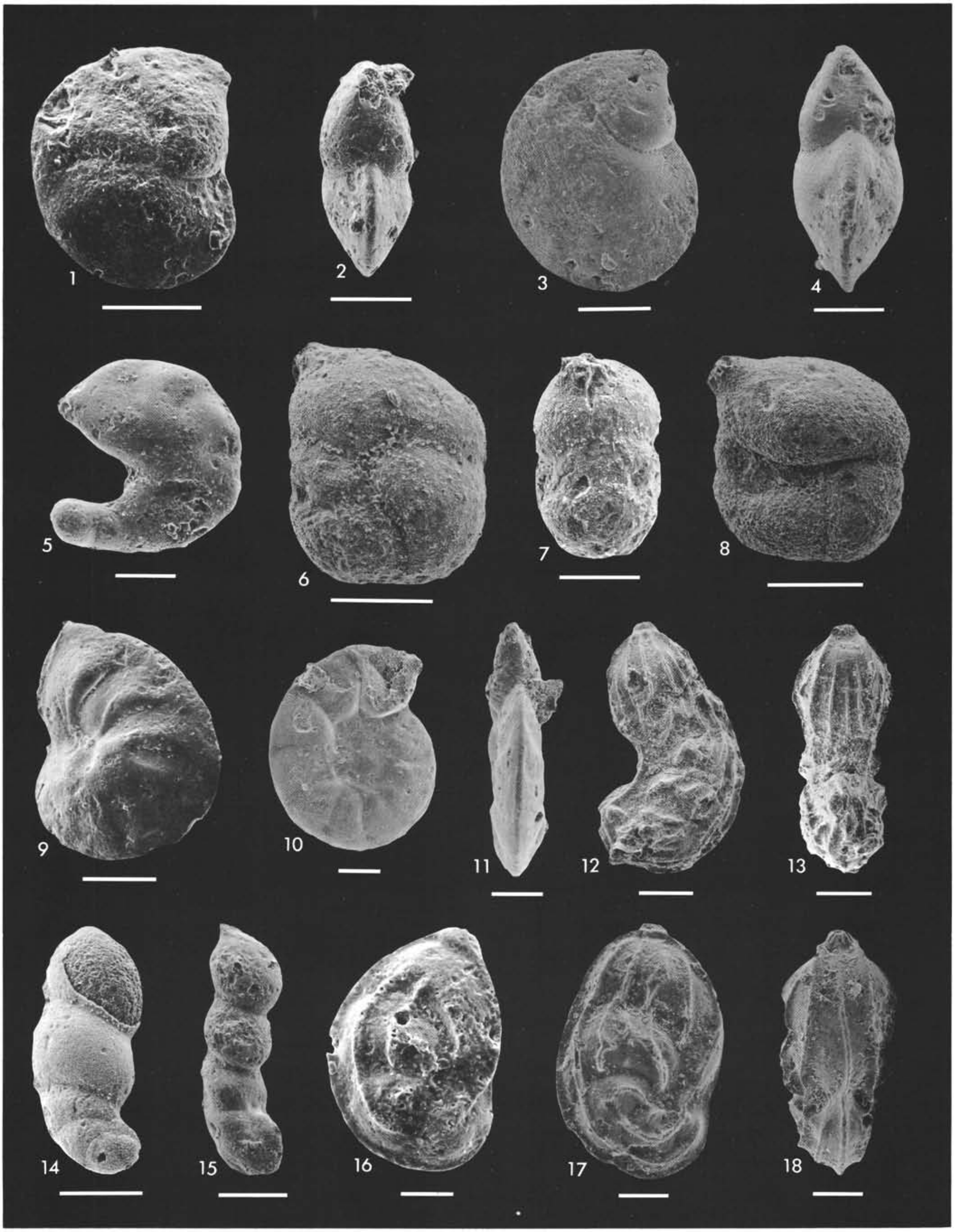


PLATE 12

Figure 1	*Marginulinopsis parkeri* (Reuss). Side view. Sample 416A-26-1, 36-38 cm. Scale 100 μm.
Figures 2, 3	*Pseudonodosaria humilis* (Roemer). Scale 100 μm. 2. Sample 416A-31-3, 7-9 cm. 3. Sample 416A-35-3, 0-1 cm.
Figure 4	*Saracenaria compacta* Espitalié and Sigal. Sample 416A-34, CC. Scale 100 μm.
Figures 5-7	*Saracenaria cushmani* Tappan. Scale 100 μm. 5. Side view. Sample 416A-28-2, 0-2 cm. 6. Side view. Sample 416A-26-1, 36-38 cm. 7. Face view of same specimen.
Figures 8, 9	*Saracenaria frankei* ten Dam. Scale 100 μm. 8. Oblique side view. Sample 416A-36-2, 96-97 cm. 9. Oblique side view. Sample 416A-25-4, 125-127 cm.
Figures 10-14	*Saracenaria saxonica saxonica* (Bartenstein and Brand). Scale 100 μm. 10. Side view. Sample 416A-40-4, 83-85 cm. 11. Side view. Sample 416A-22-4, 119-121 cm. 12. Face view of same specimen. 13. Side view. Sample 416A-26-1, 36-38 cm. 14. Face view of same specimen.
Figures 15-17	*Vaginulina recta* Reuss. 15. Side view. Sample 416A-14-2, 114-116 cm. Scale 100 μm. 16. Side view. Sample 416A-9-3, 99-100 cm. Scale 300 μm. 17. Side view. Sample 416A-9-3, 99-100 cm. Scale 300 μm.
Figure 18	*Vaginulina angustissima* Reuss. Side view. Sample 416A-9-3, 99-100 cm. Scale 150 μm.
Figures 19-20	*Vaginulina debilis* (Berthelin). Scale 100 μm. 19. Sample 416A-28-1, 17-19 cm. 20. Sample 416A-26-1, 36-38 cm.
Figures 21, 22	*Vaginulinopsis excentrica* (Cornuel). Scale 100 μm. 21. Side view. Sample 416A-12-5, 30-32 cm. 22. Face view of same specimen.

PLATE 12

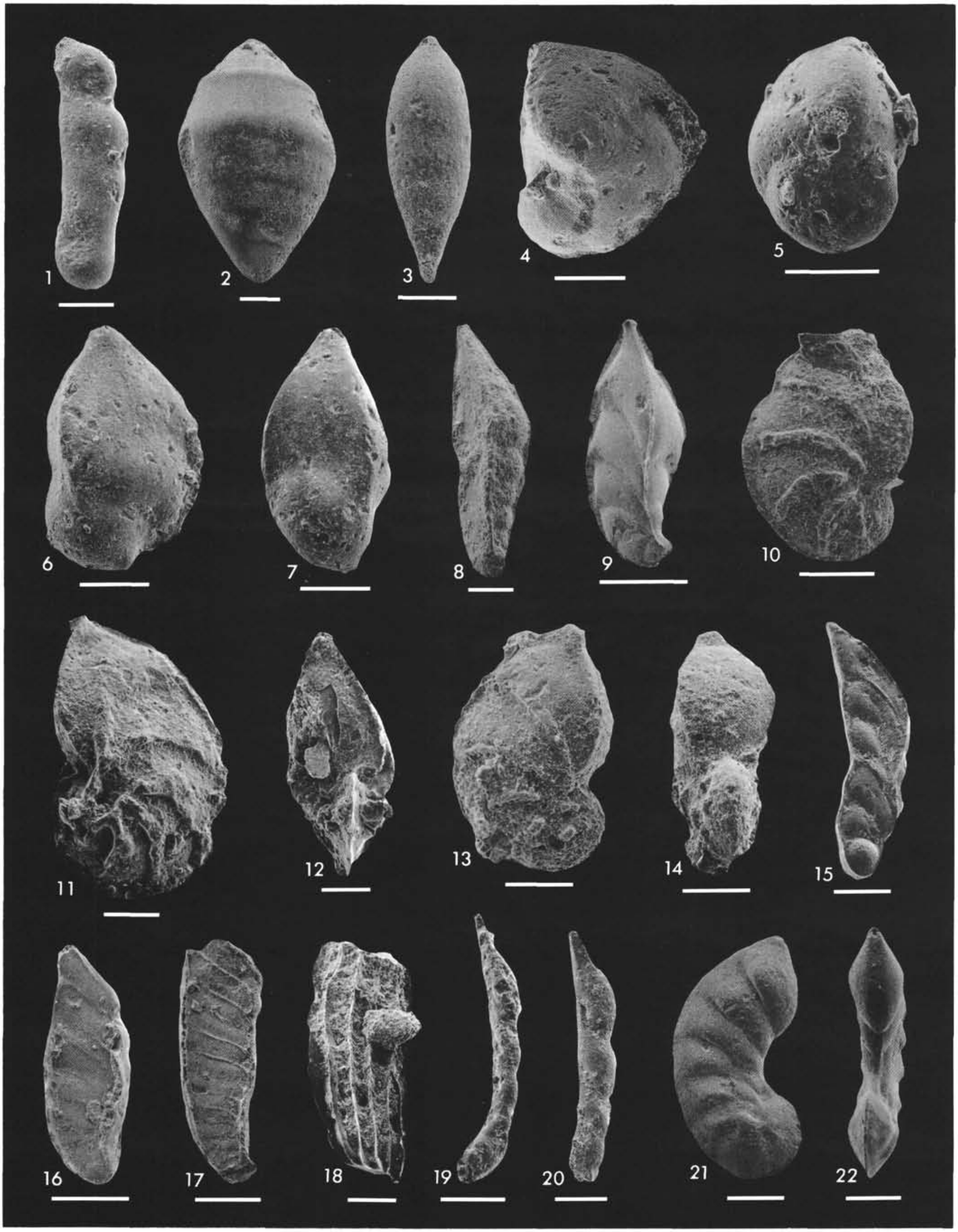


PLATE 13

Figure 1	*Vaginulinopsis excentrica* (Cornuel). Side view. Sample 416A-9-3, 99-100 cm. Scale 100 μm.
Figure 2	*Vaginulinopsis matutina* (d'Orbigny). Side view. Sample 416A-43-2, 30-32 cm. Scale 100 μm.
Figure 3	*Vaginulinopsis pseudodebilis* (Dieni and Massari). Side view of broken specimen. Sample 416A-14-2, 114-116 cm. Scale 100 μm.
Figure 4	*Vaginulinopsis reticulosa* ten Dam. Side view of specimen partially obscured by debris. Sample 416A-7-3, 33-35 cm. Scale 200 μm.
Figure 5	*Vaginulinopsis schloenbachi* (Reuss). Side view. Sample 416A-28-4, 11-13 cm. Scale 100 μm.
Figure 6	*Vaginulinopsis* sp. A. Side view. Sample 416A-46-3, 46-48 cm. Scale 100 μm.
Figures 7, 8	*Vaginulinopsis* sp. B. 7. Side view. Sample 416A-44, CC. Scale 60 μm. 8. Side view. Sample 416A-45-1, 36-38 cm. Scale 100 μm.
Figure 9	*Vaginulinopsis* sp. C. Side view. Sample 416A-43-2, 30-32 cm. Scale 100 μm.
Figure 10	*Vaginulinopsis* sp. D. Side view. Sample 416A-19-2, 111-113 cm. Scale 60 μm.
Figures 11, 12	*Lingulina loryi* (Berthelin). Scale 100 μm. 11. Side view. Sample 416A-31-3, 7-9 cm. 12. Side view. Sample 416A-25-4, 125-127 cm.
Figure 13	*Lingulina nodosaria* Reuss. Side view. Sample 416A-28-6, 149-151 cm. Scale 100 μm.
Figure 14	*Lingulina pupa* (Terquem). Side view. Sample 416A-35-2, 104-106 cm. Scale 30 μm.
Figure 15	*Lingulina semiornata* Reuss. Side view. Sample 416A-30-3, 143-144 cm. Scale 30 μm.
Figure 16	*Lingulina* sp. Side view. Sample 416A-38, CC. Scale 30 μm.
Figure 17	*Eoguttulina oolithica* (Terquem). Sample 416A-55-2, 63-65 cm. Scale 30 μm.
Figures 18, 19	*Falsoguttulina wolburgi* Bartenstein and Brand. Sample 416A-43-2, 30-33 cm. Scale 30 μm. 18. Side view. 19. Peripheral view of same specimen.
Figures 20, 21	*Globulina exserta* (Berthelin). Sample 416A-29-5, 3-5 cm. Scale 30 μm.
Figure 22	*Globulina prisca* Reuss. Sample 416A-17-3, 12-15 cm. Scale 100 μm.

PLATE 13

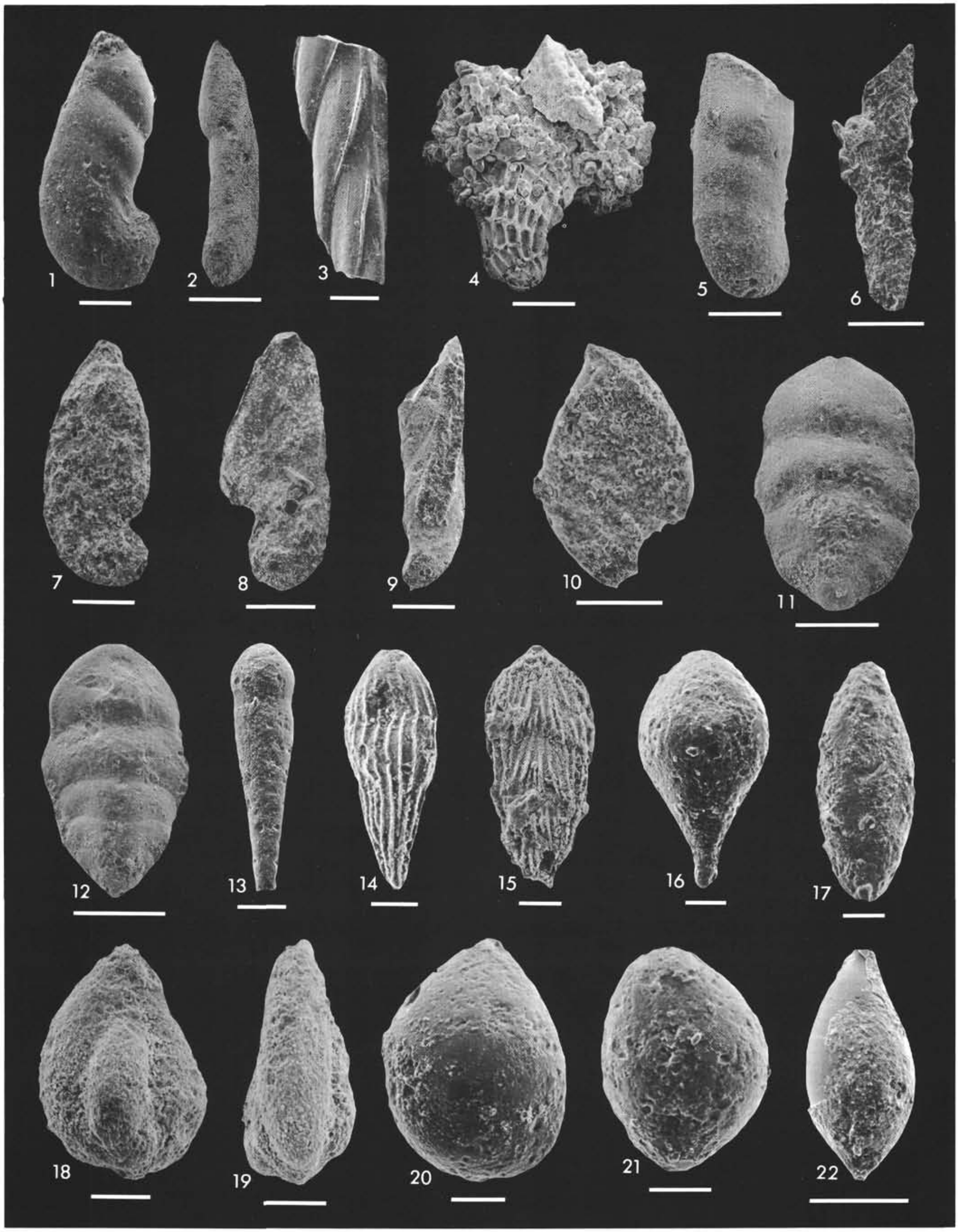


PLATE 14

Figure 1	*Globulina prisca* Reuss. Sample 416A-17-3, 12-15 cm. Scale 100 μm.
Figure 2	*Pyrulina cylindroides* (Roemer). Sample 416A-14-2, 114-116 cm. Scale 50 μm.
Figures 3, 4	*Ramulina aculeata* Wright. Scale 100 μm. 3. Globular chamber. Sample 416A-15-1, 38-39 cm. 4. Fragment of interconnecting tube. Sample 416A-19-2, 111-113 cm.
Figure 5	*Ramulina globotubulosa* Cushman. Sample 416A-27-4, 135-137 cm. Scale 100 μm.
Figure 6	*Ramulina spandeli* Paalzow. Sample 416A-55-2, 7-9 cm. Scale 100 μm.
Figures 7, 8	*Tristix acutangula* (Reuss). Scale 100 μm. 7. Sample 416A-7-3, 125-127 cm. 8. Sample 416A-12-5, 30-32 cm.
Figure 9	*Tristix excavata* (Reuss). Sample 416A-11-5, 45-46 cm. Scale 30 μm.
Figures 10-18	*Tristix lanceola* Sliter, n. sp. 10. Side view of holotype (USNM 252178). Sample 416A-17-3, 12-15 cm. Scale 60 μm. 11. Apertural view of holotype. Scale 30 μm. 12. Enlargement of apertural area of holotype. Scale 10 μm. 13. Side view of paratype (USNM 252179). Sample 416A-12-5, 30-35 cm. Scale 60 μm. 18. Apertural view of same specimen. Scale 30 μm. 14. Side view of paratype (USNM 252180). Sample 416A-17-3, 12-15 cm. Scale 60 μm. 15. Apertural view of same specimen. Scale 30 μm. 16. Apertural view of paratype (USNM 252498). Sample 416A-30-3, 143-144 cm. Scale 30 μm. 17. Side view of same specimen. Scale 60 μm.

PLATE 14

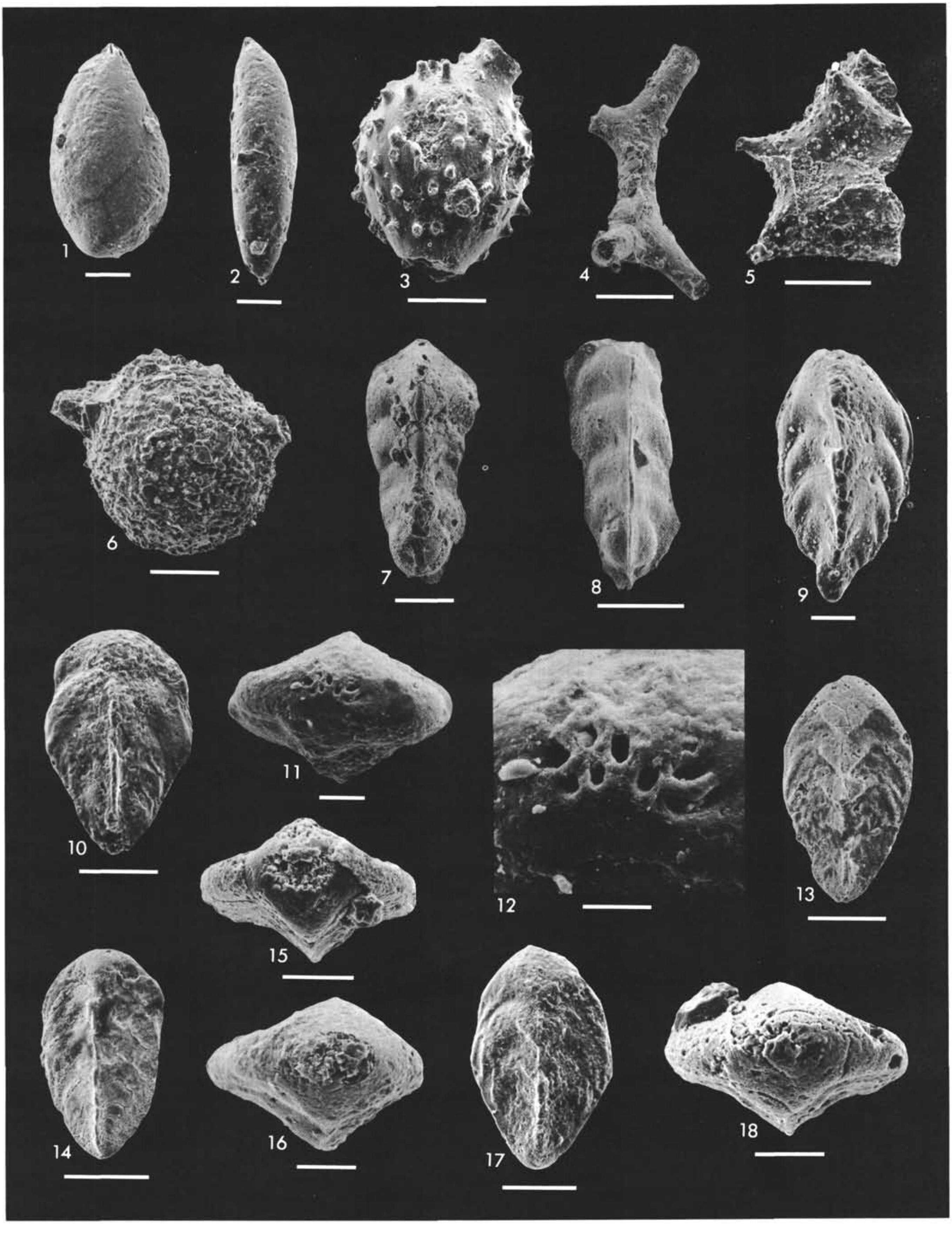


PLATE 15

Figures 1, 2	*Spirillina elongata* Bielecka and Pozaryski. Scale 30 μm. 1. Sample 416A-55-2, 7-9 cm. 2. Sample 416A-54, CC.
Figures 3, 4	*Spirillina minima* Schacko. 3. Sample 416A-35-3, 0-1 cm. Scale 60 μm. 4. Sample 416A-26-1, 36-38 cm. Scale 100 μm.
Figures 5, 6	*Spirillina tenuissima* Gümbel. Sample 416A-29-6, 4-5 cm. Scale 100 μm.
Figures 7-10	*Turrispirillina conoidea* (Paalzow). 7. Spiral view. Sample 416A-30-3, 143-144 cm. Scale 30 μm. 8. Umbilical view of same specimen. Scale 30 μm. 9. Umbilical view. Sample 416A-38, CC. Scale 50 μm. 10. Peripheral view of same specimen. Scale 30 μm.
Figures 11-15	*Patellina feifeli* (Paalzow). 11. Spiral view. Sample 416A-54, CC. Scale 60 μm. 12. Peripheral view of same specimen. Scale 30 μm. 13-15. Spiral, peripheral, and umbilical views of same specimen. Sample 416A-40-4, 83-85 cm. Scale 100 μm.

PLATE 15

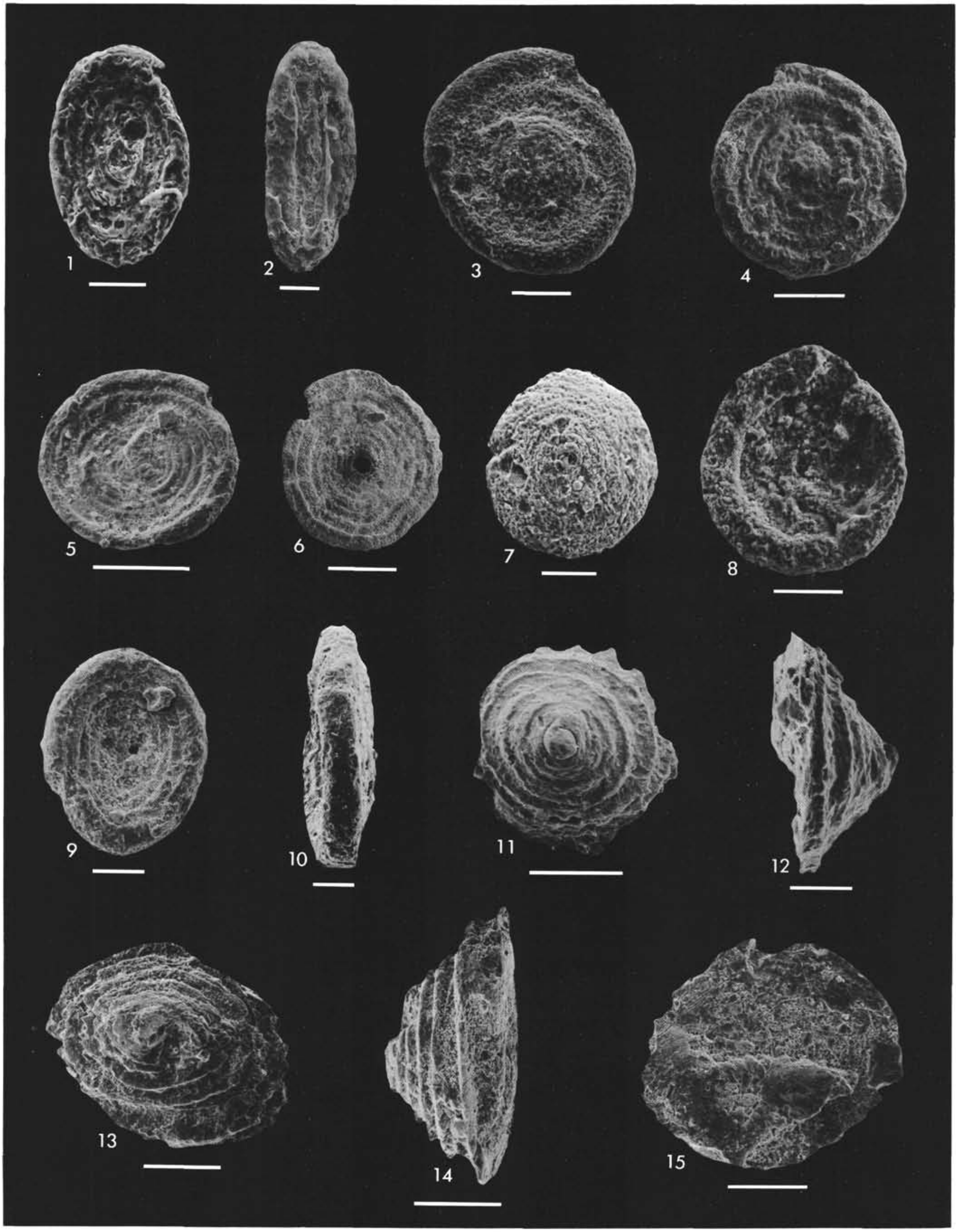


PLATE 16

Figures 1–4	*Patellina subcretacea* Cushman and Alexander. Scale 60 μm. 1–3. Spiral, peripheral and umbilical views of same specimen. Sample 416A-27-4, 135–137 cm. 4. Spiral view. Sample 416A-12-5, 30–32 cm.
Figures 5–7	*Patellina turriculata* Dieni and Massari. Spiral, peripheral, and umbilical views of same specimen. Sample 416A-17-3, 12–15 cm. 5. Scale 100 μm. 6, 7. Scale 60 μm.
Figure 8	*Guembelitria cenomana* (Keller). Sample 415A-15, CC. Scale 30 μm.
Figures 9–11	*Gubkinella graysonensis* (Tappan). Scale 30 μm. 9. Apertural view. Sample 415A-8, CC. 10. Spiral view. Sample 415A-8-2, 105–107 cm. 11. Side view. Sample 415A-8, CC.
Figures 12–14	*Heterohelix moremani* (Cushman). 12. Sample 415A-10-2, 15–18 cm. Scale 50 μm. 13. Sample 415A-9-2, 13–15 cm. Scale 30 μm. 14. Sample 415A-8-2, 105–107 cm. Scale 30 μm.
Figures 15, 16	*Globigerinelloides bentonensis* (Morrow). 15. Peripheral view. Sample 415A-12-2, 104–105 cm. Scale 100 μm. 16. Side view. Sample 415A-13-1, 64–66 cm. Scale 60 μm.

PLATE 16

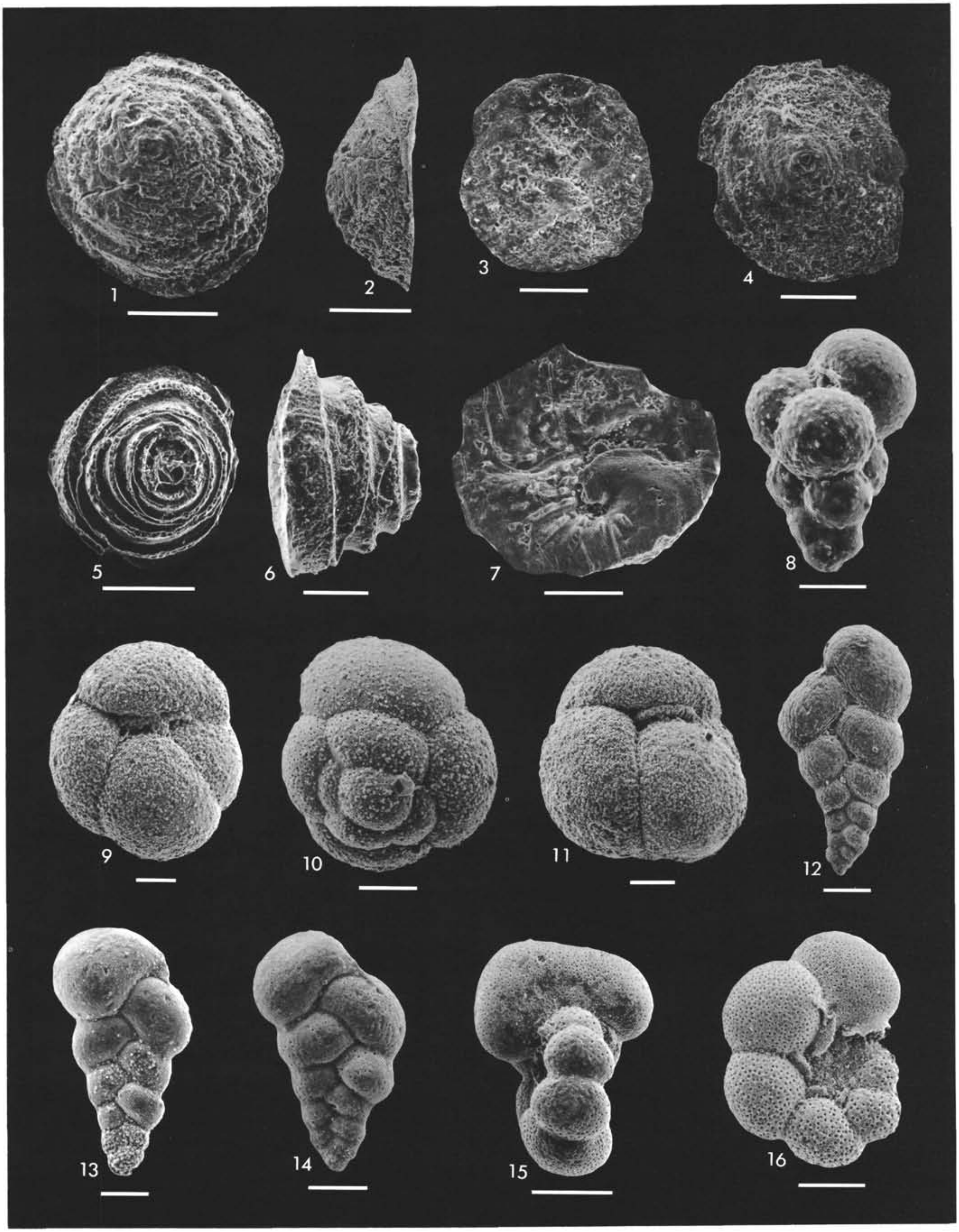


PLATE 17

Figure 1	*Globigerinelloides bentonensis* (Morrow). Peripheral view. Sample 415A-13-1, 64-66 cm. Scale 100 μm.
Figures 2, 3	*Globigerinelloides caseyi* (Bolli, Loeblich, and Tappan). Scale 30 μm. 2. Side view. Sample 415A-13-1, 64-66 cm. 3. Peripheral view. Sample 415A-14-1, 131-133 cm.
Figures 4, 8	*Schackoina cenomana* (Schacko). Scale 30 μm. 4. Side view. Sample 415A-11, CC, 13-15 cm. 8. Peripheral view. Sample 415A-13-1, 64-66 cm.
Figures 5-7, 9	*Schackoina multispinata* (Cushman and Wickenden) 5. Side view. Sample 415A-11, CC, 13-15 cm. Scale 30 μm. 6. Peripheral view. Sample 415A-12-1, 18-20 cm. Scale 30 μm. 7. Peripheral view. Sample 415A-12, CC. Scale 100 μm. 9. Side view. Sample 415A-12, CC. Scale 100 μm.
Figures 10-12	*Hedbergella delrioensis* (Carsey). Sample 415A-9-1, 88-90 cm. Scale 60 μm. 10. Umbilical view. 11. Peripheral view. 12. Spiral view.
Figures 13-16	*Hedbergella* sp. cf. *H. delrioensis* (Carsey). 13. Spiral view. Sample 415A-14-1, 131-133 cm. Scale 60 μm. 14. Peripheral view. Sample 415A-14-1, 131-133 cm. Scale 60 μm. 15. Umbilical view. Sample 415A-13-1, 64-66 cm. Scale 100 μm. 16. Spiral view. Sample 415A-11, CC, 13-15 cm. Scale 60 μm.

PLATE 17

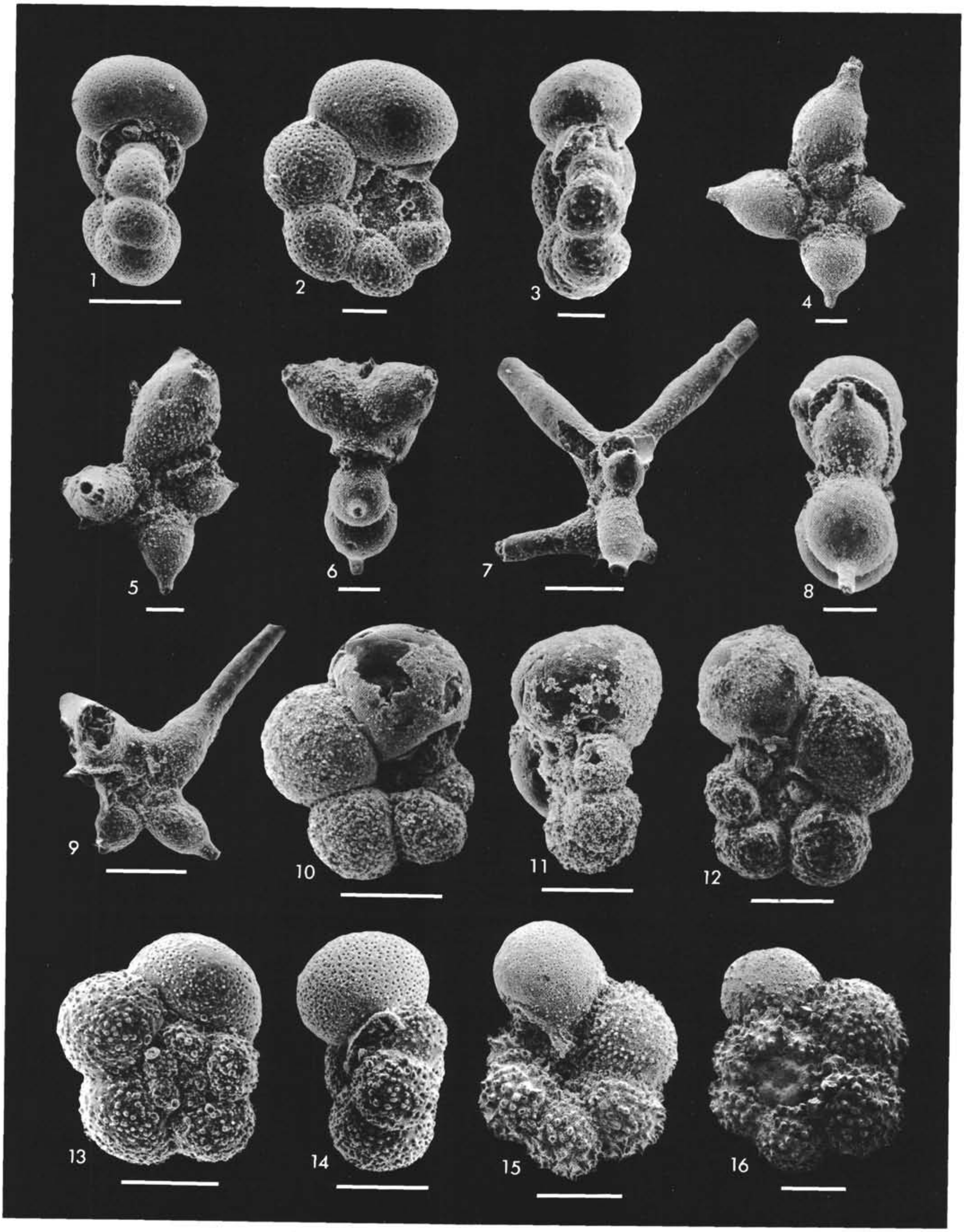


PLATE 18

Figures 1, 2 — *Hedbergella infracretacea* (Glaessner).
Sample 415A-14-1, 131-133 cm. Scale 30 μm.

Figures 3-6 — *Hedbergella planispira* (Tappan).
Scale 30 μm.
3. Spiral view. Sample 415A-9-1, 88-90 cm.
4. Peripheral view of same specimen.
5. Spiral view. Sample 415A-9-1, 88-90 cm.
6. Umbilical view. Sample 415A-8, CC.

Figures 7-10 — *Hedbergella simplicissima* (Magné and Sigal).
Scale 30 μm.
7. Spiral view. Sample 415A-15, CC.
8. Peripheral view. Sample 415A-15, CC.
9. Umbilical view. Sample 415A-15, CC.
10. Umbilical view. Sample 415A-11, CC, 13-15 cm.

Figures 11-14 — *Hedbergella* sp.
Sample 415A-11, CC, 13-15 cm. Scale 30 μm.
11. Spiral view.
12. Peripheral view.
13. Umbilical view of specimen in Figure 11.
14. Oblique peripheral view.

Figures 15, 16 — *Clavihedbergella simplex* (Morrow).
Scale 30 μm.
15. Umbilical view. Sample 415A-9-5, 10-12 cm.
16. Spiral view. Sample 415A-8, CC.

PLATE 18

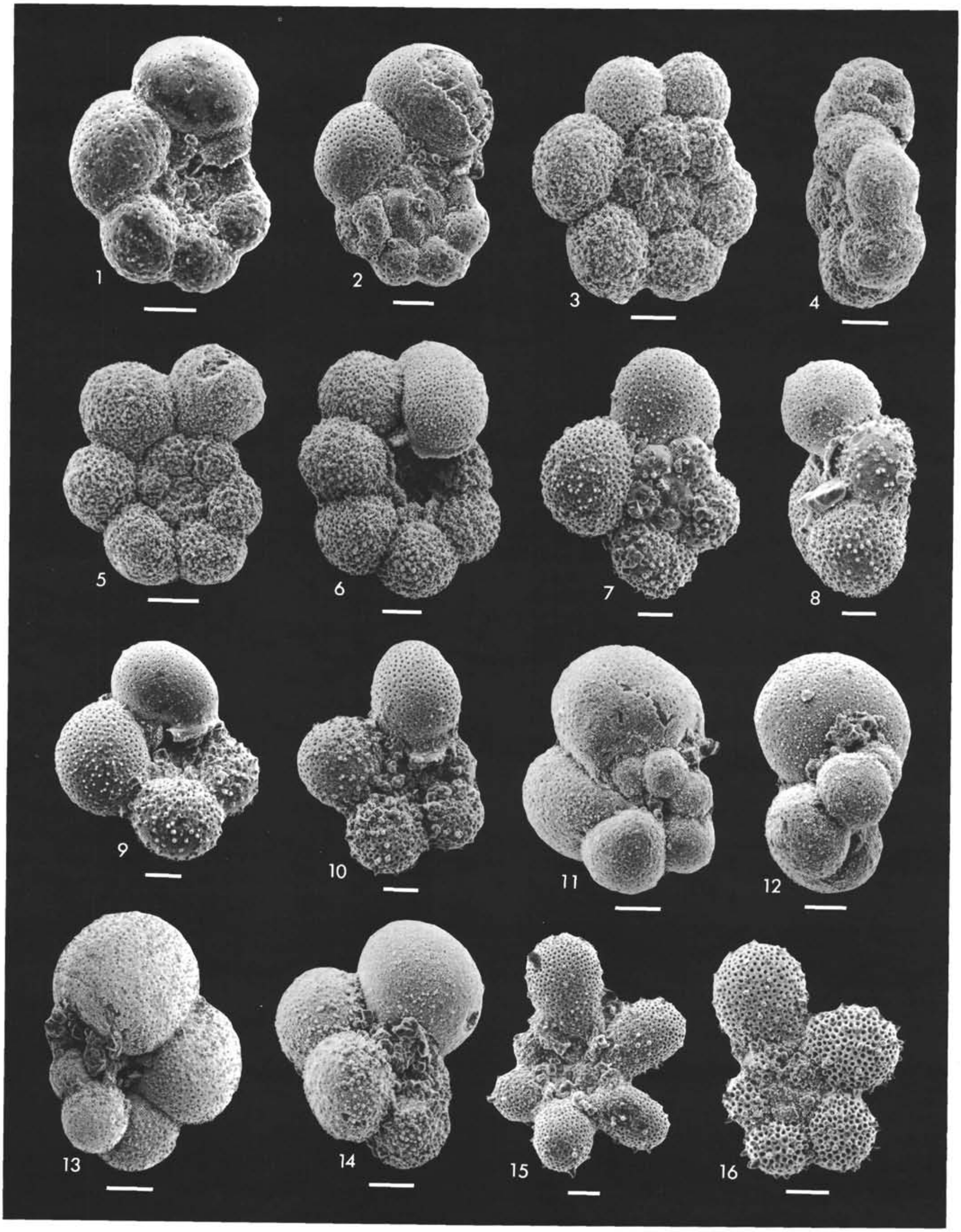


PLATE 19

Figures 1–3 — *Clavihedbergella simplex* (Morrow). Scale 100 μm.
1. Spiral view. Sample 415A-9-1, 88–90 cm.
2. Peripheral view of same specimen.
3. Umbilical view. Sample 415A-8, CC.

Figures 4–8 — *Praeglobotruncana delrioensis* (Plummer).
4. Spiral view. Sample 415A-8, CC. Scale 60 μm.
5. Umbilical view. Sample 415A-8, CC. Scale 100 μm.
6. Peripheral view. Sample 415A-11, CC, 13–15 cm. Scale 60 μm.
7. Spiral view. Sample 415A-11, CC, 13–15 cm. Scale 100 μm.
8. Umbilical view. Sample 415A-11, CC, 13–15 cm. Scale 60 μm.

Figures 9–11 — *Praeglobotruncana stephani* (Gandolfi). Sample 415A-9, CC. Scale 100 μm.
9. Spiral view.
10. Peripheral view.
11. Umbilical view.

Figure 12 — *Rotalipora appenninica* (O. Renz). Umbilical view. Sample 415A-10-2, 17–19 cm. Scale 200 μm.

Figures 13–16 — *Rotalipora cushmani* (Morrow). Sample 415A-11, CC, 13–15 cm. Scale 100 μm.
13. Spiral view.
14. Peripheral view of same specimen.
15. Umbilical view.
16. Peripheral view of same specimen.

PLATE 19

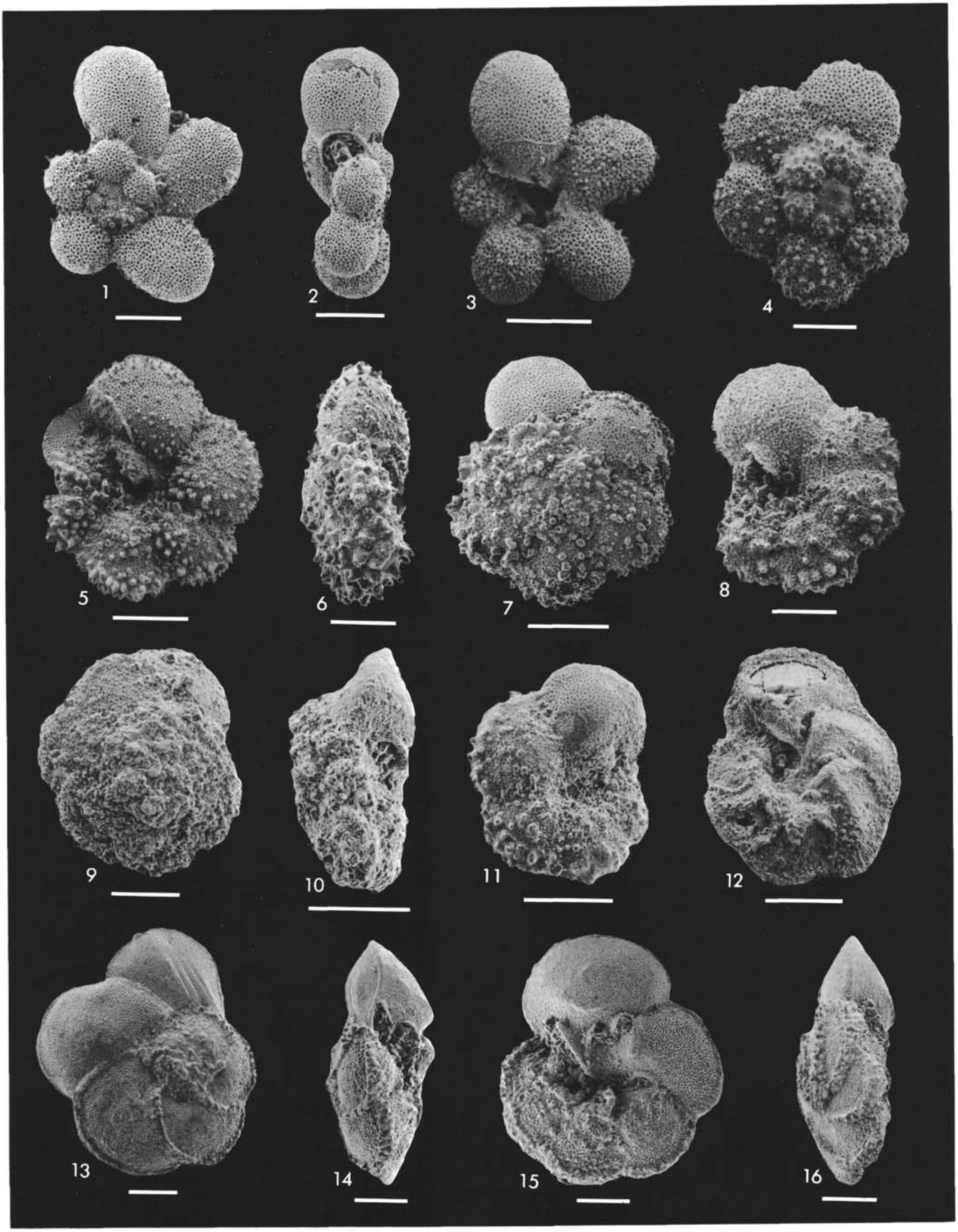


PLATE 20

Figures 1, 2	*Rotalipora cushmani* (Morrow). Sample 415A-11, CC, 13-15 cm. Scale 100 μm. 1. Spiral view. 2. Umbilical view of same specimen.
Figures 3-6	*Rotalipora evoluta* Sigal. Sample 415A-11, CC, 13-15 cm. Scale 100 μm. 3. Spiral view. 4. Peripheral view of same specimen. 5. Spiral view. 6. Umbilical view of same specimen.
Figures 7-12	*Trocholina infragranulata* Noth. Sample 416A-27-4, 135-137 cm. 7. Spiral view. Scale 100 μm. 8. Umbilical view of same specimen. Scale 100 μm. 9. Spiral view. Scale 60 μm. 10. Peripheral view. Scale 60 μm. 11. Umbilical view of specimen in Figure 9. Scale 60 μm. 12. Umbilical view. Scale 60 μm.
Figures 13, 14	*Trocholina conica* (Schlumberger). Sample 416A-54, CC. Scale 30 μm. 13. Umbilical view. 14. Peripheral view of same specimen.
Figures 15, 16	*Trocholina valdensis* (Reichel). Sample 416A-43-2, 30-32 cm. Scale 30 μm. 15. Umbilical view. 16. Peripheral view of same specimen.

PLATE 20

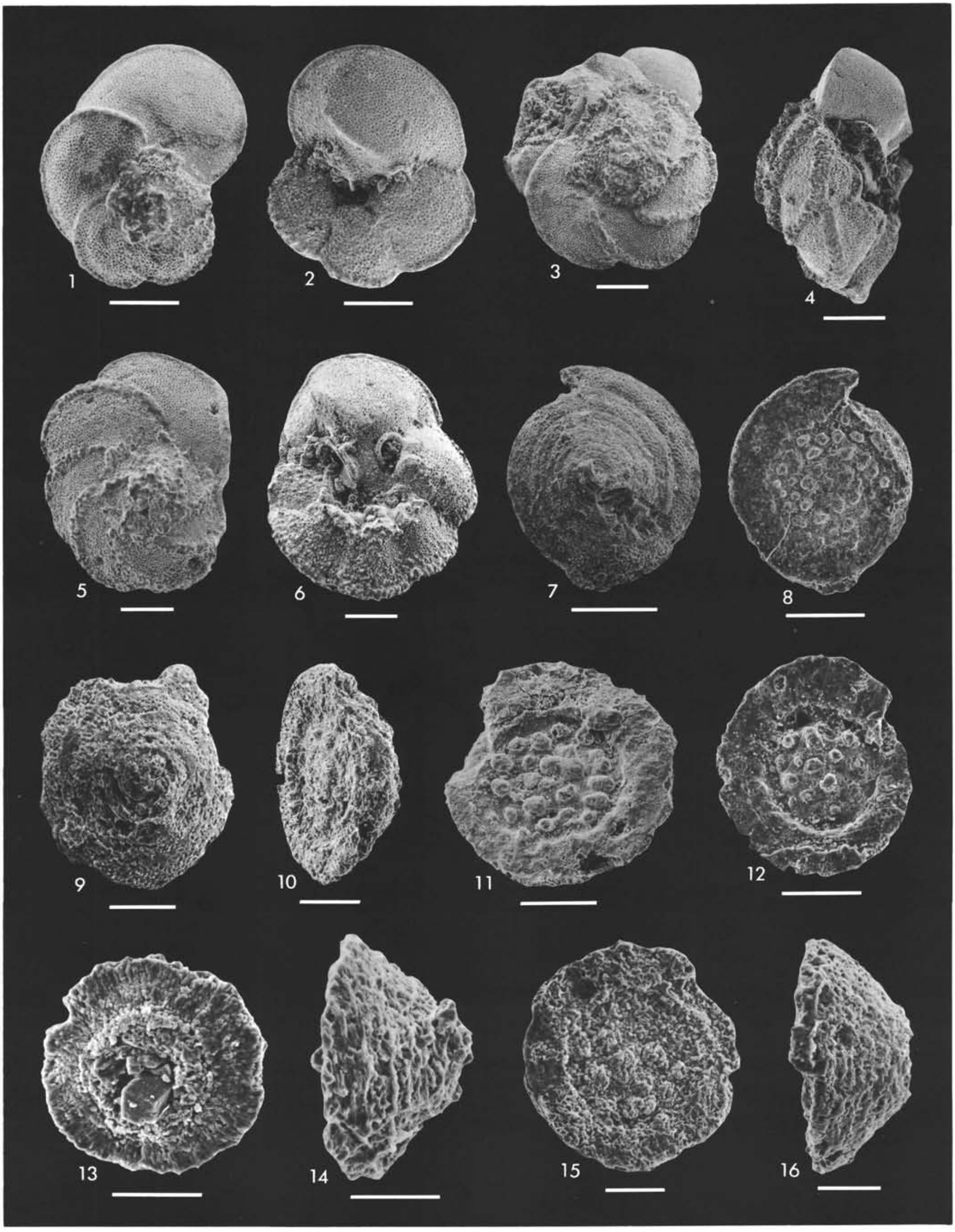


PLATE 21

Figures 1-3 *Trocholina valdensis* (Reichel). Scale 30 μm.
1. Spiral view of specimen on Plate 20, Figures 15-16. Sample 415A-43-2, 30-32 cm.
2. Peripheral view. Sample 416A-43-2, 30-32 cm.
3. Umbilical view. Sample 416A-40-4, 83-85 cm.

Figures 4-6 *Gavelinella barremiana* Bettenstaedt. Sample 416A-12-2, 144-146 cm.
4. Spiral view. Scale 30 μm.
5. Spiral view. Scale 50 μm.
6. Umbilical view. Scale 30 μm.

Figures 7, 8 *Gavelinella intermedia* (Berthelin).
Sample 416A-6, CC. Scale 60 μm.
7. Spiral view.
8. Umbilical view.

Figures 9-13 *Conorboides hofkeri* (Bartenstein and Brand). Scale 100 μm.
9. Spiral view. Sample 416A-45-1, 30-31 cm.
10. Peripheral view of same specimen.
11. Umbilical view of same specimen.
12. Peripheral view. Sample 416A-22-3, 108-109 cm.
13. Umbilical view of same specimen.

Figures 14-16 *Conorboides valendisensis* (Bartenstein and Brand).
Sample 416A-30-3, 143-144 cm. Scale 30 μm.
14. Spiral view.
15. Peripheral view of same specimen.
16. Umbilical view of same specimen.

PLATE 22

Figures 1-6 *Epistomina anterior* Bartenstein and Brand. Scale 100 μm.
1. Spiral view. Sample 416A-48, CC.
2. Peripheral view of same specimen.
3. Umbilical view of same specimen.
4. Spiral view. Sample 416A-41-4, 15-17 cm.
5. Umbilical view of same specimen.
6. Peripheral view of same specimen.

Figures 7, 8 *Epistomina coracolla* (Roemer).
Sample 416A-11-1, 57-59 cm.
7. Spiral view. Scale 100 μm.
8. Umbilical iew of same specimen. Scale 90 μm.

Figures 9, 10 *Epistomina* sp. cf. *E. carpenteri* (Reuss).
Sample 416A-38, CC. Scale 100 μm.
9. Spiral view.
10. Peripheral view of same specimen.

Figures 11, 13-15 *Epistomina uhlgi* Mjatliuk.
Sample 416A-55-2, 7-9 cm. Scale 100 μm.
11. Spiral view.
13. Spiral view.
14. Peripheral view.
15. Umbilical view.

Figures 12, 16 *Epistomina* sp.
Sample 416A-40-5, 34-36 cm. Scale 100 μm.
12. Umbilical view.
16. Spiral view of same specimen.

PLATE 21

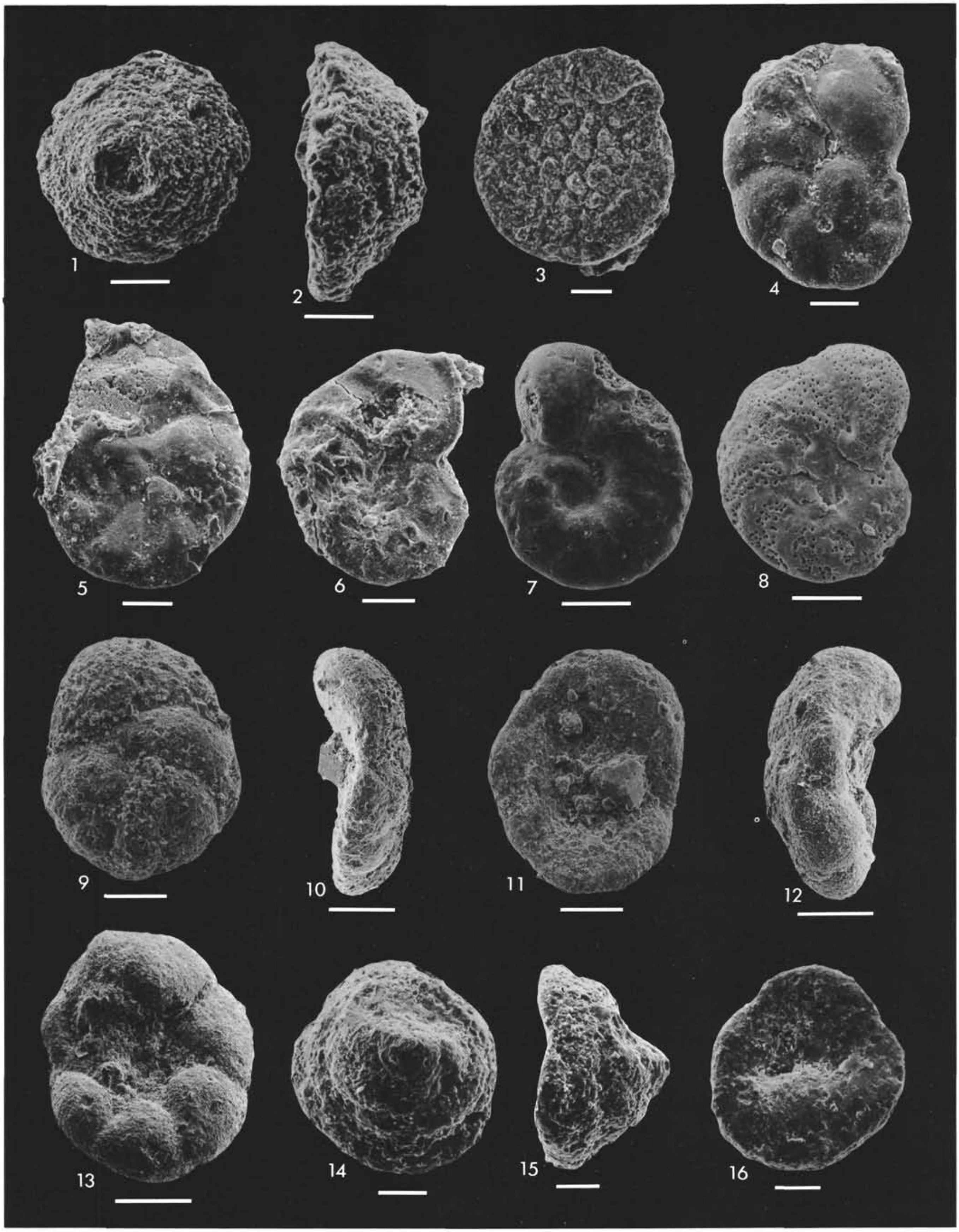
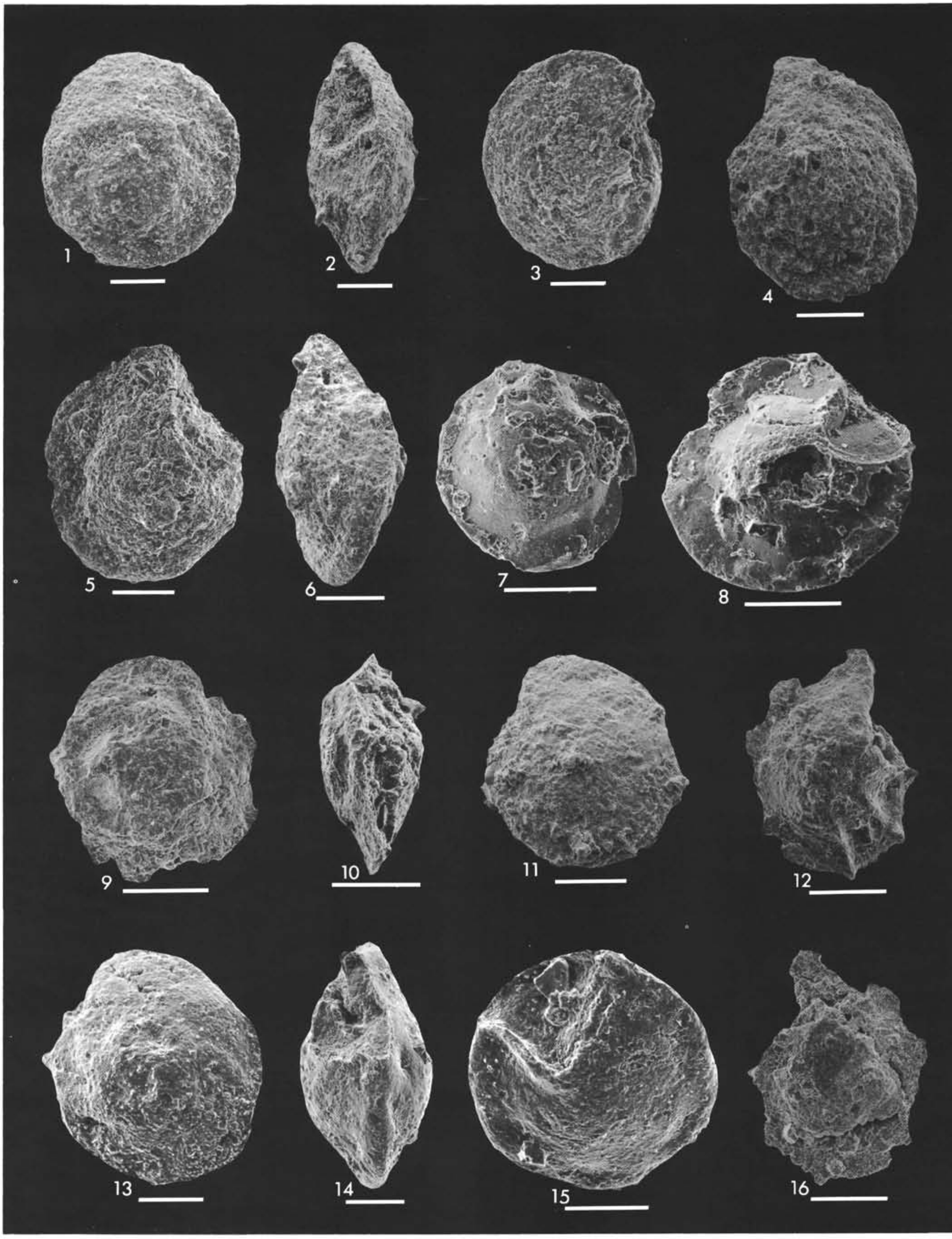


PLATE 22



APPENDIX 1
List of Foraminifers from Holes 415A and 416A

Ammobaculites(?) sp. cf. *A. cuyleri* Tappan
Ammobaculites euides Loeblich and Tappan
Ammobaculites irregularis (Gümbel) = *Marginulina irregularis* Gümbel
Ammobaculites suprajurassicus (Schwager) = *Haplophragmium suprajurassicum* Schwager
Ammodiscus rotalarius Loeblich and Tappan
Astacolus calliopsis (Reuss) = *Marginulina calliopsis* Reuss
Astacolus crepidularis (Roemer) = *Planularia crepidularis* Roemer
Astacolus gratus (Reuss) = *Cristellaria grata* Reuss
Astacolus incurvatus (Reuss) = *Cristellaria incurvata* Reuss
Astacolus mutilatus Espitalié and Sigal
Astacolus planiusculus (Reuss) = *Cristellaria planiuscula* Reuss
Bigenerina clavellata Loeblich and Tappan
Bigenerina jurassica (Haeusler) = *Pleurostomella jurassica* Haeusler
Citharina complanata perstriata (Tappan) = *Vaginulina complanata perstriata* Tappan
Citharina intumescens (Reuss) = *Vaginula intumescens* Reuss
Clavihedbergella simplex (Morrow) = *Hastigerinella simplex* Morrow
Conorboides hofkeri (Bartenstein and Brand) = *Conorbis hofkeri* Bartenstein and Brand
Conorboides valendisensis (Bartenstein and Brand) = *Conorbis valendisensis* Bartenstein and Brand
Dentalina communis d'Orbigny
Dentalina cylindroides Reuss
Dentalina distincta Reuss
Dentalina ejuncida Loeblich and Tappan
Dentalina gracilis d'Orbigny
Dentalina guttifera d'Orbigny
Dentalina jurensis (Gümbel) = *Vaginulina jurensis* Gümbel
Dentalina linearis (Roemer) = *Nodosaria linearis* Roemer
Dentalina nana Reuss
Dentalina pseudonana ten Dam
Dentalina soluta Reuss
Dentalina torta Terquem
Dentalina varians Terquem
Dorothia cornula (Reuss) = *Textularia cornulus* Reuss
Dorothia filiformis (Berthelin) = *Gaudryina filiformis* Berthelin
Dorothia hauteriviana (Moullade) = *Marssonella hauteriviana* Moullade
Dorothia kummi (Zedler) = *Marssonella kummi* Zedler
Dorothia praehauteriviana Dieni and Massari
Eoguttulina oolithica (Terquem) = *Polymorphina oolithica* Terquem
Epistomina anterior Bartenstein and Brand
Epistomina caracolla (Roemer) = *Gyroidina caracolla* Roemer
Epistomina sp. cf. *E. carpenteri* (Reuss) = *Rotalia carpenteri* Reuss
Epistomina uhligi Mjatliuk
Falsoguttulina wolburgi Bartenstein and Brand
Frondicularia didyma Berthelin
Frondicularia hastata hastata Roemer
Frondicularia intermittens Reuss
Frondicularia inversa Reuss
Frondicularia joidesi Maync
Frondicularia rehburgensis Bartenstein and Brand
Frondicularia simplicissima ten Dam
Gaudryina grandis (Crespin) = *Dorothia grandis* Crespin
Gaudryina neocomiensis (Mjatliuk) = *Verneuilina neocomiensis* Mjatliuk
Gavelinella barremiana Bettenstaedt
Gavelinella intermedia (Berthelin) = *Anomalina intermedia* Berthelin
Globigerinelloides bentonensis (Morrow) = *Anomalina bentonensis* Morrow
Globigerinelloides caseyi (Bolli, Loeblich, and Tappan) = *Planomalina caseyi* Bolli, Loeblich, and Tappan
Globulina exserta (Berthelin) = *Polymorphina exserta* Berthelin
Globulina prisca Reuss
Glomospira variabilis (Kubler and Zwingli) = *Cornuspira variabilis* Kubler and Zwingli
Glomospirella gaultina (Berthelin) = *Ammodiscus gaultinus* Berthelin
Gubkinella graysonensis (Tappan) = *Globigerina graysonensis* Tappan
Guembelitria cenomana (Keller) = *Gümbelina cenomana* Keller
Haplophragmoides concavus (Chapman) = *Trochammina concava* Chapman
Haplophragmoides haeusleri Lloyd
Haplophragmoides nonioninoides (Reuss) = *Haplophragmium nonioninoides* Reuss
Haplophragmium aequale (Roemer) = *Spirolina aequalis* Roemer
Haplophragmium inconstans erectum Bartenstein and Brand
Hedbergella delrioensis (Carsey) = *Globigerina cretacea* d'Orbigny var. *delrioensis* Carsey
Hedbergella sp. cf. *H. delrioensis* (Carsey)
Hedbergella infracretacea (Glaessner) = *Globigerina infracretacea* Glaessner
Hedbergella planispira (Tappan) = *Globigerina planispira* Tappan
Hedbergella simplicissima (Magné and Sigal) = *Hastigerinella simplicissima* Magné and Sigal
Heterohelix moremani (Cushman) = *Guembelina moremani* Cushman
Hippocrepina depressa Vasicek
Hyperammina gaultina ten Dam
Lagena globosa (Montagu) = *Vermiculum globosum* Montagu
Lagena hauteriviana cylindracea Bartenstein and Brand
Lagena hauteriviana hauteriviana Bartenstein and Brand
Lagena laevis (Montagu) = *Vermiculum laeve* Montagu
Lagena sp. cf. *L. meridionalis* Wiesner
Lagena ovata (Terquem) = *Oolina ovata* Terquem
Lagena oxystoma Reuss
Lagena sulcata (Walker and Jacob) = *Serpula (Lagena) sulcata* Walker and Jacob
Lagena sztejnae Dieni and Massari
Lenticulina busnardoi Moullade
Lenticulina eichenbergi Bartenstein and Brand
Lenticulina gaultina (Berthelin) = *Cristellaria gaultina* Berthelin
Lenticulina guttata (ten Dam) = *Planularia guttata* ten Dam
Lenticulina muensteri (Roemer) = *Robulina münsteri* Roemer
Lenticulina nodosa (Reuss) = *Robulina nodosa* Reuss
Lenticulina ouachensis multicella Bartenstein, Bettenstaedt, and Bolli
Lenticulina ouachensis ouachensis (Sigal) = *Cristellaria ouachensis* Sigal
Lenticulina praegaultina Bartenstein, Bettenstaedt, and Bolli
Lenticulina subalata (Reuss) = *Cristellaria subalata* Reuss
Lenticulina subangulata (Reuss) = *Cristellaria subangulata* Reuss
Lenticulina turgidula (Reuss) = *Cristellaria turgidula* Reuss
Lingulina lamellata Tappan
Lingulina loryi (Berthelin) = *Frondicularia loryi* Berthelin
Lingulina nodosaria Reuss
Lingulina pupa (Terquem) = *Marginulina pupa* Terquem
Lingulina semiornata Reuss
Lituotuba sp. cf. *L. nothi* (Majzon) = *Thalmannina nothi* Majzon
Marginulinopsis bettenstaedti (Bartenstein and Brand) = *Lenticulina (Marginulinopsis) bettenstaedti* Bartenstein and Brand
Marginulinopsis cephalotes (Reuss) = *Cristellaria cephalotes* Reuss
Marginulinopsis collignoni (Epistalié and Sigal) = *Lenticulina collignoni* Epistalié and Sigal
Marginulinopsis parkeri (Reuss) = *Marginulina parkeri* Reuss
Massilina sp. cf. *M. planoconvexa* Tappan
Miliammina valdensis Bartenstein and Brand
Nodobacularia nodulosa (Chapman) = *Nubecularia nodulosa* Chapman
Nodosaria sp. cf. *N. aspera* Reuss
Nodosaria sp. cf. *N. chapmani* Tappan
Nodosaria obscura Reuss
Nodosaria paupercula Reuss
Nodosaria prismatica Reuss
Nodosaria sceptrum Reuss
Nodosaria zippei Reuss
Opthalmidium sp. cf. *O. carinatum* (Kubler and Zwingli) = *Oculina carinatum* Kubler and Zwingli
Patellina feifeli (Paalzow) = *Trocholina feifeli* Paalzow
Patellina subcretacea Cushman and Alexander
Patellina turriculata Dieni and Massari
Praeglobotruncana delrioensis (Plummer) = *Globorotalia delrioensis* Plummer
Praeglobotruncana stephani (Gandolfi) = *Globotruncana stephani* Gandolfi
Psammosphaera fusca Schulze
Pseudonodosaria humilis (Roemer) = *Nodosaria humilis* Roemer
Pyrulina cylindroides (Roemer) = *Polymorphina cylindroides* Roemer
Ramulina aculeata Wright
Ramulina globotubulosa Cushman
Ramulina spandeli Paalzow
Recurvoides imperfectus (Hanzlikova) = *Haplophragmoides imperfectus* Hanzlikova
Reophax guttifer Brady
Reophax helveticus (Haeusler) = *Dentalina helveticus* Haeusler
Reophax horridus (Schwager) = *Haplostiche horrida* Schwager
Reophax minuta Tappan
Reophax multilocularis Haeusler
Reophax pilulifer Brady
Rhizammina indivisa Brady
Rotalipora appenninica (O. Renz) = *Globotruncana appenninica* O. Renz
Rotalipora cushmani (Morrow) = *Globorotalia cushmani* Morrow
Rotalipora evoluta Sigal
Saccammina lathrami Tappan
Saracenaria compacta Epistalié and Sigal
Saracenaria cushmani Tappan
Saracenaria frankei ten Dam
Saracenaria saxonica saxonica (Bartenstein and Brand) = *Lenticulina (Lenticulina) saxonica saxonica* Bartenstein and Brand
Schackoina cenomana (Schacko) = *Siderolina cenomana* Schacko
Schackoina multispinata (Cushman and Wickenden) = *Hantkenina multispinata* Cushman and Wickenden
Spirillina elongata Bielecka and Pozaryski
Spirillina minima Schacko
Spirillina tenuissima Gümbel
Spiroloculina duestensis Bartenstein and Brand
Spiroplectammina ammovitrea Tappan
Spiroplectammina longa Lalicker
Spiroplectammina sp. cf. *S. obscura* Said and Barakat
Spiroplectinata complanata (Reuss) = *Proroporus complinatus* Reuss
Textularia cordiformis Schwager
Textularia foeda Reuss
Triloculina meotica Loeblich and Tappan
Tristix acutangula (Reuss) = *Rhabdogonium acutangulum* Reuss
Tristix excavata (Reuss) = *Rhabdogonium excavatum* Reuss
Tristix lanceola Sliter, n. sp.
Tristaxia subrotunda ten Dam
Trochammina depressa Lozo
Trochammina globigeriniformis (Parker and Jones) = *Lituola nautiloidea* var. *globigeriniformis* Parker and Jones
Trochammina neocomiana Mjatliuk
Trochammina quinqueloba Geroch
Trochammina suprajurassica Seibold
Trochammina umiatensis Tappan
Trocholina conica (Schlumberger) = *Involutina conica* Schlumberger
Trocholina infragranulata Noth
Trocholina valdensis (Reichel) = *Neotrocholina valdensis* Reichel
Turrispirillina conoidea (Paalzow) = *Spirillina conoidea* Paalzow
Vaginulina angustissima Reuss
Vaginulina debilis (Berthelin) = *Marginulina debilis* Berthelin
Vaginulina gaultina Berthelin
Vaginulina recta Reuss
Vaginulinopsis excentrica (Cornuel) = *Cristellaria excentrica* Cornuel
Vaginulinopsis matutina (d'Orbigny) = *Cristellaria matutina* d'Orbigny
Vaginulinopsis pseudodebilis (Dieni and Massari) = *Marginulina pseudodebilis* Dieni and Massari
Vaginulinopsis reticulosa ten Dam
Vaginulinopsis schloenbachi (Reuss) = *Cristellaria schloenbachi* Reuss

APPENDIX 2
Barren Samples or Those with Non-diagnostic Foraminifer Faunas from Hole 416A

Sample	Sample	Sample
416A-7-2, 15-19	416A-23-4, 16-17	416A-41-5, 3-5
416A-7-2, 83-85	416A-24-1, 65-67	416A-41-5, 26-28
416A-9-1, 85-86	416A-24-2, 128-130	416A-42-1, 41-43
416A-11-2, 110-112	416A-25, CC	416A-42-2, 109-111
416A-11-3, 2-4	416A-26-3, 129-131	416A-42-3, 97-99
416A-12-1, 83-85	416A-26, CC	416A-42, CC
416A-13-2, 63-65	416A-27, CC	416A-43-3, 34-36
416A-14-3, 78-79	416A-28-4, 83-85	416A-44-1, 102-104
416A-15-2, 144-146	416A-29-1, 4-6	416A-45-2, 127-129
416A-15-3, 20-22	416A-30-1, 145-147	416A-45-2, 57-59
416A-15-4, 118-120	416A-30-4, 147-148	416A-46-1, 98-100
416A-16-1, 105-107	416A-30, CC	416A-46-2, 90-92
416A-16-3, 119-120	416A-32, CC	416A-46-3, 114-116
416A-16-5, 27-29	416A-34-1, 5-7	416A-47-1, 109-111
416A-17-2, 149-150	416A-35-2, 9-10	416A-48-1, 124-126
416A-17-4, 11-13	416A-35, CC	416A-48-2, 59-61
416A-18-2, 23-25	416A-36, CC	416A-49-2, 116-118
416A-18-3, 49-51	416A-37-3, 29-31	416A-50-1, 144-146
416A-18-4, 80-81	416A-37-3, 63-65	416A-50-2, 98-100
416A-18, CC	416A-38-1, 23-25	416A-50, CC
416A-19-1, 42-44	416A-38-2, 6-7	416A-51-1, 81-83
416A-19-3, 54-55	416A-38-2, 33-35	416A-53-1, 53-55
416A-19-4, 86-88	416A-40-2, 71-73	416A-53-1, 80-82
416A-19-5, 40-42	416A-40-3, 4-6	416A-53-2, 17-19
416A-20-3, 46-48	416A-40-3, 91-93	416A-55-2, 27-29
416A-21-2, 149-150	416A-40-4, 139-141	416A-55-2, 44-47
416A-22-1, 103-105	416A-40-6, 101-103	416A-57-1, 27-29
416A-23-1, 64-66	416A-41-2, 28-30	416A-57-1, 104-106
416A-23-2, 95-96	416A-41-3, 110-112	

APPENDIX 3

Distribution of Jurassic and Cretaceous foraminifers at Site 416. Abundances based on total fauna recovered from 10-cm^3 samples.

System	Stage	Sample (Interval in cm)	*Bigenerina jurassica*	*Haplophragmoides* sp.	*Lituotuba* sp. cf. *L. nothi*	*Trochammina neocomiana*	*Haplophragmium inconstans erectum*	*Hyperammina gaultina*	*Reophax helveticus*	*Glomospira variabilis*	*Glomospirella gaultina*	*Rhizammina indivisa*	*Lenticulina subalata*	*Dentalina jurensis*	*Eoguttulina oolithica*	*Dentalina ejuncida*	*Lagena ovata*	*Spirillina minima*	*Spirillina tenuissima*	*Nodobacularia nodulosa*	*Dentalina pseudonana*	*Trochammina quinqueloba*	*Trochammina globeriginiformis*	*Epistomina uhligi*	*Textularia cordiformis*	*Dentalina torta*	*Dentalina cylindroides*	*Astacolus gratus*	*Ramulina spandeli*	*Lenticulina muensteri*	*Vaginulinopsis excentrica*	*Dentalina gracilis*	*Haplophragmium aequale*	*Ammobaculites irregularis*	*Psammosphaera fusca*
Cretaceous	a	416A-5-CC																																	
	Aptian-Albian	6-1, 43-45									1																								
		6-2, 55-57						13		5	4	3																							
		6-3, 93-95						10			22																								
		6-3, 136-138						4			24	13																							
		6-4, 24-26						5		2	14																								
		6–CC																												1					
	Hauterivian-Barremian (?)	7-1, 49-51									1								3											2	1				
		7-1, 119-121								5	28																1					2			
		7-3, 33-35									10		3					2												10	9	6			
		7-3, 125-127											2					6	3									1		9	3	3			
		8-6, 145-147						2			1																1	1						2	
	Hauterivian	9-3, 98-102						14			20	1	11					7	2								2			23	3	5			
		9-5, 93-95																1										1				3			
		10-1, 141-143						10																											
		10-2, 0-2						24																											
		10-2, 71-72											1					1												1		2			
		11-2, 110-112						7		2			20									14					1			17					
		11-5, 45-46						1										6	5									2		5	1				
		11-6, 61-63											2														1			1					
		12-2, 144-146																	7											2		1			
		12-3, 17-19						2			2	14										5								7					
		12-4, 118-120						17																			1	1		4					
		12-5, 30-32											7					3	1									4		16	1				
		13-2, 118-120										6										8								9					
	Valanginian	14-1, 69-71						6			1	2										26								2		1			
		14-1, 119-120																														2			
		14-2, 114-116						13				2	5																	5					
		14-2, 116-118						3				2	9															1		4					
		14-4, 51-53										11										1								8					
		14-5, 137-139						8		5	1	12	1									53								11					
		15-1, 38-39						1			1		3					1	5			9								14	2	4			
		15-5, 139-141																3	2													1			
		15-6, 74-76																	10											3		5			
		16-2, 66-68						13				3																							
		17-3, 12-15											2					7	19	1										6	2				
		17 CC																3	1											3	3				
		18-1, 66-68						1											14								1					3			
		19-2, 111-113									1							3	9	3												3			
		20-1, 11-12																1	7								1			1		2			
		21-5, 117-119											1					4	11			2													
		22-3, 108-109										1	7					9	2									1		16	4	2			
		22-4, 119-121																4	2											3	1				
		23-5, 9-11																3	5											2					
		23-5, 59-60											2					4	4											3	1	3			
		24-3, 36-38						2										5	2											5	2	2			
		25-1, 6-7																	11								1								
		25-3, 51-52								4	3		1									24					1							1	
		25-4, 125-127						3		2									3			5								1					
		26-1, 36-38						3			3							10	6								3	1		9	4				
		26-4, 11-13									1	1						8		1								1				2			
		27-1, 44-46						1											7	2															
		27-4, 135-137						1										10	4									2		3		1			

APPENDIX 3 — *Continued*

Gaudryina neocomiensis	Reophax multilocularis	Reophax sp.	Trochammina suprajurassica	Turrispirillina conoidea	Ammobaculites suprajurassicus	Spirillina elongata	Trocholina conica	Lagena globosa	Pseudonodosaria sp.	Patellina feifeli	Ammodiscus sp.	Haplophragmoides haeusleri	Astacolus incurvatus	Dentalina nana	Ophthalmidium spp.	Spiroloculina spp.	Triloculina spp.	Lagena oxystoma	Hippocrepina depressa	Pyrulina cylindroides	Dentalina communis	Vaginulinopsis matutina	Vaginulina debilis	Haplophragmoides concavus	Epistomina anterior	Reophax horridus	Gaudryina grandis	Reophax pilulifer	Dorothia cornula	Globulina prisca	Bigenerina clavellata	Miliammina valdensis	Conorboides valendisensis	Vaginulinopsis sp. A	Dentalina distincta	Trocholina valdensis	Saracenaria cushmani	Astacolus planiusculus	Dorothia kummi	Vaginulinopsis sp. B	Conorboides hofkeri
																								4																		
																								2																		
																								4																		
														1																			1												
																					1			8									1												
														1								1	4			19							16									
															2							10		1	1																	
				2				4						2	1								2										1								1	2			
																						1	3						1					1	4										1		
					1			1						2		2						4	16			7					1			5									4	5		
																								1	5															2	2			
									1													1																					
									2						1								1			27				1	8						1							
							2								3		3			3			5			1								2										5		
																							1			3										1											
				1				3						2					3			3																1		1					
																										4			5														1						
	3																			1			1		5								3	1				2						
				2				2					3			1		3			8		2						2	2					2		3					
														1										1		3	8								1												
	3																								1			9																		
										3					1					1			5		6	2								1	1									1			
																1						1	3																					
																							2			11					1											1			
																							3		3	15									5												
	1					4			3					3	2						4			7			5							3					1		1				1
					2														1		3			2			5							2												1		
									3						1										6										1										2	1		
																									1																							
				2	6			1						1								4		4							4										1		10		
					2	1																																						1	3		
									1							1		2					2	5																		1		
							2		1										4		5		1	4																				6		
				2	2			1						2		1					1			3		2							1					1				1	4		
							1														1		2	3				1					3												
					10									3	2	6	10	1				2	1								1					1					8		2
					1	1		1																																	1		
					2									3		3	1		1			5																		1				
					4	1										2						4																						2		
																1								2																		1		1		
					1												3							2																						
									1						1	1						1		3			4					2	1										1	1		
																1			1					4	1		2																			3			
					2	1		1						1		15	1					9	1	2														2		1		5		
							2		1								4						1	6																			1				
							1																	3		1																					
					1					1															2		1								1					1				1	1		

APPENDIX 3 — *Continued*

System	Stage	Sample (Interval in cm)	*Lagena sztejnae*	*Ramulina aculeata*	*Lenticulina subangulata*	*Lingulina nodosaria*	*Vaginulinopsis* sp. C	*Lagena laevis*	*Falsoguttulina wolburgi*	*Astacolus calliopsis*	*Pseudonodosaria humilis*	*Citharina intumescens*	*Dentalina linearis*	*Epistomina* sp.	*Marginulinopsis bettenstaedti*	*Spiroplectammina* sp. cf. *S. obscura*	*Saracenaria saxonica*	*Lenticulina busnardoi*	*Lingulina* sp.	*Epistomina* sp. cf. *E. carpenteri*	*Nodosaria* sp. cf. *N. aspera*	*Astacolus crepidularis*	*Saracenaria frankei*	*Nodosaria sceptrum*	*Nodosaria paupercula*	*Nodosaria obscura*	*Lingulina pupa*	*Lenticulina ouachensis ouachensis*	*Saracenaria compacta*	*Vaginulina recta*	*Frondicularia rehburgensis*	*Dentalina varians*	*Nodosaria zippei*	*Lingulina loryi*
Cretaceous	a	416A-5-CC																																
	Aptian-Albian	6-1, 43-45																																
		6-2, 55-57																																
		6-3, 93-95																																
		6-3, 136-138																																
		6-4, 24-26																																
		6–CC																				1												
	Hauterivian-Barremian(?)	7-1, 49-51									2												1											
		7-1, 119-121																												1				
		7-3, 33-35		3			1				2	3					1					4	3					2						
		7-3, 125-127									2	2					1					3	2					2		3				1
		8-6, 145-147																																
	Hauterivian	9-3, 98-102		5	4						3	10	2									1		2	2			7		6			1	1
		9-5, 93-95									1																	1						
		10-1, 141-143									1																							
		10-2, 0-2																																
		10-2, 71-72		1																														
		11-2, 110-112			6						7		1								1							4						5
		11-5, 45-46		2						1	3										1							2		1				1
		11-6, 61-63		3							3																							
		12-2, 144-146		5													1						3									1		
		12-3, 17-19		1	3						3																	1						4
		12-4, 118-120		1	2			1																										
		12-5, 30-32		4	7			1			2											2	2					6		1				1
		13-2, 118-120		1	5						1																							2
	Valanginian	14-1, 69-71			2																									1				
		14-1, 119-120		4		1	1	1		1	1												1		1									
		14-2, 114-116			3						4							6										2		3				
		14-2, 116-118			5													4										5		1				
		14-4, 51-53			2												1																	
		14-5, 137-139		3	5						1																						3	
		15-1, 38-39		10	2					2	4										2	1	7		2							3		2
		15-5, 139-141		2																														
		15-6, 74-76	1	5								1																						
		16-2, 66-68																					1											
		17-3, 12-15				1											1					1	11		1					2				
		17 CC															1					1	1											
		18-1, 66-68		1									1																					
		19-2, 111-113		3							2	2									1		2	1										
		20-1, 11-12	1					1				3											6		1									
		21-5, 117-119				2		2																										
		22-3, 108-109		3	10						9						4	13			1	3	2							4				
		22-4, 119-121									3	2					1						1											2
		23-5, 9-11	1		1			1				1	1									1	1	2										
		23-5, 59-60	1									5					3						4		1									
		24-3, 36-38								1	4	4			1			4																
		25-1, 6-7																																
		25-3, 51-52	1									1						1														1	1	3
		25-4, 125-127		1	1							3											2		1									2
		26-1, 36-38		5		1					10	7			1		4	2				2	1							1		3		3
		26-4, 11-13										1													1								1	
		27-1, 44-46		3				1		1																								
		27-4, 135-137			2					1		1					1	1					1											3
		28-1, 17-19		22								1											1	1	1									
		28-2, 0-2	1									1										2		1	2									

APPENDIX 3 — *Continued*

Dorothia praehauterviana	*Frondicularia joidesi*	*Patellina subcretacea*	*Frondiculina inversa*	*Lagena sulcata*	*Lagena hauteriviana hauteriviana*	*Tristix lanceola*	*Lingulina semiornata*	*Tristix acutangula*	*Tristix excavata*	*Kyphopyxa* sp.	*Globulina exserta*	*Frondicularia simplicissima*	*Epistomina caracolla*	*Vaginulinopsis schloenbachi*	*Trocholina infragranulata*	*Marginulinopsis parkeri*	*Ammobaculites euides*	*Frondicularia* sp.	*Lenticulina* sp. A	*Frondicularia intermittens*	*Frondicularia hastata hastata*	*Lenticulina praegaultina*	*Nodosaria* sp. cf. *N. chapmani*	*Tritaxia subrotunda*	*Ammodiscus rotalarius*	*Lenticulina nodosa*	*Lenticulina turgidula*	*Dentalina guttifera*	*Reophax guttifer*	*Dentalina soluta*	*Patellina turriculata*	*Dorothia filiformis*	*Saccammina lathrami*	*Lenticulina guttata*	*Lagena* sp. cf. *L. meridionalis*	*Vaginulinopsis* sp. D	*Vaginulinopsis pseudodebilis*	*Trochammina depressa*	*Marginulinopsis cephalotes*	*Marginulinopsis collignoni*	*Lenticulina* sp. B
																									1								2								
																									12																
																									2																
																											2	1													
																												1													
																												1													
			1					2														3												1						1	
																																						2			
1	1		1										1									3		1		1	1											2		1	
					1												2																					1			
	1																									1															
	2												1				10					4				1	7											5			
	4			1	1	1			3			1															1	2			5									2	1
								1																										2						1	
				1																																					1
						1																	2															4			
																	9										1														
	1	3				3		3									1					12		1			1							1					6	1	2
					1											1																1						4			
																						1																8			
	3																					8				3								1			1				
	2																					6				4										1					
																	1																1								
																						1			2	1						12	1								
4	2		1			1	1	1								1				1		4					6					1	1	5	1						
2								1							1																										
		1																							1																
				2																																					
6	1	2		6	1	2																1								2	2										
2		2													7									1																	
					1																																				
			1																			1			3			1													
2		1				2									2	1						1					1			2											
					1																							2													
10	1		3					2							12							10	1	7	7	1	1	1	2												
1															2							2																			
2					1																1																				
4				2	1	1														1																					
			1			1										2				1																					
1																																									
								2											2																						
						2								1			1	1																							
2	1		1												5	1																									
						1		1																																	
1		1		2		1									17																										
						3																																			
						2																																			

APPENDIX 3 — *Continued*

System	Stage	Sample (Interval in cm)	*Dorothia hauteriviana*	*Nodosaria prismatica*	*Gavelinella barremiana*	*Recurvoides imperfectus*	*Lenticulina ouachensis multicella*	*Vaginulina angustissima*	*Astacolus mutilatus*	*Lagena hauteriviana cylindracea*	*Lenticulina* sp. C	*Reophax minuta*	*Citharina complanata perstriata*	*Lenticulina eichenbergi*	*Frondicularia didyma*	*Vaginulinopsis reticulosa*	*Hedbergella planispira*	*Gavelinella intermedia*	*Haplophragmoides nonioninoides*	*Trochammina umiatensis*	*Spiroplectammina ammovitrea*	*Ammobaculites* sp. cf. *A. cuyleri*	*Spiroplectammina longa*	*Hedbergella infracretacea*	*Hedbergella delrioensis*
Cretaceous	a	416A-5-CC															3							1	2
	Aptian-Albian	6-1, 43-45				2													3	13					
		6-2, 55-57				36													2	17			2		
		6-3, 93-95				7														147	28	6			
		6-3, 136-138				11														28	2				
		6-4, 24-26				23													19	5					
		6-CC															1	2							
	Hauterivian-Barremian (?)	7-1, 49-51																							
		7-1, 119-121																							
		7-3, 33-35	59	1			1							1	2	1									
		7-3, 125-127	16										1												
		8-6, 145-147	7		1							1													
	Hauterivian	9-3, 98-102	3			2	5	1	8	5	1														
		9-5, 93-95																							
		10-1, 141-143																							
		10-2, 0-2																							
		10-2, 71-72																							
		11-2, 110-112				1																			
		11-5, 45-46	3																						
		11-6, 61-63	1																						
		12-2, 144-146	6	1	3																				
		12-3, 17-19	109																						

[a] Albian-Cenomanian
[b] fine sand
[c] coarse sand

APPENDIX 3 — *Continued*

System	Stage	Sample (Interval in cm)	*Bigenerina jurassica*	*Haplophragmoides* sp.	*Lituotuba* sp. cf. *L. nothi*	*Trochammina neocomiana*	*Haplophragmium inconstans erectum*	*Hyperammina gaultina*	*Reophax helveticus*	*Glomospira variabilis*	*Glomospirella gaultina*	*Rhizammina indivisa*	*Lenticulina subalata*	*Dentalina jurensis*	*Eoguttulina oolithica*	*Dentalina ejuncida*	*Lagena ovata*	*Spirillina minima*	*Spirillina tenuissima*	*Nodobacularia nodulosa*	*Dentalina pseudonana*	*Trochammina quinqueloba*	*Trochammina globeriginiformis*	*Epistomina uhligi*	*Textularia cordiformis*	*Dentalina torta*	*Dentalina cylindroides*	*Astacolus gratus*	*Ramulina spandeli*	*Lenticulina muensteri*	*Vaginulinopsis excentrica*	*Dentalina gracilis*	*Haplophragmium aequale*	*Ammobaculites irregularis*	*Psammosphaera fusca*
Cretaceous	Valanginian	28-1, 17-19						1										2	7									1							
		28-2, 0-2									1		2						25									1		2		1			
		28-4, 11-13[b]						1										18	8	2										1					
		28-4, 11-13[c]																2	1									2		6	3				
		28-5, 123-125						3			2	2	4						1									3							
		28-6, 149-151					1				2	1							6											3	2				
		28 CC									1																	3							
		29-3, 59-60						1					3					8	9											5		1			
		29-4, 26-28										2						2	6			7					1								
		29-5, 3-5					1	6				1							1			6						3				2		2	
		29-6, 4-5						2					1					9	24								2	2							
		30-2, 58-60						4			1		2					3	1								1			1					
		30-3, 143-144											1						10																
		30-5, 36-38																4	2											2					
		31-1, 16-18																5	8									1							
		31-3, 7-9											5					26												6					
		31-4, 124-126										1																							
		31-5, 137-140										2						1	5																
		31-6, 99-100									2		3					2	4								1								
		32-3, 83-85						3				1	1					6	27								1								
		32-4, 104-106											4					16	2											4		1			
		34 CC											5					2												15		2			
		35-2, 143-145						15		12	10	9						3				7					3								
		35-3, 0-1											5					4	1											2					
		36-2, 68-70						1										10	3								2					1			
		36-2, 96-97																4														2			
		37-2, 44-46																4																	
		37 CC								1	6		5						4			11												3	
		38 CC								3	1	1	2					1	1			1					1							7	
		39 CC																4									1					1			
		40-4, 83-85											10					17	3											3		8			
		40-4, 91-93						1		1	4		3									6										1		2	
		40-5, 34-36					1			1																								1	
		40-5, 146-148						25																								2			
		40 CC (green)								6		6										1										2		3	1
		40 CC (red)					1	5		3	1	6	1					1	2			3					2					2			1
		41-1, 110-112					2	1		1												1													
		41-3, 28-30						3		5	1	7										1										1		4	
		41-4, 15-17					1			4	1		1									3										1			
		42-1, 26-27						7		3	7	2	3						2			14					3					2		3	
		42-3, 70-72					1	3		6			9						1			4					2			1				4	
		43-2, 30-32					2	1		6	1	4							10			6					3			3		5			
		43-3, 107-109					1			2	3	3															1					3			
		43-4, 105-107										3																							
		43 CC						1											9											2					
		44 CC					3	1			3	13							2			3										3		2	
		45-1, 30-31										1	1					3	3													6			
		45-1, 36-38						3										6	17													6			
		45-2, 131-133					1			1	2	2							6			1					2								
		45-3, 71-73								4	7	2	2														3					4		3	
		46-2, 64-66																3									5					2			
		46-3, 46-48										3							5			4					4					3			
		46-4, 83-85										4						1				1										2		2	
		46 CC (green)						9		5	10	3							3			18					2					7			
		46 CC (red)									2	1							2			5													
		47-2, 64-67						3		2	1											4					2					2			

APPENDIX 3 — *Continued*

Gaudryina neocomiensis	*Reophax multilocularis*	*Reophax* sp.	*Trochammina suprajurassica*	*Turrispirillina conoidea*	*Ammobaculites suprajurassicus*	*Spirillina elongata*	*Trocholina conica*	*Lagena globosa*	*Pseudonodosaria* sp.	*Patellina feifeli*	*Ammodiscus* sp.	*Haplophragmoides haeusleri*	*Astacolus incurvatus*	*Dentalina nana*	*Ophthalmidium* spp.	*Spiroloculina* spp.	*Triloculina* spp.	*Lagena oxystoma*	*Hippocrepina depressa*	*Pyrulina cylindroides*	*Dentalina communis*	*Vaginulinopsis matutina*	*Vaginulina debilis*	*Haplophragmoides concavus*	*Epistomina anterior*	*Reophax horridus*	*Gaudryina grandis*	*Reophax pilulifer*	*Dorothia cornula*	*Globulina prisca*	*Bigenerina clavellata*	*Miliammina valdensis*	*Conorboides valendisensis*	*Vaginulinopsis* sp. A	*Dentalina distincta*	*Trocholina valdensis*	*Saracenaria cushmani*	*Astacolus planiusculus*	*Dorothia kummi*	*Vaginulinopsis* sp. B	*Conorboides hofkeri*
													3								8		1							1					1						
				1				3							3					1	9														3		1	2			
					1								1		2			1			3		1												1		1				
								1					1								1		1															1	2		
													2			1					4			5						1					2			2			
													1		1						7			7		3				1					1						
								1					3		7						3		1							1									1		
1						6		1							2																							3			
1								2					1	2							3			2		1					1						1	1			
								2					2								9		1							1									2		
								1					2		6																					2		1	4		
								2					3		3						9																	2			
														1	4						2															1					
																		1		1	3		1												3						
						2									4						2		1													13		2	2		
																					1															3	1		2		
														2		1				1	3																	2			
													1	4	2				1		11		1							1					2						
				1		1								3	2	1		1		1	6		3							1						2		1			
													2		4						12														1	4		3	3		
						1							1		1						6														2	2		1			
					1																5			4		1					2										
															2						1														1	3					
														3	3					1	6									1					1			2	2	1	
													1	1	7						7															2		1	1		
																					2															1					
1													2	2						3	3			4						1							1	5			
				1									1								3			3	3				1	2	5				1	1			1	1	
						1							2							3	4																	2			
				2		1				1			1							1	1															4			1		
1																			1	2	2			6							2							1			
																								1																	
																								6																	
														4	1					1	3			2											1	1					
								1										3	1	2	4										4				1	1					
											1									1																		1			
								1					1	1										1																	
						1							2	6						3	1	2		3	7												1				
3														3							9		1			1				2	7							2			
1														3							2		1		2						3				1			4			
				1		1								6						7	1	2	1	1						1	4					2	1	2	1	4	
																				2				2							1										
																									1	1															
																								1															1	1	
																				3	1	2	1	5							2							1		1	
																																				1			1	1	1
				3		1								1							1			3															1	1	
																						1								1	3							1			
																															2						1				
				4		1														4	3						1				2				1	1					
													1	2						3	2		1	2										1	1						
																					1	1							1	1			1								
				1																2	1	2	1	4				1		2											
																				3				2						1											
													1		1									2		1			1			1									

APPENDIX 3 — *Continued*

System	Stage	Sample (Interval in cm)	*Lagena sztejnae*	*Ramulina aculeata*	*Lenticulina subangulata*	*Lingulina nodosaria*	*Vaginulinopsis* sp. C	*Lagena laevis*	*Falsoguttulina wolburgi*	*Astacolus calliopsis*	*Pseudonodosaria humilis*	*Citharina intumescens*	*Dentalina linearis*	*Epistomina* sp.	*Marginulinopsis bettenstaedti*	*Spiroplectammina* sp. cf. *S. obscura*	*Saracenaria saxonica*	*Lenticulina busnardoi*	*Lingulina* sp.	*Epistomina* sp. cf. *E. carpenteri*	*Nodosaria* sp. cf. *N. aspera*	*Astacolus crepidularis*	*Saracenaria frankei*	*Nodosaria sceptrum*	*Nodosaria paupercula*	*Nodosaria obscura*	*Lingulina pupa*	*Lenticulina ouachensis ouachensis*	*Saracenaria compacta*	*Vaginulina recta*	*Frondicularia rehburgensis*	*Dentalina varians*	*Nodosaria zippei*	*Lingulina loryi*
Cretaceous	Valanginian	28-4, 11-13[b]		1	1																									1				
		28-4, 11-13[c]		1	3						2	1						3				1								1				
		28-5, 123-125			1						1													1										
		28-6, 149-151		1		1																												
		28 CC																											1					1
		29-3, 59-60	1	2						2	1												1											
		29-4, 26-28																						2										
		29-5, 3-5										5											2		1									4
		29-6, 4-5		1		1				1		1												1	1							2		1
		30-2, 58-60			2						1												1					1				1		
		30-3, 143-144				1				1	1	4										1	1	1										
		30-5, 36-38		1																			1	1										1
		31-1, 16-18		1								1											1	1										1
		31-3, 7-9		1							3		2									1							1	2				1
		31-4, 124-126										1																						
		31-5, 137-140		2	1							1																				1		
		31-6, 99-100			4							10										1	4					1				1		
		32-3, 83-85		2								4																				1		
		32-4, 104-106		5	1							1					2					5	2						1	1	2	3	1	2
		34 CC			3												1											1	1					
		35-2, 143-145									2	2												2			1							
		35-3, 0-1			2						1							1				1												
		36-2, 68-70				1											2		1				2	2	2	1								
		36-2, 96-97																				4	2											
		37-2, 44-46		1																														
		37 CC			2					1							1		2		1													
		38 CC				1					2							2	1	1														
		39 CC			1						1																							
		40-4, 83-85		2							1					1	1	2																
		40-4, 91-93				1						2	1		1																			
		40-5, 34-36												1																				
		40-5, 146-148																																
		40 CC (green)				1						1	1																					
		40 CC (red)				2																												
		41-1, 110-112																																
		41-3, 28-30																																
		41-4, 15-17				2																												
		42-1, 26-27				1				1	1	1																						
		42-3, 70-72																																
		43-2, 30-32		3	1	1	1	1	2	1																								
		43-3, 107-109																																
		43-4, 105-107																																
		43 CC	1																															

APPENDIX 3 — *Continued*

Dorothia praehauteriviana	*Frondicularia joidesi*	*Patellina subcretacea*	*Frondiculina inversa*	*Lagena sulcata*	*Lagena hauteriviana hauteriviana*	*Tristix lanceola*	*Lingulina semiornata*	*Tristix acutangula*	*Tristix excavata*	*Kyphopyxa* sp.	*Globulina exserta*	*Frondicularia simplicissima*	*Epistomina caracolla*	*Vaginulinopsis schloenbachi*	*Trocholina infragranulata*	*Marginulinopsis parkeri*	*Ammobaculites euides*	*Frondicularia* sp.	*Lenticulina* sp. A	*Frondicularia intermittens*	*Frondicularia hastata hastata*	*Lenticulina praegaultina*	*Nodosaria* sp. cf. *N. chapmani*	*Tritaxia subrotunda*	*Ammodiscus rotalarius*	*Lenticulina nodosa*	*Lenticulina turgidula*	*Dentalina guttifera*	*Reophax guttifer*	*Dentalina soluta*	*Patellina turriculata*	*Dorothia filiformis*	*Saccammina lathrami*	*Lenticulina guttata*	*Lagena* sp. cf. *L. meridionalis*	*Vaginulinopsis* sp. D	*Vaginulinopsis pseudodebilis*	*Trochammina depressa*	*Marginulinopsis cephalotes*	*Marginulinopsis collignoni*	*Lenticulina* sp. B
								1							1																										
2													1	1																											
						2						1																													
			1		1	1																																			
					1	1																																			
					2	4		1	1		4																														
			1					1	1	1																															
			1		2																																				
			3		4	3	1																																		
					1																																				
		3	1	1																																					
	1																																								
1																																									

APPENDIX 3 — *Continued*

System	Stage	Sample (Interval in cm)	*Bigenerina jurassica*	*Haplophragmoides* sp.	*Lituotuba* sp. cf. *L. nothi*	*Trochammina neocomiana*	*Haplophragmium inconstans erectum*	*Hyperammina gaultina*	*Reophax helveticus*	*Glomospira variabilis*	*Glomospirella gaultina*	*Rhizammina indivisa*	*Lenticulina subalata*	*Dentalina jurensis*	*Eoguttulina oolithica*	*Dentalina ejuncida*	*Lagena ovata*	*Spirillina minima*	*Spirillina tenuissima*	*Nodobacularia nodulosa*	*Dentalina pseudonana*	*Trochammina quinqueloba*	*Trochammina globeriginiformis*	*Epistomina uhligi*	*Textularia cordiformis*	*Dentalina torta*	*Dentalina cylindroides*	*Astacolus gratus*	*Ramulina spandeli*	*Lenticulina muensteri*	*Vaginulinopsis excentrica*	*Dentalina gracilis*	*Haplophragmium aequale*	*Ammobaculites irregularis*	*Psammosphaera fusca*
Cretaceous	Valanginian	47-2, 97-99						2		2		2																							
		47 CC					4	12		14	10	5							1			27												3	
		48-1, 16-18						5			1		1																						
		48-3, 19-21											1						2			3												1	
		48 CC								2	12								2								2					3		9	1
	Berriasian (?)	49-1, 30-32						1																											
		50-1, 75-77						2			2	2							1																
		50-2, 6-9						2		2	11	2						2	17			4					2					9			
		50-3, 69-71						5		1												2					2					1		3	
Jurassic	Kimmeridgian-Tithonian	51-2, 67-69	1				6	2		4	1	5	3		1				8			8								2		5		2	
		51 CC	2			4	1	8	2	10	2	2	6		4			1	6		2	7			1						1	4		8	
		52-1, 129-131				4	1	3		2	5	4										4		2	1	2				2				6	
		52-2, 131-132								3	1	3			1									4		1									
		52-3, 78-80				1													2			2													
		52-3, 118-120										3							10							1	1			1		3		1	
		52-4, 35-37																1	4							1									
		52 CC					1	6		1		1										17						1						1	
		53-1, 21-23					2	2	1	2	14	4			1							3				2	1								
		53-1, 53-55	4					1	2												1														
		53-2, 124-126				5		9	1		1	1										4										1			
		53-3, 10-12	15			5	4	9	2	1	7	3										4												1	
		53-3, 45-47	4			2				1																						4			
		54 CC									1	1		2	1	1			19		1											16			
		55-1, 4-6	4				5	18	3	15	4	2							2			23											1	3	
		55-2, 7-9					2	1		1	2	3	4	1					2					13	10	2			2	2	2	4	7	3	1
		55-2, 37-39				1								1															2						
		55-2, 42-44	1			2	1	1		2		3			2	1							1	1	2	1	1	1							
		55-2, 57-59				3	2	3		7	6	1							1			2													
		55-2, 63-65												4	2	1	1	1	15	1	1														
		55 CC							1					2		2	1	1																	
		57-1, 19-21	15			7		5	3	5	2	1	2	5	2																				
		57-1, 78-80	2		1	11	1																												
		57-1, 122-124	1	3																															

APPENDIX 3 — *Continued*

Gaudryina neocomiensis	*Reophax multilocularis*	*Reophax* sp.	*Trochammina suprajurassica*	*Turrispirillina conoidea*	*Ammobaculites suprajurassicus*	*Spirillina elongata*	*Trocholina conica*	*Lagena globosa*	*Pseudonodosaria* sp.	*Patellina feifeli*	*Ammodiscus* sp.	*Haplophragmoides haeusleri*	*Astacolus incurvatus*	*Dentalina nana*	*Ophthalmidium* spp.	*Spiroloculina* spp.	*Triloculina* spp.	*Lagena oxystoma*	*Hippocrepina depressa*	*Pyrulina cylindroides*	*Dentalina communis*	*Vaginulinopsis matutina*	*Vaginulina debilis*	*Haplophragmoides concavus*	*Epistomina anterior*	*Reophax horridus*	*Gaudryina grandis*	*Reophax pilulifer*	*Dorothia cornula*	*Globulina prisca*	*Bigenerina clavellata*	*Miliammina valdensis*	*Conorboides valendisensis*	*Vaginulinopsis* sp. A	*Dentalina distincta*	*Trocholina valdensis*	*Saracenaria cushmani*	*Astacolus planiusculus*	*Dorothia kummi*	*Vaginulinopsis* sp. B	*Conorboides hofkeri*
1																								3		1	1				9										
														2										2						1											
													1											1				1	2												
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6			2									2																													
						1					1	5																													
				3		8	2	1	1	1																															
1	3	2	7	1	1																																				
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