

36. APTIAN-ALBIAN BENTHONIC FORAMINIFERA FROM DSDP LEG 27, SITES 259, 260, AND 263, EASTERN INDIAN OCEAN

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ABSTRACT

Leg 27 of the Deep Sea Drilling Project in the eastern Indian Ocean penetrated Lower Cretaceous sediments at Sites 259, 260, and 263. Benthonic foraminiferal faunas in these sediments are of the same paleobioprovincial nature and specific composition as are those occurring in coeval sediments on adjacent continents (Australia, the Indian Peninsula, and south Africa). These foraminifera show that practically the whole area lay within a nontropical climatic zone, the Austral Biogeoprovince.

A biostratigraphy based on nontropical, austral, benthonic foraminifera is just developing. Despite the increasing knowledge of Cretaceous austral foraminifera, the stratigraphical value of most of the austral foraminiferal species is not certain at present. It is possible to determine the Lower Cretaceous age and distinguish the Aptian and Albian assemblages of the inner and outer shelves. Leg 27 recovered a very important record of Albian upper-slope sediments (according to classification of Sliter and Baker, 1972), but information on the Aptian assemblages from deeper environments is still missing.

The environment of the Albian assemblages at Site 259 can be described as marine and not exceeding 1000 meters in depth, most probably between 200 and 600 meters; this is in accord with a position on the upper slope.

Foraminiferal assemblages of Site 260 form two distinct and different types: (1) The assemblage from the base (Cores 18-12) with dominant agglutinated taxa similar to those of Site 263, and (2) the assemblage from Core 12-Core 9, dominated by calcareous taxa of a composition similar to that of the assemblages of Site 259.

Changes in the nature and composition of the foraminiferal faunas of Site 260 are in good agreement with the known epeiric movements as detected in coeval sedimentary basins on adjacent continents. They are also coeval with the austrian phase of orogenic movements in the Alpides.

Foraminiferal assemblages of Site 263 are markedly different from those of Site 259 and upper parts of Site 260 (type 2). These assemblages indicate: (1) an age of Aptian or older at the base of the section, and upper Aptian-lower Albian in upper parts of the section in Site 263, and (2) a shallow-extremely shallow marine environment (less than 100 m). This shallow-water environment favors the interpretation of the Wallaby Plateau as founder continental blocks, left behind during the drift of the Australian plate.

While most species recovered from Sites 259, 260, and 263 are known to occur in coeval sediments on adjacent continents, some genera, such as *Matanzia*, *Remesella*, *Eggerella*, and *Spirobovina*, are unknown from the above sediments. Their occurrence in the Leg 27 samples is their oldest on record so far known. The identity of the shallow-water foraminiferal faunas in the eastern Indian Ocean and adjacent continents implies their dispersal along extensive shallow-water shelf areas.

The paleoenvironment of all sites studied was above the calcium carbonate dissolution depth. However, quite extensive dissolution of calcitic tests was observed in Site 263, equivalent to that observed in calcitic foraminiferal test in adjacent continents. Here, the calcareous tests were partly or completely dissolved in the sediments either soon after deposition or during the early stages of diagenesis. This interpretation is based on analogy with some present stagnant environments with low oxygen content in the bottom layers of a sediment accompanied by reducing conditions with low pH and high H₂S content, resulting in solution of calcitic particles.

INTRODUCTION

The Deep Sea Drilling Project Leg 27 in the eastern Indian Ocean recovered an important sedimentary record of the austral Lower Cretaceous at Sites 259, 260, and 263 (Figure 1). In the Lower Cretaceous practically the entire area lay within a nontropical climatic zone and consequently the nontropical Austral Biogeoprovince. As a direct consequence of paleogeographic changes during the Cretaceous considerably affecting the distribution of adjacent (Gondwana) continents (Africa, peninsular India, and Australia) the paleobioprovincial situation in some parts of the just-originating Indian Ocean and adjacent continents also changed. In some places in foraminiferal assemblages of a distinctly austral aspect (east Africa and Madagascar, southern (peninsular) India, and Western Australia) some tropical elements occurred. (For more detail see Scheibnerová, 1971d; 1971c; Belford and Scheibnerová, 1971; Narayanan and Scheibnerová, in preparation).

In this case the tropical elements are represented mainly by plankton, globotruncanids. The presence of globotruncanids can be explained in two ways: (1) In peninsular India, by its substantial northward movement into the tropical zone. (2) In east Africa and Western Australia, the paleomagnetic measurements indicate high southern paleolatitudes in the Upper Cretaceous. Therefore, the presence of globotruncanids here suggests the existence of a warm current or system of warm currents approaching from the northern tropical (Tethyan) seaway through the then-opened sea connection, especially in the northeastern Indian Ocean.

Changing paleogeography and paleobioprovinciality determined the changing biostratigraphic character. Different biostratigraphic schemes must therefore be applied to this area. In the Lower Cretaceous one must rely on just-developing nontropical austral biostratigraphy based largely on results of the study of foraminiferal faunas in adjacent areas, especially in Australia, in contrast to the Upper Cretaceous, where the presence of globotruncanids, a base of the existing tropical Cretaceous biostratigraphy, enables not only age determinations, but also a comparison of tropical and nontropical Upper Cretaceous zonations.

While the tropical (globotruncanid) Upper Cretaceous biostratigraphy is well established, the establishment of the nontropical, especially austral, Lower and Upper Cretaceous biostratigraphy is just beginning. There are still numerous problems to be solved, mainly because of gaps in basic information on the composition and nature of austral Cretaceous foraminifera. Additional detailed information has been published on Australia (Crespin, 1944; 1953; 1963; Ludbrook, 1966; Taylor, 1964; Scheibnerová, 1971d, 1971c; 1972a; 1973); peninsular India (Rasheed, 1962a, 1962b; 1963; Sastri and Sastry, 1966; Bhalla, 1969); South America (Malumian, 1968; Bertels, 1970); Madagascar (Sigal, 1956; Sigal et al., 1970); and South Africa (Dingle, 1969a; 1969b; Lambert, 1972; Lambert and Scheibnerová, in press). More or less scattered information on Upper Cretaceous foraminifera is also available from New Zealand (Finlay, 1939; 1947; Webb, 1969; 1970).

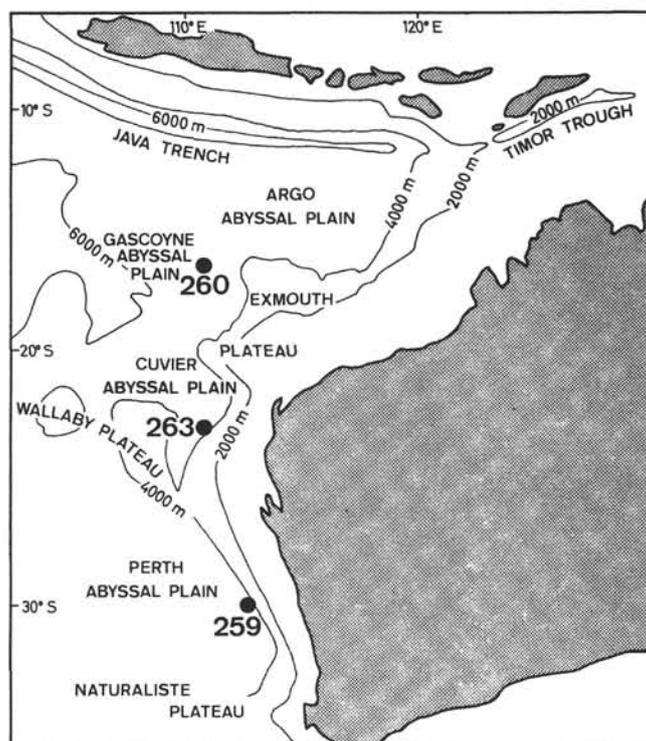


Figure 1. Location of Leg 27 Sites 259, 260, and 263.

However, the stratigraphic value of most of the austral taxa is not certain at present and must be confirmed by further detailed studies. At present it is possible to determine the Lower Cretaceous and distinguish the Albian assemblages of the inner and outer shelf (according to the bathymetric classification by Sliter, 1972, and Sliter and Baker, 1972). It is also possible to determine the Aptian assemblages of the inner and outer shelves, but information on the Aptian assemblages from deeper environments is lacking at present. At present paleontologists are seeking criteria for locating the Aptian-Albian and Albian-Cenomanian boundaries based on foraminiferal assemblages. Location of these boundaries is complicated by important facies changes due to the fluctuating sea level in the type area of the Austral Biogeoprovince (for more detail see Scheibnerová, 1973 in prep.).

Drilling in the Indian Ocean, especially on Leg 27, contributed data on deeper (upper middle slope) Albian assemblages to add to the existing information on inner and outer shelf associations in the Cretaceous (Crespin, 1953; 1963; Ludbrook, 1966; Scheibnerová, 1971a; 1971c; 1971d; 1972a) (Table 1). It also confirmed existing data (Belford, 1958; Edgell, 1957; 1962; Belford and Scheibnerová, 1971) on some Upper Cretaceous mixed (Austral and Tethyan) faunas and enabled the existing tropical biostratigraphic zonation to be correlated with the nontropical one.

The study of bioprovincial changes in the composition of the Lower Cretaceous faunas in the deep-sea cores provided very valuable information on paleo-oceanographic changes in the opening Indian Ocean. It confirmed results of the study based on the equivalent assemblages on adjacent land, which: (1)

TABLE 1
Foraminiferal Zones for Part of the Cretaceous in
Australia and the Eastern Indian Ocean

Older than Aptian	Aptian		Albian			Cenomanian	
	Lower	Upper	Lower	Middle	Upper	Lower	
Crespin did not propose any formal foraminiferal zones of the Lower Cretaceous-Upper Jurassic sediments of Australia, but the same sequences of benthonic foraminifera as described, especially in her work of 1963, have been observed by the author in the Great Artesian Basin and also in the deep-sea cores from the Indian Ocean (Leg 27).							Crespin
	<i>Trochammina raggatti</i> - <i>Textularia anacooraensis</i> Zone	<i>Hergottella jonesi</i> Zone <i>Verneuilina howchini</i> - <i>Trochammina flosculus</i> Zone			<i>Neobulimina australiana</i> Zone		Ludbrook 1966
	<i>Textularia anacooraensis</i> Zone	<i>Trochammina minuta</i> Subzone	<i>Ammobaculoides romaensis</i> Zone <i>Pseudolamarckina</i> Subzone		<i>Lingulogavelinella frankei</i> - <i>Verneuilinoides kansansensis</i> Zone <i>Discorbids</i> Subzone		Scheibnerová 1971
	? <i>Textularia anacooraensis</i> Zone (263) ? <i>Trochammina minuta</i> Subzone (263) ? ? <i>Psammipelta</i> sp. Zone (263 and 260 in part) ? <i>Eoguttulina</i> sp. Zone (263 and 260 in part) ?		<i>Pseudolamarckina</i> sp. Subzone (260)		<i>Neobulimina australiana</i> Zone (259 and 260 in part) <i>Orithostella indica-Osangularia utaturensis</i> Zone (259 and 260 in part) <i>Verneuilina howchini</i> Zone (260) <i>Discorbids</i> Subzone (259)		Informal foraminiferal zones (proposed here)

Indicated important paleogeographic and paleo-oceanographic changes in the Indian Ocean between Lower and Upper Cretaceous (Scheibnerová, 1971d; 1971c). (2) Allowed dating of the opening of the Indian Ocean (Dingle and Klinger, 1971). (3) Indicated substantial fluctuations of sea level in the Indian Ocean, apparently coeval with those recorded in epicontinental seas which transgressed over some parts of the adjacent continents at that time. These fluctuations were most important in the upper Aptian-lower Albian or lower Albian, leading to a substantial local shallowing or partial withdrawal of the sea from some parts of Australia (Canning Basin and some parts of the Great Artesian Basin); and in the Cenomanian, when most epicontinental seas withdrew definitely from the adjacent land, especially in Australia (for more detail see Whitehouse, 1928; 1954; Day, 1969; Ludbrook, 1966; Scheibnerová, 1973 in prep.).

Drilling further confirmed the existence of climatic zonation in the Cretaceous into the equatorial tropical (Tethyan) zone and polewards into nontropical (temperate, cool) zones. It confirmed the necessity of compiling parallel biostratigraphic zonations, tropical and nontropical, with subdivisions for different facies and depth zones as postulated recently (for more detail see Scheibnerová, 1971a; 1972b).

FORAMINIFERAL ASSEMBLAGES OF SITE 259

The foraminiferal faunas in samples from Site 259 consist of 63 calcareous and 40 agglutinated species. The most numerous and most important of the calcareous species are Orbitoidacea (*Gyroidinoides*, *Gavelinella* ex gr. *intermedia*, *Lingulogavelinella* cf. *frankei*, *Orithostella indica* sp. nov., and *Osangularia utaturensis*); Discorbacea (?*Discorbis*, *Valvulineria*, and *Patellinella australis* Lambert and Scheibnerová) occur abundantly in some samples (see Table 2); Orbitoidacea (*Eponides*) and Robertinacea (?*Pseudolamarckina*) are less numerous. Nodosariidae are represented by numerous species of *Lenticulina*, *Nodosaria*, and less numerous *Palmula* and *Fronicularia* as the most important ones.

Stratigraphically important are species of Lingulogavelinellidae *Orithostella indica* sp. nov. and *L.* cf. *frankei* (Bykova), slightly different from *L. frankei* occurring in the Great Artesian Basin. *Lingulogavelinella* referable to *L. frankei* (Bykova) is known to occur higher in the type Albian, but very typical forms occur also in the Cenomanian and even lower Turonian in other areas (see Scheibnerová, 1971c) within the Transitional and Boreal Biogeoprovinces in the Northern Hemisphere. In the Austral Biogeoprovince the species *frankei*, regarded as quite typical, was

TABLE 2
Distribution of Benthonic Foraminifera in Cores 11 to 17 of Site 259

Age	Upper Albian																								
	Sample (Interval in cm)		259-11, CC	259-12-1, 60-62	259-12-2, 60-62	259-12-3, 60-62	259-12-4, 80-82	259-12, CC	259-13-1, 60-62	259-13-2, 60-62	259-13, CC	259-14, CC	259-15-1, 110-112	259-15-4, 62-65	259-15-5, 124-126	259-15-6, 60-62	259-15, CC	259-16-2, 68-70	259-16-3, 80-87	259-16, CC	259-17-2, 21-23	259-17-2, 47-49	259-17-3, 38-40	259-17-3, 60-62	259-17, CC
Species																									
<i>? Alabamina</i> sp.										+															
<i>Ammodiscus</i> sp.																									
<i>A. cretaceus</i> (Reuss)																									
<i>Anomalina indica</i> Sastry and Sastri																									
<i>Clavulina gabonica</i> Calvez, Klasx, and Brun			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Coryphostoma</i> sp.																							+	+	+
<i>Dentalinoides</i> sp.																									
<i>Dentalina</i> sp.																									
<i>D. santoodnae</i> Ludbrook																									
<i>? Discorbis</i> sp.																									
<i>Dorothia</i> sp.																									
<i>Eggerella</i> sp.																									
<i>Eponides</i> sp.																									
<i>Eoguttulina</i> sp.																									
<i>Fronidularia</i> sp.																									
<i>Gaudryina</i> sp.																									
<i>Gavelinella</i> sp.			+																						
<i>G. es gr. intermedia</i> (Berthelin)																									
<i>Glomospira gordialis</i> Parker and Jones																									
<i>Gyroidinoides</i> sp.																									
<i>G. primitiva</i> Hofker			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Haplophragmoides</i> sp.																									
<i>Lagena</i> sp.																									
<i>L. hispida</i> Reuss																									
<i>Lenticulina</i> sp.			+																						
<i>L. cf. calliopsis</i> (Reuss)																									
<i>L. macrodisca</i>																									
<i>? Lingulogavelinella</i> sp.																									
<i>Lingulogavelinella cf. frankei</i> (Bykova)																									
<i>Matanzia</i> sp.			+																						
<i>Marginulina bullata</i> Reuss																									
<i>Marginulinopsis crespinae</i> Ludbrook																									
<i>Migros</i> sp.																									
<i>Neobulimina</i> sp.,																									
<i>Nodosaria</i> sp.																									
<i>Nodosarella</i> sp.																									
<i>Oolina</i> sp.																									
<i>Orithostella indica</i> n sp.																									
<i>Osangularia utaturensis</i> Sastri and Sastry			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Palmula cf. bivium</i> Finlay																									
<i>Pandaglandulina</i> sp.																									
<i>Patellinella australis</i> Lambert and Scheibnerova																									
<i>Pelosina lagenoides</i> Crespin																									
<i>Planularia</i> sp.																									
<i>Pleurostomella obtusa</i> Berthelin			+																						
<i>Praebulimina</i> sp.																									
<i>? Pseudolamarckina</i> sp.																									
<i>Pyrulinoidea</i> sp.																									
<i>Ramulina tetrahedralis</i> Ludbrook																									
<i>Rectobulimina</i> sp.																									
<i>Remesella</i> sp.																									
<i>Spirobovina australis</i> n. sp.			+																						
<i>Valvulineria</i> sp.			+																						
<i>V. cf. lenticula</i> (Reuss)																									
<i>Verneuilina</i> sp.,			+																						
<i>V. cf. howchini</i> Crespin																									
<i>Verneulinoides kansasensis</i> Tappan																									
<i>Tribrachia australiana</i> Ludbrook																									

TABLE 3
BOC of Australia Ltd.,
Dampier No. 1 Well; 29°52.21'S, 116°00.49'E

Depth (m)	Foraminiferal Species ^a	Age Based on Foraminifera
2368	<i>Clayulina</i> cf. <i>gabonica</i> , <i>Osangularia utaturensis</i> , <i>Gavelinella</i> ex. gr. <i>intermedia</i>	Albian
2621	Same assemblage as from DSDP Sample 263-29, CC	Aptian or older

^aAs determined by Scheibnerova.

TABLE 4
Stratigraphic Bore BMR 5, Giralia, Western Australia;
22°39.31'S, 114°14.45'E^a

	Core	Depth (m)	Foraminiferal Species ^b	Age Based on Foraminifera
Upper Cretaceous (? Turonian-Santonian)	2	59-62		
Marine lower upper Cretaceous	3	90-93		
	12	365-368	<i>Lingulogavelinella</i> ex gr. <i>ciryi</i> Malapris, <i>L. franki</i> , <i>Osangularia utaturensis</i> , <i>Ammobaculites</i> sp., <i>Gavelinella</i> ex. gr. <i>intermedia</i> , <i>Ramulina tetrahedralis</i>	Upper Albian, sample at 365-368m interval
Marine Lower Cretaceous	13	to 458-461	No calcareous forms, <i>Verneulina howchini</i> , <i>Ammobaculites crespinae</i> , and other agglutinated forms identical with those of the Raghavapuram Shales (Bhalla, 1969) and DSDP Sample 263-29, CC	Aptian, sample at 458-461m interval

^aBastian and Wilmott, 1965. (Palynological stratigraphy by P. R. Evans.)

^bDetermined by Scheibnerova.

described from upper part of the marine sequence of the Great Artesian Basin, where it was taken as evidence for the upper Albian/lower Cenomanian of the above sequences. The occurrence of *L. cf. franki* is here regarded as evidence for upper Albian (for more detail, see Systematic Section). *Osangularia utaturensis* Sastri and Sastry is an important species which has been described from the upper Albian of the Utatur Group of the Indian peninsula (Sastri and Sastry, 1966) together with *Anomalina indica* Sastri and Sastry, another species occurring sporadically in samples from Site 259. It has been determined also in offshore wells Stratigraphic Bore BMR No. 5, Giralia, Western Australia (see Table 3) and BOC of Australia Ltd. Dampier No. 1 well (see Table 4) in an interval determined palynologically as marine, lower Upper Cretaceous. Some other calcareous species have a similar vertical range. *Patellinella australis* has been described from the middle upper Albian in South Africa. The vertical range of others is not yet fully known in the Austral Biogeoprovince. Some of the calcareous taxa, especially the genus *Spirobovina* and *Palmula cf. bivium* Finlay were first described from the Upper Cretaceous. Their occurrence in samples from Site 259 is the oldest recorded so far.

The occurrence of *Neobulimina* and *Praebulimina* is very interesting. Similar forms are known to occur in both the Lower and Upper Cretaceous in adjacent continents, especially in Australia (Ludbrook, 1966; Taylor, 1964). In Australia they only occur in short time intervals in those parts of the Great Artesian Basin, which seem to represent the deepest facies and where the proximity of an open-marine environment is indicated.

Agglutinated taxa are represented, *Clavulina gabonica* Le Calvez, De Klasz, and Brun, *Dorothia* sp., *Matanzia* sp., *Migros* sp., and *Verneuilina* sp. being the most important ones. Of these, only *Clavulina gabonica* seems to have some stratigraphic value. It was recently described from the Cenomanian of Gabon (Le Calvez, De Klasz, and Brun, 1972). However, some of the above species, *Matanzia* and *Spirobovina*, were first described from the Upper Cretaceous and this is their oldest known record.

The paleoenvironment of this assemblage can be described as marine and of a depth not exceeding 1000 meters, probably around 600 meters. This estimate is based on comparison of the above assemblages with those from the southern Atlantic (see especially Todd, 1970; Scheibnerová, 1973a) and on the results of the study of depth habitats of Cretaceous non-tropical foraminifera of North America by Sliter and Baker (1972). According to Sliter and Baker's classification, the Site 259 assemblage corresponds to an upper slope association (between 200-600 m) (see also Scheibnerová, in press, a). No traces of extensive selective solution have been observed on calcareous foraminifera of Site 259. The original environment of these was well above the Cretaceous calcium carbonate solution depth. This is also the first record of an Albian Austral environment of comparatively greater depth than those of the inner and outer shelves.

FORAMINIFERAL ASSEMBLAGES OF SITE 260

Foraminiferal assemblages of Site 260 can be divided into two distinct and different types:

1) The assemblage from the base (Cores 18-12) with dominant agglutinated taxa is of a different nature than those of Site 259 and the upper parts of Site 260; the age, composition, and paleoenvironment of these are generally equivalent to those of Site 263 (see discussion of Site 263).

2) The assemblages from Cores 9-11 are dominated by calcareous taxa of a similar composition to that of the assemblages in Site 259. The age of this type of assemblage is regarded as more or less equivalent to that of Site 259, middle-upper Albian. Agglutinated taxa in this assemblage are also of the same nature and composition as those of Site 259.

The age and paleoenvironment of the Type 1 assemblage at Site 260 is different from that of the Type 2. The composition of the agglutinated taxa of Type 1 is markedly different from that of the upper part of the section in Site 260. It contains taxa such as *Psammimopelta* sp. and *Gaudryina bevissensis* Ludbrook which are known to occur in the Aptian of the Canning Basin or Aptian-Albian of the Great Artesian Basin. Paleogeologically, this type of assemblage is characteristic of shallow to extremely shallow environment known to occur on the adjacent continents in the Canning and Great Artesian basins and in peninsular India (Raghavapuram Shales of Trichinopoly Cretaceous, south of Madras). This paleoenvironment will be discussed in more detail in the section on Site 263.

FORAMINIFERAL ASSEMBLAGES OF SITE 263

Foraminiferal assemblages of Site 263 are markedly different from those of Site 259 and the upper parts of Site 260. They are composed of dominant agglutinated taxa of different nature and composition than those of the above two sites. The calcareous component is dominated by nodosariids. The assemblages of Site 263 indicate:

1) Aptian or older at the base of the section and upper Aptian to ?lower Albian in upper parts of the section at Site 263.

2) Shallow to extremely shallow (less than 100 m) marine environment. Stratigraphically the most important species are: *Textularia anacooraensis* Crespin, occurring in middle and upper parts of the section at Site 263 (Cores 7-16, inclusive); *Spiroplectamina cushmani* Crespin (Cores 6-29, inclusive); *Trochammina minuta* Crespin and *T. cf. minuta* Crespin (Cores 19-27, inclusive); and *Verneuilinoides crespinae* Ludbrook (Cores 11-29, inclusive).

Textularia anacooraensis Crespin is known from the Aptian of the Canning and Great Artesian basins, especially in the lower Aptian (see Crespin, 1963; Ludbrook, 1966; Scheibnerová, 1971c). *Spiroplectamina cushmani* Crespin is known from the marine Lower Cretaceous of the Great Artesian Basin, especially in the Aptian (Crespin, 1963). *Verneuilinoides crespinae* has been described as occurring in the Aptian-

Albian of the Great Artesian Basin (Ludbrook, 1966). According to the observations of the author, there is another species of *Verneulinoides* (referred here to *kansasensis*) occurring stratigraphically higher than *V. crespinae* and being different from the latter species. According to this, *V. crespinae* would represent the Aptian and *V. kansasensis* the Albian *Verneulinoides* in the Great Artesian Basin. Very prominent components in this assemblage are Polymorphinidae and Nodosariidae, represented by taxa known to occur in the Aptian and Albian of the Canning and Great Artesian basins. Upward at Site 263 there is quite a marked change in the composition of the foraminiferal assemblages; the above species disappear and other species become dominant. These are close in their composition to those of Site 260 and even Site 259 in part (*Glomospira gordialis*, *Ammodiscus cretaceus*, *Dorothia* sp. are the most important ones).

The occurrence of such species as *Lenticulina* sp. 1 (ornamented forms) very similar to those known to occur in the Cenomanian in South Africa shows that the upper parts of Site 263 probably represent the upper Aptian-lower Albian. This age is similar to that suggested for the lower parts of Site 260.

The paleoenvironment of the foraminiferal assemblages at Site 263 was shallow to extremely shallow throughout. The prominent polymorphinid component appears characteristic of an inner and middle shelf fauna (depth less than 100 m) according to Sliter and Baker's (1972) classification. Identical faunas occur in the Canning Basin where the paleoenvironment can be classified as inner shelf. Very similar assemblages of Lower Cretaceous foraminifera occur in some parts of the Great Artesian Basin, especially in those located over the ridges. These can similarly be characterized as inner shelf.

The same paleoenvironment can be postulated for the coeval Raghavapuram Shales of southern (peninsular) India. The lithology, foraminiferal faunas, and paleoenvironment of these shales were described in detail by Bhalla (1968) who suggested a brackish-water environment. Bhalla (1968) is probably correct in postulating a water (near-shore) environment with open marine connections; however, his interpretation of brackish-water conditions is strongly opposed by the diversified character of the foraminiferal assemblages in which both agglutinated and calcareous foraminifera occur in quite a variety of taxa. Predominance or exclusive representation of agglutinated taxa can be attributed to the solution of their calcitic tests shortly after burial due to a low oxygen content and acid reaction in the sediment. Indeed, different stages of dissolution of calcitic tests were observed on material from Site 263. Based on the analogy with the foraminiferal faunas of the Great Artesian Basin and other parts of the Austral Biogeoprovince, it is considered that comparatively cool temperatures prevailed in this part of the Indian Ocean at that time.

**PALEOECOLOGICAL, PALEOBIOPROVINCIAL,
AND PALEOGEOGRAPHICAL ANALYSES
OF THE
BENTHONIC CRETACEOUS FORAMINIFERA
FROM SITES 259, 260, AND 263**

The benthonic Cretaceous foraminifera recovered from Sites 259, 260, and 263 (Leg 27, southeastern Indian Ocean) closely correlate with those known to occur in coeval sediments on adjacent continents (South Africa, peninsular India, and Australia) and belong to the Austral Biogeoprovince as defined by Scheibnerová (1970; 1971d). They differ from each other by containing the assemblages of forms characteristic of different age (Sites 259 and 260 in part on one hand and Site 263 on the other) and substantially different depth. The list of species determined in the samples of the above sites are in Tables 2, 5, and 6. Except for some genera (*Matanzia*, *Remesella*, *Spirobolevina*, and *Eggerella*) all these species (including new species) have previously been reported from the adjacent Gondwana continents. On the other hand, our fauna recovered on Leg 27 show remarkable similarities in both quantitative and qualitative (especially generic) composition with those Lower Cretaceous foraminiferal faunas which are known to occur in the western interior of the United States (see especially Tappan, 1940, 1943; Scheibnerová, 1971a, 1971d) and California (Dailey, 1970) and to a lesser degree elsewhere in the the Boreal Biogeoprovince. The above similarities are a subject of further study by the author, requiring comparison of the austral species with those of the above areas, especially in North America. Further, we shall only discuss faunal similarities within the area studied, including South Africa, peninsular India, and Australia. Some very obvious affinities are discussed in systematics section.

Of special interest are benthonic foraminiferal species of Sites 259 and 260 (in part), which show remarkable similarities in their composition. These faunas show most affinities with the lower part of the Utatur Formation as described by Sastri and Sastry (1966). Almost all species described from the Utatur Formation are present also in the above samples. Of special interest are *Osangularia utaturensis* (Sastri and Sastry), many nodosariids, *Pleurostomella obtusa*, "*Virgulina* sp." (here determined as *Coryphostoma* sp.), and *Valvulinera ramaraoi* (probably equals *Lingulogavelinella* cf. *frankei*) (for more details see Systematic Section).

Many species determined in the samples from Sites 259 and 260 (in part) occur in coeval sediments in South Africa in the middle-upper Albian samples from the Umzinene section in Zululand described recently by Lambert and Scheibnerová (in press). Especially characteristic is the presence of *Orithostella* and *Lingulogavelinella*, *Patellinella australis* Lambert and Scheibnerová, all nodosariids, *Gavelinella* ex gr. *intermedia* Berthelin, *?Pseudolamarckina* sp., and *?Discorbis* sp.

TABLE 5
Distribution of Benthonic Foraminifera in Cores 8 to 18 of Site 260

Age	Middle-upper Albian	Lower Albian- Upper Aptian
Sample (Interval in cm)	260-8, CC 260-9-1, 114-116 260-9-1, 116-118 260-9, CC 260-10-1, 105-107 260-10-2, 34-36 260-10, CC 260-11-1, 100-102 260-11, CC	260-12-1, 86-88 260-12-2, 135-137 260-13, CC 260-15-2, 32-34 260-15, CC 260-17-1, 45-47 260-18-2, 84-86
Species		
<i>Clavulina gabonica</i> Le Calvez, de Klasz, and Brun	+	
<i>Conorbina</i> sp.	+	
<i>Dentalina</i> sp.	+	
<i>Eggerella</i> sp.	+	
<i>Gavelinella</i> sp.		+
<i>G. ex gr. intermedia</i> (Berthelin)	+	+
<i>Glandulina</i> sp.	+	
<i>Gyroidinoides</i> sp.	+	
<i>G. primitiva</i> Hofker	+	
<i>Haplophragmoides</i> sp.	+	
<i>H. cf. hagni</i> Bhalla	+	
<i>Lagena</i> sp.	+	
? <i>Lingulogavelinella</i> sp.	+	
<i>Matanzia</i> sp.	+	
<i>Migros</i> sp.	+	
<i>Neobulimina</i> sp.	+	
<i>Osangularia utaturensis</i> Sastri and Sastry	+	
<i>Pelosina lagenoides</i> Crespin	+	
<i>Praebulimina</i> sp.	+	
<i>Spiroplectammina cushmani</i> Crespin	+	
<i>Trochammina</i> sp.	+	
<i>Verneuilina</i> sp.	+	
<i>Coryphostoma</i> sp.	+	
<i>Ammodiscus</i> sp.	+	+
<i>Dorothia</i> sp.	+	+
<i>Valvulineria</i> sp.		+
<i>Frondicularia</i> sp.		+
<i>Ammodiscus cretaceus</i> (Reuss)		+
<i>Gaudryina</i> sp.		+
<i>G. bevisensis</i> Ludbrook		+
<i>Glomospira gordialis</i> Parker and Jones	+	+
<i>Hyperammina</i> sp.	+	+
<i>Lenticulina</i> sp. 1		+
<i>Lenticulina</i> (various species)	+	+
<i>L. cf. australiensis</i> (Crespin)	+	+
<i>L. dalhousiensis</i> Ludbrook		+
<i>L. gaultina</i> (Berthelin)		+
<i>Marginulinopsis arimensis</i> Ludbrook		+
<i>M. santoodnae</i> Ludbrook		+
<i>Nodosaria</i> sp.	+	+
<i>Psamminopelta</i> sp.		+
? <i>Pseudolamarckina</i> sp.		+

TABLE 6
Distribution of Benthonic Foraminifera in Cores 5 to 29 of Site 263

Age	a	?Upper Aptian	Aptian or Older																									
Sample (Interval in cm)	263-5, CC	263-6-6, 59-61	263-7-2, 34-36	263-7, CC	263-8, CC	263-9, CC	263-10, CC	263-11, CC	263-12, CC	263-13, CC	263-14, CC	263-15, CC	263-16, CC	263-17, CC	263-17, CC (bottom)	263-19, CC (bottom)	263-19, CC	263-20, CC	263-21-4, 35-37	263-22, CC (bottom)	263-23, CC	263-24-6 (top)	263-25, CC	263-26-5, 137-139	263-27, CC	263-29, CC		
Species																												
<i>Ammobaculites</i> sp.	+																											
<i>A. fisheri</i> Crespin					+																			+				
<i>Ammodiscus cretaceous</i> (Reuss)		+	+						+						+				+									
<i>Bathysiphon</i> sp.		+	+		+	+																						
<i>Dorothia</i> sp.	+							+		+																	+	
<i>Gaudryina beyissensis</i> Ludbrook						+																						
<i>Gavelinella</i> sp.									+																			
<i>Lenticulina gaultina</i> (Berthelin)									+																			
<i>Lingulina</i> sp.									+																			
<i>Marginulinopsis santoodnae</i> Ludbrook									+						+													
<i>Marssonella</i> sp.										+																		
<i>Planctostoma</i> sp.					+																							
<i>Psammionopelta</i> sp.	+	+								++		+	++															
<i>Psammospaera parva</i> Crespin				+						+++		++																
<i>Textularia</i> sp.										++																		
<i>T. anacooraensis</i> Crespin				+	+	+	+	+	+	+		+	+															
<i>Trochammina</i> sp.				+	+					+					+													
<i>Verneulina howchini</i> Crespin										+					+													
<i>Glomospira gordialis</i> Parker and Jones	+	+		+						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
<i>Haplophragmoides</i> sp.				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
? <i>Reophax</i> sp.															+													
<i>Hyperammina</i> sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
<i>Miliammina cf. inferior</i> Ludbrook															+												+	
<i>Lenticulina</i> (various species)	+									+					+						+	+				+		
<i>Spiroplectammina cushmani</i> Crespin	+	+								+					++	+	+	+	+	+	+	+	+	+	+	+	+	
<i>Ammobaculites crespinae</i> Bhalla																										+		
<i>A. irregulariformis</i> Bartenstein and Brand																											+	
<i>Ammodiscus</i> sp.											+				++						++					+		
<i>Amphicoryna</i> sp.															+												+	
<i>Bigenerina</i> sp.																											+	
<i>B. loeblichae</i> Crespin																						++						
<i>Citharina harcoensis delicatula</i> Sastri & Sastry															+													
<i>Dentalina</i> sp.																++	++	++	++	++	++	++	++	++	++	++	++	
<i>Eoguttulina</i> sp.															+							+	+	++	++	++	++	
<i>Fronicularia</i> sp.																						+				+		
<i>Glandulina</i> sp.																						+				++		
<i>Glandulopleurostomella</i> sp.																										+		
<i>Globulina</i> sp.																												
<i>G. lacrima</i> (Reuss)															+								+					
<i>Haplophragmoides hagni</i> Bhalla																						+						
<i>H. chapmani</i> Crespin										+	+	+			+							++	++	++	++	++	++	
<i>H. wilgunyaensis</i> Crespin															++											+		
<i>Karrerella</i> sp.																++						+						
<i>Lenticulina</i> sp.1															+++							++	++	++	++	++	++	
<i>L. australiensis</i> (Crespin)																						+	+	++	++	++	++	
<i>L. cf. calliopsis</i> (Reuss)															+											+		
<i>L. cf. chaini</i> (sensu Ludbrook, 1966)																+												
<i>L. lituola</i> (Reuss)															+													
<i>L. spinosa</i> (Berthelin)															++							++				++	++	
<i>Lingulina cf. malamlala</i> Ludbrook															+													
<i>Marginulina pudica</i> Ludbrook															++										+			
<i>Marginulinopsis arimensis</i> Ludbrook															+													
<i>Nodosaria</i> sp.															+++										+	+	+	
<i>N. gidya</i> Ludbrook																										+		
<i>N. paupercula</i> Reuss															+							+						
<i>Pyrrulinoides</i> sp.															+										+			
<i>Ramulina aculeata</i> Ludbrook															++													
<i>Scutuloris</i> sp.																											+	
<i>Textularia wilgunyaensis</i> Crespin															++							++						
<i>Trochammina minuta</i> Crespin																											+	
<i>T. cf. minuta</i> Crespin																						++			+			
<i>Verneulinoides crespinae</i> Ludbrook										+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	

The occurrence of *Lingulogavelinella* cf. *frankei* (Bykova) is very interesting. Lambert and Scheibnerová (in press) mentioned the occurrence of more than one species of *Lingulogavelinella* and noticed especially the presence of less inflated forms described as *L. frankei africana*, with a subangular periphery and more numerous chambers in the last whorl. These were compared with our specimens and found to differ. Both forms are also different from that form of *Lingulogavelinella* described as *frankei* from the Great Artesian Basin (Scheibnerová, 1971d) (for more details see Systematics Section).

Lingulogavelinella ex. gr. *frankei*, most nodosariids, *Praebulimina*, *Neobulimina*, *?Pseudolamarckina*, forms similar to *?Discorbis* sp., and most agglutinated forms are known to occur in coeval sediments in various parts of the Great Artesian Basin in Australia, especially in those representing the relatively deepest facies classified as outer shelf in the above area. Extremely interesting is the presence of Radiolaria reported both from the Utatur Formation (Sastri and Sastry, 1966) and the Great Artesian Basin Formation (Crespin, 1960; Ludbrook, 1966; Scheibnerová, 1971d).

In both Sites 259 and 260 there are certain genera unknown so far from the coeval sediments on adjacent land, namely: *Matanzia*, *Remesella*, *Eggerella*, and *Spirobolevina*. If these occurrences are in situ they can be regarded here as the oldest representatives of the above genera so far known. While *Matanzia*, *Eggerella*, and *Spirobolevina* are known to occur in the upper Cretaceous of the Austral Biogeoprovince in New Zealand and South Africa, *Remesella* has not previously been recorded in the Lower Cretaceous and only one other occurrence of this genus is known in the Austral Biogeoprovince. *Remesella* has recently been reported from the Upper Cretaceous of western Equatorial Africa by Le Calvez, de Klasz, and Brun (1972). Also striking is the occurrence in numbers of *Glomospira gordialis*. This is here regarded as an indication of depth rather than age, because it occurs in small numbers in practically all samples from Leg 27, although it is somewhat more abundant in the lower parts of Site 259.

In general, foraminiferal assemblages of Sites 259 and 260 (in part, see above) are dominated by calcareous forms. They are deeper water assemblages, which can be characterized as diversified assemblages of the upper slope (Sliter and Baker, 1972). This is in accord with present knowledge of the depth habitats of the austral and boreal foraminiferal assemblages. Many of the species recorded in the above deep-sea samples occurred also in upper parts of the boreholes BMR No. 5 and BOC Dampier No. 1 (see Tables 3 and 4). From the paleogeographical point of view the above close similarity of foraminiferal faunas of Sites 259 and 260 (in part) with those of peninsular India and South Africa favors a geographical proximity of Western Australia and peninsular India, and, to a lesser extent, with South Africa in the upper Albian.

Part of the assemblages from Site 260 (Cores 12, 15, 17, and 18) show definite differences in their composition when compared with upper parts of Site 260. They contain certain species (see Table 2) which

make them similar to those of Site 263. There is a definite decrease in the numbers of calcareous forms and an increase in the agglutinated taxa; and the appearance of species unknown in the upper parts of Site 260. These are *Lenticulina* sp. 1, *Gaudryina bevissensis* Ludbrook, and *Psamminopelta* sp. This can be explained by the shallow environment of the older sediments of Site 260 or both the shallow environment and older age of these deeper parts. An older age is preferred because the above species are characteristic of the Aptian of the Canning Basin, where no marine sediments younger than lower Aptian are known to occur. We have no accurate data on the younger-than-Aptian range of these species. However, one of these species (*Lenticulina* sp. 1) is similar to a nodosariid occurring in the Cenomanian of South Africa. The rest of the species seem to be indicative of the Aptian rather than younger sediments. Of these, especially *Psamminopelta* sp. has been reported by Crespin (1963) as Jurassic to Lower Cretaceous in age.

We can conclude that the foraminiferal species occurring in lower parts of Site 260 may be indicative of older-than-middle Albian age (i.e., upper Aptian-lower Albian). This conclusion is also supported by the fact that the change mentioned above is quite gradual and the number of the above species increases downward. Nevertheless, the environment where these sediments were deposited from Core 11 downward was markedly shallower than from Core 11 upward. This is in very good agreement with the known general shallowing (reflected in nondeposition or even local withdrawal of the sea) in other coeval sedimentary basins on adjacent continents. It is interesting to note that these epeiric movements or eustatic fluctuations are coeval with the austrian phase of orogenic movements in the Alpides. Further, the relatively shallow-water environment of the Lower Cretaceous sediments in Site 260 (in part) could be a consequence of the proximity of a mid-oceanic ridge, with fast spreading close to the continental margin. A shallow mid-oceanic ridge might indicate the intensity of sea-floor spreading. Subsidence took place during the latter part of the Lower Cretaceous. The relatively deepest environment of upper Albian sediments of Site 259 and the upper part of Site 260, despite the proximity of the continent, indicates that earlier rifting, sea-floor spreading, and subsequent subsidence of the oceanic floor occurred west of the Australian continental plate.

The benthonic foraminiferal assemblages of Site 263 are markedly different from those of Site 259 in part (see above). Besides nodosariids and polymorphinids, various agglutinated taxa are also prominent. Rotaliids are strongly reduced in their numbers or absent. The assemblages from Site 263 show remarkable identity with the taxa known to occur in shallow-water marine sediments on the adjacent eastern part of peninsular Indian (Raghavapuram Shales—see Sastri, Chandra, and Pant, 1963; Bhalla, 1965, 1969; the Sriperumbudur Beds near Madras—see Murthy and Sastri, 1960, 1962; and the Gullygoody [Dalmiapuram] Limestone, Trichinopoly Cretaceous—see Rasheed, 1962a, 1962b, 1963). Compared with the foraminiferal assemblages of Sites

259 and 260 (in part) the assemblages of Site 263 are:

1) Older—those from Samples 263-22, CC are upper Aptian to possibly ?lower Albian; those from Core 22 downward to Sample 263-29, CC are Aptian or older.

2) Markedly shallower.

As mentioned above, part of the samples from Site 263 contain some species indicating a younger age than the rest of the samples from this site. The most prominent form in these assemblages is a nodosariid here referred to as *Lenticulina* sp. 1. It is very similar to the nodosariid present in samples from Cenomanian deposits of the Umzinene River section (Zululand, South Africa) (Lambert, 1972). On the other hand, the rest of the assemblages from Site 263 show remarkable identity with a sample from the lowermost part of the borehole BOC Dampier No. 1 (see Table 3) and are not younger than Aptian, but probably older in part.

In general, samples from Site 263 contain the highest number of Nodosariids and agglutinated forms known from the Great Artesian Basin, including *Miliammina inferior* Ludbrook (one specimen only, lost during the study, see Figure 1) and some other forms similar to *Miliammina*. Especially striking is the presence of very small agglutinated taxa as known to occur in the Canning Basin (see Crespin in Veevers and Wells, 1961) and the Queensland part of the Great Artesian Basin (boreholes BMR Glenalvon No. 1, BMR Richmond No. 1, and BMR Longreach No. 1). Description and analysis of their foraminiferal faunas are being prepared for publication by Scheibnerová (in preparation). Quite striking is the absence of *Lingulogavelinella* and *Orithostella*, probably due to facies control, because these genera are known to occur in the Aptian, Albian, Cenomanian, and Turonian in the adjacent, and also more distant, parts of the Austral Biogeoprovince. This absence is here interpreted as due to extremely shallow depth. *Lingulogavelinella* and *Orithostella* species occur in otherwise identical assemblages from closely adjacent sequences recovered in the borehole BMR No. 5 drilled in the Carnarvon Basin (see Table 4).

Equally important from bioprovincial, paleogeographical, and paleoecological points of view is the identity of agglutinated taxa compared with those known to occur in the Raghavapuram Shales as described by Bhalla (1965, 1969). Several identical species were determined (*Haplophragmoides crespinae* Bhalla, *Ammobaculites hagni* Bhalla as the most important ones) in addition to those species of both agglutinated and calcareous forms (Nodosariidae and Polymorphinidae) known to occur in boreholes drilled in the shallowest facies in the Great Artesian Basin, especially in the boreholes BMR Richmond No. 1 and BMR Longreach No. 1. These undoubtedly represent the shallowest facies known in the Austral Biogeoprovince, as they were deposited on ridges dividing the relatively deeper sub-basins within the Great Artesian Basin.

However, the presence of the foraminiferal assemblages indicating shallow to extremely shallow environment in the Great Artesian Basin the present Indian Ocean at a depth of 5056 meters (Site 263) is certainly of the utmost interest. Based foraminiferal and lithologic similarities (dark to black, muddy to sandy

shales) the environment at Site 263 certainly is no deeper than of the above mentioned areas in the Canning and Great Artesian basins and in the sites of boreholes BOC Dampier No. 1 and BMR No. 5, despite the presence of Radiolaria, fish teeth, holothurian ossicles, and Pteropods, because these are also known in the undoubtedly shallow-water sediments in the epicontinental basins of the same age in Australia, peninsular India, and elsewhere. This leads to several interesting conclusions:

1) A shallow depth (most probably less than 100 m) of the Lower Cretaceous sediments at Site 260 (in part) and especially Site 263 could be explained at least two ways: (a) The site was part of the continental shelf in the Lower Cretaceous and the Wallaby Plateau represents foundered continental blocks. The southern part of the Cuvier Abyssal Plain originated by rifting and separation and by relative rotation of the Australian plate and the Wallaby Plateau continental blocks, respectively. These blocks were left behind during the drift of the Australian plate. Because no oceanic basement has been penetrated at Site 263, it could represent a sedimentary cover of a foundered continental sliver at the margin of the Cuvier Abyssal Plain. (b) The second possibility is that the oceanic part of the Cuvier Abyssal Plain originated by sea-floor spreading early in the history of the opening of the Indian Ocean, but the subsidence of this area together with the Wallaby Plateau took place much later, in the Upper Cretaceous. In possible combination of both cases a narrow rift could have developed originally in the continental shelf area, or a shelf basin formed which subsequently in the Upper Cretaceous was further opened and subsided. The shallow-water environment of Site 263 favors an interpretation that the Wallaby Plateau represents foundered continental blocks which were left behind during the drift of the Australian Plate.

2) The identity of the shallow-water foraminiferal assemblages, between the two areas implies their dispersal along extensive shallow-water shelf areas (for more detail see Scheibnerová, 1973b) which undoubtedly existed in the southeastern Indian seaway during the Lower Cretaceous and also later during the Upper Cretaceous (at least intermittently as shown by the existing sedimentary hiatuses during the Upper Cretaceous). In this connection it is very important that the Leg 27 faunas show the greatest affinity with those of the Canning Basin and northeastern and western parts of the Great Artesian Basin, in addition to the similarity with the faunas of the Raghavapuram Shales.

3) These faunas are certainly not residues of selective solution beneath the calcium carbonate dissolution depth. It would be impossible to imply the existence of the same excessive depth for the epicontinental deposits in adjacent continents yielding virtually identical assemblages. The scarcity of microfossils, especially calcareous ones, has been closely followed during the study of the Great Artesian Basin Cretaceous foraminifera. As a rule, about 200 specimens as a maximum were concentrated from samples weighing 0.5 kg; the most frequent numbers were between 10 and 50 specimens. Solution took place, but due to different reasons (see below); similar solution is evident also in

some of the samples from Site 263. In a few samples only casts of foraminifera in various stages of dissolution of the original calcareous wall are present. However, this sort of solution was even more intensive in shallow-water marine sediments deposited in epicontinental basins on adjacent land than in the samples from the deep-sea cores. The calcareous fossils were partly or completely dissolved in the sediment either soon after deposition or during the early stages of diagenesis. From the analogy with some present stagnant environments, with low oxygen content in the bottom layers, it follows that a short distance from the surface (a few tens of centimeters) the bottom sediments became devoid of oxygen. Consequently decaying organic matter causes reducing conditions with a low pH and high H₂S content resulting in dissolution of calcitic particles. Today such sediments are rich in pyrite in various forms. Changing shore lines and depth (fluctuating sea level) were reflected in an episodic occurrence (sometimes described as waves, see especially Taylor, 1964) of dark-gray to black sediments with very typical occurrences of pyrite, glauconite, or manganese nodules, characterized by agglutinated foraminiferal assemblages and only very few calcareous forms bearing signs of dissolution. During the Lower Cretaceous the austral marine environments were mostly represented by interconnected shallow seas, often of a semi-enclosed character with very little current activity due to lack of connections with open marine environments to the north or east (for more detail see Scheibnerová, 1973b). From this uniformity of the paleoenvironments follows a uniformity in the composition of faunas within the Austral Biogeoprovince. Due to the early stage of the development of continental drift and sea-floor spreading extensive areas of shallow marine basins would be expected in contrast to the present situation when continental drift (in this case of the Gondwana continents) progressed to a stage with extensive deep oceanic basins followed by regression of the sea from the adjacent continents.

SYSTEMATIC SECTION

Suborder TEXTULARIINA Delage and Hérouard, 1896

Superfamily AUMMODISCEA Reuss, 1862

Glomospira Rzehak, 1885

Glomospira gordialis Parker and Jones

(Plate 1, Figure 3)

In all three sites this species occurs in large numbers. In some samples it is a dominant component (see Tables 2, 5, 6). The species has no major stratigraphic value, although its numbers decrease upward (probably due to environmental changes).

Superfamily LITUOLACEA de Blainville, 1825

Family RZEHAKINIDAE Cushman, 1933

PSAMMINOPELTA Tappan, 1957

Psamminopelta sp. (sensu Crespin 1963)

(Plate 1, Figures 4, 5)

Several specimens of planispiral agglutinated forms occur in samples from Sites 263 (Table 6) and 260 (Table 5). They resemble closely specimens of a very similar agglutinated foraminifer referred to *Psamminopelta* cf. *brosgei* Tappan by Crespin (1963). They are

medium in size ovate in outline, planispiral and flattened from sides with chambers half a coil in length. They are often distorted. The wall is finely agglutinated, roughly finished. Crespin (1963) described these forms from the "Upper Jurassic or Lower Cretaceous" of the Canning Basin and adjacent areas in Western Australia. The identity of our specimens with Crespin's material is supported by a proximity of the occurrences, and by a similarity in age and environment.

MILIAMMINA Heron-Allen and Farland, 1930

Miliammina inferior Ludbrook

(Plate 9, Figure 1)

Miliammina inferior Ludbrook, 1966, p. 85, pl. 6, fig. 7-9

In one sample (263-17, CC) one specimen of *Miliammina*, referable to the species *inferior* Ludbrook has been found. The test was lost during the study. It is quite small, ovate in outline, inflated, quinqueloculine in plan; the chambers are relatively thick, each half a coil in length and of equal diameter for each chamber. The sutures were distinct, depressed, thin walled, finely agglutinated with much siliceous cement and surface fairly smoothly finished; the aperture is a single opening at the end of the final chamber; the figured specimen appears identical with the species known to occur in the lower Aptian of the Great Artesian Basin.

Family LITUOLIDAE de Blainville, 1825

Haplophragmoides Cushman, 1910

Haplophragmoides wilgunyaensis Crespin, 1963

Haplophragmoides wilgunyaensis Crespin, 1963, p. 32-33, pl. 7, fig. 1-10.

The test is medium-size, compressed, tightly coiled, planispiral, involute, deeply umbilicate with periphery rounded. The last-whorl is composed of 12-14 chambers increasing very gradually in width and rather rapidly in height with the last-formed chamber overlapping the early chambers of the preceding whorl. The inner margins of the chambers around the umbilicus are slightly lobate. The sutures are straight, thickened, distinct, and flush with the surface of the test. The wall is arenaceous, with fine quartz grains in siliceous cement. The surface is smooth and slightly polished. The aperture is a low arched slit at the base of the last chamber. The species occurs typically in the Aptian of western Queensland and other parts of the Great Artesian Basin.

Haplophragmoides dickinsoni Crespin

(Plate 1, Figure 6)

Haplophragmoides dickinsoni Crespin, 1953, p. 29, pl. 5, fig. 6.

The test is small, planispiral, involute. The periphery is broadly rounded and the umbilicus is shallow. The last whorl is formed of 6-8 chambers. The chambers are slightly inflated, the sutures are radial, distinct, depressed. The wall is finely arenaceous, composed of very fine quartz grains and much cement. The aperture is a low arch at the base of the last chamber. The surface is usually smooth. This species is widely distributed in the Albian deposits of the Great Artesian Basin.

Haplophragmoides hagni Bhalla, 1965

(Plate 9, Figure 2a-b)

Haplophragmoides hagni Bhalla, 1965, p. 40, text-fig. 1, no. 2a-b.

Haplophragmoides hagni Bhalla, 1969, p. 66-68, pl. 1, fig. 6, 7, text-fig. 3.

The test is planispiral, slightly evolute, inflated, medium sized; the final whorl is composed of 6-11 chambers increasing rather gradually in size as added; the test is slightly evolute, so on both sides chambers of the inner whorl are partly visible. The sutures are straight, distinct, wide, and darker than the rest of the test, almost flush with the surface. The periphery is broadly rounded, the aperture is an interiomarginal arched slit at the base of the apertural face, the wall is finely arenaceous, consisting of fine quartz grains with little cement; the surface is smooth, in some specimens shiny. Leg 27 specimens of *H. hagni* agree extremely well with the description in Bhalla (1965, 1969) and are rather typical representatives of the species.

Haplophragmoides chapmani Crespin

(Plate 1, Figure 9)

Haplophragmoides chapmani Crespin, 1953, p. 19, pl. 1, fig. 1a, 1b; 3.

Haplophragmoides chapmani, Crespin, 1953, p. 29, pl. 5, fig. 5.

Haplophragmoides chapmani Crespin, 1944, Crespin, 1963, p. 29-30, pl. 5, fig. 5-16.

Haplophragmoides chapmani Crespin, Crespin, Ludbrook, 1966, p. 86-88, pl. 2, fig. 7.

The test is medium-size, quite tightly coiled, involute, in some specimens tending to become evolute in the last chambers. The umbilicus is deep, periphery rounded. The test is compressed from sides. The last whorl is formed by 7-9 chambers of triangular shape, slightly lobate along the peripheral margin. The wall is finely agglutinated and the surface is usually smooth. The aperture is an arched slit at the base of the last chamber. A distinct lip has been described for this species. The species is widely distributed in the Aptian and Albian of the Great Artesian Basin and in Western Australia. Besides the above species, there occur some other forms, referable to cosmopolitan species, such as *H. cf. concava* (Chapman) (see Plate 1, Figures 7, 8).

AMMOBACULITES Cushman, 1910

Ammobaculites fisheri Crespin

(Plate 1, Figure 13; Plate 9, Figure 3)

Ammobaculites fisheri Crespin, 1953, p. 29, pl. 5, fig. 4, 5.

Ammobaculites fisheri Crespin, Crespin, 1963, p. 38, pl. 11, fig. 8-10.

Ammobaculites fisheri Crespin, Ludbrook, 1966, p. 91, pl. 3, fig. 9.

The test is free, small, straight, elongate with early portion compressed and uniserial portion almost rounded in section. The coiled portion consists of 3-5 chambers; the uniserial portion consists of usually 5 chambers, with greatest width near the middle of chambers. The last-formed chamber is subpyriform, becoming extended in direction of the apertural opening with greatest width in a lower third. The sutures are distinct, depressed. The wall is finely arenaceous with siliceous cement and small quartz grains. The surface is quite rough. The aperture is a terminal rounded opening, sometimes with a slight lip of siliceous material. The species is widely distributed in the Lower Cretaceous of the Great Artesian Basin (Aptian-Albian) and southern Northern Territory.

Ammobaculites crespinae Bhalla

(Plate 1, Figure 11; Plate 9, Figure 4)

Ammobaculites crespinae Bhalla, 1965, p. 42, fig. 1f.

Ammobaculites crespinae Bhalla, 1969, p. 73, 74, pl. 1, fig. 9-11, fig. 7.

The test is free, cylindrical, composed of an early coiled, slightly evolute portion composed of 4-6 chambers, and an uniserial portion with usually 5 chambers. The chambers of the coiled and uniserial portions are inflated, rounded in cross section, typically nearly all of the same size, broader than high. The periphery is lobulate, the wall is moderately thick, composed of quartz grains with much siliceous cement. The aperture is central, and some species show a very short neck. The sutures are distinct, straight, sometimes curved. The last formed chamber may be dome-shaped. Leg 27 specimens agree well with description of *A. crespinae* as given by Bhalla (1965, 1969).

Ammobaculites irregulariformis Bartenstein and Brand

(Plate 1, Figure 12; Plate 9, Figure 5)

Ammobaculites irregulariformis, Bartenstein and Brand, 1951, p. 270, pl. 2, fig. 41-44, 46.

Ammobaculites irregulariformis Bartenstein and Brand, Crespin, 1963 p. 42, pl. 10, fig. 1-3.

The test is free, elongate, compressed laterally; the initial portion is irregularly coiled, with 4-9 chambers; the uniserial portion has 3-5 chambers. The chambers are generally compressed, broader than high, and irregular in shape; the last formed chamber is largest of all. The aperture is terminal, small, irregularly elliptical, the sutures are also irregular, nearly straight, usually distinct and quite deep, especially in the uniserial portion. The wall is coarsely arenaceous of quartz grains with siliceous cement; surface is roughly finished. Leg 27 specimens agree very well with the description of this form as given by Bhalla (1965).

Ammobaculites hofkeri Bhalla

(Plate 1, Figure 15)

Ammobaculites hofkeri Bhalla, 1965, p. 41-42, text-fig. 1, no. 1.

Ammobaculites hofkeri Bhalla, Bhalla, 1969, p. 22-23, pl. 1, fig. 15-18, text-fig. 6.

The test is free, quite large, robust-elongated, and flattened. The early part of the test is irregularly planispiral or streptospiral, formed of 3-8 gradually enlarging chambers. The uniserial part is formed of 3-8 large, broad, compressed chambers increasing gradually in size as added. The last chamber has the maximum height but the penultimate one is widest of all. The sutures of the coiled portion are indistinct, but those of the uniserial portion are distinct, depressed, and straight. The periphery is lobulate. The wall is quite thick, rather coarsely agglutinated, composed of quartz grains, with normal amount of cement. The aperture is rounded, terminal. Leg 27 specimens comply very well with the description and illustration as given by Bhalla (1969).

SPIROPLECTAMMINA Cushman, 1927

Spiroplectamina cushmani Crespin

(Plate 1, Figure 16; Plate 9, Figure 6)

Spiroplectamina cushmani Crespin, 1966, p. 49-50, pl. 13, fig. 1-4.

The test is free, elongate, coiled in early portion, biserial later, periphery is rounded. Megalospheric and microspheric tests differ greatly in their length—while the megalospheric tests are small and stout, the microspheric ones are at least twice the length of the megalospheric ones, with numerous chambers gradually increasing in size. Sutures are straight, distinct. The wall is medium of fine grained, the surface is usually smooth or with polished appearance. The aperture is an elongate opening at the base of the face of the last-formed chamber. It differs from *S. aequabilis* in a larger number of chambers in the biserial portion. Leg 27 specimens are very similar to *Spiroplectamina* species occurring in the Canning Basin (see Crespin in Veevers and Walls, 1961). They also resemble remarkably the *Spiroplectamina* species described by Tappan (1940, 1943) from the Grayson Formation of Texas and from the Duck Creek Formation of Oklahoma and Texas.

TEXTULARIA DeFrance in de Blainville, 1824

Textularia wilgunyaensis Crespin

(Plate 1, Figure 17)

Textularia wilgunyaensis Crespin, 1963, p. 53-54, pl. 14, fig. 5-11.

The test is free, biserial, elongate, tapering, with chambers increasing in width and height as added. The periphery is rounded, at times lobate, and the sutures are oblique; microspheric forms are composed of about 10 pairs of chambers, which may be slightly inflated and curved. Megalospheric forms are composed of 4 or 5 pairs of chambers, increasing rather rapidly in width and height; the last-formed pair of chambers is about twice the size of the previous ones, but only slightly inflated. The wall is finely arenaceous, composed of quartz and other mineral grains in siliceous cement. The aperture is fairly large and elongate, at the base of the last formed chamber. Specimens from Site 263 are very similar to *T. wilgunyaensis* described originally from the Great Artesian Basin. They are generally smaller and thinner than the typical forms.

Textularia anacooraensis Crespin

Textularia anacooraensis Crespin, 1953, p. 31, pl. 5, fig. 15.

The test is free, small, elongate, narrow, biserial throughout. It is composed of several chambers with their periphery narrowly rounded. Proloculus is followed by 7-9 pairs of chambers increasing in size very gradually. The aperture is an elongate slit at the base of the last chamber. The wall is finely arenaceous, smoothly finished. The species is known to be widely distributed in the lower Aptian of the marine sequence of the Great Artesian and Canning basins (Crespin, 1953, 1963, Crespin in Veevers and Wall, 1961, and Ludbrook, 1966).

PLANCTOSTOMA Loeblich and Tappan, 1955

Planctostoma sp.

(Plate 9, Figure 8a, b)

The test is free, elongate, biserial or very rarely with final uniserial arrangement. The wall is agglutinated, simple. The aperture is typically formed by a rounded opening in terminal face, slightly eccentric. Leg 27 specimens seem to comply well with the above diagnosis by Loeblich and Tappan (1964). The genus has not been previously reported in deposits older than Recent.

BIGENERINA d'Orbigny, 1826

Bigenerina loeblichae Crespin

(Plate 9, Figure 7)

Bigennerina loeblichae Crespin, 1953, p. 31, pl. 5, fig. 17, 18.*Bigennerina loeblichae* Crespin, 1953, Crespin, 1963, p. 54, pl. 14, fig. 12-14.

A few small and several large specimens of *Bigennerina* corresponding well to *B. loeblichae*, described originally from the Great Artesian Basin, occur in samples from Site 263 (see Table 6).

Family TROCHAMMINIDAE Schwager, 1877

TROCHAMMINA Parker and Jones, 1859

Trochammina minuta Crespin

(Plate 1, Figures 18-20; Plate 9, Figures 9a-c, 19a-c)

Trochammina minuta Crespin, 1953, p. 32, pl. 5, fig. 19a, b.*Trochammina minuta* Crespin, Crespin, 1963, p. 62, pl. 18, fig. 1-5.

The test is free, rather small and delicate, finely agglutinated and often shiny. The globular chambers are trochospirally coiled. All chambers are visible on the spiral side, 4-6 are visible on the umbilical side. The periphery is lobulate, the umbilicus is distinct and deep. The sutures are distinct, depressed, strongly curved on the spiral side, and radial to slightly curved on the umbilical side. The aperture is an elongate slit at the base of the last chamber (interiomarginal). Noncompressed specimens are *globigerina*-like in shape (see Plate 1, Figure 18). The species is widely distributed in the Aptian of the Great Artesian Basin and also in the Canning Basin. However, very similar *Globigerina*-shaped *Trochammina* reappear in the lower Albian in the Great Artesian Basin. It is extremely interesting that at Site 263 *Trochammina* specimens referred here to *T. minuta* also change and become less typical upward. These are here determined as *T. cf. minuta* Crespin. Detailed study of these forms is continuing.

Trochammina subinflata Crespin

(Plate 9, Figure 11a-c)

Trochammina subinflata Crespin, 1963, p. 63, pl. 18, fig. 11-19.*Trochammina* sp. Church, 1968, p. 533, pl. 1, fig. 1a-c.*Trochammina tehamaensis* Dailey, 1970, p. 105, pl. 11, fig. 12.

The test is free, low trochospiral, with flat or gently convex spiral side and convex umbilical side. The outline is lobulate, periphery is broadly to sharply rounded. All chambers are visible on the umbilical side. The chambers are distinct, subglobular, 5-6 in the final whorl and gradually increase in size as added. The sutures are indistinct to distinct on the dorsal side, depressed, and radial on the ventral side. The umbilicus is narrow, depressed. The wall is coarsely agglutinated, composed of angular quartz grains and quite roughly finished. The aperture is an arched slit at the base of the last chamber. The peripheral margin has an outline of clear cement.

This *Trochammina* occurs frequently in western Queensland but virtually identical forms were also described from the Lower Cretaceous of California (Dailey, 1970). Specimens are very characteristic morphologically although their size varies considerably (see also Dailey, 1970). Leg 27 specimens were compared with those described from the Great Artesian Basin and found identical with those of the same small size (borehole Conorada Ooroonoo No. 1).

Family ATAXOPHRAGMIIDAE Schwager, 1877

VERNEULINA d'Orbigny in de la Sagra 1839

Verneulina howchini Crespin

(Plate 9, Figure 12)

Verneulina howchini Crespin, 1953, p. 31, pl. 5, fig. 16.*Verneulina howchini* Crespin, Crespin, 1953, Crespin, 1963, p. 31, pl. 5, fig. 16.*Verneulina howchini* Crespin, Ludbrook, 1966, p. 103-104, pl. 7, fig. 1-3.

The test is free, agglutinated, biserial, elongate, sharply triangular in cross section, with peripheral margins irregular; the greatest width of the test is near the apertural end. The sides are concave and the angle varies in different specimens. There are 7-9 distinct chambers on each face, gradually increasing in size. The last formed chamber is large; in gerontic stage it extends across the width of the test. The sutures are distinct, slightly curved. The wall is finely arenaceous, often with much cement. The surface is quite smooth, sometimes coarse. The aperture forms as opening at the base of the last-formed chamber; in early stages it is rounded and terminal. *Verneulina howchini* occurs most typically in western and northwestern parts of the Great Artesian Basin. Specimens vary considerably in size.

MIGROS Finlay, 1939

Migros sp.

(Plate 1, Figure 24; Plate 9, Figure 13)

The test is free, agglutinated, with triserial early stage, and biserial later portion of the test. The triserial portion is triangular with bluntly rounded but distinct edges. The biserial portion is confined to 2 or 4 chambers. The aperture is rather characteristic—it is a fairly high loop-shaped opening. The genus is characteristic of the Austral Biogeoprovince, from which it spread to the north. Leg 27 specimens referred here to the genus *Migros* occur in an assemblage of diversified nature, which can be interpreted as characteristic of the Lower Cretaceous upper slope environment (see Sliter and Baker, 1972). Species deep sediments known in the Austral Biogeoprovince, especially in New Zealand. The Leg 27 occurrence helps link the Jurassic (Said and Barakat, 1958) and Upper Cretaceous (Finlay, 1939) occurrences.

VERNEULINOIDES Loeblich and Tappan, 1949

Verneulinoides crespinae Ludbrook

(Plate 1, Figures 25, 26; Plate 9, Figure 14)

Verneulinoides crespinae Ludbrook, 1966, p. 106, pl. 7, fig. 13, 14.

This species has been described by Ludbrook (1966) to substitute for the species *V. kansasensis* previously determined by Crespin (1963). However, there occur at least two different species of *Verneulinoides*, one of which is typical for lower part of the Lower Cretaceous section of the Great Artesian Basin and the second, attributed to *V. kansasensis* by Crespin (1963) in the uppermost part of the section above. *Verneulinoides crespinae* Ludbrook corresponds to the older representative. Its test is small, free, triserial, broadly elongate, and conical. The chambers are inflated, often almost globular, the sutures are distinct. The chambers are usually few in number. The aperture is a high narrow arch at the base of the last chamber. It differs from *Verneulinoides kansasensis*, occurring later in the Albian, by its inflated to globular chambers and distinctly broader conical chape. Both *Verneulinoides kansasensis* and *V. crespinae* are widely distributed in various parts of the Great Artesian Basin. Their presence is indicative of a shallowing of the marine environment. The occurrence of the species *crespinae* at Site 263 with other shallow-water species is in a good agreement with the palaeoenvironmental interpretation of Site 263 in this contribution.

GIRAVELLINA Bronnimann, 1953

?Gravellina sp.

(Plate 1, Figure 21)

In some samples from Site 263 a few specimens of a finely agglutinated, deeply umbilicate, highly trochospiral foraminifer occurs. The number of chambers in the last whorl is four; the number of chambers in previous whorls is not clear, but seems also to be four. The aperture seems to form an interiomarginal arch. The specimens are tentatively referred to *Gravellina*. Other representatives of *Gravellina* are known to occur in the Aptian of Azerbaidzhan and Miocene of Trinidad.

DOROTHIA Plumer, 1931

Dorothia sp.

(Plate 2, Figures 1-3)

A few specimens referred here to *Dorothia* sp. occur in samples of Sites 259 (Table 2) and 260 (Table 5).

EGGERELLA Cushman, 1933

Eggerella sp.

(Plate 2, Figure 4)

In Samples 259-14, CC and 260-9, CC a few specimens of an agglutinated foraminifer with calcitic cement and mostly calcitic particles occur. They are referred here to *Eggerella* sp. Representatives of *Eggerella* have not been previously described from the Lower Cretaceous of the Austral Biogeoprovince, although they are known to occur in the Upper Cretaceous in New Zealand (Finlay, 1939; Webb, 1970). The reason for this may be ecological, because bathymetrically equivalent deposits (upper slope) are unknown in Lower Cretaceous sediments on the continents adjacent to the Indian Ocean.

CLAVULINA d'Orbigny, 1826

Clavulina gabonica Le Calvez, de Klasz and Brun
(Plate 2, Figures 5-9)

Clavulina gabonica Le Calvez, de Klasz, and Brun, 1971, p. 308, 310, pl. 1, fig. 7-9.

In samples from Sites 259 and 260 several specimens of *Clavulina* referred here to *C. gabonica* occur. The test is free, very finely agglutinated, and quite large. The initial biserial stage is followed by a uniserial stage composed of often quite long series of chambers circular in cross-section. The aperture is a terminal, rounded opening. The sutures are distinct, depressed, in uniserial part, horizontal. The wall is very finely agglutinated and smooth. Representatives of the genus *Clavulina* are unknown from the Lower Cretaceous deposits on the Great Artesian Basin, but they have been described from the Cenomanian of western equatorial Africa in Gabon (Le Calvez, de Klasz, and Brun, 1971). Leg 27 specimens closely resemble the African specimens. Specimens of *Clavulina* identical with those from the DSDP in the Indian Ocean were found by the author in samples from the borehole Dampier No. 1 at 7783' and 7778' depth (see Table 5).

MATANZIA Palmer, 1936

Matanzia sp.
(Plate 9, Figure 15a-b)

Typical *Matanzia* with a short, stout, and smooth test with poorly developed vertical partitions projected inward from quite a thick wall. The test is free and finely agglutinated with calcareous particles in considerable cement. The early stages are trochospiral, later biserial. The chambers are quite inflated, especially those of the biserial portion. The surface is smooth and characterized by long thin particles (most probably sponge spicules) seemingly radially arranged. The aperture is a rounded, quite large interiomarginal opening. The species occurs in a diversified assemblage characteristic of the Cretaceous upper slope environment.

JARVISSELLA Brönnimann, 1953

Jarvisella sp.
(Plate 9, Figure 16)

In Sample 263-19, CC one specimen of a trochospiral, later triserial, agglutinated form was found. The chambers are partially subdivided by vertical infolding of walls. The wall is finely agglutinated, thin, the aperture is interiomarginal. The form is tentatively placed in *Jarvisella*.

REMESELLA Vasicek, 1947

Remesella sp.
(Plate 2, Figure 10; Plate 9, Figure 17a-b)

A few specimens of an agglutinated form occur in Sample 259-14, CC with early stages triserial and later ones biserial with incomplete vertical partitions. The interiomarginal aperture is in the form of quite a wide opening with a thickened rim. It is the oldest known representative referable to *Remesella*; it is quite primitive, so that the incomplete vertical partitions are reflected on the surface in the form of grooves, but only very slightly. Recently, representatives of the genus *Remesella* (*R. africana*) have been reported from the Paleocene of Gabon (Le Calvez, de Klasz, and Brun, 1971).

Superfamily MILIOLACEA EHRENBERG, 1839

Family MILIOLIDAE Ehrenberg, 1829

SCUTULORIS Loeblich and Tappan

Scutuloris sp.
(Plate 9, Figure 18a-b)

The only specimen referable to *Scutuloris* was found in Sample 263-19, CC. It is very poorly preserved (mechanically corroded). Nevertheless, its aperture is rather characteristic and it resembles specimens of *Scutuloris* as known to occur in some Aptian samples in the Great Artesian Basin (Scheibnerová, in press, a).

Suborder ROTALIINA Delage and Herouard, 1876

Superfamily NODOSARIACEA Ehrenberg, 1838

Family NODOSARIIDAE Ehrenberg, 1838

NODOSARIA Lamarck, 1812

Nodosaria cf. gidya Ludbrook, 1966
(Plate 2, Figure 14; Plate 10, Figure 1)

Nodosaria gidya Ludbrook, 1966, p. 108, pl. 7, fig. 17.

The specimens recovered from Sample 263-23, CC resemble Australian specimens described by Ludbrook (1966) as *Nodosaria gidya*. They differ in having 4-5 instead of 3 chambers following the proloculus. Identical specimens were determined by the author in samples from the boreholes Dampier No. 1 and BMR No. 5 drilled in the Carnarvon Basin. They also resemble *Nodosariid* described as *N. obscura* Reuss by Tappan (1943, pl. 80, fig. 1, 2) from the Duck Creek Formation of Oklahoma and Texas.

LENTICULINA Lamarck, 1804

Lenticulina sp. 1

(Plate 3, Figures 16-22; Plate 10, Figures 2a-b)

The test is free, planispiral, tightly coiled. The thickness of the test is one third or slightly more of the diameter. The sutures are distinctly limbate, much raised and forming thickened ridges, especially at the inner ends. The test tends to uncoil. The periphery has a distinct keel. Leg 27 specimens resemble an Upper Cretaceous form known as *Robulus navarroensis extruatus* Cushman. Very similar specimens occur in samples from the Cenomanian of Zululand (South Africa) described by Lambert (1972). Determination of the above form requires more study.

Lenticulina sp. 2

(Plate 2, Figure 29; Plate 10, Figure 3)

These *Lenticulina* specimens are identical with those reported recently from the middle-upper Albian of Zululand (South Africa) by Lambert and Scheibnerová (in press).

Lenticulina spinosa (Eichenberg)

(Plate 3, Figures 9-15; Plate 10, Figure 4)

Lenticulina (S.) spinosa (Eichenberg, 1935), Bartenstein, Bettenstaedt, and Bolli, 1966, p. 27, pl. 2, fig. 21, 22.

The test is free, fairly large; the early portion is completely coiled, later chambers are somewhat uncoiled and the test becomes triangular in transverse section; the chambers are distinct, 6-9 in the uncoiled part. The sutures are distinct but not depressed, and curved. The wall is calcareous, smooth except for the sides of the apertural face, which are somewhat thickened or even spiny. There is a tendency for the periphery and the sides to become carinate. The radiate aperture is at the angle of the upper end. Somewhat similar forms, but with fewer chambers in the uncoiled part, have been described by Dailey (1970) from the Aptian of the Budden Canyon Formation, northwestern Sacramento Valley, California.

Saracenaria erlita Ludbrook

(Plate 2, Figures 25, 26)

Saracenaria erlita Ludbrook, 1966, p. 125, pl. 8, fig. 10.

The test is free, robust, with the early portion coiled and later one uncoiled. Only the last chamber is not in contact with the coiled portion. The coiled portion consists of six chambers and is followed by two chambers in an almost straight line. The first of these chambers extends over the coiled portion. The last two chambers are inflated, triangular in cross-section, and the final chamber is strongly inflated ventrally. The sutures are distinct, curved and slightly depressed in the coiled portion, distinctly depressed and oblique in the straight portion. The wall is calcareous, very finely perforate, and the surface is smooth. The radiate aperture is at the peripheral angle. Specimens from Site 263 are identical with those described from the Aptian of the Great Artesian Basin.

Saraceneria kattarensis Ludbrook

(Plate 10, Figure 8)

Saraceneria kattarensis Ludbrook, 1966, p. 126, pl. 8, fig. 11-13.

The test is free, of medium size, making a robust impression. The early portion, consisting of about 3-6 chambers, is coiled, the uncoiled portion is formed of 3 chambers of which only 1 extends over the coiled portion. The final chambers are triangular in section. The sutures are distinct and curved, flush with surface except for 1 or 2 last ones,

which tend to be slightly depressed. The species is very similar to *S. erlita*, from which it differs in having typically 3, rather than 2, chambers in a straight series. The species is typical of the Aptian of the Great Artesian Basin.

Saraceneria lutanata Ludbrook
(Plate 3, Figures 7, 8)

Saraceneria lutanata Ludbrook, 1966, p. 126-127; pl. 8, fig. 18.

The test is free, of medium size with the early portion coiled and consisting of a small globular protoculus and four gradually enlarging chambers followed by 3-4 uncoiled chambers in a gently curved series. In Ludbrook (1966, pl. 8, fig. 18) there is a discrepancy between the 4 described chambers of the uncoiled portion and the 6 figured chambers in the holotype. The bluntly carinate ventrally on each margin of the apertural face. The chambers of the uncoiled portion are inflated ventrally, the final one being most inflated. The sutures are distinct, only slightly depressed and curved. The wall is calcareous, very finely perforate; the radial aperture is at the peripheral angle. The species is characteristic of the Aptian and Albian of the Great Artesian Basin.

Marginulina sp.
(Plate 2, Figure 30)

Specimens found at Site 263 are identical with those described by Ludbrook (1966, p. 129) as *Vaginulina tripleura* (Reuss) from the Aptian of the Great Artesian Basin. Revisional studies of this and other Nodosariids occurring typically in the Great Artesian Basin are continuing.

Marginulinopsis kareelensis Ludbrook
(Plate 2, Figure 27)

Marginulinopsis kareelensis Ludbrook, 1966, p. 121, pl. 9, fig. 16, 17.

The test of this small- to medium-size nodosariid is free, ovate to circular in section. The early portion, consisting of indistinct 5-6 chambers, is followed by 2 or 3 chambers in almost rectilinear series. The chambers are broader than high and the final chamber is globular and inflated. The sutures are distinct, slightly depressed and obscured by interrupted longitudinal ribs. The wall is calcareous, finely perforate, and covered by about 11 longitudinal elevated ribs discontinuous over the sutures except for the 2 continuing without interruption along the periphery of the uncoiled portion to the aperture. The aperture is radiate, at the peripheral angle, protruding. The species is typical for some parts of the Great Artesian Basin, especially in the Aptian.

Marginulinopsis arimensis Ludbrook
(Plate 3, Figure 4)

Marginulinopsis arimensis Ludbrook, 1966, p. 119, pl. 9, fig. 10-12.

The test is free, of medium size, making a robust impression, elongate, and slightly depressed laterally. The coiled portion consist of 4-6 indistinct chambers followed by 3-5 (mostly 4) chambers in a rectilinear series. The last chamber is inflated. The sutures are radial or curved and indistinct in the coiled portion and oblique and distinct in the rectilinear portion. The wall is calcareous, finely perforate, and smooth. The aperture is radiate at the peripheral angle. The species is typical of the upper Aptian-lower Albian of the Great Artesian Basin.

FRONDICULARIA DeFrance in d'Orbigny, 1826

Frondicularia sp.
(Plate 10, Figure 5)

In two samples from Site 259 a few specimens of *Frondicularia* sp. occur. They are long slender forms with flat sides and sharp-angled margins.

TRIBRACHIA Schubert, 1912

Tribrachia australiana Ludbrook, 1966
(Plate 2, Figure 16; Plate 10, Figure 6)

Tribrachia australiana Ludbrook, 1966, p. 128, pl. 8, fig. 19, 20.

The test of this single specimen found in Sample 259-15-5, 124-126 cm is quite large, uniserial, triangular in section with 7 chambers. The chambers are low, broad, and increase very slightly in height as added. The three faces of the test are deeply concave, with the chambers strongly arched and extending backwards towards the proloculus at the angles which are rounded and carinate. The sutures are distinct,

depressed, the wall is calcareous finely perforate, but with a layer of imperforate (or extremely finely perforate) calcite on edges and sutures. The surface is smooth and shiny. The aperture is a terminal rounded opening.

PALMULA Lea, 1833

Palmula cf. bivium Finlay
(Plate 2, Figures 17-22, Plate 10, Figures 7a-c)

Palmula bivium Finlay, 1939, p. 315, pl. 26, fig. 59.

This is a very characteristic component of the assemblages from Site 259. It is characterized by a prominent planispiral stage composed of about 6 chambers and heavily noduled, raised sutures, and 6-7 high-arched uniserial chambers with limbate but less nodular sutures. The sides are sharply carinate and end faces are truncate. Specimens are large, up to 1.35 mm in length. Because *Palmula bivium* was originally described as a Tertiary species (an index species of upper Bortonian) Leg 27 specimens are only compared with Finlay's species. They may be similar to the form known to occur in the upper Albian of the Utatur Group of the East Coast Gondwanas described by Sastri and Sastry (1966) as *Palmula suturalis* (Cushman). However, the illustrations given by the above authors do not indicate any heavily noduled sutures so characteristic of the Leg 27 specimens.

Family POLYMORPHINIDAE d'Orbigny, 1839

EOGUTTULINA Cushman and Ozawa, 1930

Eoguttulina sp. group
(Plate 3, Figures 24-27)

Samples from Site 263 contain several specimens of a polymorphinid referred here to *Eoguttulina* sp. It is quite a prominent constituent of the assemblages (see Table 6). The test is free, medium-size, robust, with chambers added in elongate spiral series in planes less than 90° apart. Four chambers are usual. Identical specimens of *Eoguttulina* sp. occur in samples from the offshore borehole Dampier No. 1 (see Table 4) and in the Great Artesian Basin in the core samples from the boreholes BMR Richmond No. 1, BMR Longreach No. 1, and lower parts of the DM Weilmoringle No. 1.

Family GLANDULINIDAE Reuss, 1860

Glandulina sp.
(Plate 10, Figure 9)

A few specimens of *Glandulina* sp. were found in Sample 263-29, CC. They are quite small, smooth, thin-walled, and identical with *Glandulina* sp. reported from the coeval sediments in the Great Artesian Basin.

Superfamily BULIMINACEA Jones, 1875

Family TURRILINIDAE Cushman, 1927

NEOBULIMINA Cushman and Wickenden, 1928

Neobulimina australiana Ludbrook
(Plate 4, Figures 1, 2; Plate 10, Figures 10, 11)

Neobulimina australiana Ludbrook, 1966, p. 132, pl. 10, fig. 20.

Neobulimina australiana is a prominent constituent in some samples from Sites 259 and 260 (see Tables 2, 5). The test is free, very tiny, stout, triserial and later biserial, smooth, with inflated chambers. These specimens are identical with *Neobulimina* known from the western and northeastern parts of the Great Artesian Basin (Ludbrook, 1966). These occur in sediments characterized by a relatively deep-water (outer shelf) assemblages with planktonic foraminifera (*Hedbergella*) present.

PRAEBULIMINA Hofker, 1953

Praebulimina sp.
(Plate 4, Figure 3; Plate 10, Figure 12)

A few specimens of praebuliminas triserial throughout occur in Sites 259 and 260 (see Tables 2, 5). They appear very similar to the species occurring in the deeper facies (outer shelf) of the Great Artesian Basin. They are especially close to those specimens from the borehole Conrada Ooroonoo No. 1 in western Queensland and especially from northeastern South Australia referable to *Praebulimina* cf. *nannina* (Ludbrook, 1966).

RECTOBULIMINA Marie, 1956

Rectobulimina sp.
(Plate 10, Figure 13)

The only specimen found, in Sample 259-17-3, 38-40 cm, is very small and fragile. The initial part is triserial, later biserial or cuneate, and finally uniserial. The wall is calcareous, finely perforate. The aperture is terminally rounded, flush with the surface. No lip or neck is present. The internal structure is unknown because of lack of additional specimens for more detailed study. The occurrence of *Rectobulimina* in the Albian sediments in the Indian Ocean is very interesting from the evolutionary point of view—it is the oldest known representative of the genus so far discovered.

SPIROBOLIVINA Hofker, 1956

Spirobolivina australis n. sp.
(Plate 4, Figure 4; Plate 10, Figure 14)

Holotype: specimen no. MMMC 00650, figured in this contribution on Plate 10, Figure 14.

Type locality: DSDP Leg 27, Site 259, Sample 14, CC.

Type horizon: upper Albian.

Dimensions of the holotype: length, 0.350 mm; width, 0.250 mm; thickness, 0.151 mm.

Derivation of the name: *australis*—after its first occurrence within the Austral Biogeoprovince.

Diagnosis: *Spirobolivina* with flat, parallel sides; broad, flat periphery; and sharp-angled edges.

The test is free, calcareous, initially spiral, later biserial. The chambers are low, broad, flat, the sutures are straight, horizontal, limbate. The periphery is broad, flat, the side edges are sharp and limbate. The loop-shaped aperture with a small internal tooth plate is at the base of the apertural face of the last chamber. The genus was described from the Paleocene-upper Eocene and the Leg 27 species is the oldest representative of the genus.

Superfamily DISCORBACEA Ehrenberg, 1838

Family DISCORBIDAE Ehrenberg, 1838

DISCORBIS Lamarck, 1804

?Discorbis sp.
(Plate 4, Figures 5-7)

In several samples from Site 259 specimens strongly resembling *Discorbis* sp. (Scheibnerová, 1972a) known to occur in the Albian of the Great Artesian Basin and South Africa occur sporadically. They are free, trochospiral, plano-convex or concavo-convex, flattened on the umbilical side. All chambers are visible on the spiral side, only 5-6 chambers of the last whorl are visible on the umbilical side. The primary aperture is an interiomarginal extra-umbilical arch. The secondary sutural openings are at opposite sides of a chamber flap and remain open. The periphery is gently angled or narrowly rounded. The wall is calcareous and with characteristically widely scattered coarse perforations (see also, Scheibnerová, 1972a, and Lambert and Scheibnerová, in press): The same forms also occur in the "middle Inoceramus" beds (upper Albian-lower Cenomanian) of Argentina (Malumian, personal communication). The above and associated forms of *?Discorbis* sp. are being studied in more detail. Their occurrence in the samples of comparatively deeper sediments from the deep-sea cores are extremely important for environmental studies in the Austral Biogeoprovince.

PATELLINELLA Cushman, 1928

Patellinella australis Lambert and Scheibnerová
(Plate 4, Figures 8-10; Plate 10, Figure 15a-c)

Patellinella australis Lambert and Scheibnerová, in press p. 82, pl. 3, fig. 5, text-fig. 12.

The test is free, conical-trochoid, plano-convex; the earliest whorl is usually composed of 3 chambers and mostly broken off. Later there are only 2 chambers in the whorl. All whorls are visible on the dorsal side, only the final 2 chambers are visible on the ventral side. The wall is calcareous, very finely perforate, and radial in structure. The aperture is a ventral broad arch opening into the umbilicus. The last 2 chambers are broader (flat or lobulate) than the previous ones. Specimens of *Patellinella australis* Lambert and Scheibnerová are identical with those found in the deep-sea samples in

the Indian Ocean. They form a very characteristic constituent of the assemblage in Site 259, as they do in South African samples as described by Lambert and Scheibnerová (in press). In this connection it is quite significant that sediments yielding *P. australis* in South Africa are of shallow-water origin (inner neritic with open marine connections). The species has originally been reported from the middle-upper Albian in South Africa (Lambert and Scheibnerová, in press). As originally described, *Patellinella australis* occurred in shallow-water marine (inner neritic with open-marine connections) environment. The occurrence of this species in Site 259 shows that, if this material is in situ, the species occurs also in deeper waters, perhaps down to about 600 meters.

VALVULINERIA Cushman, 1926

Valvulineria sp.
(Plate 10, Figures 16a-c; 17a-c)

In Sample 259-14, CC, numerous specimens of small, thin-walled trochospiral calcareous foraminifera were found, here referred to as *Valvulineria* sp. They are rarely larger than 0.3 mm in diameter, smooth, thin-walled, quite flat both sides, and chambers only very moderately inflated. They are either oval or rounded in outline, with 6-7 chambers in the last whorl and narrowly rounded periphery. The aperture is interiomarginal, extra-umbilical-umbilical, with thin apertural flap projecting over the umbilicus. The sutures are radial, depressed, distinct.

Superfamily ORBITOIDACEA Schwager 1876

Family EPONIDIDAE Hofker, 1951

EPONIDES Montfort, 1808

Eponides sp.
(Plate 4, Figures 11, 12; Plate 11, Figure 1a-c)

In samples from Site 259 there are a few specimens of rotaloids, which are here placed in *Eponides* sp. They are very small, calcareous, trochospiral faunas with flat or concave spiral side and convex to strongly convex umbilical sides. Sutures of the spiral side are distinct to limbate, curved, those of the umbilical side are radial and depressed. Chambers of the spiral side are flat or concave, those of the umbilical side are inflated. The periphery is sharply angled, the last 2-3 chambers are strongly sloping. The aperture is interiomarginal. The species occurring in the deep-sea samples from Site 259 of upper Albian age are quite similar to those very characteristic of the Upper Cretaceous in the eastern South Atlantic deep-sea cores, described recently in Scheibnerová (1973a). They probably belong to the same group and may represent the ancestral forms, from which the Upper Cretaceous forms evolved. Representatives of the genus *Eponides* are very characteristic constituents in the Cretaceous (especially upper) marine assemblages in the Austral Biogeoprovince. They indicate a slightly deeper environment of an upper slope (down to about 1000 m in depth).

Superfamily CASSIDULINACEA d'Orbigny 1839

Family PLEUROSOMELLIDAE Reuss, 1860

Genus PLEUROSOMELLA Reuss, 1860

Pleurostomella obtusa Berthelin
(Plate 11, Figure 2)

Pleurostomella obtusa Berthelin, 1880, p. 29, pl. 1, fig. 9a-b.

Pleurostomella obtusa Berthelin, Neagu, 1965, p. 29, pl. 1, fig. 29-32 (cum syn.)

Pleurostomella obtusa Berthelin, Gawor-Biedowa, 1972 p. 93-94, pl. 13, fig. 1-4

The test is small, elongate; chambers are cuneate (biserial) and alternating in position, later uniserial; the sutures in early stages are oblique, later becoming nearly straight and horizontal. The wall is calcareous, very finely perforate, and granular in structure. The aperture is terminal with a projecting hood at one side, two small teeth in the opposite side, and an internal tube. The surface is smooth. Specimens from Site 259 (see Table 1) are very similar to the forms described from the Polish Lowlands (upper Albian-Turonian) by Gawor-Biedowa (1972).

Family CAUCASINIDAE Bykova, 1959

CORYPHOSTOMA Loeblich and Tappan, 1962

Coryphostoma sp.

(Plate 4, Figures 13-26; Plate 11, Figure 3)

In several late Albian samples from Leg 27 (see Tables 1, 4) extremely small, tiny, fragile, generally biserial, and characteristically twisted, calcareous forms occur. They seem biserial throughout, but later chambers tend to be cuneiform or even uniserial. The aperture is generally loop-shaped extending from the base of the final chamber along the apertural face. The form is tentatively placed in the genus *Coryphostoma*. Further detailed studies of sectioned specimens are necessary.

Family OSANGULARIIDAE Loeblich and Tappan

OSANGULARIA Brotzen, 1940

Osangularia utaturensis (Sastri and Sastri)

(Plate 4, Figures 27, 28; Plate 5, Figures 1-9; Plate 11, Figures 4a-c, 5a-c)

Eponides utaturcusis Sastri and Sastry, 1966, p. 292, pl. 19, fig. 6a-c.*Osangularia californica* Dailey, 1970 p. 108, 109, pl. 13, fig. 3, 4.

The test is free, circular or nearly circular in outline, equally biconvex or with spiral side more convex than umbilical. The periphery is bluntly acute to acute. The chambers are nearly flat, generally 10-12 in the final whorl and increasing gradually in size as added. The chambers of 1½-3 whorls are visible spirally, only those of the final whorl are visible ventrally. The sutures are distinct, oblique, straight to slightly curved initially and becoming strongly curved later, both spirally and ventrally. All sutures, with the exception of those between the final 2-3 chambers, are limbate and raised, sometimes meeting at the periphery to form quite acute and elevated margins (keels). The wall is calcareous, finely perforate, smooth, with layers of imperforate secondary calcite along the sutures and central part of the test on both sides. The aperture is V-shaped and forms a slit at the base of the final chamber, then bends obliquely up the apertural face; occasionally two isolated slits (an interiomarginal and the other areal) occur.

The author had an opportunity to compare the specimens studied with those described by Dailey (1970) as *Osangularia californica* from the Aptian-Albian of the northwestern Sacramento Valley, California. Leg 27 forms correlate extremely well with the Californian specimens except that the degree of sharpness of the periphery varies more in Leg 27 specimens and the ventral umbilical plug is present only in some specimens. Sastri and Sastry (1966) described this species from upper Albian of the Utatur Formation of the Trichinopoly district (Madras, India as *Eponides utaturensis*. Although their description is far from being exhaustive, their illustration and the general identity of the foraminiferal assemblages in the samples studied and those of the Utatur Formation which was due to the paleogeographical proximity of their paleoenvironments, leaves little doubt about the identity of Leg 27 specimens and the otherwise very characteristic species *utaturensis*. At the same time, I regard the species *utaturensis* to be a senior synonym of *Osangularia californica*. The generic position of the species *utaturensis* has been referred to *Osangularia*. Specimens referable to *Osangularia utaturensis* have been reported in the Indian part of the Austral Biogeoprovince from the upper Albian of the Trichinopoly district by Sastri and Sastry (1966)¹ as mentioned above. The present author identified specimens referable to *Osangularia utaturensis*, identical with the specimens from the deep-sea cores studied, in the borehole Dampier No. 1, and offshore borehole drilled under the subsidy of the Bureau of Mineral Resources at 19°52.21'S; 16°00.49'E (Core 8, depth 2621 m [8600 ft 0 in.]), and in the borehole BMR No. 5 drilled by the Bureau of Mineral Resources in the

Carnarvon Basin (see Bastian and Wilmott, 1965) in the following samples: Core 12, depth 365-368 m (1200-1210 ft); Core 11, depth 334-339 m (1096-1106 ft) (bottom); Core 15, 458-461 m (1505-1515 ft) (middle). Core 15, depth 458-461 m (1505-1515 ft) (bottom).

A wide geographical distribution of *Osangularia utaturensis* shows a strongly cosmopolitan nature of this species within the non-tropical waters of the Austral and Boreal biogeoprovinces. The typical occurrence in epicontinental sediments deposited in mostly outer neritic environments characterizes this species as a shallow-water faunal element (neritic to upper slope).

GYROIDINOIDES Brotzen, 1942

Gyroidinoides cf. *primitiva* Hofker

(Plate 5, Figures 10-12; Plate 11, Figure 6a-c)

Gyroidinoides primitiva Hofker, 1957, p. 393, fig. 436.

The test is small, trochospiral, planoconvex, with strongly convex umbilical side. Usually 7 strongly ventrally inflated chambers in the last whorl. The periphery is broadly rounded. The aperture is peripheroventral and covered by a distinct narrow lip. The umbilicus is very narrow. Although the specimens are small, they make a robust impression. They closely resemble the specimens of *Gyroidinoides* from the comparative samples from northwestern Germany. They also resemble the species described recently as *Gyroidinoides primitiva* forma *australis* from the Great Artesian Basin in Australia (Scheibnerová, in press a), but the chambers of the Indian form are more inflated, the spiral side less involute and the periphery more rounded.

GAVELINELLA Brotzen, 1942

Gavelinella ex. gr. *intermedia* (Berthelin)

(Plate 5, Figures 18-24; Plate 6, Figures 1-4)

Anomalina intermedia Berthelin, 1880, p. 67-68, pl. 4, fig. 14a-c.*Gavelinella* (*Berthelina*) *intermedia*, Malapris, 1965, p. 138-139, pl. 1, fig. 2-4, 6 (non-fig. 1, 5, 7), pl. 2, fig. 2-4 (non-fig. 2, 5, 7).*Gavelinella intermedia* (Berthelin, 1880), Michael, 1966, p. 432, 434, pl. 50, fig. 4-13 (cum syn).*Gavelinella* (*Berthelina*) *intermedia* (Berthelin), Gawor-Biedowa, 1972, p. 120-121, pl. 15, fig. 7-9 (a-c), fig. 12.

The test is free, calcareous, palinspiral, nearly bilaterally symmetrical, round in outline. The dorsal side is more convex than the ventral, semi-involute, with chambers of 1½ whorl visible. The last whorl is composed of 9-12 chambers (mostly 9-10). The umbilical depression in the spiral side is sometimes filled with an imperforate secondary calcite, sometimes forming a knob. The apertural part of the test involute and bears a slit-like interiomarginal-equatorial aperture. The aperture is covered by a more or less wide imperforate lip entering into the ventral side and reaching under the imperforate flaps of the last chambers. The sutures are slightly curved on both sides and distinct only between 3-5 last chambers of the last whorl. The periphery is narrowly rounded. *Gavelinella intermedia* shows an extensive individual variability in size, convexity of the test and chambers, especially in the ventral side, and in the extent of deposition of the imperforate secondary calcite. Specimens described as *Gavelinella* ex. gr. *intermedia* were reported recently from the middle-upper Albian of the Umzinene River section Zululand (South Africa) (Lambert and Scheibnerová, in press).

Family ANOMALINIDAE Cushman, 1927

ANOMALINA d'Orbigny, 1826

Anomalina indica Sastri and Sastry 1966

(Plate 5, Figures 13-17; Plate 11, Figure 7a-c)

Anomalina indica Sastri and Sastry, 1966, p. 293, 294, pl. 19, 10a-c.

A few specimens found in samples from Site 259 (see Table 2) are of medium size, slightly asymmetrically planispiral with one side slightly more involute than the other. The last whorl is composed of 10 chambers, slightly inflated initially, the last 2 chambers being strongly inflated. The periphery is sub-acute, becoming rounded in the last formed chambers. The sutures are slightly curved, distinct, moderately to strongly depressed. There are narrow, small umbilici, the less involute one is filled with a small boss. The aperture is a distinct, narrow equatorial arch. The surface is smooth, the wall is calcareous, finely perforate. *Anomalina indica* was described by Sastri and Sastry (1966) from the lower Utatur Stage (upper Albian) of the east coast

¹Rasheed (1962a, 1962b, 1963) described several benthonic, both agglutinated and calcareous, taxa from the Culligoody (Dalmiapuram) Limestone (Trichinopoly Cretaceous) of peninsular India near Madras. As Rasheed's illustrations show, these foraminifera are practically identical with those recovered by the Deep Sea Drilling Project. However, more precise stratigraphic determinations and taxonomic revision are necessary to allow successful comparison.

Gondwanas. It is a very characteristic and figure given by the above authors. Nevertheless, there is also a remarkable similarity between our specimens and those described as *Anomalina plummerae* Tappan (Tappan, 1940, 1943). Comparison of the Leg 27 and American specimens would be necessary to state the degree of this similarity.

Family LINGULOGAVELINELLIDAE Scheibnerová, 1972

LINGULOGAVELINELLA Malapris, 1965

***Lingulogavelinella* cf. *frankei* (Bykova 1953)**

(Plate 7, Figures 5-7; Plate 11, Figure 8a-c)

(See also Plate 6, Figures 5-16; Plate, Figures 1-3)

Specimens found in the Site 259 samples are not very typical representatives of *L. frankei*. They have mostly 4-4½ chambers in the last whorl, rarely 5. They are strongly inflated with rounded, broad, lobulate periphery. Both sides of this trochospiral form are completely involute. The ventral sutures are radial and depressed, the dorsal ones are curved and covered by perforate chamber wall extensions, which in most specimens are quite indistinct. Morphologically, the closest specimens to the ones recovered on Leg 27 come from the western part of the Great Artesian Basin, from the borehole Conrada Ooroonoo No. 1 in southwestern Queensland. Very similar forms were described by Ludbrook (1966) as *Anomalinoidea innaminckae* from the Aptian of the South Australian part of the Great Artesian Basin, and by Sastri and Sastry (1966) from the Utatur Group (India, Trichinopoly district) as *Anomalina tennesseensis*. However, a study of the latter specimens and comparison with the deep-sea material would be necessary to confirm this. The genus *Lingulogavelinella* has recently been reported to occur in India by Narayanan and Scheibnerová (in preparation). The only Albian report of *Lingulogavelinella frankei* (or forms closely resembling this species) came from the Albian type area in France (Malapris, 1965; Malapris-Bizouard, 1967). However, the species occurs typically in the Cenomanian and Turonian of the Crimea and Caucasus (most recent data from Maslakova, personal communication) and Cenomanian and lower Turonian of the Mangyshlak area (Vasilenko, 1961).

As mentioned above and as discussed elsewhere (Malapris-Bizouard, 1967, and Scheibnerová, 1971c) strongly involute, small, rounded *Lingulogavelinella* referable to the species *frankei* have been reported from sediments ranging in age between Albian and Turonian within the non-tropical Cretaceous climatic zone. Malapris-Bizouard (1967) expressed an interesting opinion that the species *frankei* may actually represent aberrant forms of the *albiensis* population. Therefore, she modified her own previous determination as *Lingulogavelinella* aff. *frankei* (Malapris, 1965; Malapris-Bizouard, 1967) and referred the small involute forms to "forme anonçant *frankei*" to express to their resemblance with *Pseudovalvulineria frankei* (Bykova) in Vasilenko (1961) reported from the Cenomanian of Mangyshlak. She questioned the biological reality of this form.

As far as the morphology of these small involute *Lingulogavelinella* is concerned, there is little doubt of their generic position. Regarding their specific position, it is impossible to overlook that they are characterized by a very stable morphology (number of chambers varying between 5-7, inflation of chambers, involution of the tests, the presence and form of apertural flaps, even distribution of pores) over widely separated areas. Specimens described and figured by Malapris (1965), Malapris-Bizouard (1967), and Vasilenko (1961) certainly appear strikingly identical with the author's specimens from the Great Artesian Basin. This fact is emphasized by confirmation by Maslakova who inspected the Australian specimens and agreed that such specimens, identified as *L. frankei* do occur in numbers in the Cenomanian and even in the Turonian of the Crimea and Caucasus. Thus, the morphology of *Lingulogavelinella frankei* does not pose any serious problem. However, stratigraphically, it is difficult to decide whether it is an Albian (upper), Cenomanian, or Turonian species. The only undoubtedly Albian record is that by Malapris (1965) and Malapris-Bizouard (1967) from the upper part of the Albian type section in France. All other occurrences are younger than Albian. Therefore, when describing this species from the Great Artesian Basin the author regarded this species as indicating also the possibility of a lower Cenomanian age of the upper part of the marine Cretaceous profile of the Great Artesian Basin. Unfortunately, drilling on Leg 27 did not recover material which would elucidate the problem. Specimens of *Lingulogavelinella* are not typical *L. frankei* as known from the closely adjacent area in Australia; this could be explained by the undoubtedly Albian (upper) age of the Leg 27 assemblages in

which typical *L. frankei*, if being a Cenomanian species could have not yet occurred. However, another explanation is possible: namely, that the environment of the upper Albian sediments in Site 259 was deeper than the optimum depth required by *Lingulogavelinella frankei*.

ORITHOSTELLA Eicher and Worstell, 1970

***Orithostella indica* n. sp.**

(Plate 7, Figures 4, 8-13; Plate 8, Figures 1-9; Plate 11, Figure 9a-c)

Holotype: Specimen No. MMMC 00651 described and figured in this paper.

Material: More than 50 specimens from Sites 259 and 260.

Type locality: DSDP Leg 27, Site 259, Sample 14, CC.

Type horizon: upper Albian.

Dimensions of the holotype: Maximum diameter, 0.370 mm; minimum diameter, 0.310 mm; thickness, 0.170 mm.

Diagnosis: *Orithostella* with less convex umbilical side when compared with the type species *viriola*, with narrowly rounded or bluntly angular periphery, sometimes with an imperforate keel present and only moderately inflated chambers on the ventral (aboral) side.

The test is free, of medium size, calcareous, trochospiral, involute, with slightly less involute umbilical (ventral, aboral) side, and involute dorsal (oral) side. Only the chambers of the last whorl are visible on both sides. There are 7-9 flat, slightly but distinctly inflated chambers on the dorsal (oral) side. Those of the ventral (aboral) side are more convex, but less than in the type species *viriola*. The aperture is periphero-dorsal. The dorsal part of the aperture is covered by quite long tongue-like extensions of the chamber wall along the sutures between the chambers covering about one third of the length of the sutures. They are typically imperforate as also are those of the type species *Orithostella viriola* Eicher and Worstell (Eicher and Worstell, 1970, pl. 6, fig. 6-8). The peripheral part of the aperture is bordered by a rim, sometimes indistinct. The periphery is narrow, subangular, sometimes with a non-perforate keel present.

Orithostella indica sp. nov. differs from an Aptian-lower Albian *Orithostella australis* Scheibnerová by more numerous chambers in the last whorl and an oval rather than round shape (outline) of the test as well as a higher stratigraphical occurrence. When compared with the representatives of the genus *Lingulogavelinella*, species referred to *Orithostella* show close similarity. They were placed in the *Lingulogavelinella* family by the present author (Scheibnerová, 1972a). Eicher and Worstell (1970) took an extreme convexity of an aboral side of the test as the most important difference between these two genera and also between *Gavelinella* and *Orithostella*. Since the genera *Orithostella* has been established some other species belonging to this genus have been found. Mostly they are strongly convex aborally (*O. formosa* [Brotzen]) but a few forms also occur in which the aboral side is still distinctly more convex than the oral one, but to a lesser degree (*O. australis*, *O. indica* sp. nov.). However, new data show that there is another, probably more important, feature distinguishing *Lingulogavelinella* and *Orithostella* namely a perforate nature of apertural flaps in *Lingulogavelinella* and imperforate character of these in *Orithostella*. It will be interesting to follow this feature in other species of *Orithostella*. However, it appears as a stable feature because both the type species and the group of other species of *Orithostella* known so far show an imperforate nature of apertural flaps covering the dorsal part of the aperture. Specimens identical with *Orithostella indica* sp. nov. occur in the upper Albian of the Utatur Group in South India (for more detail see Narayanan and Scheibnerová, in preparation).

Superfamily ROBERTINACEA Reuss, 1850

Family CERATOBULIMINIDAE Cushman, 1927

PSEUDOLAMARCKINA Myatlyuk in Rauser-Chernousova and Fursenko, 1959

?*Pseudolamarckina* sp.

(Plate 8, Figures 10-19)

Further extremely interesting forms of uncertain systematic position are represented by a group of quite small, trochospiral, plano-convex or concavo-convex foraminifera with 6-8 chambers in the last whorl. The sutures are slightly curved, not very deep. The periphery is gently angular. The umbilicus is shallow and closed. The aperture is interior marginal, at the base of the last-formed chamber, slit-like or slightly arched. The surface is smooth, shiny. ?*Pseudolamarckina* sp. described here resembles *Pseudolamarckina* sp. as described from the

Albian of the Great Artesian Basin (Scheibnerová, 1972a). It differs in having an oval rather than rounded outline, more numerous chambers (6-8 instead of 4-6) and slightly curved rather than radial sutures. These differences, however, can be attributed to a further evolution of the same species group during the Albian (the Australian forms occur earlier in the lower Albian in contrast to Leg 27 forms occurring in the upper Albian).

ACKNOWLEDGMENTS

The author thanks Dr. H. M. Bolli (Swiss Federal Institute of Technology, Zürich, Switzerland), the paleontologist on Leg 27 for giving her the opportunity to work on the Lower Cretaceous benthonic foraminifera from Leg 27. H. M. Bolli also provided laboratory treatment of all samples studied and the SEM photographs of most of the species mentioned in this paper.

The above study was extremely important for the author's study on the Lower Cretaceous foraminifera of the Great Artesian Basin, because both areas belonged to the same nontropical Austral Biogeoprovince.

Mr. G. Rose, Director of the Geological Survey of New South Wales kindly gave his consent with the author's participation in the study of Cretaceous faunas recovered by the Deep Sea Drilling Project.

The author thanks Dr. D. J. Belford (Bureau of Mineral Resources, Geology and Geophysics, Canberra, Australia) for making available several samples of Lower Cretaceous foraminifera from the areas adjacent to Leg 27, deposited in the collections of the above institution. Dr. P. Kaye, Chief Geologist of the BOC of Australia Ltd. kindly gave his consent to refer in this report to the samples from the borehole BOC of Australia Ltd. Dampier No. 1 (Table 4). Miss Georgina Lambert of the Department of Botany, University of Durban, South Africa helped the author by very efficiently and promptly sending her several samples of both Lower and Upper Cretaceous foraminifera from Zululand (South Africa) for comparison. The cooperation of Dr. V. Narayanan of the Ground Water Division, Madras, India with whom the author prepared a joint publication on the occurrence of *Lingulogavelinella* and *Orithostella* from the Utatur Stage of the Trichinopoly District (southern peninsular India) was very helpful. Permission to publish this contribution was given by the Under Secretary, New South Wales Department of Mines.

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PLATE 1

- Figure 1 *Hyperammina* sp. Sample 263-17, CC; $\times 50$.
- Figure 2 *Ammodiscus cretaceus* (Reuss). Sample 263-17, CC; $\times 50$.
- Figure 3 *Glomospira gordialis* Parker and Jones. Sample 259-14, CC; $\times 100$.
- Figures 4, 5 *Psamminopelta* sp. Sample 263-17, CC; $\times 50$.
- Figure 6 *Haplophragmoides dickinsoni* Crespín. Sample 263-29, CC; apertural view; $\times 40$.
- Figure 7, 8 *Haplophragmoides* sp. Sample 263-17, CC; $\times 100$.
- Figure 9 *Haplophragmoides chapmani* Crespín, Sample 263-9, CC; oblique apertural view; \times
- Figure 10 *Recurvoides* sp. Sample 263-29, CC; $\times 100$.
- Figure 11 *Ammobaculites crespinae* Bhalla. Sample 263-29, CC; $\times 50$.
- Figure 12 *Ammobaculites irregulariformis* Bartenstein and Brand. Sample 263-17, CC, $\times 50$.
- Figure 13 *Ammobaculites fisheri* Crespín. Sample 263-29, CC, $\times 100$.
- Figure 14 *Ammobaculites* cf. *abnormalis* Crespín. Sample 263-29, CC; $\times 100$.
- Figure 15 *Ammobaculites hofkeri* Bhalla. Sample 263-29, CC; $\times 100$.
- Figure 16 *Spiroplectammina cushmani* Crespín. Sample 263-17, CC; $\times 75$.
- Figure 17 *Textularia* cf. *wilgunyaensis* Crespín. Sample 263-17, CC, $\times 75$.
- Figure 18 *Trochammina minuta* Crespín. Sample 263-17, CC; $\times 100$.
- Figure 19 *Trochammina* cf. *minuta* Crespín. Sample 263-29, CC; $\times 100$.
- Figure 20 *Trochammina minuta* Crespín. Sample 263-29, CC, $\times 75$.
- Figure 21 ?*Gravellina* sp. Sample 263-29, CC; $\times 100$.
- Figure 22 *Verneuilina* sp. Sample 259-14, CC; $\times 50$.
- Figure 23 *Gaudryina* sp. Sample 259-14, CC; $\times 100$.
- Figure 24 *Migros* sp. Sample 259-14, CC, $\times 75$.
- Figures 25, 26 *Verneuilinoides crespinae* Ludbrook. Sample 263-17, CC; $\times 100$.
25. Umbilical view.
26. Spiral side.

PLATE 1

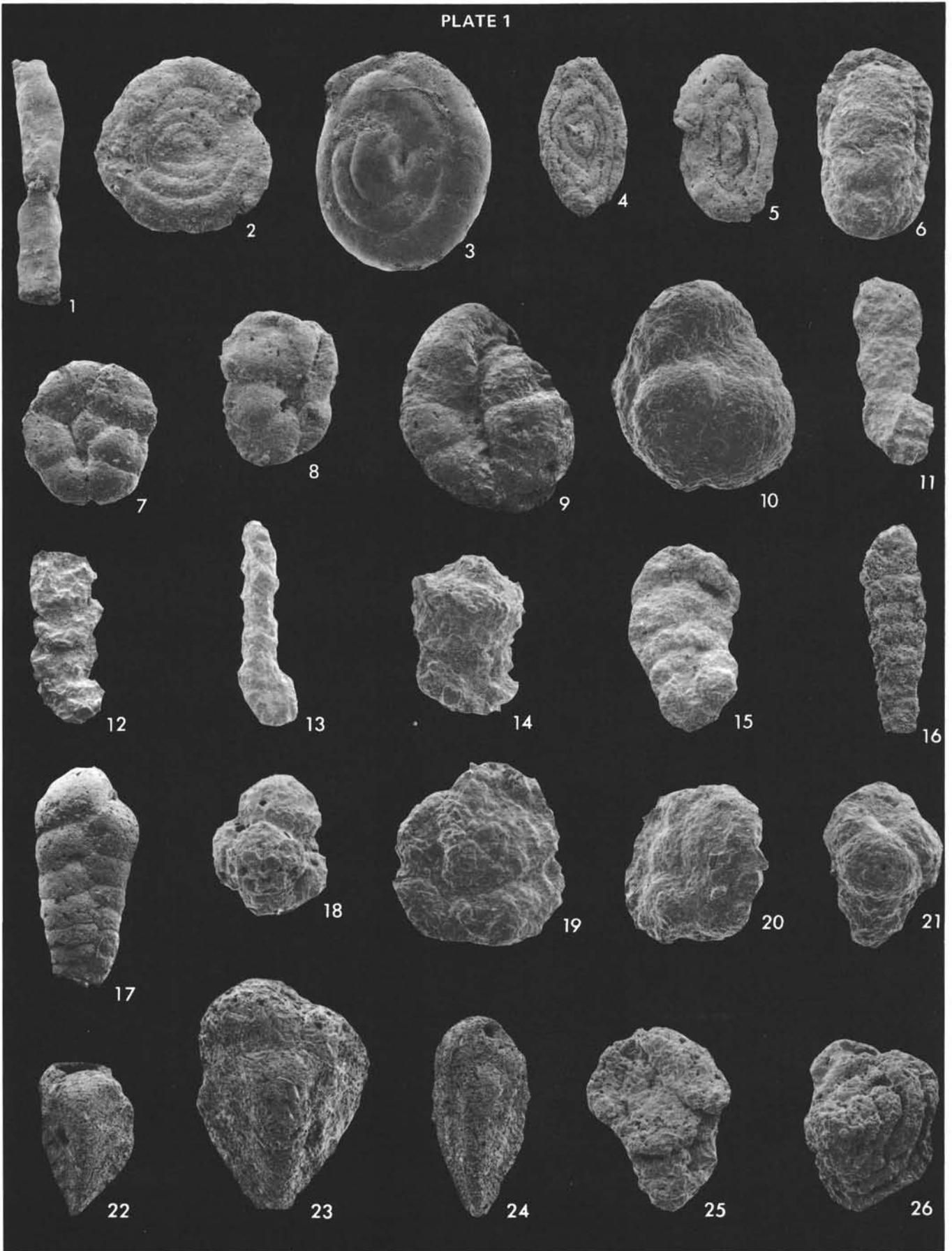


PLATE 2

- Figures 1-3 *Dorothia* sp. Sample 259-13, CC; $\times 75$.
- Figure 4 *Eggerella* sp. Sample 259-14, CC; $\times 150$.
- Figures 5-7 *Clavulina gabonica* Le Calvez, de Klasz, and Brun. Sample 259-14, CC.
5. $\times 37.5$
6. $\times 75$
7. $\times 50$
- Figures 8, 9 *Clavulina gabonica* Le Calvez, de Klasz, and Brun. Sample 259-13, CC; $\times 75$.
- Figure 10 *Remešella* sp. Sample 259-14, CC; $\times 50$.
- Figure 11 *Nodosaria* sp. Sample 263-17, CC; $\times 50$.
- Figure 12 *Dentalina soluta* Reuss. Sample 259-14, CC; $\times 75$.
- Figure 13 *Dentalina* cf. *deflexa* Reuss. Sample 263-17, CC; $\times 50$.
- Figure 14 *Nodosaria* cf. *gidya* Ludbrook. Sample 259-29, CC; $\times 40$.
- Figure 15 *Dentalina communis* d'Orb. Sample 259-13, CC; $\times 25$.
- Figure 16 *Tribrachia australiana* Ludbrook. Sample 259-15-5, 124-126 cm; $\times 50$.
- Figure 17-22 *Palmula* cf. *bivium* Finlay. Sample 259-14, CC.
17, 18, 20. $\times 50$.
19, 22. $\times 37.5$.
21. $\times 20$.
- Figure 23 *Vaginulina* cf. *recta* Reuss. Sample 259-14, CC; $\times 15$.
- Figure 24 *Vaginulina* sp. Sample 259-14, CC; $\times 37.5$.
- Figure 25, 26 *Saracenaria erlita* Ludbrook. Sample 263-29 CC,
25. $\times 75$.
26. $\times 100$.
- Figure 27 *Marginulinopsis kareelensis* Ludbrook. Sample 263-29, CC; $\times 100$.
- Figure 28 *Saracenaria* sp. Sample 263-29, CC; $\times 100$.
- Figure 29 *Lenticulina* sp. (= *Lenticulina* sp. of Lambert and Scheibnerová, in press). Sample 263-29, CC; $\times 100$.
- Figure 30 *Marginulina* sp. Sample 263-17, CC; $\times 75$.
- Figure 31 *Lenticulina* sp. Sample 263-29, CC; $\times 100$.
- Figure 32 *Lenticulina* sp. Sample 263-29, CC; $\times 100$.

PLATE 2

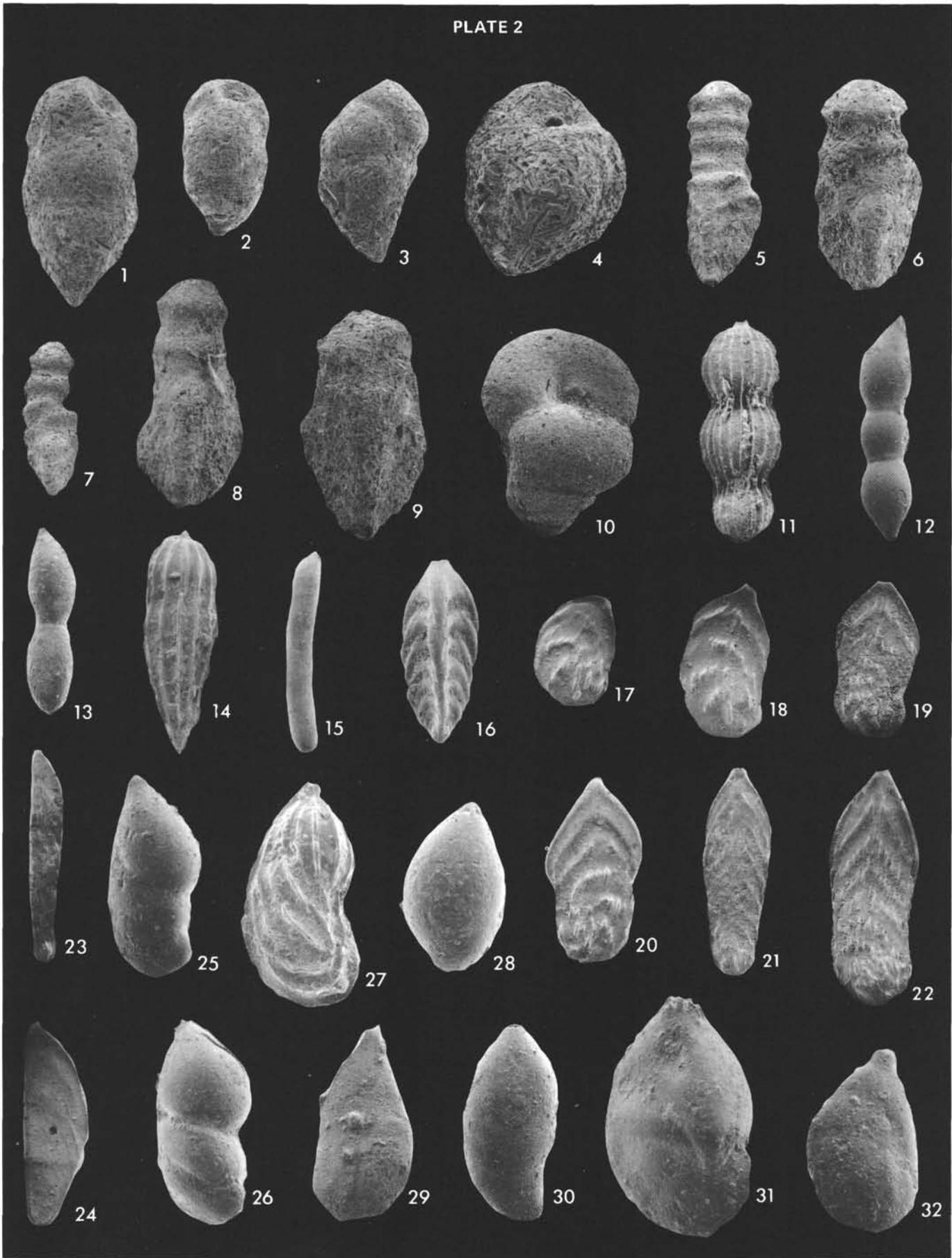


PLATE 3

- Figures 1, 2 *Lenticulina* cf. *excentrica* (Cornuel). Sample 263-29, CC; $\times 50$.
- Figure 3 *Lenticulina* cf. *lituola* (Reuss). Sample 263-17, CC; $\times 50$.
- Figure 4 *Marginulinopsis arimensis* Ludbrook. Sample 263-17, CC; $\times 50$.
- Figure 5 *Lenticulina* sp. Sample 263-29, CC; $\times 100$.
- Figure 6 *Lenticulina* cf. *crepidularis* (Roemer). Sample 263-29, CC; $\times 100$.
- Figures 7, 8 *Saracenaria lutanata* Ludbrook. Sample 263-29, CC;
7. $\times 100$.
8. $\times 75$.
- Figures 9-15 *Lenticulina* cf. *spinosa* (Eichenberg). Sample 263-29, CC.
9, 12. $\times 40$.
10. $\times 25$.
11. $\times 75$.
13-15. $\times 50$.
- Figures 16, 17 *Lenticulina* sp. Oldest form; Sample 263-29, CC.
16. $\times 25$.
17. Slightly aberrant form; $\times 40$.
- Figures 18-22 *Lenticulina* sp.
18. typical form; Sample 263-29, CC; $\times 50$.
19. Sample 263-29, CC; $\times 50$.
20, 21. Sample 263-17, CC; $\times 50$.
22. Sample 260-10-1, 105-107 cm; $\times 100$.
- Figure 23a-c *Ramulina tetrahedralis* Ludbrook. Sample 259-14, CC; a. $\times 75$; b. $\times 250$; c. $\times 1500$.
- Figures 24-27 *Eoguttulina* sp. group. Sample 263-29, CC;
24, 25, 27. $\times 50$.
26. $\times 40$.
- Figure 28 *Pyruinoides* sp. Sample 263-29, CC; $\times 100$.
- Figure 29 Polymorphinid. Sample 259-14, CC; $\times 75$.

PLATE 3

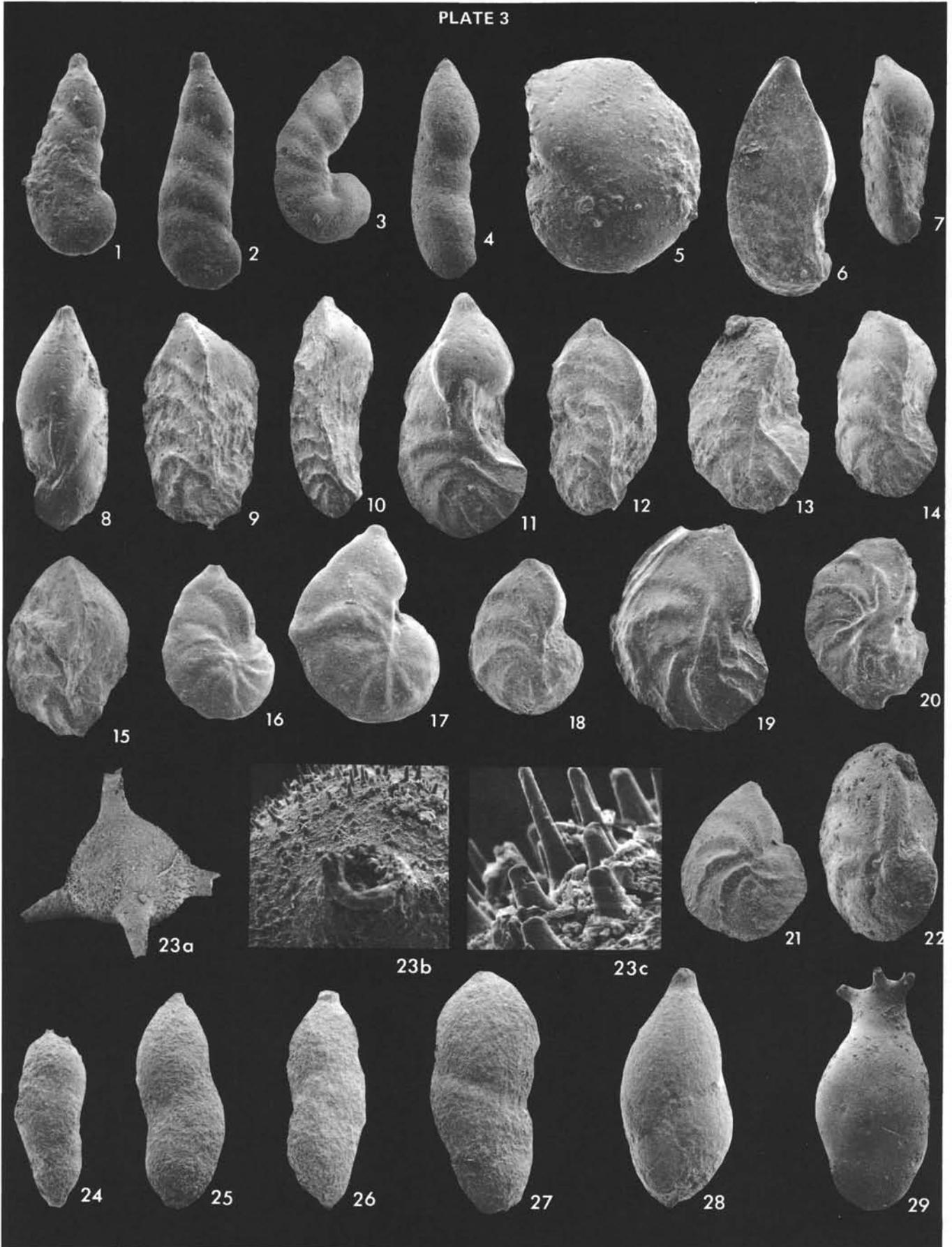


PLATE 4

- Figures 1, 2 *Neobulimina australiana* Ludbrook. $\times 150$.
 1. Sample 259-13-1, 60-62 cm.
 2. Sample 259-16-2, 68-70 cm.
- Figure 3 *Praebulimina* sp. Sample 260-10-1, 105-107 cm;
 $\times 200$.
- Figure 4 *Spirobovina australis* n. sp. paratype. Sample 259-14, CC, $\times 100$.
- Figures 5-7 ?*Discorbis* sp. Sample 259-14, CC; $\times 100$.
- Figures 8-10 *Patellinella australis* Lambert and Scheibnerová.
 Sample 259-14, CC.
 8. $\times 100$.
 9. $\times 50$.
 10. $\times 75$.
- Figures 11, 12 *Eponides* sp. Sample 259-17-2, 41-49 cm.
 11. umbilical side; $\times 150$.
 12. spiral side; $\times 200$.
- Figures 13-26 *Coryphostoma* sp.
 13-16. Sample 259-17-2, 47-49 cm; $\times 100$.
 17, 20, 23. Sample 259-14, CC; $\times 150$.
 18. $\times 250$.
 19, 25. $\times 750$.
 21. $\times 200$.
 22. $\times 1500$.
 24. $\times 175$.
 26. $\times 2000$.
- Figures 27, 28 *Osangularia utaturensis* (Sastri and Sastry).
 Sample 259-17-3, 38-40 cm; $\times 100$.
 27. Spiral view.
 28. Umbilical view.

PLATE 4

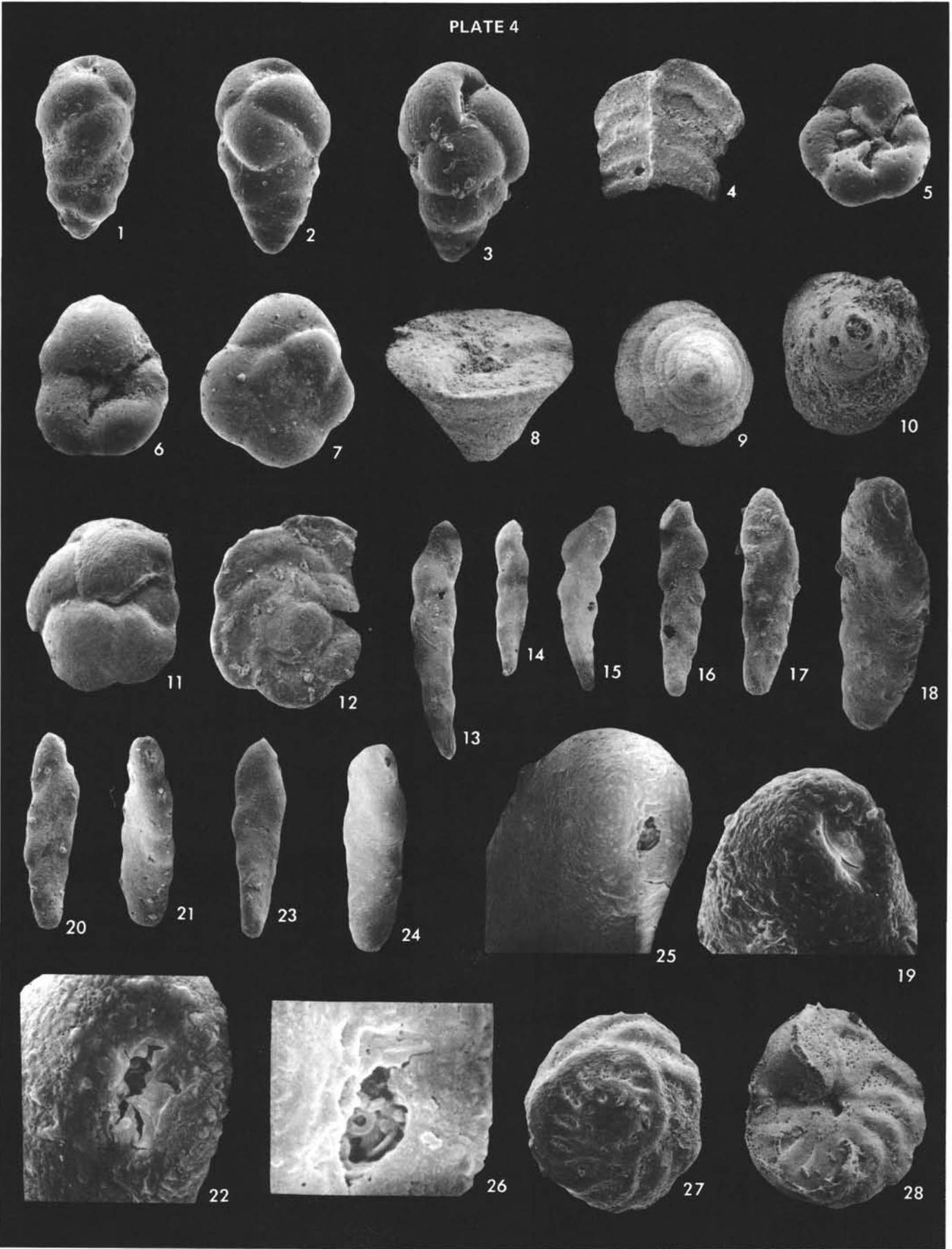


PLATE 5

- Figures 1-3 *Osangularia utaturensis* (Sastri and Sastry).
Sample 259-17-13, 38-40 cm; $\times 100$.
1, 3. Umbilical views.
2. Spiral view.
- Figures 4-9 *Osangularia utaturensis* (Sastri and Sastry).
Sample 259-14, CC.
4, 5. Umbilical view; $\times 75$.
6, 7. Spiral views; $\times 100$.
8, 9. Umbilical views; $\times 100$.
- Figures 10-12 *Gryoidinoides* cf. *primitiva* Hofker. Sample 259-13,
CC; $\times 100$.
- Figures 13-17 *Anomalina indica* Sastri and Sastry. Sample 259-
17-2, 21-23 cm;
13-15. $\times 90$,
16, 17. detail of umbilicus and aperture; $\times 250$.
- Figures 18-24 *Gavelinella* ex. gr. *intermedia* (Berthelin). Sample
259-14, CC.
18, 19, 21-24. $\times 100$.

PLATE 5

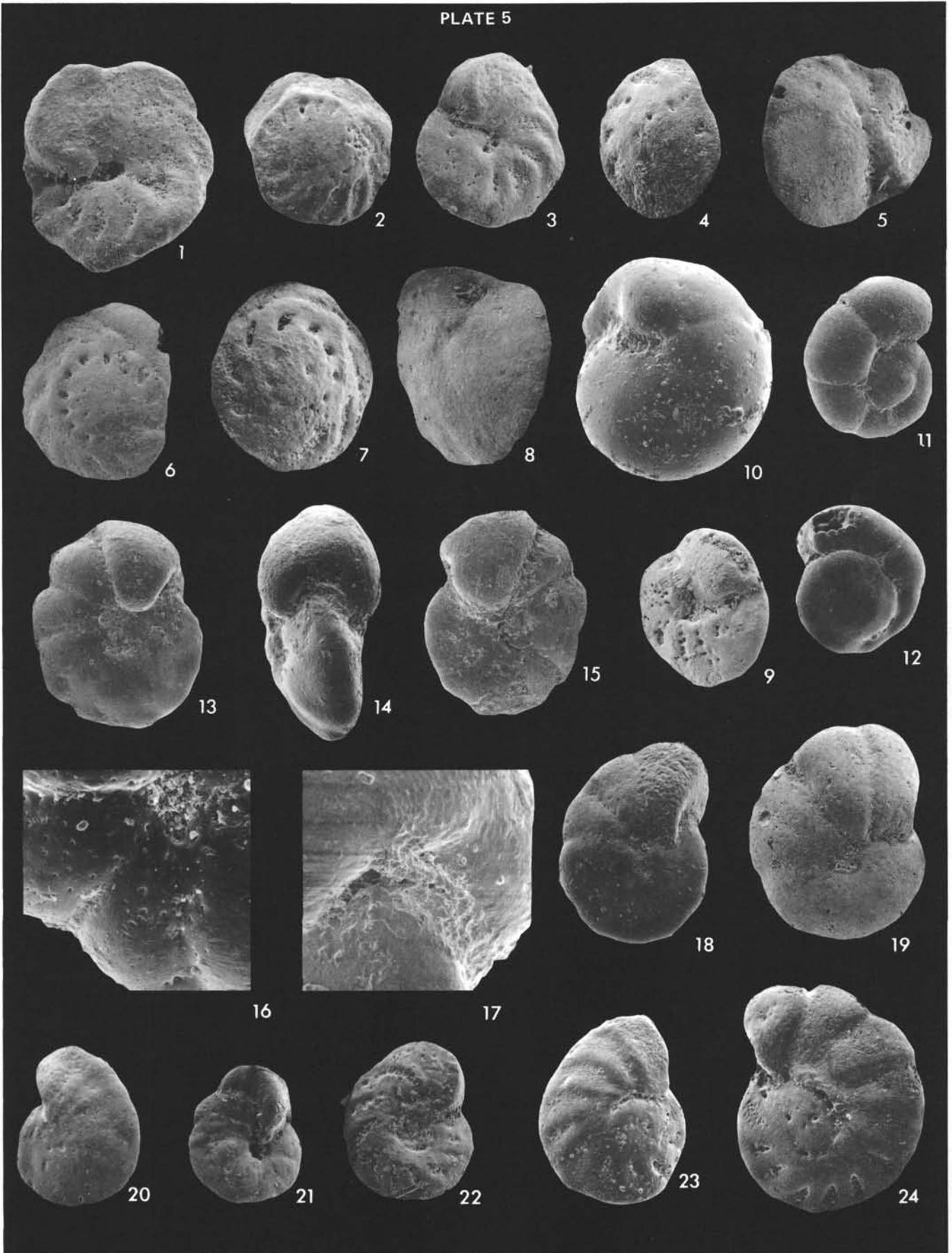


PLATE 6

- Figures 1-4 *Gavelinella* ex. gr. *intermedia* (Berthelin). Sample 259-14, CC; $\times 100$.
- Figures 5-8 ?*Lingulogavelinella* sp. Sample 259-14, CC.
5, 6. Dorsal (oral) sides; $\times 100$.
7. Detail of Figure 6, $\times 250$.
8. Detail of Figure, wall of penultimate chamber; $\times 1000$.
- Figures 9-11 ?*Lingulogavelinella* sp. Sample 259-17-2, 47-49 cm.
9. Dorsal (oral) side; $\times 75$.
10. Detail of Figure 9, center of penultimate chamber; $\times 500$.
11. Same as Figure 10; $\times 1500$.
- Figures 12-16 ?*Lingulogavelinella* sp. Sample 259-14, CC.
12. Dorsal (oral) Side; $\times 150$.
13. Detail of Figure 12; $\times 250$.
14. Peripheral view; $\times 150$.
15. Detail of Figure 14; $\times 250$.
16. Detail of Figure 14; $\times 1000$.

PLATE 6

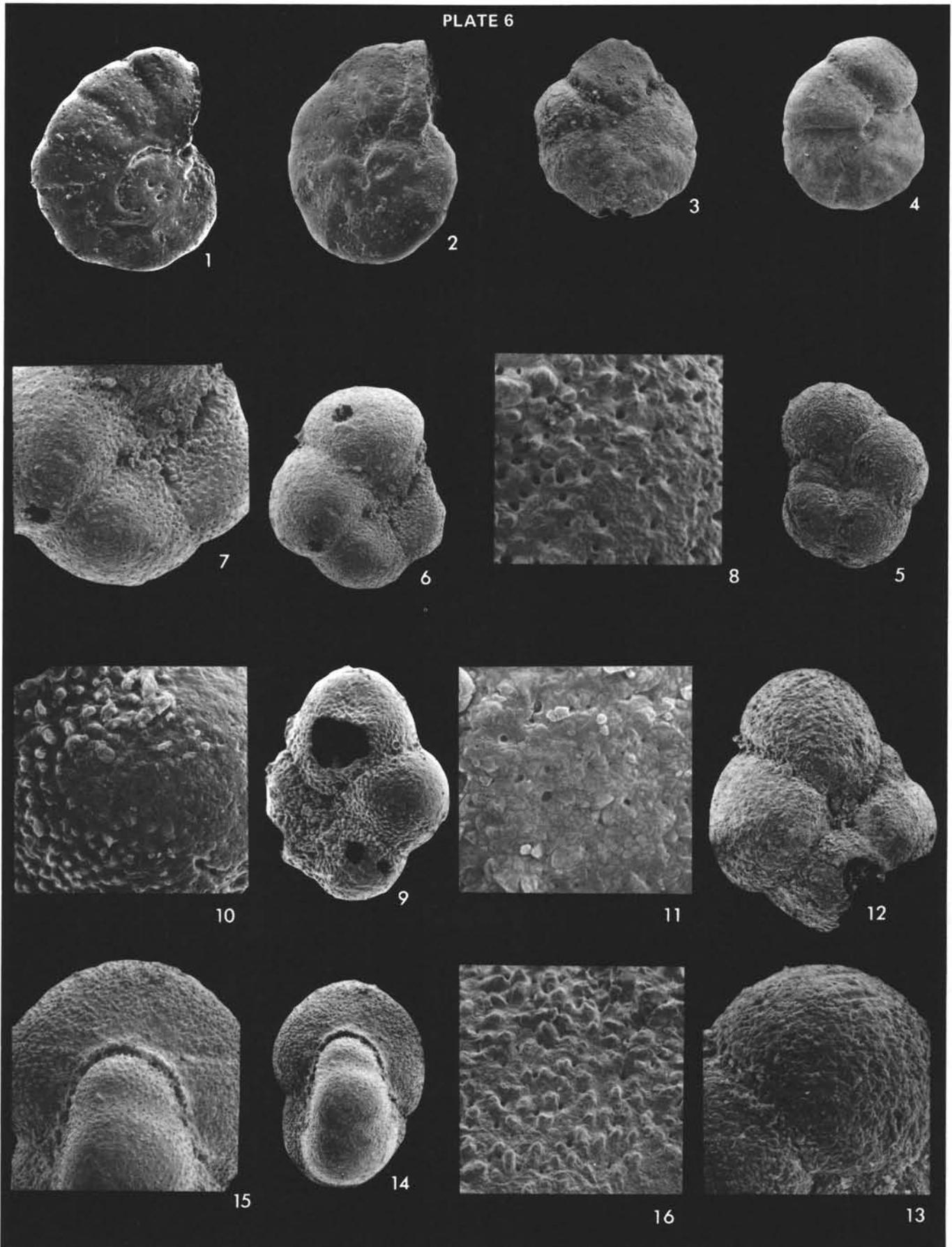
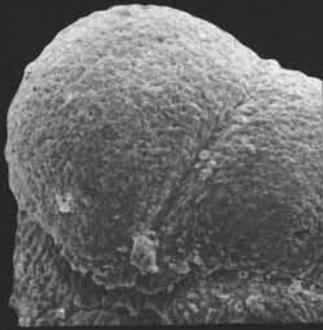


PLATE 7

- Figures 1-3 *?Lingulogavelinella* sp. Sample 259-17-2, 47-49 cm.
1. Dorsal (oral) side; $\times 150$.
2. Detail of Figure 1; $\times 250$.
3. Detail of Figure 1 perforate wall; $\times 1500$.
- Figure 4 *Orithostella indica* n. sp. Sample 259-17-2, 47-49 cm; umbilical (aboral) view; $\times 100$.
- Figures 5-7 *Lingulogavelinella* cf. *frankei* (Bykova). Sample 260-10-1, 105-107 cm;
5. umbilical (aboral) side; $\times 300$.
6. Detail of the ultimate chamber; $\times 400$.
7. Detail of wall surface; $\times 1500$.
- Figures 8-13 *Orithostella indica* n. sp. Sample 259-14, CC.
8. dorsal (oral) Side, $\times 150$.
9. Detail of Figure 8, imperforate apertural flaps; $\times 250$.
10. Detail of Figure, perforate part of the wall of the ultimate chamber; $\times 150$.
11. Dorsal (oral) Side; $\times 150$.
12. Detail of Figure 11, imperforate apertural flaps; $\times 250$.
13. Detail of Figure 11, perforate wall of the ultimate chamber; $\times 150$.

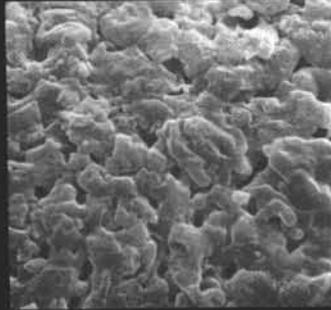
PLATE 7



2



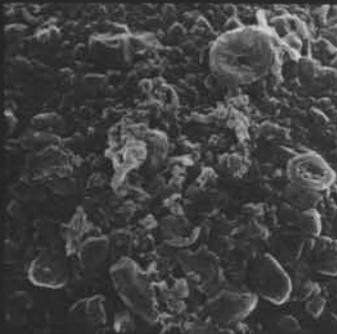
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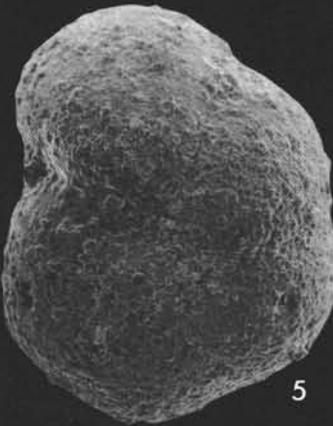
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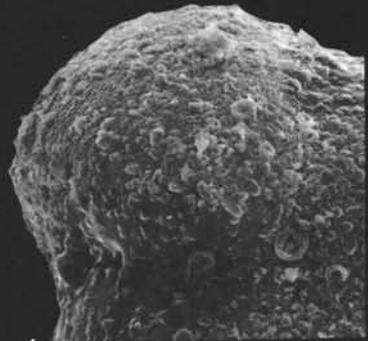
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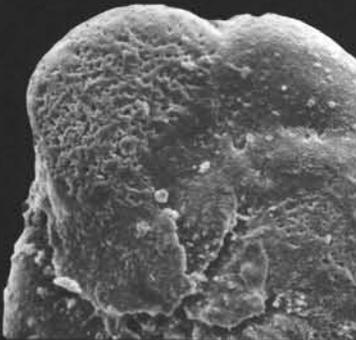
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5



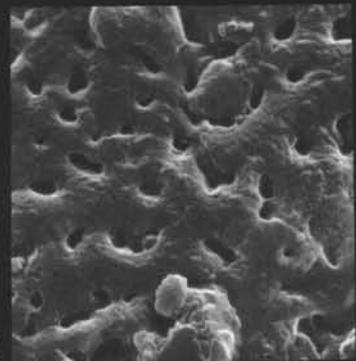
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9



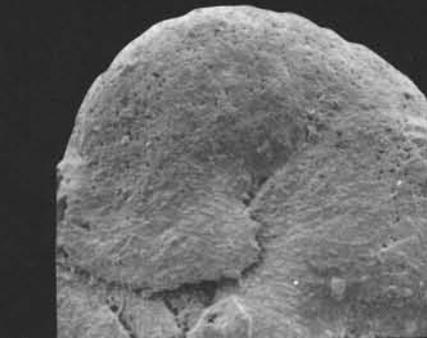
8



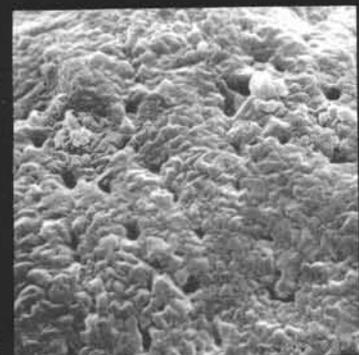
10



11



12



13

PLATE 8

- Figures 1-6 *Orithostella indica* n. sp. Sample 259-14, CC.
1. Dorsal (oral) side; $\times 140$;
2. Detail of Figure 1, imperforate apertural flaps; $\times 250$.
3. Detail of Figure 1, perforate wall of ultimate chamber; $\times 1000$.
4. Ventral (aboral) side; $\times 140$.
5. Detail of Figure 4; $\times 250$.
6. Ventral (aboral) side; $\times 150$.
- Figures 7-9 *Orithostella indica* n. sp. Sample 259-17-2, 47-49 cm.
7. Dorsal (oral) side; $\times 140$.
8. Detail of Figure 7, imperforate apertural flaps and perforate chamber wall; $\times 250$.
9. Detail of Figure 7, perforate wall of ultimate chamber; $\times 1500$.
- Figures 10-19 *Pseudolamarckima* sp. $\times 100$.
10. Sample 260-10, CC; umbilical (apertural) view.
11. Sample 260-10, CC; spiral view.
12. Sample 260-10, CC; umbilical (apertural) view.
13. Sample 259-14, CC; spiral view.
14. Sample 259-14, CC; umbilical (apertural) view.
15. Sample 260-10, CC; umbilical (apertural) view.
16. Sample 260-10, CC; spiral view.
17. Sample 259-14, CC; umbilical (apertural) view.
18. Sample 259-14, CC; peripheral view.
19. Sample 259-14, CC; spiral view.

PLATE 8

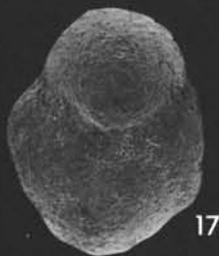
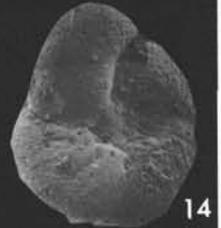
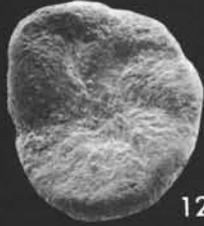
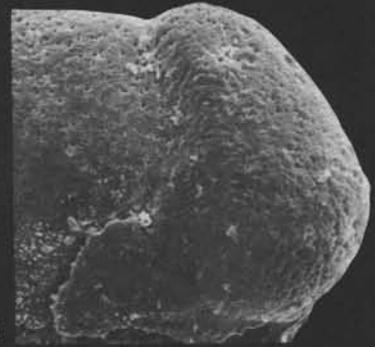
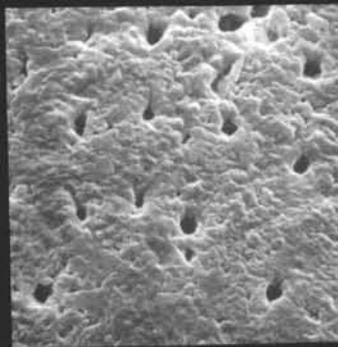
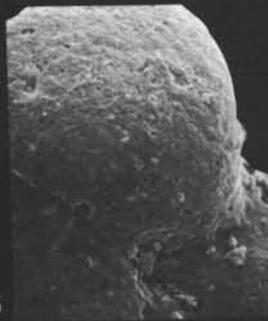
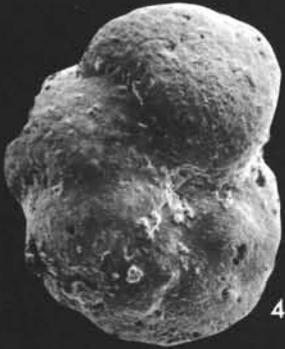
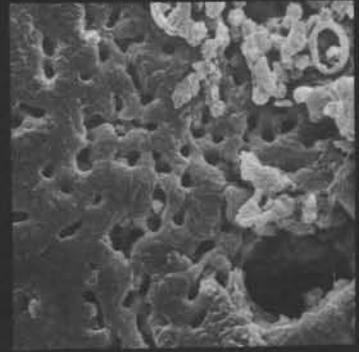
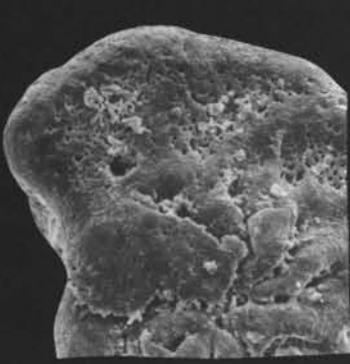


PLATE 9

- Figure 1 *Nodosaria* cf. *gidya* Ludbrook. Sample 263-23, CC; $\times 70$.
- Figure 2a, b *Lenticulina* sp. 1. Sample 263-22, bottom; $\times 35$.
- Figure 3 *Lenticulina* sp. 2. (sensu Lambert and Scheibnerová, in press). Sample 263-29, CC; $\times 35$.
- Figure 4 *Lenticulina spinosa* (Berthelin). Sample 263-22, bottom; $\times 35$.
- Figure 5 *Fronicularia* sp. Sample 259-14, CC; Late Aptian. $\times 35$.
- Figure 6 *Tribrachia australiana* Ludbrook. Sample 259-15-5, 124-126 cm; $\times 50$.
- Figure 7a-c *Palmula* cf. *bivium* Finlay. Sample 259-14, CC; showing various stages of ontogenesis; $\times 70$.
- Figure 8 *Saracenaria kattarensis* Ludbrook. Sample 263-29, CC; $\times 50$.
- Figure 9 *Glandulina* sp. Sample 263-29, CC; $\times 70$.
- Figures 10, 11 *Neobulimina australiana* Ludbrook. $\times 70$.
10. Sample 259-16-2, 68-70 cm.
11. Sample 259-13-1, 60-62 cm.
- Figure 12 *Praebulimina* sp. Sample 260-9-1, 116-118 cm; $\times 70$.
- Figure 13 *Rectobulimina* sp. Sample 259-17-3, 38-40 cm; $\times 70$.
- Figure 14 *Spirobulimina australis* n. sp. holotype. Sample 259-14, CC; $\times 70$.
- Figure 15a-c *Patellinella australis* Lambert and Scheibnerová. Sample 259-14, CC; $\times 70$.
- Figures 16a-c, 17a-c *Valvulineria* sp. Sample 259-14, CC: a, spiral view; b, apertural view; and c, umbilical view; $\times 70$.

PLATE 9

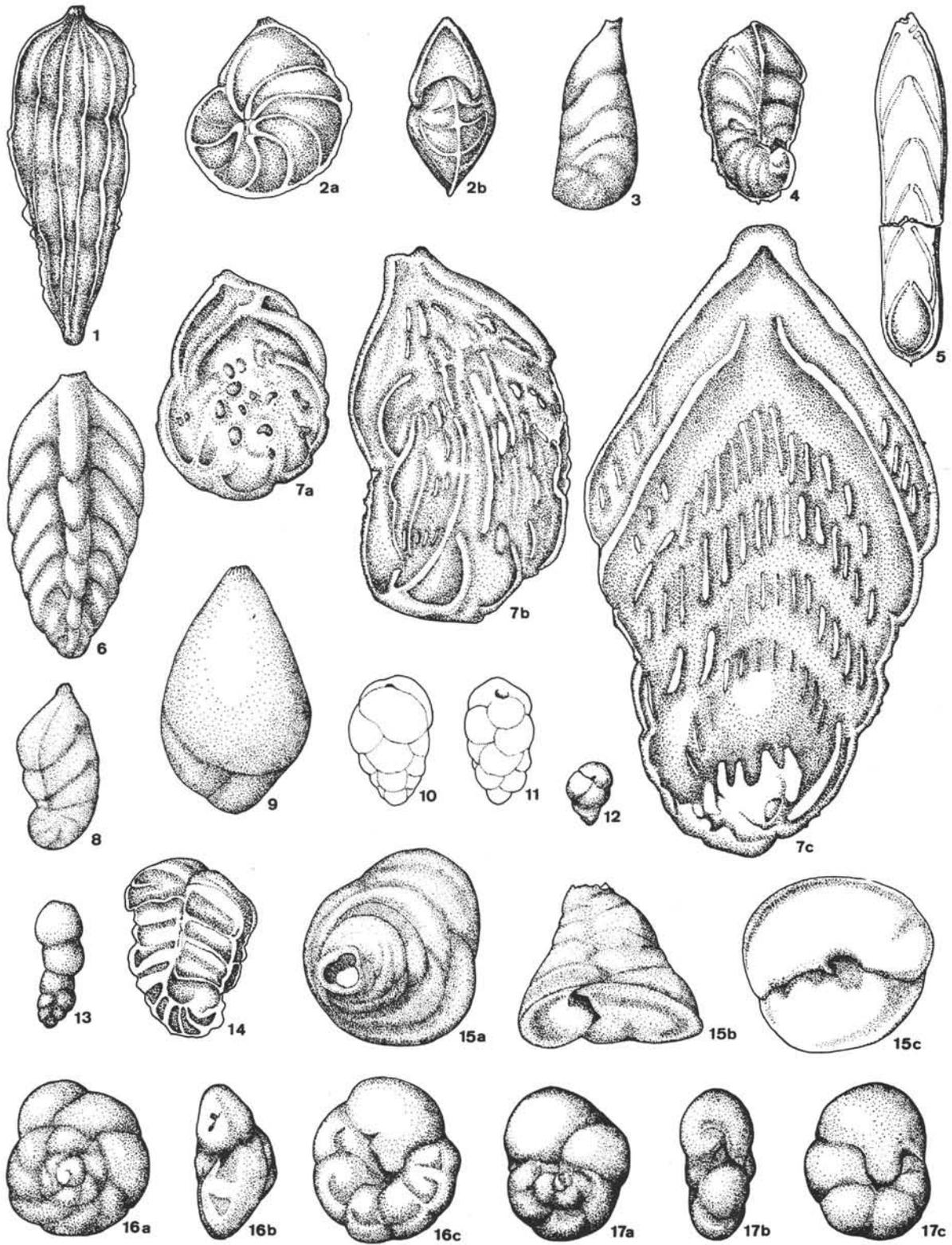


PLATE 10

- Figure 1 *Miliammina inferior* Ludbrook. Sample 263-17, CC; $\times 70$.
- Figure 2a, b *Haplophragmoides hagni* Bhalla. Sample 263-23, CC; $\times 70$.
- Figure 3 *Ammobaculites fisheri* Crespin. Sample 263-29, CC; $\times 35$.
- Figure 4 *Ammobaculites crespinae* Bhalla. Sample 263-9, CC; $\times 70$.
- Figure 5 *Ammobaculites irregulariformis* Bartenstein and Brand. Sample 263-29, CC; $\times 35$.
- Figure 6 *Spiroplectammina cushmani* Crespin. Sample 263-17, CC; $\times 70$.
- Figure 7 *Bigerina loeblichae* Crespin. Sample 263-29, CC; $\times 70$.
- Figure 8a, b *Planctostoma* sp. Sample 263-8, CC; $\times 70$.
- Figure 9a-c *Trochammina minuta* Crespin. Sample 263-19, CC; $\times 70$.
- Figure 10a-c *Trochammina minuta* Crespin. Sample 263-19, CC; $\times 70$.
- Figure 11a-c *Trochammina subinflata* Crespin. Sample 263-17, CC; $\times 70$.
- Figure 12 *Verneuilina howchini* Crespin. Sample 263-17, CC; $\times 70$.
- Figure 13 *Migros* sp. Sample 259-14, CC; $\times 70$.
- Figure 14 *Verneuilinoides crespinae* Ludbrook. Sample 263-22, bottom, $\times 70$.
- Figure 15a, b *Matanzia* sp. Sample 259-14, CC; $\times 35$.
- Figure 16 *Jarvisella* sp. Sample 263-19, CC; $\times 70$.
- Figure 17a, b *Remesella* sp. Sample 259-14, CC; $\times 70$.
- Figure 18a, b *Scutuloris* sp. Sample 263-29, CC; $\times 70$.

PLATE 10

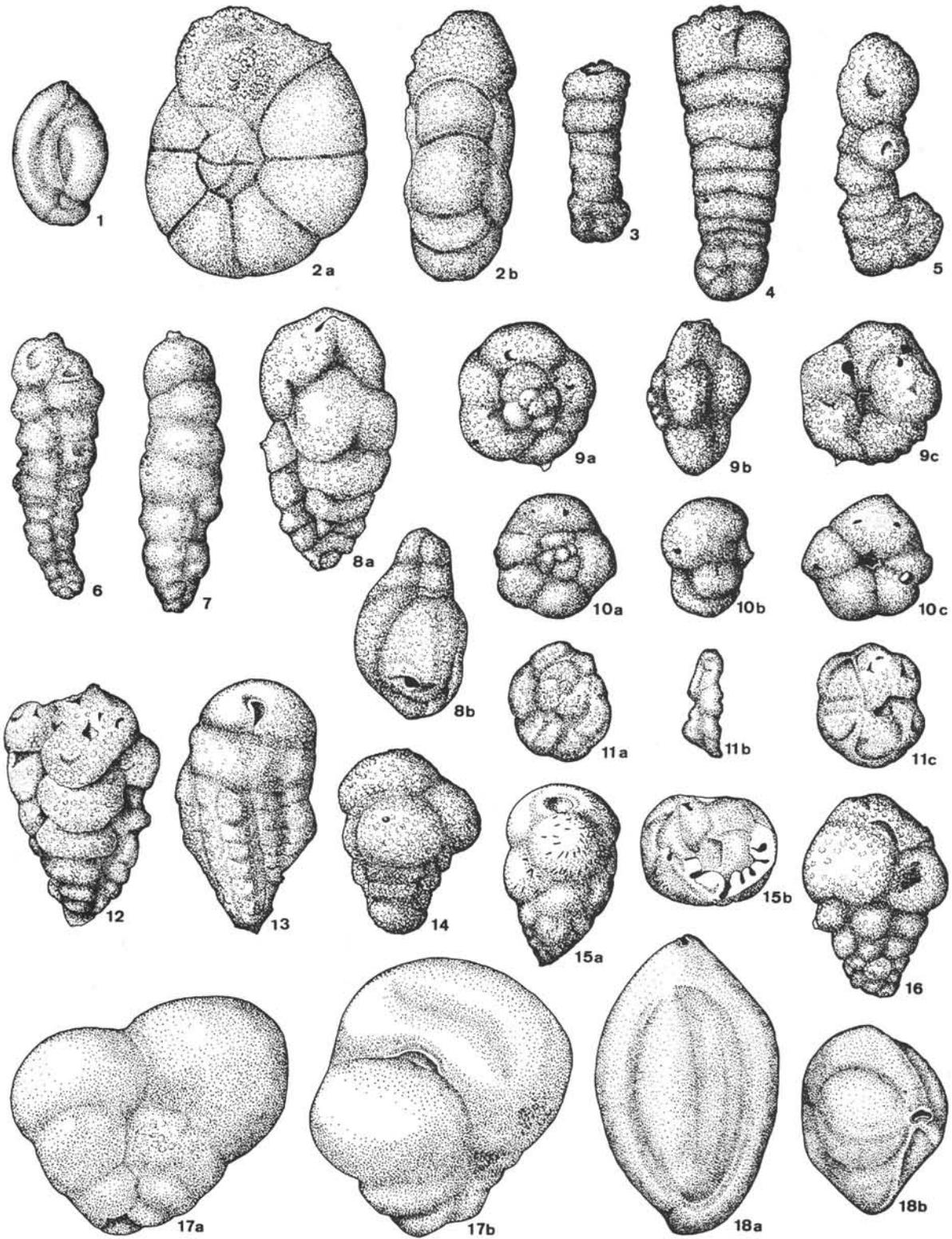


PLATE 11

(All figures $\times 70$.)

- Figure 1a-c *Eponides* sp. Sample 259-14, CC; a, spiral view; b, apertural view; and c, umbilical view.
- Figure 2 *Pleurostomella obtusa* Berthelin. Sample 259-14, CC.
- Figure 3 *Coryphostoma* sp. Sample 259-17-2, 47-49 cm.
- Figures 4a-c, *Osangularia utaturensis* (Sastri and Sastry). a, spiral view; b, apertural view; and c, umbilical view.
 5a-c
 4. Sample 259-17-3, 38-40 cm.
 5. Sample 259-14, CC.
- Figure 6a-c *Gyroidinoides primitiva* Hofker. Sample 259-14, CC.
- Figure 7a-c *Anomalina indica* Sastri and Sastry. Sample 259-17-2, 21-23 cm; a, spiral view; b, apertural view; and c, side view.
- Figure 8a-c *Lingulogavelinella* cf. *frankei* (Bykova). Sample 259-14, CC; a, spiral view; b, side view; and c, umbilical view.
- Figure 9a-c *Orithostella indica* n. sp. Sample 259-14, CC; a, spiral view; b, side view; and c, umbilical view.

PLATE 11

