Larger Foraminifera From Eniwetok Atoll Drill Holes

GEOLOGICAL SURVEY PROFESSIONAL PAPER 260-V

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By W. STORRS COLE

BIKINI AND NEARBY ATOLLS, MARSHALL ISLANDS

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Sixty-two species and one variety of larger Foraminifera from Eniwetok Atoll drill holes are identified; 11 are new

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LARGER FORAMINIFERA FROM ENIWETOK ATOLL DRILL HOLES

By W. Storrs Cole

ABSTRACT

Sixty-two species and one variety of larger Foraminifera from the Eniwetok Atoll drill holes K–1B, E–1, and F–1 were identified and many of these are described, discussed, and illustrated. Five species are listed from the Recent, Pleistocene, and Pliocene. There are 35 species, 3 new, and 1 variety reported from the Miocene. They are divided according to the Indo-Pacific time scale as follows: 5 species from Tertiary *g*, 4 species and 1 variety from Tertiary *f*, and 26 species from Tertiary *e*. Of the 23 species found in the upper Eocene, Tertiary *b*, 8 are new. One of these Eocene species is still living. No species were found which could be considered diagnostic of the Oligocene, Tertiary *c* and *d*.

The stratigraphic section is as follows: 0–615 feet, Recent, Pleistocene, and Pliocene; 615–860 feet, Tertiary *g*, Miocene; 860–1,080 feet, Tertiary *f*, Miocene; 1,080–2,687 feet, Tertiary *e*, Miocene; 2,687–2,780 feet, without diagnostic fossils; 2,780–4,553 feet, Tertiary *b*, upper Eocene.

The Eniwetok Atoll drill holes are correlated with those at Bikini island using as points of reference the first appearance of diagnostic species. In the Eniwetok Atoll holes these points of reference, with one exception, are higher than those at Bikini. The top of the *Lepidocyclina* (*Eulepidina*) *abdopustula* zone (lowermost Tertiary *e*, Miocene) in all the drill holes occurs at nearly the same depth.

It is possible to correlate the major part of the section in these drill holes with surface outcrops of Saipan, the Malay Archipelago and other Pacific localities. However, the lower section of Tertiary *e* between 1,925 and 2,687 feet in the drill holes does not appear to have a stratigraphic equivalent so far reported from outcrops in the Pacific area.

Most of the sediments seem to have accumulated at depths somewhere between 20 and 70 fathoms, and the sediments containing larger Foraminifera probably accumulated in quiet water at a depth between 20 and 40 fathoms. These shallow-water conditions are indicated by the extreme scarcity of *Cycloclypeus*, a deep-water genus.

INTRODUCTION

During the years 1951 and 1952, three holes were drilled on Eniwetok Atoll as a part of a test program of the Atomic Energy Commission and the Los Alamos Scientific Laboratory. In 1951 the first of these, designated K–1B, was drilled on Engebi Island to a depth of 1,285 feet. During the summer of 1952, hole F–1 was drilled on Elugelab Island to a depth of 4,630 feet, and hole E–1 on Parry Island was completed at a depth of 4,222 feet. A preliminary report on the drilling operations, sample recovery, and geology has been published (Ladd and others, 1953). The index map (fig. 254) shows the location of the drill holes.

The writer examined all the samples from hole K–1B and the cores from the two other holes. In the time available, however, he was not able to examine all the samples of cuttings; larger Foraminifera from these samples were obtained for detailed study by Mrs. Evelyn Bourne under the supervision of H. S. Ladd, who says (written communication)—

> Depth figures for cuttings from the drill holes on Bikini island and Eniwetok Atoll have not been corrected for lag. During the drilling of F–1 and E–1 on Eniwetok Atoll, a series of dye tests was made, and the amount of lag at different depths calculated. A full report on the tests and a tabular listing of the corrections will appear in later chapter describing drilling procedure. It must be remembered, however, that the calculated corrections are interpretations based upon somewhat inadequate data. For this reason, in the present report and in others that will follow the depth figures used record the depth of the bit at the time the samples were collected.

Matrix-free specimens were obtained in abundance from many of the cuttings and from certain of the cores that could be disintegrated readily. Some 700 oriented thin sections of the larger Foraminifera recovered from these samples were made by the writer. In addition, several hundred thin sections of the cores were studied in detail as a check against the results of the study of matrix-free specimens.

From hole K–1B there are samples of cuttings from 337 feet to 1,238 feet with a core at 1,038–1,040 feet. From hole E–1 there are samples of cuttings from 600 feet to 3,130 feet with cores at 2,003–2,028 feet (core 1), 2,802–2,808 feet (core 2), and 4,078–4,100 feet (core 3). From hole F–1 there are samples of cuttings from 20–970 feet, 1,040–1,240 feet and 2,000–2,130 feet with cores at 170–190 feet (core 1), 600–625 feet (core 2), 1,230–1,248 feet (core 3), 1,718–1,740 feet (core 4), 1,978–2,003 feet (core 5), 2,662–2,687 feet (core 6), 3,052–3,055 feet

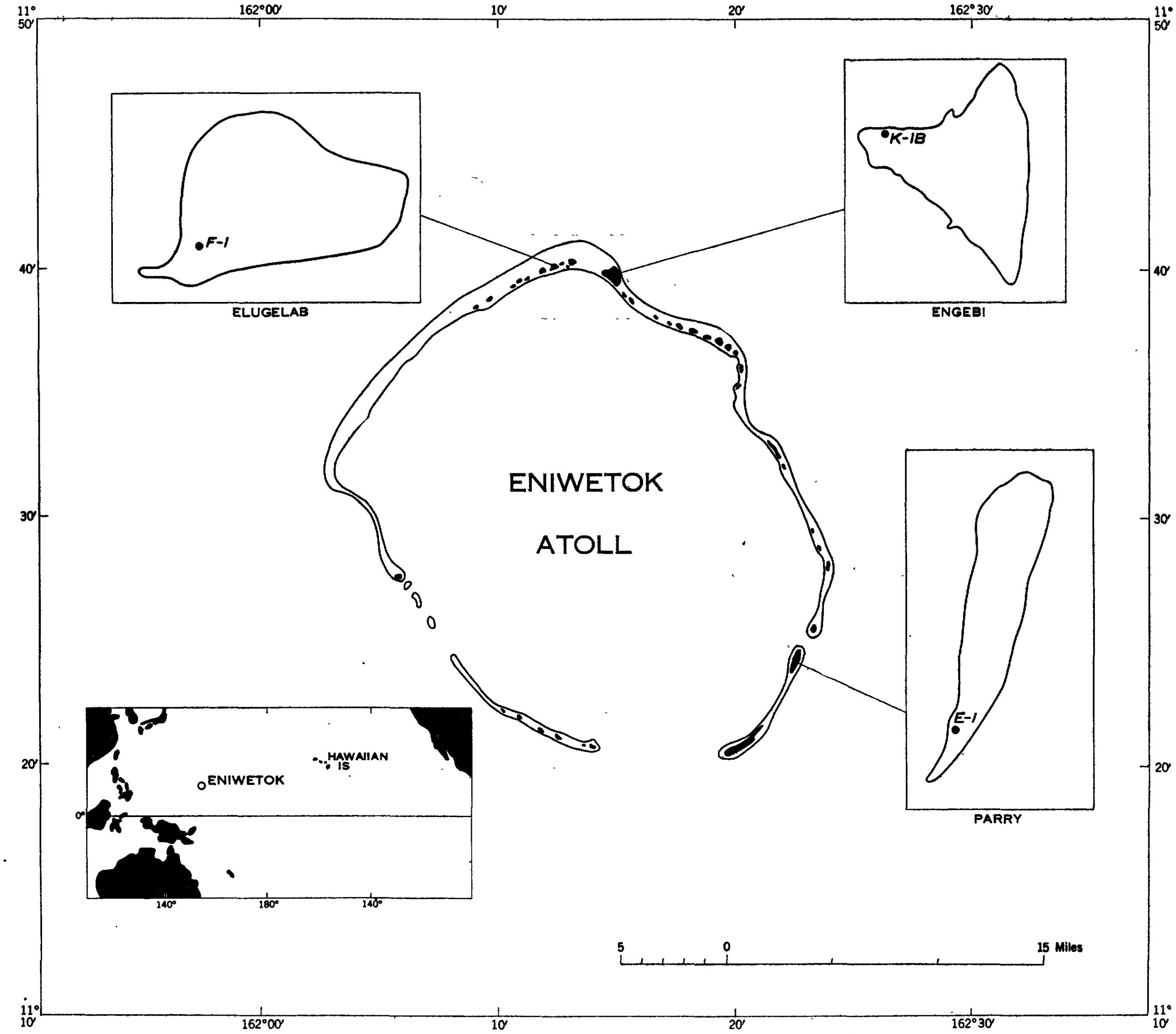

FIGURE 254.—Map showing location of the drill holes.

(core 7), 3,350–3,353 feet (core 8), 3,655–3,665 feet (core 9), 3,963–3,988 feet (core 10), 4,197–4,222 feet (core 11), 4,316–4,341 feet (core 12), 4,406–4,431 feet (core 13), 4,500–4,525 feet (core 14) and 4,528–4,553 feet (core 15).

All the specimens studied are deposited in the collections of the United States National Museum. All types, illustrated specimens, and those referred to in discussions have been assigned United States National Museum catalog numbers.

The correlation of the Eniwetok Atoll drill holes with those on Bikini island (Cole, 1954) by means of the larger Foraminifera is shown on plate 230, and the distribution of the species in the Eniwetok Atoll drill holes is given in table 1.

These holes for the first time give valuable information about the deeper subsurface geology of a coral atoll. Through this test program, the depth to the basalt and the character and age of the sediments above it were made available for at least one atoll. Information of this sort has been desired by geologists and biologists since the time of Darwin.

It has been possible to correlate the sections from these drill holes with each other and with those on Bikini, and correlations can be extended to the surface outcrops of Saipan, the Philippine Islands, and the Malay Archipelago.

The combination of samples of cuttings with the cores gives an adequate, if not complete, picture of the sequence of faunas of larger Foraminifera and some information on their stratigraphic range.

Most specimens were well preserved, and where they occurred they occurred very abundantly, and it has been possible to make complete studies of many of the species. This has resulted in a consolidation of many specific names, largely of species which had been described inadequately or had been known previously from but a few specimens. Definite correlation must be based upon species whose range of individual variation is completely documented.

Although Van der Vlerk (1955, p. 72) has emphasized the value of genera of larger Foraminifera in the Tertiary of the Far East in age determination and correlation, species afford a more precise tool. At Eniwetok Atoll both the genera and the species follow the stratigraphic distribution known and proved in the Malay Archipelago.

At Eniwetok Atoll where drill holes penetrated flat-lying beds, it has been possible to establish the stratigraphic distribution of genera and species at one place. If this sequence and distribution had been developed from studies of discontinuous outcrops on high islands, such as Saipan and Guam, a great many geologic sections would have had to be analyzed to obtain results comparable to those of the drill holes. Even after extensive studies, reasonable doubts about the proper stratigraphic sequence of some outcrops might have remained.

Since the data obtained from the Eniwetok Atoll section agree with those from the known and proved sections of the Malay Archipelago, it will be possible to analyze samples from surface outcrops elsewhere in the central Pacific area with greater confidence.

With the geologic age of this sequence firmly established and with information suggesting the depth of water in which the sediments accumulated, it has been possible to suggest a rate of subsidence.

STRATIGRAPHY

RECENT, PLEISTOCENE, AND PLIOCENE

From the surface to a depth of about 610 feet, the samples contain only species of larger Foraminifera which are still living. The following were recorded in varying abundance in virtually all of the samples from this depth range: *Calcarina spengleri*, *Heterostegina suborbicularis*, *Marginopora vertebralis*, and *Sorites marginalis*. It is of interest to note that only two specimens of *Cycloclypeus* (*Cycloclypeus*) *carpenteri* H. B. Brady were found here. Most living specimens of this species are known to occur at depths of 50–180 fathoms. Their rarity at Eniwetok suggests shallow-water conditions.

Two cores were taken in hole F–1, one at 170–190 feet and the other at 600–625 feet. So far as could be ascertained neither core contained larger Foraminifera, except for a few specimens of *Marginopora vertebralis* in the one at 170–190 feet.

It is impossible on the basis of larger Foraminifera to subdivide this interval. At 610 feet species appear that are thought to characterize the top of Tertiary *g*, upper Miocene.

MIOCENE

Tertiary g.—From the data obtained in the study of the Eniwetok Atoll drill holes, it has been necessary to revise slightly the interpretation of the section given for the Bikini drill holes. This revision is shown in table 2 to which have been subjoined the major subdivisions recognized at Eniwetok Atoll.

TABLE 2.—*Original and revised major subdivisions at Bikini compared with those at Eniwetok Atoll*

Bikini				Eniwetok Atoll	
Original (260–O)		Revised (260–V)		Stratigraphic divisions	Depth (feet)
Stratigraphic divisions	Depth (feet)	Stratigraphic divisions	Depth (feet)		
Post-Miocene	0– 850	Post-Miocene	0– 700	Post-Miocene	0– 615
Tertiary *g*	850–1,030	Tertiary *g*	700– 980	Tertiary *g*	615– 860
f_3	1,030–1,130				
f_{1-2}	1,130–1,380	*f*	980–1,166	*f*	860–1,080
e	1,380–2,070	*e*	1,166–2,556+	*e*	1,080–2,687
d(?)	2,070–2,349			Unknown	2,687–2,780
c(?)	2,349–2,556			*b*	2,780–basalt

Although the top of the Miocene in the Bikini drill holes was placed at 852 feet, reexamination of this section suggests that it should have been placed at 700 feet. At this depth (694 feet in Bikini hole 2A and 705 feet in Bikini hole 2B), there were found many specimens of *Operculinoides rectilata* Cole, a species which is related closely to *O. amplicuneata* Cole. Although *O. amplicuneata* had been chosen to mark the top of the Miocene, a more logical evolutionary choice appears to be *O. rectilata* inasmuch as these two species are so closely related that they can be distinguished from each other only by very detailed examination. As these species were not known from other areas, the original selection of *O. amplicuneata* to mark the top of the Miocene was based on differences in preservation (Cole, 1954, p. 570), a criterion which does not now appear to be valid. Moreover, Wells (1954, p. 609) identified corals which he considered to be Miocene in the Bikini drill holes starting at a depth of about 725 feet.

In the Eniwetok Atoll drill holes *O. rectilata* was recovered at a depth of 610–620 feet in drill hole K–1B, at a depth of 620–630 feet in drill hole E–1, and at a depth of 650–660 feet in drill hole F–1. As some of the cutting samples from drill hole F–1 were not very satisfactory, the top of the Miocene, Tertiary *g*, is placed at 615 feet in the Eniwetok drill holes. Thus, the top of the Miocene at Eniwetok Atoll is approximately 85 feet higher than at Bikini.

Species which characterize this section of the drill holes are *Alveolinella quoii*, *Borelis schlumbergeri*, *Operculina lucidisutura*, *Operculinoides amplicuneata*, and *O. rectilata*.

Tertiary f.—At Bikini the top of Tertiary *f* was placed at 1,030 feet on the basis of the occurrence of *Miogypsinoides cupulaeformis*. This species was found at a depth of 880–890 feet in Eniwetok Atoll drill hole E–1 and at a depth of 870–880 feet in F–1. It was not found in drill hole K–1B except as fragments at much lower depths.

In the core at 1,038–1,040 feet in drill hole K–1B, two specimens of *Cycloclypeus*, identified as *C.* (*Cycloclypeus*) *indopacificus vandervlerki*, were found in association with many specimens of *Operculinoides bikiniensis*. Inasmuch as this variety of *Cycloclypeus* was found (Tan, 1932, p. 68) at its type locality in association with known Tertiary *f* species of *Lepidocyclina*, the assumption is made that it occurs at Eniwetok in strata of similar age. Thus, the previous assignment of strata containing *Miogypsinoides cupulaeformis* to Tertiary *f* is strengthened as *C.* (*C.*) *indopacificus vandervlerki* occurs in the same zone. Moreover, it seems probable that *Operculinoides bikiniensis* is another marker in this general area for Tertiary *f*.

O. bikiniensis was found at a depth of 873–883 feet in drill hole K–1B, at a depth of 880–890 feet in drill hole E–1, and at a depth of 850–860 feet in drill hole F–1. The top of Tertiary *f* is placed at 860 feet in these drill holes. If this species had been used at Bikini rather than *Miogypsinoides cupulaeformis*, the top of Tertiary *f* would be at 980 feet. Thus, the top of Tertiary *f* at Eniwetok Atoll would be approximately 120 feet higher than at Bikini.

Species which characterize the upper part of Tertiary *f* are *Cycloclypeus* (*Cycloclypeus*) *indopacificus vandervlerki*, *Miogypsinoides cupulaeformis*, and *Operculinoides bikiniensis*.

The first *Lepidocyclina* of Tertiary *f* affinities, *L.* (*Nephrolepidina*) *orientalis*, was found in Bikini drill hole 2A at a depth of 1,082–1,088 feet. This same species was found at a depth of 1,070–1,080 feet in Eniwetok Atoll drill hole K–1B. It was not recovered from the other two drill holes. This is not surprising as very few specimens were found either in Bikini drill hole 2A or in Eniwetok Atoll drill hole K–1B.

Miogypsina (*Miogypsina*) *indonesiensis*, a Tertiary *f* species, was found at 1,135–1,145 feet in Bikini drill hole 2A. It also occurred in Bikini drill hole 2B at a depth of 1,167–1,177 feet. In this drill hole, however, samples were not obtained from 957–1,167 feet.

In Bikini drill hole 2A the interval between 1,135 and 1,166 feet is retained in Tertiary *f*, but the strata below, previously thought to be Tertiary *f*, are assigned to Tertiary *e* because of the first appearance of *Miogypsina* (*Miogypsina*) *thecideaeformis*, a Tertiary *e* species. However, the first sample, at 1,167–1,177 feet, in Bikini drill hole 2B below the interval of missing samples represents Tertiary *e* because of the presence of *Miogypsina* (*Miogypsina*) *thecideaeformis*. The specimens of *M.* (*M.*) *indonesiensis* in this sample probably represent cavings from above.

Only a very few specimens of *Miogypsina* (*Miogypsina*) *indonesiensis* were found in Eniwetok Atoll drill holes K–1B and E–1, and these were cuttings from well below the top of Tertiary *e*. These specimens appear to be cavings from above.

Tertiary e.—At Bikini the section between the first occurrence of *Miogypsina* at 1,135 feet in drill hole 2A and the first appearance of *Miogypsinoides dehaartii* at a depth of 1,387 feet in drill hole 2B was assigned to Tertiary f_{1-2}. This assignment was based on the identification of *Miogypsina* (*Miogypsina*) *borneensis*, *Lepidocyclina* (*Nephrolepidina*) *parva* and *L.* (*N.*) *verrucosa*.

Study of more abundant thin sections of Eniwetok Atoll specimens in conjunction with a large suite of specimens from Saipan Island (Cole, 1957) has proved that *M.* (*M.*) *borneensis* should be classified as *M.* (*M.*) *thecideaeformis* and that both *L.* (*N.*) *parva* and *L.* (*N.*) *verrucosa* are forms of *L.* (*N.*) *sumatrensis*. Therefore, the section of the Bikini drill holes between 1,166 and 1,387 feet previously thought to be Tertiary f_{1-2} is assigned to upper Tertiary *e*.

Upper Tertiary *e* appears at Eniwetok Atoll at a depth of 1,080–1,090 feet in drill hole K–1B and at a depth of 1,070–1,080 feet in drill hole E–1. The samples at comparable depths in drill hole F–1 did not contain diagnostic larger Foraminifera. Diagnostic species were not found in this drill hole between 970 and 1,140 feet.

The top of upper Tertiary *e* is placed at 1,080 feet at Eniwetok Atoll; therefore, it is about 90 feet higher than at Bikini.

Miogypsinoides dehaartii, a species occurring at 1,387–1,398 feet in Bikini drill hole 2B, was found at a depth of 1,227–1,238 feet in Eniwetok Atoll drill hole K–1B, at a depth of 1,190–1,200 feet in drill hole E–1 and at a depth of 1,160–1,170 feet in drill hole F–1.

It is interesting to note that in drill hole E–1 this species appeared in abundance also at 1,365–1,375 feet as well as at 1,190–1,200 feet. The specimens at the lower depth had a slightly different color and state of preservation and probably represent specimens from this depth, not cavings from the higher zone.

A core was taken in Eniwetok Atoll drill hole F–1 between 1,230 and 1,248 feet (core 3). In the thin sections from this core, *Miogypsinoides dehaartii* was found, but it was extremely rare. Twenty-three thin sections of large size (approximately 3.5 by 5.5 cm) were examined, and 11 specimens of *M. dehaartii* were found. In these same thin sections only one specimen of *Miogypsina* (*Miogypsina*) *thecideaeformis* was observed.

In this same core there are a few specimens of *Gypsina marianensis* and *Lepidocyclina* (*Nephrolepidina*) *sumatrensis*. The four species associated in this core occurred together in many samples from Saipan Island (Cole, 1957) from strata assigned to upper Tertiary *e*.

A few specimens of *Flosculinella globulosa* were found at a depth of 1,130–1,140 feet in Eniwetok Atoll drill hole E–1. This genus elsewhere (Van der Vlerk, 1955, p. 73) ranges from upper Tertiary *e* through Tertiary *f* with the species *F. globulosa* reported only from upper Tertiary *e*.

The first appearance of *Spiroclypeus* occurred in the Eniwetok Atoll drill hole E–1 at a depth of 1,190–1,200 feet associated with *Miogypsinoides dehaartii*. This genus was not found at comparable depths either at Bikini or in the other Eniwetok Atoll drill holes.

These specimens are assigned to the species *S. higginsi*. This species occurred with *M. dehaartii* on Saipan Island (Cole, 1957, p. 339) and Guam (Cole, 1939, p. 183).

As *M. dehaartii* and *Spiroclypeus* are recorded elsewhere (Mohler 1949, p. 526) as occurring in upper Tertiary *e*, the strata containing these species at Eniwetok Atoll are believed to represent this stratigraphic unit.

Species diagnostic of upper Tertiary *e* at Eniwetok Atoll are *Flosculinella globulosa*, *Gypsina marianensis*, *Lepidocyclina* (*Nephrolepidina*) *sumatrensis*, *Miogypsina* (*Miogypsina*) *thecideaeformis*, *Miogypsinoides dehaartii*, and *Spirocylpeus higginsi*.

At 1,210–1,220 feet in Eniwetok Atoll drill hole E–1 rare specimens of *Heterostegina borneenis* appear. No other specimens of this species were found until the sample at 1,688–1,715 feet of this same well was examined. In this and succeeding samples this species appeared in abundance.

Van der Vlerk (1955, p. 73) believed that *Heterostegina borneensis* was a definite marker for lower Tertiary *e*. It was discovered on Saipan (Cole, 1957) that *H. borneensis* occurred at a lower horizon than *Miogypsinoides dehaartii* and was used on that island as one of the diagnostic fossils for lower Tertiary *e*. On Saipan, however, *H. borneensis* always seemed to be stratigraphically lower than *M. dehaartii*. However, if the specimens of *M. dehaartii* in Eniwetok drill hole E–1 at a depth of 1,365–1,375 feet actually came from that depth and are not cavings, *H. borneensis* occurs in the zone of *M. dehaartii*.

It is difficult, therefore, in the Eniwetok Atoll drill holes to decide whether the top of lower Tertiary *e* should be placed on the first appearance of *H. borneensis*, on the first abundant occurrence of this species, or disregarded as a recognizable point. For practical purposes the occurrence of rare specimens of *H. borneensis* at 1,210–1,220 feet in drill hole E–1 are disregarded, and no attempt is made to specify the exact top of lower Tertiary *e*. However, the rocks between 1,688–1,925 feet in drill hole E–1 contain species in abundance which elsewhere characterize lower Tertiary *e*.

Another species which occurred infrequently above its zone of marked abundance is *Lepidocyclina* (*Eulepidina*) *ephippioides*. Single specimens were recovered from the samples at 1,394–1,424 and 1,541–1,569 feet in Eniwetok Atoll drill hole E–1. Abundant specimens were found first at a depth of 1,629–1,658 feet.

The following table gives a comparison between the depths at which certain key species appear in the Eniwetok Atoll drill hole E–1 and Bikini drill hole 2B.

TABLE 3.—*First appearance of certain key species in the Eniwetok Atoll and Bikini island drill holes*

Species	Depth in drill hole—		Difference in depth (feet)
	E–1 at Eniwetok (feet)	2B at Bikini (feet)	
Spiroclypeus leupoldi Van der Vlerk; *margaritatus* (Schlumberger)	1,452–1,482	1,597–1,608	145
Lepidocyclina (*Nephrolepidina*) *pumilipapilla* Cole; *Miogypsinoides ubaghsi* Tan	1,541–1,569	1,597–1,608	56
Lepidocyclina (*Eulepidina*) *ephippioides* Jones and Chapman [1]; *Spiroclypeus yabei* Van der Vlerk	1,629–1,658	1,723–1,734 1,660–1,671	94 31
Heterostegina borneensis Van der Vlerk [1]	1,688–1,715	1,818–1,828	130

[1] First abundant specimens; other species selected on first appearance.

The table demonstrates that these horizons in the Eniwetok drill holes are higher than in the Bikini drill holes. There is a very close agreement between the difference in depth of the first occurrence of *S. leupoldi*-*S. margaritatus* in both areas and of the first abundance of *H. borneensis* in these areas.

Species which characterize the *Heterostegina borneensis* zone, including *Borelis pygmaeus*, *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* (=*L. parva*) and *L.* (*Eulepidina*) *ephippioides* (=*L. formosa*), are associated elsewhere. Hanzawa (1930) reported a similar fauna from a limestone at the northern foot of Pasir Pabeasan, lying west of the village of Tagogapoe (Tagogapu), Java. Miss Crespin (1938, p. 9–12) recorded these species from the Ok Ti river in Papua. Cole (1957, p. 324) found this fauna at many lower Tertiary *e* localities on Saipan Island. Yabe and Hanzawa (1929) report a similar fauna from many localities in the Philippine Islands.

Heterostegina borneensis and *Lepidocyclina* (*Eulepidina*) *ephippioides* occur at Eniwetok Atoll as deep as core 5 (1,978–2,003 ft) in drill hole F–1. Thin sections from the upper part of this core (5–1 through 5–3) contain many specimens of these species. Moreover, in these thin sections there are several specimens of the form of *L.* (*E.*) *ephippioides* which has been recorded elsewhere either as *L. stereolata* or *L. monstrosa.*

At greater depths in this core, these species are replaced by *Heterostegina duplicamera* Cole, n. sp., and *Lepidocyclina* (*Eulepidina*) *abdopustula*. These species appear in samples of cuttings from Eniwetok Atoll drill hole E–1 at a depth of 1,925–1,955 feet. As these species occur in core 6 (2,662–2,687 feet) in drill hole F–1, they have a stratigraphic range of at least 680 feet.

Although *Heterostegina duplicamera* was not reported from the Bikini drill holes, reexamination of the samples from Bikini drill hole 2B proved that it was present at a depth of 2,007–2,017 feet. *Lepidocyclina* (*Nephrolepidina*) *augusticamera* is associated in the Eniwetok drill holes with *Heterostegina duplicamera* and *L.* (*Eulepidina*) *abdopustula;* the zone characterized by these species in Bikini drill hole 2B is at 1,933–1,949 feet.

The top of this zone, therefore, occurs at about the same depth at Bikini and Eniwetok Atoll. The depths are as follows: Bikini 2B, 1,933 feet; Eniwetok E–1, 1,925 feet; Eniwetok F–1, 1,978 feet. This is the only zone found at Eniwetok Atoll which was not slightly higher than its comparable reference point at Bikini.

Core 1 (2,003–2,028 ft) of Eniwetok Atoll drill hole E–1 has rare specimens of *L.* (*Eulepidina*) *abdopustula* but abundant specimens of smaller Foraminifera. Among these were many specimens of the genus *Austrotrillina.* This genus has not been reported to date below Tertiary *e*. Although this genus was not found either in core 5 (1,975–2,003 feet) or core 6 (2,662–2,687 feet) of drill hole F–1, its presence in core 1 (2,003–2,028 feet) of drill hole E–1 is of special significance because it dates this core as Tertiary *e*.

Because core 6 (2,662–2,687 ft) in drill hole F–1 contains *Heterostegina duplicamera* and *Lepidocyclina* (*Eulepidina*) *abdopustula*, the strata represented by this core are believed to be Tertiary *e* because of the association of *L.* (*E.*) *abdopustula* with *Austrotrillina* in core 1 (2,003–2,028 ft) in drill hole E–1.

The only additional species contained in the samples of cuttings in drill hole E–1 from 1,925 to 2,780 feet was *Gypsina vesicularis.* This species also occurs in core 10 (3,963–3,988 ft) in drill hole F–1 in unquestioned Tertiary *b* (Eocene). As this species is still living, its presence both in the Eocene and Miocene is without stratigraphic significance.

If the information obtained from drill holes E–1 and F–1 is combined, there is a section between 2,687 feet in drill hole F–1 and 2,780 feet in drill hole E–1 in which diagnostic larger Foraminifera have not been found. This 93-foot interval could be either Eocene, Miocene, or possibly Oligocene.

Larger Foraminifera of the type elsewhere reported from the Oligocene (Tertiary *c* and *d*) have not been recovered from the Eniwetok samples. During the Oligocene, Eniwetok Atoll may have maintained a constant position in such shallow water that sediments did not accumulate, may have sunk to such depths that sedimentary accumulation was vastly retarded, or may have been elevated, so that slight erosion occurred. It is probable, however, that any erosion was slight as the upper part of the Tertiary *b* section seems to be rather complete.

This lower section of Tertiary *e*, characterized by *Borelis primitivus* Cole, n. sp., *Heterostegina duplicamera* Cole, n. sp., *Lepidocyclina* (*Nephrolepidina*) *augusticamera*, and *L.* (*Eulepidina*) *abdopustula*, has not been reported from the Malay Archipelago. It corresponds, however, to the lower section at Bikini in which three of the species *H. duplicamera*, *L.* (*N.*) *augusticamera* and *L.* (*E.*) *abdopustula*, were found. It probably also includes the section at Bikini below 2,349 feet which was assigned either to the Oligocene or Eocene on the presence of *Halkyardia.*

EOCENE

Tertiary b.—The first definite Eocene genus of larger Foraminifera occurs in the sample from 2,840–2,850 feet in Eniwetok Atoll drill hole E–1. At this depth three specimens of *Asterocyclina matanzensis* were found. The following sample at a depth of 2,850–2,860 feet had two specimens of this species and rather abundant specimens were discovered at a depth of 2,910–2,920 feet.

Although the core from 2,802–2,808 feet in drill hole E–1 was devoid of larger Foraminifera, it contained numerous smaller Foraminifera, one of which belongs to the Genus *Pseudochrysalidina*. This genus was described from the middle Eocene of Florida (Cole, 1941, p. 35) and later was reported (Henson, 1949, p. 175) as having a stratigraphic range from basal Cretaceous to upper Eocene. The first appearance of this genus in the Eniwetok Atoll drill hole E–1 at 2,780–2,790 feet is taken as the top of the Eocene.

The next significant Eocene species is *Coskinolina rotaliformis* Cole, n. sp., which first appears at a depth of 2,890–2,900 feet in Eniwetok drill hole E–1. In this same drill hole *Camerina djokdjokarta* appears at 2,930–2,940 feet, and *Camerina pengaronensis* occurs at 2,940–2,950 feet. The only other species of importance, *Boreloides eniwetokensis* Cole, n. sp., in the samples of cuttings from Eniwetok Atoll drill hole E–1 occurs at a depth of 2,990–3,000 feet. The last sample of cuttings from this hole came from a depth of 3,120–3,130 feet.

At depths below 3,130 feet, the Eocene is represented by 1 core in drill hole E–1 and 9 cores in drill hope F–1. The species recovered from these cores are shown in the following table.

TABLE 4.—*Distribution of Tertiary* b *species in the Eniwetok Atoll drill cores and on Saipan*

[r, rare; c, common; a, abundant; x, known from Saipan]

Species	Saipan	E–1 core—	F–1 core—								
		3	7	8	9	10	11	12	13	14	15
		(4,078–4,100 ft)	(3,052–3,055 ft)	(3,350–3,353 ft)	(3,655–3,665 ft)	(3,963–3,988 ft)	(4,197–4,222 ft)	(4,316–4,341 ft)	(4,406–4,431 ft)	(4,500–4,525 ft)	(4,528–4,553 ft)
Asterocyclina centripilaris Cole, n. sp.	------	r	------	------	------	------	c	c	r	r	r
incisuricamerata Cole	x	------	------	------	------	------	------	c	r	r	r
matanzensis Cole	x	r	------	------	------	------	r	r	------	r	r
penuria Cole	x	------	------	------	------	r	------	r	a	r	r
praecipua Cole, n. sp.	------	------	------	------	------	------	------	r	c	------	r
Biplanispira fulgeria (Whipple)	x	------	------	------	------	------	r	------	------	------	------
mirabilis (Umbgrove)	x	------	------	------	------	------	a	------	------	------	------
Camerina pengaronensis (Verbeek)	x	------	------	------	------	------	------	------	a	------	------
Fabiania saipanensis Cole	x	------	------	------	------	------	r	r	------	------	------
Gypsina vesicularis (Parker and Jones)	------	------	------	------	------	c	------	------	------	------	------
Heterostegina aequatoria Cole, n. sp.	------	------	------	------	c	------	------	------	------	------	------
saipanensis Cole	x	------	a	c	------	------	------	c	------	------	------
Operculina eniwetokensis Cole, n. sp.	------	------	------	------	------	c	------	------	------	------	------
Operculinoides saipanensis Cole	x	------	------	------	------	------	------	r	r	r	r
subformai (Provale)	------	------	------	------	------	------	------	------	------	r	------
Pellatispira orbitoidea (Provale)	x	------	------	------	------	r	------	a	------	------	------
Spiroclypeus albapustula Cole, n. sp.	------	------	------	------	------	------	------	r	------	------	------
vermicularis Tan	x	------	------	------	------	------	c	------	------	------	------

Two important facts concerning the distribution of the species in cores need emphasizing: the discontinuous but long range of certain species, especially *Asterocyclina matanzensis*, *Camerina pengaronensis*, and *Heterostegina saipanensis;* and the occurrence of species known elsewhere near or at the top of the Eocene, Tertiary *b*, at a great stratigraphic distance from the top of the Eocene in these drill holes.

To illustrate these points: *Camerina pengaronensis* occurred first in the samples of cuttings at a depth of 2,940–2,950 feet in drill hole E–1. Specimens of this species occur in other samples of cuttings to a depth of 3,130 feet (last sample of cuttings). In the cores, however, it was not found until core 13 at a depth of 4,406–4,431 feet in drill hole F–1 was examined. In this core the specimens were abundant and well preserved.

Specimens representing such species as *Biplanispira mirabilis* and *Spirocylpeus vermicularis* were found in core 11 at a depth of 4,222–4,316 feet in drill hole F–1. From the data at hand these species occur at Eniwetok Atoll about 1,440 feet below the top of Tertiary *b*. On Saipan, however, these species occurred in samples which were believed to represent the highest Eocene of that island.

Van der Vlerk (1955, p. 73) stated that the genera *Flosculina, Miscellanea*, and *Ranikothalia* (=*Operculinoides*) are the only genera restricted to Tertiary *a* in the Far East. Similarly, he stated that *Biplanispira* and *Lepidocyclina* (*Polylepidina*) are the only genera or subgenera restricted to Tertiary *b*. Although the genus *Spiroclypeus* ranges from Tertiary *b* into Tertiary *e*, the species *S. vermicularis* has been found only in Tertiary *b*. *Biplanispira mirabilis* and *Spiroclypeus* *vermicularis* occur together in core 11 at a depth of 4,222–4,316 feet in drill hole F–1.

Of the 23 species of larger Foraminifera recovered from the Tertiary *b*, upper Eocene, section of the Eniwetok Atoll drill holes, 8 are new species. Of the 15 previously described species 12 occur in the Tertiary *b*, upper Eocene, of Saipan (table 4).

PALEOECOLOGY

Although certain genera of larger Foraminifera, such as *Asterocyclina*, *Lepidocyclina*, and *Miogypsina*, are extinct, several other genera survive in the existing seas. *Alveolinella, Borelis*, *Cycloclypeus*, *Heterostegina*, *Operculina*, and *Operculinoides* have living representatives. As these genera are found either alone or in association with extinct genera, in many of the samples from the Eniwetok drill holes, it is possible to make certain deductions concerning the depths at which these genera lived during the accumulation of the sediments in which they are entombed at Eniwetok.

The genus *Heterostegina* occurred in abundance at many depths throughout the Eniwetok Atoll drill holes. R. D. Norton (1930, p. 347) stated "*Heterostegina* seems to thrive in temperatures from about 22°C to 27°C and in depths down to perhaps 40 fathoms."

The following table was prepared from the extensive data given by J. A. Cushman (1921) on the distribution of the Foraminifera adjacent to the Philippines and by J. A. Cushman, Ruth Todd and Rita Post (1954, table 3) on the occurrence of certain larger Foraminifera in the vicinity of Bikini in order to verify the above quoted statement.

TABLE 5.—*Depths of occurrence of certain Recent genera in the vicinity of the Philippine Islands and Bikini*

Genus	Reference	Number of localities	Minimum depth (fathoms)	Maximum depth (fathoms)	Number of localities at which reported common or frequent.	Maximum and minimum depths at which reported common or frequent (fathoms)	Average depth at which reported common or frequent (fathoms)
Alveolinella	P. 488 [1]	13	10	318	7	10–38	20
Cycloclypeus	P. 387 [1]	4	24	565	4	24–565	181
Heterostegina	P. 385, 386 [1]	34	10	565	5	20–37	32
Operculina	P. 375–384 [1]	174	10	1, 105	67	10–565	70
Heterostegina	Table 3 [2]	134	6	410	55	6–40	25
Operculina	Table 3 [2]	61	10	410	5	23–30	25

[1] Cushman (1921).
[2] Cushman, Todd, and Post (1954).

The abundant or common occurrence of *Heterostegina* at average depths of 25–32 fathoms agrees with the 40 fathoms given by R. D. Norton.

Alveolinella and *Borelis* occur in existing seas at very shallow depths. In the vicinity of the Philippine Islands, the average depth for *Alveolinella* is 20 fathoms. H. B. Brady (1884, p. 223) stated regarding *Alveolinella* "rare at depths greater than 30 fathoms * * *" and of *Borelis* (p. 224) "no case greater than 40 fathoms."

Operculina, however, seems to have a greater depth range. Although abundant specimens occur at depths of 10 fathoms or less, the average depth in the vicinity of the Philippines is 70 fathoms. *Cycloclypeus* seems to favor still greater depths as the average depth at which it occurred in common numbers in the Philippine area is 181 fathoms.

However, S. Hanzawa (1951, p. 8) lists 15 localities from the vicinity of Ryukyu islands from which living *Cycloclypeus* was obtained. Here, they occurred in depths of from 34 to 128 fathoms with an average depth of 72 fathoms. T. F. Grimsdale (1952b, p. 2) stated that in the vicinity of the Funafuti Atoll "at a depth of 50–60 fathoms large quantities of both A and B (generations of *Cycloclypeus*) were dredged in equal proportions." At Bikini abundant megalospheric and microspheric specimens were dredged at depths of 96–133 fathoms.

L. W. LeRoy (1938, p. 130–133) in a study of microfaunas at Teluk Lada (formerly Peper Bay), Java, reported a *Dendritina-Alveolinella* facies in water with depths of 7–26 meters and an *Operculina-Ozawaia* facies in water with depths of 18–32 meters. Moreover, the *Dendritina-Alveolinella* fauna occurred in "protected marine shoal conditions * * *," whereas the *Operculina-Ozawaia* fauna grew in "marine conditions of more or less open sea nature."

Very few specimens of *Cycloclypeus* were found in the drill holes at Eniwetok Atoll. Their scarcity is suggestive that the depths at which the sediments collected were too shallow and too protected to favor them. T. F. Grimsdale (1952b, p. 3) has stated "*Cycloclypeus* when found is almost invariably characteristic for open sea conditions, living or having lived in waters less than say 200 fathoms deep."

Operculina and its close relative *Operculinoides* are found in abundance in certain of the cores from the Eocene, at 1,130–1,140 feet in Tertiary *e* and at several depths between 610 and 900 feet in Tertiary *g* and *f*. In Tertiary *b*, Eocene, *Operculina* occurs in certain samples without other larger Foraminifera except *Gypsina*. Such sediments as those, for example, in core 10 (3,963–3,988 ft) of drill hole F–1, probably accumulated in water at depths below the optimum for the development of *Heterostegina*, probably near 70 fathoms. The sediments which contain *Heterostegina*, *Lepidocyclina*, and similar genera probably accumulated at shallower depths. The best estimate for depth of accumulation of such sediments would be around 25–40 fathoms.

However, it should be noted that R. Fusejima, M. Marubashi, and U. Kitazaki (1943, p. 9) after a detailed analysis of the data given by J. A. Cushman (1921) wrote: "Camerinidae and Peneroplidae are most numerous in species in shallow warm water. Cushman (1940, p. 44) stated that they are restricted to bottoms overgrown with seaweeds, but the Diagram indicates that their distribution is not so limited. Those on the Pacific coast, for example, are most prolific at depths greater than 700 meters (383 fathoms) and seem to be controlled by water temperatures."

The tests of the larger Foraminifera rarely show any signs of abrasion which suggests that they were accumulated in quiet waters below the zone of wave or current action. Such habitats would be found in the shallow quiet waters of lagoons or in the deeper waters of the outer slopes of an atoll, where *Cycloclypeus* lives.

The evidence so far available suggests that *Alveolinella*, *Borelis*, and *Heterostegina* require warm, shallow, protected situations. *Operculina* favors partly protected situations but is more tolerant of greater depth and lower temperature. *Cycloclypeus* flourishes at still greater depths but on the seaward slopes. If these conclusions are valid, the Eniwetok Atoll sediments which contain an abundance of larger Foraminifera were accumulated in large part as lagoonal deposits.

RATE OF SUBSIDENCE

The suggestions of the approximate rates of subsidence of the Eniwetok Atoll area in the following table are based on the assumptions that Tertiary *b*, upper Eocene, represents about one-half of the duration of the Paleocene and Eocene epochs and that the thin undated strata above the Eocene beds is included in the Miocene.

TABLE 6.—*Time scale and rate of subsidence*

Age	Thickness (feet)	Time in millions of years	Rate of subsidence per million years (feet)
Recent, Pleistocene, Pliocene	615	12	50±
Miocene	2,165	16	130±
Eocene (Tertiary *b*)	1,773	10	170±

These figures suggest that very slow overall subsidence would satisfy the conditions necessary to accumulate these predominantly shallow-water sediments. The rate of subsidence has probably decreased.

SYSTEMATIC DESCRIPTIONS

Family VALVULINIDAE

Genus PSEUDOCHRYSALIDINA Cole, 1941

Pseudochrysalidina eniwetokensis Cole, n. sp.

Plate 233, figures 5–10

Typical specimens have a length of 1.4–2.15 mm and a diameter near the apertural face of 1.1–1.5 mm. The wall is calcareous, imperforate, and microgranular with a very small amount of arenaceous material. The chambers are triserially arranged. The main revolving suture is strongly depressed, but the sutures between the chambers are very slightly depressed. The apertures are a number of rather large pores on the surface of the final chamber.

Thin sections show a labyrinthic column through the center of the test with rather large, open chambers on either side of this column.

First appearance.—At a depth of 2,780–2,790 feet (Tertiary *b*) in Eniwetok Atoll drill hole E–1; abundant at a depth of 2,802–2,808 feet (core 2) in this same drill hole.

Discussion.—This new species superficially resembles *P. floridana* Cole (1941, p. 36) from the middle Eocene of Florida. The chambers are less inflated than those of *P. floridana*, and the labyrinthic axis is larger.

Genus COSKINOLINA Stache, 1875

Coskinolina rotaliformis Cole, n. sp.

Plate 233, figures 11–26

The test is subconical with a distinctly coiled initial part from which the test rapidly expands in diameter to the apertural surface which may be either opposite the initial end or twisted, so that it lies on one side of the test. Unabraided tests have slightly depressed concentric depressions which are nearly perpendicular to the axis of the test. Slightly abraided tests (pl. 233, fig. 15) show the chamberlets of the marginal trough. These rectangular chamberlets are connected to the labyrinthic interior of the test by a single round stoloniferous passage with a diameter of about 30μ on the inner wall. The apertural face is dotted with irregularly distributed subcircular pores with an average diameter of about 40μ. (pl. 233, fig. 13). The wall of the test beyond the apertural face is imperforate and composed mainly of calcareous material.

Measurements of thin sections are given in the following table.

Measurements of axial sections of Coskinolina rotaliformis *from drill hole E–1, 2,910–2,920 feet*

Dimensions	Specimen shown on pl. 233—				
	Fig. 26	Fig. 18	Fig. 25	Fig. 20	Fig. 19
Height ... mm	0.95	1.03	1.18	0.98	0.73
Width at base ... mm	1.1	0.85	1.03	0.88	0.6
Embryonic chambers:					
Diameters of initial chamber ... μ	90 x 100	70 x 90	100 x 95	100 x 120	85 x 105
Diameters of second chamber ... μ	70 x 90	50 x 100	45 x 70	----------	70 x 90
Distance across both chambers ... μ	175	150	160	----------	165
Width of marginal trough ... μ	100	130–150	100–170	120–150	--------
Distance between chamber partitions ... μ	80–100	80–130	120–160	100–150	--------
Thickness of floor of marginal trough ... μ	20	20	20	20	--------
Thickness of outer wall ... μ	20–30	20	20–30	20–30	30

Some axial sections show a short horizontal plate projecting inward from the outer wall at about midway between the floors of the marginal trough. These plates have a length of 40μ–70μ and a thickness of 10μ.

First appearance.—At a depth of 2,890–2,900 feet (Tertiary *b*) in Eniwetok Atoll drill hole E–1.

Discussion.—There is some resemblance to a species named *Dictyoconus daviesi* Silvestri (1939, p. 70) from the middle Eocene of northern Somaliland. *D. daviesi* has single horizontal plates which project into each chamber of the marginal trough, whereas such plates in chambers of the marginal trough on *C. rotaliformis* are rare. The initial spire of *D. daviesi* is less pronounced, and the central shield is less labyrinthic. Finally, *D. daviesi* is regularly conical in external shape, whereas *C. rotaliformis* is more irregular with the apertural face of the test extending to one side rather than being directly opposite the initial end as it is in *D. daviesi.*

The question of whether *D. daviesi* is a true *Dictyoconus* cannot be resolved from a study of the description and illustrations given by Silvestri. He does not indicate whether vertical plates are present. If such plates are present *D. daviesi* should be classified as a primitive *Dictyoconus*; otherwise, this species should be considered to be an advanced *Coskinolina.*

I. Crespin (1938, p. 7) illustrated a species of *Coskinolina* without specific designation from the Eocene of New Guinea where it occurs in association with *Lacazina wichmanni* Schlumberger and *Biplanispira mirabilis* (Umbgrove). However, there is not sufficient information given to demonstrate if it is the same as the Eniwetok species.

Family CAMERINIDAE

Genus CAMERINA Bruguière, 1792

Camerina djokdjokarta (Martin)

Plate 232, figures 24–27

1881. *Nummulina djokdjokartae* Martin, Geol. Reichs-Mus., Leiden, Samml., ser. 1, v. 1, p. 109, 110, pl. 5, figs. 8–11.
1934. *Camerina djokdjokartae* (Martin). Caudri, Tertiary Deposits of Soemba, Amsterdam, p. 67–72, text fig. 19 [references].
1957. *Camerina djokdjokarta* (Martin). Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 329, pl. 102, fig. 21.

The test is small, evenly lenticular with distinct, slightly raised, irregularly distributed papillae on the surface.

The embryonic chambers are bilocular with a very large, rudely spherical initial chamber followed by a smaller reniform chamber.

Measurements of thin sections follow.

Measurements of sections of Camerina djokdjokarta *from drill hole E–1*

Dimensions	Specimen from—			
	2,930–2,940 feet shown on pl. 232—			2,940–2,950 feet shown on pl. 232—
	Fig. 24	Fig. 25	Fig. 27	Fig. 26
Height ... mm	2.6	3.15	3.05	3.35
Width ... mm	2.55	3.05	--------	--------
Thickness ... mm	--------	--------	1.95	1.8
Diameters of initial chamber ... μ	510 x 490	440 x 550	--------	--------
Diameters of second chamber ... μ	120 x 360	150 x 490	--------	--------
Distance across both chambers ... μ	660	610	720	470
Whorls ... number	3¼	3½	--------	--------
Chambers in first volution ... number	8	7	--------	--------
Chambers in final volution ... number	21	20	--------	--------
Surface diameter of pillars ... μ	--------	--------	130–200	120–250

In median sections the chambers are low and elongated. The chamber walls are straight but not radially arranged. Each chamber wall encloses a canal about 5μ in diameter, and at its distal end the wall bifurcates, so that a small, open, conical area is formed bounded by the divided chamber wall and the inner side of the revolving wall.

Rather heavy pillars are scattered irregularly throughout the transverse sections.

First appearance.—At a depth of 2,930–2,940 feet (Tertiary *b*) in Eniwetok Atoll drill hole E–1.

Occurrences elsewhere.—In the Tertiary *b* of Java, Celebes, New Caledonia, Soemba, and Saipan.

Camerina pengaronensis (Verbeek)

Plate 231, figures 1–17

1871. *Nummulites pengaronensis* Verbeek, Neues Jahrb. für Min., Geol. und Pal., p. 3–6, pl. 1, figs. 1 a-k.

1892. *Nummulites nanggoelani* Verbeek, Natuurk. tijdschr. Ned-Indië, v. 51, no. 2, p. 116, 118 [1891].

1932. *Camerina pengaronensis* Doornink, Geol.-mijnb. genootsch. Nederland en Kolonien, Verh., Geol. ser., v. 9, p. 283, 284, pl. 4, figs. 1–3; pl. 6, fig. 12 [references].

1932. *Camerina semiglobula* Doornink, idem, p. 292–295, pl. 7, figs. 1–14; text figs. d, e.

1953. *Camerina saipanensis* Cole, U. S. Geol. Survey Prof. Paper 253, p. 20, 21, pl. 2, figs. 7–19.

Megalospheric generation.—The test is small, biconvex, sloping regularly and rather steeply from the umbo to the margin. The umbo has an area of smooth, dense shell material beyond which faint traces of the radial septal sutures appear. The sutures are flush with the surface and show as faint lines of clear shell material.

Measurements of typical megalospheric specimens follow.

Measurements of Camerina pengaronensis *from drill hole F–1, 4,406–4,431 feet (core 13)*

Dimensions	Specimen shown on pl. 231—						
	Fig. 15	Fig. 13	Fig. 14	USNM P-3720 (not illustrated)	Fig. 2	Fig. 3	Fig. 6
Height .... mm	3.05	3.9	3.08	3.45	3.+	3.17	3.67
Width .... mm	3.2	3.75	2.85				
Thickness .... mm				1.63	1.8	1.75	1.85
Embryonic chambers:							
Diameters of initial chamber .... μ	160 x 130	180 x 140	215 x 200		240 x 180	180 x 160	190 x 180
Diameters of second chamber .... μ	170 x 90	140 x 80	180 x 90		160 x 110	120 x 60	
Distance across both chambers .... μ	230	230	310		320	230	
Whorls .... number	4¾	5½	4¼				
Chambers in first volution .... number	9	8	9				
Chambers in final volution .... number	26	28	25				
Chambers in all volutions .... number	95	114	80				
Surface diameter of axial plug .... μ				1,150	1,150	900	1,030

The septa are straight for approximately three-fourths of their length and then recurve. The axial plugs are not solid but are composed of radiating columns of dark and clear shell material.

Microspheric generation.—Externally, microspheric specimens are similar to the megalospheric form, but they are larger. An average microspheric specimen has a diameter of about 6.0 mm and a thickness of about 4.0 mm.

There are about 8 whorls with approximately 36 chambers in the final volution. Transverse sections show a distinct axial plug with a surface diameter of about 2.5 mm. The plugs are not solid but are composed of columns of dark shell material interspersed with columns of more transparent shell material.

First appearance.—At a depth of 4,406–4,431 feet (Tertiary *b*) (core 13) in Eniwetok Atoll drill hole F–1; also known from cuttings at a depth of 2,940–2,950 feet (Tertiary *b*) in hole E–1.

Discussion.—The Eniwetok Atoll specimens are identical with specimens from the Tertiary *b* (upper Eocene) of Java described under the name *C. semiglobula* by H. W. Doornink (1932, p. 292). Later, T. F. Grimsdale (1952a, p. 236) described and figured microspheric specimens from the Oligocene of Kirkuk, Iraq, which he considered to be the same species as the one from Java. However, he made Doornink's species a variety of *C. vasca* (Joly and Leymerie).

Earlier, R. D. M. Verbeek had erected the names *Nummulites pengaronensis* (1871, p. 3) for certain specimens from Borneo and *N. nanggoelani* (1891, p. 118) for other specimens from Java. H. Douvillé (1912, p. 285) and Doornink (1932, p. 284) concluded that Verbeek's species should be combined, as they believed *N. pengaronensis* was the megalospheric form and *N. nanggoelani* was the microspheric form of the same species. Reexamination of Verbeek's original illustrations does not substantiate the conclusion that one is the megalospheric form and the other is the microspheric as both names are obviously based on microspheric specimens. However, the types are so similar to each other that there is no question that only one specific name should be used.

Although Doornink reported that *C. pengaronensis* and *C. semiglobula* occurred together at many localities in Borneo, he separated *C. semiglobula* from *C. pengaronensis* by the presence of a "central column head" in the former and its absence in the latter species. *C. semiglobula* is also smaller. Verbeek's figure (Verbeek and Fennema, 1896, pl. 8, fig. 113) of a transverse section of *N. nanggoelani* shows that a distinct axial plug is present. This plug should appear as a mass of dense shell material on the surface of the test, especially if the test were slightly abraided.

Van der Vlerk's illustration (1929, fig. 35b) of a megalospheric specimen which he referred to *N. pengaronensis* shows a distinct axial plug. These specimens are slightly larger than *C. semiglobula*, but otherwise similar. Thus, it would appear that *C. semiglobula* represents small megalospheric specimens of *C. pengaronensis.*

Cole (Cole and Bridge, 1953, p. 20) erected the name *C. saipanensis* for specimens found in the Tertiary *b* (upper Eocene) of Saipan. He stated that these specimens were similar to *C. pengaronensis* (Verbeek), but he believed the Saipan specimens could be distinguished from the Malay Archipelago species on size and transverse shape.

In the Eniwetok Atoll cores there occurred both megalospheric and microspheric specimens of a *Camerina.* The megalospheric specimens are identical with *C. semiglobula* and with certain specimens of *C. saipanensis.* However, other specimens of *C. saipanensis* do not have as distinct axial plugs. The microspheric specimens from the Eniwetok Atoll cores are similar to Verbeek's illustration (Verbeek and Fennema, 1896, pl. 8, fig. 112, 113) of *N. nanggoelani.* This illustration is much better than the one of *N. pengaronensis.*

Inasmuch as only one species of *Camerina* was present in the above mentioned Eniwetok core, it was concluded that it should be referred to *C. pengaronensis* (Verbeek). Reexamination of many specimens from Saipan demonstrated that the degree of development of the axial plugs is variable. In some specimens they show clearly, whereas in others they are weakly developed. Yet, in all other features the specimens are similar.

M. G. Rutten (*in* Bemmelen, 1949, p. 85, table 12) gave the range of *C. pengaronensis* as Tertiary *a* (lower Eocene) through Tertiary *d* (Oligocene). This long stratigraphic range may be caused by misidentification of certain specimens.

In the sample of cuttings at a depth of 2,940–2,950 feet in drill hole E–1 there are many specimens of a small *Camerina* which are similar to the specimens described above. These specimens are illustrated and measurements of these specimens follow.

Measurements of Camerina pengaronensis *from drill hole E–1, 2,940–2,950 feet*

Dimensions	Specimen shown on pl. 231—						
	USNM P-3721 (not illustrated)	Fig. 12	Fig. 16	Fig. 8	Fig. 5	Fig. 7	Fig. 1
Height mm	2. 0	2. 3	3. 1	2. 35	2. 0	2. 05	2. 9
Width mm	2. 0	2. 05	3. 25				
Thickness mm				1. 15	1. 05	1. 15	1. 35
Diameters of initial chamber μ	110 x 140	90 x 120	100 x 140	130 x 130		130 x 140	130 x 150
Diameters of second chamber μ	75 x 140	70 x 120	80 x 130			40 x 70	30 x 50
Distance across both chambers μ	210	180	200			190	170
Whorls number	3½	3¾	5				
Chamber in first volution number	8	9	8				
Chambers in final volution number	23	22	34				
Chambers in all volutions number	61	69	105				
Surface diameter of axial plug μ				400–500	370–450	500	650

There are 1,466 feet of beds between the first appearance of *Camerina* in the cuttings at 2,940 feet in hole E–1 and the second occurrence of this genus in core 13 at 4,406–4,431 feet in hole F–1. As comparatively few samples (either cores or cuttings) were obtained in this 1,466 feet, there may or may not be other occurrences.

The species of *Camerina* in hole E–1 at 2,940–2,950 feet appears to be identical with the one in core 13 at 4,406–4,431 feet in hole F–1.

Genus OPERCULINOIDES Hanzawa, 1935

Operculinoides amplicuneata Cole

1954. *Operculinoides amplicuneata* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 573, 574, pl. 204, figs. 7–10, 16–18.

This species is very similar to *O. rectilata*, but differs in having convex umbos and distinct axial plugs. Moreover, the outer wall of the test is much thinner. The thickness through the center is 1.22 to 1.4 mm.

Although the differences by which the two species were distinguished in the Bikini holes are the same in specimens recovered from the Eniwetok Atoll holes, these differences may be the result of environment rather than evolution. However, in both the Bikini and Eniwetok Atoll holes, *O. rectilata* occurs stratigraphically higher than does *O. amplicuneata.* As there appears to be a stratigraphically different distribution and as the features of the transverse section are sufficiently distinct to recognize two different kinds, the two specific names are retained.

First appearance.—At a depth of 663–673 feet (Tertiary *g*) in Eniwetok Atoll drill hole K–1B; at a depth of 800–810 feet (Tertiary *g*) in drill hole E–1; at a depth of 790–800 feet (Tertiary *g*) in drill hole F–1.

Operculinoides bikiniensis Cole

1954. *Operculinoides bikiniensis* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 574, pl. 204, figs. 19–23.

This species differs from *O. amplicuneata* and *O. rectilata* in having a more compressed evolute test and better developed surface ornamentation. The thickness through the center is 0.84 to 0.93 mm. Distinct axial plugs are present.

First appearance.—At a depth of 873–883 feet (Tertiary *f*) in Eniwetok Atoll drill hole K–1B; also in the core at 1,038–1,040 feet of this same hole; at a depth of 880–890 feet (Tertiary *f*) in drill hole E–1; at a depth of 850–860 feet (Tertiary *f*) in drill hole F–1.

Operculinoides rectilata Cole

1954. *Operculinoides rectilata* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 575, pl. 204, figs. 11–15; pl. 205, figs. 15–17.

The nearly parallel sides of the test, as seen in transverse sections, is a characteristic feature of this species. The outer wall of the test is thick, and the coils are fused into continuous masses on each side of the embryonic chambers, but distinct axial plugs are not present. The thickness through the center is 1.32 to 1.6 mm.

First appearance.—At a depth of 610–621 feet (Tertiary *g*) in Eniwetok Atoll drill hole K–1B; at a depth of 620–630 feet (Tertiary *g*) in drill hole E–1; at a depth of 650–660 feet (Tertiary *g*) in drill hole F–1.

Operculinoides saipanensis Cole

Plate 232, figures 7–14; plate 233, figures 31, 32

1957. *Operculinoides saipanensis* Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 331, pl. 102, figs. 15, 16.

The test is small, either evenly lenticular in transverse section or with a highly inflated initial portion partly bordered toward the distal side by a narrow, flat rim. A mass of dense shell material occurs on each side of the test over the embryonic chambers and indistinct sutures show on the rim.

Measurements of six thin sections follow.

Measurement of sections of Operculinoides saipanensis *from drill hole F–1, 4,406–4,431 feet (core 13)*

Dimensions	Specimen shown on pl. 232—					
	Fig. 11	Fig. 12	Fig. 10	Fig. 14	Fig. 8	Fig. 7
Height mm	1. 7	2. 1	1. 44	1. 62	1. 87	2. 0
Width mm	1. 58	1. 66	1. 32	1. 35	---	---
Thickness mm	---	---	---	---	0. 85	0. 78
Embryonic chambers:						
Diameters of initial chamber μ	40 x 40	40 x 40	40 x 40	30 x 30	55 x 60	---
Diameters of second chamber μ	20 x 50	40 x 80	30 x 65	30 x 60	45–50	---
Distance across both chambers μ	70	90	80	70	110	---
Whorls number	3	3⅛	3	3¼	---	---
Chambers in first volution number	10	7	8	9	---	---
Chambers in final volution number	18	25	26	22	---	---
Chambers in all volutions number	47	55	57	54	---	---
Surface diameter of axial plug μ	---	---	---	---	350	240

First appearance.—At a depth of 4,316–4,341 feet (Tertiary *b*) (core 12) in Eniwetok Atoll drill hole F–1.

Discussions.—This species is identical with the types from Tertiary *b*, Eocene, of Saipan Island.

Three microspheric specimens were found, one each in cores 12, 13, and 14, which probably belong to this species.

Operculinoides subformai (Provale)

Plate 232, figures 1–6

1908. *Nummulites* (*Gümbelia*) *sub-formai* Provale, Riv. italiana paleontologia, v. 14, p. 64–66, pl. 4, figs. 16–20.

The test is small with the subcentral part, which is inflated and evenly lenticular in cross section, surrounded by a fragile rim with a width of about 1 mm and a thickness of about 0.2 mm. Small, slightly raised papillae cover the umbonal area and extend outward as lines of beads on many of the sutures.

Measurements of five thin sections follow.

Measurement of sections of Operculinoides subformai *from drill hole F–1, 4,500–4,525 feet (core 14)*

Dimensions	Specimen shown on pl. 232—				
	Fig. 1	Fig. 2	Fig. 3	Fig. 4	Fig. 5
Height mm	2. 35	1. 7	2. 0	1. 95	2. 25
Width mm	2. 04	1. 65	1. 6	---	---
Thickness mm	---	---	---	0. 98	0. 76
Embryonic chambers:					
Diameters of initial chamber μ	80 x 80	60 x 65	80 x 90	85 x 80	---
Diameters of second chamber μ	50 x 140	50 x 115	60 x 110	30 x 70	---
Distance across both chambers μ	150	140	170	140	---
Whorls number	3⅛	3⅛	3	---	---
Chambers in first volution number	7	7	7	---	---
Chambers in final volution number	18	20	17	---	---
Chambers in all volutions number	41	43	38	---	---
Surface diameter of axial plug μ	---	---	---	330	220

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The chamber walls are straight and radial for about one-fourth of their length and then recurve slowly and evenly.

First appearance.—At a depth of 4,500–4,525 feet (Tertiary *b*) (core 14) in the Eniwetok Atoll drill hole F–1.

Discussion.—This species differs from *O. saipanensis* Cole in having beaded sutures, a relatively large initial chamber, and fewer chambers in the final volution. The specimens from Eniwetok Atoll are identical with the specimens from the Eocene of Borneo described by Provale.

Genus OPERCULINA D'Orbigny, 1826

Operculina eniwetokensis Cole, n. sp.

Plate 232, figures 15–23

The test is small, thin, and evolute, with a slightly inflated subcentral area over the embryonic chambers surrounded by a rim which progressively widens distally. The sutures of the chamber walls show on the surface of the flat rim as slightly raised, gently recurved lines.

Measurements of thin sections follow.

Measurement of sections of Operculina eniwetokensis *from drill hole F–1, 3,963–3,988 feet, (core 10)*

Dimensions	Specimen shown on pl. 232—				
	Fig. 22	Fig. 23	Fig. 21	Fig. 18	Fig. 17
Height mm	1.76	1.95	1.7	2.3	2.1
Width mm	1.56	1.6	1.4	--------	--------
Thickness mm	--------	--------	--------	0.65	0.55
Embryonic chambers:					
Diameters of initial chamber μ	50 x 60	40 x 40	30 x 35	50 x 55	20 x 20
Diameters of second chamber μ	30 x 80	30 x 60	30 x 40	--------	20 x 25
Distance across both chambers μ	105	80	70	--------	60
Whorls number	2¾	3⅛	3	--------	--------
Chambers in first volution number	7	7	8	--------	--------
Chambers in final volution number	17	15	17	--------	--------
Chambers in all volutions number	38	37	38	--------	--------
Surface diameter of axial plug μ	--------	--------	--------	380	300

First appearance.—At a depth of 3,963–3,988 feet (Tertiary *b*) (core 10) in Eniwetok Atoll drill hole F–1.

Discussion.—This species somewhat resembles specimens from the Tertiary *a–b* of Borneo and Sumatra which D. D. Bannink (1948) assigned to *Operculina heberti* Munier-Chalmas. This European species is larger, the sutures are raised and prominent, and the chambers of the final volution increase markedly in height.

Operculina lucidisutura Cole

1954. *Operculina lucidisutura* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 575, pl. 204, figs. 1–6.

A thin compressed test with raised limbate sutures characterizes this species.

First appearance.—At a depth of 684–694 feet (Tertiary *g*) in Eniwetok Atoll drill hole K–1B; at a depth of 690–700 feet (Tertiary *g*) in drill hole E–1; at a depth of 720–730 feet (Tertiary *g*) in drill hole F–1.

Operculina victoriensis Chapman and Parr

Plate 233, figures 28–30

1938. *Operculina victoriensis* Chapman and Parr, Royal Soc. Victoria Proc., v. 50, p. 284–287, pl. 16, figs. 3–8, text fig. 2.

1953. *Operculina victoriensis* Chapman and Parr. Cole, U. S. Geol. Survey Prof. Paper 253, p. 21, pl. 5, figs. 1–7.

The test is small with a height from 2.0 to 2.65 mm and a width from 1.65 to 2.2 mm. The thickness through the umbo is from 0.83 to 0.96 mm. The inflated umbonate part with a diameter of 1.2 to 1.4 mm is bordered by a flange which widens regularly toward the apertural face where it has a width of 0.75 to 0.9 mm and a thickness of 0.35 to 0.38 mm. Surface of the test is smooth except near the distal part of the flange where a few raised sutures occur.

The initial chamber is circular with an internal diameter of about 50μ and the second chamber is reniform with internal diameters of 40μ by 80μ.

There are 8–9 chambers in the first volution, 17–19 in the final volution and about 47 in all the coils of which there are 3¼–3½. The chamber walls are straight and radial, except near their distal ends where sharp recurvature occurs.

Distinct axial plugs with surface diameters of about 300μ occur on each side of the embryonic chambers.

First appearance.—At a depth of 1,122–1,133 feet (Tertiary *e*) in Eniwetok Atoll drill hole K–1B; at a depth of 1,130–1,140 feet (Tertiary *e*) in drill hole E–1.

Discussion.—Although the Eniwetok specimens are thicker through the umbo than are the specimens from Saipan which were referred to this species, the other characters are so similar that the Eniwetok Atoll specimens are also assigned to this species. The types, the specimens from Saipan, and the ones from Eniwetok Atoll have small embryonic chambers and comparatively few chambers in the final volution.

Genus HETEROSTEGINA D'Orbigny, 1826

Heterostegina aequatoria Cole, n. sp.

Plate 234, figures 1–12

The test is small, typically with a distinct subcentral umbonate area surrounded by a narrow rim. In most specimens the separation of the umbonate part from the rim is sharp, but in a few specimens the parts gradually merge. The surface of the umbonate area is nearly flat, and in transverse sections the sides are parallel. The surface is without ornamentation.

Measurements of thin sections follow.

Measurements of sections of Heterostegina aequatoria *from drill hole F–1, 3,655–3,665 feet (core 9)*

Dimension	Specimen shown on pl. 234—									
	Fig. 8	Fig. 11	Fig. 10	Fig. 6	Fig. 9	Fig. 5	Fig. 4	Fig. 3	Fig. 1	Fig. 2
Height ... mm	2.7	1.8	3.0	1.85	2.2	1.65	2.85	1.95	1.8	2.35
Width ... mm	2.25	1.7	2.0	1.7	2.24					
Thickness ... mm						0.5	0.46	0.9	0.89	0.8
Embryonic chambers:										
Diameters of initial chamber ... μ	50 x 50	30 x 35	40 x 40	30 x 30	30 x 35	40 x 40			40 x 40	30 x 30
Diameters of second chamber ... μ	25 x 60	20 x 50	20 x 50	15 x 40	20 x 40	15 x 30			20 x 20	
Distance across both chambers ... μ	90	70	70	50	60	60			75	50
Operculine chambers ... number	14	11	12	15	12					
Whorls ... number	3¾	3¼	4	3¾	4					
Surface diameter of axial plug ... μ						200		440	390	260

First appearance.—At a depth of 3,655–3,665 feet (Tertiary *b*) (core 9) in Eniwetok Atoll drill hole F–1.

Discussion.—This species has 11–15 operculine chambers before the primary chambers are subdivided into chamberlets. The maximum number of operculine chambers found in *H. saipanensis* Cole is 8.

Heterostegina borneensis Van der Vlerk

Plate 237, figures 1–23

1929. *Heterostegina borneensis* Van der Vlerk, Nederlandsche Akad. Wetensch. Meded., no. 9, p. 16, figs, 6a–c, 25a–b.

1930. *Heterostegina borneensis* Van der Vlerk. Hanzawa, Tōhoku Imp. Univ., Sci. Rep., 2d ser., Geol., v. 14, p. 95, pl. 26, figs. 11, 19; pl. 27, figs. 4–8.

1938. *Heterostegina borneensis* Van der Vlerk. Crespin, Australia, Palaeont. Bull. 3, p. 10, pl. 3, figs. 6–9.

1953. *Heterostegina borneensis* Van der Vlerk. Cole, U. S. Geol. Survey Prof. Paper 253, p. 23, pl. 2, figs. 1–3, 5; pl. 4, figs. 16–18.

1954. *Heterostegina nigripustula* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 575, 576, pl. 209, figs. 1–8.

1954. *Heterostegina pusillumbonata* Cole, idem, p. 576, pl. 206, figs. 3–9.

The external appearance of the test ranges from thin, compressed fragile specimens with small projecting papillae (*H. pusillumbonata*) to thick lenticular specimens with coarse protuberant papillae (*H. nigripustula*). Although these two extremes appear to represent distinct species, study of a large suite of specimens arranged in a series as on plate 237 shows there is complete gradation.

Measurements of median sections follow.

Measurements of median sections of Heterostegina borneensis *from drill holes E–1 and F–1*

Dimensions	Specimen from E–1 at—										Specimen from F–1 at—
	1,210–1,220 feet shown on—	1,688–1,715 feet		1,715–1,746 feet shown on—					1,746–1,776 feet shown on—		1,718–1,740 feet (core)
	Pl. 237, fig. 18	USNM P–3722	USNM P–3723	USNM P–3724 (not illustrated)	Pl. 237, fig. 22	Pl. 237, fig. 21	USNM P–3725 (not illustrated)	Pl. 237, fig. 19	Pl. 237, fig. 23	USNM P–3726 (not illustrated)	USNM P–3727
Shape of transverse section	(1)	(1)	(2)	(1)	(2)	(1)	(1)	(1)	(2)	(2)	(2)
Height ... mm	2.25	2.55	2.1	3.2	3.2	2.45	2.75	2.1	3.55	3.2	2.4
Width ... mm	1.8	2.85	2.1	3.4	2.35	2.4	2.4	2.0	3.25	2.6	2.2
Embryonic chambers:											
Diameters of initial chamber ... μ	190 x 240	170 x 200	170 x 180	130 x 150	180 x 240	140 x 160	110 x 130	140 x 160	240 x 260	190 x 240	90 x 110
Diameters of second chamber ... μ	90 x 270	100 x 250	70 x 220	60 x 180	110 x 220	90 x 170	60 x 160	70 x 200	110 x 280	120 x 250	40 x 120
Distance across both chambers ... μ	300	290	260	210	310	240	190	230	370	330	160
Operculine chambers ... number	1	1	1	1	1	1	1	1	1	1	1
Diameters of operculine chamber ... μ	160 x 40	230 x 50	100 x 40	170 x 50	250 x 80	170 x 50	180 x 60	160 x 50	260 x 90	240 x 90	130 x 50
Chamberlets in first divided chamber ... number	4	4		2	5	3		2	2	3	2
Volutions ... number	2	2	2	3	2¼	2	2¾	2	2⅛	2¼	2¾

[1] Compressed.
[2] Inflated.

Measurements of transverse sections follow.

Measurements of transverse sections of Heterostegina borneensis *from drill holes E–1 and F–1*

Dimensions	Specimen from E–1 at depth of—														Specimen from F–1 at depth of—	
	1,210–1,220 feet shown on pl. 237—	1,688–1,715 feet shown on pl. 237—		1,715–1,746 feet shown on pl. 237—							1,746–1,776 feet shown on pl. 237—				1,718–1,740 feet shown on pl. 237— (core 4)	
	Fig. 4	Fig. 3	Fig. 7	Fig. 5	Fig. 11	Fig. 6	Fig. 1	Fig. 8	Fig. 2	Fig. 13	Fig. 10	Fig. 12	Fig. 9	Fig. 14	Fig. 20	Fig. 15
Height ... mm	3.1	2.4+	2.83	3.2	2.52	2.85	2.37+	3.0	2.65	2.7+	3.95	3.3+	3.25	3.45+	3.55+	3.57
Thickness at center ... mm	0.64	0.57	0.88	0.83	1.22	0.7	0.63	0.95	0.65	1.18	0.95	1.52	1.0	1.3	1.35	1.3
Diameter of umbo ... mm	1.3	1.1	1.5	1.5	1.7	1.3	1.3	1.7	1.25	2.7	1.8	3.3	2.0	2.3	2.4	2.3
Width of flange ... mm	1.0	0.8+	0.9	1.3	0.6+	1.3	0.75+	1.2	1.2	(1)	1.5	(1)	1.2	(1)	0.7+	1.1
Thickness of flange ... mm	0.26	0.3	0.2	0.34	0.23	0.34	0.27	0.3	0.3	(1)	0.4	(1)	0.2	(1)	0.35	0.33
Embryonic chambers:																
Diameters of initial chamber ... μ	140 x 160	140 x 160	160 x 200	110 x 120	120 x 140	180 x 180	160 x 150	170 x 180	200 x 220	140 x 140	250 x 270	250 x 290	200 x 290	180 x 230	----------	90 x 110
Diameters of second chamber ... μ	60 x 90	70 x 90	50 x 110	60 x 80	70 x 70	80 x 90	----------	40 x 75	40 x 60	40 x 90	----------	80 x 150	60 x 250	80 x 160	----------	40 x 70
Distance across both chambers ... μ	210	220	230	190	210	280	----------	230	260	190	----------	350	350	280	----------	150
Thickness of median plane ... μ	70	50–70	60–80	70	80–90	40–70	60	60–80	80–100	60–90	70–100	60–90	80	60–90	80–100	80–100
Surface diameter or umbonal plugs ... μ	280–370	290	380–490	350–460	500	400–470	320	320	450	100–300	250–300	550–750	100	500–600	450	480–600
Surface diameter of other pillars ... μ	60–80	50–70	50–100	60–150	80–200	70	60–70	40–150	70	60–210	50–110	110–200	80–180	50–100	70–180	90–240

[1] Broken.

First appearance.—At a depth of 1,210–1,220 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1; abundant at a depth of 1,688–1,715 feet of this same hole; at a depth of 1,718–1,740 feet (Tertiary *e*) (core 4) in Eniwetok Atoll hole F–1; at a depth of 1,975–1,978 feet (core 5) of this same drill hole.

Discussion.—The first specimens which could be assigned to this species occurred in Eniwetok Atoll hole E–1 at 1,210–1,220 feet in a cutting sample. As no other specimens were found until the cutting sample from 1,688–1,715 feet was examined, it was thought the specimens at 1,210–1,220 feet might represent contamination. However, additional material at this depth was examined later, and other specimens were found. In hole E–1 this species, however, occurs most abundantly from 1,688 feet to probably 1,925 feet.

The most abundant specimens in this lower zone are those with the compressed tests and small papillae. The specimens with the inflated tests and coarse papillae occur in smaller numbers and with the greatest concentration in the sample from 1,746–1,776 feet in hole E–1. It is of interest to note that the coarse-structured type of *Lepidocyclina ephippioides* Jones and Chapman (commonly identified as *L. gibbosa* Yabe) occurs in abundance at this same depth. It may well be that some ecological condition existed which promoted the development of coarse structures in these two unrelated species.

The compressed type was called *H. pusillumbonata* in the Bikini report, and the inflated ones with coarser papillae were designated *H. nigripustula.* As there is complete gradation between these two types, they are assigned to *H. borneensis,* inasmuch as the intermediate specimens between the two extreme types seem to be identical with *H. borneensis.*

Two microspheric specimens were recovered; one from a depth of 1,715–1,746 feet in Eniwetok Atoll drill hole E–1 and the other from a depth of 1,718–1,740 feet (core 4) in drill hole F–1. These specimens have from 14 to 16 operculine chambers before the chambers with chamberlets develop.

Heterostegina duplicamera Cole, n. sp.

Plate 236, figures 1–23

The test has a strongly inflated lenticular central part bordered by a narrow flat rim. The surface of the central part is covered with large, rudely circular pillar heads which are flush with the surface. The sutures of the chambers and chamberlets appear as lines of clear shell material on the narrow flange.

Measurements of median sections follow.

Measurements of median sections of Heterostegina duplicamera *from drill hole E–1, 1,955–1,985 feet*

Dimensions	Specimen shown on—			
	Pl. 236, fig. 23	Pl. 236, fig. 22	USNM P–3728 (not illustrated)	USNM P–3729 (not illustrated)
Height____mm	2. 5	2. 1	2. 35	3. 2
Width____mm	2. 4	2. 2	2. 1	2. 6
Embryonic chambers:				
Diameters of initial chamber____μ	100 x 120	90 x 100	90 x 100	90 x 120
Diameters of second chamber____μ	60 x 140	50 x 150	50 x 160	50 x 140
Distance across both chambers____μ	180	160	160	160
Operculine chambers____number	2	2	2	2
Volutions____number	3	3	3	3

The 4 median sections have 2 operculine chambers following the bilocular embryonic chambers. After these the chambers are divided into chamberlets, the normal number being 2 chamberlets per chamber throughout the first volution.

Measurements of transverse sections follow.

Measurements of transverse sections of Heterostegina duplicamera *from drill hole E–1, 1,955–1,985 feet*

Dimensions	Specimen shown on pl. 236—		
	Fig. 16	Fig. 19	Fig. 15
Height____mm	2. 35	3. 35	2. 65
Thickness____mm	1. 18	1. 16	1. 15
Embryonic chambers:			
Diameters of initial chamber____μ	90 x 80	100 x 110	110 x 125
Diameters of second chamber____μ	50 x 40	40 x 50	70 x 60
Distance across both chambers____μ	160	150	190
Height of median plane____μ	90	50–90	60–80
Surface diameter of umbonal plug____μ	470	400–450	400–500

The umbonal plugs are well developed and extend from the embryonic chambers to the surface of the test. Strong secondary pillars occur surrounding the umbonal plugs, and smaller pillars are scattered throughout the rest of the inflated central part of the test. The flange is either without pillars or with very small ones.

First appearance.—At a depth of 1,925–1,955 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1; at a depth of 1,978–2,003 feet (Tertiary *e*) (core 5) in drill hole F–1; probably this same species at a depth of 2,220–2,230 feet (Tertiary *e*) in drill hole E–1 and at a depth of 2,662–2,688 feet (Tertiary *e*) (core 6) in drill hole F–1.

Discussion.—The specimens selected as types differ from *Heterostegina borneensis* in having two operculine chambers. Other specimens which will be described separately in the following paragraphs also have more operculine chambers than does *H. borneensis.*

Reexamination of certain of the samples from Bikini drill hole 2B proves this species is present at a depth of 2,007–2,017 feet. It apparently was overlooked in the original examination or confused with *H. borneensis* which occurs commonly in the lower Bikini samples as cavings from higher strata.

Specimens in the lower part of core 5 (1,975–2,003 feet) in Eniwetok Atoll drill hole F–1 resemble this species. A single nearly oriented median section is illustrated on plate 236, figure 8. In the samples of cuttings from this hole at a depth of 2,080–2,090 feet many specimens of *Heterostogina* were found which externally appeared to be this species. A transverse section (pl. 236, fig. 14) and one of the median sections (pl. 236, fig. 18) made from these specimens were identical with those made from specimens at 1,955–1,985 feet in drill hole E–1. However, the other median section (pl. 236, fig. 17) has 4 operculine chambers rather than 2.

Other specimens of *Heterostegina* were found in the samples at 2,220–2,230 and 2,230–2,240 feet in drill hole E–1 and at 2,662–2,688 feet (core 6) in drill hole F–1. Although these specimens are assigned to this species, they will be described as they show deviation from the specimens selected as types. The specimens from drill hole E–1 will be described first.

The test has a very slightly inflated lenticular initial part which is bordered by a wide, thin, flat rim. The surface is smooth.

Measurements of five median sections follow.

Measurements of median sections of Heterostegina duplicamera *from drill hole E–1, 2,230–2,240 feet*

Dimensions	Specimen shown on pl. 236—				
	Fig. 13	Fig. 7	Fig. 6	Fig. 12	USNM P–3730 (not illustrated)
Height ... mm	2.6	2.75	2.4	2.65	2.0
Width ... mm	2.5	2.55	2.2	2.7	1.8
Embryonic chambers:					
Diameters of initial chamber ... μ	100 x 110	100 x 100	80 x 85	110 x 110	90 x 80
Diameters of second chamber ... μ	70 x 110	55 x 110	60 x 100	70 x 125	50 x 90
Distance across both chambers ... μ	180	165	150	190	150
Operculine chambers ... number	5	3	5	2	5
Volutions ... number	2¾	2½	2½	3	2¾

Measurements of transverse sections follow.

Measurements of transverse sections of Heterostegina duplicamera *from drill hole E–1, 2,230–2,240 feet*

Dimensions	Specimen shown on pl. 236—		
	Fig. 5	Fig. 4	Fig. 3
Height ... mm	2.6	2.3	2.95
Thickness ... mm	0.7	0.8	0.95
Surface diameter of axial plug ... μ	270	250	550

The specimens from core 6 in drill hole F–1 were observed only in thin section as it was impossible to break the limestone in such a manner that matrix free specimens could be obtained. Although many oriented transverse sections were available in the thin sections made of the limestone, only four median sections were found which were suitable for detailed study. Measurements of these median sections follow.

Measurements of median sections of Heterostegina duplicamera *from drill hole F–1, 2,662–2,688 feet (core 6)*

Dimensions	Specimen shown on pl. 236—			
	Fig. 1	Fig. 2	Fig. 9	USNM P–3731 (not illustrated)
Height ... mm	1.87	2.05	1.4	2.1
Width ... mm	1.7	------	1.2	------
Diameters of initial chamber ... μ	140 x 140	95 x 100	120 x 130	140 x 150
Diameters of second chamber ... μ	120 x 200	60 x 140	70 x 160	60 x 130
Distance across both chambers ... μ	270	170	210	210
Operculine chambers ... number	8	10	7	7+
Coils ... number	2	2¼	2	2

Measurements of four transverse sections of specimens from core 6 follow.

Measurements of transverse sections of Heterostegina duplicamera *from drill hole F–1, 2,662–2,688 feet (core 6)*

Dimensions	Specimen shown on—			
	USNM P–3732 (not illustrated)	USNM P–3733 (not illustrated)	Pl. 236, fig. 11	Pl. 236, fig. 10
Height ... mm	2.25+	2.69	2.2+	2.5
Thickness ... mm	0.81	0.67	0.9	0.75
Surface diameter of axial plug ... μ	320	420	360	240

These specimens differ from the types mainly in having slightly more compressed tests initially and developing, except in one specimen, more operculine chambers. The writer does not believe these differences are sufficiently significant to separate these specimens specifically.

Heterostegina saipanensis Cole

Plate 234, figures 13–24; plate 235, figures 1–13

1953. *Heterostegina saipanensis* Cole, U. S. Geol. Survey Prof. Paper 253, p. 23, 24, pl. 2, figs. 4, 6.

1957. *Heterostegina saipanensis* Cole. Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 331, pl. 102, figs. 17–19.

The test is small with the initial part evenly lenticular with a moderately wide, thin flange on the distal part. A small, slightly elevated boss occurs on the surface of the test directly over the embryonic chambers. The rest of the test is either smooth or has the chamberlet sutures showing indistinctly on the rim.

Measurements of thin sections follow.

Measurements of sections of Heterostegina saipanensis *from drill hole F–1, 3,052–3,053 feet (core 7)*

Dimensions	Specimen shown on—							
	Pl. 235, fig. 10	Pl. 235, fig. 12	Pl. 234, fig. 23	Pl. 234, fig. 22	Pl. 234, fig. 19	Pl. 234, fig. 15	Pl. 235, fig. 5	Pl. 234, fig. 13
Height ... mm	2.7	2.8	2.3	3.0	1.3	2.2+	2.5	1.93
Width ... mm	2.5	2.45	2.0	2.5	1.05			
Thickness ... mm						0.95	1.0	0.65
Embryonic chambers:								
Diameters of initial chamber ... μ	70 x 80	90 x 115	90 x 100	95 x 115	80 x 80	100 x 120	70 x 90	90 x 90
Diameters of second chamber ... μ	35 x 70	70 x 150	60 x 125	40 x 135	30 x 30			70 x 70
Distance across both chambers ... μ	130	190	170	160	120			170
Operculine chambers ... number	4	2	3	3	3			
Whorls ... number	3¼	2½	2¾	3⅛	2			
Surface diameter of axial plug ... μ						380	400	350

In the core 8 at 3,350–3,353 feet and core 12–3 at 4,316–4,341 feet of the Eniwetok Atoll drill hole F–1, specimens similar to those found in core 7 at 3,052–3,055 feet of this same drill hole were found. Although minor differences in the surface diameter of the axial plug and the average number of operculine chambers appear, all of these specimens seem to represent only one species. A separate description of the specimens in each of the lower cores follows with those from core 8 described first.

The test is small with the subcentral part evenly lenticular in transverse section with a flat rim developed distally. The surface is smooth.

Measurements of thin sections follow as shown in table at right.

The test is small with the central part inflated, evenly lenticular in transverse section, and bordered by a flat thin rim. A small slightly elevated boss occurs in a subcentral position directly over the embryonic chambers on each side of the test. The surface of the test is smooth.

Measurements of sections of Heterostegina saipanensis *from drill hole F–1, 3,350–3,353 feet (core 8)*

Dimensions	Specimen shown on—				
	Pl. 234, fig. 18	Pl. 234, fig. 16	Pl. 234, fig. 21	Pl. 235, fig. 3	Pl. 235, fig. 1
Height ... mm	2.35	2.7	2.65	3.03	2.15
Width ... mm	2.38	2.05	2.55		
Thickness ... mm				0.95	0.61
Embryonic chambers:					
Diameters of initial chamber ... μ	60 x 80	90 x 100	60 x 60		
Diameters of second chamber ... μ	40 x 90	50 x 130	30 x 70		
Distance across both chambers ... μ	120	160	100		
Operculine chambers ... number	7	6	7		
Whorls ... number	3⅛	3	3⅛		
Surface diameter of axial plug ... μ				360	300

Measurements of thin sections follow.

Measurements of sections of Heterostegina saipanensis *from drill hole F–1, 4,316–4,341 feet (core 12)*

Dimensions	Specimen shown on—							
	Pl. 234, fig. 20	Pl. 235, fig. 9	Pl. 235, fig. 11	Pl. 235, fig. 13	Pl. 235, fig. 2	USNM P-3734 (not illustrated)	Pl. 235, fig. 4	Pl. 235, fig. 6
Height ... mm	2.83	2.4	2.43	2.6	2.25	2.5	2.6	2.78
Width ... mm	2.5	2.3	1.95	2.1				
Thickness ... mm					0.97	1.08	1.0	0.83
Embryonic chambers:								
Diameters of initial chamber ... μ	80 x 80	60 x 80	70 x 80	70 x 80				70 x 80
Diameters of second chamber ... μ	40 x 90	50 x 80	25 x 60	40 x 110				20 x 30
Distance across both chambers ... μ	135	130	120	130		110		110
Operculine chambers ... number	8	4	6	4				
Whorls ... number	3⅛	2½	3	3				
Surface diameter of axial plug ... μ					700	550	500	600

First appearance.—At a depth of 3,052–3,053½ feet (Tertiary *b*) (core 7) in Eniwetok drill hole F–1; also at a depth of 3,350–3,353 feet (Tertiary *b*) (core 8) and at 4,316–4,341 feet (Tertiary *b*) (core 12–3).

Discussion.—This species was described from two median sections. Later, three additional matrix-free specimens were studied. The specimens from Eniwetok Atoll drill hole F–1 have internal structures which are identical with those of the types.

The number of operculine chambers seemingly ranges from 1 to 8. There are 2 satisfactory median thin sections of Saipan specimens and 12 of Eniwetok specimens. The number of operculine chambers found in the specimens from the several samples is shown in the following table.

Number of specimens with regard to the number of operculine chambers

Number of operculine chambers	Saipan	Eniwetok			Total individuals
		Core 7	Core 8	Core 12	
1	1				1
2		1			1
3		3			3
4	1	1		2	4
5					
6			1	1	2
7			2		2
8				1	1

Heterostegina suborbicularis D'Orbigny

Plate 235, figures 14–20

1826. *Heterostegina suborbicularis* D'Orbigny, Ann. Sci. Nat., v. 7, p. 305.

1954. *Heterostegina suborbicularis* D'Orbigny. Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 576, pl. 205, figs. 5–8 [references].

The test has a moderately inflated, lenticular central part which is bordered by a narrow thin rim. Surface is seemingly smooth, but if it is moistened the umbonal plug and the pillar heads show as lighter colored areas of shell material on the central part, and faint traces of the sutures of the chambers appear on the rim.

Measurements of median sections follow.

Measurements of median sections of Heterostegina suborbicularis *from drill hole E–1*

Dimensions	Specimen from—					
	2,930–2,940 feet shown on pl. 235—	2,940–2,950 feet shown on pl. 235—				
	Fig. 19	Fig. 17	Fig. 16	Fig. 18	Fig. 15	USNM P-3735 (not illustrated)
Height ... mm	2. 5	2. 48	2. 42	2. 25	2. 45	2. 2
Width ... mm	2. 63	1. 97	2. 66	2. 4	2. 25	1. 95
Embryonic chambers:						
Diameters of initial chamber ... μ	70 x 70	90 x 90	80 x 80	80 x 70	70 x 60	70 x 80
Diameters of second chamber ... μ	50 x 130	50 x 130	50 x 110	50 x 120	40 x 80	40 x 90
Distance across both chambers ... μ	140	150	140	140	120	130
Operculine chambers ... number	22	14	21	21	24	20
Volutions ... number	3½	3⅛	3⅛	3⅛	3½	3⅛

The operculine type of chambers occurs in the first two volutions. At about the beginning of the third volution, chamberlets appear, but the first chamberlets occur only at the distal ends of the chambers, so that the chambers are largely undivided. The chambers are completely subdivided by chamberlets only near the end of the final volution.

One transverse section with a height of 2.3 mm and a thickness at the center of 0.96 mm has a narrow rim, about 0.35 mm wide, and marked umbonal plugs which have a surface diameter of 350μ. The embryonic chambers in this section have a height of 80μ. Another transverse section with a height of 2.4 mm and a thickness at the center of 1.1 mm has a narrow rim, about 0.3 mm wide, at only one end. The umbonal plugs of this specimen have a surface diameter of 400μ, and a few pillars are scattered irregularly throughout the rest of this section. The embryonic chambers have a height of about 85μ.

First appearance.—At a depth of 2,930–2,940 feet (Tertiary *b*) in Eniwetok Atoll drill hole E–1; also in most of the samples near or at the surface of the drill holes.

Occurrence elsewhere.—Most of the records of this species are those of living forms.

Discussion.—Many specimens of this species occur in the post-Miocene samples of the drill holes. These specimens are not filled with calcite or other materials. At 2,930–2,940 feet in the Tertiary *b* in drill hole E–1 many specimens of this species occur which have the interior filled with calcite and other material. So far as could be discovered, no other specimens which could be assigned to this species occur in the intervening samples. Yet, the Tertiary *b* specimens are identical with the living specimens, except for differences in preservation.

Genus SPIROCLYPEUS H. Douvillé, 1905

Spiroclypeus albapustula Cole, n. sp.

Plate 238, figures 7, 13–18

The test is small, compressed, and evenly lenticular in transverse section, with a narrow, flat, thin rim.

TABLE 1.—*Distribution of species in Eniwetok drill holes at indicated depths, in feet, arranged according to first appearance*

Species	Recent to Pliocene		Miocene																										
	20–45	210–220	610–621	620–630	650–660	663–670	684–694	690–700	720–730	790–800	800–810	820–831	850–860	870–880	873–883	880–890	1,038–1,040 (core)	1,059–1,070	1,070–1,080	1,080–1,090	1,100–1,110	1,122–1,133	1,130–1,140	1,143–1,154	1,160–1,170	1,170–1,180	1,190–1,200	1,210–1,220	1,227–1,238
Calcarina spengleri (Gmelin)	F-1																												
Heterostegina suborbicularis D'Orbigny	F-1																												
Marginopora vertebralis Quoy and Gaimard	F-1																												
Sorites marginalis (Lamarck)	F-1																												
Cycloclypeus (*Cycloclypeus*) *carpenteri* Brady		F-1																											
Operculinoides rectilata Cole			K-1B	E-1	F-1																								
Amplicuneata Cole						K-1B				F-1	E-1																		
Operculina lucidisutura Cole							K-1B	E-1	F-1																				
Alveolinella quoii (D'Orbigny)										F-1	E-1	K-1B																	
Borelis schlumbergeri (Reichel)										F-1	E-1	K-1B																	
Operculinoides bikiniensis Cole													F-1		K-1B	E-1	K-1B												
Miogypsinoides cupulaeformis (Zuffardi-Comerci)														F-1		E-1		K-1B											
Cycloclypeus (*Cycloclypeus*) *indopacificus vandervlerki*																	K-1B												
Lepidocyclina (*Nephrolepidina*) *orientalis* Van der Vlerk																			K-1B										
(*Nephrolepidina*) *sumatrensis* (Brady)																			E-1	K-1B									
Miogypsina (*Miogypsina*) *thecideaeformis* (L. Rutten)																			E-1	K-1B									
(*Miogypsina*) *indonesiensis* Tan																					E-1	K-1B							
Operculina victoriensis Chapman and Parr																						K-1B	E-1						
Miogypsina (*Miogypsina*) *musperi* Tan																							E-1						
Flosculinella globulosa L. Rutten																							E-1						
Lepidocyclina (*Nephrolepidina*) *bikiniensis* Cole																								K-1B		F-1		E-1	
Miogypsinoides dehaartii (Van der Vlerk)																									F-1		E-1		K-1B
Spiroclypeus higginsi Cole																											E-1		
Heterostegina borneensis Van der Vlerk																												E-1	
Miogypsinoides grandipustula Cole																												E-1	
Borelis melo (Fichtel and Moll)																													
Gypsina marianensis Hanzawa																													
Lepidocyclina (*Nephrolepidina*) *cubiculirhombidea* Cole																													
(*Eulepidina*) *ephippioides* Jones and Chapman																													
Spiroclypeus leupoldi Van der Vlerk																													
margaritatus (Schlumberger)																													
Lepidocyclina (*Nephrolepidina*) *pumilipapilla* Cole																													
Miogypsinoides ubagshi Tan																													
Spiroclypeus yabei Van der Vlerk																													
Borelis pygmaeus Hanzawa																													
Eorupertia semiornata (Howchin)																													
Archaias eniwetokensis Cole, n. sp.																													
Borelis primitivus Cole, n. sp.																													
Heterostegina duplicamera Cole, n. sp.																													
Lepidocyclina (*Eulepidina*) *abdopustula* Cole																													
(*Nephrolepidina*) *augusticamera* Cole																													
Gypsina vesicularis (Parker and Jones)																													
Pseudochrysalidina eniwetokensis Cole, n. sp.																													
Asterocyclina matanzensis Cole																													
Coskinolina rotaliformis Cole, n. sp.																													
Camerina djokdjokarta (Martin)																													
pengaronensis (Verbeek)																													
Boreloides eniwetokensis Cole, n. sp.																													
Heterostegina saipanensis Cole																													
aequatoria Cole, n. sp.																													
Asterocyclina penuria Cole																													
Operculina eniwetokensis Cole, n. sp.																													
Pellatispira orbitoidea (Provale)																													
Asterocyclina centripilaris Cole, n. sp.																													
Biplanispira fulgeria (Whipple)																													
mirabilis (Umbgrove)																													
Fabiania saipanensis Cole																													
Spiroclypeus vermicularis Tan																													
Asterocyclina incisuricamerata Cole																													
praecipua Cole, n. sp.																													
Spiroclypeus albapustula Cole, n. sp.																													
Operculinoides saipanensis Cole																													
subformai (Provale)																													

Species	Miocene																		
	1,230–1,248 (core)	1,365–1,375	1,394–1,424	1,452–1,482	1,541–1,569	1,569–1,599	1,629–1,658	1,688–1,715	1,718–1,740 (core)	1,805–1,835	1,865–1,895	1,925–1,955	1,975–1,978 (core)	1,978–2,003 (core)	2,003–2,028 (core)	2,080–2,090	2,220–2,230	2,530–2,540	2,662–2,688 (core)
Calcarina spengleri (Gmelin)																			
Heterostegina suborbicularis D'Orbigny																			
Marginopora vertebralis Quoy and Gaimard																			
Sorites marginalis (Lamarck)																			
Cycloclypeus (*Cycloclypeus*) *carpenteri* Brady																			
Operculinoides rectilata Cole																			
Amplicuneata Cole																			
Operculina lucidisutura Cole																			
Alveolinella quoii (D'Orbigny)																			
Borelis schlumbergeri (Reichel)																			
Operculinoides bikiniensis Cole																			
Miogypsinoides cupulaeformis (Zuffardi-Comerci)																			
Cycloclypeus (*Cycloclypeus*) *indopacificus vandervlerki*																			
Lepidocyclina (*Nephrolepidina*) *orientalis* Van der Vlerk																			
(*Nephrolepidina*) *sumatrensis* (Brady)																			
Miogypsina (*Miogypsina*) *thecideaeformis* (L. Rutten)	F-1																		
(*Miogypsina*) *indonesiensis* Tan																			
Operculina victoriensis Chapman and Parr																			
Miogypsina (*Miogypsina*) *musperi* Tan																			
Flosculinella globulosa L. Rutten																			
Lepidocyclina (*Nephrolepidina*) *bikiniensis* Cole																			
Miogypsinoides dehaartii (Van der Vlerk)	F-1	E-1																	
Spiroclypeus higginsi Cole																			
Heterostegina borneensis Van der Vlerk								E-1	F-1				F-1						
Miogypsinoides grandipustula Cole						E-1													
Borelis melo (Fichtel and Moll)	F-1																		
Gypsina marianensis Hanzawa	F-1																		
Lepidocyclina (*Nephrolepidina*) *cubiculirhombidea* Cole		E-1																	
(*Eulepidina*) *ephippioides* Jones and Chapman			E-1		E-1		E-1	E-1	F-1				F-1						
Spiroclypeus leupoldi Van der Vlerk				E-1															
margaritatus (Schlumberger)				E-1															
Lepidocyclina (*Nephrolepidina*) *pumilipapilla* Cole					E-1				F-1										
Miogypsinoides ubagshi Tan					E-1														
Spiroclypeus yabei Van der Vlerk							E-1												
Borelis pygmaeus Hanzawa									F-1		E-1								
Eorupertia semiornata (Howchin)									F-1										
Archaias eniwetokensis Cole, n. sp.										E-1									
Borelis primitivus Cole, n. sp.												E-1		F-1	E-1				F-1
Heterostegina duplicamera Cole, n. sp.												E-1		F-1		F-1	E-1		F-1
Lepidocyclina (*Eulepidina*) *abdopustula* Cole												E-1		F-1	E-1				F-1
(*Nephrolepidina*) *augusticamera* Cole												E-1		F-1					F-1
Gypsina vesicularis (Parker and Jones)																		E-1	
Pseudochrysalidina eniwetokensis Cole, n. sp.																			
Asterocyclina matanzensis Cole																			
Coskinolina rotaliformis Cole, n. sp.																			
Camerina djokdjokarta (Martin)																			
pengaronensis (Verbeek)																			
Boreloides eniwetokensis Cole, n. sp.																			
Heterostegina saipanensis Cole																			
aequatoria Cole, n. sp.																			
Asterocyclina penuria Cole																			
Operculina eniwetokensis Cole, n. sp.																			
Pellatispira orbitoidea (Provale)																			
Asterocyclina centripilaris Cole, n. sp.																			
Biplanispira fulgeria (Whipple)																			
mirabilis (Umbgrove)																			
Fabiania saipanensis Cole																			
Spiroclypeus vermicularis Tan																			
Asterocyclina incisuricamerata Cole																			
praecipua Cole, n. sp.																			
Spiroclypeus albapustula Cole, n. sp.																			
Operculinoides saipanensis Cole																			
subformai (Provale)																			

Species	Eocene																
	2,802–2,808 (core)	2,840–2,850	2,890–2,900	2,930–2,940	2,940–2,950	2,990–3,000	3,052–3,055 (core)	3,350–3,353 (core)	3,655–3,665 (core)	3,963–3,988 (core)	4,078–4,100 (core)	4,197–4,222 (core)	4,208–4,222 (core)	4,316–4,341 (core)	4,406–4,431 (core)	4,500–4,525 (core)	4,528–4,553 (core)
Calcarina spengleri (Gmelin)																	
Heterostegina suborbicularis D'Orbigny				E-1													
Marginopora vertebralis Quoy and Gaimard																	
Sorites marginalis (Lamarck)																	
Cycloclypeus (*Cycloclypeus*) *carpenteri* Brady																	
Operculinoides rectilata Cole																	
Amplicuneata Cole																	
Operculina lucidisutura Cole																	
Alveolinella quoii (D'Orbigny)																	
Borelis schlumbergeri (Reichel)																	
Operculinoides bikiniensis Cole																	
Miogypsinoides cupulaeformis (Zuffardi-Comerci)																	
Cycloclypeus (*Cycloclypeus*) *indopacificus vandervlerki*																	
Lepidocyclina (*Nephrolepidina*) *orientalis* Van der Vlerk																	
(*Nephrolepidina*) *sumatrensis* (Brady)																	
Miogypsina (*Miogypsina*) *thecideaeformis* (L. Rutten)																	
(*Miogypsina*) *indonesiensis* Tan																	
Operculina victoriensis Chapman and Parr																	
Miogypsina (*Miogypsina*) *musperi* Tan																	
Flosculinella globulosa L. Rutten																	
Lepidocyclina (*Nephrolepidina*) *bikiniensis* Cole																	
Miogypsinoides dehaartii (Van der Vlerk)																	
Spiroclypeus higginsi Cole																	
Heterostegina borneensis Van der Vlerk																	
Miogypsinoides grandipustula Cole																	
Borelis melo (Fichtel and Moll)																	
Gypsina marianensis Hanzawa																	
Lepidocyclina (*Nephrolepidina*) *cubiculirhombidea* Cole																	
(*Eulepidina*) *ephippioides* Jones and Chapman																	
Spiroclypeus leupoldi Van der Vlerk																	
margaritatus (Schlumberger)																	
Lepidocyclina (*Nephrolepidina*) *pumilipapilla* Cole																	
Miogypsinoides ubagshi Tan																	
Spiroclypeus yabei Van der Vlerk																	
Borelis pygmaeus Hanzawa																	
Eorupertia semiornata (Howchin)																	
Archaias eniwetokensis Cole, n. sp.																	
Borelis primitivus Cole, n. sp.																	
Heterostegina duplicamera Cole, n. sp.																	
Lepidocyclina (*Eulepidina*) *abdopustula* Cole																	
(*Nephrolepidina*) *augusticamera* Cole																	
Gypsina vesicularis (Parker and Jones)										F-1							
Pseudochrysalidina eniwetokensis Cole, n. sp.	E-1																
Asterocyclina matanzensis Cole		E-1									E-1	F-1		F-1		F-1	F-1
Coskinolina rotaliformis Cole, n. sp.			E-1														
Camerina djokdjokarta (Martin)				E-1													
pengaronensis (Verbeek)					E-1										F-1		
Boreloides eniwetokensis Cole, n. sp.						E-1											
Heterostegina saipanensis Cole							F-1	F-1						F-1			
aequatoria Cole, n. sp.									F-1								
Asterocyclina penuria Cole										F-1				F-1	F-1	F-1	F-1
Operculina eniwetokensis Cole, n. sp.										F-1							
Pellatispira orbitoidea (Provale)										F-1				F-1			
Asterocyclina centripilaris Cole, n. sp.											E-1	F-1		F-1	F-1	F-1	F-1
Biplanispira fulgeria (Whipple)												F-1					
mirabilis (Umbgrove)												F-1					
Fabiania saipanensis Cole												F-1	F-1				
Spiroclypeus vermicularis Tan												F-1					
Asterocyclina incisuricamerata Cole														F-1	F-1	F-1	F-1
praecipua Cole, n. sp.														F-1	F-1		F-1
Spiroclypeus albapustula Cole, n. sp.														F-1			
Operculinoides saipanensis Cole														F-1	F-1	F-1	F-1
subformai (Provale)																F-1	

The surface is completely covered with slightly elevated prominent papillae.

Measurements of thin sections follow.

Measurements of sections of Spiroclypeus albapustula *from drill hole F–1, 4,316–4,341 feet (core 12)*

Dimensions	Specimen shown on pl. 238—				
	Fig. 15	Fig. 17	Fig. 18	Fig. 7	Fig. 14
Height ... mm	3.25	2.65	3.1	3.1	3.6
Width ... mm	2.7	2.4	2.5	--------	--------
Thickness ... mm	--------	--------	--------	1.3	1.3
Embryonic chambers:					
Diameters of initial chamber ... μ	80 x 80	50 x 60	80 x 80	60 x 70	90 0
Diameters of second chamber ... μ	40 x 100	40 x 110	50 x 110	--------	30 x 40
Distance across both chambers ... μ	130	100	140	--------	140
Operculine chambers ... number	9	8	8	--------	--------
Volutions ... number	3½	3½	3	--------	--------
Lateral chambers:					
Number	--------	--------	--------	5	3
Length ... μ	--------	--------	--------	110–250	110–420
Height ... μ	--------	--------	--------	5–30	5–20
Thickness of floors and roofs ... μ	--------	--------	--------	50–110	80–200
Surface diameter of pillars ... μ	--------	--------	--------	150–200	120–180

The lateral chamber cavities are low and are between very thick floors and roofs. They are irregularly distributed in the transverse sections except where they occur between pillars in which situations they are alined in regular tiers.

Heavy pillars are irregularly distributed throughout transverse sections with the best developed pillars in the central part.

First appearance.—At a depth of 4,316–4,341 feet (Tertiary *b*) (core 12–3) in Eniwetok Atoll drill hole F–1.

Discussion.—*S. vermicularis* Tan is the only species of *Spiroclypeus* previously reported from the Eocene. *S. albapustula* has more operculine chambers, stronger and more frequent pillars, and thicker roofs and floors of the lateral chambers.

Spiroclypeus higginsi Cole

Plate 239, figures 11, 12, 14

1939. *Spiroclypeus higginsi* Cole, Jour. Paleontology, v. 13, p. 185, 186, pl. 23, figs. 10–15; pl. 24, fig. 13.

1953. *Spiroclypeus higginsi* Cole. Cole, U. S. Geol. Survey Prof. Paper 253, p. 24, 25, pl. 4, figs. 1–3, 13, 14, 19; pl. 5, figs. 10–12; pl. 8, figs. 16, 17.

1957. *Spiroclypeus higginsi* Cole. Cole, idem, 280–I, p. 332, pl. 95, figs. 1–5; pl. 109, fig. 16.

The test is small, evenly lenticular, and seemingly without a rim. The surface is covered with very slightly elevated, but not prominent, papillae which are arranged in a rude concentric manner around a larger central one. The papillae are irregular in shape.

Measurements of median sections follow.

Measurements of median sections of Spiroclypeus higginsi *from drill hole E–1*

Dimensions	Specimen from—			
	1,210–1,220 feet shown on—	1,394–1,424 feet		1,569–1,599 feet
	Pl. 239, fig. 12	USNM P–3496b	USNM P–3496a	USNM P–3736
Height ... mm	2.27	2.3	2.1	2.5
Width ... mm	2.22	2.45	1.9	2.4
Embryonic chambers:				
Diameters of initial chamber ... μ	170 x 210	160 x 180	130 x 150	150 x 140
Diameters of second chamber ... μ	90 x 220	60 x 180	60 x 200	70 x 150
Distance across both chambers ... μ	280	240	210	230
Operculine chambers ... number	1	1	1	1
Volutions ... number	2	2¼	2	2¼

The bilocular embryonic chambers are followed by a single undivided chamber before the heterostegine type of chambers appears. The first one of these has four chamberlets.

Measurements of transverse sections follow.

Measurements of transverse sections of Spiroclypeus higginsi *from drill hole E–1*

Dimensions	Specimen from—				
	1,210–1,220 feet shown on—	1,230–1,240 feet	1,394–1,424 feet		1,569–1,599 feet
	Pl. 239, fig. 11	USNM P–3498	USNM P–3499	USNM P–3500a	USNM P–3500b
Height ... mm	2.1	2.3	2.3	2.33	2.4
Thickness ... mm	1.3	1.25	1.3	1.22	1.27
Embryonic chambers:					
Distance across both chambers ... μ	230	220	270	280	160
Height ... μ	130	190	200	150	80
Thickness of median plane ... μ	30	50	50	30	30–50
Lateral chambers:					
Number on each side of median plane	5	7	6	7	8
Length ... μ	130	90–200	80–180	70–160	60–140
Height ... μ	10	10–20	10–30	10–20	10–20
Thickness of floors and roofs ... μ	60–80	30–70	40–80	30–70	20–100
Surface diameter of pillars ... μ	80–580	80–290	280–700	100–400	60–400

The lateral chamber openings are slitlike between thick floors and roofs. Strong pillars are scattered irregularly throughout the transverse sections with normally a very large pillar on each side of the embryonic chambers.

First appearance.—At a depth of 1,190–1,200 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1.

Occurrence elsewhere.—The type specimens of this species were found on Guam in beds assigned to Tertiary *e*. It was found later in beds of the same age on Saipan.

Discussion.—Internally, this species is very similar to *Spiroclypeus yabei*, but externally these species differ markedly. *S. yabei* is larger and has a broad thin flange and raised papillae which are especially prominent on the inflated umbonal area.

Spiroclypeus leupoldi Van der Vlerk

1925. *Spiroclypeus leupoldi* Van der Vlerk, Nederlandsche Akad. Wetensch. Meded., no. 3, p. 14, 15, pl. 2, fig. 16; pl. 5, figs. 41, 48.

1954. *Spiroclypeus leupoldi* Van der Vlerk. Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 577, 578, pl. 208, figs. 1–19.

This species is characterized by open cavities of the lateral chambers between thin roofs and floors. The lateral chambers are arranged in regular tiers, and pillars are absent.

Although the type specimens are thick lenticular in transverse section, many specimens recovered both from the Bikini and Eniwetok Atoll holes are compressed. However, these specimens have the same internal structure as that of the type specimens.

First appearance.—At a depth of 1,452–1,482 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1.

Spiroclypeus margaritatus (Schlumberger)

1902. *Heterostegina margaritata* Schlumberger, Geol. Reichs-Mus. Leiden Samml., v. 6, p. 252, 253, pl. 7, fig. 4.

1954. *Spiroclypeus margaritatus* (Schlumberger). Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 578–580, pl. 206, figs. 10–25; pl. 207, figs. 15, 16 [references].

The specimens from the Eniwetok hole are identical with those which were found in Bikini hole 2B.

First appearance.—At a depth of 1,452–1,482 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1.

Spiroclypeus vermicularis Tan

Plate 238, figures 1–6, 8–10, 11, 12

1937. *Spiroclypeus vermicularis* Tan, De Ingenieur in Nederlandsche-Indië—IV Mijnbouw en geologie, Jaarg. 4, no. 10, p. 187–190, pl. 1, figs. 7, 8; pl. 2, figs. 6–10; pl. 3, figs. 13–23; pl. 4, figs. 11–18.

1953. *Spiroclypeus vermicularis* Tan. Cole, U. S. Geol. Survey Prof. Paper 253, p. 18, pl. 14, fig. 7.

S. H. Tan has given a complete description of the type specimens. The specimens from the Eniwetok Atoll drill hole are identical with the types. Measurements of the internal features follow.

Measurements of sections of Spiroclypeus vermicularis *from drill hole F–1*

Dimensions	Specimen from— 4,197–4,222 feet (top of core 11) shown on pl. 238—							4,222–4,316 feet (4 inches from bottom of core 11) shown on pl. 238—			
	Fig. 10	Fig. 3	Fig. 1	Fig. 11	Fig. 4	Fig. 5	Fig. 8	Fig. 2	Fig. 9	Fig. 6	Fig. 12
Height, mm	3.05+	2.95+	2.+	2.95	2.6	2.4	2.3+	2.6+	2.25+	3.5	2.4+
Width, mm	----	----	----	2.35	2.3	2.0	1.7+	----	----	2.95	1.75+
Thickness, mm	1.05	0.9	0.78	----	----	----	----	0.75	0.8	----	----
Embryonic chambers:											
Diameters of initial chamber, μ	170 x 150	140 x 100	140 x 120	150 x 150	110 x 100	100 x 80	130 x 120	130 x 100	100 x 90	140 x 140	170 x 140
Diameters of second chamber, μ	80 x 50	60 x 20	80 x 40	225 x 40	110 x 50	150 x 40	150 x 55	70 x 30	----	120 x 40	140 x 70
Distance across both chambers, μ	230	140	190	210	170	160	200	160	----	200	225
Operculine chambers, number	----	----	----	1	1	1	2	----	----	1	1
Volutions, number	----	----	----	2½	2½	2½	2¼	----	----	2¾	2
Lateral chambers:											
Length, μ	100–300	80–230	60–120	----	----	----	----	50–120	50–120	----	----
Height, μ	10–20	10–25	10–30	----	----	----	----	10	10	----	----
Number on each side of center	6	6	4	----	----	----	----	3	5	----	----
Thickness of spiral sheet, μ	30–50	30–50	30–100	----	----	----	----	70–90	30–70	----	----
Diameter of pillars, μ	60–80	80–150	220	----	----	----	----	70–100	150	----	----

First appearance.—At a depth of 4,197–4,222 feet (Tertiary *b*) (core 11) in Eniwetok Atoll drill hole F–1.

Occurrence elsewhere.—In Tertiary *b* at Koetai, East Borneo; Saipan island.

Discussion.—Some specimens develop a prominent umbonal pillar (pl. 238, fig. 9), whereas others have small pillars (pl. 238, fig. 10) irregularly scattered throughout the test. Tan stated that the types had this same arrangement of the pillars.

Spiroclypeus yabei Van der Vlerk

Plate 239, figures 9, 10

1925. *Spiroclypeus yabei* Van der Vlerk, Nederlandsche Akad. Wetensch. Meded, no. 3, p. 16, pl. 2, fig. 19; pl. 5, figs. 40, 50.

1931. *Spiroclypeus pleurocentralis* Krijnen [not *Orbiculina pleurocentralis* Carter 1857]. Krijnen, Geol. mijnb. genootsch. Nederland en Koloneen, Verh., Geol. ser., v. 9, p. 89, 90, pl. 1, figs. 8–10.

1937. *Spiroclypeus yabei* Van der Vlerk. Tan, De Ingenieur in Nederlandsche-Indië—IV Mijnbouw en geologie, Jaarg. 4, p. 182, 183, pl. 1, figs. 5, 6; pl. 3, figs. 10, 11; pl. 4, figs. 8–10.

1954. *Spiroclypeus yabei* Van der Vlerk. Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 580, 581, pl. 207, figs. 1–14; pl. 208, figs. 20–26.

The external and internal appearance of this species has been described and illustrated by specimens from the Bikini drill hole 2B. Measurements of the internal structures of specimens from the Eniwetok Atoll drill hole E–1 follow.

Measurements of median sections of Spiroclypeus yabei *from drill hole E–1, 1,658–1,688 feet*

Dimensions	Specimen		
	USNM P–3513a	USNM P–3737	USNM P–3513b
Height ... mm	3.35	3.9	3.5
Width ... mm	2.8	3.2	3.6
Embryonic chambers:			
Diameters of initial chamber ... μ	160 x 180	300 x 360	220 x 230
Diameters of second chamber ... μ	70 x 190	100 x 410	110 x 290
Distance across both chambers ... μ	250	420	340
Operculine chambers ... number	1	1	1
Volutions ... number	2¼	2⅛	2¼

Measurements of transverse sections follow.

Measurements of transverse sections of Spiroclypeus yabei *from drill hole E–1*

Dimensions	Specimen from—			
	1,629–1,658 feet	1,658–1,688 feet		
	USNM P–3511	USNM P–3512c	USNM P–3512a	USNM P–3512b
Height ... mm	3.7	4.0	3.5	3.82
Thickness ... mm	1.2	1.25	1.65	1.3
Embryonic chambers:				
Distance across both chambers ... μ	230	270	220	140
Height ... μ	190	220	180	100
Thickness of median plane ... μ	50	60	60	40–50
Lateral chambers:				
Number on each side of median plane	6	6	10	7
Length ... μ	90–130	110–150	100–170	100–180
Height ... μ	10–30	10–30	10–30	10–20
Thickness of floors and roofs ... μ	40–70	40–90	20–100	20–80
Surface diameter of pillars ... μ	90–250	100–480	70–500	100–600

The lateral chamber cavities are low and slitlike between thick roofs and floors. Strong pillars are scattered irregularly throughout the transverse sections.

First appearance.—At a depth of 1,629–1,658 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1.

Occurrence elsewhere.—This species was described from Tertiary *e* beds in eastern Borneo.

Discussion.—In the samples of cuttings from between 1,658 and 1,715 feet in Eniwetok Atoll drill hole E–1, there were many specimens of the microspheric generation of *Spiroclypeus*. Thin sections of typical representatives of these microspheric forms are illustrated (pl. 239, figs. 9, 10). As these specimens were associated with many megalospheric forms of *Spiroclypeus yabei*, they are assigned to that species. However, there is always the possibility that these microspheric forms may be cavings or may represent some other species.

Genus **PELLATISPIRA** Boussac, 1906

Pellatispira orbitoidea (Provale)

Plate 239, figure 18

1908. ***Assilina madaraszi orbitoidea*** Provale, Riv. italiana paleontologia, v. 14, p. 71, pl. 5, fig. 5 [1909].

1957. *Pellatispira orbitoidea* (Provale). Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 333, pl. 96, figs. 3–5, 7–9; pl. 97, figs. 1–12; pl. 99, fig. 7–11 [synonomy].

Cole studied several hundred specimens from Saipan concluding that several previously named species should be combined because of the extreme range in form which occurs in individuals in a single population. As the specimens from the Eniwetok drill hole show the same range and are similar to specimens from Saipan, they are assigned to this species.

First appearance.—At a depth of 3,963–3,988 feet (Tertiary *b*) (core 10) in Eniwetok Atoll drill hole F–1, very rare; abundant at a depth of 4,316–4,341 feet (core 12) of this same drill hole.

Occurrence elsewhere.—Borneo; Eua, Tonga; Saipan; Palau islands.

Genus **BIPLANISPIRA** Umbgrove, 1937

Biplanispira fulgeria (Whipple)

1932. *Pellatispira fulgeria* Whipple, B. P. Bishop Mus. Bull. 96, p. 82, pl. 20, figs. 2, 3, 5, 6, 7.

1938. *Biplanispira absurda* Umgrove, Leidsche Geol. Meded., v. 10, p. 82–89, text figs. 1–17.

1957. *Biplanispira fulgeria* (Whipple). Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 333, pl. 98, figs. 13–18.

A few specimens were found which are assigned to this species.

First appearance.—At a depth of 4,197–4,222 feet (Tertiary *b*) (core 11–34) in Eniwetok Atoll drill hole F–1.

Occurrence elsewhere.—In Tertiary *b*, upper Eocene, Borneo; Eua, Tonga; Saipan.

Biplanispira mirabilis (Umbgrove)

1936. *Heterospira mirabilis* Umbgrove, Leidsche Geol. Meded., v. 8, p. 155–159, 1 pl., figs. 1–11.

1937. *Heterospira* [preoccupied, changed to *Biplanispira*] idem, v. 8, p. 309.

1957. *Biplanispira mirabilis* (Umbgrove). Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 334, pl. 99, figs. 1–6; pl. 100, figs. 1–3 [references].

Typical specimens of this species are so easily recognized that no description is needed.

First appearance.—At a depth of 4,197–4,222 feet (Tertiary *b*) (core 11) in Eniwetok Atoll drill hole F–1.

Occurrence elsewhere.—In Tertiary *b*, upper Eocene, Borneo; New Guinea; Saipan.

Genus CYCLOCLYPEUS W. B. Carpenter, 1856

Cycloclypeus (Cycloclypeus) indopacificus vandervlerki Tan

Plate 233, figure 27

1932. *Cycloclypeus indopacificus* var. *vandervlerki* Tan, Wetensch. Meded. no. 19, p. 67, 68, pl. 17, figs. 5, 6; pl. 18, figs. 5, 6.

The test is small and thin with a diameter of 2.0–2.5 mm. The surface is covered with small, slightly raised papillae arranged in concentric circles.

The two available specimens were ground for equatorial sections. One of these is not satisfactory for detailed study. The following data are from the other section. The initial chamber has an internal diameter of 170μ; the second chamber has internal diameters of 130μ by 340μ. The distance across both chambers is 330μ. There are six nepionic chambers before the annular rings develop.

First appearance.—At a depth of 1,038–1,040 feet (Tertiary *f*) (core) in Eniwetok Atoll drill hole K–1B.

Occurrence elsewhere.—In Borneo in strata assigned to Tertiary f_3.

Discussion.—The types of this variety are from high Tertiary *f* strata in Borneo associated with *Lepidocyclina* (*Nephrolepidina*) *rutteni* Van der Vlerk. The Eniwetok Atoll specimens are associated with *Operculinoides bikiniensis* Cole and occur above the first strata containing *Lepidocyclina* which appear in drill hole K–1B at 1,070 feet.

In the analysis of the section at Bikini the top of Tertiary f_3 was selected at the first appearance of *Miogypsinoides* in the samples, a correlation which is changed for the Eniwetok Atoll drill holes to include the first appearance of *Operculinoides bikiniensis* in Tertiary f_3.

Family PENEROPLIDAE

Genus ARCHAIAS Montfort, 1808

Archaias eniwetokensis Cole, n. sp.

Plate 240, figures 14, 15

1954. *Archaias?* sp., Todd and Post, U. S. Geol. Survey Prof. Paper 260–N, p. 557, pl. 202, figs. 6, 7.

The test is circular in outline and involute, with only the chambers of the final volution showing at the surface. The chambers are long, narrow, and recurved. The outer wall of the chambers is imperforate, and the sutures between the chambers are very slightly depressed and composed of lighter colored shell material. In eroded parts with the removal of the outer wall, the chamberlets into which the chambers are subdivided appear. A well-developed specimen had a height of 1.4 mm, a width of 1.3 mm, and a thickness of 0.5 mm.

The embryonic chambers have a diameter of about 130μ. There appear to be three undivided chambers following the embryonic chambers before the chambers with chamberlets are developed.

First appearance.—At a depth of 1,805–1,835 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1.

Discussion.—This species is smaller and has a more compact internal structure than do Saipan specimens which were referred to *A. vandervlerki* De Neve (1947, p. 13). Moreover, it seemingly occurs at a lower stratigraphic horizon.

Todd and Post (1954, pl. 202, fig. 7) have given an excellent illustration of the external appearance of a specimen from the Bikini drill hole 2B.

Genus MARGINOPORA Quoy and Gaimard in Blainville, 1830

Marginopora vertebralis Quoy and Gaimard

1830. *Marginopora vertebralis* Quoy and Gaimard *in* Blainville, Dict. Sci. Nat., v. 60, p. 377.

1954. *Marginopora vertebralis* Quoy and Gaimard. Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 581–583, pl. 210, figs. 10–13; pl. 211, figs. 3–29.

This species is found in varying abundance in all the drill holes from the top to considerable depths. Specimens in cores from Bikini drill hole 2A demonstrate that it lived in this region from the upper Miocene to Recent.

Family ALVEOLINELLIDAE

Genus BORELIS Montfort, 1808

Borelis melo (Fichtel and Moll)

Plate 240, figure 2

Two accidental sections of a small *Borelis* were found in the thin sections made from core 3 (1,230–1,248 ft) in drill hole F–1. The sections were not oriented in a manner that the species could be identified with absolute certainty. However, the structures which could be studied suggest that these specimens should be referred to this species.

First appearance.—At a depth of 1,230–1,248 feet (Tertiary *e*) in core 3, Eniwetok Atoll drill hole F–1.

Borelis primitivus Cole, n. sp.

Plate 240, figures 3–10

The test is small and globular to subglobular with clearly marked depressed sutures which extend across the test from one axial pole to the other. The apertural face is clearly visible and has a row of subquadrate shaped pores at the base.

The initial chamber is spherical with a diameter of about 50μ. The second chamber has diameters of about 10μ by 60μ.

Measurements of the internal structures follow.

Measurements of thin sections of Borelis primitivus *from drill hole E–1*

Dimensions	Specimen from— 1,925–1,955 feet shown on pl. 240—			2,003–2,028 feet (core 1–1) shown on pl. 240—			
	Fig. 8	Fig. 9	Fig. 7	USNM P–3738 (not illustrated)	Fig. 5	USNM P–3739 (not illustrated)	Fig. 6
Height ... mm	0. 55	0. 77	0. 53	0. 55	0. 5	0. 67	0. 48
Length ... mm	0. 52	0. 82	0. 62	0. 51	0. 71	0. 75	0. 6
Diameter of initial chamber ... μ	40	------	50	------	50	50	------
Diameters of second chamber ... μ	20 x 40	------	10 x 30	------	10 x 40	10 x 40	------
Miliolid coils ... number	1	2	3	2	2	2	2
Chambers with chamberlets ... number	3	5	4	5	5	5	4
Chamberlets in final chamber ... number	10	18	16	11	17	16	20

First appearance.—At a depth of 1,925–1,955 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1; also at a depth of 2,003–2,028 feet (core 1–1) of this same drill hole.

Discussion.—This species differs from *B. pygmaeus* Hanzawa in its smaller size and the smaller number of chamberlets in the final chamber. Moreover, it has a smaller number of chambers in the adult test.

Borelis pygmaeus Hanzawa

Plate 240, figures 11–13

1930. *Borelis* (*Fasciolites*) *pygmaea* Hanzawa, Tōhoku Imp. Univ. Sci. Rep., 2d ser. (Geol.), v. 14, no. 1, p. 94, pl. 26, figs. 14, 15.

1953. *Borelis pygmaeus* Hanzawa. Cole, U. S. Geol. Survey Prof. Paper 253, p. 27, pl. 12, fig. 16; pl. 13, figs. 4–7 [references].

First appearance.—At a depth of 1,718–1,740 feet (Tertiary *e*) in core 4–10, Eniwetok Atoll drill hole F–1; as matrix-free specimens at a depth of 1,865–1,895 feet (Tertiary *e*) in drill hole E–1.

Borelis schlumbergeri (Reichel)

1937. *Neoalveolina pygmaea schlumbergeri* Reichel, Schweizerische Palaeont. Gesell. Abhand., v. 59, p. 110–112, pl. 10, figs. 1–3; pl. 11, fig. 6b.

1954. *Borelis schlumbergeri* (Reichel). Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 583, 584, pl. 209, figs. 10–18.

First appearance.—At a depth of 820–831 feet (Tertiary *g*) in Eniwetok Atoll drill hole K–1B; at a depth of 800–810 feet (Tertiary *g*) in drill hole E–1; at a depth of 790–800 feet (Tertiary *g*) in drill hole F–1.

Genus FLOSCULINELLA Schubert, 1910

Flosculinella globulosa L. Rutten

Plate 240, figure 1

1917. *Alveolinella* (*Flosculinella*) *globulosa* L. Rutten, Geol. Reichs-Mus. Leiden Samml., Neue Folge, v. 2, pt. 7, p. 277, pl. 5, figs. 140–141.

1954. *Flosculinella globulosa* L. Rutten. Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 584, pl. 209, fig. 9.

1957. *Flosculinella globulosa* L. Rutten. Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 336, pl. 110, figs. 1–4.

The test is small and subspherical with a diameter of about 0.7 mm.

First appearance.—At a depth of 1,130–1,140 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1.

Discussion.—In the Bikini report a single specimen from a depth of 2,133–2,143½ feet from drill hole 2B was discussed. In a reexamination of samples from this drill hole, another specimen was found at a depth of 1,314–1,324½ feet. This specimen has a diameter of 0.9 mm and has internal structures identical with those in the specimen from Eniwetok Atoll.

Similar but slightly larger specimens with a diameter of 1.1 mm were recovered from certain samples from Saipan. Although W. A. Mohler (1949, p. 521) has named small specimens from the Tertiary e_5 of Borneo *F. reicheli*, it seems probable that these specimens are not a distinct species.

Genus ALVEOLINELLA H. Douvillé, 1909

Alveolinella quoii (D'Orbigny)

Plate 240, figures 16–25

1826. *Alveolina quoii* D'Orbigny, Annales Sci. Nat., v. 7, p. 307, no. 7, pl. 17, figs. 11–13.

1954. *Alveolinella quoii* (D'Orbigny). Todd and Post, U. S. Geol. Survey Prof. Paper 260–N, p. 558, pl. 202, figs. 5, 8 [references].

First appearance.—At a depth of 820–831 feet (Tertiary *g*) in Eniwetok Atoll drill hole K–1B; at a depth of 800–810 feet (Tertiary *g*) in drill hole E–1; at a depth of 790–800 feet (Tertiary *g*) in drill hole F–1.

Family CYMBALOPORIDAE

Genus FABIANIA A. Silvestri, 1926

Fabiania saipanensis Cole

Plate 245, figures 1, 2

1953. *Fabiania saipanensis* Cole, U. S. Geol. Survey Prof. Paper 253, p. 28, pl. 15, figs. 1, 2.

1956. *Fabiania indica*, Nagappa, Jour. Palaeontology. Soc. India, v. 1, no. 1, p. 192–195, pl. 30, figs. 1–9; pl. 31, figs. 1–3.

1957. *Fabiania saipanensis* Cole. Cole, idem, 280–I, p. 337, pl. 102, figs. 7–9; pl. 118, fig. 8.

This species, which occurred rather commonly in certain of the Tertiary *b*, upper Eocene, samples from Saipan island, is rarely found at Eniwetok Atoll, but the specimens appear to be identical with the types.

First appearance.—At a depth of 4,197–4,222 feet (Tertiary *b*) in core 11–5 and 11–18, Eniwetok Atoll drill hole F–1.

Family PLANORBULINIDAE

Genus GYPSINA Carter, 1877

Gypsina vesicularis (Parker and Jones)

Plate 239, figures 13, 15–17, 19–21

1860. *Orbitolina concava* Lamarck var. *vesicularis* Parker and Jones, Annals and Mag. Nat History, ser. 3, v. 6, p. 31, 38.

1947. *Gypsina vesicularis* (Parker and Jones). Bursch, Schweizer. palaeont. Gesell, Abh., v. 65, p. 42, 43, pl. 3, fig. 1; pl. 5, fig. 2; text fig. 15 [references].

1954. *Gypsina vesicularis* (Parker and Jones). Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 585, pl. 210, figs. 14, 15.

This species has a series of rectangular lateral chambers (truncate lateral chambers) on one side of the equatorial layer and arcuate lateral chambers on the other side of this layer.

First appearance.—At a depth of 2,530–2,540 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1; also at a depth of 3,963–3,988 feet (Tertiary *b*) in core 10, drill hole F–1.

Gypsina marianensis Hanzawa

1957. *Gypsina marianensis* Hanzawa. Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 337, pl. 103, figs. 1–4 [reference].

This species occurs only rarely at Eniwetok Atoll. The specimens are identical with those from Saipan island.

First appearance.—At a depth of 1,230–1,248 feet (Tertiary *e*) in core 3–3 and 3–10, Eniwetok Atoll drill hole F–1.

Discussion.—This species occurs on Saipan island in association with *Miogypsina* (*Miogypsina*) *thecideaeformis* (L. Rutten) and *Miogypsinoides dehaartii* (Van der Vlerk) in upper Tertiary *e*. The association and age at Eniwetok Atoll is the same.

Family EORUPERTIIDAE

Genus EORUPERTIA Yabe and Hanzawa, 1925

Eorupertia semiornata (Howchin)

1899. *Pulvinulina semiornata* Howchin, Royal Soc. South Australia Trans., v. 12, p. 14, pl. 1, figs. 12a–c.

1957. *Eorupertia semiornata* (Howchin). Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 338, pl. 103, figs. 11–16 [references and synonyms].

A few typical specimens occur. They are the same as specimens referred to this species from Saipan island.

First appearance.—At a depth of 1,718–1,740 feet (Tertiary *e*) in core 4, Eniwetok Atoll drill hole F–1.

Family AMPHISTEGINIDAE

Genus BORELOIDES Cole and Bermudez, 1947

Boreloides eniwetokensis Cole, n. sp.

Plate 233, figures 1–4

The test is subspherical to fusiform with the surface smooth or with small rectangular pits in areas which have been slightly abraded. The pits represent the chamberlets of the final volution. Measurements of the length and diameter of five specimens follow.

Specimen	*Length (mm)*	*Diameter (mm)*
1	1.7	1.2
2	1.8	1.1
3	2.4	1.4
4	2.6	1.4
5	2.8	1.7

The embryonic chambers are bilocular. The initial chamber is subspherical with diameters of 100μ by 90μ to 150μ by 160μ. The second chamber has diameters of 40μ by 80μ to 50μ by 100μ. The distance across both chambers is 170μ to 220μ.

The embryonic chambers are followed by a zone in which the main shell wall is arranged in a rude hemispherical to triangular pattern. The outer zone has the main shell wall ellipsoidal.

In the outer zone the areas between the main shell walls are divided into nearly square chambers. The inner zone may or may not have chamberlets. Where chamberlets occur in the inner zone, their arrangement is irregular.

The main shell wall in the axial zone is composed of alternating bands of dark and light shell material, but elsewhere does not have this dual character so clearly formed.

First appearance.—At a depth of 2,990–3,000 feet (Tertiary *b*) in Eniwetok Atoll drill hole E–1.

Discussion.—The general arrangement and internal structure is very similar to that of the type of the genus, *B. cubensis* Cole and Bermúdez (1947, p. 197). The major difference occurs in the structure of the main shell wall which in the type does not show the alternating light and dark bands found in the Eniwetok Atoll specimens.

Family MIOGYPSINIDAE

Genus MIOGYPSINOIDES Yabe and Hanzawa, 1928

Miogypsinoides cupulaeformis (Zuffardi-Comerci)

1928. *Miogypsina cupulaeformis* Zuffardi-Comerci, Soc. geol. italiana Boll., v. 47, p. 142, pl. 9, figs. 12, 13, 20 [1929].
1954. *Miogypsinoides cupulaeformis* (Zuffardi-Comerci). Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 601, 602, pl. 221, fig. 1; pl. 222, figs. 4–11.

First appearance.—At a depth of 880–890 feet (Tertiary *f*) in Eniwetok Atoll drill hole E–1; at a depth of 870–880 feet (Tertiary *f*) in drill hole F–1; at a depth of 1,059–1,070 feet (Tertiary *f*) in drill hole K–1B.

Miogypsinoides dehaartii (Van der Vlerk)

Plate 243, figures 1–3; plate 244, figure 3

1924. *Miogypsina dehaartii* Van der Vlerk, Eclogae geol. Helvetiae, v. 28, p. 429–432, text figs. 1–3.
1957. *Miogypsinoides dehaartii* (Van der Vlerk). Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 339, pl. 111, figs. 5–16 [references].

The tangled nomenclature of this characteristic and widely distributed species was discussed by Cole (1957, p. 340). Additional illustrations are given to show the internal structure of the Eniwetok Atoll specimens.

First appearance.—At a depth of 1,227–1,238 feet (Tertiary *e*) in Eniwetok Atoll drill hole K–1B; at a depth of 1,190–1,200 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1; at a depth of 1,160–1,170 feet (Tertiary *e*) in Eniwetok Atoll drill hole F–1.

Discussion.—In Eniwetok Atoll drill hole E–1, this species occurred in abundance also at 1,365–1,375 feet with many of the samples of cuttings between this depth and first appearance in this drill hole at 1,190–1,200 feet either devoid of specimens or with few specimens of this species. This lower occurrence may be the result of caving from the higher level, or it may represent a lower stratigraphic occurrence of this species. Inasmuch as the lower specimens appear to be slightly different in coloration, the second interpretation is favored. Moreover, a few specimens were found in all the thin sections of core 3 (1,230–1,248 ft) of drill hole F–1.

Miogypsinoides grandipustula Cole

Plate 243, figures 4–9, 12

1954. *Miogypsinoides grandipustula* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 602, 603, pl. 221, figs. 2–4, 19–22; pl. 222, figs. 12, 14 [not pl. 221, fig. 1, which is *Miogypsinoides cupulaeformis* (Zuffardi-Comerci)].

Megalospheric generation.—One equatorial section of a megalospheric specimen was available from the Eniwetok drill holes. Measurements of this section follow: Length, 1.5 mm; width, 1.2 mm; diameter of initial chamber, 130μ; diameters of second chamber, 90μ by 150μ; distance across both embryonic chambers, 240μ; thickness of wall of embryonic chambers, 20–60μ; number of coils of the periembryonic chambers, 2; chambers in first volution, 11; total number of chambers, 26; diameters of embryonic apparatus, 1,200μ by 1,500μ; radial diameter of equatorial chambers, 110μ; tangential diameter of equatorial chambers, 90μ–110μ.

Microspheric generation.—The test is small with an inflated initial end which is bordered on the distal margin by a narrow, thinner zone which comprises the equatorial layer. The surface is thickly studded with large raised papillae which are largest directly over the embryonic chambers and commonly arranged in a rude spiral. The papillae elsewhere are slightly smaller, with those over the equatorial layer the smallest.

Three equatorial sections were available for study. The best section is a specimen with a length of 2.1 mm and a width of 1.9 mm. The embryonic chambers are small and bilocular with a distance across both chambers of about 25μ. There are 4½ coils of 49 periembryonic chambers. A specimen with a length of 1.8 mm and a width of 1.4 mm has embryonic chambers, with a distance across both chambers of about 30μ. There are 4¼ coils of 45 periembryonic chambers. The third specimen with a length of 1.65 mm and a width of 1.5 mm has 3¾ coils with about 44 periembryonic chambers. The initial chambers of this section do not show.

The best section has four rows of equatorial chambers on the distal margin. Another section has two rows, and the third section has only a few equatorial chambers in a partial row. All of the sections have large, coarse pillars in the revolving wall of the periembryonic coil, especially in the final volution.

The vertical sections are not absolutely centered; therefore, the periembryonic rather than the embryonic chambers show at the center. Very coarse pillars occur on either side of the test at the proximal end. Certain of these pillars have surface diameters of 300μ, although others are smaller. At the distal ends of these sections, the equatorial layer forms a slight projection, but the major part of the vertical sections is composed of the embryonic apparatus.

First appearance.—At a depth of 1,569–1,599 feet (Tertiary *e*) in the Eniwetok Atoll drill hole E–1; possibly at a depth of 1,210–1,220 feet in this same drill hole.

Discussion.—At 1,210–1,220 feet in Eniwetok Atoll drill hole E–1, a single specimen was recovered which superficially resembled this species. This specimen was made into an equatorial section, illustrated on plate 243, figure 8. Although this specimen does not have definite equatorial chambers, there is a suggestion on the distal margin that these chambers were present.

Measurements of this section follow: Length, 1.2 mm; width, 1.1 mm; diameter of initial chamber, 90μ; diameters of second chamber, 60μ by 90μ; distance across both chambers, 170μ; thickness of outer wall, 20μ–50μ; number of coils of periembryonic chambers, 2; number of chambers in first volution, 9; total number of chambers, 24; diameters of embryonic apparatus, 1,000μ by 1,100μ.

Although this specimen has smaller embryonic chambers than do typical specimens of this species, they are alike in other respects. Therefore, the specimen is tentatively assigned to this species.

Miogypsinoides ubaghsi Tan

Plate 243, figures 10, 11, 13–19

1936. *Miogypsinoides ubaghsi* Tan, De Ingenieur in Nederl-andsche-Indië—IV Mijnbouw en geologie, Jaarg. 3, p. 47, 48, pl. 1, figs. 1–7.

1954. *Miogypsinoides ubaghsi* Tan. Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 603, 604, pl. 221, figs. 5, 9–18; pl. 222, figs. 13, 15 [not pl. 222, fig. 14, which is *Miogypsinoides grandipustula* Cole].

1954. *Miogypsinoides borodinensis* Cole [not Hanzawa, 1940], idem, p. 600, 601, pl. 221, figs. 6–8.

The external appearance of a typical specimen is illustrated on plate 243, figure 10. Measurements of the internal features of megalospheric specimens follow.

Measurements of equatorial sections of Miogypsinoides ubaghsi *from drill hole E–1*

Dimensions	Specimen from—					
	1,541–1,569 feet shown on—			1,569–1,599 feet shown on Pl. 243, fig. 13	1,688–1,715 feet shown on—	
	USNM P–3740 (not illustrated)	USNM P–3741 (not illustrated)	Pl. 243, fig. 14		Pl. 243, fig. 19	USNM P–3742 (not illustrated)
Greatest length mm	1.57	1.4	1.3	1.25	1.7	1.15
Greatest width mm	1.45	1.44	1.07	0.9	1.9	1.2
Embryonic chambers:						
Diameters of initial chamber μ	95 x 100	120 x 120	90 x 100	100 x 90	90 x 100	100 x 130
Diameters of second chamber μ	70 x 90	90 x 120	70 x 110	60 x 100	80 x 120	40 x 90
Distance across both chambers μ	180	220	180	175	190	150
Thickness of outer wall μ	20	20	20	20	20	30
Periembryonic chambers:						
Coils number	1¾	1½	2	1¾	1½	1½
Chambers in first volution	10	10	9	10	9	9
Total chambers number	21	19	26	21	20	20
Diameters of periembryonic coil μ	870 x 950	820 x 820	850 x 930	780 x 820	800 x 900	750 x 800
Equatorial chambers:						
Radial diameter μ	80	100–130	80–110	90	80–140	70–100
Tangential diameter μ	90	110–130	80	90	50–140	70–140

Measurements of vertical sections of Miogypsinoides ubaghsi *from drill hole E–1*

Dimensions	Specimen from—		
	1,541–1,569 feet shown on—		1,746–1,776 feet shown on—
	USNM P–3567 (not illustrated)	Pl. 243, fig. 15	Pl. 243, fig. 18
Length mm	1.25	1.3	1.3
Thickness through initial part mm	0.6	([1])	0.5
Thickness through distal part mm	0.32	0.3	0.33
Embryonic chambers:			
Length μ	190	----------	
Height μ	130	----------	130
Internal height of equatorial layer μ	170	150	120
Surface diameter of pillars on dorsal side over embryonic chambers μ	50–120	----------	70–110
Surface diameter of pillars on ventral side over embryonic chambers μ	70–150	----------	90–130
Surface diameter of pillars over equatorial chambers μ	30–70	50	50

[1] Not centered.

Microspheric generation.—Microspheric specimens are similar in external appearance to the megalospheric ones except they are slightly larger. The specimen which was made into an equatorial section (pl. 243, fig. 11) has a length of 2.1 mm and a maximum width of 2.3 mm. The specimen which was made into a vertical section has a length of 1.9 mm, a thickness at the embryonic apparatus of 0.85 mm, and a thickness near the distal end of 0.5 mm.

The embryonic chambers are bilocular, very small with a distance across both chambers of about 40μ. There are 3⅛ coils of 38 periembryonic chambers. The diameters of the embryonic apparatus are 900μ by 950μ.

In vertical sections there are heavy pillars on each side of the embryonic apparatus. Dorsally, 5 pillars with surface diameters of 80μ–150μ extend through the wall of the test to the coils of the embryonic apparatus.

Ventrally, 3 pillars with surface diameters of 100μ–170μ occur in the outer wall of the test. At their proximal ends these pillars may continue inward through the rotalid coil of the embryonic apparatus or fuse at the inner edge of the outer wall with internal pillars which extend inward to the embryonic chambers.

The wall covering the equatorial chambers contains small wedge-shaped pillars with surface diameters of 50μ–100μ.

First appearance.—At a depth of 1,541–1,569 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1.

Genus MIOGYPSINA Sacco, 1893

Miogypsina (Miogypsina) indonesiensis Tan

1936. *Miogypsina indonesiensis* Tan., De Ingenieur in Nederlandsche-Indië—IV Mijnbouw en geologie, Jaarg. 3, no. 3, p. 54, 55, pl. 2, figs. 3–6.
1954. *Miogypsina (Miogypsina) indonesiensis* Tan. Cole U. S. Geol. Survey Prof. Paper 260–O, p. 599, 600, pl. 219, figs. 1–15; pl. 220, fig. 22.

A few specimens were recovered which represent this species. They are, however, obviously "cavings" from higher strata.

First appearance.—At a depth of 1,100–1,110 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1; at a depth of 1,122–1,133 feet (Tertiary *e*) in drill hole K–1B.

Miogypsina (Miogypsina) musperi Tan

Plate 244, figures 8–10

1936. *Miogypsina musperi* Tan, De Ingenieur in Nederlandsche-Indië—IV Mijnbouw en geologie, Jaarg. 3, no. 3, p. 55, pl. 1, fig. 20; pl. 2, figs. 15–18.

Several small digitate specimens occurred in the samples from Eniwetok Atoll drill hole E–1 which very closely resemble specimens from east Borneo which Tan described. However, there were too few specimens recovered for a complete analysis.

First appearance.—At a depth of 1,130–1,140 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1.

Miogypsina (Miogypsina) thecideaeformis (L. Rutten)

Plate 244, figures 1, 2, 4–7, 11–14

1911. *Lepidosemicyclina thecideaeformis* L. Rutten. K. Akad. Wetensch. Amsterdam Verh., p. 1135, 1136.
1912. *Miogypsina thecideaeformis* (L. Rutten). Rutten, Geol. Reichs-Mus. Leiden Samml., sec. 1, v. 9, p. 204–207, pl. 12, figs. 1–5.
1927. *Miogypsina thecideaeformis* (L. Rutten). Umbgrove, Nederlandsche Akad. Wetensch. Meded. no. 5, p. 32, 33, pl. 2, figs. 1–4.
1929. *Miogypsina thecideaeformis* (L. Rutten). Van der Vlerk, idem, no. 9, p. 26, figs. 50a–d.
1931. *Miogypsina kotoi* Hanzawa, Tōhoku Imp. Univ. Sci. Reps., 2d ser. (Geol.), v. 12, no. 2A, p. 154, pl. 25, figs. 14–18.
1935. *Miogypsina kotoi* Hanzawa. Hanzawa, idem, v. 18, no. 1, p. 23–25, pl. 3.
1936. *Miogypsina borneensis*, Tan, De Ingenieur in Nederlandsche-Indië—IV Mijnbouw en geologie, Jaarg. 3, no. 3, p. 53, 54, pl. 1, fig. 19 [not pl. 1, fig. 18].
1937. *Miogypsina kotoi* Hanzawa. Tan, idem, Jaarg. 4, no. 2, p. 31, 32, 6 figs.
1937. *Miogypsina borneensis* Tan. Tan, idem, Jaarg. 4, no. 6, p. 90, pl. 1, figs. 1, 2.
1940. *Miogypsina borneensis* Tan. Hanzawa, Jubilee Pub. in commemoration of Prof. H. Yabe's 60th birthday, v. 2, p. 783–785, pl. 41, figs. 11–23.
1953. *Miogypsina thecideaeformis* (L. Rutten). Drooger, K. Akad. Wetensch. Amsterdam Verh., ser. B, no. 1, p. 109, 110, pl. 1, figs. 10–14, 32.
1954. *Miogypsina (Miogypsina) borneensis* Tan. Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 598, 599, pl. 220, figs. 9–21.
1957. *Miogypsina (Miogypsina) thecideaeformis* (L. Rutten). Cole, idem, 280–I, p. 340, pls. 112–114.

Although specimens identical with those recovered from the Eniwetok Atoll drill holes were identified as *Miogypsina borneensis* Tan in the report on the Bikini drill holes, additional study has demonstrated that the specimens from all these drill holes are *Miogypsina thecideaeformis* (L. Rutten). Moreover, it seems probable that the specimens on which S. H. Tan based the species *M. borneensis* in reality represent two species, *Miogypsina thecideaeformis* and *Miogypsinoides dehaartii* (Van der Vlerk).

Tan (1936, pl. 1, figs. 18, 19) gave two illustrations of the embryonic apparatus of *M. borneensis*. The one which he labels *typus* (Tan, 1936, pl. 1, fig. 18) has a coil of rude subquadrate periembryonic chambers partly encircling the embryonic chambers. The arrangement and shape of these periembryonic chambers is identical with those of *Miogypsinoides dehaartii* (compare Tan's illustration with pl. 244, fig. 3 of this report). The other illustration (Tan, 1936, pl. 1, fig. 19) shows periembryonic chambers of a more elongate shape which are similar in number and arrangement to those found in *M. thecideaeformis* (compare Tan's illustration with pl. 244, fig. 1, of this report).

The late Mrs. Helen Jeanne Plummer had given me some 15 specimens labeled "*Miogypsina thecideaeformis* (L. Rutten), Balik Papan, oost Borneo." These specimens are seemingly topotypes. One equatorial section (pl. 244, fig. 11) is illustrated for comparison with the specimens from the Eniwetok Atoll drill holes.

The embryonic apparatus (pl. 244, fig. 11) of a topotype of *M. thecideaeformis* has the same number and arrangement of the periembryonic chambers as do specimens from the Eniwetok drill holes (pl. 244, fig. 6). It was difficult, however, to make equatorial sections of the Eniwetok specimens which showed the entire periembryonic series. On many specimens making the section destroyed smaller periembryonic chambers on the opposite side of the embryonic chambers from the major periembryonic chambers. However, these chambers were present and observed in the preparation of most of the thin sections.

In a discussion of *Miogypsina kotoi* Hanzawa, Tan (1937, p. 32) described the presence of a "funnel-shaped deuteroconchal stolon." This funnel-shaped stolon occurs in specimens from the Eniwetok drill holes (see pl. 244, fig. 14, lower left side of the second embryonic chamber) and in topotypes of *M. thecideaeformis* (pl. 244, fig. 12, same position).

An equatorial section of *M. kotoi* generously given to me by Dr. Hanzawa is illustrated (pl. 244, fig. 2). Although this specimen does not show the funnel-shaped stolon, it is similar in other respects to topotypes of *M. thecideaeformis* and to specimens from the Eniwetok drill holes referred to that species. Therefore, it appears that *M. kotoi* is a synonym of *M. thecideaeformis*.

First appearance.—At a depth of 1,070–1,080 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1; at a depth of 1,080–1,090 feet (Tertiary *e*) in drill hole K–1B; rare at a depth of 1,230–1,248 feet (Tertiary *e*) in core 3, drill hole F–1.

Occurrence elsewhere.—Borneo; Madoera; Saipan; Japan.

Family ORBITOIDIDAE

Genus LEPIDOCYCLINA Gümbel, 1870

Subgenus NEPHROLEPIDINA H. Douvillé, 1917

Lepidocyclina (Nephrolepidina) augusticamera Cole

Plate 239, figures 7, 8

1954. *Lepidocyclina* (*Nephrolepidina*) *augusticamera* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 585, 586, pl. 217, figs. 1–5.

This species has nephrolepidine embryonic chambers, hexagonal equatorial chambers, and the lateral chambers arranged in regular tiers.

An equatorial section from the Eniwetok Atoll drill hole E–1 is identical with the equatorial section figured from the Bikini drill hole (Cole, 1954, pl. 217, fig. 3), and a vertical section resembles the one from the Bikini drill hole closely (pl. 217, fig. 4).

First appearance.—At a depth of 1,925–1,955 feet (Tertiary *e*) from the Eniwetok Atoll drill hole E–1; at a depth of 1,978–2,003 feet (Tertiary *e*) in core 5, drill hole F–1 and at a depth of 2,662–2,688 feet in core 6 of this same drill hole.

Lepidocyclina (Nephrolepidina) bikiniensis Cole

Plate 242, figure 21

1954. *Lepidocyclina* (*Nephrolepidina*) *bikiniensis* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 586, pl. 214, figs. 1–8.

A complete description of this species was given by Cole (1954).

The large short spatulate equatorial chambers are very distinctive and unlike those of any other species found either in the Bikini or Eniwetok Atoll drill holes. The illustration (pl. 242, fig. 21) should be compared with the illustrations of Bikini specimens (Cole, 1954, pl. 214, figs. 5, 6).

The lateral chambers have open elongate cavities.

First appearance.—At a depth of 1,143–1,154 feet (Tertiary *e*) in Eniwetok Atoll drill hole K–1B; at a depth of 1,170–1,180 feet (Tertiary *e*) in drill hole F–1; at a depth of 1,210–1,220 feet (Tertiary *e*) in drill hole E–1.

Lepidocyclina (Nephrolepidina) cubiculirhomboidea Cole

1954. *Lepidocyclina* (*Nephrolepidina*) *cubiculirhomboidea* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 587, 588, pl. 213, figs. 10–19.

Externally, this species resembles *Lepidocyclina sumatrensis* (Brady), but the internal structure is slightly different.

The equatorial chambers are radially elongate. The lateral chambers have open rectangular cavities, and the floors and roofs are thin and straight.

First appearance.—At a depth of 1,365–1,375 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1.

Discussion.—This species occurs in the Eniwetok Atoll drill holes in association with *Miogypsinoides dehaartii* (Van der Vlerk), an association also found in the Bikini drill hole 2B.

Eventually, this species may be combined with *L. sumatrensis*, but at present it appears that the two can be distinguished.

Lepidocyclina (Nephrolepidina) orientalis Van der Vlerk

1924. *Lepidocyclina munieri* Lemoine and R. Douvillé var. *orientalis* Van der Vlerk, Nederlandsche Akad. Wetensch. Meded. no. 1, p. 22, 23, pl. 4, figs. 5–8.

1954. *Lepidocyclina* (*Nephrolepidina*) *orientalis* Van der Vlerk. Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 588, 589, pl. 215, figs. 11–21 [references].

A few specimens assigned to this species were recovered from Eniwetok Atoll drill hole K–1B. This species occurs rarely in a restricted zone, inasmuch as no other specimens were found either in the other Eniwetok Atoll drill holes or in samples of cuttings in drill hole K–1B below the sample which contained the specimens.

First appearance.—At a depth of 1,070–1,080 feet (Tertiary *f*) in Eniwetok Atoll drill hole K–1B.

Occurrence elsewhere.—In deposits assigned to Tertiary f_3 in Java and from Japan (described as *L.* (*N.*) *makiyamai*).

Lepidocyclina (Nephrolepidina) pumilipapilla Cole

Plate 242, figures 1, 2

1954. *Lepidocyclina* (*Nephrolepidina*) *pumilipapilla* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 592, 593, pl. 214, figs. 15–17, 19; pl. 215, figs. 1–8.

The external appearance and the internal structure of this species were described by Cole (1954). The specimens from the Eniwetok Atoll drill holes are identical.

Measurements of equatorial sections follow.

Measurements of equatorial sections of Lepidocyclina pumilipapilla *from drill hole E–1*

Dimensions	Specimen from—				
	1,599–1,629 feet	1,688–1,715 feet	1,715–1,746 feet		1,746–1,776 feet
	USNM P–3605	USNM P–3743	USNM P–3744	USNM P–3603	USNM P–3604
Diameter mm	2.65	2.75	2.1	1.48	2.1
Embryonic chambers:					
Diameters of initial chamber μ	110 x 150	130 x 190	100 x 150	120 x 150	140 x 180
Diameters of second chamber μ	110 x 240	120 x 260	110 x 215	85 x 200	95 x 220
Distance across both chambers μ	240	260	230	220	260
Thickness of outer wall μ	30	30	25	20	20
Equatorial chambers:					
Radial diameter μ	50	40–50	30–50	50	40–50
Tangential diameter μ	35	20–40	25–35	30–40	30–40

Measurements of vertical sections follow.

Measurements of vertical sections of Lepidocyclina pumilipapilla *from drill hole E–1*

Dimensions		Specimen from—							
		1,541–1,569 feet	1,599–1,629 feet	1,688–1,715 feet		1,715–1,746 feet			1,746–1,776 feet
		USNM P–3601	USNM P–3602	USNM P–3745	USNM P–3746	USNM P–3599c	USNM P–3599b	USNM P–3599a	USNM P–3600
Diameter	mm	1.85+	2.34	2.5	2.3	2.15	1.5	1.47+	2.35
Thickness	mm	0.85	0.91	1.1	1.1	0.86	0.75	0.8	0.85
Embryonic chambers:									
Internal length	μ	250	240	270	260	230	220	190	230
Internal height	μ	180	180	190	180	170	150	150	180
Thickness of outer wall	μ	30	30	40	35	10	15	20	15
Equatorial layer:									
Height at center	μ	65	75	60	70	60	70	60	70
Height at periphery	μ	110	170	120	120	150	110	80	110
Lateral chambers:									
Number		8	9	12	9	8	8	8	7
Length	μ	50–240	50–110	40–150	120–220	50–170	50–90	120–180	100–200
Height	μ	20–40	25–40	20–30	20–30	20–40	15–40	20–40	30–40
Thickness of floors and roofs	μ	20	10–15	15–20	10–20	10–15	10–15	10	10–15
Surface diameter of pillars	μ	50	50	60–100	50–180	50–100	100	100–150	50

First appearance.—At depth of 1,541–1,569 feet in Eniwetok Atoll drill hole E–1; at a depth of 1,718–1,740 feet (core 4) in F–1.

Lepidocyclina (Nephrolepidina) sumatrensis (Brady)

Plate 239, figures 1–4; plate 241, figures 1–30; plate 242, figures 3–20

1875. *Orbitoides sumatrensis* Brady, Geol. Mag., decade 2, v. 2, p. 536, pl. 14, figs. 3a–b.

1924. *Lepidocyclina brouweri* L. Rutten, Jaarb. mijnwezen in Nederlandsch Oost-Indie, Verh., p. 182, figs. 22–29.

1939. *Lepidocyclina sumatrensis* (Brady). Caudri, Geol.-mijnb. genootsch.. Nederland en Kononien Verh., Geol. ser., v. 12, p. 185–197, 243, 247, 250, 251, pl. 7, figs. 36–41, 44 [references and synonyms].

1939. *Lepidocyclina verrucosa* Scheffen. Caudri, idem, p. 179–185, 242, 247, 251, pl. 7, figs. 26–31 [references and synonyms].

1953. *Lepidocyclina* (*Nephrolepidina*) *brouweri* L. Rutten. Cole, U. S. Geol. Survey Prof. Paper 253, p. 28, 29, pl. 8, fig. 1; pl. 9, fig. 1; pl. 11, fig. 3; pl. 12, figs. 5, 14.

1953. *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* (Brady). Cole, idem, p. 32, 33, pl. 10, figs. 7–10; pl. 11, figs. 4, 5.

1954. *Lepidocyclina* (*Nephrolepidina*) *parva* Oppenoorth. Cole, idem, 260–O, p. 589–592, pl. 212, figs. 1–28; pl. 217, figs. 12–14; pl. 222, figs. 1–3 [references and synonyms].

1954. *Lepidocyclina* (*Nephrolepidina*) *verrucosa* Scheffen. Cole, idem, p. 593, 594, pl. 213, figs. 1–9.

1957. *Lepidocyclina* (*Nephrolepidina*) *brouweri* L. Rutten. Cole, idem, 280–I, p. 342, pl. 105, figs. 1–10.

1957. *Lepidocyclina* (*Nephrolepidina*) *parva* Oppenoorth. Cole idem, p. 343, pl. 104, figs. 10–17; pl. 107, fig. 17.

1957. *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* (Brady). Cole, idem, p. 343, pl. 104, figs. 1–9; pl. 106, fig. 5; pl. 109, figs. 1–3.

1957. *Lepidocyclina* (*Nephrolepidina*) *verrucosa* Scheffen. Cole, idem, p. 345, pl. 105, figs. 11–17; pl. 109, figs. 4–6.

It was proved in the Bikini report (Cole, 1954, p. 591) that individuals assigned to the species *Lepidocyclina parva* Oppenoorth ranged from small compressed specimens with very small pillars to much larger inflated ones with strong pillars (*L. atjehensis*). At that time, however, the maximum range which could occur between specimens which belong to this species was not fully appreciated because a sufficient number of thin sections was not available for study.

In the study of certain samples from the Eniwetok Atoll drill hole E–1, many specimens were sectioned. Some of these were selected on external appearance to represent *L. parva;* others were chosen to represent *L. verrucosa* Scheffen, and a final group was selected to illustrate *L. sumatrensis* (Brady) and its varieties. After making thin sections it was found that the internal structure of all these specimens was alike in major features. The minor differences were in the cross sectional shape in vertical sections and in the number of lateral chambers to a tier.

All of these specimens have nephrolepidine embryonic chambers, and the equatorial chambers are predominantly diamond shaped although some are short spatulate to hexagonal. All three kinds may occur in a single equatorial section.

The cross sectional shape in vertical section ranges from compressed lenticular (pl. 241, fig. 1) to nearly globular (pl. 241, fig. 29). Some specimens have many lateral chambers to a tier (pl. 241, fig. 30), whereas others have only a few lateral chambers (pl. 241, fig. 1). In some specimens the pillars are weak (pl. 241, fig. 14) or are not present (pl. 241, fig. 23); in others the pillars are moderately developed (pl. 241, fig. 17), but certain specimens have strong pillars (pl. 241, fig. 24).

However, all these specimens have the equatorial layer with comparatively thick floors and roofs, lateral chambers which are arranged in regular tiers and these chambers have open cavities with curved roofs and floors.

It is possible to arrange the vertical sections in a gradational series, and it is impossible to discover any criteria by which this series may be separated into distinct species. However, if certain specimens be selected from the series without regard for the other specimens, it is possible to correlate these specimens with previously described species.

If the specimen illustrated by plate 241, figure 1, be considered alone, it would be identified as *L. parva* Oppenoorth. Likewise, plate 241, figure 23, represents *L. sumatrensis* (Brady); plate 241, figure 22, would be assigned to *L. sumatrensis inornata* L. Rutten; and plate 241, figure 17, would be *L. verrucosa* Scheffen.

Vertical sections of specimens assigned at first to Lepidocyclina sumatrensis inornata *from drill holes E–1 and K–1B*

Dimensions	Specimen from E–1 at 1,130–1,140 feet shown on pl. 241—	Specimen from K–1 Bat 1,143–1,154 feet shown on pl. 241—		
	Fig. 28	Fig. 26	Fig. 22	Fig. 23
Diameter mm	2.7	2.46	2.7	2.3
Thickness mm	1.78	1.05	1.25	1.45
Embryonic chambers:				
Internal length μ	320	170	150	300
Internal height μ	190	140	140	140
Thickness of outer wall μ	20	25	20–40	30
Equatorial layer:				
Height at center μ	70	70	70	70
Height at periphery μ	150	170	120	130
Lateral chambers:				
Number	14	9	10	13
Length μ	80–160	70–170	100–160	50–130
Height μ	20–40	20–30	20–40	30–40
Thickness of floors and roofs μ	15–20	20	10–20	10–20
Surface diameter of pillars μ	160	150	200	100

Vertical sections of specimens assigned at first to Lepidocyclina parva *from drill holes E–1, F–1, and K–1B*

Dimensions	Specimen from E–1 at—									Specimen from F–1 at—	Specimen from K–1B at—	
	1,070–1,080 feet shown on—		1,310–1,320 feet shown on—	1,365–1,375 feet shown on—	1,569–1,599 feet shown on—	1,658–1,688 feet shown on—			1,715–1,746 feet shown on—	1,718–1,740 feet shown on—	1,112–1,122 feet shown on—	
	Pl. 241, Fig. 1	Pl. 241, Fig. 8	Pl. 241, Fig. 7	Pl. 241, Fig. 6	Pl. 241, Fig. 2	Pl. 241, Fig. 15	Pl. 241, Fig. 13	Pl. 241, Fig. 12	Pl. 241, Fig. 14	Pl. 241, Fig. 4	Pl. 241, Fig. 5	USNM P–3747 (not illustrated)
Diameter mm	1.85	2.4	1.9	2.05	2.3	2.3	3.16	3.7	2.6	1.85	2.4	2.5
Thickness mm	0.55	1.1	1.1	0.85	0.8	1.16	1.35	1.37	1.1	0.85	0.95	0.98
Embryonic chambers:												
Internal length μ	160	190	240	200	220	230	260	320	300	300	240	240
Internal height μ	100	110	160	100	160	220	210	240	190	120	140	170
Thickness of outer wall μ	10	20	30–40	20	20	15–30	30	30	40	20	20–30	20
Equatorial layer:												
Height at center μ	70	60	80	70	70	70	70	100	80	70	70	70
Height at periphery μ	100	130	120	120	110	130	160	150	150	110	110	120
Lateral chambers:												
Number	9	10	9	8	7	11	12	11	11	7	11	9
Length μ	50–100	110–200	80–200	100–150	50–130	150	110–190	120–200	80–200	90–140	100–180	80–130
Height μ	20–25	30–40	40	20–30	15–20	20–40	20–40	20–40	20–40	20–30	20	20–40
Thickness of floors and roofs μ	10	10–15	20	20	10–20	10–20	20	15–20	10–20	10–20	10	20
Surface diameter of pillars μ	60–100	80–120	50–200	100–200	40–110	50–170	150	100–130	70–100	60	100–130	50–110

Other examples could be given, but those cited prove the case.

The specific name *L. sumatrensis* (Brady) has priority; therefore, all the names listed in the synonymy must be suppressed. B. Caudri (1939, p. 244) previously stated concerning *L. parva*, "Probably a form of *L. sumatrensis*," an opinion which is substantiated by this study.

Tables of measurements of vertical sections give the detailed information concerning the degree of difference which may occur between individual specimens. (See p. 774 and below.)

First appearance.—At a depth of 1,070–1,080 feet (Tertiary *e*) in Eniwetok Atoll drill hole E–1; at a depth of 1,080–1,091 feet (Tertiary *e*) in drill hole K–1B.

Vertical sections of specimens assigned at first either to Lepidocyclina sumatrensis *or* L. verrucosa *from drill holes E–1 and K–1B*

Dimensions	Specimen from E–1 at—									Specimen from K–1B at—				
	1,070–1,080 feet shown on pl. 241—			1,130–1,140 feet shown on pl. 241—	1,140–1,150 feet shown on pl. 241—			1,569–1,599 feet shown on pl. 241—		1,122–1,133 feet shown on pl. 241—				
	Fig. 11	Fig. 10	Fig. 9	Fig. 25	Fig. 30	Fig. 21	Fig. 24	Fig. 16	Fig. 19	Fig. 20	Fig. 17	Fig. 27	Fig. 18	P–3749 (not illustrated)
Diameter mm	1.93	1.7	2.25	2.47	2.6	3.1	1.9	2.25	2.1	2.05	2.3	2.35	2.6	3.13
Thickness mm	1.0	1.08	1.2	1.72	1.95	1.5	1.48	1.0	1.6	1.3	1.43	1.4	1.8	1.65
Embryonic chambers:														
Internal length μ	160	220	210	220	220	230	190	190	260	250	220	210	320	360
Internal height μ	120	160	130	170	130	150	150	150	220	170	150	140	210	160
Thickness of outer wall μ	30	25–40	30–50	20–30	20–30	25	20	20–30	20–30	40	30	30	25–30	25–35
Equatorial layer:														
Height at center μ	80	70	80	80	80	80	70	80	90	80	70	80	80	90
Height at periphery μ	120	110	110	110	120	160	90	120	110	130	150	110	110	170
Lateral chambers:														
Number	8	10	11	17	16	16	16	8	15	11	12	12	14	15
Length μ	100–200	100–180	150–200	100–150	150–200	110–180	100–150	80–150	80–190	90–200	150	110–150	120–180	80–200
Height μ	20–30	20–40	30–40	30–40	30–40	20–40	20–30	20–30	15–35	20–40	40	30	30–50	20–30
Thickness of floors and roofs μ	20–30	20	15–30	20	20	10–20	10–20	20	15–20	10–20	15	40	15–20	25–30
Surface diameter of pillars μ	100–150	100–150	70–170	200–350	200–400	80–200	150–420	100–150	130–200	100–150	80–150	70–200	130–280	50–330

Subgenus EULEPIDINA H. Douvillé, 1911

Lepidocyclina (Eulepidina) abdopustula Cole

1954. *Lepidocyclina* (*Eulepidina*) *abdopustula* Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 594, pl. 215, figs. 9, 10; pl. 218, figs. 7–11.

First appearance.—At a depth of 1,925–1,955 feet in cuttings from Eniwetok Atoll drill hole E–1; also at a depth of 2,003–2,028 feet (core 1) of this same drill hole; at a depth of 1,978–2,003 feet (core 5) and 2,662–2,687 feet (core 6) in drill hole F–1; all Tertiary *e*.

Lepidocyclina (Eulepidina) ephippioides Jones and Chapman

Plate 239, figures 5, 6

1900. *Orbitoides* (*Lepidocyclina*) *ephippioides* Jones and Chapman *in* Andrews, C. W., A monograph of Christmas Island (Indian Ocean): British Mus. (Nat. Hist.), London, p. 251, 252, 256, pl. 20, fig. 9; pl. 21, fig. 15.

1952. *Lepidocyclina ephippioides* Jones and Chapman. Grimsdale, British Mus. (Nat. Hist.) Geol. Bull., v. 1, no. 8, p. 240–244, pl. 23, figs. 8, 17, 18 [references].

1954. *Lepidocyclina* (*Eulepidina*) *formosa* Schlumberger. Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 594–597, pl. 216, figs. 1–16; pl. 217, figs. 9–11; pl. 218, figs. 1, 3, 4.

1954. *Lepidocyclina* (*Eulepidina*) *gibbosa* Yabe. Cole, idem, p. 597, pl. 217, figs. 15–18; pl. 218, fig. 2.

1954. *Lepidocyclina* (*Eulepidina*) *planata* Oppenoorth. Cole, idem, p. 597, 598, pl. 217, figs. 7, 8; pl. 218, figs. 5, 6.

1957. *Lepidocyclina* (*Eulepidina*) *ephippioides* Jones and Chapman. Cole, idem, 280–I, p. 346, pl. 15, figs. 4–13; pl. 16, figs. 11–15.

The reader is referred to the discussion of this species by Cole (1957, p. 346). As some workers may not agree to the combining of specific names as indicated above, the first appearance of the individual structural types which have been combined into one species are given.

First appearance.—At a depth of 1,394–1,424 feet in Eniwetok Atoll drill hole E–1 a single specimen occurred (*L. planata*); at 1,541–1,569 feet in this drill hole a second specimen (*L. planata*) occurred; at 1,629–1,658 feet of this drill hole abundant specimens appear (*L. planata* and *L. formosa*); at 1,688–1,715 feet (*L. stereolata*) and at 1,715–1,746 feet (*L. gibbosa*); at a depth of 1,975–1,978 feet (core 5) in drill hole F–1 (*L. formosa* and *L. stereolata*); all Tertiary *e*.

Family DISCOCYCLINIDAE

Genus ASTEROCYCLINA Gümbel, 1870

Asterocyclina centripilaris Cole, n. sp.

Plate 248, figures 1–7, 9–11

The test is small and strongly biconvex, with a narrow encircling rim on which appear 4 small rays at approximately 90° apart. There is a single large central papilla on each side of the test which either projects above the surface or is flush with the surface. The rest of the surface is covered with small polygonal pits.

Measurements of equatorial sections follow.

Measurements of equatorial sections of Asterocyclina centripilaris *from drill hole F–1, 4,197–4,222 feet (core 11)*

Dimensions	Specimen shown on—			
	Pl. 248, fig. 7	Pl. 248, fig. 2	USNM P-3750 (not illustrated)	USNM P-3751 (not illustrated)
Diameter (mm)	1.7	1.0	1.15	1.07
Embryonic chambers:				
Diameters of initial chamber (μ)	40 x 50	35 x 35	20 x 30	30 x 35
Diameters of second chamber (μ)	35 x 70	30 x 50	30 x 40	25 x 40
Distance across both chambers (μ)	80	80	60	65
Thickness of outer wall (μ)	5	5	5	5
Equatorial chambers:				
In rays:				
Tangential diameter (μ)	10–20	--------	15	10–20
Radial diameter (μ)	40–50	--------	30–50	30–40
In interray areas:				
Tangential diameter (μ)	15–20	20	15–25	10–20
Radial diameter (μ)	15–30	20	15–20	10–20

Typically, there are two rather large periembryonic chambers, one at each end of the dividing wall between the embryonic chambers. These chambers have internal diameters of 20μ by 70μ.

In well-oriented equatorial sections, four rays appear demarked by radially elongate equatorial chambers.

The interray equatorial chambers have tangential and radial diameters approximately equal. Many of these chambers are faintly hexagonal in outline rather than perfectly square or rectangular.

Measurements of vertical sections follow.

Measurements of vertical sections of Asterocyclina centripilaris *from drill hole F–1, 4,197–4,222 feet (core 11)*

Dimensions	Specimen shown on —			
	Pl. 248 fig. 6	Pl. 248 fig. 3	USNM P-3752 (not illustrated)	Pl. 248 fig. 5
Diameter (mm)	1.08	1.25	0.91	1.1
Thickness (mm)	0.85	0.85	0.87	0.9
Embryonic chambers:				
Height (μ)	40	40	--------	--------
Length (μ)	70	60	50	--------
Equatorial layer:				
Height at center (μ)	10	10	--------	--------
Height at periphery (μ)	25	35	--------	--------
Lateral chambers:				
Number	14	14	12	12
Length (μ)	25–50	70–100	60–85	100
Height (μ)	10	10–15	10–18	10–15
Thickness of floors and roofs (μ)	5–8	10	8	10
Surface diameter of axial pillar (μ)	150	160	150	200

The lateral chambers are arranged in regular tiers On each side of the embryonic chambers, there is a single strong central pillar.

First appearance.—In Tertiary *b* at a depth of 4,197–4,222 feet (core 11) in Eniwetok Atoll drill hole F–1 and at a depth of 4,078–4,100 feet (core 3) of drill hole E–1.

Discussion.—This small species with the single large pillar on each side of the embryonic chambers is different from any described species of *Asterocyclina.*

Asterocyclina incisuricamerata Cole

Plate 245, figures 3–10, 13–15, 17

1957. *Asterocyclina incisuricamerata* Cole, U. S. Geol. Survey Prof. 280–I, p. 349, pl. 117, figs. 1–5.

The test is small with an inflated umbo and a thin undulatory rim across which 5 rays project. The rays are narrow at their proximal ends, where they fuse with the umbonate part of the test, but they widen distally. There are a few indistinct apical papillae. The rest of the surface is covered with a reticulate mesh.

Measurements of equatorial sections follow.

Measurements of equatorial sections of Asterocyclina incisuricamerata *from drill hole F–1, 4,500–4,525 feet (core 14)*

Dimensions	Specimen shown on pl. 245—		
	Fig. 10	Fig. 5	Fig. 9
Diameter (mm)	2.0	2.5	1.9
Embryonic chambers:			
Diameters of initial chamber (μ)	85 x 90	70 x 80	60 x 70
Diameters of second chamber (μ)	40 x 160	50 x 135	30 x 100
Distance across both chambers (μ)	150	130	110
Thickness of outer wall (μ)	20	15	20
Equatorial chambers:			
In rays:			
Tangential diameter (μ)	20	15–20	10–15
Radial diameter (μ)	30–50	30–50	40
In interray areas:			
Tangential diameter (μ)	20–25	20	15–40
Radial diameter (μ)	20–50	20–40	10–20

The embryonic chambers are surrounded by a complete ring of elongate rectangular periembryonic chambers.

Five rays show in each of the equatorial sections. The chambers in the rays are radially elongate, whereas the interray chambers are either square or tangentially elongate.

Measurements of vertical sections follow.

Measurements of vertical sections of Asterocyclina incisuricamerata *from drill hole F–1, 4,500–4,525 feet (core 14)*

Dimensions	Specimen shown on pl. 245—		
	Fig. 7	Fig. 8	Fig. 17
Diameter (mm)	2.4+	2.6	2.1+
Thickness (mm)	0.82	1.02	0.9
Diameter of umbo (mm)	1.35	1.7	1.2
Width of ray (mm)	1. +	0.5	0.85
Thickness of ray (mm)	0.32	0.16	0.33
Embryonic chambers:			
Height (μ)	70	45	40
Length (μ)	110	100	100
Equatorial layer:			
Height at center (μ)	20	20	30
Height at periphery (μ)	20	30	40
Lateral chambers:			
Number	10	12	14
Height (μ)	3	5	3–5
Length (μ)	70–140	50–100	50–110
Thickness of roofs and floors (μ)	30–50	20–50	20–40
Surface diameter of pillars (μ)	280	300	50–300

The cavities of the lateral chambers are extremely low and slitlike between very thick roofs and floors and are irregularly arranged.

Several large pillars occur in the central part of the test; only 1 or 2 show in each vertical section.

First appearance.—At a depth of 4,316–4,341 feet (Tertiary *b*) in core 12, Eniwetok Atoll drill hole F–1.

Discussion.—The slitlike cavities of the lateral chambers between thick floors and roofs and their irregular distribution in the vertical sections characterize this species.

Asterocyclina matanzensis Cole

Plate 249, figures 1–17

1957. *Asterocyclina matanzensis* Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 350, pl. 117, figs. 6–10; pl. 118, figs. 9–18.

The test is moderate size, either compressed lenticular or inflated, with four short distinct rays which merge into the central umbonate area. The compressed type (pl. 249, fig. 15) has triangular interray areas which merge gradually with the rays, and the outline of the test is quadrate. The inflated type (pl. 249, fig. 14) has no distinct interray areas, and the outline of the test is cruciate. The entire surface is covered with raised papillae, which are smaller on the compressed type than the ones on the inflated type.

Measurements of equatorial sections follow.

Measurements of equatorial sections of Asterocyclina matanzensis *from drill hole E–1, 2,910–2,920 feet*

Dimensions	Specimen shown on—		
	Pl. 249, fig. 10	USNM P-3753 (not illustrated)	Pl. 249, fig. 3
Diameter mm	1.96	1.9	2.5
Embryonic chambers:			
Diameters of initial chamber μ	80 x 70	70 x 60	80 x 70
Diameters of second chamber μ	85 x 50	80 x 40	80 x 40
Distance across both chambers μ	140	110	120
Thickness of outer wall μ	10	5	10
Equatorial chambers:			
In rays:			
Radial diameter μ	----------	40	40
Tangential diameter μ	----------	10–20	20
In interray areas:			
Radial diameter μ	20–30	20–30	25–30
Tangential diameter μ	10–15	15–20	20

The lateral chambers are arranged in regular tiers. The chamber cavities are very low and slitlike between moderately thick roofs and floors.

Moderately heavy pillars are irregularly scattered throughout the length of the test.

First appearance.—In Tertiary *b* at a depth of 2,840–2,850 feet in Eniwetok Atoll drill hole E–1 and at a depth of 4,197–4,222 feet (core 11) in drill hole F–1.

Measurements of vertical sections follow.

Measurements of vertical sections of Asterocyclina matanzensis *from drill hole E–1*

Dimensions	Specimen from—			
	2,910–2,920 feet shown on—			2,940–2,950 feet shown on—
	USNM P-3754 (not illustrated)	Pl. 249, fig. 9	Pl. 249, fig. 1	Pl. 249, fig. 2
Diameter mm	2.2+	2. +	2.05+	2.9
Thickness mm	0.65	0.66	1.15	1 53
Embryonic chambers:				
Length μ	90	130	80	----------
Height μ	50	70	80	100
Thickness of outer wall μ	10	10	10	10
Equatorial layer:				
Height at center μ	15	15	15	15
Height at periphery μ	20	15	15	15
Lateral chambers:				
Number no.	16	15	20	24
Length μ	40–60	30–40	40–60	30–60
Height μ	5–10	5–10	5–10	10
Thickness of floors and roofs μ	10	10	20	20
Surface diameter of pillars μ	30–50	50	50–100	100

Discussion.—The internal features of the Eniwetok Atoll specimens are the same as those of the types from Saipan island. However, the embryonic chambers of the types were destroyed by recrystallization; therefore, the embryonic chambers could not be compared.

In the Eniwetok Atoll drill hole F–1 at 4,197–4,222 feet (core 11) specimens were found that have the same features as the specimens from 2,840–2,850 feet in drill hole E–1, but the specimens in drill hole F–1 have the embryonic chambers destroyed in the same manner as the types from Saipan.

At a depth of 4,500–4,525 feet (core 14) in drill hole F–1, rare specimens of *Asterocyclina* occur which resemble the types closely, but they show some minor differences in that the rays are better developed and there are fewer lateral chambers to a tier.

The specimens at 4,197–4,222 feet (core 11) and at 4,500–4,525 feet (core 14) in drill hole F–1 are described below in the event it is desirable later to recognize these specimens as distinct species. The description of the specimens from 4,197–4,222 feet (core 11) of drill hole F–1 follows.

The test is moderate size and compressed lenticular in vertical section with four low rays radiating at right angles from a low umbonate central area, the rays only slightly elevated above the intervening interray areas. The surface is completely covered with small raised papillae.

The embryonic chambers in every specimen sectioned were destroyed by replacement.

The equatorial section shows the four rays distinctly. The chambers in the interray areas have radial diameters from 20μ to 50μ and tangential diameters of 15μ to 20μ. Chambers in the rays have radial diameters from 30μ to 70μ and tangential diameters of 20μ to 30μ.

Measurements of 3 vertical sections follow.

Measurements of vertical sections of Asterocyclina matanzensis *from drill hole F–1, 4,197–4,222 feet* (*core 11*)

Dimensions	Specimen shown on pl. 249—		
	Fig. 11	Fig. 12	Fig. 17
Diameter mm	2.05+	2.4	3.7
Thickness mm	0.7	0.82	1.15
Embryonic chambers:			
Length μ	150±	200	170±
Height μ	120±	80	120±
Equatorial layer:			
Height at center μ	10	10	10
Height at periphery μ	----------	10	20
Lateral chambers:			
Number	18	19	27
Length μ	40–80	40	50
Height μ	10	10	10
Thickness of floors and roofs μ	10	10	10
Surface diameter of pillars μ	50–130	60–100	60–90

The lateral chambers are arranged in regular tiers. The cavities are low and rectangular between floors and roofs which have about the same thickness as the height of the chamber cavity.

Small pillars are irregularly scattered throughout the length of the vertical sections.

The description of the specimens from 4,500–4,525 feet (core 14) in drill hole F–1 follows:

The test is small with an inflated umbonal area from which radiate four well-developed rays. The surface of the umbonate area and the axial part of the rays is covered with small but marked papillae. The rest of the surface is covered by shallow polygonal pits.

An equatorial section with a diameter of 1.5 mm has 4 rays. The embryonic chambers are bilocular with the second chamber only slightly embracing the initial chamber which has an internal diameter of 30μ. The second chamber has diameters of 30μ by 60μ. The distance across both chambers is 80μ. The equatorial chambers are nearly square with radial and tangential diameters of 10μ–20μ.

A vertical section with a diameter of 1.55+ mm and a thickness at the center of 0.65 mm has the lateral chambers arranged in regular tiers. There are about 12 lateral chambers to a tier on each side of the embryonic chambers. These chambers have a length of 50μ–80μ, a height of about 10μ, and floors and roofs about 10μ thick. Pillars with a surface diameter of 50μ–100μ are irregularly scattered throughout the section.

Asterocyclina penuria Cole

Plate 246, figure 1–11; plate 247, figures 1–15; plate 248, figures 8, 12–17

1957. *Asterocyclina penuria* Cole. Cole, U. S. Geol. Survey Prof. Paper 280–I, p. 350, pl. 116, figs. 1–10 [references and discussion]. [Nom. nov. for *Orthophragmina pentagonalis* Deprat 1905, preoccupied by *Asterodiscus pentagonalis* Schafhault, 1863.]

Megalospheric generation.—The test is medium size with a strong inflated central part surrounded by a wide rim across which are 5–6 low rays. Most specimens have a prominent papillae on the umbo and the rays. The papillae have a diameter of 200μ. The interray areas are flat and without papillae. The measurements of the four specimens which illustrate the external appearance follow.

Specimen shown on—	Diameter (mm)	Diameter of umbo (mm)	Width of flange (mm)	Thickness (mm)	Number of rays
Pl. 248, fig. 8	7.4	3.3	2.3	3.1	5
Pl. 248, fig. 13	7.8	3.3	2.6	3.9	6
Pl. 246, fig. 8	5.8	2.5	1.9	2.5	5
Pl. 248, fig. 12	3.9	2.5	.8	2.4	6

The embryonic chambers are bilocular. The second chamber is wider than the initial chamber but does not embrace it. The embryonic chambers are completely enclosed by periembryonic chambers, the shape of which are illustrated on plate 246, figure 9.

Measurements of horizontal and vertical sections follow.

Measurements of horizontal sections of Asterocyclina penuria *from drill hole F–1, 4,406–4,431 feet (core 13)*

Dimensions	Specimen shown on pl. 246—				
	Fig. 4	Fig. 7	Fig. 9	Fig. 5	Fig. 10
Diameter mm	1.7	2.3	3.45	3.95	4.0
Embryonic chambers:					
Diameters of initial chamber μ	100 x 130	150 x 170	150 x 200	110 x 150	150 x 240
Diameters of second chamber μ	90 x 200	120 x 170	130 x 260	110 x 230	150 x 310
Distance across both chambers μ	210	290	300	230	320
Thickness of outer wall μ	15	10	15	15	10
Equatorial chambers:					
Radial diameter μ	20–50	30–70	20–80	100–120	40–150
Tangential diameter μ	10–30	15–30	15–30	20–30	20–30

Measurements of vertical sections of Asterocyclina penuria *from drillhole F–1, 4,406–4,431 feet (core 13)*

Dimensions	Specimen shown on pl. 247—								
	Fig. 2	Fig. 4	Fig. 11	Fig. 6	Fig. 10	Fig. 14	Fig. 15	Fig. 8	Fig. 5
Diameter mm	1.6	1.8+	2.4	3.23+	4.2+	4.2+	4.35+	4.87	6.5
Thickness mm	.8	.92	1.1	1.15	1.75	2.95	2.22	1.85	3.08
Diameter of umbo mm	1.2	1.4	1.6	2.3	3.0	3.6	3.0	3.0	3.9
Width of flange mm	.25	[1]	.45+	.6	[1]	[1]	[1]	1.3	1.35+
Thickness of flange near umbo mm	.17	.17	.2	.22	.38	.3	.36	.3	.85
Thickness of flange at periphery mm	.1	[1]	[1]	.16	[1]	[1]	[1]	.25	.55
Embryonic chambers:									
Length μ	320	280	200	260	320	285	245	330	230
Height μ	150	140	160	150	130	140	160	90	160
Thickness of outer wall μ	10	15	10	15	10	15	15	10	10
Equatorial layer:									
Height at center μ	40	20	40	20	20	15	30	10	20
Height at periphery μ	40	--------	40	30	--------	--------	--------	50	60
Lateral chambers:									
Number	10	11	15	20	30	48	34	32	45
Length μ	70–110	70–100	110–150	110–160	90–140	60–200	90–150	100–170	130–280
Height μ	10–20	10	10–15	10–20	10–20	10	10	10–20	10–30
Thickness of floors and roofs μ	10–15	10–18	10–15	10–20	10–20	10–20	10–20	10–20	10–20
Surface diameter of pillars μ	100	150	120–170	130–170	100–150	250–300	110–150	150–200	130–200

[1] Broken.

The lateral chambers are arranged in regular tiers. The cavities are low, and the floors and roofs, moderately thick.

Microspheric generation.—These specimens are larger than the megalospheric, and the available specimens have less distinct rays. The specimen (pl. 248, fig. 14) which illustrates the external appearance has a diameter of 7.6 mm, a thickness of 4.5 mm, an umbonal diameter of 5.1 mm, and a flange 1.5 mm wide.

A specimen with a broken flange has an umbonal diameter of 5.0 mm and a thickness of 4.2 mm. This specimen has 48 layers of lateral chambers on each side of the equatorial layer at the center of the test. Pillars are well developed and have a surface diameter of 100μ–300μ.

First appearance.—At a depth of 3,963–3,988 feet (Tertiary *b*) in core 10, Eniwetok drill hole F–1.

Occurrence elsewhere.—New Caledonia; Soemba; Saipan.

Discussion.—This species is characterized by large bilocular embryonic chambers which are completely surrounded by long narrow periembryonic chambers and by lateral chambers arranged in regular tiers. Between individual specimens, however, there is a considerable range in diameter, thickness, and number of lateral chambers to a tier.

M. J. Deprat (1905, p. 507) stated that the maximum diameter of the New Caledonia specimens was 2 mm and the thickness, 1 mm. The Eniwetok Atoll specimens have diameters from 1.6 to 6.5 mm and thicknesses from 0.8 mm to 3.08 mm. These specimens form a size-graded series; some of the small specimens (similar to the one illustrated on pl. 247, fig. 4) conform very closely to the illustration of a vertical section given by Deprat.

Specimens which are very similar to those described above were found at 4,316–4,341 feet (core 12) in the Eniwetok drill hole F–1. However, these specimens have larger and more irregularly formed embryonic chambers than do the specimens in core 13. Although these specimens are assigned to this species, a separate description was prepared.

The test is moderate in size with an inflated umbo bordered by a thin rim. Rays appear only on the rim and are not prominent. Surface of the test is covered by low indistinct but large papillae between which occur shallow polygonal pits.

Measurements of equatorial sections of Asterocyclina penuria *from drill hole F–1, 4,316–4,341 feet (core 12)*

Dimensions	Specimen shown on Pl. 246—	
	Fig. 1	Fig. 2
Diameter mm	3.6+	3.7+
Embryonic chambers:		
Diameters of initial chamber μ	230 x 540	280 x 480
Diameters of second chamber μ	220 x 550	200 x 600
Distance across both chambers μ	470	490
Thickness of outer wall μ	30	30
Equatorial chambers:		
In interray areas:		
Radial diameter μ	50–80	50–80
Tangential diameter μ	20–30	20–30
In rays:		
Radial diameter μ	80–120	70–120
Tangential diameter μ	20	20–30

A third equatorial section has a large irregular embryonic apparatus consisting of three chambers (pl. 246, fig. 3). The initial chamber appears to be subdivided into two parts followed by a normal appearing second chamber.

Although the periembryonic chambers in all the sections were not suitably exposed, they seem to surround the embryonic chambers completely. These periembryonic chambers that are exposed range from small, nearly square chambers to elongate, narrow chambers.

Measurements of vertical sections of Asterocyclina penuria *from drill hole F–1, 4,316–4,341 feet (core 12)*

Dimensions	Specimen shown on—			
	Pl. 246, fig. 11	Pl. 247, fig. 13	Pl. 247, fig. 3	Pl. 247, fig. 9
Diameter mm	4.25+	5.5+	4.+	3.8+
Thickness mm	2.4	2.9	1.6	2.0
Diameter of umbo mm	3.0	4.2	4.0	2.5
Embryonic chambers:				
Length μ	580	670	620	620
Height μ	250	250	320	350
Thickness of outer wall μ	20	20	20	20
Equatorial layer:				
Height at center μ	20	20	60	20
Height at periphery μ	40	40	50	20
Lateral chambers:				
Number	28	32	18	23
Length μ	90–210	110–200	60–200	150–200
Height μ	20	10–15	10	20
Thickness of floors and roofs μ	10	10–15	20	10
Surface diameter of pillars μ	160–200	200–300	250–300	100–300

The lateral chamber cavities are long and low between moderately thick roofs and floors. Normally, they are alined in regular tiers.

Thick pillars are irregularly scattered throughout the transverse section.

Asterocyclina praecipua Cole, n. sp.

Plate 245, figures 11, 12, 16, 18–20

The test is moderate in size and stellate with four prominent rays. The rays radiate from the inflated central area and are slightly elevated, so that the four triangular interray areas are clearly defined. The surface of the test is completely covered with large prominent papillae. The specimen (pl. 245, fig. 12) has a diameter of 3.8 mm and papillae with a diameter of about 300μ.

Measurements of thin sections follow.

Measurements of equatorial sections of Asterocyclina praecipua *from drill hole F–1, 4,316–4,341 feet (core 12)*

Dimensions	*Specimen shown on Pl. 245, fig. 19*
Diameter mm	3.7
Embryonic chambers:	
Diameters of initial chamber μ	50 × 60
Diameters of second chamber μ	30 × 60
Distance across both chambers μ	110
Thickness of outer wall μ	10
Equatorial chambers:	
In interray areas:	
Radial diameter μ	30–50
Tangential diameter μ	10–20
In rays:	
Radial diameter μ	50
Tangential diameter μ	20–25

Measurements of vertical sections of Asterocyclina praecipua *from drill hole F–1, 4,316–4,341 feet (core 12)*

Dimensions	Specimen shown on pl. 245—		
	Fig. 20	Fig. 11	Fig. 18
Diameter mm	2.7+	3.05	2.6+
Thickness mm	1.47	1.5	1.36
Embryonic chambers:			
Length μ	90	80	60
Height μ	60	70	40
Thickness of outer wall μ	10	10	10
Equatorial layer:			
Height at center μ	20	20	10
Height at periphery μ	60	40	20
Lateral chambers:			
Number	19	20	17
Length μ	50–100	30–50	50–80
Height μ	10–20	5–15	10–20
Thickness of roofs and floors μ	10–30	20–30	20
Surface diameter of pillars μ	150–300	200–350	150–200

The lateral chamber cavities are low and appressed between thick roofs and floors. The chambers are arranged in regular tiers where they occur in a single tier between two pillars, but elsewhere they are irregular and overlapping.

The pillars are well formed and show prominently in transverse sections. They are irregularly scattered throughout transverse sections.

First appearance.—At a depth of 4,316–4,341 feet (Tertiary *b*) in core 12, Eniwetok Atoll drill hole F–1.

Discussion.—This species which has many large, prominent papillae over the entire surface is easily recognized. The small bilocular embryonic chambers, the thick floors and roofs of the lateral chambers, and the many heavy pillars characterize it internally.

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[Page numbers in italic indicate descriptions]

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PLATES 231–249

PLATE 231

FIGURES 1–17. *Camerina pengaronensis* (Verbeek) (p. 753).

1–3, 5–8. Transverse sections of megalospheric specimens, × 20; 1, 5, 7, 8, USNM P–3401a–d, from hole E–1 at 2,940–2,950, feet; 2, 3, 6, USNM P–3402a–c, from hole F–1 at 4,406–4,431 feet, core 13.

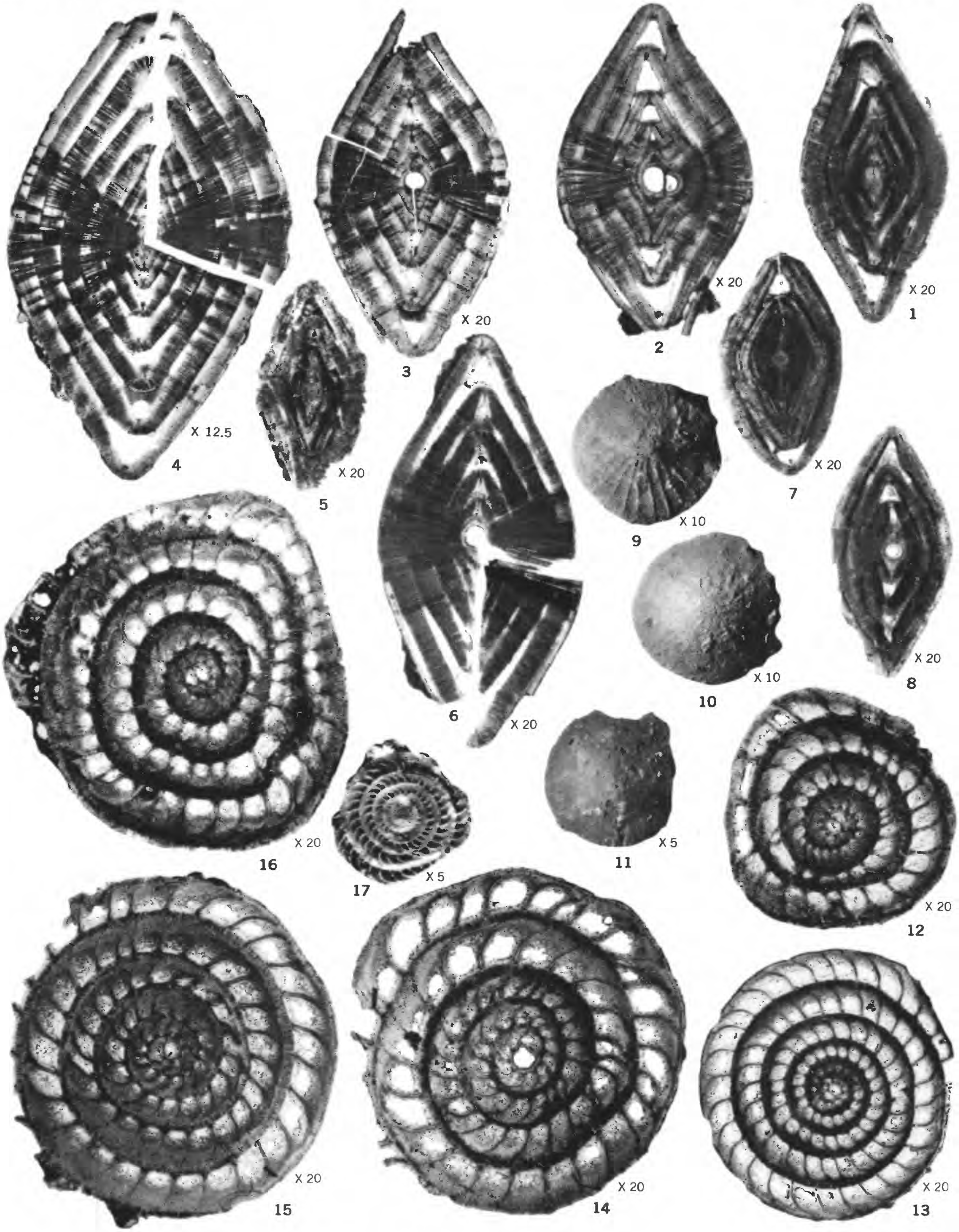
4. Transverse section of microspheric specimen, × 12.5; USNM P–3403, from hole F–1 at 4,406–4,431 feet, core 13.

9, 10. External views of megalospheric specimens, × 10; USNM P–3404a, b, from hole F–1 at 4,406–4,431 feet, core 13.

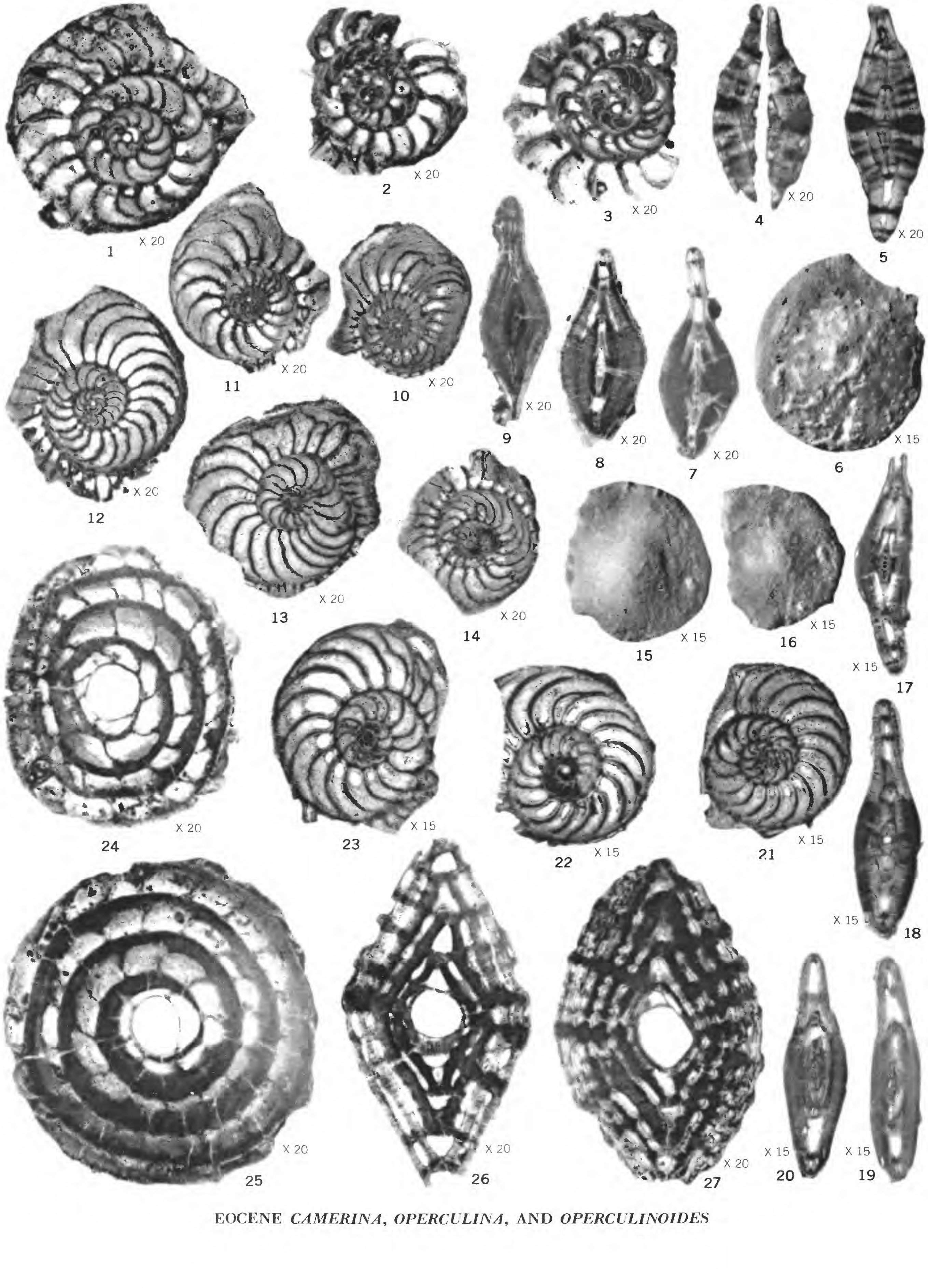
11 External view of microspheric specimen, × 5; USNM P–3405, from hole F–1 at 4,406–4,431 feet, core 13.

12–16. Median sections of megalospheric specimens, 12, 14–16, × 20; 13, × 12.5; 12, 16, USNM P–3406a–b, from hole E–1 at 2,940–2,950 feet; 13–15, USNM P–3407a–c, from hole F–1 at 4,406–4,431 feet, core 13.

17. Natural median section of microspheric specimen, × 5; USNM P–3408, from hole F–1 at 4,406–4,431 feet, core 13.



EOCENE *CAMERINA*



EOCENE *CAMERINA*, *OPERCULINA*, AND *OPERCULINOIDES*

PLATE 232

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4, 5. Transverse sections, × 20, of specimens from hole F–1 at 4,500–4,525 feet, core 14. 4, USNM P–3411; 5, USNM P–3412.

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7–14. *Operculinoides saipanensis* Cole (p. 755).

7–9. Transverse sections, × 20, USNM P–3414a–c, from hole F–1 at 4,406–4,431 feet, core 13.

10–14. Median sections, × 20, USNM P–3415a–e, from hole F–1 at 4,406–4,431 feet, core 13.

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15, 16. External views, × 15, of specimens from hole F–1 at 3,963–3,988 feet, core 10. 15, holotype, USNM P–3416; 16, USNM P–3417.

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21–23. Median sections, × 20, of specimens from hole F–1 at 3,963–3988 feet, core 10. 23, USNM P–3420; 21, 22, USNM P–3421a, b.

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24, 25. Median sections, × 20, of specimens from hole E–1 at 2,930–2,940 feet. USNM P–3422a, b.

26, 27. Transverse sections, × 20; 26, USNM P–3423, from hole E–1 at 2,940–2,950 feet; 27, USNM P–3424, from hole E–1 at 2,930–2,940 feet.

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PLATE 233

FIGURES 1–4. *Boreloides eniwetokensis* Cole, n. sp. (p. 768).

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5–7. Axial sections, × 20, of specimens from hole E–1. 5, USNM P–3541, and 6, USNM P–3542, at 2,790–2,802 feet; 7, USNM P–3543 at 2,870–2,880 feet.

8. Transverse section, × 20, USNM P–3540, from hole E–1 at 2,870–2,880 feet.

9, 10. External views, × 15, of specimens from hole E–1 at 2,802–2,808 feet, core 2. 9, USNM P–3562a; 10, holotype USNM P–3562b.

11–26. *Coskinolina rotaliformis* Cole, n. sp. (p. 751).

11–16. External views, × 10, of specimens from hole E–1; USNM P–3553a–f, at 2,910–2,920 feet. 12, holotype USNM P–3553b. 11, 16, side views; 12, 15, side views of slightly eroded specimens illustrating the chamberlets of the marginal trough; 13, view of the apertural face; 14, view of the apex of the test.

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28. Median section, × 20; USNM P–3427d, from hole K–1B at 1,122–1,133 feet.

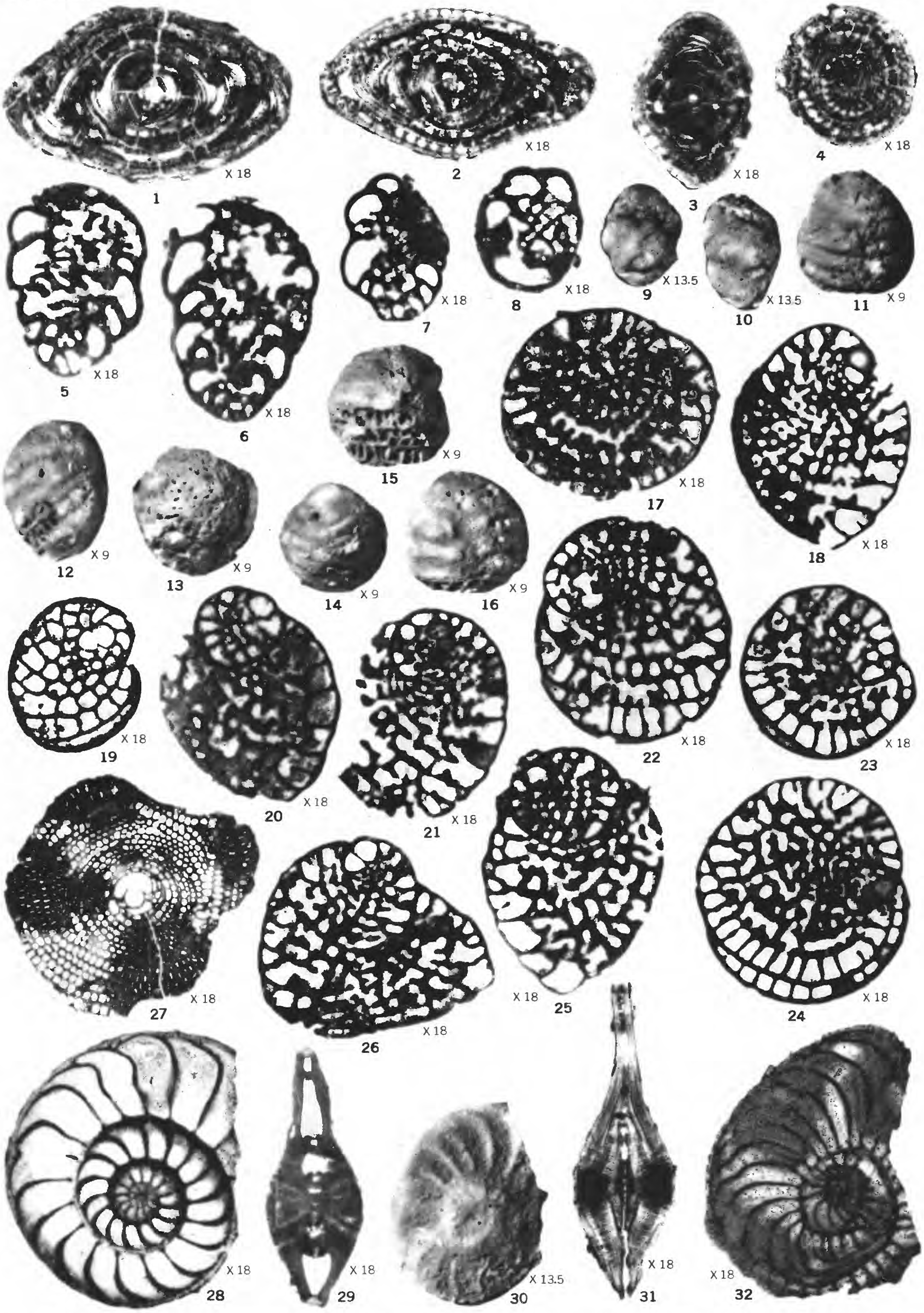
29. Transverse section, × 20; USNM P–3428, from the same sample as figure 28.

30. External view, × 15; USNM P–3426, from the same sample as figure 28.

31, 32. *Operculinoides saipanensis* Cole (p. 755).

31. Transverse section of a microspheric specimen, × 20; USNM P–3566, from hole F–1 at 4,500–4,525 feet, core 14.

32. Median section of a microspheric specimen, × 20; USNM P–3565, from hole F–1 at 4,406–4,431 feet, core 13.



EOCENE *BORELOIDES*, *COSKINOLINA*, *OPERCULINOIDES*, AND *PSEUDOCHRYSALIDINA* AND MIOCENE *CYCLOCLYPEUS* AND *OPERCULINA*

EOCENE *HETEROSTEGINA*

PLATE 234

FIGURES 1–12. *Heterostegina aequatoria* Cole, n. sp. (p. 756).

1–5. Transverse sections, × 20, illustrating variation in thickness, hole F–1 at 3,655–3,665 feet, core 9. 2, holotype, USNM P–3443; 1, 3–5, USNM P–3444a–d.

6–12. Median sections, × 20; 8, USNM P–3445; 6, 7, 9–12, USNM P–3446 a–f; the same sample as figures 1–5.

13–24. *Heterostegina saipanensis* Cole (p. 760).

13–15. Transverse sections, × 20; USNM P–3447a–c; from hole F–1 at 3,052–3,055 feet, core 7.

16–23. Median sections, × 20, of specimens from hole F–1: 16, 18, 21, USNM P–3448a–c, at 3,350–3,353 feet, core 8; 17, 19, 22, 23, USNM P–3449a–d, at 3,052–3,055 feet, core 7; 20, USNM P–3450, at 4,316–4,341 feet, core 12.

24. External view, × 15, USNM P–3451, from hole F–1 at 3,052–3,055 feet, core 7.

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PLATE 235

FIGURES 1–13. *Heterostegina saipanensis* Cole (p. 760).

1–6. Transverse sections, × 20, of specimens from hole F–1. 1, 3, USNM P–3452a, b, at 3,353 feet, core 8; 2, 4, 6, USNM P–3453a–c, at 4,316–4,341 feet, core 12; 5, USNM P–3454, at 3,052–3,055 feet, core 7.

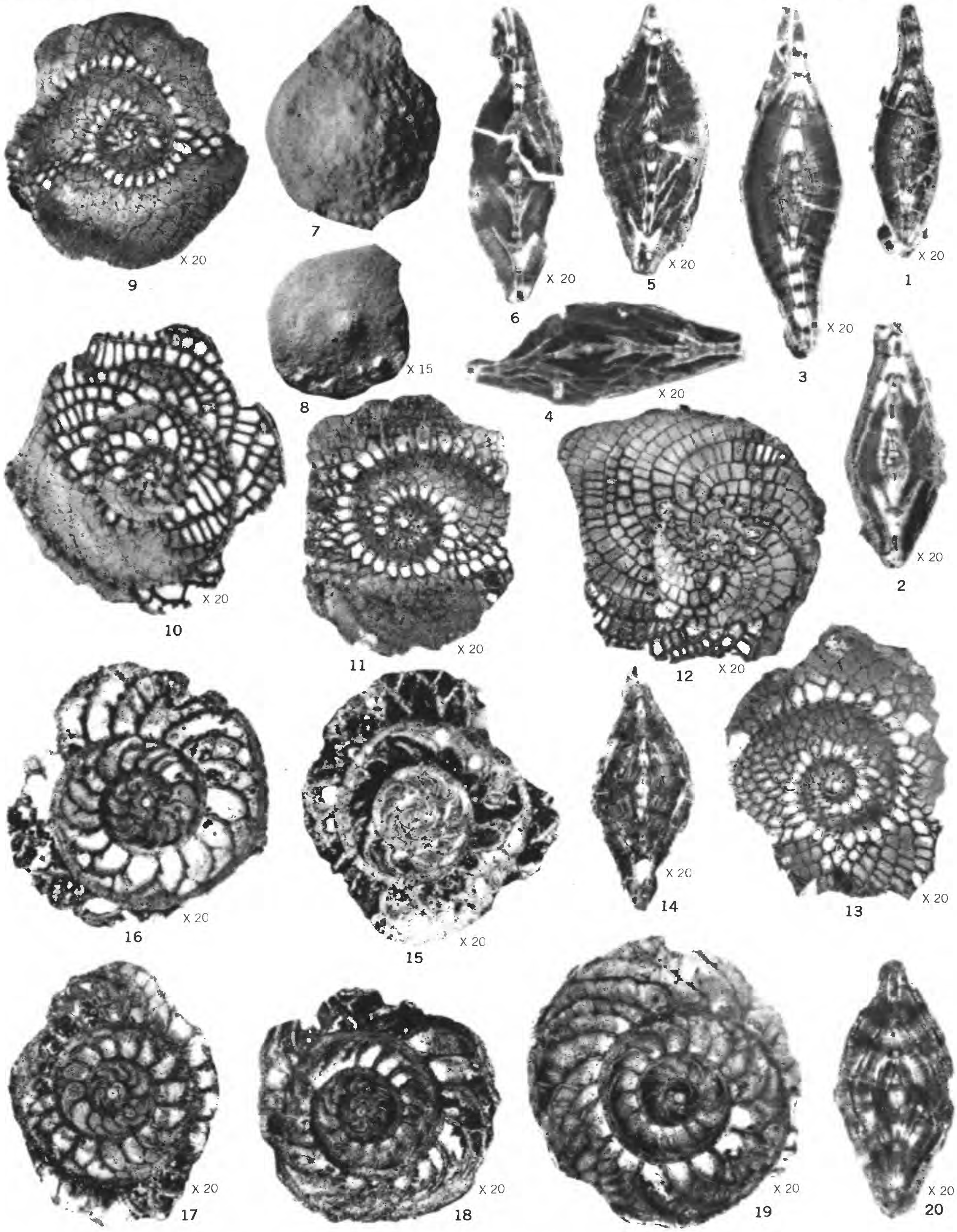
7, 8. External views, × 15, of specimens from hole F–1. 7, USNM P–3455, at 3,052–3,055 feet, core 7; 8, USNM P–3456, at 4,316–4,341 feet, core 12.

9–13. Median sections, × 20, of specimens from hole F–1. 9, 11, 13, USNM P–3457a–c, at 4,316–4,341 feet, core 12; 10, 12, USNM P–3458a, b, at 3,052–3,055 feet, core 7.

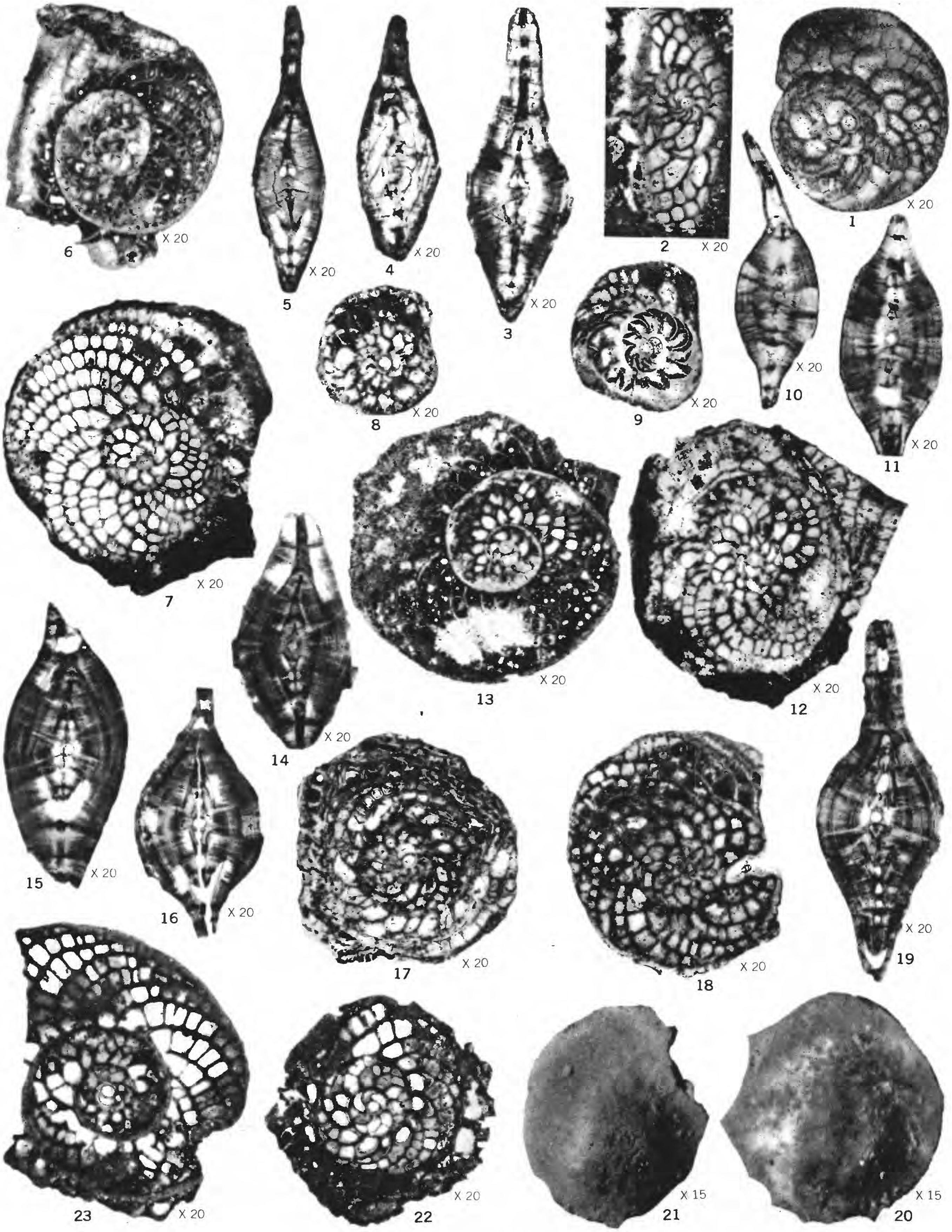
14–20. *Heterostegina suborbicularis* D'Orbigny (p. 762).

14, 20. Transverse sections, × 20, USNM P–3459a, b, from hole E–1 at 2,940–2,950 feet.

15–19. Median sections, × 20, of specimens from hole E–1; 15–18, USNM P–3460a–d, at 2,940–2,950 feet; 19, USNM P–3461, at 2,930–2,940 feet.



EOCENE *HETEROSTEGINA*



MIOCENE *HETEROSTEGINA*

PLATE 236

FIGURES 1–23. *Heterostegina duplicamera* Cole, n. sp. (p. 759).

1, 2, 6–9, 12, 13, 17, 18, 22, 23. Median sections, × 20. From hole F–1: 1, 2, 9, USNM P–3462a–c, at 2,662–2,687 feet, core 6; 8, USNM P–3463, at 1,978–2,003 feet, core 5; 17, 18, USNM P–3464a, b, at 2,080–2,090 feet. From hole E–1: 6, 7, 12, 13, USNM P–3465a–d, at 2,230–2,240 feet; 22, 23, USNM P–3466a, b, at 1,955–1,985 feet.

3–5, 10, 11, 14–16, 19. Transverse sections, × 20. From hole E–1: 3–5, USNM P–3467a–c, at 2,230–2,240 feet; 15, 16, 19, USNM P–3468a–c, at 1,955–1,985 feet. From hole F–1: 10, 11, USNM P–3469a, b, at 2,662–2,687 feet, core 6; 14, USNM P–3470, at 2,080–2,090 feet.

20, 21. External views, × 15; 20, holotype, USNM P–3471a; 20, 21, USNM P–3471a, b, from hole E–1 at 1,955–1985 feet.

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PLATE 237

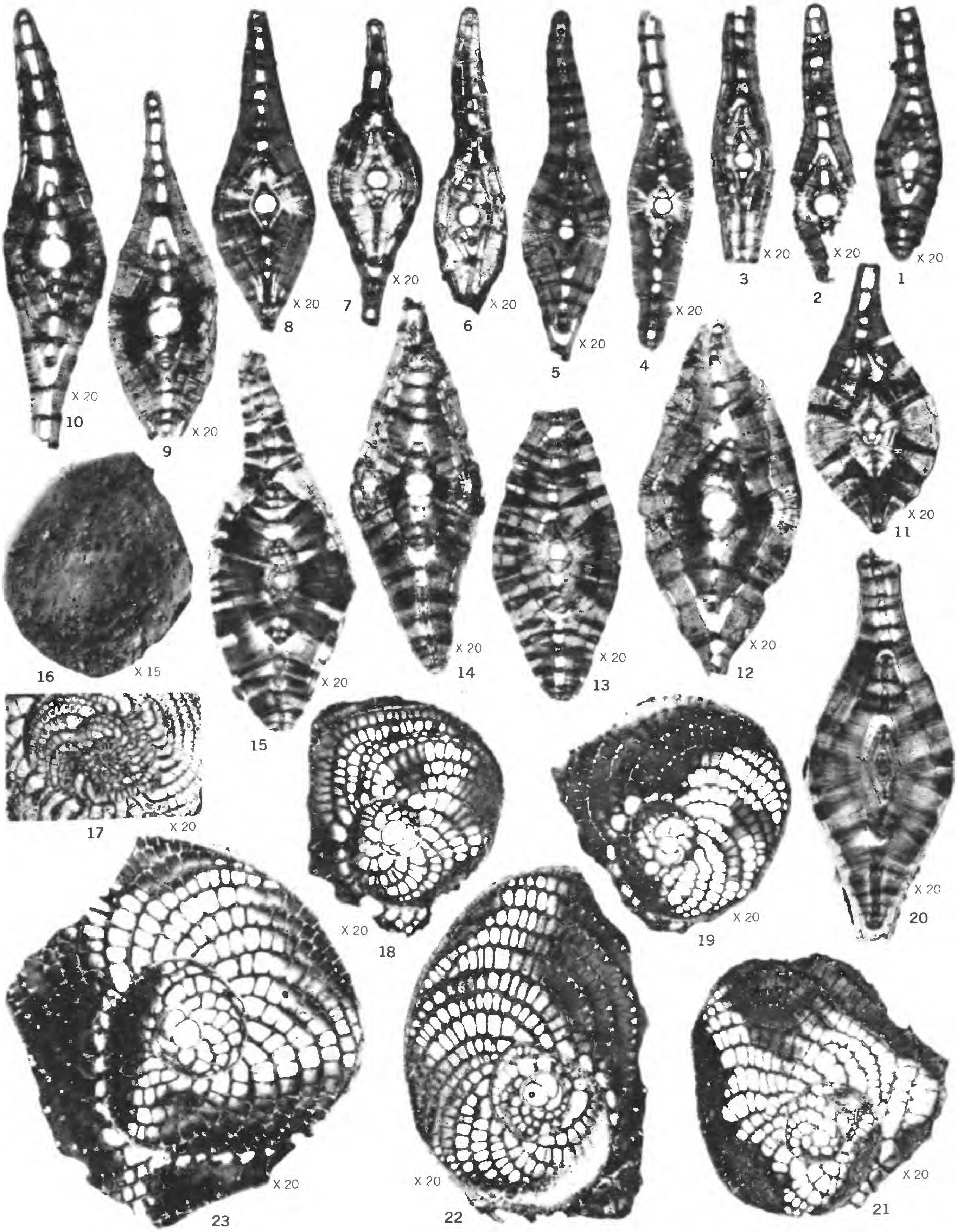
FIGURES 1–23. *Heterostegina borneensis* Van der Vlerk (p. 757).

1–15, 20. Transverse sections, × 20, illustrating the gradation from thin compressed specimens (*H. pusillumbonata* of Cole, 1954) to thick lenticular specimens (*H. nigripustula* of Cole, 1954). From hole E–1: 1, 2, 5, 6, 8, 11, 13, USNM P–3472a–g, at 1,715–1,746 feet; 3, 7, USNM P–3473a, b, at 1,688–1,715 feet; 4, USNM P–3474, at 1,210–1,220 feet; 9, 10, 12, 14, USNM P–3475a–d, at 1,746–1,776 feet. From F–1: 15, 20, USNM P–3476a, b, at 1,718–1,740 feet, core 4.

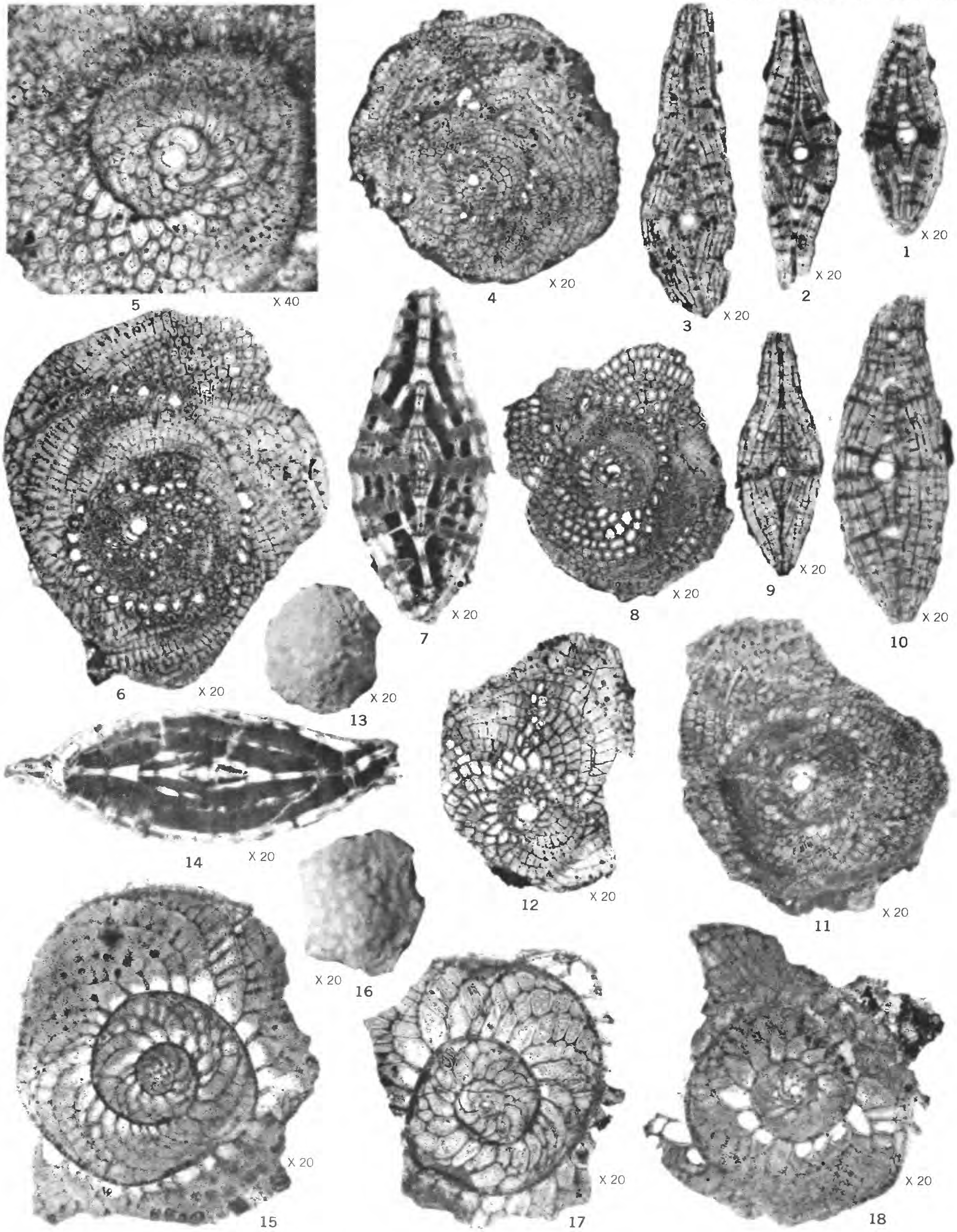
16. External view, × 15, of a specimen with surface sculpture intermediate between that of *H. pusillumbonata* and *H. nigripustula*, USNM P–3477, from hole E–1 at 1,715–1,746 feet.

17. Part of a median section, × 20, of a microspheric specimen illustrating the initial chamber, USNM P–3478, from hole F–1 at 1,718–1,740 feet, core 4.

18, 19, 21–23. Median sections, × 20: 21, a compressed individual, the transverse section of which would resemble that shown as figure 1; 23, a strongly inflated individual with large surface pustules, the transverse section of which would resemble that shown as figure 12; from hole E–1: 18, USNM P–3479, at 1,210–1,220 feet; 19, 21, 22, USNM P–3480a–c, at 1,715–1,746 feet; 23, USNM P–3481, at 1,746–1,776 feet.



MIOCENE *HETEROSTEGINA*



EOCENE *SPIROCLYPEUS*

PLATE 238

FIGURES 1–6, 8–10, 11, 12. *Spiroclypeus vermicularis* Tan (p. 764).

1–3, 9, 10. Transverse sections, × 20, USNM P–3482a–e, from hole F–1 at 4,197–4,222 feet, core 11.

4, 6, 8, 11, 12. Median sections, × 20, USNM P–3483a–e, from the same sample as the transverse sections.

5. Part of a median section, × 40, illustrating the embryonic chambers and the single operculine chamber following these; USNM P–3484, from the same sample as the transverse sections.

7, 13–18. *Spiroclypeus albapustula* Cole, n. sp. (p. 762).

7, 14. Transverse sections, × 20, from hole F–1 at 4,316–4,341 feet, core 12. 7, USNM P–3485; 14, USNM P–3486.

13, 16. External views, × 10. 16, holotype, USNM P–3487; 13, USNM P–3488, from the same sample as figures 7, 14.

15, 17, 18. Median sections, × 20. 15, USNM P–3489; 17, 18, USNM P–3490a, b, from the same sample as figures 7, 14.

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PLATE 239

FIGURES 1–4. *Lepidocyclina (Nephrolepidina) sumatrensis* (Brady) (p. 773).

1–4. External views, × 15, of megalospheric specimens illustrating differences in appearance from K–1B. 1, specimen of the kind formerly called *L. parva* Oppenoorth; 2, specimen of the kind formerly called *L. verrucosa* Scheffen; 3, 4, typical specimens of *L. sumatrensis*; 1, 2, USNM P–3636a, b, at 1,122–1,133 feet; 3, 4, USNM P–3635a, b, at 1,143–1,154 feet.

5, 6. *Lepidocyclina (Eulepidina) ephippioides* Jones and Chapman (p. 775).

5, 6. Vertical sections, × 20, of specimens of the kind formerly called either *L. stereolata* Oppenoorth or *L. monstrosa* Yabe; 5, USNM P–3611, from hole F–1, at 1,975–1,978 feet; 6, USNM P–3612, from hole E–1; at 1,688–1,715 feet.

7, 8. *Lepidocyclina (Nephrolepidina) augusticamera* Cole (p. 772).

7. Part of an equatorial section, × 20, illustrating the nephrolepidine embryonic chambers and the short hexagonal equatorial chambers, from hole F–1; USNM P–3627 at 1,978–2,003 feet.

8. Vertical section, × 20, of specimen from hole F–1; USNM P–3626b, at 2,662–2,687 feet, core 6.

9, 10. *Spiroclypeus yabei* Van der Vlerk (p. 764).

9. Transverse section of a microspheric specimen, × 12.5, USNM P–3508, from hole E–1, at 1,688–1,715 feet.

10. Part of a median section of a microspheric specimen, × 40, USNM P–3510, from the same sample as figure 9.

11, 12, 14. *Spiroclypeus higginsi* Cole (p. 763).

11. Transverse section, × 20, illustrating the heavy pillars and the low slitlike lateral chambers between very thick roofs and floors; USNM P–3501, from hole E–1, at 1,210–1,220 feet.

12. Median section, × 20, USNM P–3497, from the same sample as figure 11.

14. External view, × 15, illustrating the large surface pustules; UNSM P–3502 from hole E–1; from the same sample as figure 11.

13, 15–17, 19–21. *Gypsina vesicularis* (Parker and Jones) (p. 768).

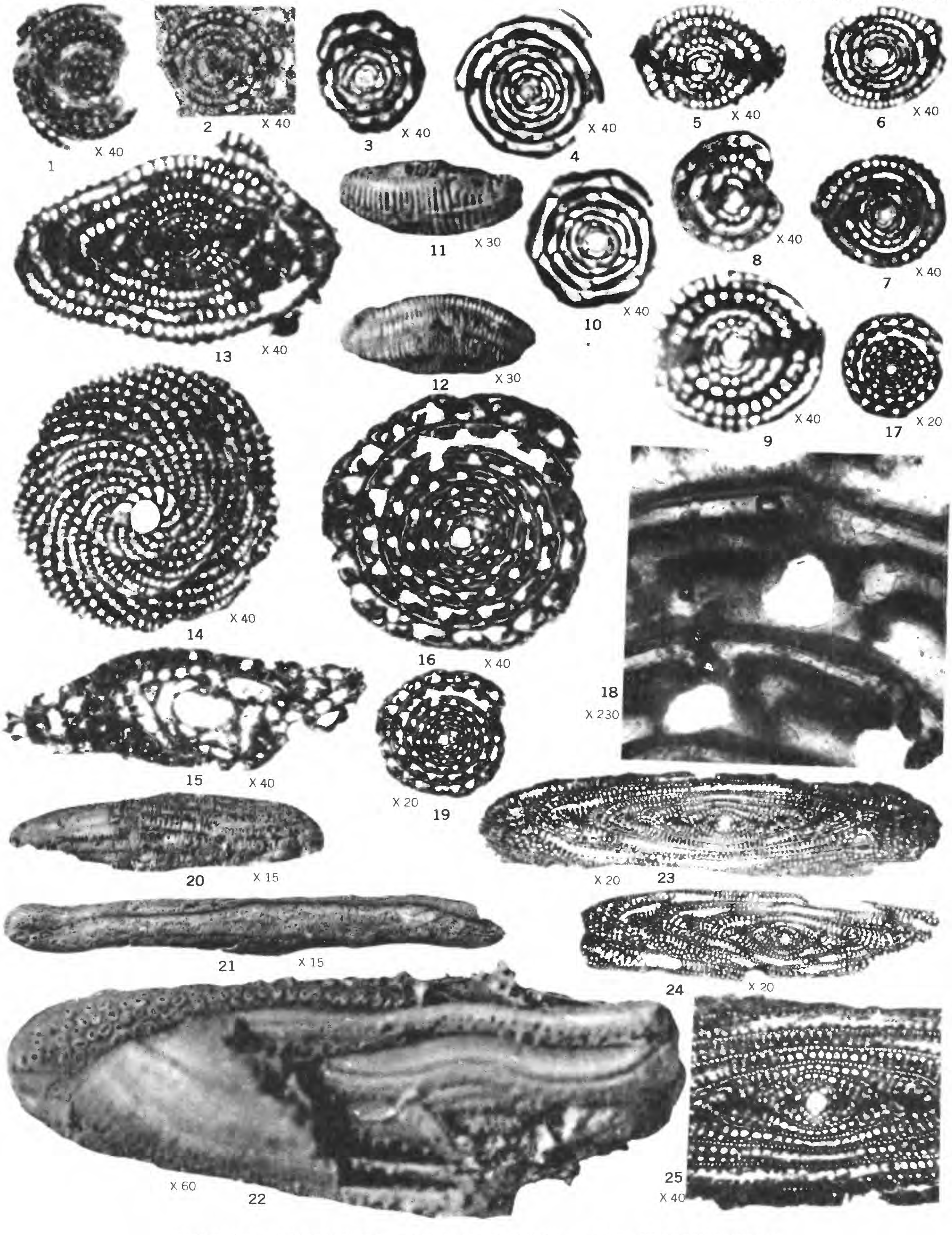
13, 16, 19, 20. Parts of equatorial sections, × 40, illustrating the embryonic apparatus and the equatorial chambers. From hole F–1: 13, 19, USNM P–3569a, b, at 3,963–3,988 feet, core 10. From hole E–1: 16, USNM P–3557, at 2,690–2,700 feet; 20, USNM P–3556, at 2,530–2,540 feet.

15, 17, 21. Vertical sections; 15, × 20; 17, 21, × 40. From hole E–1: 15, USNM P–3558a, at 2,690–2,700 feet; 21, USNM P–3559, at 2,530–2,540 feet. From hole F–1; 17, USNM P–3568, at 3,963–3,988 feet, core 10.

18. *Pellatispira orbitoidea* (Provale) (p. 765).

External view, × 5; USNM P–3514a, from hole F–1 at 4,316–4,341 feet, core 12.

EOCENE *PELLATISPIRA* AND *GYPSINA* AND MIOCENE *GYPSINA*, *LEPIDOCYCLINA* (*NEPHROLEPIDINA*), *LEPIDOCYCLINA* (*EULEPIDINA*), AND *SPIROCLYPEUS*



MIOCENE *ALVEOLINELLA, ARCHAIAS, BORELIS,* AND *FLOSCULINELLA*

PLATE 240

FIGURE 1. *Flosculinella globulosa* L. Rutten (p. 767).

Axial section, × 40, USNM P–3524, from hole E–1 at 1,130–1,140 feet.

2. *Borelis melo* (Fichtel and Moll) (p. 766).

Axial section, × 40, USNM P–3525, from hole F–1 at 1,230–1,248 feet, core 3.

3–10. *Borelis primitivus* Cole, n. sp. (p. 766).

3, 4, 10. Transverse sections, × 40, of specimens from hole E–1. 3, 10, USNM P–3526a, b, at 1,925–1,955 feet; 4, holotype, USNM P–3527, at 2,003–2,028 feet, core 1.

5–9. Axial sections, × 40, of specimens from hole E–1. 5, 6, USNM P–3528a, b, at 2,003–2,028 feet, core 1; 7–9, USNM P–3529a–c, at 1,925–1,955 feet.

11–13. *Borelis pygmaeus* Hanzawa (p. 767).

11, 12. External views, × 30; USNM P–3530a, b, from hole E–1 at 1,865–1,895 feet.

13. Axial section, × 40, USNM P–3531, from hole E–1 at 1,895–1,925 feet.

14, 15. *Archaias eniwetokensis* Cole, n. sp. (p. 766).

14. Median section, × 40, of holotype, USNM P–3532, from hole E–1 at 1,925–1,955 feet.

15. Transverse section, × 40, USNM P–3533, from hole E–1 at 1,925–1,955 feet.

16–25. *Alveolinella quoii* (D'Orbigny) (p. 767).

16, 17, 19. Transverse sections, USNM P–3534a, b, from hole K–1B at 831–841 feet. 16, × 40, an enlargement of figure 19; 17, 19, × 20.

18. Part of the axial section of specimen shown in figure 17 illustrating the stoloniferous passages, × 230.

20–22. External views of specimens from hole K–1B; 20, USNM P–3535 at 831–841 feet, × 15; 21, USNM P–3536 at 904–915 feet, × 15; 22, USNM P–3537 at 841–852 feet, × 60.

23, 24. Axial sections, × 20, USNM P–3538a, b, from hole K–1B at 831–841 feet.

25. Part of an axial section, × 40, illustrating the embryonic chambers, USNM P–3539, from hole K–1B at 831–841 feet.

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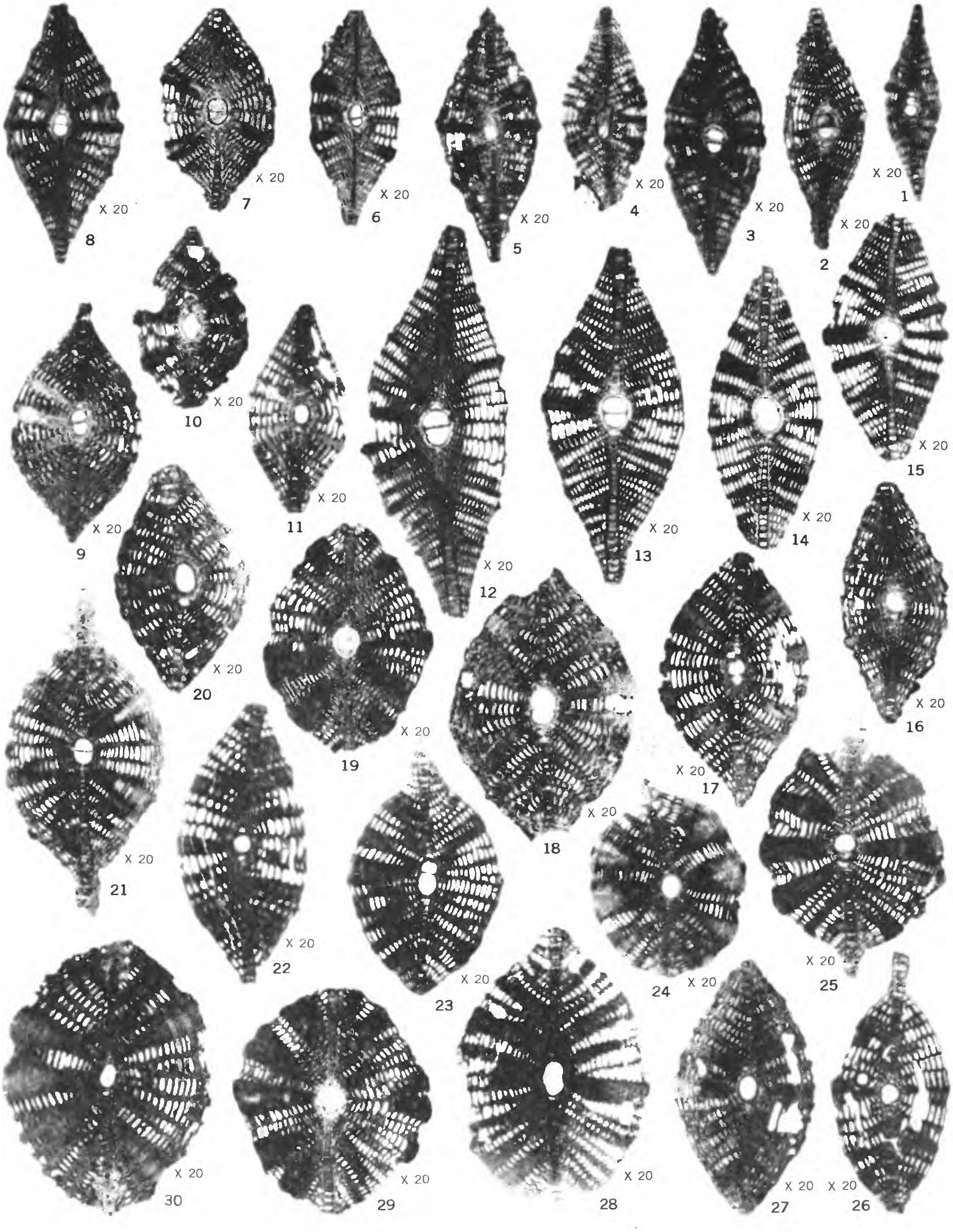
PLATE 241

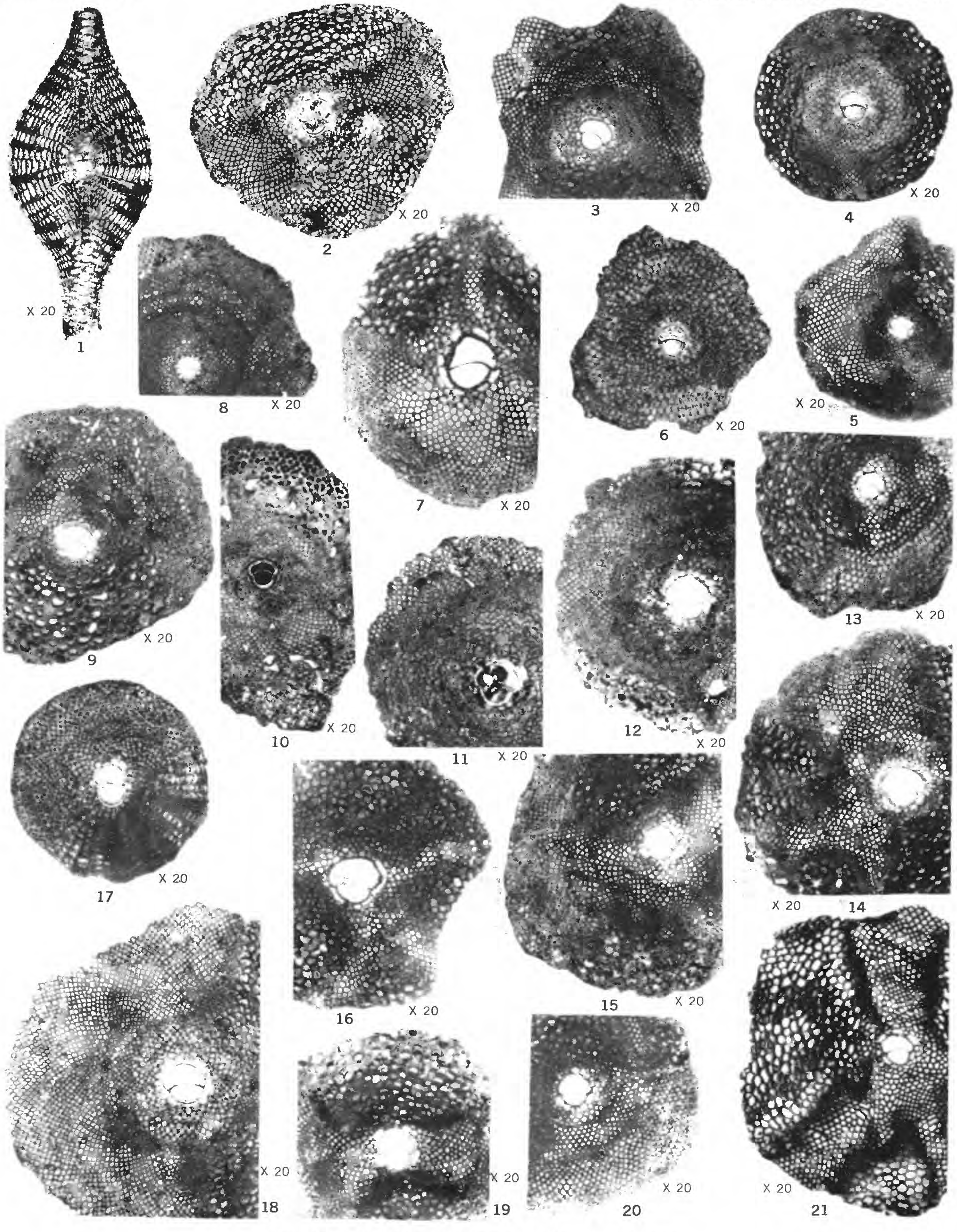
FIGURES 1–30. *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* (Brady) (p. 773).

Vertical sections, × 20, illustrating the gradation from thin, compressed specimens to nearly globular ones, the range in number of lateral chambers and the degree of development of pillars; Eniwetok drill holes K–1B, E–1, and F–1.

1, 8, 9, 10, 11. USNM P–3570a–e, from hole E–1 at 1070–1080 feet.
2, 16, 19. USNM P–3571a–c, from hole E–1 at 1,569–1,599 feet.
3, 5, 17, 18, 20, 27. USNM P–3572a–f, from hole K–1B at 1,112–1,122 feet.
4. USNM P–3573, from hole F–1 at 1,718–1,740 feet, core 4.
6. USNM P–3574, from hole E–1 at 1,365–1,375 feet.
7. USNM P–3575, from hole E–1 at 1,310–1,320 feet.
12, 13, 15. USNM P–3576a–c, from hole E–1 at 1,658–1,688 feet.
14. USNM P–3577, from hole E–1 at 1,715–1,746 feet.
21, 24, 30. USNM P–3578a–c, from hole E–1 at 1,140–1,150 feet.
22, 23, 26. USNM P–3579a–c, from hole K–1B at 1,143–1,154 feet.
25, 28. USNM P–3580a, b, from hole E–1 at 1,130–1,140 feet.
29. USNM P–3581, from hole E–1 at 1,688–1,715 feet.



MIOCENE *LEPIDOCYCLINA* (*NEPHROLEPIDINA*)



MIOCENE *LEPIDOCYCLINA* (*NEPHROLEPIDINA*)

PLATE 242

FIGURES 1, 2. *Lepidocyclina* (*Nephrolepidina*) *pumilipapilla* Cole (p. 773).

1. Vertical section, × 20, USNM P–3582, from hole F–1 at 1,718–1,740 feet, core 4.
2. Equatorial section, × 20, USNM P–3583, from the same sample as figure 1.

3–20. *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* (Brady) (p. 773).

Equatorial sections, × 20, illustrating the range in size of the embryonic chambers; these sections are companion ones at comparable depths to the vertical sections illustrated on plate 241.

3. USNM P–3584, from hole E–1 at 1,715–1,746 feet.
4, 11, 12. USNM P–3585a–c, from hole E–1 at 1,569–1,599 feet.
5. USNM P–3586, from hole E–1 at 1,070–1,080 feet.
6. USNM P–3587, from hole F–1 at 1,718–1,740 feet, core 4.
7–9, 13–16, 20. USNM P–3588a–h, from hole K–1B at 1,122–1,133 feet.
10. USNM P–3589, from hole E–1 at 1,365–1,375 feet.
17. USNM P–3590, from hole E–1 at 1,688–1,715 feet.
18. USNM P–3591, from hole E–1 at 1,658–1,688 feet.
19. USNM P–3592, from hole E–1 at 1,140–1,150 feet.

21. *Lepidocyclina* (*Nephrolepidina*) *bikiniensis* Cole (p. 772).

Equatorial section, × 20, introduced for comparison with the equatorial sections of *L.* (*N.*) ***sumatrensis;*** USNM P–3593, from hole K–1B at 1,143–1,154 feet.

PLATE 243

FIGURES 1–3. *Miogypsinoides dehaartii* (Van der Vlerk) (p. 769).

1, 3. Equatorial sections, × 20, USNM P–3642a, b, from hole E–1 at 1,365–1,375 feet.

2. Vertical section, × 20, USNM P–3643, from the same sample as figures 1 and 3.

4–9, 12. *Miogypsinoides grandipustula* Cole (p. 769).

4, 5. External views, × 20, illustrating the very large, coarse pustules which characterize this species; USNM P–3644a, b, from hole E–1 at 1,746–1,776 feet.

6, 7. Vertical sections, from hole E–1. 6, megalospheric specimen × 40, USNM P–3645, at 1,746–1,776 feet; 7, microspheric specimen × 20, USNM P–3646, at 1,658–1,688 feet.

8, 9. Equatorial sections, × 40, of megalospheric specimens from hole E–1; 8, USNM P–3647, at 1,210–1,220 feet, probably represents this species; 9, USNM P–3648, at 1,629–1,658 feet undoubted specimen of this species.

12. Equatorial section, × 20, of a microspheric specimen, USNM P–3649, from the same sample as figure 9.

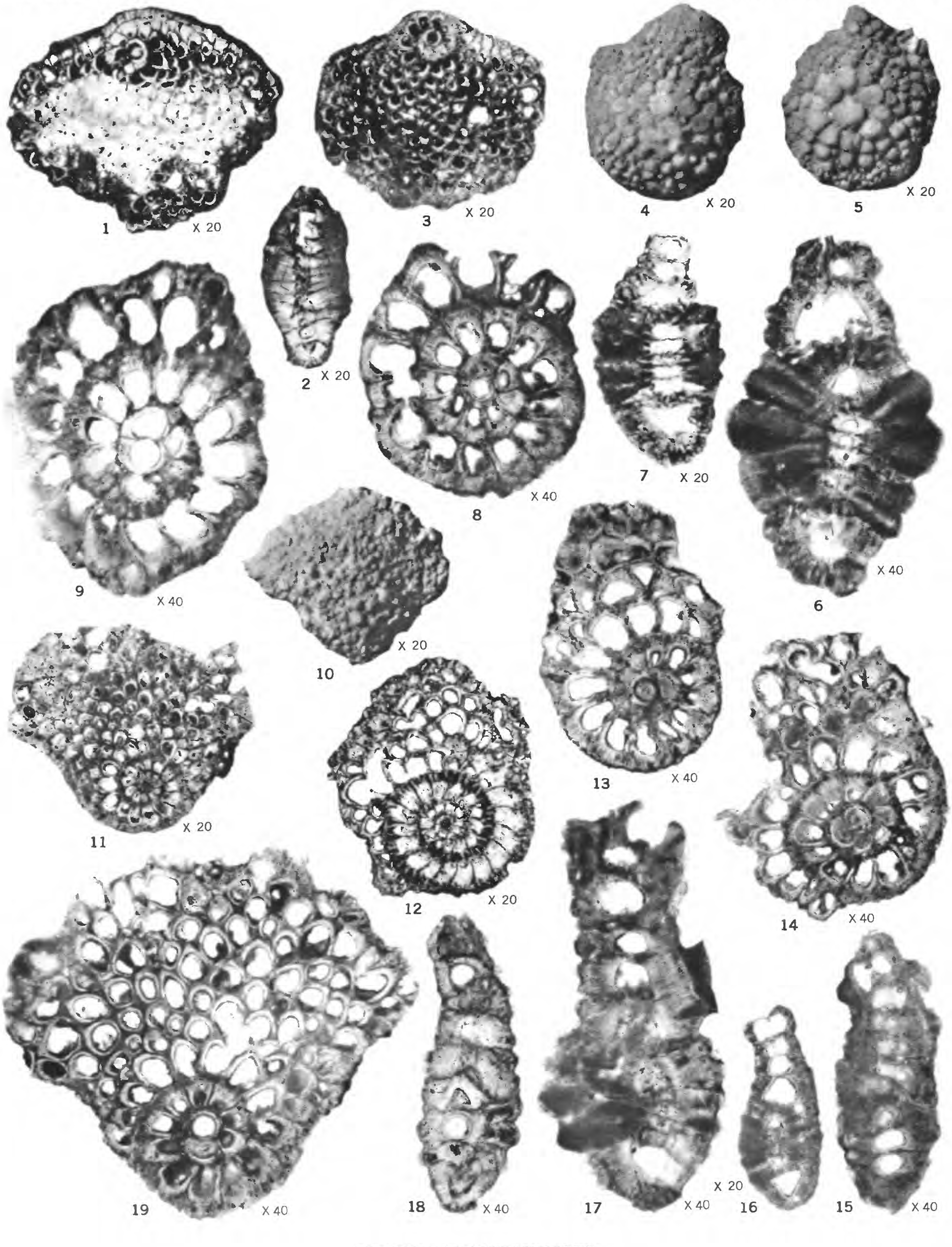
10, 11, 13–19. *Miogypsinoides ubaghsi* Tan. (p. 770).

10. External view, × 20, illustrating the characteristic fan shape of the test and the small pustules; USNM P–3650, from hole E–1 at 1,629–1,658 feet.

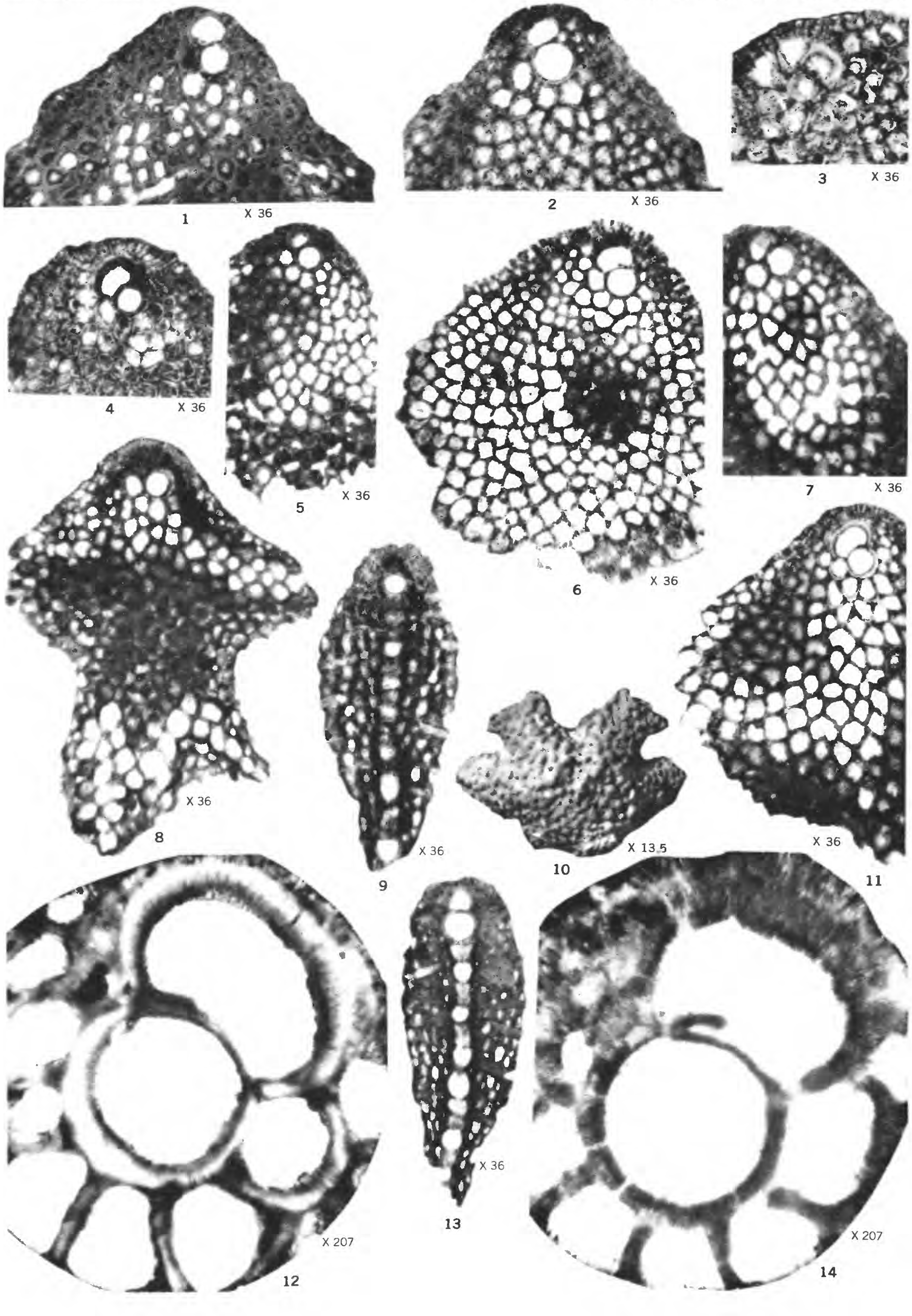
11. Equatorial section, × 20, of a microspheric specimen; USNM P–3651, from hole E–1 at 1,569–1,599 feet.

13, 14, 19. Equatorial sections, × 40, of megalospheric individuals from hole E–1. 13, USNM P–3652, at 1,569–1,599 feet; 14, USNM P–3653, at 1,541–1,569 feet; 19, USNM P–3654, at 1,688–1,715 feet.

15–18. Vertical sections of specimens from hole E–1. 15, megalospheric specimen, × 40, USNM P–3655, at 1,541–1,569 feet; 16, microspheric specimen, × 20, USNM P–3656, at 1,658–1,688 feet; 17, microspheric specimen, × 40, USNM P–3657, at 1,715–1,746 feet; 18, megalospheric specimen, × 40, USNM P–3658, at 1,746–1,776 feet.



MIOCENE *MIOGYPSINOIDES*



MIOCENE *MIOGYPSINOIDES* AND *MIOGYPSINA*

PLATE 244

FIGURES 1, 2, 4–7, 11–14. *Miogypsina* (*Miogypsina*) *thecideaeformis* (L. Rutten) (p. 771).

1, 2, 4–7, 11. Parts of equatorial sections, × 40, illustrating the embryonic, periembryonic, and equatorial chambers. From hole K–1B: 1, USNM P–3659a, at 1,133–1,143 feet; 2, topotype of *M.* (*M.*) *kotoi* Hanzawa from Inokosi, Kayamaiti, Koyama-mur, Kawakanir-gun, Okayama Prefecture, Japan. From hole E–1: 4, USNM P–3660c, at 1,100–1,110 feet; 5, USNM P–3662, at 1,140–1,150 feet; 6, USNM P–3660b, at 1,100–1,110 feet; 7, USNM P–3663, at 1,160–1,170 feet; 11, probable topotype of *M.* (*M.*) *thecideaeformis* from Balik-Papan, East Borneo.

12, 14. Part of the embryonic apparatus, × 230, illustrating the details of the chambers and the stoloniferous passages. 12, part of the section illustrâted as figure 11; 14, part of the section illustrated as figure 6; 12, 14, taken from the opposite sides of the sections from the other views.

13. Vertical section, × 40, USNM P–3668, from hole E–1 at 1,140–1,150 feet.

3. *Miogypsinoides dehaartii* (Van der Vlerk) (p. 769).

Part of an equatorial section, × 40, illustrating the embryonic and periembryonic chambers from hole E–1, USNM P–3674, at 1,200–1,210 feet.

8–10. *Miogypsina* (*Miogypsina*) *musperi* Tan (p. 771).

8. Equatorial section, × 40, from hole E–1, USNM P–3666, at 1,290–1,300 feet.

9. Vertical section, × 40, from hole E–1, USNM P–3664, at 1,130–1,140 feet.

10. External view, × 15, USNM P–3665, from the same sample as figure 9.

PLATE 245

FIGURES 1, 2. *Fabiania saipanensis* Cole (p. 767).

1. Axial section, × 40, USNM P–3676, from hole F–1 at 4,197–4,222 feet, core 11.
2. Transverse section, × 40, USNM P–3677, from the same sample as figure 1.

3–10, 13–15, 17. *Asterocyclina incisuricamerata* Cole (p. 776).

3, 7, 8, 14, 17. Vertical sections of specimens from hole F–1. 3, 14, × 40, USNM P–3678a, b, at 4,406–4,431 feet, core 13; 7, 8, 17, × 20, USNM P–3679a–c, at 4,500–4,525 feet, core 14.

4, 5, 9, 10. Equatorial sections from hole F–1. 4, × 40, USNM P–3680, at 4,406–4,431 feet, core 13; 5 (× 20), 9 (× 40), 10 (× 20), USNM P–3681a–c, at 4,500–4,525 feet, core 14.

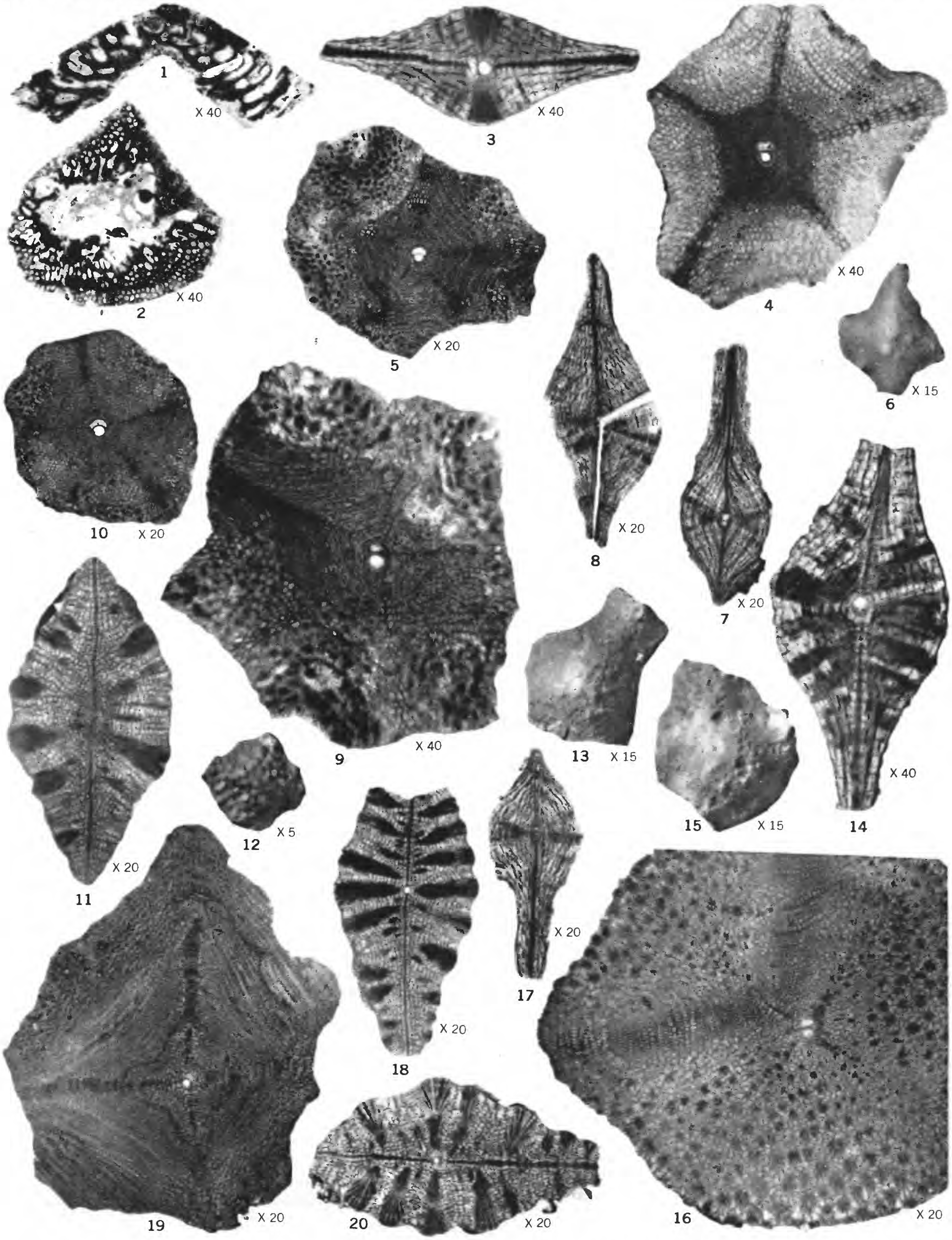
6, 13, 15. External views, × 15, from hole F–1. 6, USNM P–3682, at 4,406–4,431 feet, core 13; 13, 15, USNM P–3683a, b, at 4,500–4,525 feet, core 14.

11, 12, 16, 18–20. *Asterocyclina praecipua* Cole, n. sp. (p. 780).

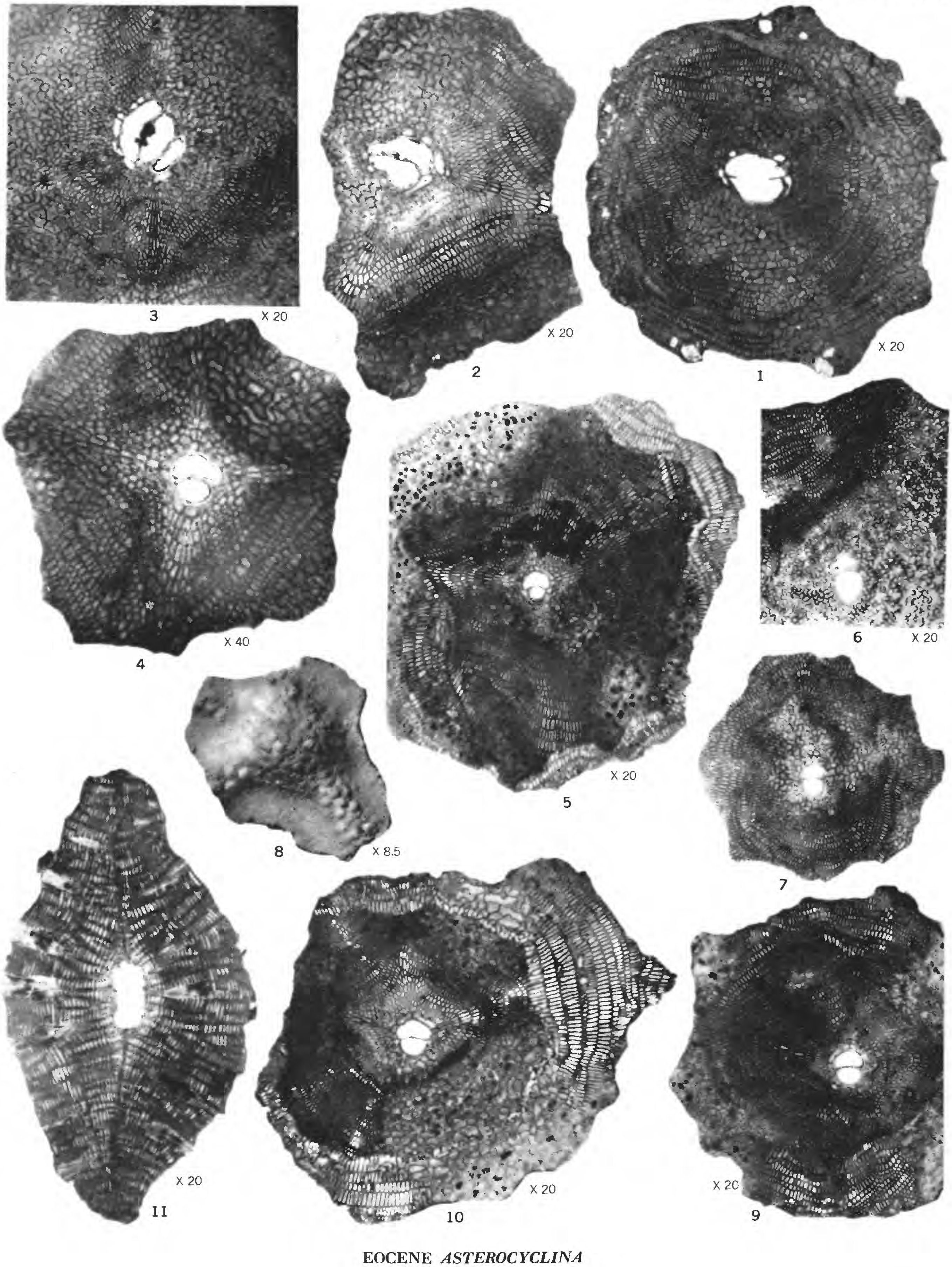
11, 18, 20. Vertical sections, × 20, USNM P–3684 a–c, from hole F–1 at 4,316–4,341 feet, core 12.

12. External view, × 5. illustrating the four rays and coarsely pustulose surface; holotype, USNM P–3685, from the same sample as figures 11, 18, 20.

16, 19. Equatorial sections, × 20, USNM P–3686a, b, from the same sample as figures 11, 18, 20.



EOCENE *ASTEROCYCLINA* AND *FABIANIA*



EOCENE *ASTEROCYCLINA*

PLATE 246

Figures 1–11. *Asterocyclina penuria* Cole (p. 778).

1–7, 9, 10. Equatorial sections from hole F–1. 1–3, × 20, specimens with large irregular embryonic chambers, USNM P–3687a–c, respectively at 4,316–4,341 feet, core 12; 4, × 40, specimen with normal embryonic chambers, USNM P–3688a, at 4,406–4,431 feet, core 13; 5, × 20, specimen with normal embryonic chambers, USNM P–3688b, at 4,406–4,431 feet, core 13; 6, × 20, USNM P–3689, at 4,500–4,525 feet, core 14; 7, × 20, specimen with normal embryonic chambers, USNM P–3688c, at 4,406–4,431 feet, core 13; 9, × 20, specimen with normal embryonic chambers, USNM P–3688d, at 4,406–4,431 feet, core 13; 10, × 20, specimen with normal embryonic chambers, USNM P–3688e, at 4,406–4,431 feet, core 13.

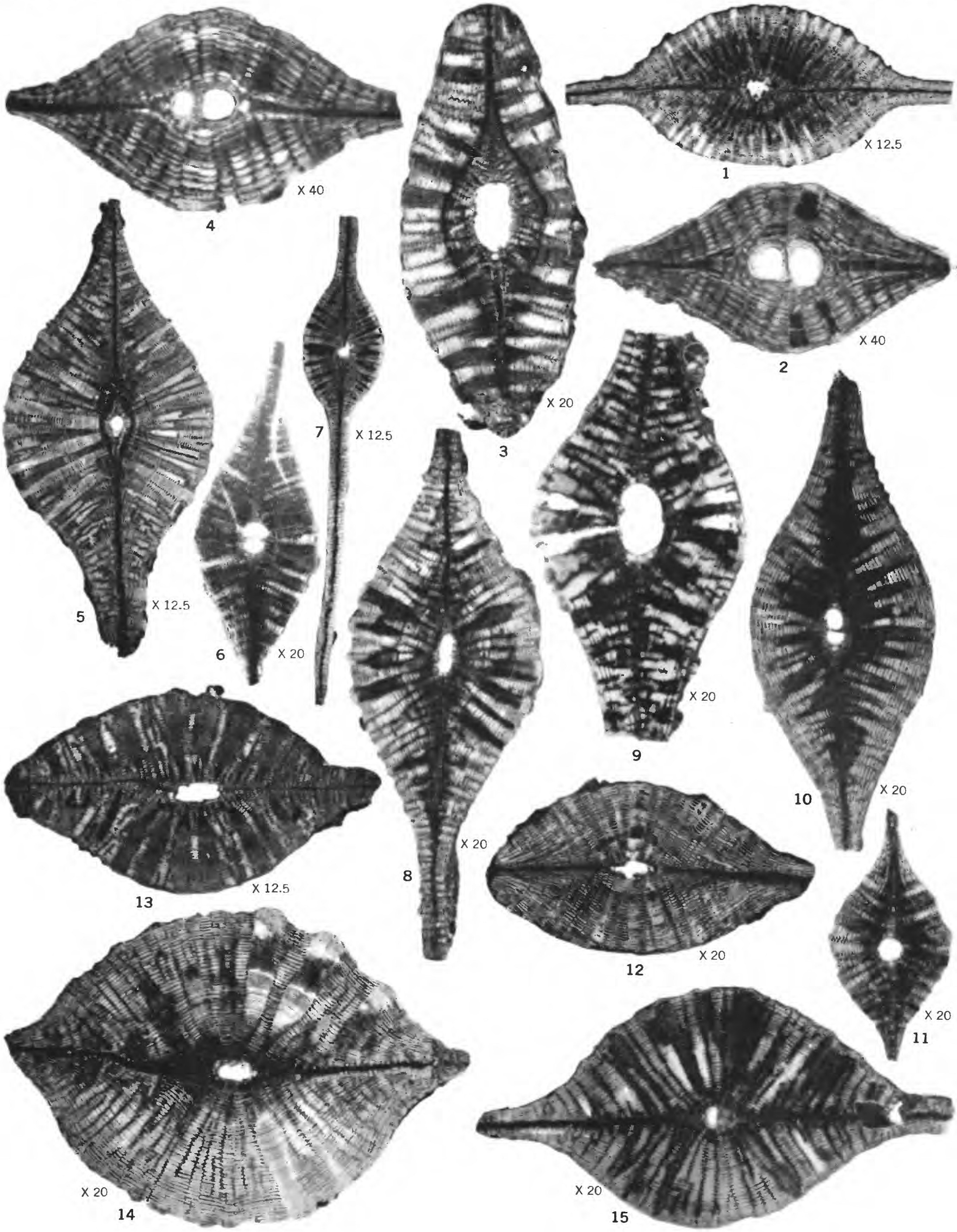
8. External view, × 8.5, USNM P–3690, from hole F–1, at 4,406–4,431 feet, core 13.

11. Vertical section, × 20, USNM P–3691, from hole F–1 at 4,316–4,341 feet, core 12.

PLATE 247

FIGURES 1–15. *Asterocyclina penuria* Cole (p. 778).

Vertical sections illustrating the gradation from small specimens to those with a distinctly inflated umbo surrounded by a wide fragile rim; from hole F–1. 1, 5, 7, 13, × 12.5; 2, 4, × 40; 3, 6, 8–12, 14, 15, × 20; 1, 7, 12, USNM P–3692a–c, at 4,500–4,525 feet, core 14; 2, 4–6, 8, 10, 11, 14, 15, USNM P–3693a–i, at 4,406–4,431 feet, core 13; 3, 9, 13, USNM P–3694a–c, at 4,316–4,341 feet, core 12.



EOCENE *ASTEROCYCLINA*

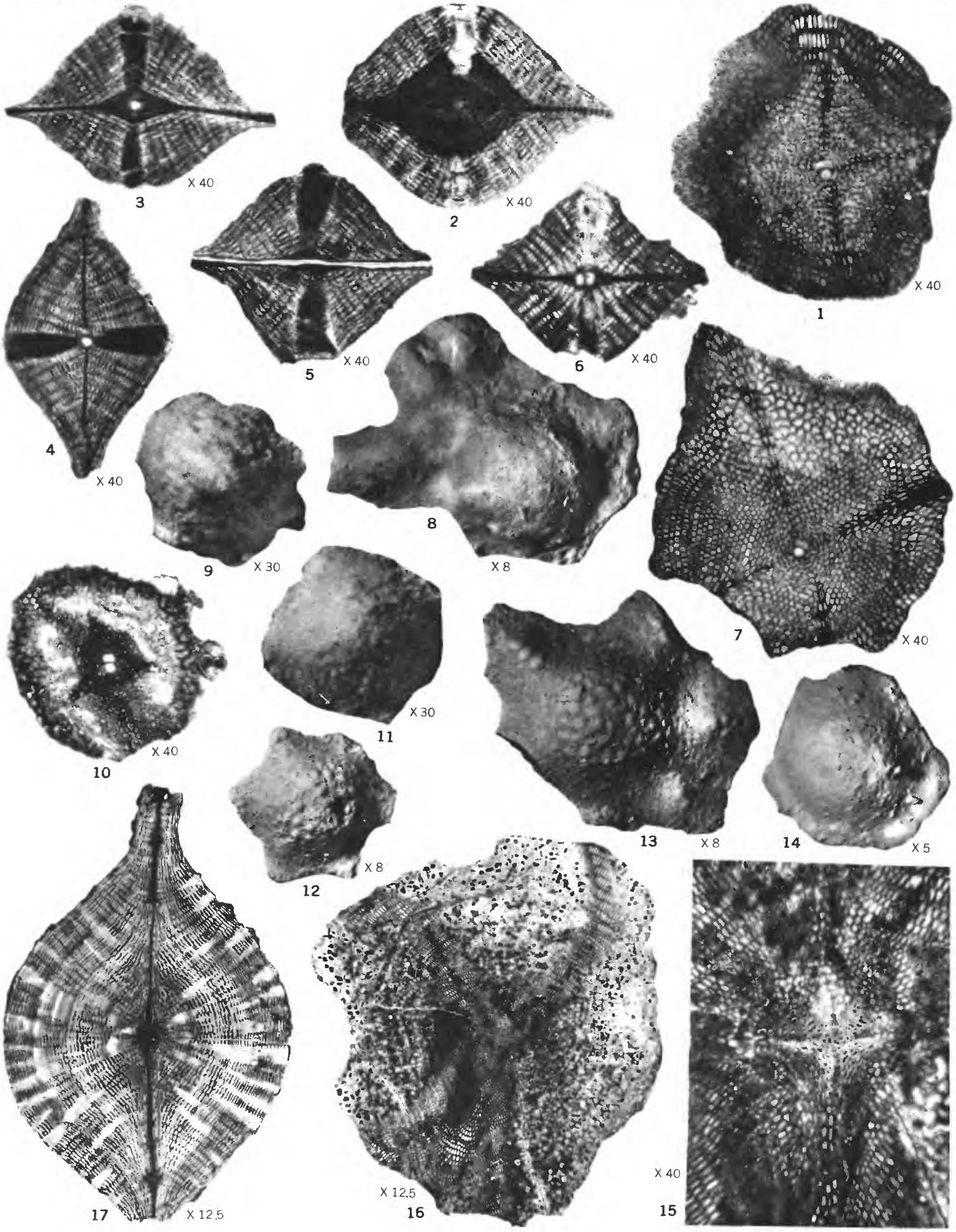


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PLATE 248

FIGURES 1–7, 9–11. *Asterocyclina centripilaris* Cole, n. sp. (p. 775).

1, 7, 10. Equatorial sections, × 40, of specimens from hole F–1. 1, USNM P–3695, at 4,316–4,341 feet, core 12; 7, 10, USNM P–3696a, b, at 4,197–4,222 feet, core 11.

2–6. Vertical sections, ×40, of specimens from hole F–1. 2, USNM P–3697, at 4,406–4,431 feet, core 13; 3, 5, 6, USNM P–3698a–c, at 4,197–4,222 feet, core 11; 4, USNM P–3699, at 4,316–4,341 feet, core 12.

9, 11. External views, × 30, of specimens from hole F–1 at 4,197–4,222 feet, core 11. 9, holotype, USNM P–3700a; 11, USNM P–3700b.

8, 12–17. *Asterocyclina penuria* Cole (p. 778).

8, 12–14. External views, of specimens from hole F–1 at 4,406–4,431 feet, core 13. 8, 12, 13, megalospheric specimens, USNM P–3701a–c, respectively, × 8; 14, microspheric specimen, USNM P–3701d, ×5.

15, 16. Equatorial section of microspheric specimen, USNM P–3702, from hole F–1 at 4,406–4,431 feet, core 13. 15, a × 40 enlargement of central part of figure 16; 16, × 12.5.

17. Vertical section, × 12.5, of microspheric specimen, USNM P–3703, from the same sample as figures 15, 16.

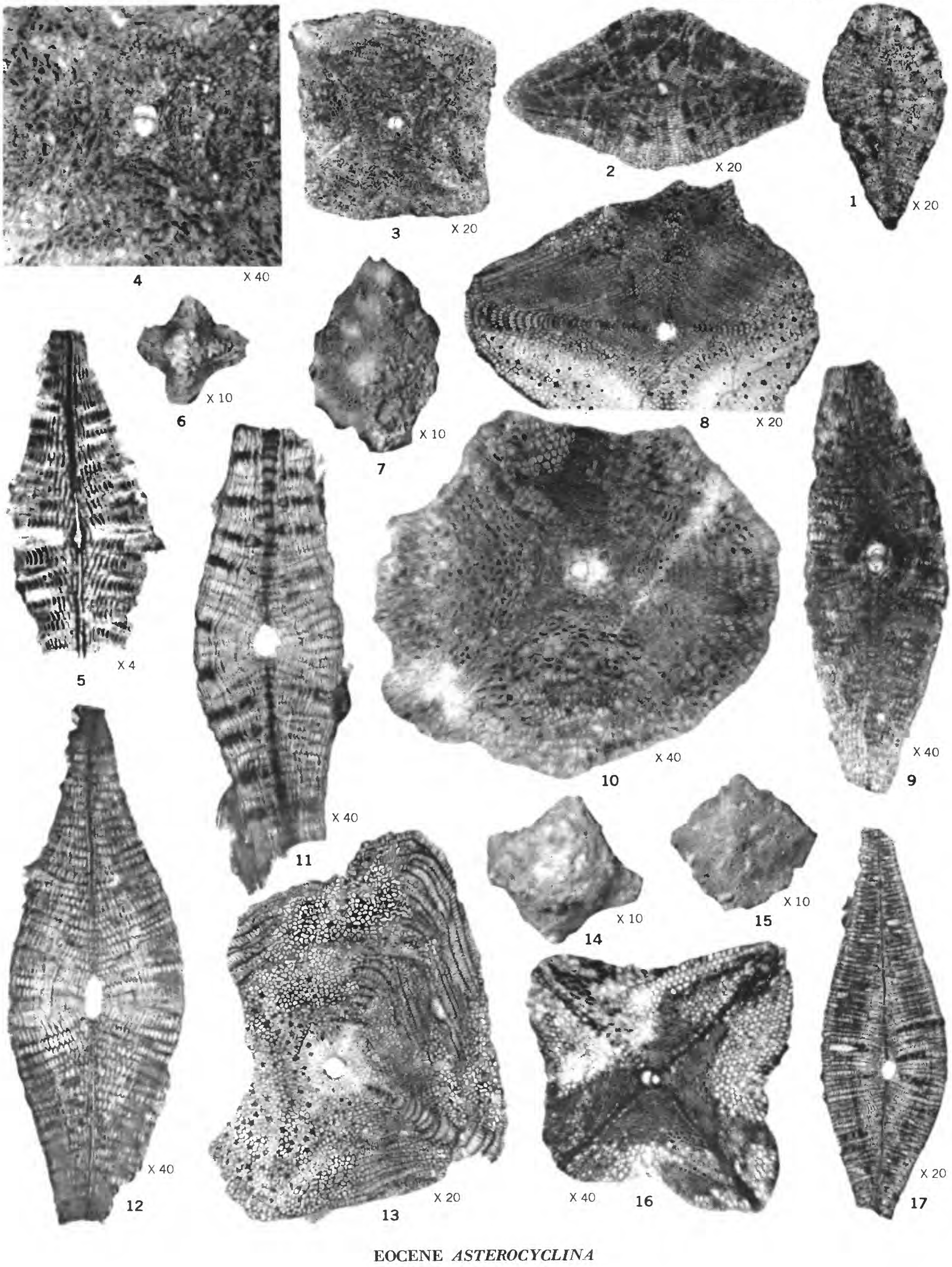
PLATE 249

FIGURES 1–17. *Asterocyclina matanzensis* Cole (p. 777).

1, 2, 5, 9, 11, 12, 17. Vertical sections, 1, 2, 17, × 20. 5, 9, 11, 12, × 40. From hole E–1: 1, 9, USNM P–3704a, b, at 2,910–2,920 feet; 2, USNM P–3705, at 2,940–2,950 feet. From hole F–1: 5, USNM P–3706, at 4,500–4,525 feet, core 14; 11, 12, 17, USNM P–3707a–c, at 4,197–4,222 feet, core 11.

3, 4, 8, 10, 13, 16. Equatorial sections, 3, 8, 13, × 20; 4 (central part of figure 3), 10, 16, × 40. From hole E–1: 3, 4, 10, USNM P–3708a, b, at 2,910–2,920 feet. From hole F–1: 8, 13, USNM P–3709a, b, at 4,197–4,222 feet, core 11; 16, USNM P–3710, at 4,500–4,525 feet, core 14.

6, 7, 14, 15. External views of specimens, × 10. From hole F–1: 6, USNM P–3711, at 4,500–4,525 feet, core 14; 7, USNM P–3712, at 4,197–4,222 feet, core 11. From hole E–1: 14, 15, USNM P–3713a, b, at 2,910–2,920 feet



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