Eocene and Oligocene Larger Foraminifera From the Panama Canal Zone and Vicinity

GEOLOGICAL SURVEY PROFESSIONAL PAPER 244

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By W. STORRS COLE

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Prepared under the auspices of the
Technical Cooperation Administration
of the United States Department of State

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1952

UNITED STATES DEPARTMENT OF THE INTERIOR

Oscar L. Chapman, *Secretary*

GEOLOGICAL SURVEY

W. E. Wrather, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price $1.25 (paper)

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EOCENE AND OLIGOCENE LARGER FORAMINIFERA FROM THE PANAMA CANAL ZONE AND VICINITY

By W. Storrs Cole

ABSTRACT

Forty species and two varieties from the Eocene and Oligocene of the Panama Canal Zone and vicinity are discussed and illustrated. Twenty-one species and one variety are reported from the middle (?) and upper Eocene Gatuncillo formation. Eight upper Eocene species, including two species not found in the Gatuncillo formation, occur in a marine tongue (?) in the Bohio (?) formation of the Gatun Lake area. Nine species, of which one, *Lepidocyclina* (*Pliolepidina*) *gubernacula*, is new, are recorded for the first time in the Eocene of Panama. Seventeen species and a variety are found in the upper Oligocene part of the Caimito formation and in the fossiliferous upper Oligocene part of the Bohio formation in the Pacific coastal area. Ten species and one variety were not known previously in the Oligocene of Panama.

At least most of the Gatuncillo formation, by means of its fauna of larger Foraminifera, is correlated with the upper Eocene San Fernando (or Mount Moriah) formation of Trinidad and the upper Eocene Ocala limestone of Florida. It should be noted, however, that the Gatuncillo contains two species which are reported only from the middle Eocene. The parts of the Caimito formation containing larger Foraminifera and the upper part of the Bohio formation in the Pacific coastal area are correlated with the Suwannee limestone of Florida, the Antigua formation of Antigua, and the Meson formation of Mexico, all of late Oligocene age.

INTRODUCTION

During the past year and a half it has been a great pleasure to study the larger Foraminifera in a series of samples from the Eocene and Oligocene strata of the Panama Canal Zone and vicinity. These samples were collected by W. P. Woodring of the U. S. Geological Survey, in cooperation with T. F. Thompson, former Chief of the Geological Section of the now abolished Special Engineering Division of the Panama Canal. Mr. Thompson and the geologists of his staff, particularly S. M. Jones, J. R. Schultz, R. H. Stewart, and J. A. Tavelli, not only provided assistance in making the collections, but also supplied stratigraphic data. Mr. Woodring in turn freely and generously placed all of this information at my command. To all of these geologists, and especially to Mr. Woodring, I am indebted and grateful.

The stratigraphic terminology recently proposed by Woodring and Thompson (1949, pp. 992–996), shown with slight modification in figure 1, is used in the present report. Jones (1950, pp. 893–922) in an article entitled "Geology of Gatun Lake and vicinity, Panama" does not entirely agree with the terminology proposed by Woodring and Thompson. It is beyond the scope of the present work, however, to attempt to reconcile these differences.

Twenty-nine samples, of which 16 are referred to the Eocene and 13 to the Oligocene, were studied. The samples were selected from a group of 45 to represent different geographic areas, the greatest possible stratigraphic range, and various lithologic facies. The index map (fig. 2) shows the localities where the specimens were collected. The description of the localities is given in the discussion under the heading "Distribution and correlation of faunas." Although larger Foraminifera could be collected at an almost indefinite number of localities in the Gatuncillo and Caimito formations, particularly in the limestones of the Gatuncillo and in limestones of the middle member of the Caimito in the Gatun Lake area (Woodring, oral communication), it is believed that the representative samples which were selected give an accurate reflection of the Panamanian faunas.

Forty distinct species and two varieties are discussed and illustrated. Of these, 23 species and 1 variety are from the Eocene, and 17 species and 1 variety are from the Oligocene. Nine species, of which 1 is new, are recorded for the first time in the Eocene of Panama and 10 species and 1 variety not previously known in the Oligocene of Panama are placed on record. All of the Panamanian specimens are deposited in the collec-lection of the U. S. National Museum.

PREVIOUS RECORDS OF LARGER FORAMINIFERA

Lemoine and R. Douvillé (1904, pp. 14, 20, 21) described the first larger Foraminifera from Panama when they named specimens from their Haut-Chagres locality (San Juan de Pequení, a locality in the upper Chagres Valley submerged by Madden Lake) *Lepidocyclina chaperi*, and others from Peña Blanca (submerged by Gatun Lake) *Lepidocyclina canellei*. These species were assigned to the Aquitanian (upper Oligocene or lower Miocene).

Cushman (1919a, pp. 89–102) reported on collections made by T. Wayland Vaughan and D. F. MacDonald in the Canal Zone and by MacDonald in western Panama. He recorded 10 species, all of which he placed in the Oligocene, although he questioned this assignment in the case of 3 species. The names used by

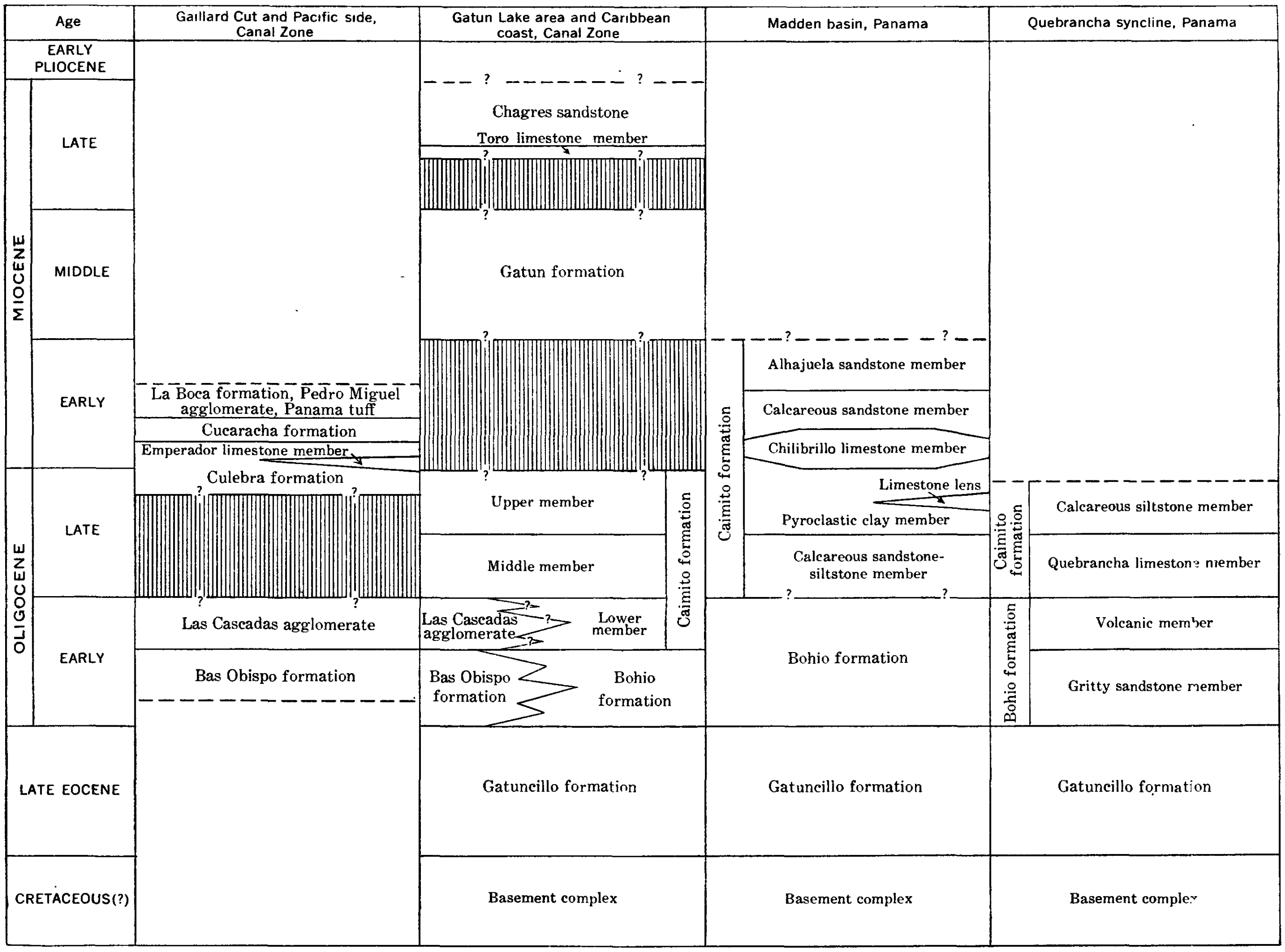

FIGURE 1.—Tertiary formations of Panama Canal Zone and adjoining parts of Panama. (After Woodring and Thompson (1949, fig. 2) with slight modification.)

Cushman, except *Orbitolites americana* which does not occur in the collections described in the present report, are given in the following table with the names which are assigned these species at present. Cushman's species that were recorded only from localities in western Panama are so specified in the table.

Larger Foraminifera from the Canal Zone and Panama recorded by Cushman (1919a)

Name used by Cushman	Name used at present
Lepidocyclina canellei Lemoine and R. Douvillé (pl. 34, figs. 1–6)	*L.* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé.
Lepidocyclina chaperi Cushman [not Lemoine and R. Douvillé] (pl. 35, figs. 1–3; pl. 36).	Probably *L.* (*Lepidocyclina*) *waylandvaughani* Cole.
Lepidocyclina vaughani Cushman (part: pl. 37, figs. 4, 5; pl. 38)	*L.* (*Nephrolepidina*) *vaughani* Cushman.
Lepidocyclina vaughani Cushman (part: pl. 37, figs. 1 (?), 2, 3)	Probably *L.* (*Lepidocyclina*) *waylandvaughani* Cole.
Lepidocyclina panamensis Cushman (pl. 39, figs. 1–6), western Panama	*L.* (*Pliolepidina*) *pustulosa tobleri* H. Douvillé.
Lepidocyclina macdonaldi Cushman (pl. 40, figs. 1–6), western Panama	*L.* (*Pliolepidina*) *macdonaldi* Cushman.
Multicyclina duplicata Cushman (pl. 41, figs. 2–4), western Panama	*L.* (*Pliolepidina*) *pustulosa* H. Douvillé, microspheric generation.
Orthophragmina minima Cushman (pl. 41, fig. 1), western Panama	*Asterocyclina minima* (Cushman).
Heterosteginoides panamensis Cushman (part: pl. 43, figs. 3–8)	*Miogypsina* (*Miolepidocyclina*) *panamensis* (Cushman).
Heterosteginoides panamensis Cushman (part: pl. 43, figs. 1, 2)	*Miogypsina* (*Miogypsina*) *antillea* (Cushman).
Nummulites panamensis Cushman (pl. 43, figs. 9, 10)	*Operculinoides panamensis* (Cushman).
Nummulites davidensis Cushman (pl. 43, fig. 11), western Panama	Probably *Operculinoides ocalanus* (Cushman).

Later, Cushman (1920, p. 39) in a summary entitled "The American Species of *Orthophragmina* and *Lepidocyclina*" correctly assigned the limestone at David (in Chiriqui Province, western Panama) containing *Orthophragmina minima* to the Eocene, but he placed *L. panamensis* and *L. duplicata* in both the Eocene and Oligocene.

Vaughan (1923, p. 257) reclassified specimens included by Cushman in *Lepidocyclina vaughani* and described another new species which he named *L. miraflorensis*. Later, Vaughan (1924) divided *Heterosteginoides panamensis* Cushman and named the new species *Miogypsina cushmani*. Vaughan (1926) recognized as upper Eocene the following species from San

Juan de Pequení, the type locality of *Lepidocyclina chaperi* in the Chagres Valley, now flooded by Madden Lake: *Operculina* sp. cf. *O. ocalana* Cushman, *Heterostegina ocalana glabra* Cushman, *Asteriacities georgiana* (Cushman), *Lepidocyclina* (*Nephrolepidina*) *chaperi* Lemoine and R. Douvillé, *Lepidocyclina* sp., and *Discocyclina* sp.

Coryell and Embich (1937, p. 305) described a new species, *Asterocyclina gamboaensis*, from Eocene strata in the upper Chagres Valley near the village of Tranquilla, also now flooded by Madden Lake. This species is illustrated by a drawing of only the exterior and, therefore, cannot be recognized definitely. It is probably a specimen of *A. georgiana* (Cushman).

Cole (1949, pp. 267–275) described an Eocene fauna from core hole SL–84 in the Río Agua Salud area (Canal Zone), 3.6 miles northwest of Frijoles, and from outcrop float from the same locality. A list of the species recorded from these samples is included in the list of species recovered from the Gatuncillo formation in the samples discussed in the present paper.

The only species described from Panama concerning which uncertainty must exist is *Lepidocyclina* (*Nephrolepidina*) *decorata* H. Douvillé (1924), from the type locality of *L. chaperi*. At the present time it is impossible to identify this species with any of the known Panamanian species. There is the possibility that it was based on a form of *L. chaperi* with unusually large pillars.

DISTRIBUTION AND CORRELATION OF FAUNAS

GATUNCILLO FORMATION (MIDDLE(?) AND UPPER EOCENE)

The Gatuncillo formation is the oldest fossiliferous formation in the Canal Zone and nearby. The distribution of the species in the Gatuncillo is shown in the chart on page 4, which includes the species previously reported from the Río Agua Salud area (Cole, 1949, pp. 267–275). The description of the localities follows the chart.

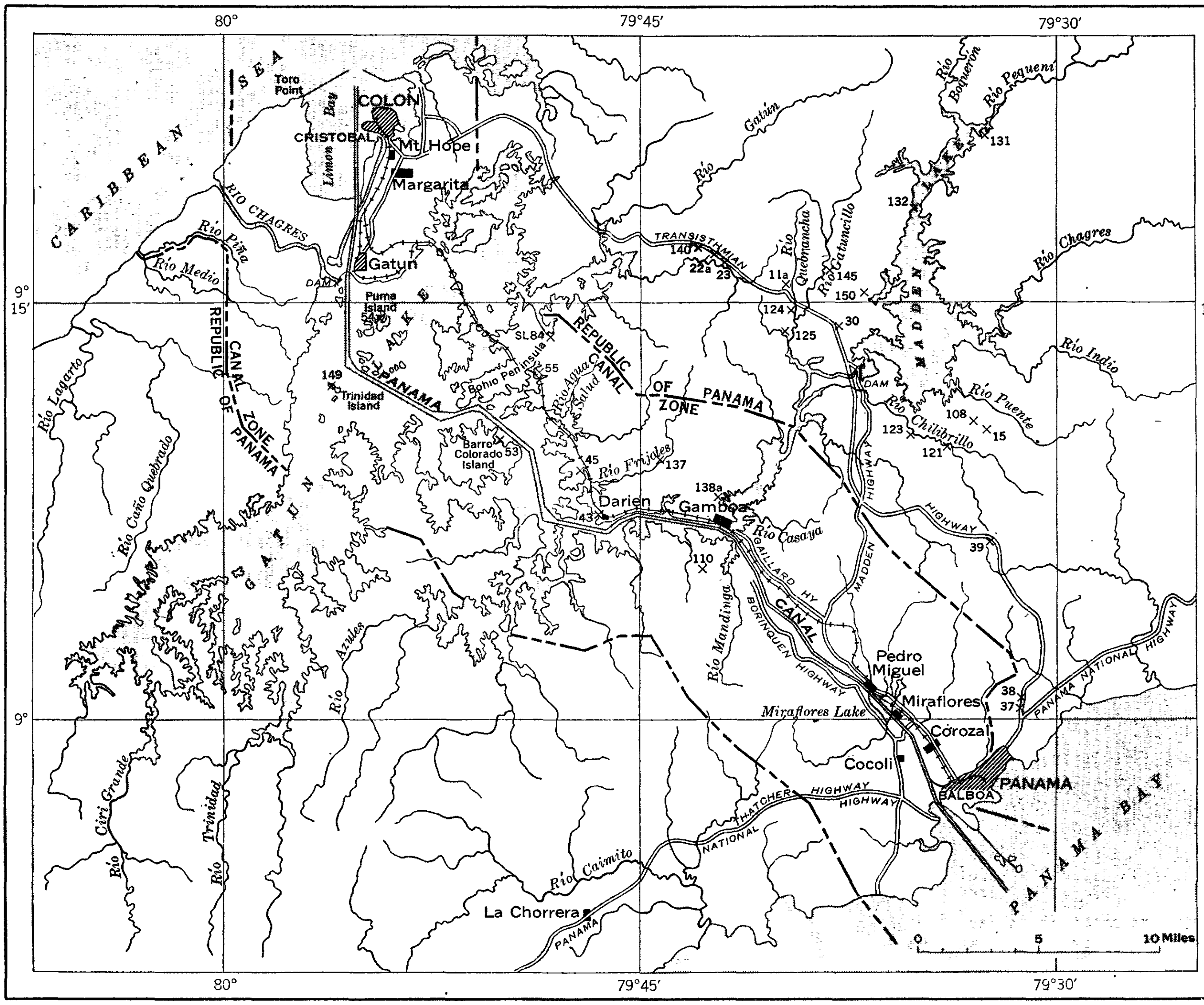

FIGURE 2.—Map of Panama Canal Zone and adjoining parts of Panama showing location of samples studied for present report. (After Woodring and Thompson (1949, fig. 1) with slight modification.)

Distribution of species from the Gatuncillo formation

	Madden basin						Quebrancha syncline						Río Agua Salud	Río Frijoles	Gamboa
	Fossil collecting localities														
	15	108	131	131a	132	150	22a	23	124	125	140	145	SL–84	137	138a
Yaberinella jamaicensis Vaughan			X	X											
Operculinoides floridensis (Heilprin)		X											X		
jacksonensis (Gravell and Hanna)		X													
moodybranchensis (Gravell and Hanna)		X													
ocalanus (Cushman)				X	X					X	X		X		X
vaughani (Cushman)				X							X				
Camerina striatoreticulata (L. Rutten)								X		X	X	X	X	X	
Heterostegina ocalana Cushman							X			X	X				
Fabiania cubensis (Cushman and Bermúdez)	X		X	X			X				X				X
Helicostegina soldadensis Grimsdale							X								
Lepidocyclina (*Lepidocyclina*) *montgomeriensis* Cole		X								X			X		
(*Pliolepidina*) *gubernacula* Cole, n. sp.							X	X							
macdonaldi Cushman	X		X	X	X	X			X	X	X	X	X		X
pustulosa H. Douvillé	X		X	X	X	X	X		X		X	X	X	X	X
pustulosa tobleri H. Douvillé		X		X	X				X			X	X		X
(*Nephrolepidina*) *chaperi* Lemoine and R. Douvillé	X					X	X	X		X	X			X	X
Helicolepidina spiralis Tobler					X	X	X			X			X	X	
Asterocyclina georgiana (Cushman)					X		X		X	X		X	X		
mariannensis (Cushman)											X				
minima (Cushman)							X				X		X		
Pseudophragmina (*Proporocyclina*) *flintensis* (Cushman)										X	X		X		

Madden Basin, Panama

15. Madden Airfield, about 1,000 feet north of north end of paved runway. Algal limestone. J. R. Schultz, T. F. Thompson, and W. P. Woodring, 1947.
108. Road to Madden Airfield, 0.5 mile northeast of Calzada Larga. Marly limestone. T. F. Thompson, 1948. Also a collection made by T. F. Thompson and W. P. Woodring, 1949.
131. South side of Río Pequení near head of Madden Lake, 400 feet west of former Canal Zone Pequení Police Substation. Thin-bedded limestone, 8 feet above base of Gatuncillo formation. T. F. Thompson and W. P. Woodring, 1949.
131a. Same locality. Thin-bedded nodular-weathering limestone, 25 feet higher stratigraphically. T. F. Thompson and W. P. Woodring, 1949.
132. West shore of Madden Lake at abandoned Salamanca Gaging Station. Fairly soft limestone. T. F. Thompson and W. P. Woodring, 1949.
150. Trail west of Madden Lake, 3 miles north of Madden Dam. Limestone. T. F. Thompson and W. P. Woodring, 1949.

Quebrancha syncline, Panama

22a. Transisthmian Highway, 4.1 miles in direct line northwest of Río Gatuncillo bridge. Calcareous sandstone, 0.25 to 0.5-inch thick, in silty mudstone. J. R. Schultz and W. P. Woodring, 1947.
23. Transisthmian Highway, 3.6 miles in direct line northwest of Río Gatuncillo bridge. Calcareous mudstone. J. R. Schultz and W. P. Woodring, 1949.
124. Road to Nuevo San Juan, 0.4 mile southwest of junction with Transisthmian Highway. Fairly soft limestone. T. F. Thompson and W. P. Woodring, 1949.
125. Road to Nuevo San Juan, 1.3 miles southwest of junction with Transisthmian Highway. Fairly soft limestone. T. F. Thompson and W. P. Woodring, 1949.
140. Transisthmian Highway, 4.6 miles in direct line northwest of Río Gatuncillo bridge. Poorly sorted, gritty sandstone. T. F. Thompson and W. P. Woodring, 1949.
145. Trail on east side of Río Gatuncillo, 1.3 miles northeast of Transisthmian Highway bridge across Río Gatuncillo. Soft limestone. W. P. Woodring, 1949.

Río Agua Salud area, Canal Zone

SL–84. Core hole SL–84; 1,000 feet southeast of head of Quebrada La Chinilla arm of Gatun Lake and 200 feet northeast of pipeline road. Moderately soft limestone. Drilled in 1947.

Río Frijoles Area, Canal Zone

137. Pipeline road, 4 miles northwest of west end of Gamboa bridge. Fairly soft limestone. W. P. Woodring, 1949.

Gamboa Area, Canal Zone

138a. 1.2 miles north-northwest of west end of Gamboa bridge, on road to core holes SL–94 and SL–96, 50 feet south of bridge across drainage ditch. Fairly soft limestone. T. F. Thompson and W. P. Woodring, 1949.

The larger Foraminifera of the Gatuncillo formation consist overwhelmingly of species recorded elsewhere in formations of late Eocene age. Three of the species, however, evidently are found also in the middle Eocene; in fact, two (*Yaberinella jamaicensis* and *Fabiania cubensis*) up to this time have been recorded only from the middle Eocene.

Two samples from the base of the Gatuncillo contain *Yaberinella jamaicensis* Vaughan, a species recorded only from the Yellow limestone of Jamaica, which is assigned to the middle Eocene. Moreover, several samples from widely different parts of the Gatuncillo contain *Fabiania cubensis* (Cushman and Bermúdez). This species is reported, to date, only from the middle Eocene of Cuba and Florida. Yet in Panama these two species occur with many others which elsewhere mark the upper Eocene.

The genus *Yaberinella* has been reported from a known upper Eocene unit in Jamaica (Vaughan, 1929, p. 374). These specimens, however, were referred to a distinct species, *Y. trelawniensis*. In the present study it was found that this species and *Y. jamaicensis* could not be discriminated. It is assumed that the range of *Y. jamaicensis* extends from middle to upper Eocene.

Fabiania occurs in Cuba not only in deposits which contain middle Eocene species, but also in deposits which the writer and others consider to be late Eocene in age. Thus far, no satisfactory criteria have been devised from distinguishing specimens of this genus found in the middle Eocene from those which occur in the upper Eocene. Therefore, *F. cubensis* may range from middle to late Eocene, or the understanding of the criteria upon which differentiation could be based is not developed sufficiently.

There are other records which suggest that certain species of larger Foraminifera commonly thought to be restricted to the upper Eocene range from middle to upper Eocene. Vaughan (1928, pp. 281, 290) reported the occurrence of *Lepidocyclina pustulosa* with *Dictyoconus puilboreauensis* (=*D. americanus*) in Jamaica. Cole (1944, pp. 34, 69) recorded the occurrence of *L. pustulosa* in a deep well in Florida occurring stratigraphically below the *D. americanus* zone and in association with other middle Eocene species.

It would appear from these scattered records that certain species range from middle into upper Eocene. The writer, however, does not know of any authenticated record of upper Eocene larger Foraminifera occurring in the lower Oligocene. Because the Gatuncillo may include deposits of middle Eocene age, it is referred to the middle (?) and late Eocene.

The fauna of the Gatuncillo formation is dominated by species which are characteristic of the Ocala limestone of Florida and the San Fernando (or Mount Moriah) formation of Trinidad. There is an intermingling of species from these areas. Certain species of the known fauna of Panama and Trinidad, as *Camerina striatoreticulata*, have not been reported to date from Florida; whereas others that occur in Panama and Florida, as *Asterocyclina mariannensis*, have not been reported from Trinidad. These omissions may be the result of insufficient collecting or of regional faunal differentiation.

MARINE TONGUE (?) IN BOHIO (?) FORMATION, GATUN LAKE AREA, CANAL ZONE (UPPER EOCENE OR LOWER OLIGOCENE)

Two samples from Trinidad Island, in the western part of Gatun Lake, contain the species listed in the following chart:

Species from Trinidad Island

Species	Localities 149	149b
Operculinoides jacksonensis (Gravell and Hanna)	X	X
kugleri Vaughan and Cole	X	X
trinitatensis (Nuttall)	X	X
Camerina striatoreticulata (L. Rutten)		X
Fabiania cubensis (Cushman and Bermúdez)		X
Lepidocyclina (Pliolepidina) macdonaldi Cushman	X	X
pustulosa H. Douvillé	X	X
pustulosa tobleri H. Douvillé		X

149. Northeast coast of Trinidad Island. Dark gray sandy siltstone, basal 10 feet of exposed section. T. F. Thompson and W. P. Woodring, 1949.

149*b*. Same locality, about 10 feet higher stratigraphically. Three-foot ledge-forming silty medium-grained calcareous sandstone containing few small pebbles, few worn small heads of calcareous algae, and worn tips of *Turritella*. T. F. Thompson and W. P. Woodring, 1949.

The two samples from Trinidad Island contain eight species of larger Foraminifera, all of which, with the exception of *L. (P.) pustulosa* and *Fabiania cubensis*, are restricted to the upper Eocene elsewhere. The assignment of these samples to the Eocene on the basis of the larger Foraminifera was made before formation assignment of the samples was known to the writer. Woodring (oral communication), however, doubtfully places these samples in a marine tongue in the Bohio formation. According to him, the molluscan fauna from the siltstone exposed on Trinidad Island is the same as the lower Oligocene fauna reported from Vamos Vamos and Palenquilla Point (Woodring and Thompson, 1949, pp. 230–231), and the provisional formation assignment used for those localities is adopted for Trinidad Island. The Bohio formation overlies the Gatuncillo formation in the northeastern part of the Canal Zone and east of the Zone.

It should be noted that the samples from Trinidad Island are the only ones upon which there is not complete age agreement on the basis of the larger Foraminifera and mollusks. Because these samples contain eight species of larger Foraminifera, none of which has been reported from the lower Oligocene, it is not possible at the present to reconcile the conflicting evidence. For the time being the siltstone at Trinidad Island is considered upper Eocene or lower Oligocene.

There is always the possibility that the larger Foraminifera in these samples were reworked, but the evidence is against this hypothesis, as the specimens show little or no evidence of erosion. Moreover, there is not an admixture of faunas; the species are all from the Eocene, and all except two occur in the Gatuncillo formation. No discocyclinids were found at Trinidad Island, but none was found in seven samples from the Gatuncillo. If these localities represent the lower Oligocene as it is known in Florida, such species as *Lepidocyclina mantelli* and *Operculinoides dius* might be expected to occur instead of Eocene species.

THIN LENSES OF ALGAL LIMESTONE IN UPPER PART BOHIO FORMATION OF PACIFIC COASTAL AREA (UPPER OLIGOCENE)

At two localities in the Pacific coastal area, thin lenses of algal limestone in typical massive poorly sorted or unsorted basaltic conglomerate of the Bohio formation yielded the following species. Both localities represent horizons near the top of the Bohio of that area.

Species from Bohio formation of Pacific coastal area

	Localities	
	38	39
Heterostegina antillea Cushman	X	X
Lepidocyclina (Lepidocyclina) parvula Cushman	----	X
waylandvaughani Cole	X	----
yurnagunensis Cushman	----	X
yurnagunensis morganopsis Vaughan	X	X
(Nephrolepidina) vaughani Cushman	X	----
(Eulepidina) favosa Cushman	X	X
gigas Cushman	----	X

38. Transisthmian Highway. 0.6 mile north-northwest of junction with Panama National Highway. J. A. Tavelli and W. P. Woodring, 1947.
39. Transisthmian Highway, 5.7 miles north-northwest of junction with Panama National Highway, about 200 feet north of last (proceeding northward) crossing of Continental Divide. J. A. Tavelli and W. P. Woodring, 1947.

The only species found in the Bohio formation but not in the overlying Caimito formation are *Lepidocyclina (Eulepidina) favosa* Cushman and *L. gigas* Cushman. In the Gulf Coast of the United States in a zonation proposed by Gravell and Hanna (1938, p. 987) there are four larger foraminiferal zones above the top of the Eocene in ascending order: (1) *Lepidocyclina mantelli* zone, (2) *Lepidocyclina supera* zone, (3) *Lepidocyclina (Eulepidina)* zone, and (4) *Miogypsina-Heterostegina* zone. In Panama there is a similarity in that *Eulepidina* appears in the Bohio formation and in one sample from the lower part of the middle member of the Caimito formation in the Gatun Lake area. Three samples from the Caimito formation, however (including two from the member just mentioned) contain *Miogypsina*. The two lower zones have not been found as yet in Panama.

In the Gulf Coast of the United States *Lepidocyclina favosa* and *L. undosa* occur in the Suwannee limestone of Florida and in the Chickasawhay limestone of Alabama (Cole, 1945, p. 22; Gravell and Hanna, 1938, p. 987; Cooke, Gardner, Woodring, 1943, p. 1715). These formations correlate with the Meson formation of the Tampico Embayment and the Antigua formation of Antigua, as well as other beds elsewhere in tropical America.

MacNeil (1944, p. 1314) placed the Chickasawhay limestone and its equivalent, the Suwannee limestone, above the Vicksburg group and below the Tampa limestone. This would be the equivalent of the Chattian stage, or upper Oligocene.

For many years the *Eulepidina* zone was considered to be in the Glendon limestone on the mistaken assumption that this unit in Florida is the one which contains these forms (Cooke and Mossom, 1929, pp. 67–73). Recently, MacNeil (1944, p. 1351) and Cooke (1945, p. 90) have assigned the limestone containing *Eulepidina* in Florida to the Suwannee limestone.

The Meson formation of the Tampico Embayment and the Antigua formation of Antigua are late Oligocene in age, correlating with the Suwannee limestone of Florida, rather than middle Oligocene, an age which was assigned them because of the erroneous correlation with the Glendon Limestone (Vaughan, 1933, p. 40).

CAIMITO FORMATION (UPPER OLIGOCENE PART)

The following chart shows the distribution of species from the Caimito formation, which overlies the Bohio formation. No fossils have so far been found in the lower member of the Caimito in the Gatun Lake area. The upper three members in Madden basin contain mollusks of early Miocene age. (See fig. 1.)

Undifferentiated Caimito Formation, Pacific Coastal Area, Panama (Upper Oligocene)

37. Transisthmian Highway, 0.25 mile north-northwest of junction with Panama National Highway. Thin lens of algal limestone in tuff and tuffaceous sandstone. J. A. Tavelli and W. P. Woodring, 1947.

Middle Member, Gatun Lake Area, Canal Zone (Upper Oligocene)

43. About 150 feet eastward up path from west landing at Darien. Algal limestone. One-quarter mile southwest of U.S.G.S. locality 6021 (a cut, now covered with soil and vegetation, on Panama Railroad), the type locality of *Lepidocyclina (Nephrolepidina) vaughani*, but presumably a little higher stratigraphically in middle member. S. M. Jones and W. P. Woodring, 1947.
45. Peninsula north of Barbacoas Island, in field 0.8 mile northeast of Lighthouse 13. Pebbly calcareous tuffaceous sandstone. S. M. Jones and W. P. Woodring, 1947.
53. Low garden islet 0.25 mile northeast of landing at Barro Colorado Island. Soft sandy calcareous siltstone. S. M. Jones and W. P. Woodring, 1947.
55. Panama Railroad, east side of second cut southeast of Bohio Peninsula. Soft calcareous tuffaceous sandstone. U.S.G.S. locality 6025, the type locality of *Lepidocyclina pancanalis* and *Miogypsina (Miolepidocyclina) panamensis*. S. M. Jones and W. P. Woodring, 1947.
110. Northward-flowing stream 0.25 mile east of Río Caraba, 2.1 miles southwest of west end of Gamboa bridge. Medium-grained poorly sorted silty tuffaceous sandstone resting on conglomerate. R. H. Stewart, 1948. Also a collection made by W. P. Woodring, 1949.

Distribution of species from upper Oligocene part of Caimito formation

	Pacific coastal area	Gatun Lake area						Madden basin			Quebrancha syncline area
	Undifferentiated member	Middle member					Upper member	Calcareous sandstone-siltstone member			Quebrancha limestone member
	Localities										
	37	43	45	53	55	110	54	30	121	123	11a
Operculinoides panamensis (Cushman)					X						
Heterostegina antillea Cushman	X	X	X								X
israelskyi Gravell and Hanna					X	X					
panamensis Gravell					X						X
Lepidocyclina (*Lepidocyclina*) *asterodisca* Nuttall						X					
canellei Lemoine and R. Douvillé		X		X	X			X			X
parvula Cushman	X		X		X						X
waylandvaughani Cole											X
yurnagunensis Cushman			X		X		X				
yurnagunensis morganopsis Vaughan	X		X	X							X
(*Nephrolepidina*) *dartoni* Vaughan											X
tournoueri Lemoine and R. Douvillé			X								
vaughani Cushman	X	X		X				X	X	X	X
(*Eulepidina*) *undosa* Cushman			X								
Miogypsina (*Miogypsina*) *antillea* (Cushman)	X			X							
(*Miolepidocyclina*) *panamensis* (Cushman)					X						

Upper Member, Gatun Lake Area, Canal Zone (Upper Oligocene)

54. Puma Island, in front of shed near crest of island. Hard calcareous sandstone. S. M. Jones and W. P. Woodring, 1947.

Calcareous Sandstone-Siltstone Member, Madden Basin, Panama (Upper Oligocene)

30. Transisthmian Highway, 2 miles in direct line north-northwest of Río Chagres bridge. Medium-grained calcareous tuffaceous sandstone. W. P. Woodring, 1947.
121. Río Chilibrillo, 0.4 mile in direct line above bridge on road to Madden Airfield. Coarse-grained poorly sorted calcareous somewhat tuffaceous sandstone, about 50 feet above base of Caimito formation. W. P. Woodring, 1949.
123. Río Chilibrillo, 0.6 mile in direct line below bridge on road to Madden Airfield. Medium-grained somewhat calcareous and somewhat tuffaceous sandstone, about 1,000 feet above base of Caimito formation. W. P. Woodring, 1949.

Quebrancha Limestone Member, Quebrancha Syncline, Panama (Upper Oligocene)

11a. Quarry of Panama Cement Company, 200 feet north of Transisthmian Highway and 0.9 mile in direct line northwest of highway bridge across Río Gatuncillo. Middle part of member. J. R. Schultz and W. P. Woodring, 1947.

The lithology at locality 53 suggests descriptions of the marl at the submerged locality at Peña Blanca, the type locality for *Lepidocyclina canellei* Lemoine and R. Douvillé. Locality 43 is reasonably close to U.S.G.S. locality 6021, the type locality of *Lepidocyclina vaughani* Cushman. U.S.G.S. locality 6021 is not exposed at present, although it probably could be if the vegetation and mantle debris were cleared away.

The Caimito formation contains *Miogypsina* as well as *Eulepidina*. Gravell and Hanna (1938, p. 987) proved that the *Miogypsina-Heterostegina* zone in the Gulf Coast of the United States occurs stratigraphically above the *Eulepidina* zone. *Heterostegina israelskyi* and a stellate lepidocycline are index fossils of the zone. Ellisor (1944, pp. 1355–1375) included the *Miogypsina-Heterostegina* zone of Gravell and Hanna in the Anahuac formation, a subsurface unit which she placed between "the basal sands of the Fleming above and the subsurface Frio below." Cole (1938, p. 19) encountered the *Miogypsina-Heterostegina* zone in the Port St. Joe test well 3 stratigraphically above beds containing *Eulepidina* and below beds assigned to the Tampa limestone. Although these beds were referred only to the Oligocene, they should be considered to represent the Suwannee limestone. In other words, their stratigraphic position is above the Byram formation with *Lepidocyclina supera* and below the Tampa limestone.

The Suwannee limestone is apparently divisible into two zones, the lower one, the *Eulepidina* zone, and the upper one, the *Miogypsina-Heterostegina* zone. In these terms the upper part of the Bohio formation in the Pacific coastal area and at least the lower part of the middle member of the Caimito formation in the Gatun Lake area are the stratigraphic equivalents of the *Eulepidina* zone of the Suwannee limestone. The remainder of the Caimito formation is the stratigraphic equivalent of the *Miogypsina-Heterostegina* zone of the Suwannee limestone.

Woodring and Thompson (1949, p. 234) in discussing the upper member of the Caimito formation on Puma Island stated that it contains a small *Lepidocyclina* which, on the basis of field identification, was recorded as "probably *L. canellei.*" The sample from this locality (54) contains only *L. yurnagunensis*. The rest of their field identifications that were checked prove to be correct.

DESCRIPTION OF SPECIES

Family LITUOLIDAE
Genus YABERINELLA Vaughan, 1928
Yaberinella jamaicensis Vaughan

Plate 6, figures 1–8

1928. *Yaberinella jamaicensis* Vaughan, Jour. Paleontology, vol. 2, pp. 7–12, pls. 4, 5.
1929. *Yaberinella trelawniensis* Vaughan, idem, vol. 3, pp. 374, 376, pl. 39, fig. 1.

The specimens of *Yaberinella jamaicensis* from Panama occur in limestone, and it is difficult to obtain specimens from which oriented sections can be prepared. These specimens appear to represent the same species as the one from Jamaica for which Vaughan gives a complete and accurate description.

Although the median section (pl. 6, fig. 6) shows normally a single embryonic chamber, one not centered oblique median section (pl. 6, fig. 2) has a bilocular embryonic apparatus. The single-chambered embryonic apparatus has diameters of 640 by 680 μ. The bilocular embryonic chambers are nephrolepidine in type. The initial chamber has internal diameters of 310 by 450 μ and the second chamber measures 180 by 480 μ.

In both the median and transverse sections the initial chamber or chambers are surrounded by a ring of small, square chambers. Topotypes of *Yaberinella jamaicensis* also possess this feature and are illustrated (pl. 6, figs. 7, 8) for comparison.

The largest specimen observed has a diameter of 26 mm. There is considerable range in size, many specimens having a diameter of 5 mm or less.

Occurrence.—Locs. 131, 131a. Distribution elsewhere: Middle (as *Y. jamaicensis*) and upper (as *Y. trelawniensis*) Eocene of Jamaica.

Remarks.—Although the diameter of the embryonic chamber is normally about 600 μ, one specimen has an embryonic chamber with diameters of 820 by 740 μ. This is approximately the size of the embryonic chamber of the topotype which is figured. The diameters of this chamber are 860 by 680 μ.

Vaughan (1929, p. 376) in the discussion of the distinguishing features between *Y. jamaicensis* and *Y. trelawniensis* wrote:

> Very marked differences between the form now described and *Y. jamaicensis* are not obvious. The initial chamber of *Y. trelawniensis* seems to be smaller and because the interspaces between the skeletal elements are narrower the internal structure appears finer than that of *Y. jamaicensis*.

Vaughan gave the diameters of the initial chamber of *Y. trelawniensis* as 400 by 350 μ.

The specimens from Panama are identical with *Y. jamaicensis* which Vaughan reports from the middle Eocene Yellow limestone. *Y. trelawniensis* occurs in the upper Eocene part of the overlying White limestone.

Because there seems to be no reliable criterion by which to discriminate *Y. jamaicensis* from *Y. trelawniensis*, these two species are combined. The stratigraphic range of the combined species is middle and upper Eocene.

Family CAMERINIDAE
Genus CAMERINA Bruguière, 1792
Camerina striatoreticulata (L. Rutten)

Plate 3, figures 12–20

1928. *Nummulities striatoreticulatus* L. Rutten, K. Akad. Wetensch. Amsterdam, Proc., vol. 31, pp. 1068–1070, text figs. 41–50, pl., figs. F–J.
1929. *Camerina* sp. Vaughan, Jour. Paleontology, vol. 3, p. 377, pl. 40, fig. 1.
1935. *Camerina petri* M. G. Rutten, idem, vol. 9, pp. 530, 531, text fig. 2, pl. 59, figs. 1–5 [not *Nummulites petri* Mancini, 1928].
1938. *Nummulites striatoreticulatus* L. Rutten. Barker, Geol. Mag., vol. 75, pp. 49–51, pl. 3, figs. 1–5.
1941. *Camerina striatoreticulata* (L. Rutten). Vaughan and Cole, Geol. Soc. America Spec. Paper 30, pp. 31, 32, pl. 8, figs. 5–7.
1949. *Camerina striatoreticulata* (L. Rutten). Cole, Jour. Paleontology, vol. 23, p. 269, pl. 52, figs. 11–13; pl. 55, fig. 7.

Test biconvex, sloping regularly from the center to the periphery. Slightly weathered specimens have a central mass of clear shell material beyond which there are a few pustules of clear shell material arranged in an irregularly circular manner around the central mass. These pustules occur in the intersutural areas and are elongated radially. They have diameters of 100 by 200 μ on the average. Larger and smaller pustules occur. The sutures appear as distinctly raised lines of clear shell material radiating from the center to the periphery. Their course is slightly wavy.

Measurements of sections of Camerina striatoreticulata *from locality 140*

	Median		Transverse
	Specimen		
	1	2	3
Height	4.8 mm	3.6 mm	4.16 mm
Width	4.5 mm	3.6 mm	
Thickness			1.5 mm
Diameters of initial chamber	210×260 μ	200×270 μ	260×240 μ
Diameters of second chamber	100×200 μ	100×180 μ	
Number of whorls	6¼	5¼	
Number of chambers in first volution	7	8	
Number of chambers in final volution	21	19	
Surface diameter of umbonal plug			240–400 μ

Occurrence.—Locs. 23, 125, 137, 140, 145, 149b. Distribution elsewhere: Upper Eocene of Trinidad, Curaçao, Jamaica, and Cuba.

Genus OPERCULINOIDES Hanzawa, 1935

Operculinoides floridensis (Heilprin)

1885. *Nummulites floridensis* Heilprin, Nat. Acad. Sci. Proc., Philadelphia, pp. 321, 322, text fig.
1949. *Operculinoides floridensis* (Heilprin). Cole, Jour. Paleontology, vol. 23, p. 270, pl. 52, fig. 3.

Specimens which are identical with those reported previously from Panama occur in one sample.

Occurrence.—Loc. 108. Distribution elsewhere: Upper Eocene of Florida.

Operculinoides jacksonensis (Gravell and Hanna)

Plate 1, figures 1–9, 20, 21; plate 3, figure 8.

1935. *Camerina jacksonensis* Gravell and Hanna, Jour. Paleontology, vol. 9, p. 331, pl. 29, figs. 1–5, 7, 8, 10–11, 13, 14.
1939. *Camerina jacksonensis* Gravell and Hanna. Barker, U. S. Nat. Mus. Proc., vol. 86, no. 3052, p. 324, pl. 13, fig. 6; pl. 20, fig. 8; pl. 22, fig. 9.
1942. *Camerina jacksonensis* Gravell and Hanna. Cole, Florida Geol. Survey Bull. 20, pp. 26, 27, pl. 8, figs. 3–5.
1945. *Camerina jacksonensis* Gravell and Hanna. Cole, idem, Bull. 28, pp. 101, 102, pl. 13, figs. 3–6.

Operculinoides jacksonensis is similar in internal structure and type of aperture to *O. moodybranchensis*, which has been transferred in this paper from *Camerina*. However, *O. jacksonensis* is smaller than *O. moodybranchensis* and has beads of clear shell material developed on the surface of the test, whereas *O. moodybranchensis* is unornamented except for an umbonal mass of clear shell material.

Operculinoides jacksonensis and *O. kugleri* intergrade. Eventually the two species may be combined. However, *O. jacksonensis* is more inflated, the beads on the sutures are larger, and the axial plug is more distinct.

Occurrence.—Locs. 108, 149, 149b. Distribution elsewhere: Moodys Branch formation of the Jackson group or its equivalents in Texas, Louisiana, and Mississippi; the Ocala limestone of Florida; the Tantoyuca formation of the Tampico Embayment.

Operculinoides kugleri Vaughan and Cole

Plate 3, figures 1–7.

1941. *Operculinoides kugleri* Vaughan and Cole, Geol. Soc. America Spec. Paper 30, pp. 42, 43, pl. 10, figs. 3–5, 7, 8; pl. 13, figs. 1–3.

Specimens assigned to *Operculinoides kugleri* are small, compressed, completely involute and costate, with beads on many of the costae. The outer volution near the apertural end of the test is, normally, extremely compressed, and fragile.

Measurements of sections of Operculinoides jacksonensis

	Median			Transverse				
	Specimen							
	1 [1]	2 [1]	3 [2]	4 [1]	5 [1]	6 [1]	7 [1]	8 [2]
Height	1.5 mm	2.1 mm	1.32 mm	1.66 mm	1.96 mm	2.44 mm	2.6 mm	1.56 mm
Width	1.4 mm	2.1 mm	1.2 mm					
Thickness				0.6 mm	0.82 mm	0.9 mm	0.94 mm	0.74 mm
Diameters of initial chamber	90×80 μ	80×70 μ	70 μ					
Diameters of second chamber	90×50 μ	80×50 μ	80×40 μ					
Distance across both chambers.	140 μ	130 μ	120 μ					
Number of whorls	4¾	5¼	3½					
Number of chambers in first volution.		8	8					
Number of chambers in final volution.	23	25	26					
Surface diameter of axial plug.				200 μ	220 μ	260 μ	240 μ	200 μ

[1] Locality 108. [2] Locality 149.

Measurements of sections of Operculinoides kugleri

	Median				Transverse	
	Specimen					
	1	2	3	4	5	6
Height	1.83 mm	1.74 mm	1.57 mm	1.56 mm	1.49 mm	1.35 mm
Width	1.74 mm	1.66 mm	1.45 mm	1.44 mm		
Thickness					0.45 mm	0.41 mm
Surface diameter of axial plug					None	None
Diameters of initial chamber	40×45 μ	50×60 μ	40×40 μ	80×80 μ		
Diameters of second chamber	25×50 μ	30×65 μ	30×50 μ	45×80 μ		
Distance across both chambers	75 μ	90 μ	75 μ	130 μ		
Number of whorls	5½	5¼	5¼	4		
Number of chambers in first volution	9	8	7	9		
Number of chambers in final volution	32	24	18	24		

Occurrence.—Locs. 149, 149b. Distribution elsewhere: Upper Eocene of Trinidad.

Remarks.—The more inflated specimens of *Operculinoides kugleri* intergrade with *O. jacksonensis* (Gravell and Hanna) and *O. trinitatensis* (Nuttall). However, until a detailed study can be made of a larger suite of thin sections, the three specific names are retained.

Operculinoides moodybranchensis (Gravell and Hanna)

Plate 1, figures 10–19

1935. *Camerina moodybranchensis* Gravell and Hanna, Jour. Paleontology, vol. 9, pp. 332, 333, pl. 29, figs. 15, 22–24.
1939. *Camerina moodybranchensis* Gravell and Hanna. Barker, U. S. Nat. Mus. Proc., vol. 86, no. 3052, pp. 323, 324, pl. 13, fig. 5; pl. 20, fig. 2; pl. 22, fig. 2.
1941. *Camerina moodybranchensis* Gravell and Hanna. Cole, Florida Geol. Survey Bull. 19, p. 28, pl. 9, fig. 9; pl. 11, figs. 9–15.
1942. *Camerina moodybranchensis* Gravell and Hanna. Cole, idem, Bull. 20, p. 27, pl. 8, figs. 6–8.
1945. *Camerina moodybranchensis* Gravell and Hanna. Cole, idem, Bull. 28, pp. 102, 103, pl. 13, figs. 2, 7–9, 12.

Although *Operculinoides moodybranchensis* has been referred to the genus *Camerina*, detailed study of the well-preserved specimens from Panama demonstrate that it possesses all the characteristics of *Operculinoides wilcoxi* (Heilprin), the genotype of *Operculinoides* Hanzawa, 1935. Details of the wall structure and the aperture are illustrated on plate 1, figure 11.

Measurements of sections of Operculinoides moodybranchensis *from locality 108*

	Median						Transverse	
	Specimen							
	1	2	3	4	5	6	7	8
Height	2.44 mm	2.6 mm	2.8 mm	3.0 mm	3.0 mm	3.6 mm	3.5 mm	2.5+ mm
Width	2.3 mm	2.5 mm	2.4 mm	2.7 mm	2.7 mm	3.36 mm		
Thickness							0.9 mm	0.64 mm
Diameters of initial chamber	100×120 μ	80 μ		80×70 μ	100×90 μ	100 μ		
Diameters of second chamber	120×40 μ	80×40 μ		110×60 μ	100×60 μ			
Distance across both chambers	150 μ	120 μ		140 μ	160 μ		165 μ	120+ μ
Number of whorls	5⅛	About 5		5½	5	About 5		
Number of chambers in first volution	11			8	10			
Number of chambers in final volution	32	27	30	27	30	33		
Surface diameter of axial plug							300 μ	200 μ

Occurrence.—Loc. 108. Distribution elsewhere: Moodys Branch formation of the Jackson group or its equivalents in Texas, Louisiana, and Mississippi; the Ocala limestone of Florida; the Tantoyuca formation of the Tampico Embayment.

Operculinoides ocalanus (Cushman)

Plate 2, figures 5–11

1921. *Operculina? ocalana* Cushman, U. S. Geol. Survey Prof. Paper 128, p. 129, pl. 19, figs. 4, 5.
1941. *Operculinoides ocalanus* (Cushman). Cole, Florida Geol. Survey Bull. 19, pp. 31, 32, pl. 10, figs. 4–7 (references).
1944. *Operculinoides ocalanus* (Cushman). Cole, idem, Bull. 26, pp. 48, 49, pl. 1, figs. 5, 10; pl. 2, fig. 8; pl. 5, figs. 1, 4–6; pl. 7, figs. 18, 20.
1949. *Operculinoides ocalanus* (Cushman). Cole, Jour. Paleontology, vol. 23, p. 270, pl. 52, figs. 1, 2.

The Panamanian specimens of *Operculinoides ocalanus* are identical with specimens from Florida. Several external views and thin sections are illustrated to show the characteristics of this species.

Occurrence.—Locs. 125, 131a, 132, 138a, 140. Distribution elsewhere: Ocala limestone of Alabama, Georgia, and Florida; the Tantoyuca formation of the Tampico Embayment; the upper Eocene of Ecuador; probably from the upper Eocene of Haiti.

Operculinoides panamensis (Cushman)

Plate 2, figures 1–4

1919. *Nummulites panamensis* Cushman, U. S. Nat. Mus. Bull. 103, p. 98, pl. 43, figs. 9, 10.
1941. *Operculinoides panamensis* (Cushman). Vaughan and Cole, Geol. Soc. America Spec. Paper 30, pp. 46, 47, pl. 10, figs. 13–16; pl. 11, figs. 1–4, and probably fig. 5.

Vaughan and Cole redescribed this species from topotypes. The specimens in the present collection resemble the topotypes.

Measurements of sections of Operculinoides panamensis *from locality 55*

	Specimen		
	1	2	3
Height	1.7 mm	1.4 mm	1.74 mm
Width	1.6 mm	1.3 mm	
Thickness			0.64 mm
Diameter of initial chamber	20 μ	20 μ	
Diameters of second chamber	20×30 μ	15×30 μ	
Distance across both chambers	45 μ	40 μ	
Number of coils	4⅛	4⅛	
Number of chambers in first volution	8		
Number of chambers in final volution	24	20	
Surface diameter of axial plug			160–240 μ

Occurrence.—Loc. 55. Distribution elsewhere: Upper Oligocene of Trinidad.

Operculinoides trinitatensis (Nuttall)

Plate 2, figures 17–19; plate 3, figures 9–11

1928. *Operculina trinitatensis* Nuttall, Geol. Soc. London, Quart. Jour., pp. 102, 103, pl. 8, figs. 10, 11; text figs. 7–9.

1941. *Operculinoides trinitatensis* (Nuttall). Vaughan and Cole, Geol. Soc. America Spec. Paper 30, pp. 47–50, pl. 10, fig. 12; pl. 13, figs. 4–14.

The three specimens of *Operculinoides trinitatensis* which illustrate the external appearance have the following measurements:

Height	2.74 mm	1.91 mm	1.82 mm
Width	2.41 mm	1.71 mm	1.7 mm
Thickness	1.16 mm	0.96 mm	0.83 mm
Costae or septal filaments	16	19	16

The following measurements are from the four thin sections available:

	Median		Transverse	
Height	2.3 mm	1.9 mm	2.49 mm	1.82 mm
Width	1.9 mm	1.9 mm		
Thickness			0.9 mm	1.09 mm
Diameter of axial plug			85 μ	None
Diameters of initial chamber	50×50 μ	50×50 μ		
Diameters of second chamber	30×60 μ	30×50 μ		
Distance across both chambers	86 μ	90 μ		
Number of whorls	4¾	5		
Number of chambers in first volution	7	7		
Number of chambers in final volution		About 15		

The final volution has been infiltrated so badly that an accurate count of chambers is impossible.

Occurrence.—Locs. 149, 149b. Distribution elsewhere: Upper Eocene of Trinidad.

Remarks.—The original description and illustrations of this species were not entirely adequate, but Vaughan and Cole studied topotype and other specimens assigned to this species, giving an expanded description and numerous illustrations.

In Trinidad this species is associated with *O. kugleri* Vaughan and Cole, an association which occurs also in Panama. As Vaughan and Cole (1941, p. 50) have noted, "* * * the more compressed, more costate forms approach *O. kugleri.*"

Operculinoides vaughani (Cushman)

Plate 2, figures 12–16

1921. *Operculina vaughani* Cushman, U. S. Geol. Survey Prof. Paper 128–E, p. 128, pl. 19, figs. 6, 7.

1935. *Operculina vaughani* Cushman. Gravell and Hanna, Jour. Paleontology, vol. 9, p. 334, pl. 29, figs. 6. 9, 12, 16–21.

1945. *Operculinoides vaughani* (Cushman). Cole, Florida Geol. Survey Bull. 28, pp. 104, 105, pl. 16, figs. 11–13.

The external view of a microspheric and of a megalospheric specimen of *Operculinoides vaughani* are illustrated to demonstrate the differences in surface ornamentation between generations. The microspheric individual has much heavier and more pronounced sutures than does the smaller megalospheric individual.

The outer wall of one of the megalospheric specimens (pl. 2, fig. 15) shows canals of the type illustrated by Vaughan and Cole (1936, p. 491, pl. 36, fig. 4a) for *O. vicksburgensis.*

Occurrence.—Locs. 131a, 140. Distribution elsewhere: Moodys Branch formation of the Jackson group or its equivalents in Texas, Louisiana, Mississippi, and Georgia; the Ocala limestone of Florida.

Genus HETEROSTEGINA D'Orbigny, 1826

Heterostegina antillea Cushman

Plate 5, figures 1–11

1919. *Heterostegina antillea* Cushman, Carnegie Inst. Washington, Pub. 291, pp. 49, 50, pl. 2, fig. 1b; pl. 5, figs. 1, 2.

1941. *Heterostegina antillea* Cushman. Vaughan and Cole, Geol. Soc. America Spec. Paper 30, p. 54, pl. 15, figs. 10–12; pl. 16.

Heterostegina antillea is characterized by an inflated umbonal area surrounded by a relatively wide and comparatively thin rim. The embryonic chambers are large and have relatively thick walls.

Measurements of typical sections of Heterostegina antillea

	Locality							
	38			39		43		45
	Median		Transverse	Median	Transverse	Median	Transverse	Median
Height	3.2 mm	3.16+ mm	3.3 mm	2.5+ mm	3+ mm	4.2 mm	3.9 mm	2.8+ mm
Width	2.9 mm	2.7+ mm		2.1+ mm		3.8 mm		2+ mm
Thickness through center			0.72 mm		0.76 mm		1.04 mm	
Diameter of umbo					1.2 mm		2.0 mm	
Thickness through flange			--		0.52 mm		0.34 mm	
Surface diameter of axial plug			190 μ				440–480 μ	
Diameters of initial chamber	185×220 μ	200×220 μ		170×210 μ		195×220 μ		90×110 μ
Diameters of second chamber	100×220 μ	115×320 μ		60×230 μ		140×260 μ		55×130 μ
Distance across both chambers	300 μ	325 μ		240 μ		340 μ	240 μ	160 μ
Number of operculine chambers	1	1		1		1		
Number of coils	2½	2		2		2¼		2⅛

Occurrence.—Locs. 11a, 37, 38, 39, 43, 45. Distribution elsewhere: Upper Oligocene of Antigua and Trinidad.

Heterostegina israelskyi Gravell and Hanna

Plate 1, figure 22; plate 4, figure 1; plate 5, figures 12–14; plate 6, figures 17, 18

1937. *Heterostegina israelskyi* Gravell and Hanna, Jour. Paleontology, vol. 11, pp. 524, 525, pl. 62, figs. 1–4.
1937. *Heterostegina texana* Gravell and Hanna, Jour. Paleontology, vol. 11, pp. 525, 526, pl. 63, figs. 1–4.
1938. *Heterostegina texana* Gravell and Hanna. Cole, Florida Geol. Survey Bull. 16, pp. 40, 41, pl. 5, figs. 18–21; pl. 6, figs. 1, 2.
1941. *Heterostegina texana* Gravell and Hanna. Cole, idem, Bull. 19, p. 33, pl. 10, figs. 8, 9; pl. 11, figs. 1, 2.
1944. *Heterostegina texana* Gravell and Hanna. Cole, idem, Bull. 26, p. 52, pl. 6, figs. 7–9.
1945. *Heterostegina texana* Gravell and Hanna. Cole, idem, Bull. 28, pp. 110, 111, pl. 15, figs. 9, 10.

Test thin, fragile, with a very small, slightly elevated umbo over the embryonic chambers. Surface of the test unornamented, but slightly weathered specimens show the sutures of the chambers and the chamberlets. The thickness through the embryonic chambers is about 0.44 mm and the flange thickness is 0.16 to 0.18 mm. In the flange the thickness of the median layer is 60 to 80 μ; each wall of the flange has a thickness of 40 μ to 60 μ. Average sized specimens have diameters of about 6 mm.

The embryonic chambers are bilocular, with a thick wall on the side away from the first median chamber and a thin wall on the side adjacent to the first median chamber. Three median sections from locality 110 show the embryonic chambers.

The measurements of two of these are in close agreement, but those of the third show a much larger embryonic apparatus and a smaller operculine chamber.

All of the sections have one operculine chamber following the embryonic chambers. The succeeding chamber is divided into three or more chamberlets.

In one transverse section the distance across both embryonic chambers is 260 μ and the height of these chambers is 120 μ; in another section the distance across both chambers is 220 μ and the height is 180 μ.

The chamberlets are rectangular in shape and vary considerably in size. Certain chambers have radial diameters of 80 μ, whereas adjacent ones have radial diameters of 220 μ. The tangential diameters of the chamberlets in both of these chambers is about 85 μ.

Occurrence.—Loc. 55 (rare), 110 (abundant). Distribution elsewhere: Anahuac formation (*Heterostegina* zone) (Ellisor, 1944, pp. 1355–1375) of late Oligocene age of Texas; the Suwannee limestone of Florida; the Meson formation of the Tampico Embayment.

Remarks.—The compressed, fragile test and the small umbo of these specimens are indicative of *Heterostegina israelskyi*, but the dimensions of the embryonic chambers are similar to those of *H. texana*. It is apparent that there is complete gradation between these species, and as the stratigraphic horizon of the type specimens is the same, it would appear that they should be combined.

Measurements of median sections of Heterostegina israelskyi *from locality 110*

	Specimen		
	1	2	3
Internal distance across both chambers	230 μ	220 μ	320 μ
Internal diameters of initial chamber	140×140 μ	130×140 μ	180×240 μ
Internal diameters of second chamber	90×200 μ	80×180 μ	120×200 μ
Thickness of outer wall	20 μ	20 μ	30 μ
Internal diameters of operculine chambers	60×220 μ	60×200 μ	100×160 μ

Heterostegina ocalana Cushman

Plate 4, figures 2–18

1921. *Heterostegina ocalana* Cushman, U. S. Geol. Survey Prof. Paper 128–E, pp. 130, 131, pl. 21, figs. 15–18.
1921. *Heterostegina ocalana glabra* Cushman, idem, p. 131, pl. 21, fig. 19.
1941. *Heterostegina ocalana* Cushman. Cole, Florida Geol. Survey Bull. 19, pp. 32, 33, pl. 11, figs. 3–6.

Heterostegina ocalana was described by Cushman (1921, pp. 130, 131) from specimens obtained from the Cummer Lumber Company's phosphate plant no. 6, 1¼ miles south of Newberry, Alachua County, Fla. Although the internal structure of this species was not described or illustrated, the photomicrographs of the external appearance are exceptionally clear.

Cole (1941, pp. 32, 33) assigned certain specimens from the United Brotherhood of Carpenter and Joiner's of America, Power House well no. 2, located two miles north of Lakeland, Polk County, Fla., to this species. Five specimens were illustrated, two of which demonstrated the details of the median section and two the details of the transverse section.

In the Panamanian deposits certain specimens resemble the description and illustrations of the internal features given by Cole, but other specimens appear to have a larger number of operculine chambers.

Therefore, thin sections were made of specimens from the Cummer Lumber Company's phosphate pit no. 6, collected by Dr. H. G. Naegeli of the Florida Geological Survey, to ascertain the internal features of specimens which would be virtual topotypes of *H. ocalana*.

Other specimens, collected by Dr. Herman Gunter and the writer from Red Bluff, Flint River, about 7 miles above Bainbridge, Ga., were sectioned also because these specimens were identified by their external appearance as *H. ocalana*.

The Florida specimens have from three to seven operculine chambers following the embryonic chambers. These specimens are megalospheric, as one of the specimens from Red Bluff (pl. 4, fig. 16) is a microspheric one. This specimen has fifteen operculine chambers.

Although most of the specimens from Panama have from 8 to 14 operculine chambers, they are so similar to typical *H. ocalana* that they may be referred to that species. However, it should be noted that specimens from locality 140 have only two operculine chambers and the embryonic chambers are much larger than any observed in typical *H. ocalana*.

It is extremely doubtful, however, that a new species should be proposed for these specimens from locality 140. Because typical specimens of *H. ocalana* show so much variation at a single locality, it is entirely logical to find marked variation in individuals from different localities, as food, depth, salinity, and like factors presumably play an important role in the individual's development.

Measurements of the specimens from Panama, Georgia, and Florida follow:

Measurements of sections of Heterostegina ocalana

	Median										
	22a		125			140		Near Newberry, Alachua County, Fla.			Red Bluff, Ga.
Height	2.5 mm	2.7 mm	2.56 mm	2.14 mm	2.8 mm	3.7 mm	2.7 mm	4.0 mm	3.6 mm	3.5 mm	4.0 mm
Width	2.0 mm	2.1 mm	2.3 mm	1.7 mm	2.3 mm	2.4 mm	2.9 mm	3.3 mm	3.0 mm	2.8 mm	3.2 mm
Thickness											
Diameter of umbo											
Thickness of flange											
Surface diameter of axial plug.											
Diameters of initial chambers.	45×60 µ	60×60 µ	45 µ	55 µ	50 µ	120 µ	100 µ	80×90 µ	70×80 µ	80×85 µ	40 µ
Diameters of second chamber.	35×80 µ	50×100 µ	30×60 µ	40×85 µ	40×60 µ	60×210 µ	70×180µ	55×160 µ	40×140 µ	60×140 µ	50×100 µ
Distance across both chambers.	80 µ	120 µ	80 µ	100 µ	95 µ	200 µ	180 µ	150 µ	120 µ	150 µ	100 µ
Number of operculine chambers.	14	8	8	8	10	2	2	6	6	3	7
Number of coils	3¼	3½	4	3	4	2½	2¾	3½	3¼	4	3¾

	Transverse				
	22a		125	140	Red Bluff, Ga.
Height	2.4 mm	2.2 mm	2.6 mm	2.9+ mm	2.64 mm
Width	0.8 mm				
Thickness	0.8 mm	0.74 mm	0.86 mm	0.92 mm	0.76 mm
Diameter of umbo	1.4 mm	1.4 mm	1.5 mm	1.8 mm	1.5 mm
Thickness of flange	0.18 mm	0.2 mm	0.14 mm	0.3 mm	0.22 mm
Surface diameter of axial plug.	300–400 µ	400 µ	140 µ	320–380 µ	200 µ
Diameters of initial chambers.			60 µ		40 µ
Diameters of second chamber.					
Distance across both chambers.					
Number of operculine chambers.					
Number of coils					

Occurrence.—Locs. 22a, 125, 140. Distribution elsewhere: Ocala limestone of Florida and Georgia.

Heterostegina panamensis Gravell

Plate 5, figures 15–19

1933. *Heterostegina panamensis* Gravell, Smithsonian Misc. Coll., vol. 89, no. 11, pp. 17, 18, pl. 1, figs. 10, 11.

The specimens of *Heterostegina panamensis* from Panama are slightly thicker through the center than the type specimens from Venezuela. The type specimens have four operculine chambers, whereas those in the present collection have one or two. As these differences are slight, the specimens from Panama are referred to this species.

Occurrence.—Locs. 11a, 55. Distribution elsewhere: San Louis limestone of late Oligocene age in Venezuela.

Remarks.—This species is a small, more or less evenly biconvex one with a very pronounced axial plug.

Family AMPHISTEGINIDAE

Genus HELICOSTEGINA Barker and Grimsdale, 1936

Helicostegina soldadensis Grimsdale

Plate 6, figures 9–12

1941. *Helicostegina soldadensis* Grimsdale, Geol. Soc. America Spec. Paper 30, pp. 77, 86, 87, pl. 45, fig. 4; pl. 46, figs. 1–7.

The specimens of *Helicostegina soldadensis* from Panama are identical with the types from central Trinidad and Soldado Island. Moreover, the association of other species with it is nearly the same.

Occurrence.—Loc. 22a. Distribution elsewhere: Upper Eocene of Trinidad and Soldado Island.

Family CYMBALOPORIDAE

Genus FABIANIA A. Silvestri, 1926

Fabiania cubensis (Cushman and Bermudez)

Plate 6, figures 13–16

1936. *Pseudorbitolina cubensis* Cushman and Bermúdez, Cushman Lab. Foram. Research Contr., vol. 12, p. 59, pl. 10, figs. 27–30.

1944. *Eodictyoconus cubensis* (Cushman and Bermúdez). Cole and Bermudez, Bull. Am. Paleontology, vol. 28, no. 113, pp. 336–340, pl. 27, fig. 1; pl. 28, figs. 1–12; pl. 29, figs. 1–5 (references).

Test plano-convex with a deeply excavated umbilicus on the ventral side. An average specimen of *Fabiania cubensis* has a diameter of 1.2 mm; a height of 1.0 mm; and the umbilicus has a diameter of 0.6 mm. The dorsal surface is covered by a reticulate mesh formed by the sutures of the chambers and chamberlets.

Occurrence.—Locs. 15, 22a, 131, 131a, 138a, 140, 149b. Distribution elsewhere: Middle Eocene of Cuba and Florida.

Remarks.—There does not appear to be any reliable feature on which to distinguish the Panamanian specimens from the type specimens from Cuba. In Cuba this species occurs with typical middle Eocene species, such as, *Dictyoconus americanus* (Cushman) and *Gunteria floridana* Cushman and Ponton. In Florida this species is found in sediments assigned to the middle Eocene (Cole, 1944, p. 36). However, in Panama it is associated with definite late Eocene species.

Measurements of sections of Heterostegina panamensis

	Locality			
	11a		55	
	Median	Transverse	Median	Transverse
Height	2.4 mm	2.5 mm	1.8 mm	1.84 mm
Width	2.1 mm		1.7 mm	
Thickness		1.06 mm		0.92 mm
Surface diameter of axial plug		580 μ		520 μ
Diameters of initial chamber	130×140 μ		115×125 μ	
Diameters of second chamber	80×185 μ		60×180 μ	
Distance across both chambers	220 μ	215 μ	185 μ	2[illegible]0 μ
Number of operculine chambers	1			
Number of coils	2½			

Measurements of sections of Helicostegina soldadensis *from locality 22a*

	Median			Transverse
Diameter	0.8 mm	1.4 mm	1.2 mm	0.9 mm
Thickness				0.46 mm
Number of coils in spire	3+	3¼	4	
Number of chambers in last coil	22	22	27	
Internal diameters of initial chamber	75×80 μ	80×70 μ	40×40 μ	80×80 μ
Internal diameters of second chamber	30×80 μ	20×30 μ	20×40 μ	30×50 μ
Internal diameter of both chambers	110 μ	100 μ	80 μ	125 μ
Wall thickness of initial chamber	20 μ	20 μ	20 μ	20 μ
Dimensions of flange chamberlets:				
Radial diameters		20–40 μ	20–50 μ	
Tangential diameters		50–80 μ	20–80 μ	

Family ORBITOIDIDAE

Subfamily LEPIDOCYCLINAE Tan

Genus LEPIDOCYCLINA Gümbel, 1870

Subgenus PLIOLEPIDINA H. Douvillé, 1917

Lepidocyclina (Pliolepidina) gubernacula Cole, n. sp.

Plate 8, figures 9–14; plate 9, figures 1, 2; plate 12, figure 16; plate 20, figure 17; plate 23, figure 13

Megalospheric generation.—Test of medium size from 8.5 to 10 mm in diameter, disc-shaped. The central area is very slightly inflated and is bounded by a thinner portion beyond which the test thickens into a distinctly elevated rim at the periphery of the test. The edge of the test is corrugated, the individual ridges of which are the eroded walls of the equatorial chambers. The shape of the equatorial chambers in plan view can be ascertained for a short distance inward from the periphery, as the equatorial chambers at the margin of the test are not covered by lateral chambers. The low, slightly inflated central portion of the test is covered by a reticulate mesh formed by the walls of the lateral chambers. The development of pillars is variable. Unweathered specimens have low, indistinct pillars over the central portion, but slightly weathered specimens have distinct, small pillars with diameters of about 100 μ, evenly scattered over the central area. Neither type appears to have pillars in the depressed zone or on the inflated rim.

The embryonic chambers are large, thin-walled, bilocular; the initial chamber is larger than the second chamber. Normally, there are two large periembryonic chambers, one at each end of the dividing partition between the embryonic chambers. A well-developed periembryonic chamber has internal diameters of 140 by 460 μ.

The equatorial chambers as viewed in equatorial section are larger near the center of the test and decrease in size toward the periphery. The normal shape of these chambers is rhombic, but some have curved outer walls and pointed inner ends.

The equatorial layer expands regularly toward the periphery of the test. The outer 0.5 mm of the equatorial layer is not covered by lateral chambers; therefore these chambers comprise the entire thickness of the test in this zone.

Measurements of equatorial sections of Lepidocyclina (Pliolepidina) gubernacula *from locality 23*

	Specimen		
	1	2	3
Diameter	7.8 mm	5.9 mm	7.4 mm
Embryonic chambers:			
Diameters of initial chamber	600×940 μ	670×940 μ	680×840 μ
Diameters of second chamber	480×960 μ	360×660 μ	340×780 μ
Distance across both chambers	1100 μ	1050 μ	1040 μ
Thickness of outer wall	20–30 μ	18 μ	20–30 μ
Equatorial chambers:			
Near center:			
Radial diameter	170 μ	140 μ	160 μ
Tangential diameter	160 μ	160 μ	160 μ
Near periphery:			
Radial diameter	120 μ	120 μ	100 μ
Tangential diameter	140 μ	120 μ	140 μ

Measurements of vertical sections of Lepidocyclina (Pliolepidina) gubernacula *from locality 23*

	Specimen		
	1	2	3
Diameter	9.6 mm	8.6 mm	8.6 mm
Thickness at center	0.92 mm	1.66 mm	1.08 mm
Thickness at periphery	0.6 mm	0.6 mm	0.68 mm
Thickness 0.8 mm from periphery	0.48 mm	0.46 mm	0.54 mm
Thickness 2 mm from periphery	0.62 mm	0.64 mm	0.7 mm
Embryonic chambers:			
Length	600 μ	900 μ	800 μ
Height	440 μ	540 μ	600 μ
Thickness of outer wall	20 μ	35–40 μ	25 μ
Equatorial layer:			
Thickness at center	200 μ	220 μ	200 μ
Thickness at periphery	600 μ	600 μ	680 μ
Thickness 0.8 mm from periphery	310 μ	360 μ	400 μ
Thickness 2 mm from periphery	240 μ	280 μ	300 μ
Lateral chambers:			
Number on each side of the embryonic chamber	5	7	5
Length	120–160 μ	80–300 μ	160–280 μ
Height	30 μ	40–50 μ	20–30 μ
Thickness of floors and roofs	20 μ	20–30 μ	15 μ
Surface diameter of pillars	60 μ	100–140 μ	60 μ

The lateral chambers are not arranged in regular tiers. These chambers are relatively long, low, but with open, distinct cavities. The floors and roofs are relatively thin. The floors and roofs are either straight or slightly convex toward the outside of the test. The number of lateral chambers to a tier decreases regularly toward the periphery of the test, but the peripheral zone of the test is devoid of lateral chambers.

Thin, cylindrical pillars occur irregularly in the central area of the test, but decrease in size and distribution toward the periphery.

Microspheric generation.—Test large, having a diameter of 20 mm or more. There is a distinct central umbo which is bordered by a thinner area which in turn is surrounded by an elevated rim. The inflated central portion has distinct, slightly elevated papillae which become smaller and more scattered toward the edge of the test which is devoid of papillae.

The vertical section (pl. 23, fig. 13) adequately illustrates the internal features of this type of section.

A fragment from the same specimen from which the vertical section was made shows equatorial chambers of the same type as those possessed by the megalospheric individuals. These chambers have thicker walls than those of the megalospheric generation and are slightly larger in size.

Holotype: U.S.N.M. 561091; paratypes: U.S.N.M. 561052, 561053, 561055.

Occurrence.—Loc. 23.

Remarks.—The distinctly elevated rim of the test is a characteristic feature of this species externally. No other American species from the Eocene possesses this feature. *Lepidocyclina* (*L.*) *novitasensis* and *L.* (*L.*) *meinzeri* from the Eocene of Cuba have rather large embryonic and rhombic equatorial chambers but these two species are very different in vertical sections.

Specimens identified as *L.* (*L.*) sp. aff. *L. ocalana pseudocarinata* Cushman by Vaughan and Cole (1941, p. 68, pl. 31, figs. 10, 11) most certainly are *L. gubernacula*. The specimens from Trinidad have rhombic-shaped equatorial chambers, whereas all the forms of *L. ocalana* have arcuate to short-spatulate equatorial chambers. Moreover, the vertical section illustrated by Vaughan and Cole shows the rapid expansion of the equatorial layer in the peripheral zone which is characteristic of *L. gubernacula*.

Three small specimens (pl. 8, figs. 9–11) were found at locality 22a. At first these specimens were thought to constitute a distinct species, but detailed study demonstrates that they are probably small individuals of this new species.

If size is disregarded, the main difference between these specimens and the typical specimens from locality 23 appears in the shape of the equatorial chambers. Although many of the chambers in the specimens from locality 22a are rhombic, those near the periphery become spatulate. However, the fundamental pattern is the same in the specimens from both localities, as some of the rhombic chambers in the specimens from locality 23 tend toward the spatulate.

Lepidocyclina (Pliolepidina) macdonaldi Cushman

Plate 7, figures 1–19; plate 8, figures 1–4; plate 14, figure 11; probably plate 20, figure 16

1919. *Lepidocyclina macdonaldi* Cushman, U. S. Nat. Mus. Bull. 103, p. 94, pl. 40, figs. 1–6.
1933. *Lepidocyclina* (*Lepidocyclina*) *macdonaldi* Cushman. Gravell, Smithsonian Misc. Coll., vol. 89, no. 11, pp. 25, 26, pl. 5, figs. 1–3. [Probably not fig. 2 which appears to be *L. pustulosa* H. Douvillé.]
1941. *Lepidocyclina* (*Pliolepidina*) *macdonaldi* Cushman. Vaughan and Cole, Geol. Soc. America Spec. Paper 30, p. 67, pl. 31, figs. 1, 2.
1945. *Lepidocyclina* (*Pliolepidina*) *macdonaldi* Cushman. Cole, Florida Geol. Survey Bull. 28, pp. 117–120, pl. 19, figs. 1–13.

Typical specimens of *Lepidocyclina* (*Pliolepidina*) *macdonaldi* were found in most of the Eocene samples examined. The vertical section shows the equatorial layer expanding regularly toward the periphery. The lateral chambers have low cavities between thick roofs and floors.

Occurrence.—Locs. 15, 124, 125, 131, 131a, 138a, 140, 145, 149, 149b, 150. Distribution elsewhere: Upper Eocene of Trinidad, Venezuela, the Tampico Embayment and the State of Chiapas, Mexico, Jamaica, and as reworked specimens in the Oligocene of Florida where it occurs with reworked middle Eocene species.

Lepidocyclina (Pliolepidina) pustulosa H. Douvillé

Plate 13, figures 1–20; plate 14, figures 1–10; plate 15, figures 14–16; plate 20, figures 14, 15; plate 23, figures 1–3, 10

1917. *Isolepidina pustulosa* H. Douvillé, Paris Acad. Sci., C. R., vol. 161, p. 844, text figs. 1–4.
1919. *Orthophragmina hayesi* Cushman, U. S. Geol. Survey Prof. Paper 125, p. 43, pl. 8, figs. 8–10.
1928. *Lepidocyclina subglobosa* Nuttall, Geol. Soc. London, Quart. Jour., vol. 84, p. 104, pl. 7, figs. 3, 5–7.
1941. *Lepidocyclina* (*Pliolepidina?*) *subglobosa* Nuttall. Vaughan and Cole, Geol. Soc. America Spec. Paper 30, pp. 67, 68, pl. 31, figs. 8, 9.
1941. *Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé. Vaughan and Cole, idem, pp. 65, 66 (references and synonymy).
1949. *Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé. Cole, Jour. Paleontology, vol. 23, p. 272, pl. 54, fig. 5; pl. 55, fig. 8.

A great number of different specific names have been applied to individuals of *Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé which possess the same basic features, but differ from one another in shape, size, or other minor elements. Vaughan and Cole (1941, p. 65) have demonstrated that these names should be suppressed.

The sample from locality 140 contained many individuals which represent this species. A series of seven vertical sections (pl. 13, figs. 5, 8–10, 12, 14, 16) demonstrate the extreme variability of individuals of this species from one another in one sample. But, the essential features of all are the same.

It is apparent from the study of many thin sections that *L. subglobosa* Nuttall represents small specimens of *L. pustulosa.* The features of the equatorial and vertical sections are the same. Although Vaughan and Cole retained *L. subglobosa* as a distinct species in their report on the larger Foraminifera of Trinidad, the suite of thin sections available now demonstrates that *L. subglobosa* is *L. pustulosa.*

Orthophragmina hayesi Cushman from the Brito formation of Nicaragua was shown by Vaughan (1924, p. 790) to be a *Lepidocyclina* with rhomboid equatorial chambers. The vertical sections of the Nicaraguan specimens are similar to specimens in Panama (pl. 13, fig. 19) which are referred to *L. pustulosa.* There is little doubt that *L. hayesi* is *L. pustulosa.*

Occurrence.—Locs. 15, 22a, 124, 131, 131a, 137, 138a, 140, 149, 149b, 150. Distribution elsewhere: Upper Eocene of the Isthmus of Tehuantepec and Rio Vinazco, Chicontepec, state of Veracruz, Mexico; Jamaica; Panama; Curaçao; Venezuela; Nicaragua; and from the middle Eocene of Florida.

Lepidocyclina (Pliolepidina) pustulosa tobleri H. Douvillé

Plate 13, figure 21; plate 14, figures 12, 13; plate 15, figures 17–21

1917. *Pliolepidina tobleri* H. Douvillé, Paris Acad. Sci., C. R., vol. 164, p. 844, text figs. 5, 6.
1919. *Lepidocyclina panamensis* Cushman, U. S. Nat. Mus. Bull. 103, pp. 94, 95, pl. 39, figs. 1–6; pl. 42.
1919. *Lepidocyclina duplicata* Cushman, idem, p. 96, pl. 41, figs. 2–4.
1924. *Pliolepidina tobleri* H. Douvillé. H. Douvillé, Soc. Géol. France Mém., n. s., vol. 1, no. 2, pp. 43, 44, text figs 34, 35.
1926. *Lepidocyclina (Polylepidina) zuliana* H. Hodson, Bull. Am. Paleontology, vol. 12, no. 47, pp. 25, 26, pl. 7, figs. 1–3.
1926. *Lepidocyclina (Polylepidina) mirandana* H. Hodson, idem, pp. 26, 27, pl. 7, figs. 4–6.
1928. *Lepidocyclina curasavica* Koch, Eclogae geol. Helvetiae, vol. 21, pp. 54–56, pl. 3, figs. 1–5.
1928. *Lepidocyclina (Pliolepidina) tobleri* H. Douvillé. L. Rutten, K. Akad. Wetensch. Amsterdam, Proc., vol. 31, p. 1067, text figs. 19–35, pl. figs. C, D.
1928. *Lepidocyclina* sp. aff.? *Polylepidina proteiformis* Vaughan. L. Rutten, idem, p. 6, pl. fig. E [not *Lepidocyclina (Polylepidina) proteiformis* Vaughan, 1924].
1932. *Lepidocyclina (Pliolepidina) tobleri* H. Douvillé. Rutten and Vermunt, idem, vol. 35, pp. 12, 13, pl. 1, fig. 5; pl. 2, figs. 3, 7, 8.
1932. *Lepidocyclina curasavica* Koch. Rutten and Vermunt, idem, p. 8, pl. 1, figs. 1, 2; pl. 2, fig. 5.
1941. *Lepidocyclina (Pliolepidina) pustulosa* forma *tobleri* H. Douvillé, forma teratologica. Vaughan and Cole, Geol. Soc. America Spec. Paper 30, pp. 66, 67, pl. 24.
1949. *Lepidocyclina (Pliolepidina) pustulosa* forma *tobleri* H. Douvillé, forma teratologica. Cole, Jour. Paleontology, vol. 23, p. 272, pl. 52, fig. 4; pl. 54, fig. 9.

Several equatorial and horizontal sections of *Lepidocyclina (Pliolepidina) pustulosa tobleri* H. Douvillé are illustrated to show the individual differences which may occur. Vertical sections are particularly variable. The equatorial chambers have the same shape and pattern as do those of typical *L. pustulosa* H. Douvillé. Although this form is so closely related to *L. pustulosa* that specific discrimination is not possible, it can be questioned that it is a teratologic type. The so-called abnormal embryonic chambers may be a normal tendency in this particular race (Woodring, 1927).

Occurrence.—Locs. 108, 124, 131a, 132, 138a, 145, 149b. Distribution elsewhere: Upper Eocene of Curaçao; Rio Vinazco, Canton of Chicontepec, Veracruz, Mexico; Trinidad.

Remarks.—Cushman (1919a, p. 90) tentatively (and incorrectly) recorded this species under the name *L. panamensis* in the Culebra formation and the Emperador limestone.

Subgenus LEPIDOCYCLINA Gümbel, 1870

Lepidocyclina (Lepidocyclina) asterodisca Nuttall

Plate 17, figure 4

1932. *Lepidocyclina (Lepidocyclina) asterodisca* Nuttall, Jour. Paleontology, vol. 6, pp. 34, 35, pl. 7, figs. 5, 8; pl. 9, fig. 10.
1932. *Lepidocyclina (Lepidocyclina) falconensis* Gorter and van der Vlerk, Leidsche Geol. Meded., vol. 4, pp. 105, 106, pl. 11, figs. 4–6.
1937. *Lepidocyclina (Lepidocyclina) texana* Gravell and Hanna, Jour. Paleontology, vol. 11, pp. 527–529, pl. 65, figs. 1–7.
1941. *Lepidocyclina (Lepidocyclina) asterodisca* Nuttall. Vaughan and Cole, Geol. Soc. America Spec. Paper 30, p. 73, pl. 39, figs. 3, 4.

Although the sample from which the specimen assigned to *Lepidocyclina (Lepidocyclina) asterodisca* contains abundant specimens of *Heterostegina,* only one specimen of *L. (L.) asterodisca* was found. A description of this specimen follows:

Test stellate with five rays which radiate from a central umbo. The umbo has a diameter of about 2.1 mm. The rays are narrowest at their juncture with the umbo and widen as they approach the periphery of the test. The interray areas are flat. The diameter of the test is about 7.8 mm.

The equatorial chambers are arranged in conformity with the stellate pattern of the test. These chambers are short-spatulate in shape with radial diameters of 100μ and tangential diameters of 80μ.

Occurrence.—Loc. 110. Distribution elsewhere: As *L. asterodisca* from the Alazan formation of the Tampico Embayment and the upper Oligocene of Trinidad, from the Anahuac formation of Texas as *L. texana,* and from the Churuguara series of central Falcon, Venezuela, as *L. falconensis.*

Remarks.—*L. asterodisca* was described from specimens obtained in the Alazan formation of the Tampico Embayment area. Later, Vaughan and Cole (1941, p. 73) assigned specimens from three localities in

Trinidad to this species. Vaughan and Cole noted that *L. asterodisca* is very close to *L. texana* Gravell and Hanna (1937, pp. 527, 528).

Gravell and Hanna separated their species from *L. asterodisca* by its larger size and its possession of five instead of four rays. Because there is considerable variation in such characters in other species of *Lepidocyclina*, these species are combined.

In Trinidad *L. asterodisca* is associated with *Heterostegina antillea*, *Lepidocyclina* (*Lepidocyclina*) *parvula*, *L.* (*L.*) *yurnagunensis*, *L.* (*Nephrolepidina*) *tempanii*, and *L.* (*Eulepidina*) *undosa*. In Texas *L. asterodisca* is associated with new species of *Operculinoides*, *Heterostegina*, and *Lepidocyclina*. In Panama *L. asterodisca* occurs with abundant specimens assigned to *Heterostegina israelskyi*, one of the species with which it occurs in Texas.

Lepidocyclina (Lepidocyclina) canellei Lemoine and R. Douvillé

Plate 16, figures 1–22; plate 17, figures 1–3

1904. *Lepidocyclina canellei* Lemoine and R. Douvillé, Soc. Géol. France Mém,. vol. 12, p. 20, pl. 1, fig. 1; pl. 3, fig. 5.

1919. *Lepidocyclina canellei* Lemoine and R. Douvillé. Cushman, U. S. Nat. Mus. Bull. 103, p. 91, pl. 34, figs. 1–6.

1920. *Lepidocyclina canellei* Lemoine and R. Douvillé. Cushman, U. S. Geol. Survey Prof. Paper 125, p. 75, pl. 32, figs. 1–5.

1924. *Lepidocyclina* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé. Vaughan, Geol. Soc. America Bull., vol. 35, pp. 797, 819, pl. 33, fig. 4.

1928. *Lepidocyclina* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé. Vaughan, Jour. Paleontology, vol. 1, p. 290, pl. 49, figs. 1–5, 7–9.

1932. *Lepidocyclina* (*Lepidocyclina*) *pancanalis* Vaughan and Cole, Jour. Washington Acad. Sci., vol. 22, pp. 510–514, figs. 1–9.

1933. *Lepidocyclina* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé. Vaughan, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 14, 15, pl. 6, figs. 1–5.

1933. *Lepidocyclina* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé. Gravell, idem, vol. 89, no. 11, pp. 24, 25, pl. 5, figs. 4–8.

1941. *Lepidocyclina* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé. Vaughan and Cole, Geol. Soc. America Spec. Paper 30, pp. 70, 71, pl. 35, figs. 6, 7; pl. 41, figs. 4, 5.

1941. *Lepidocyclina* (*Lepidocyclina*) *pancanalis* Vaughan and Cole, idem, p. 71, pl. 35, figs. 8, 9.

Two closely related species, *Lepidocyclina* (*L.*) *canellei* Lemoine and R. Douvillé and *L.* (*L.*) *pancanalis* Vaughan and Cole, have been described from the Oligocene of Panama. Vaughan and Cole stated:

> *L. canellei* is usually larger, but the senior author has specimens of a dwarf variety from Arbol Grande, near Tampico, Mexico. In *L. canellei* the ratio of the diameter to thickness is greater, and in perfectly preserved specimens there is a distinct flange which may be peripherally thickened. *L. canellei* lacks the pillars and the thickened surface papillae and costulations of *L. pancanalis*. The equatorial chambers of *L. canellei* are strikingly regular hexagonal in shape, while those of *L. pancanalis* are dominantly of diamond or short-spatulate form.

Certain specimens in the present collection were recognized immediately as *L. canellei* and others were assigned to *L. pancanalis*. Other specimens appeared to be intermediate between the two species.

An equatorial section and two vertical sections were made of topotypes of *L. pancanalis*. Measurements of these follow:

Measurements of equatorial sections of topotype and holotype of Lepidocyclina (L.) pancanalis

	Topotype	Holotype [after Vaughan and Cole, 1932]
Diameter	1.5 mm	1.5–2.0 mm
Embryonic chambers:		
Distance across both chambers	220 μ	185 μ
Maximum width	180 μ	145 μ
Thickness of outer wall	20 μ	25 μ
Equatorial chambers:		
Radial diameter	20–60 μ	60 μ
Tangential diameter	20–40 μ	50 μ
Shape	Rhombic, short-spatulate, hexagonal	Rhombic, short-spatulate, hexagonal

Measurements of vertical sections of topotypes and holotype of Lepidocyclina (L.) pancanalis

	Topotypes		Holotype [after Vaughan and Cole, 1932]
Diameter	1.6 mm	1.5 mm	1.5–2.0 mm
Thickness	0.8 mm	0.7 mm	0.75–1.0 mm
Embryonic chambers:			
Length	180 μ	180 μ	185 μ
Height	160 μ	160 μ	
Thickness of outer wall	30 μ	40 μ	25 μ
Equatorial layer:			
Height at center	70 μ	60 μ	
Height at periphery	80 μ	80 μ	
Lateral chambers:			
Number	8	6	10
Length	70–95 μ	60–90 μ	60 μ
Height	35 μ	40 μ	40 μ
Thickness of floors and roofs	8 μ	7 μ	
Surface diameter of pillars	60 μ	50–60 μ	Present

Measurements of equatorial sections of specimens from locality 53 assigned without question to Lepidocyclina canellei

	Specimen		
	1	2	3
Diameter	3.4 mm	3.1 mm	2.6 mm
Embryonic chambers:			
Distance across both chambers	260 μ	280 μ	200 μ
Maximum width	220 μ	240 μ	160 μ
Thickness of outer wall	20–40 μ	20–30 μ	30 μ
Equatorial chambers:			
Radial diameter	60–7 μ	70–80 μ	60–80 μ
Tangential diameter	60–80 μ	60–80 μ	40–60 μ
Shape	Short-spatule	Hexagonal	Rhombic, short-spatulate, hexagonal

Measurements of vertical sections of specimens from locality 53 assigned without question to Lepidocyclina canellei

	Specimen						
	1	2	3	4	5	6	7
Diameter	3.3 mm	3.1 mm	3.3 mm	3.06 mm	2.2 mm	2.0 mm	1.7 mm
Thickness	0.92 mm	0.96 mm	0.76 mm	1.0 mm	0.98 mm	0.92 mm	0.92 mm
Width of flange			0.16 mm	0.2 mm			
Embryonic chambers:							
Length	220 μ	280 μ	220 μ	180 μ	200 μ	180 μ	180 μ
Height	190 μ	240 μ	220 μ	180 μ	170 μ	180 μ	120 μ
Thickness of outer wall	40 μ	50 μ	20–40 μ	30 μ	20–30 μ	20 μ	20 μ
Equatorial layer:							
Height at center	80 μ	80 μ	80 μ	80 μ	65 μ	70 μ	70 μ
Height at periphery	140 μ	140 μ	160 μ	140 μ	120 μ	120 μ	100 μ
Lateral chambers:							
Number	12	9	9	10	10	10	10
Length	60–120 μ	60–80 μ	60–80 μ	60–80 μ	60–140 μ	60–110 μ	40–80 μ
Height	40 μ	30–40 μ	20–30 μ	30–40 μ	30–40 μ	20–40 μ	35–40 μ
Thickness of floors and roofs	6 μ	8 μ	6 μ	7 μ	8 μ	5–8 μ	8 μ
Surface diameter of pillars	None	None	None	None	None	None	None

The greatest difference between the specimens of *L. pancanalis* and *L. canellei* is the presence of pillars in *L. pancanalis* and their apparent absence in *L. canellei.* In other features there is a striking similarity.

Measurements of specimens of Lepidocyclina canellei *from localities other than no. 53*

Equatorial sections

	Specimen			
	[1] 1	[2] 2	[3] 3	[3] 4
Diameter	1.9 mm	2.94 mm	2.9 mm	2.2 mm
Embryonic chambers:				
Distance across both chambers	195 μ	260 μ	230 μ	230 μ
Maximum width	175 μ	220 μ	200 μ	185 μ
Thickness of outer wall	20–35 μ	20–30 μ	20–30 μ	30 μ
Equatorial chambers:				
Radial diameter	40–60 μ	50–70 μ	80 μ	80 μ
Tangential diameter	40–60 μ	50–60 μ	60 μ	60 μ
Shape	Short-spatulate	Short-spatulate, hexagonal	Short-spatulate	Short-spatulate

Measurements of specimens of Lepidocyclina cancellei *from localities other than no. 53*—Continued

Vertical sections

	Specimen				
	[1] 1	[2] 2	[3] 3	[3] 4	[3] 5
Diameter	2.44 mm	2.6 mm	2+ mm	2.2 mm	2.8 mm
Thickness	1.1 mm	1.1 mm	1.26 mm	1.1 mm	1.04 mm
Width of flange	0.2 mm	0.14 mm		0.14+ mm	
Embryonic chambers:					
Length	160 μ	220 μ	220 μ	200 μ	240 μ
Height	180 μ	180 μ	160 μ	180 μ	210 μ
Thickness of outer wall	20–30 μ	20–40 μ	20 μ	20–50 μ	40 μ
Equatorial layer:					
Height at center	80 μ	60 μ	75 μ	70 μ	70 μ
Height at periphery	120 μ	110 μ	100 μ	120 μ	140 μ
Lateral chambers:					
Number	10	11	11	10	12
Length	40–100 μ	80–100 μ	80–100 μ	80–100 μ	60–140 μ
Height	20–40 μ	30–40 μ	30–40 μ	30–40 μ	20–40 μ
Thickness of floors and roofs	10 μ	10 μ	5–8 μ	10 μ	10 μ
Surface diameter of pillars	None	100 μ	100 μ	60–100 μ	40 μ

[1] Locality 11a. [2] Locality 30. [3] Locality 43.

Specimens from stations 11a, 30, and 43 are intermediate in character between *L. pancanalis* and *L. canellei*. Therefore, as no reliable criterion was discovered by which this entire series could be broken at one definite point, these two species are combined.

Occurrence.—Locs. 11a, 30, 43, 53, 55. Distribution elsewhere: Upper Oligocene of Trinidad, Jamaica, Venezuela, near Tampico, Mexico, Antigua, and late Oligocene(?) part of Culebra formation, Canal Zone (Cushman, 1919a, p. 92, station 6019a, pl. 34, figs. 2, 3, identification questioned by Cushman; Woodring and Thompson, 1949, p. 238).

Lepidocyclina (Lepidocyclina) montgomeriensis Cole

Plate 15, figures 11–13; plate 20, figure 7; plate 23, figure 4

1949. *Lepidocyclina (Lepidocyclina) montgomeriensis* Cole, Jour. Palentology, vol. 23, pp. 270–272, pl. 53, figs. 2–11; pl. 54, fig. 8 (references and synonymy).

Typical specimens of *Lepidocyclina (L.) montgomeriensis* occur at two stations. Because this species has been illustrated by Panamanian specimens and discussed recently, additional remarks will not be given.

Occurrence.—Locs. 108, 125. Distribution elsewhere: Upper Eocene of the United States and Trinidad.

Lepidocyclina (Lepidocyclina) parvula Cushman

Plate 15, figures 6–10

1919. *Lepidocyclina parvula* Cushman, Carnegie Inst. Washington Publ. 291, p. 58, pl. 3, figs. 4–7.

1945. *Lepidocyclina (Lepidocyclina) parvula* Cushman. Cole, Florida Geol. Survey Bull. 28, pp. 30, 31, pl. 7, figs. 2–13; pl. 11, figs. 1, 2 (references and synonymy).

Small specimens having thick-walled, lepidocycline sensu stricto embryonic chambers, hexagonal to short-spatulate equatorial chambers, strong pillars and thick floors and roofs for the lateral chambers are assigned to this well-known and well-described species.

Occurrence.—Locs. 11a, 37, 39, 45, 55. Distribution elsewhere: Upper Oligocene of Antigua, eastern Mexico, Jamaica, Florida, and Trinidad.

Lepidocyclina (Lepidocyclina) waylandvaughani Cole

Plate 18, figures 1–10, 16, 17

1919. *Lepidocyclina vaughani?* Cushman (part), U. S. Nat. Mus. Bull. 103, p. 93, pl. 37, figs. 1, 2, 3 [not figs. 4, 5, nor pl. 38].

1923. *Lepidocyclina miraflorensis?* Vaughan, Nat. Acad. Sci. Proc., vol. 9, p. 257.

1924. *Lepidocyclina (Lepidocyclina) miraflorensis?* Vaughan. Vaughan, Geol. Soc. America Bull., vol. 35, p. 797.

1927. *Lepidocyclina (Lepidocyclina) miraflorensis?* Vaughan (part). Vaughan, U. S. Nat. Mus. Proc., vol. 71, art. 8, p. 4, pl. 4, fig. 3 [not figs. 4, 5 which are *L. (Nephrolepidina) vaughani* Cushman].

1928. *Lepidocyclina (Lepidocyclina) waylandvaughani* Cole, Bull. Am. Paleontology, vol. 14, no. 53, pp. 21, 22, pl. 4, figs. 1–8, 10.

1933. *Lepidocyclina (Lepidocyclina) waylandvaughani* Cole. Vaughan, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 13, 14, pl. 5, figs. 1–3, 5, 6.

Cushman (1919a, pp. 93, 94) under the name *L. vaughani* figured specimens of two distinct species, one of which belongs to the subgenus *Nephrolepidina* and the other to the subgenus *Lepidocyclina*. Vaughan (1923, p. 257) recognized this fact, and proposed the name *L. miraflorensis* for those specimens that represented *Lepidocyclina* sensu stricto.

Vaughan considered that Cushman's (1919a) figure 5 on plate 37 demonstrates the features of the vertical section of *L. miraflorensis*. This section shows that the lateral chambers are rectangular and have open cavities with very thin roofs and floors. Vaughan wrote:

The margins of *L. miraflorensis* are somewhat swollen but are rounded, not so much thickened and abruptly truncate as in

L. vaughani. There are no stout pillars in the vertical sections of *L. miraflorensis*, while there are such pillars in *L. vaughani.*

The sample from locality 11a contained specimens that in equatorial section suggest *L. miraflorensis*, but in vertical section appear to be *L. waylandvaughani* Cole, a closely related species. Consequently, it is desirable to ascertain the characters by which several similar Oligocene species of *Lepidocyclina* s. s. can be distinguished one from the other. These species are *L. mantelli* (Morton), *L. supera* (Conrad), *L. forresti* Vaughan, *L. miraflorensis* Vaughan, and *L. waylandvaughani* Cole. All of these species possess very similar features in equatorial section, but are described as differing in vertical section.

The swollen edge of certain of the specimens designated by Vaughan as *L. miraflorensis* suggests that the specimens that possess this feature may be *L. vaughani.* Moreover, in preparing vertical sections of *L. vaughani* one observes that the lateral chambers beyond the center are shorter than those over the embryonic chambers, and that those areas outside the central zone are devoid of pillars.

A vertical section (pl. 18, fig. 14) was prepared from a specimen of *L. vaughani* from locality 11a. At this locality *L. vaughani* occurs with the *Lepidocyclina* which appears to be *L. waylandvaughani.* This vertical section which was not ground to the center has thin-walled, open, lateral chambers of the type assigned to *L. miraflorensis.*

In the sample from locality 30 there are many well-preserved specimens of *L. vaughani.* One of these (pl. 18, fig. 15) is so ground that it is a virtual duplicate of the section that Vaughan used as one of the cotypes of *L. miraflorensis.*

The similarity in these off-center and oblique "vertical" sections, as well as oriented vertical sections, proves that Vaughan used specimens of *L. vaughani* for the description of the vertical section of *L. miraflorensis*, just as Cushman included in *L. vaughani* specimens of the subgenus *Lepidocyclina* as well as the subgenus *Nephrolepidina.*

Specimens belonging to the subgenus *Lepidocyclina* from locality 11a were compared with closely related species of the same subgenus illustrated on plate 18: *L. waylandvaughani* (figs. 1–10), *L. forresti* (fig. 11), *L. supera* (fig. 12), and *L. mantelli* (fig. 13).

Comparison of views of enlarged vertical sections shows that *L. mantelli* (Morton) has long lateral chambers with very low chamber cavities. It is a distinct species.

In *L. supera* (Conrad) the lateral chambers are shorter and the cavities more open than in *L. mantelli.* But, the vertical section of *L. forresti* Vaughan has the same features as *L. supera.* Vaughan (1927, p. 2) distinguished *L. forresti* from *L. supera* by the fact that "*L. supera* has well-developed pillars and papillae." This restudy of the type vertical section of *L. forresti* and topotypes of *L. supera* demonstrates that this feature is not a valid criterion for discriminating these two species. Therefore, *L. forresti* Vaughan is a synonym of *L. supera* (Conrad).

The specimens from Panama under discussion have the same features in vertical section as do topotypes of *L. waylandvaughani* from Mexico. However, both the Mexican and the Panamanian specimens have lateral chambers with thicker floors and roofs and less regular alinement in tiers than does the only vertical section of *L. miraflorensis* Vaughan (1927, pl. 4, fig. 5). This vertical section was published by Vaughan several years after his original description of *L. miraflorensis.*

The opinion has been expressed already in this discussion that the off-center, oblique "vertical" section figured by Cushman (1919a, pl. 37, fig. 5) and used by Vaughan in the type description of *L. miraflorensis* represents a section of *L. vaughani.* The oriented vertical section (Vaughan, 1927) appears also to represent *L. vaughani* for the following reasons: the lateral chambers are arranged in very regular tiers; the cavities of the lateral chambers are open, high, and rectangular; the roofs and floors of the equatorial chambers are thin; the equatorial layer expands rapidly toward the periphery of the test; and the central area of the test is dome-shaped. Oriented vertical sections of *L. vaughani* have all of these features and may be observed in the specimens illustrated as figures 6–10 on plate 21.

Therefore, it would appear that in the two available descriptions by Vaughan of *L. miraflorensis* vertical sections of *L. vaughani* have been used. There is, however, in the sample from the U.S.G.S. locality 6255, half a mile south of Miraflores Station, Canal Zone, a *Lepidocyclina* s. s. known from the equatorial sections which Cushman and Vaughan have published. It is these equatorial sections to which the name *L. miraflorensis* should be applied. The oblique "horizontal" section (Cushman, 1919a, pl. 37, fig. 3) is designated the lectotype of this species. No vertical section of this species has been made.

Although it is highly probable that *L. miraflorensis* and *L. waylandvaughani* are conspecific, some doubt must exist until vertical sections of authentic *L. miraflorensis* are available. Therefore, the Panamanian specimens in this collection are assigned to *L. waylandvaughani.*

Measurements and a brief description of the internal features of the specimens from locality 11a follow:

Measurements of vertical sections of Lepidocyclina (L.) waylandvaughani *from locality 11a*

	Specimen			
	1	2	3	4
Diameter	3.6+ mm	4+ mm	4.7+ mm	4.6+ mm
Thickness	0.7 mm	0.9 mm	1.0 mm	0.83 mm
Embryonic chambers:				
Length	280 μ	280 μ	180 μ	220 μ
Height	220 μ	160 μ	140 μ	220 μ
Thickness of outer wall	30 μ	25 μ	30 μ	30 μ
Equatorial layer:				
Height at center	80 μ	90 μ	80 μ	100 μ
Height at periphery	140 μ	180 μ	200 μ	240 μ
Lateral chambers:				
Number	7	8	8	7
Length	80–140 μ	60–160 μ	80–160 μ	60–200 μ
Height	10–15 μ	30–40 μ	20–35 μ	20–40 μ
Thickness of floors and roofs	10 μ	20 μ	10–20 μ	20 μ
Surface diameter of pillars	80 μ	100 μ	80 μ	60 μ

Measurements of vertical sections of topotypes of Lepidocyclina (L.) waylandvaughani

	Specimen			
	1	2	3	4
Diameter	6.5 mm	6.6 mm	4.2+ mm	4+ mm
Thickness	0.76 mm	0.7 mm	0.83 mm	1.0 mm
Embryonic chambers:				
Length	360 μ	380 μ	300 μ	300 μ
Height	250 μ	220 μ	250 μ	240 μ
Thickness of outer wall	40 μ	20 μ	40 μ	40 μ
Equatorial layer:				
Height at center	100 μ	85 μ	100 μ	80 μ
Height at periphery	260 μ	320 μ	220 μ	200 μ
Lateral chambers:				
Number	7	7	6	10
Length	40–180 μ	60–180 μ	80–180 μ	80–180 μ
Height	10–35 μ	20–25 μ	20 μ	20 μ
Thickness of floors and roofs	10 μ	10 μ	10 μ	10 μ
Surface diameter of pillars	80 μ	40 μ	80 μ	60–200 μ

The embryonic chambers are bilocular, surrounded by a relatively thick wall whose width in equatorial sections is about 40 μ. The distance across both chambers is 340 μ and the maximum width is 270 μ in the available section. The dividing partition is thin and straight. Small periembryonic chambers with internal diameters of about 50 by 140 μ occur opposite either end of the dividing partition. Several other periembryonic chambers border the bilocular chambers.

The equatorial chambers are arcuate near the center of the test and have radial diameters of about 60 μ and tangential diameters of about 60 μ. The chambers near the periphery are short-spatulate, and have radial diameters of about 80 μ and tangential diameters of about 80 μ.

The lateral chambers are not in regular tiers. There is considerable overlapping of the lateral chambers from one tier to the adjacent one.

Measurements of four vertical sections from topotypes of *L. waylandvaughani* are given for comparison with the specimens from Panama assigned to this species.

Occurrence.—Locs. 11a, 38. Distribution elsewhere: Upper Oligocene of Mexico, Antigua, and Trinidad.

Lepidocyclina (Lepidocyclina) yurnagunensis Cushman

Plate 15, figure 3; plate 17, figures 5–18; plate 20, figures 11, 12

1919. *Lepidocyclina canellei* Lemoine and R. Douvillé, variety *yurnagunensis* Cushman, Carnegie Inst. Washington Publ. 291, p. 57, pl. 12, figs. 7, 8.

1926. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman. Vaughan, Geol. Soc. London, Quart. Jour., vol. 82, pp. 391–393, pl. 25, figs. 2–6 (references and synonymy).

1934. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman. Cole, Jour, Paleontology, vol. 8, pp. 24, 25, pl. 3, figs. 4–6; pl. 4, figs. 8, 9.

1941. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman. Vaughan and Cole, Geol. Soc. America Spec. Paper 30, p. 72, pl. 38, figs. 1–7.

1945. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman. Cole, Florida Geol. Survey Bull. 28, p. 31, pl. 6, figs. 5, 6.

The widely distributed *Lepidocyclina (L.) yurnagunensis* has been adequately described and illustrated. The specimens in the present collection conform to the descriptions given from other localities. Two tables giving measurements of typical specimens follow.

Measurements of equatorial sections of Lepidocyclina (L.) yurnagunensis *from locality 45*

	Specimen			
	1	2	3	4
Diameter	2.9 mm	2.6 mm	3.5 mm	3.6 mm
Embryonic chambers:				
Type	Lepidocycline	Nephrolepidine	Lepidocycline	Nephrolepidine
Distance across both chambers	260 μ	240 μ	180 μ	420 μ
Maximum width	220 μ	240 μ	180 μ	400 μ
Thickness of outer wall	20 μ	20 μ	10 μ	20 μ
Equatorial chambers:				
Radial diameter	60 μ	60 μ	60 μ	80 μ
Tangential diameter	40 μ	40 μ	40 μ	60 μ

Measurements of vertical sections of Lepidocyclina (L.) yurnagunensis *from locality 45*

	Specimen				
	1	2	3	4	5
Diameter	2.4 mm	2.0 mm	2.5 mm	2.8 mm	2.9 mm
Thickness	0.8 mm	0.78 mm	0.92 mm	0.9 mm	1.0 mm
Embryonic chambers:					
Length	330 μ	190 μ	210 μ	290 μ	230 μ
Height	170 μ	120 μ	140 μ	180 μ	120 μ
Thickness of outer wall	25 μ	15 μ	15 μ	20 μ	15 μ
Equatorial layer:					
Height near center	80 μ	60 μ	80 μ	80 μ	80 μ
Height at periphery	160 μ	90 μ	120 μ	140 μ	130 μ
Lateral chambers:					
Number	8	8	6	10	9
Length	100–140 μ	120 μ	80–300 μ	100–240 μ	180–220 μ
Height	20–40 μ	20–30 μ	30–80 μ	20–40 μ	20 μ
Thickness of roofs and floors	15 μ	10 μ	15 μ	15 μ	20 μ
Surface diameter of pillars	80 μ	60 μ	100 μ	60 μ	50 μ

Occurrence.—Locs. 39, 45, 54. Distribution elsewhere: Upper Oligocene of Cuba; Cayman Brac, Cayman Islands; Haiti; Antigua formation of Antigua; Moneague formation of Jamaica; Suwannee limestone of Florida; Trinidad.

Lepidocyclina (Lepidocyclina) yurnagunensis morganopsis Vaughan

Plate 15, figures 1, 2, 4, 5; plate 23, figures 5–7, 9

1933. *Lepidocyclina yurnagunensis*, var. *morganopsis* Vaughan, Jour. Washington Acad. Sci., vol. 23, p. 354.

1945. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis*, var. *morganopsis* Vaughan. Cole, Florida Geol. Survey Bull. 28, pp. 31, 32, pl. 6, figs. 1–4, 7, 8 (references).

Megalospheric individuals of *Lepidocyclina* (*L.*) *yurnagunensis morganopsis* possess the same type of embryonic and equatorial chambers as does *L.* (*L.*) *yurnagunensis*. The variety, however, has very heavy pillars which appear in vertical sections, and large papillae which show in external views.

The microspheric specimens are relatively large and, therefore, in a sample of indurated rock that is being broken for specimens for oriented sections, the microspheric forms are more easily obtained than the smaller, more fragile megalospheric specimens. This may account for the apparent abundance of microspheric individuals which were obtained from the present collection.

Occurrence.—Microspheric specimens, locs. 11a, 37, 38, 39, 45, 53; megalospheric specimens, loc. 53. Distribution elsewhere: Upper Oligocene of Cuba, Florida, and Trinidad.

Subgenus NEPHROLEPIDINA H. Douvillé, 1911

Lepidocyclina (Nephrolepidina) chaperi Lemoine and R. Douvillé

Plate 8, figures 5–8; plate 9, figures 3–19; plate 10, figures 1–10; plate 11, figures 1–8; plate 12, figures 1–15; plate 20, figures 8–10; plate 23, figures 8, 11, 12.

1904. *Lepidocyclina chaperi* Lemoine and R. Douvillé, Soc. Géol. France Mém., vol. 12, pp. 14, 15, pl. 2, fig. 5.

1919. *Lepidocyclina subraulinii* Cushman, Carnegie Inst. Washington Pub. 291, pp. 62, 63, pl. 11, figs. 6, 7 [probably not pl. 12, figs. 5, 6].

1919. *Lepidocyclina perundosa* Cushman, idem, p. 63, pl. 11, fig. 8.

1920. *Lepidocyclina fragilis* Cushman, U. S. Geol. Survey Prof. Paper 125, pp. 63, 64, pl. 22, figs. 1, 2.

1928. *Lepidocyclina* (*Nephrolepidina*) *haddingtonensis* Vaughan, Jour. Paleontology, vol. 1, pp. 292–294, pl. 50, figs. 1, 2.

1933. *Lepidocyclina* (*Nephrolepidina*) *semmesi* Vaughan and Cole. Vaughan, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 29, 30, pl. 15, figs. 3–5; pl. 30, fig. 1; pl. 31, figs. 1, 1a; pl. 32, figs. 2, 3.

1933. *Lepidocyclina* (*Nephrolepidina*) *semmesi* var. *granosa* Vaughan and Cole, idem, p. 30, pl. 30, fig. 2.

1933. *Lepidocyclina* (*Nephrolepidina*) *tantoyucensis* Vaughan and Cole, idem, pp. 30, 31, pl. 15, figs. 1, 2.

1937. *Lepidocyclina* (*Nephrolepidina*) *fragilis* Cushman, var. *cubensis* Thiadens, Jour. Paleontology, vol. 11, p. 104, pl. 17, fig. 6; pl. 18, fig. 7.

1937. *Lepidocyclina* (*Lepidocyclina*) *tschoppi* Thiadens, idem, pp. 103, 104, pl. 17, figs. 1, 3; pl. 18, fig. 6; pl. 19, fig. 1; text fig. 3H.

1941. *Lepidocyclina* (*Nephrolepidina*) *sanfernandensis* Vaughan and Cole, Geol. Soc. America Spec. Paper 30, pp. 73, 74, pl. 42, figs. 1–6; pl. 43, figs. 1–3; pl. 44, fig. 1.

1945. *Lepidocyclina* (*Nephrolepidina*) *sanfernandensis* Vaughan and Cole, var. *tallahasseensis* Cole, Florida Geol. Survey Bull. 28, pp. 34–39, pl. 1, figs, 16, 17; pl. 2, figs. 5–7; pl. 3, figs. 1–6.

Lemoine and R. Douvillé (1904, pp. 14, 15) described *Lepidocyclina chaperi* as a new species from Haut-Chagres, Panama. The original description is so brief that it is impossible to recognize the species from the details given. The species is illustrated by one external view.

Fortunately, H. Douvillé (1924, pp. 44, 45) later gave a fuller description of this species and illustrated it by two detailed photomicrographs of the surface of the species and several drawings of the embryonic apparatus, equatorial chambers, and the distribution of the pillars. Woodring supplied topotypes collected by E. R. Lloyd in 1918. Although these specimens are partly silicified, satisfactory equatorial and vertical thin sections were made.

Therefore, it is possible to assign certain specimens from locality 23 to *Lepidocyclina chaperi* with absolute certainty. These specimens possess every feature mentioned or illustrated by Douvillé and are identical with the topotypes. A description of the specimens from locality 23 follows:

Megalospheric generation.—Test of moderate size, having diameters from 6 to 11 mm; disc-shaped, with a thin outer edge. The central area is slightly inflated, and the test slopes more or less regularly from this area to the periphery. Most of the specimens are very slightly selliform, but a few are strongly so. The central area has small, indistinct low papillae evenly scattered over it. The peripheral zone of the test is without papillae and usually the outlines of the equatorial chambers can be seen in this peripheral area.

The embryonic chambers are nephrolepidine, large, and have outer walls that may be either thin or thick. Several elongate periembryonic chambers occur with the two larger ones opposite the ends of the dividing partition between the embryonic chambers. Some specimens have initial and second embryonic chambers of almost the same size (pl. 11, fig. 5). In this type the second chamber barely embraces the initial chamber. Specimens with this type of embryonic apparatus do not differ in any other respect from those with the strongly embracing second chamber.

The equatorial chambers have several shapes; some are short-hexagonal, others are arcuate, and a few are

Measurements of equatorial sections of Lepidocyclina (N.) chaperi *from locality 23*

	Specimen			
	1	2	3	4
Diameter	8.3 mm	11.0 mm	12.0 mm	8.0 mm
Embryonic chambers:				
Diameters of initial chamber	520×860 μ	520×820 μ	480×750 μ	500×760 μ
Diameters of second chamber	300×1040 μ	460×1160 μ	520×1180 μ	300×830 μ
Distance across both chambers	840 μ	1010 μ	1010 μ	820 μ
Thickness of outer wall	80 μ	30 μ	30 μ	60 μ
Equatorial chambers:				
Near center:				
Radial diameter	60–100 μ	140 μ	120 μ	100 μ
Tangential diameter	100–140 μ	140 μ	100–160 μ	100 μ
Near periphery:				
Radial diameter	40–60 μ	80 μ	60–80 μ	70 μ
Tangential diameter	80–100 μ	80–90 μ	100–120 μ	90 μ

Measurements of vertical sections of Lepidocyclina (N.) chaperi *from locality 23*

	Specimen					
	1	2	3	4	5	6
Diameter	6.7 mm	8.1 mm	8.4 mm	9.2 mm	10.8 mm	9.8+ mm
Thickness	1.62 mm	1.72 mm	1.54 mm	1.44 mm	1.5 mm	1.6 mm
Embryonic chambers:						
Length	840 μ	700 μ	750 μ	840 μ	860 μ	780 μ
Height	640 μ	460 μ	560 μ	600 μ	540 μ	340 μ
Thickness of outer wall	60 μ	60 μ	60 μ	40 μ	60 μ	60 μ
Equatorial layer:						
Height at center	140 μ	140 μ	150 μ	150 μ	180 μ	140 μ
Height at periphery	200 μ	260 μ	220 μ	300 μ	300 μ	340 μ
Lateral chambers:						
Number on each side of embryonic chamber.	8	12	12	10	12	11
Length	80–140 μ	100–160 μ	110–220 μ	100–220 μ	120–160 μ	120–240 μ
Height	20 μ	20 μ	10–20 μ	20 μ	10 μ	10–15 μ
Thickness of roofs and floors	20–40 μ	15–30 μ	10–20 μ	10 μ	20 μ	20–30 μ
Surface diameter of pillars	60–80 μ	100–160 μ	80–140 μ	100 μ	100 μ	100–120 μ

Measurements of equatorial sections of topotypes of Lepidocyclina (N.) fragilis *Cushman*

	Specimen			
	1	2	3	4
Diameter	4.7 mm	4.6 mm	7.4 mm	8.5 mm
Embryonic chambers:				
Diameters of initial chamber	620×880 μ	840×1140 μ		530×780 μ
Diameters of second chamber	480×940 μ	540×1280 μ		440×960 μ
Distance across both chambers	1120 μ	1420 μ	1180 μ	990 μ
Thickness of outer wall	60 μ	40 μ	60 μ	40 μ
Equatorial chambers:				
Near center:				
Radial diameter	140 μ	120 μ	140 μ	140 μ
Tangential diameter	120 μ	110 μ	140 μ	130 μ
Near periphery:				
Radial diameter	120 μ	140 μ	100 μ	120 μ
Tangential diameter	120 μ	90 μ	100 μ	140 μ

Measurements of vertical sections of topotypes of Lepidocyclina (N.) fragilis *Cushman*

	Specimen			
	1	2	3	4
Diameter	5.8 mm	6.5+ mm	7.8+ mm	8.1+ mm
Thickness	1.42 mm	0.96 mm	1.44 mm	1.42 mm
Embryonic chambers:				
Length	1060 μ	720 μ	1020 μ	920 μ
Height	480 μ	240 μ	600 μ	500 μ
Thickness of outer wall	45 μ	20 μ	60 μ	40 μ
Equatorial layer:				
Height at center	160 μ	150 μ	150 μ	140 μ
Height at periphery	160 μ	140 μ	160 μ	160 μ
Lateral chambers:				
Number	9	7	7	12
Length	140–240 μ	100–320 μ	80–140 μ	160–260 μ
Height	20 μ	10–20 μ	20–30 μ	20–40 μ
Thickness of floors and roofs	20–30 μ	20–40 μ	20 μ	20 μ
Surface diameter of pillars	100 μ	60–100 μ	60–100 μ	60 μ

rhombic. The largest equatorial chambers occur near the center of the test and they become progressively smaller toward the periphery.

The lateral chambers may be arranged in rather regular tiers (pl. 9, fig. 9) or they may overlap from one tier into the adjacent one (pl. 9, fig. 11). The chamber cavities are long, low. In some specimens the chamber cavities are more appressed than in others. In the specimens with the most appressed chamber cavities the roof and floors of the chambers are very thick. In both types the floors and roofs of the lateral chambers are thicker in the chambers adjacent to the equatorial plane and thinner in the chambers near the surface. Moreover, there is complete gradation between the types with thin roofs and floors and those with thick ones.

Small wedge-shaped pillars are irregularly distributed in the central area.

The details of *L. chaperi* suggest features similar to those noted previously in the preparation of a suite of thin sections of topotypes of *L. fragilis* Cushman.

As the sections of the Panamanian specimens assigned to *L. chaperi* and those of topotypes of *L. fragilis* are studied, it becomes more and more apparent that it is impossible to distinguish the two species, and, therefore *L. fragilis* is a synonym of *L. chaperi.*

Topotypes of *L. sanfernandensis tallahasseensis* Cole from a well in Florida were available for study. These specimens were separated into two lots, one containing inflated specimens, the other lenticular specimens. The inflated type is illustrated by a vertical section (pl. 9, fig. 19) and two equatorial sections (pl. 11, figs. 1, 2). The lenticular type is illustrated by a vertical section (pl. 9, fig. 18) and a horizontal section (pl. 11, fig. 3). These illustrations prove that there are no essential differences between certain specimens named *L. fragilis* and others called *L. sanfernandensis tallahasseensis* (compare fig. 17 with 18, pl. 9, and fig. 3, pl. 11 with figs. 1, 2, pl. 10).

Because there is complete gradation between specimens of the lenticular and the inflated type named *L. sanfernandensis tallahasseensis*, all of these must be assigned to *L. fragilis* and therefore, to *L. chaperi.* It is, moreover, clear that the specimens from Trinidad named *L. sanfernandensis* Vaughan and Cole fall within this series.

Other specimens in the Panamanian collection had been identified as *L.* (*Nephrolepidina*) *semmesi* Vaughan and Cole, a species from the Mexican upper Eocene.

These specimens occur principally at localities 125 and 140. A brief description of the specimens from locality 125 follows:

The normal embryonic chambers are nephrolepidine, but there is considerable variation in both shape and size. In some specimens the embryonic chambers are nearly lepidocycline sensu stricto, whereas others have gigantic nephrolepidine embryonic chambers.

Measurements of equatorial sections of Lepidocyclina (N.) chaperi *from locality 125*

	Specimen							
	1	2	3	4	5	6	7	8
Diameter	3.8 mm	4.5 mm	4.2 mm	5.2 mm	6.0 mm	6.8 mm	7.4 mm	8.0 mm
Embryonic chambers:								
Diameters of initial chamber	470×680 μ	600×870 μ	440×620 μ	470×680 μ	880×1020 μ	330×480 μ	340×570 μ	300× 480 μ
Diameters of second chamber	310×720 μ	420×1050 μ	340×800 μ	450×760 μ	440×1480 μ	300×600 μ	280×660 μ	320 ×620 μ
Distance across both chambers	810 μ	1040 μ	790 μ	940 μ	1340 μ	640 μ	640 μ	640 μ
Thickness of outer wall	40 μ	20 μ	40 μ	35 μ	35 μ	45 μ	50 μ	40 μ
Equatorial chambers:								
Near center:								
Radial diameter	120 μ	120 μ	130 μ	120 μ	110 μ	110 μ	90 μ	100 μ
Tangential diameter	120 μ	120 μ	100 μ	120 μ	130 μ	110 μ	80 μ	110 μ
Near periphery:								
Radial diameter	120 μ	100 μ	80 μ	100 μ	110 μ	110 μ	110 μ	100 μ
Tangential diameter	120 μ	110	80 μ	140 μ	100 μ	140 μ	110 μ	140 μ

The equatorial chambers are commonly short-spatulate, but some are hexagonal and others are arcuate. All three types may occur in the same equatorial section.

Measurements of vertical sections of Lepidocyclina (N.) chaperi *from locality 125*

	Specimen								
	1	2	3	4	5	6	7	8	9
Diameter	2.6 mm	4.2+ mm	4.4 mm	6.3+ mm	5.3 mm	6+ mm	8+ mm	6.6 mm	7.1+ mm
Thickness	0.78 mm	1.06 mm	1.22	1.5 mm	1.24 mm	1.6 mm	1.7 mm	1.8 mm	2.2 mm
Embryonic chambers:									
Length	640 μ	500 μ	640 μ	700 μ	760 μ	720 μ	820 μ	880 μ	700 μ
Height	260 μ	320 μ	460 μ	240 μ	340 μ	420 μ	380 μ	360 μ	460 μ
Thickness of outer wall	50 μ	60 μ	60 μ	50 μ	60 μ	60 μ	40 μ	60 μ	60 μ
Equatorial layer:									
Thickness at center	150 μ	140 μ	140 μ	160 μ	140 μ	160 μ	200 μ	190 μ	150 μ
Thickness at periphery	160 μ	160 μ	160 μ	190 μ	190 μ	200 μ	260 μ	190 μ	210 μ
Lateral chambers:									
Number	5	8	7	12	8	12	14	12	18
Length	80–100 μ	100–210 μ	80–220 μ	80–300 μ	70–200 μ	120–140 μ	160–240 μ	120–180 μ	100–300 μ
Height	10 μ	10 μ	20 μ	10 μ	10–20 μ	10–20 μ	20 μ	20 μ	20 μ
Thickness of roofs and floors	30–40 μ	20–40 μ	20 μ	20–30 μ	20–30 μ	20–30 μ	20 μ	20 μ	20 μ
Surface diameter of pillars	80–100 μ	60–140 μ	100–160 μ	80–140 μ	120–200 μ	120 μ	80–100 μ	60–260 μ	160–200 μ

The lateral chambers are not arranged in regular tiers. There is overlapping from one tier to the adjacent one. The cavities of the lateral chambers adjacent to the equatorial layer are low and slitlike between very thick roofs and floors, but those near the periphery are more open and their floors and roofs have a thickness about equal to the height of the cavities. The thinner specimens do not possess this outer zone of open lateral chambers.

Although these specimens at first glance appear to be different from those assigned to *L. chaperi*, detailed study shows that there are no valid characters upon which a separation can be based. Vaughan and Cole (1933, p. 31) wrote:

> *Lepidocyclina semmesi* and *L. tantoyucensis* both belong to the subgenus *Nephrolepidina* and are so closely related to *L.* (*Nephrolepidina*) *fragilis* Cushman that the senior author has vacillated between referring them to that species and assigning new names to them.

If Vaughan and Cole had had available the present collections, they would have assigned the Mexican forms to *L. fragilis* without question.

Associated with the larger specimens already described are certain small, strongly umbonate specimens. A description follows:

Small specimens with a strong umbo and a narrow rim occur infrequently in the sample from locality 125. Measurements of an equatorial and a vertical section follow:

Diameter, 2.26 mm; thickness through center, 1.0 mm; diameter of umbo, 1.2 mm; width of rim, 0.5 mm; thickness of rim, 0.24 mm.

The distance across both embryonic chambers is 780 μ and the height of the embryonic chambers is 640 μ.

The equatorial chambers are short-spatulate. Those near the periphery have radial diameters of 130 μ and tangential diameters of 80 μ.

There are two or three layers of lateral chambers over the embryonic chambers. The cavities of these chambers are low and slitlike between thick floors and roofs.

These specimens were identified as *Lepidocyclina (Lepidocyclina) tschoppi* Thiadens (1937, pp. 103, 104) but study demonstrated that they represent immature specimens of *L. (Nephrolepidina) chaperi*. The large thick-walled embryonic apparatus, the short-spatulate equatorial chambers, and the low, slitlike cavities of the lateral chambers are features which characterize *L. (Nephrolepidina) chaperi*.

The Cuban specimens were not referred to the correct subgenus. The embryonic apparatus of *L. (Nephrolepidina) chaperi* varies from nearly lepidocycline sensu stricto to nephrolepidine. *L. tschoppi* occurs in Cuba in beds which Thiadens referred to "transitional beds between the upper Eocene and Oligocene." These same beds contain *L. (Nephrolepidina) fragilis cubensis* Thiadens. This new variety of *L. fragilis* represents one of the adult stages of *L. (Nephrolepidina) chaperi*.

Microspheric generation.—A vertical section of a microspheric individual with a diameter of 12 mm and a thickness through the center of 2.8 mm has an umbonate portion with a diameter of 5 mm surrounded by a rim 4 mm wide.

The equatorial layer has a height at the center of the test of 120 μ and at the periphery 300 μ; these measurements include the thickness of the roofs and floors.

There are 22 lateral chambers to a tier on each side of the equatorial layer at the center of the test. The lateral chambers are arranged in tiers, but there is overlapping from one tier to the adjacent one. The cavities of the lateral chambers are low and slitlike between thick roofs and floors in a zone adjacent to the equatorial layer. In the peripheral zone the cavities of the lateral chambers become more open and the roofs and floors are thinner. The cavities of the lateral chambers in this outer zone have a height of 30 to 40 μ and a length of 160 to 360 μ. The thickness of the roofs and floors of these chambers is from 20 to 40 μ.

The inflated portion of the test has long, slender pillars. Average pillars have a surface diameter of 200 μ.

A specimen with a thickness through the center of 3.8 mm has 25 lateral chambers to a tier on each side of the equatorial layer. The other details of this specimen are similar to the details of the other available thin section.

These microspheric specimens from locality 125 agree in every detail with *L. (Lepidocyclina) subraulinii* Cushman as illustrated by Vaughan (1933, pl. 2, figs. 1–3). The vertical section (Vaughan, 1933, pl. 3, fig. 1) of a megalospheric specimen assigned by Vaughan probably to *L. subraulinii* shows many of the features of the inflated type of specimen from Florida called *L. sanfernandensis tallahasseensis*.

Occurrence.—Locs. 15, 23, 125, 137, 138a, 140, 150. Distribution elsewhere: Upper Eocene of Florida (as *L. fragilis* and *L. sanfernandensis tallahasseensis*), Cuba (as *L. perundosa* and *L. subraulinii*), Mexico (as *L. semmesi* and *L. tantoyucensis*), Trinidad (as *L. sanfernandensis*) and Jamaica (as *L. haddingtonensis*).

Remarks.—From beds assigned to the uppermost Eocene [2] in America seven species and three varieties of *Nephrolepidina* have been described:

Lepidocyclina (Nephrolepidina) chaperi Lemoine and R. Douvillé (1904) Panama; *perundosa* Cushman (1919) Cuba; *fragilis* Cushman (1920) Florida; *fragilis cubensis* Thiadens (1937) Cuba; *haddingtonensis* Vaughan (1928) Jamaica; *semmesi* Vaughan and Cole (1933) Mexico; *semmesi granosa* Vaughan and Cole (1933) Mexico; *tantoyucensis* Vaughan and Cole (1933) Mexico; *sanfernandensis* Vaughan and Cole (1941) Trinidad; *sanfernandensis tallahasseensis* Cole (1943) Florida.

To this list should be added probably *L. persimilis* H. Douvillé (1924) from beds reported by him to be Oligocene in age at Erin Point, Trinidad. This species is inadequately described and is illustrated only by drawings of the embryonic and equatorial chambers and distribution of pillars. These features suggest that *L. persimilis* is in reality *L. chaperi*, but a positive statement should not be made until topotypes can be examined.

All of these species possess large nephrolepidine embryonic chambers, short-spatulate to arcuate equatorial chambers, low cavities in the lateral chambers with floors and roofs about equal in thickness to the height of the cavities, and usually small pillars. The characters of individuals from one locality vary, and the predominant types of individuals vary from locality to locality, but the essential characters are similar in all of these specimens. Thus, the author believes them to be of only one species.

Lepidocyclina (Nephrolepidina) dartoni Vaughan

Plate 19, figures 1–8

1933. *Lepidocyclina (Nephrolepidina) dartoni* Vaughan, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 36, 37, pl. 25, figs. 1, 2; pl. 26, figs. 1–3.

Test with a central, evenly inflated umbonate area which is surrounded by an undulating rim. Several rays on the rim give the test a stellate margin. These rays are faint in some specimens and strong in others. The rays do not extend into the umbonal area in either

[2] Recently, MacNeil (1944, pp. 1324–1328) placed the *L. fragilis* zone in Florida in the lower Oligocene. New evidence from Florida (Wayne Moore, personal communication) indicates that this assignment is incorrect. Moore places the *L. fragilis* zone in the uppermost Eocene because of the presence of *Helicolepidina spiralis* Tobler.

type. Slightly weathered specimens have relatively large polygonal pits on the surface of the umbo. These pits are a reflection of the large, open lateral chambers. A specimen with a diameter of more than 4.3 mm has an umbo with a diameter of about 2.6 mm. A strong ray projects 0.6 mm beyond the periphery of the test. The measurable diameter of the largest specimen is 4.8 mm, but a part of the rim has been destroyed. This specimen has an umbo with a diameter of 2.8 mm.

The embryonic chambers are nephrolepidine. There are four principal periembryonic chambers, one of them lying at each end of the curved dividing partition between the embryonic chambers. The other two are situated so that one is on each side of the larger, reniform embryonic chamber.

Measurements of equatorial sections follow:

Measurements of equatorial sections of Lepidocyclina (N.) dartoni *from locality 11a*

	Specimen	
	1	2
Diameter	4.44 mm	3.54 mm
Embryonic chambers:		
Diameters of initial chamber	160×240 μ	140×180 μ
Diameters of second chamber.	180×350 μ	100×260 μ
Distance across both chambers.	360 μ	260 μ
Thickness of outer wall	25 μ	25 μ
Equatorial chambers:		
Near center:		
Radial diameter	60 μ	60 μ
Tangential diameter	60 μ	40 μ
Near periphery:		
Radial diameter	60–120 μ	60–110 μ
Tangential diameter	60 μ	50–60 μ

Measurements of vertical sections of Lepidocyclina (N.) dartoni *from locality 11a*

	Specimens		
	1	2	3
Total diameter	4.0+ mm	2.5+ mm	3.4+ mm
Diameter of umbo	2.2 mm	1.3 mm	2.6 mm
Width of rim	0.6 mm		0.5+ mm
Thickness	1.52 mm	1.0 mm	1.2 mm
Embryonic chambers:			
Length	260 μ	250 μ	360 μ
Height	160 μ	180 μ	220 μ
Thickness of outer wall	20 μ	20 μ	30 μ
Equatorial layer:			
Height at center	80 μ	80 μ	60 μ
Height at periphery	120 μ	140 μ	110 μ
Lateral chambers:			
Number	10	9	9
Length	240 μ	180–220 μ	120–300 μ
Height	40 μ	40 μ	40 μ
Thickness of floors and roofs	20 μ	20 μ	20 μ
Surface diameter of pillars	100 μ		95 μ

The equatorial chambers are rhombic near the center of the test, but toward the periphery they become spatulate to elongate-hexagonal, with radial diameters greater than the tangential. The radiate character of the test is expressed by the arrangement of the equatorial chambers.

The lateral chambers are arranged in regular tiers. They have large, open rectangular cavities between rather strong roofs and floors. Slender pillars may or may not be present in the umbonal area.

Occurrence.—Loc. 11a. Distribution elsewhere: Only at type locality in Cuba in Oligocene beds.

Remarks.—The thin sections on which the type description of this species is based are random ones cut from the matrix material in which the specimens were found. Although the specimens from Panama are smaller and have considerably smaller embryonic chambers than the type specimens, the other similarities of the internal features of the Cuban and Panamanian specimens are proof that the specimens in the present collection should be referred to the Cuban species.

Lepidocyclina (Nephrolepidina) tournoueri Lemoine and R. Douvillé

Plate 19, figures 9–12

1904. *Lepidocyclina tournoueri* Lemoine and R. Douvillé, Soc. Géol. France Mém. 32, p. 19, pl. 1, fig. 5; pl. 2, figs. 2, 14; pl. 3, fig. 1.

1924. *Lepidocyclina tournoueri* Lemoine and R. Douvillé. H. Douvillé, Soc. Géol. France Mém., n. s., vol. 2, no. 2, p. 78, pl. 6, figs. 8–12, text figs. 62–68.

1924. *Lepidocyclina tournoueri* Lemoine and R. Douvillé. Vaughan, Geol. Soc. America Bull., vol. 35, p. 798, pl. 33, figs. 6, 7.

1933. *Lepidocyclina* (*Nephrolepidina*) *tournoueri* Lemoine and R. Douvillé. Vaughan, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 25, 26, pl. 13, figs. 1, 2.

1933. *Lepidocyclina* (*Nephrolepidina*) *tempanii* Vaughan and Cole. Vaughan, idem, pp. 26, 27, pl. 13, figs. 3–6.

1941. *Lepidocyclina* (*Nephrolepidina*) *tempanii* Vaughan and Cole. Vaughan and Cole, Geol. Soc. America Spec. Paper 30, p. 75, pl. 39, figs. 5–9.

1945. *Lepidocyclina* (*Nephrolepidina*) *tournoueri* Lemoine and R. Douvillé. Cole, Florida Geol. Survey Bull. 28, p. 34, pl. 5, figs. 18, 19.

The two species, *Lepidocyclina tournoueri* and *L. tempanii*, are distinguished by the fact that *L. tempanii* has much more elongate equatorial chambers than *L. tournoueri*. The maximum radial diameter of peripheral equatorial chambers of *L. tournoueri* is given by Vaughan (1933, p. 26) as 67 μ whereas equatorial chambers of *L. tempanii* have a maximum radial diameter of about 110 μ.

The writer prepared several additional equatorial sections of *L. tournoueri* from Arbol Grande, near Tampico, Tamaulipas, Mexico, for comparison. These sections have peripheral equatorial chambers which have radial diameters from 65 to 120 μ. It would appear from this that it is impossible to distinguish between these two species.

L. (*Nephrolepidina*) *lehneri* van de Geyn and van der Vlerk (1935, p. 251, figs. 14, 15), an inadequately described and illustrated species from the Oligocene, is probably a synonym of *L. tournoueri*.

Occurrence.—Loc. 45. Distribution elsewhere: Reported from Antigua and Trinidad as *L. tempanii*, and from near Tampico, Tamaulipas, Mexico.

Lepidocyclina (Nephrolepidina) vaughani Cushman

Plate 18, figures 14, 15; plate 20, figures 1–6; plate 21, figures 1–15

1919. *Lepidocyclina vaughani* Cushman, U. S. Nat. Mus. Bull. 103, p. 93, pl. 37, figs. 4, 5 [not figs. 1, 2, 3]; pl. 38.

1933. *Lepidocyclina* (*Nephrolepidina*) *vaughani* Cushman. Vaughan, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 32, 33, pl. 16, figs. 1–5 (references).

Externally this species is characterized by a small umbo bordered by a wide rim, the outer edge of which is thickened so that a raised flange borders the outer periphery of the test.

Vaughan has discussed this species rather fully. Measurements of equatorial and vertical sections which demonstrate the variation among individuals follow.

Measurements of equatorial sections of Lepidocyclina (Nephrolepidina) vaughani

	Locality				
	30		38		43
	Specimen				
	1	2	3	4	5
Diameter	8.6 mm	7+ mm	Broken	Broken	5.7+ mm
Embryonic chambers:					
Diameters of initial chamber	260×340 μ	290×340 μ	420×460 μ	440×550 μ	590×900 μ
Diameters of second chamber	160×620 μ	340×660 μ	360×720 μ	300×860 μ	395×1340 μ
Distance across both chambers	460 μ	650 μ	800 μ	760 μ	1000 μ
Thickness of outer wall	20–30 μ	20 μ	20 μ	20 μ	20 μ
Equatorial chambers:					
Near center:					
Radial diameter	60 μ	120 μ	120 μ	110 μ	100–160 μ
Tangential diameter	60 μ	80 μ	90 μ	100 μ	90–100 μ
Near periphery:					
Radial diameter	60–80 μ	100–150 μ	Broken	Broken	120 μ
Tangential diameter	60–80 μ	100 μ	do	do	80 μ

Measurements of vertical sections of Lepidocyclina (Nephrolepidina) vaughani

	Locality							
	11a	30		38		43		123
	Specimen							
	1	2	3	4	5	6	7	8
Diameter	9.4 mm	8.0 mm	7.2+ mm	Broken	Broken	Broken	Broken	7.9+ mm
Thickness	1.54 mm	1.7 mm	1.44 mm	1.4 mm	1.2 mm	1.7 mm	1.42 mm	1.3 mm
Diameter of umbonal area	3.0 mm	3.0 mm	2.4 mm	2.4 mm	2.6 mm	3.4 mm	3.4 mm	2.0 mm
Thickness of flange at its center	0.44 mm	0.56 mm	0.4 mm	Broken	Broken	0.56 mm	Broken	0.4 mm
Thickness of expanded edge of flange	0.66 mm	0.7 mm	0.44+ mm	do	do	Broken	do	0.52 mm
Embryonic chambers:								
Length	500 μ	540 μ	360 μ	1100 μ	780 μ	960 μ	600 μ	600 μ
Height	240 μ	320 μ	200 μ	320 μ	330 μ	340 μ	380 μ	290 μ
Thickness of outer wall	20 μ	30–40 μ	20 μ	20 μ	20 μ	20 μ	20 μ	20–30 μ
Equatorial layer:								
Height at center	120 μ	120 μ	100 μ	120 μ	120 μ	130 μ	120 μ	110 μ
Height at periphery	660 μ	720 μ	440+ μ	Broken	Broken	Broken	Broken	500 μ
Lateral chambers:								
Number	8	9	10	8	7	10	9	7
Length	140–240 μ	100–280 μ	140–280 μ	200–280 μ	140–260 μ	120–280 μ	140–340 μ	140–280 μ
Height	20–80 μ	50–70 μ	20–60 μ	40–80 μ	40–60 μ	50–80 μ	30–60 μ	30–60 μ
Thickness of roofs and floors	20 μ	20 μ	20 μ	20 μ	20 μ	20 μ	20 μ	20 μ
Surface diameter of pillars	60–80 μ	80 μ	100 μ	80 μ	60 μ	100 μ	60–80 μ	100 μ

Occurrence.—Locs. 11a, 30, 37, 38, 43, 53, 121, 123. Distribution elsewhere: Upper Oligocene of Antigua.

Remarks.—*Lepidocyclina* (*Nephrolepidina*) *verbeeki* Barker (1932, pp. 278, 279, pl. 16, figs. 2, 3, 5, not figs. 1, 4), [not Newton and Holland, 1875], from the Oligocene of San Pedro, Peru, is without question *L. vaughani.* In Peru this species occurs with *Miogypsina* (*Miolepidocyclina*) *panamensis* (Cushman).

Subgenus EULEPIDINA H. Douvillé, 1911

Lepidocyclina (Eulepidina) favosa Cushman

Plate 22, figures 1–5

1919. *Lepidocyclina favosa* Cushman, Carnegie Inst. Washington Pub. 291, p. 66, pl. 3, figs. 1b, 2; pl. 15, fig. 4.
1945. *Lepidocyclina* (*Eulepidina*) *favosa* Cushman. Cole, Florida Geol. Survey Bull. 28, pp. 41–43, pl. 4, figs. 3, 4, 7, 11; pl. 8, figs. 1, 2; pl. 9, figs. 1–7; pl. 10, figs. 1–9; pl. 11, fig. 9 (references and synonymy).

Lepidocyclina (*E.*) *favosa* has been discussed in detail by Vaughan (1933), pp. 37–41) and later by Cole (1945, pp. 41–43).

An equatorial and a vertical section of megalospheric individuals are figured, also several sections of microspheric individuals. In the material available the microspheric generation appears to be the common one, but this may be due to the manner in which the specimens were selected.

Occurrence.—Locs. 38, 39. Distribution elsewhere: The same as that of *L. undosa.*

Lepidocyclina (Eulepidina) undosa Cushman

Plate 22, figures 6–8

1919. *Lepidocyclina undosa* Cushman, Carnegie Inst. Washington Pub. 291, p. 65, pl. 2, fig. 1a.
1945. *Lepidocyclina* (*Eulepidina*) *undosa* Cushman. Cole, Florida Geol. Survey Bull. 28, pp. 43, 44, pl. 1, figs. 14, 15; pl. 2, fig. 8; pl. 8, fig. 7; pl. 11, fig. 8. (references and synonymy).

The equatorial sections of *Lepidocyclina favosa* and *L. undosa* are similar. The differences occur in the vertical sections. At most localities these two species occur together. It is extremely probable that only one highly variable species is represented, and that *L. gigas* Cushman is the microspheric form of the combined species.

Although *L. undosa* is found only at locality 45 in Panama, it may occur at localities 38 and 39 at which *L. favosa* is found. Few specimens were recovered from these localities and these with some difficulty because of the indurated nature of the matrix material.

Occurrence.—Loc. 45. Distribution elsewhere: Upper Oligocene in the Antigua formation of Antigua; Moneague formation of Jamaica; limestone of Cayman Brac, Cayman Islands; Meson formation of Mexico; Chickaswhay limestone of Alabama; Suwanee limestone of Florida; San Luís series of Venezuela; and in Trinidad.

Lepidocyclina gigas Cushman

Plate 22, figure 9

1919. *Lepidocyclina gigas* Cushman, Carnegie Inst. Washington Pub. 291, p. 64, pl. 1, figs. 3–5; pl. 5, fig. 4.
1945. *Lepidocyclina gigas* Cushman. Cole, Florida Geol. Survey Bull. 28, pp. 44, 45, pl. 8, figs. 5, 6 (references and synonymy).

Vaughan (1924, p. 799) as early as 1924 expressed the opinion that *Lepidocyclina gigas* is the microspheric generation of *L. undosa.* As *L. undosa* and *L. favosa* occur together, *L. gigas* could be the microspheric generation of one or the other. However, if *L. undosa* and *L. favosa* are combined, *L. gigas* is the microspheric generation of the combined species. Although this is undoubtedly the correct relationship, the name *L. gigas* is used in this report because of the tentative retention of the specific names, *L. undosa* and *L. favosa.*

Occurrence.—Loc. 39. Distribution elsewhere: The same as that of *L. undosa.*

Subfamily HELICOLEPIDINAE Tan

Genus HELICOLEPIDINA Tobler, 1922

Helicolepidina spiralis Tobler

Plate 24, figures 1–16; plate 20, figure 13

1922. *Helicolepidina spiralis* Tobler, Eclogae geol. Helvetiae, vol. 17, pp. 380–384, text figs. 1–3.
1934. *Helicolepidina spiralis* Tobler. Barker, Jour. Paleontology, vol. 8, pp. 345, 346, pl. 47, figs. 1–4; text figs. 1a, c (references and synonymy).
1936. *Helicolepidina spiralis* Tobler. Barker and Grimsdale, idem, vol. 10, p. 243, pl. 33, fig. 7.
1936. *Helicolepidina spiralis* Tobler. Vaughan, idem, vol. 10, p. 251, pl. 39, fig. 5; pl. 40, figs. 6–8.
1936. *Helicolepidina nortoni* Vaughan, idem, vol. 10, pp. 248–251, pl. 39, figs. 1–4; pl. 40, figs. 1–5.
1941. *Helicolepidina spiralis* Tobler. Vaughan and Cole, Geol. Soc. America Spec. Paper 30, p. 76, pl. 45, fig. 1.
1949. *Helicolepidina spiralis* Tobler. Cole, Jour. Paleontology, vol. 23, p. 272, pl. 52, figs. 9, 10.

Three topotypes of *Helicolepidina nortoni* Vaughan from Louisiana are illustrated for comparison with the Panamanian specimens identified as *H. spiralis* Tobler. Vaughan (1936, p. 251) wrote, "The principal difference, however, seems to be in the spiral chambers of *H. nortoni* not extending so clearly to the embryonic chambers as in *H. spiralis.*"

In preparing equatorial sections of several specimens of *H. spiralis*, one finds that the extent of the spiral chambers in the plane of the equatorial section depends on the accuracy with which the section is ground. This relationship is shown by figures 7–10 on plate 24.

Occurrence.—Locs. 22a, 124, 125, 132, 145. Distribution elsewhere: Upper Eocene in Trinidad, the Seroe di Cueba limestone of Curaçao; northwest Peru; Venezuela; the Tampico Embayment, Mexico; Louisiana (as *H. nortoni*) and in the *L. chaperi* zone (= *L. fragilis*) of Florida (Wayne Moore, personal communication).

Family DISCOCYCLINIDAE

Genus ASTEROCYCLINA Gümbel, 1870

Asterocyclina georgiana (Cushman)

Plate 27, figures 6–12

1917. *Orthophragmina georgiana* Cushman, U. S. Geol. Survey Prof. Paper 108–G, pp. 117, pl. 41, figs. 2, 3; pl. 42, fig. 3; pl. 43, figs. 2, 3.

1949. *Asterocyclina georgiana* (Cushman). Cole, Jour. Paleontology, vol. 23, pp. 273, 274, pl. 52, figs. 7, 8; pl. 53, fig. 1; pl. 55, figs. 1–5.

Some typical specimens of *Asterocyclina georgiana* have 4 rays projecting from a central area, and others have in addition to these an extension of the equatorial layer between the rays. Such specimens have a quadrangular outline.

Occurrence.—Locs. 22a, 124, 125, 137, 145. Distribution elsewhere: Upper Eocene of Florida, Cuba, Jamaica, Venezuela, and Nicaragua.

Asterocyclina mariannensis (Cushman)

Plate 27, figures 1–5; plate 28, figures 1–3

1917. *Orthophragmina mariannensis* Cushman, U. S. Geol. Survey Prof. Paper 108–G, pp. 116, 117, pl. 40, fig. 5; pl. 42, fig. 2.

1917. *Orthophragmina mariannensis* Cushman, var. *papillata* Cushman, idem, p. 117, pl. 43, fig. 1; pl. 44.

1920. *Orthophragmina mariannensis* Cushman. Cushman, U. S. Geol. Survey Prof. Paper 125, p. 46, pl. 11, fig. 1.

1920. *Orthophragmina mariannensis* Cushman, var. *papillata* Cushman. Cushman, idem, p. 47, pl. 11, fig. 2.

1945. *Discocyclina* (*Asterocyclina*) *mariannensis* (Cushman). Vaughan, Geol. Soc. America Mem. 9, pp. 80–82, pl. 28; pl. 29.

Test stellate, composed of a small, pronounced central umbo from which radiate 5 or 6 raised rays between which there are more or less flat interray areas. Some specimens have large, raised papillae in the umbonal area and papillae of similar size and shape on the raised portions of the rays. Other specimens have small, indistinct papillae on the umbonal area and rays. In both types the interray areas are either devoid of papillae, or the papillae are very small and widely scattered. A polygonal mesh of ridges occurs among the papillae and on the interray areas. The largest specimen available has a diameter of 6 mm, but complete specimens would have a much greater size; every specimen recovered has chipped outer edges.

Four equatorial sections were studied, one of which represents a microspheric individual. One of the sections of a megalospheric individual is moderately satisfactory, another does not quite penetrate to the equatorial plane at the embryonic chambers, and the third is entirely unsatisfactory.

The least satisfactory section of the embryonic chambers shows large bilocular embryonic chambers. The initial chamber has diameters of about 240 by 340 μ. The second chamber has diameters of 260 by 420 μ. The distance across both chambers is 520 μ. The outer wall of the chambers is only about 10 μ thick. The periembryonic chambers are too indistinct to describe.

The other section shows large bilocular embryonic chambers. The initial chamber has diameters of 310 by 440 μ and the second chamber has diameters of 340 by 520 μ. The distance across both chambers is 660 μ. The outer wall is about 10 μ thick and is composed of an outer and inner layer between which there is a very fine canal (pl. 28, fig. 3). There are several periembryonic chambers. At one end of the partition between the embryonic chambers is a very large periembryonic chamber having diameters of 50 by 340 μ. The periembryonic chamber at the other end is much smaller, 70 by 140 μ. On the outer periphery of the larger embryonic chamber are 4 periembryonic chambers, 2 on one side and 2 on the other. Between these two sets of chambers there are 4 small square chambers. The periembryonic chambers on the outer margin of the initial chamber are too indistinct to be described.

The equatorial chambers are arranged so that the stellate pattern of the test is repeated in the arrangement of the equatorial chambers. One of the equatorial sections shows 5 rays and the other 6 rays.

The equatorial chambers in the rays have radial diameters as long as 100 μ and tangential diameters of 10 to 20 μ. Equatorial chambers in the interray position have radial diameters of 40 μ and tangential diameters of 20 μ.

The three vertical sections available are made from specimens broken in removal from the matrix material and now incomplete.

The cavities of the lateral chambers are long and low, with moderately thick roofs and floors. In two of the sections the lateral chambers are arranged in very regular tiers, but in the third section the lateral chambers are arranged in regular tiers for about three-quarters of the distance from the embryonic chambers to the periphery and then they overlap from one tier to the adjacent one.

Two of the vertical sections have heavy pillars irregularly distributed in the umbonal area and extending from the embryonic chambers to the surface of the test. The third section also has heavy pillars, but these do not extend beyond the beginning of the outer zone of overlapping lateral chambers. Actually the pillars may extend to the surface and are not visible because the section may be slightly oblique; smaller pillars extending from the embryonic chambers to the surface would seem to bear this out.

Occurrence.—Loc. 140. Distribution elsewhere: Upper Eocene of Florida and Cuba.

Remarks.—The specimens from Panama are similar in all respects to those from the vicinity of Nuevitas, Cuba, assigned by Vaughan (1945, pp. 80–82) to *Asterocyclina mariannensis* (Cushman). As Vaughan has noted, there is a difference in the shape and arrange-

Measurements of vertical sections of Asterocyclina mariannensis *from locality 140*

	Specimen		
	1	2	3
Actual diameter	3.4 mm	5.0 mm	4.8 mm
Diameter of the umbo	1.2 mm	2.0 mm	2.0 mm
Thickness through center	1.1 mm	1.8 mm	1.8 mm
Flange thickness at juncture with umbo	0.66 mm	0.72 mm	0.9 mm
Flange thickness at outer edge		0.24 mm	
Embryonic chambers:			
Length	440 μ	540 μ	420 μ
Height	220 μ	160 μ	280 μ
Thickness of outer wall	10 μ	10 μ	10 μ
Equatorial layer:			
Height at center	40 μ	60 μ	55 μ
Height at periphery		60 μ	
Lateral chambers:			
Number	16	25	29
Length	40–80 μ	140–200 μ	60–100 μ
Height	10–15 μ	5–15 μ	5–15 μ
Thickness of floors and roofs	10 μ	10–20 μ	10–20 μ
Surface diameter of pillars in umbo	80–160 μ	100–180 μ	80 μ
Surface diameter of pillars in flange	100 μ	None	60 μ

ment of the embryonic chambers between the typical specimens from the Ocala limestone of Florida and those from Cuba.

The specimens from Panama have embryonic chambers which resemble those found in the Cuban specimens, but none of the specimens from Panama has embryonic chambers similar to specimens from Florida.

Asterocyclina minima (Cushman)

Plate 26, figures 1–20; plate 28, figures 4–6

1919. *Orthophragmina minima* Cushman, U. S. Nat. Mus. Bull. 103, pp. 97, 98, pl. 41, fig. 1.
1919. *Orthophragmina sculpturata* Cushman, Carnegie Inst. Washington Pub. 291, pp. 54, 55, pl. 9, figs. 8, 9.
1920. *Orthophragmina minima* Cushman. Cushman, U. S. Geol. Survey Prof. Paper 125, p. 41, pl. 7, fig. 3.
1920. *Orthophragmina sculpturata* Cushman. Cushman, idem, p. 43, pl. 8, figs. 3–7.
1924. *Discocyclina minima* (Cushman). Vaughan, Geol. Soc. America Bull., vol. 35, p. 792.
1924. *Discocylina sculpturata* (Cushman). Vaughan, idem, p. 793.
1928. *Asterodiscocyclina stewarti* Berry, Eclogae geol. Helvetiae, vol. 21, pp. 405–407, pl. 33.
1933. *Discocyclina* (*Asterocyclina*) *kugleri* Gravell, Smithsonian Misc. Coll., vol. 89, no. 11, pp. 23, 24, pl. 3, figs. 1–5.
1935. *Discocyclina* (*Asterocyclina*) *kugleri* Gravell. Rutten, Jour. Paleontology, vol. 9, p. 542, pl. 62, fig. 1.
1935. *Discocyclina* (*Asterocyclina*) *vermunti* Rutten, idem, p. 542, pl. 61, figs. 4, 5; pl. 62, fig. 7.
1935. *Discocyclina* (*Asterocyclina*) sp. Rutten, idem, p. 542, pl. 62, fig. 6.
1945. *Discocyclina* (*Discocyclina*) *minima* (Cushman). Vaughan, Geol. Soc. America Mem. 9, p. 76, pl. 25, figs. 4–7.
1945. *Discocyclina* (*Discocyclina*) sp. cf. *D.* (*D.*) *minima* (Cushman). Vaughan, idem, p. 77, pl. 25, fig. 8.
1945. *Discocyclina* (*Asterocyclina*) *rutteni* Vaughan, idem, pp. 82, 83, pl. 30, figs. 1–5.
1945. *Discocyclina* (*Asterocyclina*) *sculpturata* (Cushman). Vaughan, idem, pp. 83–85, pl. 30, fig. 6; pl. 31.
1949. *Discocyclina* (*Discocyclina*) *minima* (Cushman). Cole, Jour. Paleontology, vol. 23, p. 273, pl. 52, fig. 14; pl. 54, figs. 6,7; pl. 55, fig. 6.

In 1919 Cushman (1919b, p. 54) described *Orthophragmina sculpturata* from Nuevitas, Cuba. Two illustrations are given of this new species, one an oblique "vertical" section, and the other an oblique "equatorial" section.

The oblique "vertical" section has a diameter of about 4 mm. The inflated central portion has a diameter of 1.5 mm and a thickness through the center of about 1 mm. Three rays are shown. The best developed ray has a length of about 1.8 mm and a thickness of about 0.2 mm. The central, umbonal portion has heavy pillars, and relatively long lateral chambers are arranged in regular tiers between the pillars.

The oblique "equatorial" section has a maximum diameter of about 2.5 mm. Heavy pillars occur in the umbonal area.

Later, Cushman (1920, p. 43) republished the description and the original illustrations of *O. sculpturata.* To these he added three more illustrations, one of an external view of a specimen from the type locality at Nuevitas and the others of two vertical sections of specimens from the Gloria mine, Oriente Province, Cuba. Neither the type illustrations nor the supplemental ones present an adequate picture of this species.

Willard Berry (1928, p. 406) described a new genus, *Asterodiscocyclina,* for a new species from a locality near Calita Sal, Department of Piura, Peru. This new species, *A. stewarti,* is not compared to any previously described species.

Gravell (1933, p. 23) in the description of a new species of *Asterocyclina, A. kugleri* from the upper Eocene of Venezuela, compared it to *A. stewarti* (Berry) in the following sentence: "It (*A. kugleri*) has distinct *Asterocyclina* arms, although they are small and often broken off, and its test is thicker than that of *D*[*iscocyclina*] (*Asterodiscocyclina*) *stewarti* Berry."

Cole and Ponton (1934, p. 141) reported a new species of *Asterocyclina*, *A. monticellensis*, from the Southern States Oil Corporation well in Jefferson County, Fla. Later, Cole (1944, p. 76; 1945, p. 122) recorded the presence of this species in two other Floridian wells. In all of these wells this species is assumed to occur in strata assigned to the middle Eocene.

Rutten (1935, p. 542) identified *A. kugleri* Gravell from upper Eocene strata of Cuba. From the same locality he described a new species, *Discocyclina* (*Asterocyclina*) *vermunti* and illustrated another probable species of *Asterocyclina* without giving it a name.

Recently, Vaughan (1945, pp. 80, 82) reexamined and described species of *Asterocyclina* from Cuba. From a locality "4.5 kilometers west of Guanajay on the road to Mariel (Palmer 1102)" Vaughan reported *A. sculpturata* and a new species, *A. rutteni*. As the late Mrs. Dorothy Palmer had sent me material from this station, it was possible to study specimens similar to those described by Vaughan.

All of these species are characterized in vertical section by the presence of many open lateral chambers having thin floors and roofs and arranged in regular tiers. Certain of the species have heavy pillars, whereas others are described as not possessing pillars. Although all of the species have the equatorial chambers arranged so that equatorial sections show rays, arms are developed externally only in the peripheral area. In certain species the external rays are so weakly developed that they are either not apparent or appear as very slight undulations. A rim may or may not be present.

Vaughan (1945, p. 83) distinguished *A. rutteni* from *A. stewarti* and *A. kugleri* by the presence of large papillae and pillars in the first species. Although Vaughan does not specifically compare *A. rutteni* with *A. sculpturata* except in shape of the pillars, *A. rutteni* has few and large papillae, whereas the papillae of *A. sculpturata* are smaller and are arranged in a different pattern. Moreover, *A. scupturata* has better developed rays and these extend higher on the umbo.

Although it is entirely possible to distinguish certain specimens of *A. rutteni* (pl. 26, fig. 1), from others which may be assigned to *A. sculpturata* (pl. 26, fig. 4) by external appearance, the differences on which this identification is made disappear when thin sections alone are studied. For example, Vaughan (1945, pp. 83, 85) wrote of *A. rutteni*, "The section cuts two nodules longitudinally, the larger is 0.29 mm thick at the surface; and there are some smaller pillars." Of the pillars of *A. sculpturata* he recorded, "Pillars are well developed, some of them are large, as much as 280μ thick." It would seem, therefore, that the surface diameter of the pillars in the two species is virtually the same.

However, Vaughan (1945, p. 85) stated concerning *A. sculpturata:*

> As seen in longitudinal section the pillars have pointed inner ends and soon attain their maximum diameter which is maintained with only slight change to the surface. This differs from the longitudinal sections of the nodules of *D* [*iscocyclina*] (*A.*) *rutteni.*

It should be noted that Vaughan had only one vertical section of each of these species. Moreover, neither of these sections passes through the center. If Vaughan had had several accurately oriented vertical sections, he would have been able to observe that the pillars in these two species are the same.

Also, in the Cuban sample there are many specimens which externally appear to be intermediate between *A. rutteni* and *A. sculpturata*. In every character examined, these species appear to be alike.

There remains, however, the question whether such species as *A. kugleri*, which is described as not possessing pillars, should be included in *A. sculpturata*. Rutten (1935, p. 528) recorded *A. kugleri* as a rare species occurring at the same locality as *A. vermunti*, a species which Vaughan correctly considered to be *A. sculpturata*.

It is entirely possible for a species which has pillars not to show these externally because the surface of the test may be worn. Also, it is not unusual for a test to be sectioned in a way that does not reveal the pillars, as the writer has observed on many occasions. Micropaleontologists should themselves make their thin sections so that they can study the internal features as the section is being ground.

The presence or absence of pillars is not a firm criterion on which to base a species. It has been proven with too many species that there is individual variation from very weak pillars to exceptionally strong ones.

Inasmuch as *A. kugleri* and *A. sculpturata* occur in the same samples and inasmuch as they are identical in all internal structures except that of pillars, these species should be combined. The description and illustrations of *A. stewarti* are not good, but it would seem that *A. stewarti* is another synonym of *A. sculpturata*.

Finally, *Orthophragmina minima* Cushman (1919a, p. 41) from the upper Eocene of Panama should be discussed. The holotype of this species is a single, not centered, vertical section. New illustrations of this specimen are given on plate 26, figures 14, 15. Figure 14 is a photomicrograph taken by ordinary transmitted light and figure 15 is the same specimen photographed by dark field illumination. These excellent photographs were made by Mr. Lloyd Henbest of the U. S. Geological Survey.

Vaughan (1924, p. 792) assigned *O. minima* to the genus *Discocyclina* s. s. Recently, Vaughan (1945, pp. 76, 77) briefly discussed this species, refigured the holotype, and gave illustrations of three additional specimens from the type locality of this species. In addition, he illustrated a single vertical section of a specimen from Jamaica which he compared with *D.* (*D.*) *minima.*

Cole (1949, p. 273) figured 4 not centered, vertical sections of specimens from the upper Eocene of Panama which he considered should be referred to *D.* (*D.*) *minima.*

With the exception of the single highly oblique "equatorial" section illustrated by Vaughan, all the other sections are vertical ones. It became apparent when the holotype was photographed by dark field illumination that it displayed all the internal features of *A. sculpturata.* Reexamination of other specimens with this point in mind demonstrates the uniform similarity between the specimens referred to *D. minima* and those assigned to *A. sculpturata.* It appears, therefore, that the species called *D. minima* is the same as *A. sculpturata.* Inasmuch as the specific name, *A. minima*, has priority over all the other names, the entire group must be called *A. minima.*

Although *Asterocyclina monticellensis* from the assumed middle Eocene strata of Florida is related closely to *A. minima*, it would appear that the two species can be distinguished. *A. monticellensis* is smaller, it has fewer lateral chambers to a tier, and more important, the floors and roofs of these lateral chambers are slightly curved, whereas those of *A. minima* are straight.

Measurements of equatorial sections of Asterocyclina minima

	Locality			
	140			22a
	Specimen			
	1	2	3	4
Diameter	3.5 mm	2.34 mm	2.9 mm	2.82 mm
Embryonic chambers:				
Diameters of initial chamber	120×120 μ	110×160 μ	100×140 μ	100×125 μ
Diameters of second chamber	100×180 μ	120×220 μ	130×230 μ	110×220 μ
Distance across both chambers	220 μ	250 μ	240 μ	220 μ
Thickness of outer wall	10 μ	10 μ	5 μ	5 μ
Equatorial chambers:				
Chambers in rays:				
Radial diameter	80 μ	60 μ	80 μ	60 μ
Tangential diameter	15 μ	20 μ	20 μ	20 μ
Chambers in interray areas:				
Radial diameter	40 μ	40 μ	40 μ	80 μ
Tangential diameter	10 μ	15 μ	20 μ	20 μ

Measurements of vertical sections of Asterocyclina minima

	Locality				
	140			22a	
	Specimen				
	1	2	3	4	5
Diameter	2.0 mm	3.3 mm	4.6 mm	2.26 mm	1.56 mm
Diameter of umbo	1.7 mm	2.1 mm	3.2 mm	1.92 mm	1.4 mm
Thickness through center	1.14 mm	1.5 mm	2.36 mm	1.21 mm	0.9 mm
Thickness of rim	0.1 mm	0.32 mm	0.26 mm	0.2 mm	0.1 mm
Embryonic chambers:					
Length	180 μ	200 μ	170 μ		100 μ
Height	120 μ	120 μ	120 μ		80 μ
Thickness of outer wall	10 μ	5 μ	5 μ		5 μ
Equatorial layer:					
Height at center	30 μ	40 μ	20 μ	25 μ	25 μ
Height at periphery	40 μ	65 μ	40 μ	60 μ	40 μ
Lateral chambers:					
Number	16	24	35	18	15
Height	20 μ	10–20 μ	10–20 μ	20–30 μ	20 μ
Length	40–60 μ	60–100 μ	60–140 μ	80–100 μ	80 μ
Surface diameter of pillars	100–200 μ	60–200 μ	140–320 μ	100–160 μ	80–180 μ

Vertical sections of Cuban specimens (pl. 26, figs. 8–13) of *A. sculpturata* and *A. rutteni* are illustrated to demonstrate how these two species intergrade and for comparison with similar Panamanian specimens.

Occurrence.—Locs. 22a, 140. Distribution elsewhere: Upper Eocene of Cuba (as *A. sculpturata*, *A. vermunti* and *A. rutteni*), Venezuela (as *A. kugleri*), Jamaica (as *D. minima*), and Peru (as *A. stewarti*).

Genus PSEUDOPHRAGMINA H. Douvillé, 1923
Subgenus PROPOROCYCLINA Vaughan and Cole, 1940
Pseudophragmina (Proporocyclina) flintensis (Cushman)

Plate 28, figures 7–16

1917. *Orthophragmina flintensis* Cushman, U. S. Geol. Survey Prof. Paper 108–G, p. 115, pl. 11, figs. 1, 2.
1945. *Pseudophragmina* (*Proporocyclina*) *flintensis* (Cushman). Vaughan, Geol. Soc. America Mem. 9, pp. 89–92, pl. 36; pl. 37, fig. 1.
1949. *Pseudophragmina* (*Proporocyclina*) *flintensis* (Cushman). Cole, Jour. Paleontology, vol. 23, p. 274, pl. 54, figs. 1–4.

The description which follows is based on specimens of *Pseudophragmina* (*P.*) *flintensis* from locality 140.

Test thin, fragile, compressed, with a small umbonal area which is surrounded by a thinner rim. Surface ornamentation consists of concentric circles of small, sharp papillae which are the same from the central area to the periphery of the test.

The embryonic chambers are bilocular. The initial chamber is circular with an internal diameter of about 40 μ. The second chamber has internal diameters of 55 by 80 μ and very slightly embraces the initial chamber. The distance across both chambers is 95 μ. The embryonic chambers are completely surrounded by a ring having 11 periembryonic chambers.

The equatorial chambers near the center of the test are square, but they become radially elongated toward the periphery. Chambers near the periphery have radial diameters of about 100 μ and tangential diameters of about 40 μ. The radial chamber walls are complete and in alinement. The annular stolon is at the distal end of the radial chamber walls.

The cavities of the lateral chambers are slitlike between thick roofs and floors. The lateral chambers are not in definite tiers.

Occurrence.—Locs. 124, 140. Distribution elsewhere: Occurrence of specimens which probably represent this species are given under the discussion.

Remarks.—As Vaughan (1945, pp. 88) clearly stated, there are five upper Eocene species of *Pseudophragmina* (*Proporocyclina*) which are closely related. These are *P.* (*P.*) *flintensis* (Cushman) from Florida, Cuba, and Panama; *P.* (*P.*) *citrensis* (Vaughan) (1928, p. 159) from Florida; *P.* (*P.*) *mirandana* (Hodson) (1926, p. 8) from Trinidad and Venezuela; *P.* (*P.*) *tobleri* Vaughan and Cole (1941, p. 62) from Trinidad; and *P.* (*P.*) *blumenthali* (Gorter and van der Vlerk) (1932, p. 111) from Venezuela. Vaughan discussed these species in detail and gave a diagnostic key for their identification. The differences among the species are slight.

Although there were not enough specimens from Panama to make a large suite of oriented thin sections, there is a suggestion that these species should be combined, with the possible exception of *P.* (*P.*) *tobleri*. Vaughan (1945, p. 89) indicated this idea also when he wrote, "It seems probable that *P.* (*P.*) *citrensis* is a small, perhaps immature, varietal form of *P. flintensis*, representing the umbonal part of the test of that species. *P.* (*P.*) *mirandana* is similar except that it is nonumbonate." It is extremely doubtful that development of the umbo or lack of an umbo is a reliable character for distinguishing species.

Measurements of vertical sections of Pseudophragmina flintensis

	Specimen	
	1	2
Diameter	3.8 mm	3.4 mm
Diameter of umbo	0.7 mm	0.96 mm
Thickness at center	0.52 mm	0.46 mm
Thickness of flange near umbo	0.4 mm	0.32 mm
Thickness of flange at periphery	0.2 mm	0.18 mm
Embryonic chambers:		
Length	65 μ	60 μ
Height	35 μ	40 μ
Thickness of outer wall	4 μ	5 μ
Equatorial layer:		
Height at center	40 μ	30 μ
Height at periphery	40 μ	55 μ
Lateral chambers:		
Number	10	8
Length	30–40 μ	
Height	5 μ	5 μ
Thickness of roofs and floors	10 μ	5–10 μ
Surface diameter of pillars	30 μ	20 μ

Family MIOGYPSINIDAE
Genus MIOGYPSINA Sacco, 1893
Subgenus MIOGYPSINA Sacco, 1893
Miogypsina (Miogypsina) antillea (Cushman)

Plate 24, figure 17; plate 25, figures 13–15

1919. *Heterosteginoides panamensis* Cushman, U. S. Nat. Mus. Bull. 103, p. 97, pl. 43, figs. 1, 2 [not figs. 3–8].
1919. *Heterosteginoides antillea* Cushman, Carnegie Inst. Washington Pub. 291, p. 5, pl. 5, figs. 5, 6.
1924. *Miogypsina cushmani* Vaughan, Geol. Soc. America Bull., vol. 35, p. 813, pl. 36, figs. 4–6.
1933. *Miogypsina bramlettei* Gravell, Smithsonian Misc. Coll., vol. 89, no. 11, pp. 32–34, pl. 6, figs. 5–10.
1941. *Miogypsina antillea* (Cushman). Vaughan and Cole, Geol. Soc. America Spec. Paper 30, pp. 78, 79, pl. 45, figs. 5–7.
1941. *Miogypsina cushmani* Vaughan. Cole, Florida Geol. Survey Bull. 19, pp. 47, 48, pl. 17, figs. 3–5.

Test small, with a length of 1.6 to 1.8 mm and a width of 1.3 to 1.5 mm. Its maximum thickness is from 0.7 to 0.8 mm. Its surface is covered with small, slightly raised papillae.

The embryonic chambers are bilocular, the initial chamber is circular to subcircular, with internal diameters of 100 by 110 μ in one specimen and 120 by 140 μ in another specimen. The second chamber is slightly reniform, with internal diameters of 100 by 140 μ in one specimen and 95 by 160 μ in the other. There is a partial coil of rudely subquadrate periembryonic chambers which surrounds the embryonic chambers on the distal side. Six of these chambers appear in one specimen and 8 in the other.

The equatorial chambers are diamond shaped. Those near the distal margin have radial diameters of 60 to 140 μ and tangential diameters of 50 to 100 μ.

A well-oriented vertical section has embryonic chambers 200 μ long and 100 μ high.

The equatorial layer has a height of 65 μ near the embryonic chambers and a height of 100 μ at the distal margin of the test; these measurements include the thickness of the floors and roofs.

The lateral chambers occur in regular tiers between the pillars, but where pillars are not developed, the chambers overlap. In the thickest portion of the test there are about 8 lateral chambers to a tier on each side of the equatorial layer. The lateral chambers have open cavities with a height of about 18 μ and the floors and roofs have thicknesses of about 10 μ. Fine pillars with a surface diameter of about 60 μ are present.

Occurrence.—Locs. 37, 53. Distribution elsewhere: Upper Oligocene in Anguilla, Venezuela, and the Marathon well on Key Vaca, Florida.

Remarks.—Vaughan and Cole (1941, pl. 45, figs. 5–7) figured three topotypes of this species. The vertical section which they illustrate is not centered and is comparable to the one of a Panamanian specimen given as figure 13, plate 25. These sections are almost identical. Also, the equatorial sections of the specimens from Anguilla and Panama are identical.

No criteria are known for distinguishing this species from those from Venezuela which were named *M. bramlettei* by Gravell. Also, it is entirely probable that *M. hawkinsi* Hodson (1926, p. 28) should be combined with *M. antillea*. However, this problem requires more study than can be given at the present time.

Subgenus **MIOLEPIDOCYCLINA** A. Silvestri, 1907

Miogypsina (Miolepidocyclina) panamensis (Cushman)

Plate 25, figures 1–8

1919. *Heterosteginoides panamensis* Cushman, U. S. Nat. Mus. Bull. 103, p. 97, pl. 43, figs. 3–8 [not figs. 1, 2].
1924. *Miogypsina panamensis* (Cushman). Vaughan, Geol. Soc. America Bull., vol. 35, pp. 802, 803, 813, pl. 36, fig. 7.
1932. *Miogypsina* aff. *panamensis* (Cushman). Barker, Geol. Mag., vol. 69, pp. 280, 281, pl. 16, fig. 7.
1936. *Miolepidocyclina ecuadorensis* Tan, De Ing. in Ned.-Indië, 4. Mijnb. en Geol., 3 Jaarg., p. 58.
1941. *Miogypsina* (*Miolepidocyclina*) *panamensis* (Cushman). Vaughan and Cole, Geol. Soc. America Spec. Paper 30, p. 78.
1947. *Heterosteginoides panamensis* Cushman. Hanzawa, Jour. Paleontology, vol. 21, pp. 260–263, pl. 41, figs. 1–13.

The following tables give measurements of the internal features of *Miogypsina* (*M.*) *panamensis.*

Measurements of equatorial sections of Miogypsina (Miolepidocyclina) panamensis *from locality 55*

Length	1.8 mm	1.64 mm	1.3 mm	1.6 mm	1.7 mm	1.84 mm
Width	1.6 mm	1.5 mm	1.2 mm	1.4 mm	2.0 mm	2.0 mm
Embryonic chambers:						
Diameters of initial chamber	100 μ	105 μ	80×100 μ	80×90 μ	105×120 μ	80 μ
Diameters of second chamber	70×120 μ	65×100 μ	70×100 μ	40×90 μ	55×100 μ	60×60 μ
Distance across both chambers	180 μ	185 μ	160 μ	140 μ	170 μ	165 μ
Distance from periphery of test to edge of initial chamber.	0.28 mm	0.34 mm	0.3 mm	0.4 mm	0.4 mm	0.3 mm
Number of coils made by periembryonic chambers.	1⅛	1¼	1½	1½	1½	1½
Number of periembryonic chambers	11	16	16	15	17	15
Equatorial chambers:						
Radial diameter	100 μ	70 μ	90 μ	120 μ	105 μ	100 μ
Tangential diameter	70 μ	50–80 μ	70 μ	80 μ	90 μ	70 μ

Measurements of vertical sections of Miogypsina (Miolepidocyclina) panamensis *from locality 55*

Length	1.3 mm	1.6 mm
Thickness	0.7 mm	0.54 mm
Embryonic chambers:		
Length	220 μ	180 μ
Height	105 μ	140 μ
Distance from proximal edge to edge of initial embryonic chamber.	0.36 mm	0.4 mm
Equatorial layer:		
Height at proximal edge	120 μ	
Height at distal edge	140 μ	120 μ
Lateral chambers:		
Number	5	4
Length	60–100 μ	40–60 μ
Height	20–60 μ	20–30 μ
Thickness of floors and roofs	20–40 μ	20 μ
Surface diameter of pillars	60 μ	40–60 μ

Occurrence.—Loc. 55. Distribution elsewhere: Oligocene of Ecuador.

Remarks.—Two species referred to the subgenus *Miolepidocyclina* have been described from America, the species under discussion and *M.* (*M.*) *mexicana* Nuttall (1933, p. 175) from the Alazan formation of Mexico. Several thin sections of the Mexican form are illustrated (pl. 25, figs. 9–12) for comparison with the Panamanian form.

It should be noted that the vertical sections of the two species are very similar (compare fig. 10 with fig. 1, pl. 25). However, the Mexican species normally has larger embryonic chambers and the coil of periembryonic chambers is somewhat different from the one developed in *M.* (*M.*) *panamensis.*

The embryonic apparatus of *M.* (*M.*) *mexicana* is similar to the one developed by the type species *M.* (*M.*) *burdigalensis* (Gümbel). Brönnimann (1940, pl. 7, fig. 4) illustrated a specimen of the latter species whose embryonic apparatus is entirely comparable to the Mexican species.

Hanzawa (1947) has recently reinstated the generic name *Heterosteginoides*. Although the embryonic chambers lie in a subcentral position in both *Miolepidocyclina* and *Heterosteginoides*, Hanzawa distinguished the two types by the development of the coil of periembryonic chambers. In *Miolepidocyclina* this coil is incomplete, whereas in *Heterosteginoides* the coil is complete. As there seems to be complete gradation between the two types, the necessity for two separate genera is questioned. It would appear that the degree of the development of the periembryonic coil is a specific, if not, an individual characteristic.

Although *M.* (*M.*) *panamensis* and *M.* (*M.*) *mexicana* are related closely, for the present the two specific names are retained because it appears possible to distinguish the two species by the features of the embryonic apparatus. However, certain specimens (see pl. 25, fig. 12) do not differ markedly in this feature from *M.* (*M.*) *panamensis*. More thin sections of *M.* (*M.*) *mexicana* are needed.

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INDEX

[Italic numbers indicate descriptions]

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PLATES 1–28

PLATE 1

FIGURES 1–9, 20–21. *Operculinoides jacksonensis* (Gravell and Hanna), (p. 9).

1–4. Transverse sections, × 20, of 4 specimens; locality 108. U.S.N.M. 560930.

5, 6. Median sections, × 20, of 2 specimens; locality 108. U.S.N.M. 560931.

7a–9b. External views, × 15, of 6 specimens illustrating the surface ornamentation; locality 108. U.S.N.M. 560932.

20. Transverse section, × 20, showing the axial plugs and the surface beading; locality 149. U.S.N.M. 560937.

21. Median section, × 20; locality 149. U.S.N.M. 560938.

10–19. *Operculinoides moodybranchensis* (Gravell and Hanna) (p. 10).

10. External view, × 15; locality 108. U.S.N.M. 560933.

11. Part of the transverse section, figure 13, × 40, illustrating marginal cord and apertures; locality 108. U.S.N.M. 560934.

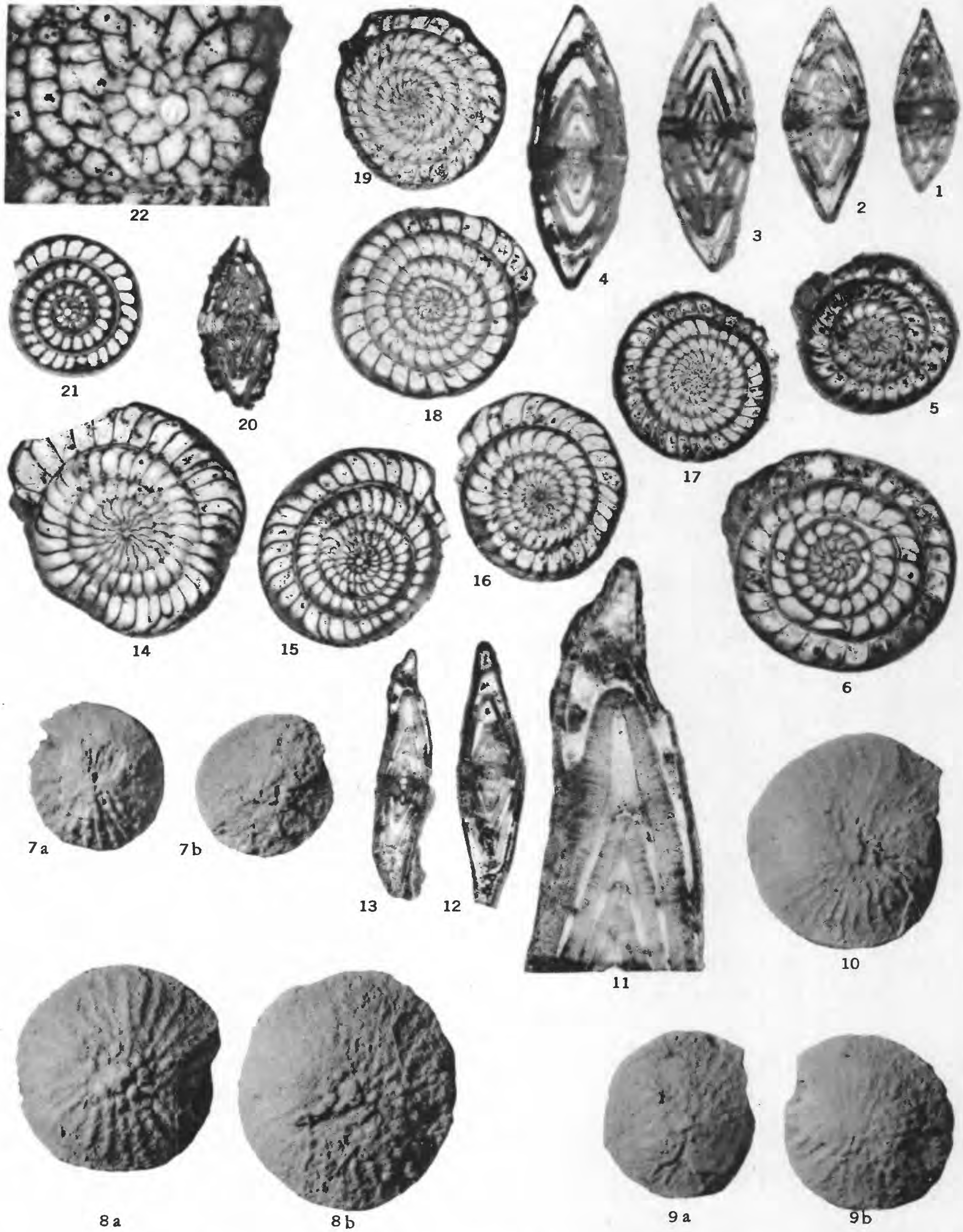
12. Transverse section, × 20; locality 108. U.S.N.M. 560935.

13. Transverse section, × 12.5; locality 108. U.S.N.M. 560934.

14–19. Median sections, × 12.5, showing individual differences; locality 108. U.S.N.M. 560936.

22. *Heterostegina israelskyi* Gravell and Hanna (p. 12).

Part of an equatorial section, × 40, showing the embryonic chambers and the single operculine chamber; locality 110. U.S.N.M. 560939.



EOCENE *OPERCULINOIDES* AND OLIGOCENE *HETEROSTEGINA*

PLATE 2

FIGURES 1–4. *Operculinoides panamensis* (Cushman) (p. 10).

1a–1d. External view, × 15, of 4 specimens; locality 55. U.S.N.M. 560940.

2. Transverse section, × 20, showing the large umbonal plug and nearly parallel sides of the test; locality 55. U.S.N.M. 560941.

3, 4. Median sections, × 20; locality 55. U.S.N.M. 560942.

5–11. *Operculinoides ocalanus* (Cushman) (p. 10).

5. Median section, × 20; locality 125. U.S.N.M. 560943.

6. Median section, × 12.5; station 131a. U.S.N.M. 560944.

7. Transverse section, × 20, of a specimen with a large umbo; locality 125. U.S.N.M. 560945.

8. Transverse section, × 20, of a specimen with a low umbo; locality 131a. U.S.N.M. 560946.

9. External view, × 10, of a specimen with a low umbo and strongly raised sutures; locality 125. U.S.N.M. 560947.

10. External view, × 10, of a specimen with a small, strong umbo and slightly raised sutures; locality 132. U.S.N.M. 560948.

11. External view, × 10, of a specimen with raised sutures and supplemental beading along the sutures; locality 140. U.S.N.M. 560949.

12–16. *Operculinoides vaughani* (Cushman) (p. 11).

12. External view, × 10, of a megalospheric individual; locality 140. U.S.N.M. 560950.

13. External view, × 10, of a microspheric individual; locality 140. U.S.N.M. 560951.

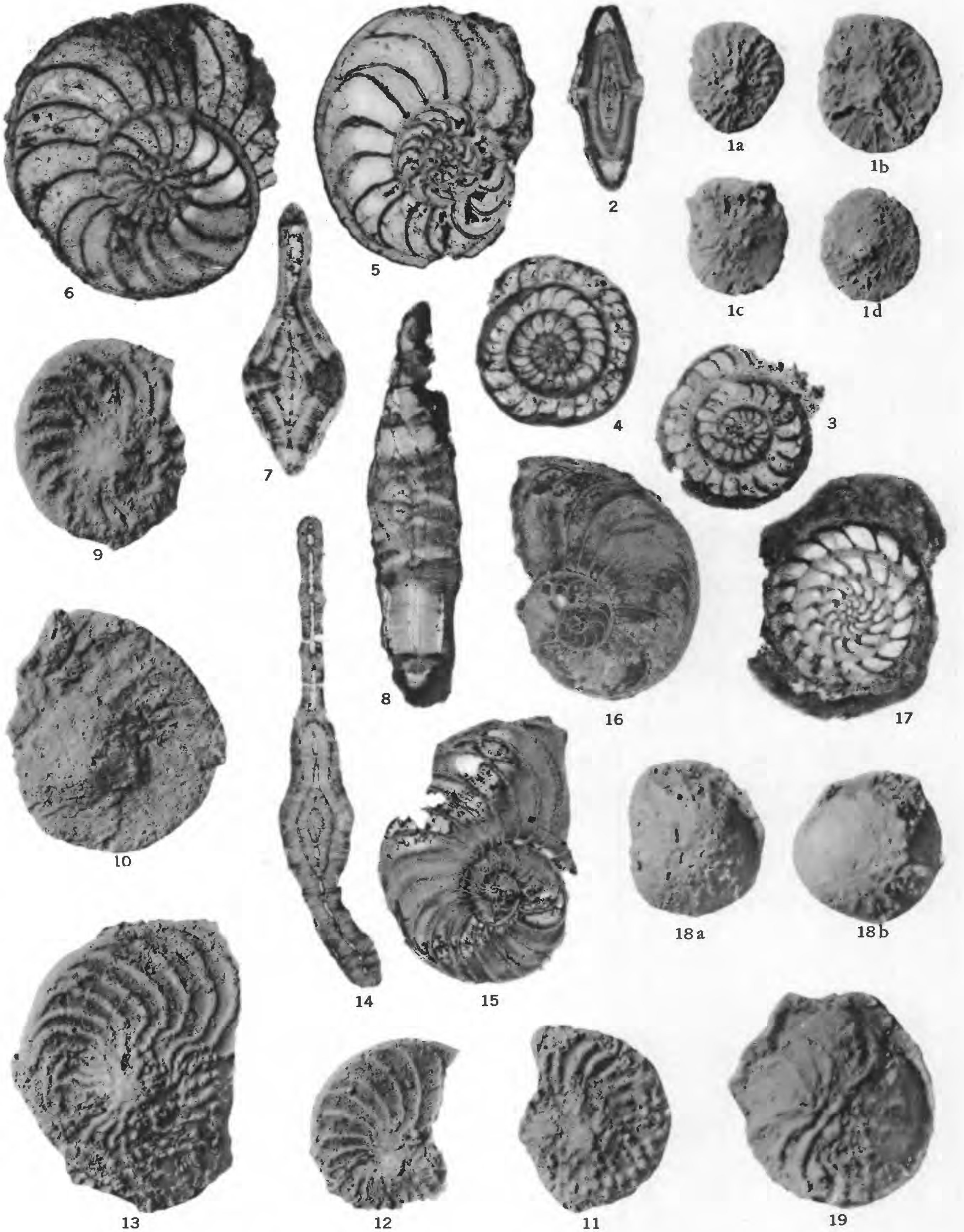
14. Transverse section, × 12.5, of a microspheric individual; locality 140. U.S.N.M. 560952.

15, 16. Median sections, × 12.5; locality 140. U.S.N.M. 560953.

17–19. *Operculinoides trinitatensis* (Nuttall) (p. 11).

17. Median section, × 20, showing the heavy revolving wall; locality 149b. U.S.N.M. 560954.

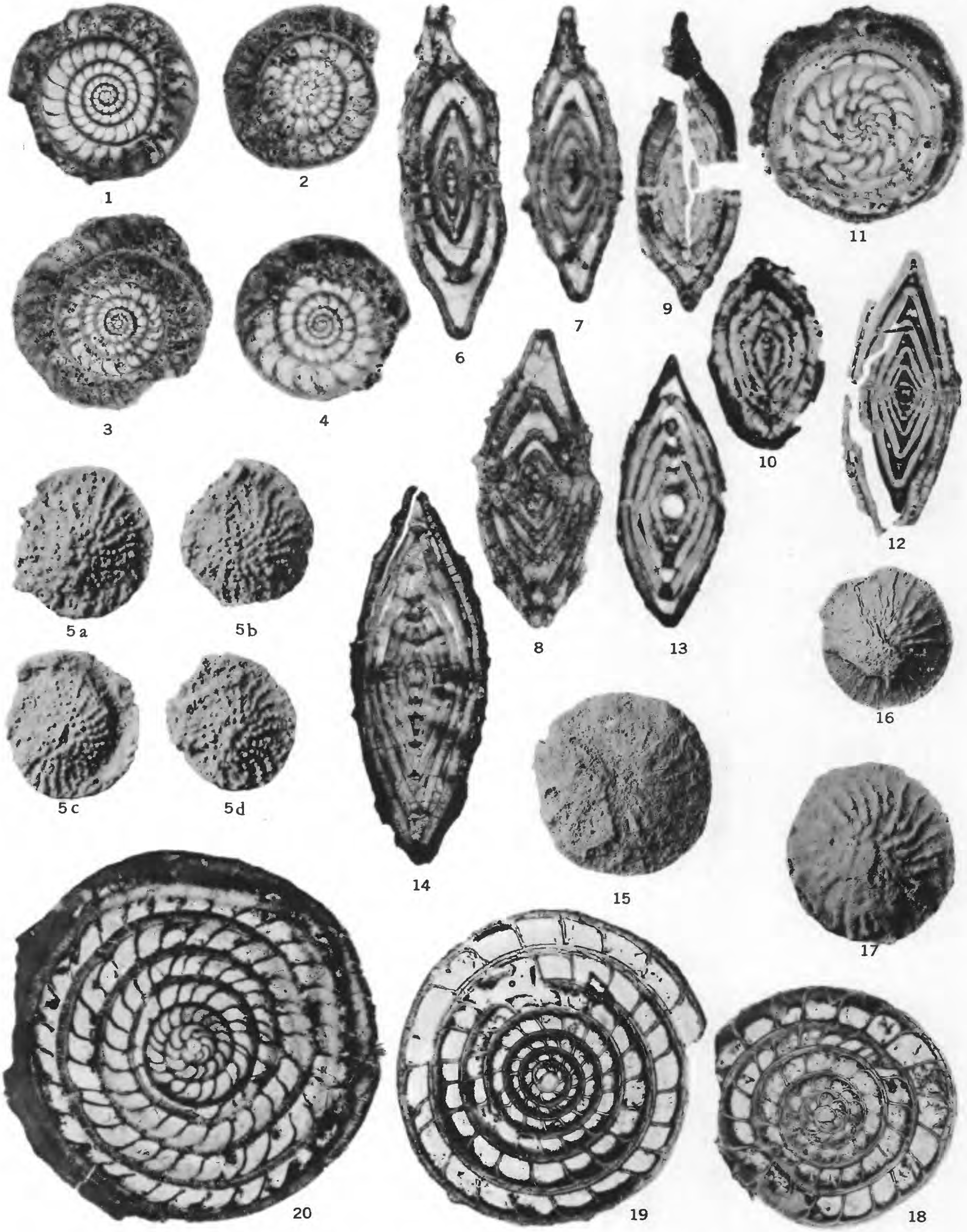
18, 19. External views, × 15, showing surface ornamentation; locality 149b. U.S.N.M. 560955.



EOCENE AND OLIGOCENE *OPERCULINOIDES*

PLATE 3

FIGURES 1–7. *Operculinoides kugleri* Vaughan and Cole (p. 9).
1–4. Median sections, × 20; locality 149b. U.S.N.M. 560956.
5a–5d. External view, × 15, of 4 specimens illustrating surface ornamentation; locality 149b. U.S.N.M. 560957.
6–7. Transverse sections, × 40; locality 149b. U.S.N.M. 560958.
8. *Operculinoides jacksonensis* (Gravell and Hanna) (p. 9).
Transverse section, × 40, showing the contrast between this species and *O. kugleri;* locality 149b. U.S.N.M. 560959.
9–11. *Operculinoides trinitatensis* (Nuttall) (p. 11).
9, 10. Transverse sections, × 20; locality 149b. U.S.N.M. 560960.
11. Median section, × 20, showing thick revolving wall and oblique chamber walls; locality 149b. U.S.N.M. 560961.
12–20. *Camerina striatoreticulata* (L. Rutten) (p. 8).
12. Transverse section, × 12.5; locality 140. U.S.N.M. 560962.
13. Transverse section, × 20, of a small individual; locality 149b. U.S.N.M. 560963.
14. Transverse section, × 12.5, of a normal sized specimen; locality 149b. U.S.N.M. 560964.
15. External view, × 5, of an eroded specimen which does not show surface ornamentation; locality 125. U.S.N.M. 560965.
16, 17. External view, × 5, of two slightly eroded specimens with the ornamentation largely preserved; locality 140. U.S.N.M. 560966.
18. Median section, × 12.5, of a specimen similar to the one illustrated as figure 16; locality 140. U.S.N.M. 560967.
19. Median section, × 12.5, of a specimen similar to the one illustrated as figure 17; locality 140. U.S.N.M. 560968.
20. Median section, × 12.5; locality 149b. U.S.N.M. 560969.



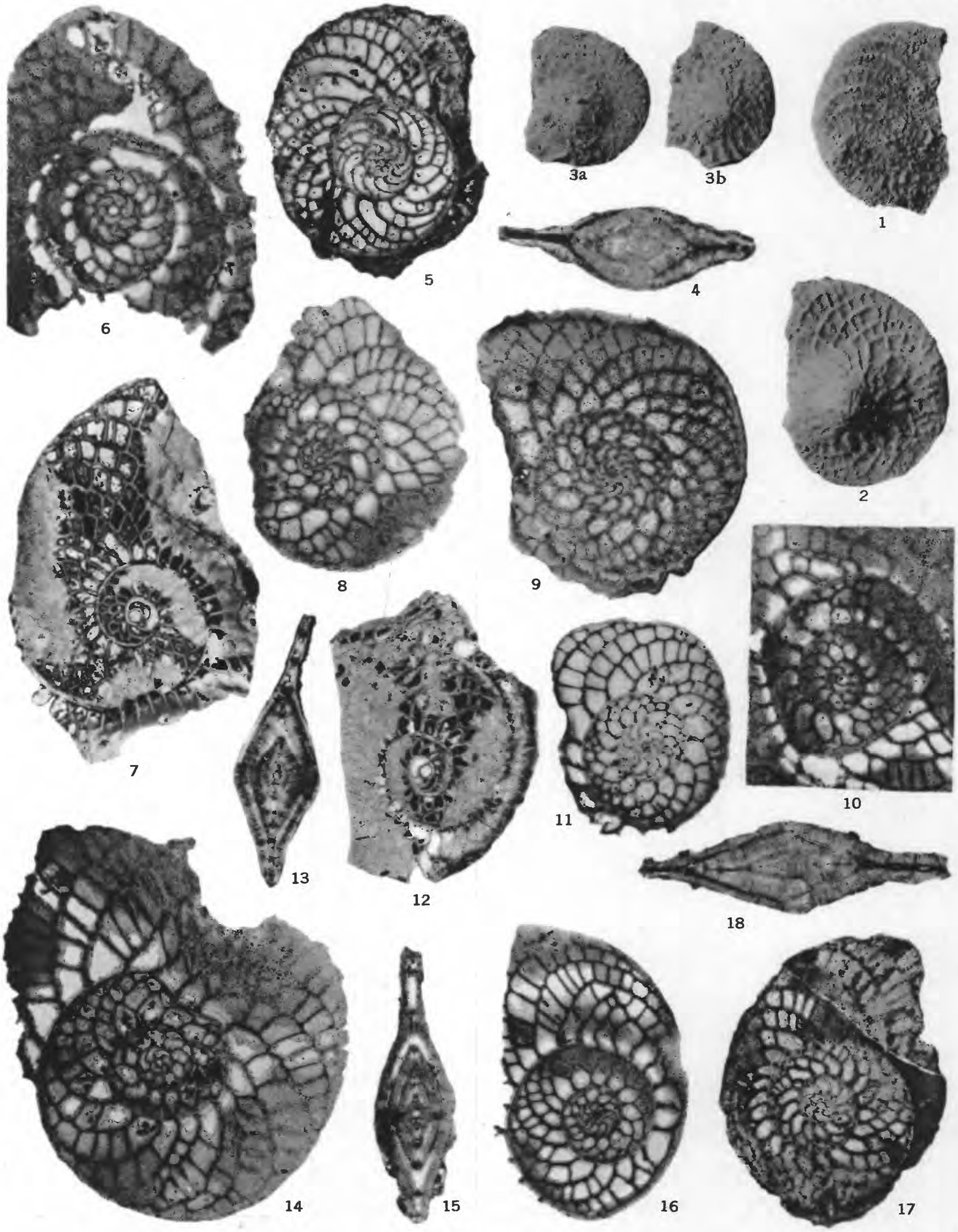
EOCENE AND OLIGOCENE *OPERCULINOIDES* AND *CAMERINA*

PLATE 4

FIGURE 1. *Heterostegina israelskyi* Gravell and Hanna (p. 12.)
External view, × 10, of the only specimen of this species recovered from this sample; locality 55. U.S.N.M. 560970.

2–18. *Heterostegina ocalana* Cushman (p. 13).

2. External view, × 10, of a virtual topotype; from Ocala limestone, Cummer Lumber Company Phosphate Pit no. 6, 1 mile south of Newberry, Alachua County, Fla. U.S.N.M. 560971.
3. External view, × 10, of two specimens from Panama showing their similarity to the Floridian specimen; locality 140. U.S.N.M. 560972.
4. Transverse section, × 20; locality 22a. U.S.N.M. 560973.
5. Median section, × 20; locality 22a. U.S.N.M. 560974.
6. Part of a median section, × 20, which has 3 operculine chambers following the embryonic chambers; from Ocala limestone, same locality as fig. 2. U.S.N.M. 560975.
7. Median section, × 20; locality 140. U.S.N.M. 560976.
8. Median section, × 20, of a specimen which has 7 operculine chambers following the embryonic chambers; from Ocala limestone, Red Bluff, Ga. U.S.N.M. 560977.
9. Median section, × 20, with 10 operculine chambers; locality 125. U.S.N.M. 560978.
10. Part of a median section, × 20, with 6 operculine chambers; from Ocala limestone, same locality as fig. 2. U.S.N.M. 560979.
11. Median section, × 20; locality 125. U.S.N.M. 560980.
12. Median section, × 20, with 2 operculine chambers; locality 140. U.S.N.M. 560981.
13. Transverse section, × 20; locality 125. U.S.N.M. 560982.
14. Median section, × 20, with 7 operculine chambers; from Ocala limestone, Red Bluff, Ga. U.S.N.M. 560983.
15. Transverse section, × 20; from Ocala limestone, Red Bluff, Ga. U.S.N.M. 560984.
16. Median section, × 20, of a microspheric specimen with 15 operculine chambers; from Ocala limestone, Red Bluff, Ga. U.S.N.M. 560985.
17. Median section, × 20, of a megalospheric specimen with 8 operculine chambers; locality 22a. U.S.N.M. 560986.
18. Transverse section, × 20; locality 140. U.S.N.M. 560987.



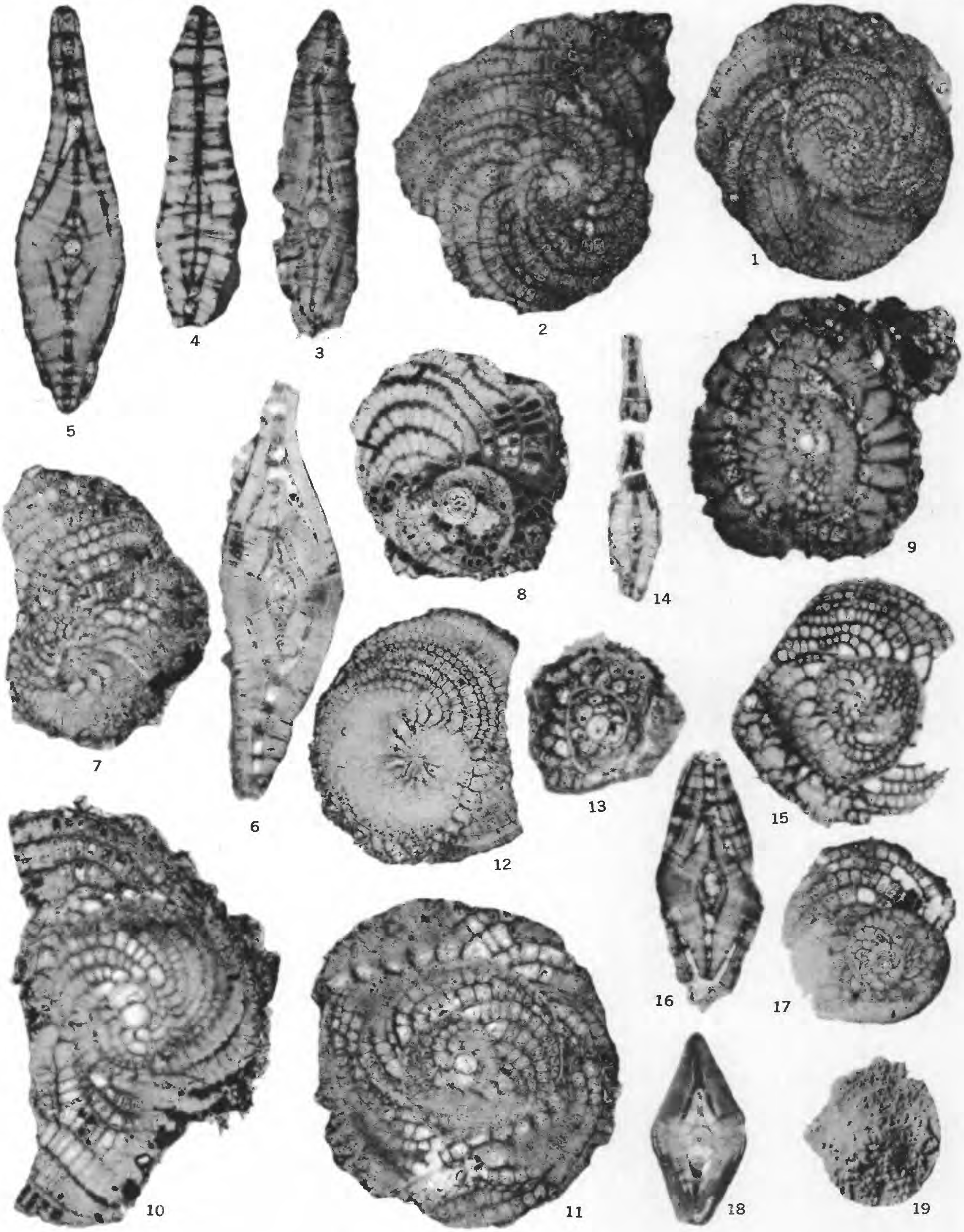
EOCENE AND OLIGOCENE *HETEROSTEGINA*

PLATE 5

FIGURES 1–11. *Heterostegina antillea* Cushman (p. 11).
1. Median section, × 12.5; locality 43. U.S.N.M. 560988.
2. Median section, × 20; locality 38. U.S.N.M. 560989.
3. Transverse section, × 20; locality 38. U.S.N.M. 560990.
4. Transverse section, × 20, not centered; locality 39. U.S.N.M. 560991.
5. Transverse section, × 20, of a well-developed individual with heavy axial plugs; locality 43. U.S.N.M. 560992.
6. Transverse section, × 20; locality 37. U.S.N.M. 560993.
7. Median section, × 20, not absolutely in the median plane; locality 45. U.S.N.M. 560994.
8. Median section, × 20; locality 39. U.S.N.M. 560995.
9. Median section, × 20; locality 37. U.S.N.M. 560996.
10. Median section, × 20, showing the large, relatively thick-walled embryonic chambers and the single, large operculine chamber; locality 45. U.S.N.M. 560997.
11. Median section, × 20; locality 38. U.S.N.M. 560998.

12–14. *Heterostegina israelskyi* Gravell and Hanna (p. 12).
12. Median section, × 12.5, of a probable microspheric specimen; locality 110. U.S.N.M. 560999.
13. Portion of a median section, × 20, showing the embryonic chambers; locality 110. U.S.N.M. 561000.
14. Transverse section, × 20, of a megalospheric individual; locality 110. U.S.N.M. 561001.

15–19. *Heterostegina panamensis* Gravell (p. 15).
15. Median section, × 20; locality 11a. U.S.N.M. 561002.
16. Transverse section, × 20; locality 11a. U.S.N.M. 561003.
17. Median section, × 20; locality 55. U.S.N.M. 561004.
18. Transverse section, × 20; locality 55. U.S.N.M. 561005.
19. External view, × 15; locality 55. U.S.N.M. 561006.



OLIGOCENE *HETEROSTEGINA*

PLATE 6

FIGURES 1–8. *Yaberinella jamaicensis* Vaughan (p. 8).
1. Transverse section, × 20; locality 131. U.S.N.M. 561007.
2. Transverse section, × 20, showing in the embryonic chamber a curved partition which may indicate that the embryonic apparatus is bilocular; locality 131. U.S.N.M. 561008.
3. Several random transverse sections, × 20; locality 131. U.S.N.M. 561009.
4, 5. Transverse sections, × 20; locality 131. U.S.N.M. 561010.
6. Part of a median section, × 20; locality 131. U.S.N.M. 561011.
7. Median section, × 12.5, of a topotype specimen introduced for comparison with the Panamanian specimens; from yellow limestone, locality J505M., Phantillands parochial road, 1.8 miles from the main road, Jamaica. U.S.N.M. 561012.
8. Transverse section, × 12.5, of a topotype specimen introduced for comparison with the Panamian specimens; from same locality as fig. 7. U.S.N.M. 561013.

9–12. *Helicostegina soldadensis* Grimsdale (p. 14).
9–11. Median sections, × 40; locality 22a. U.S.N.M. 561014.
12. Transverse section, × 40; locality 22a. U.S.N.M. 561015.

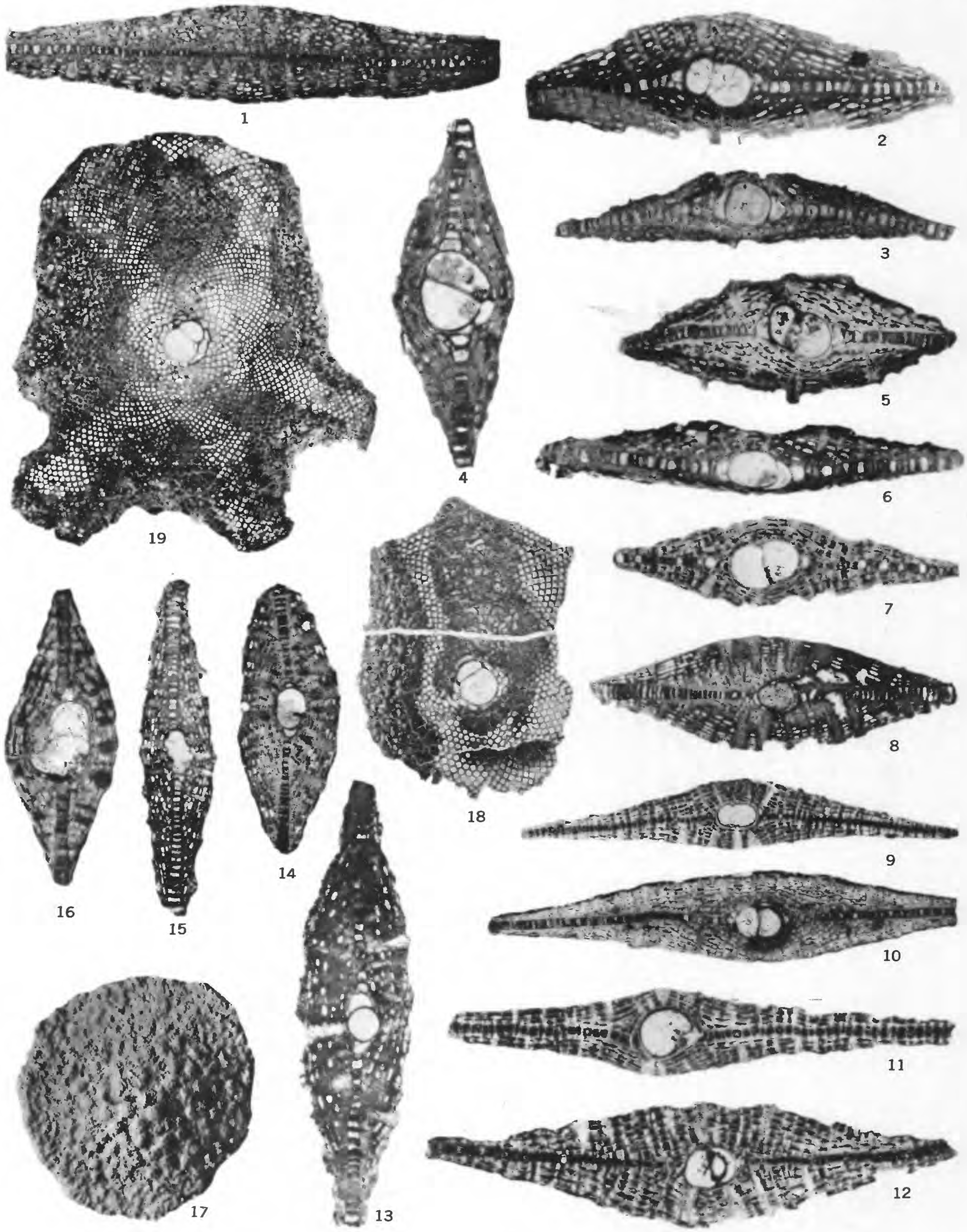
13–16. *Fabiania cubensis* (Cushman and Bermudez) (p. 14).
13. Axial section, × 20; locality 140. U.S.N.M. 561016.
14. External view, × 15, of the ventral region; locality 149b. U.S.N:M. 561017.
15. External view, × 15, of the dorsal aspect; locality 140. U.S.N.M. 561018.
16. Part of an axial section, × 40; locality 22a. U.S.N.M. 561019.

17, 18. *Heterostegina israelskyi* Gravell and Hanna (p. 12).
17. Median section, × 20; locality 110. U.S.N.M. 561020.
18. Several random transverse sections, × 12.5; locality 110. U.S.N.M. 561021.

EOCENE *YABERINELIA*, *HELICOSTEGINA*, AND *FABIANIA*, AND OLIGOCENE *HETEROSTEGINA*

PLATE 7

FIGURES 1–19. *Lepidocyclina* (*Pliolepidina*) *macdonaldi* Cushman (p. 16).
1. Vertical section, × 12.5, of a microspheric individual; locality 149b. U.S.N.M. 561022.
2–16. Vertical sections of megalospheric individuals, showing variation.
2. × 20; locality 132. U.S.N.M. 561023.
3. × 20; locality 15. U.S.N.M. 561024.
4. × 20; locality 125. U.S.N.M. 561025.
5. × 20; locality 125. U.S.N.M. 561026.
6. × 20; locality 131. U.S.N.M. 561027.
7. × 20; locality 140. U.S.N.M. 561028.
8. × 12.5; locality 125. U.S.N.M. 561029.
9. × 12.5; locality 140. U.S.N.M. 561030.
10. × 12.5; locality 150. U.S.N.M. 561031.
11. × 20; locality 140. U.S.N.M. 561032.
12. × 20; locality 140. U.S.N.M. 561033.
13. × 20; locality 149b. U.S.N.M. 561034.
14. × 12.5; locality 125. U.S.N.M. 561035.
15. × 12.5; locality 149b. U.S.N.M. 561036.
16. × 20; locality 125. U.S.N.M. 561037.
17. External view, × 10, of a megalospheric specimen, showing raised pustules; locality 125. U.S.N.M. 561038.
18. Equatorial section, × 12.5, of a megalospheric individual; locality 132. U.S.N.M. 561039.
19. Equatorial section, × 12.5, of a megalospheric individual; locality 149b. U.S.N.M. 561040.



EOCENE *LEPIDOCYCLINA*

PLATE 8

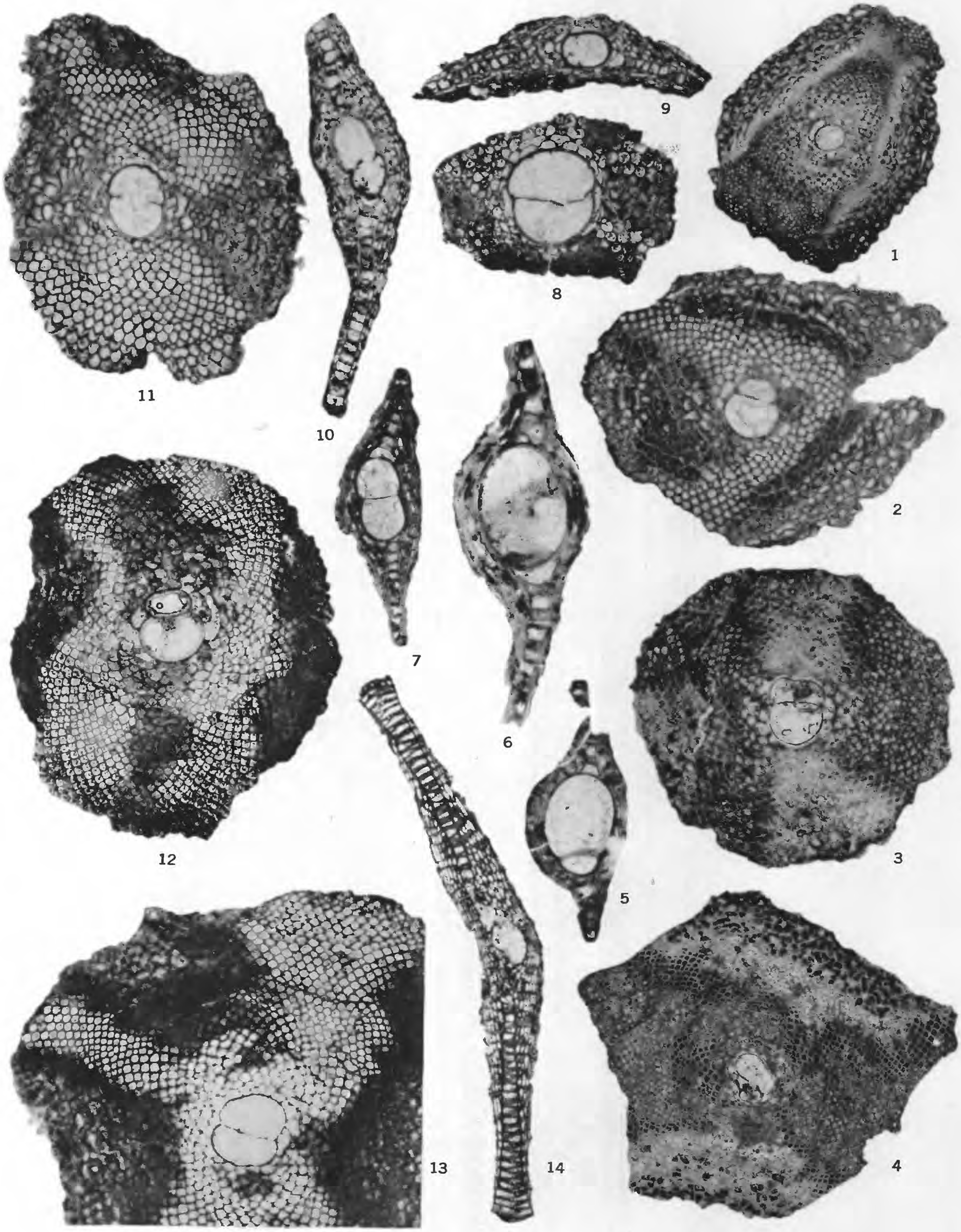
FIGURES 1–4. *Lepidocyclina* (*Pliolepidina*) *macdonaldi* Cushman (p. 16).
1. Equatorial section, × 12.5; locality 125. U.S.N.M. 561041.
2. Equatorial section, × 20; locality 132. U.S.N.M. 561042.
3. Equatorial section, × 20; locality 125. U.S.N.M. 561043.
4. Equatorial section, × 12.5; locality 140. U.S.N.M. 561044.

5–8. *Lepidocyclina* (*Nephrolepidina*) *chaperi* Lemoine and R. Douvillé (p. 23).
5. Vertical section, × 20; locality 125. U.S.N.M. 561045.
6. Vertical section, × 40; locality 22a. U.S.N.M. 561046.
7. Vertical section, × 20; locality 22a. U.S.N.M. 561047.
8. Equatorial section, × 20; locality 22a. This type of specimen has been named by Thiadens (1937, p. 103) *L.* (*L.*) *tschoppi*. U.S.N.M. 561048.

9–14. *Lepidocyclina* (*Pliolepidina*) *gubernacula* Cole, n. sp. (p. 15).
9. Vertical section, × 20; locality 22a. U.S.N.M. 561049.
10. Vertical section, × 20, of a small specimen; locality 22a. U.S.N.M. 561050.
11. Equatorial section, × 20, of a small specimen showing in the peripheral zone radially elongate equatorial chambers; locality 22a. U.S.N.M. 561051.

12, 13. Equatorial sections, × 12.5, of two paratypes showing embryonic chambers and the rhombic equatorial chambers; locality 23. U.S.N.M. 561052.

14. Vertical section, × 12.5, of a paratype showing the great expansion of the equatorial layer at the periphery of the test and the open lateral chambers with thin floors and roofs; locality 23. U.S.N.M. 561053.



EOCENE *LEPIDOCYCLINA*

PLATE 9

FIGURES 1, 2. *Lepidocyclina* (*Pliolepidina*) *gubernacula* Cole, n. sp. (p. 15).

1. Vertical section, × 12.5, of a compressed specimen; locality 23. U.S.N.M. 561054.
2. Vertical section, × 12.5, of an inflated paratype; locality 23. U.S.N.M. 561055.

3–19. *Lepidocyclina* (*Nephrolepidina*) *chaperi* Lemoine and R. Douvillé (p. 23).

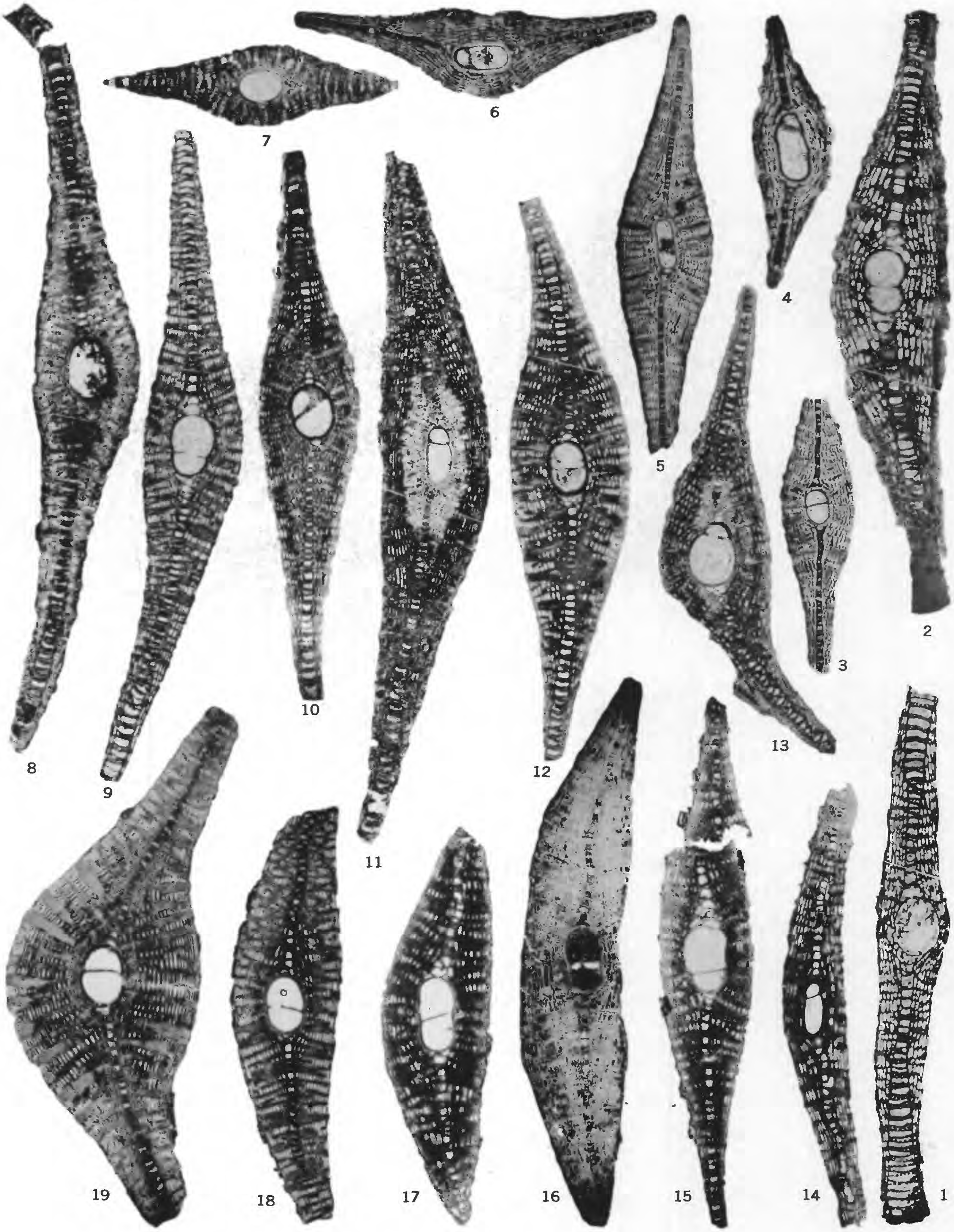
3. Vertical section, × 12.5, showing the slitlike cavities of the lateral chambers between thick roofs and floors; locality 125. U.S.N.M. 561056.
4. Vertical section, × 20, of a specimen with few lateral chambers; locality 125. U.S.N.M. 561057.
5. Vertical section, × 12.5, of a large well-developed specimen; locality 125. U.S.N.M. 561058.
6. Vertical section, × 12.5, of a specimen intermediate in development between the one illustrated as figure 4 and the one shown by figure 3; locality 125. U.S.N.M. 561059.
7. Vertical section, × 12.5, of a small specimen; locality 125. U.S.N.M. 561060.

8–13. Vertical sections, × 12.5, of typical specimens; locality 23. U.S.N.M. 561061.

14–17. Vertical sections, × 12.5, of topotypes of Cushman's "*L. fragilis*" from Ocala limestone at a cave, 200 yards below the former wagon bridge over the Chipola River near Marianna, Fla. U.S.N.M. 561062.

18. Vertical section, × 12.5, of a compressed specimen of Cole's "*L. sanfernandensis tallahasseensis*" showing the similarity among it, "*L. fragilis,*" and *L. chaperi;* from Ocala limestone, City of Tallahassee water well no. 6 at a depth of 406 feet. U.S.N.M. 561063.

19. Vertical section, × 12.5, of an inflated specimen of "*L. sanfernandensis tallahasseensis*" from same locality as figure 18. U.S.N.M. 561064.

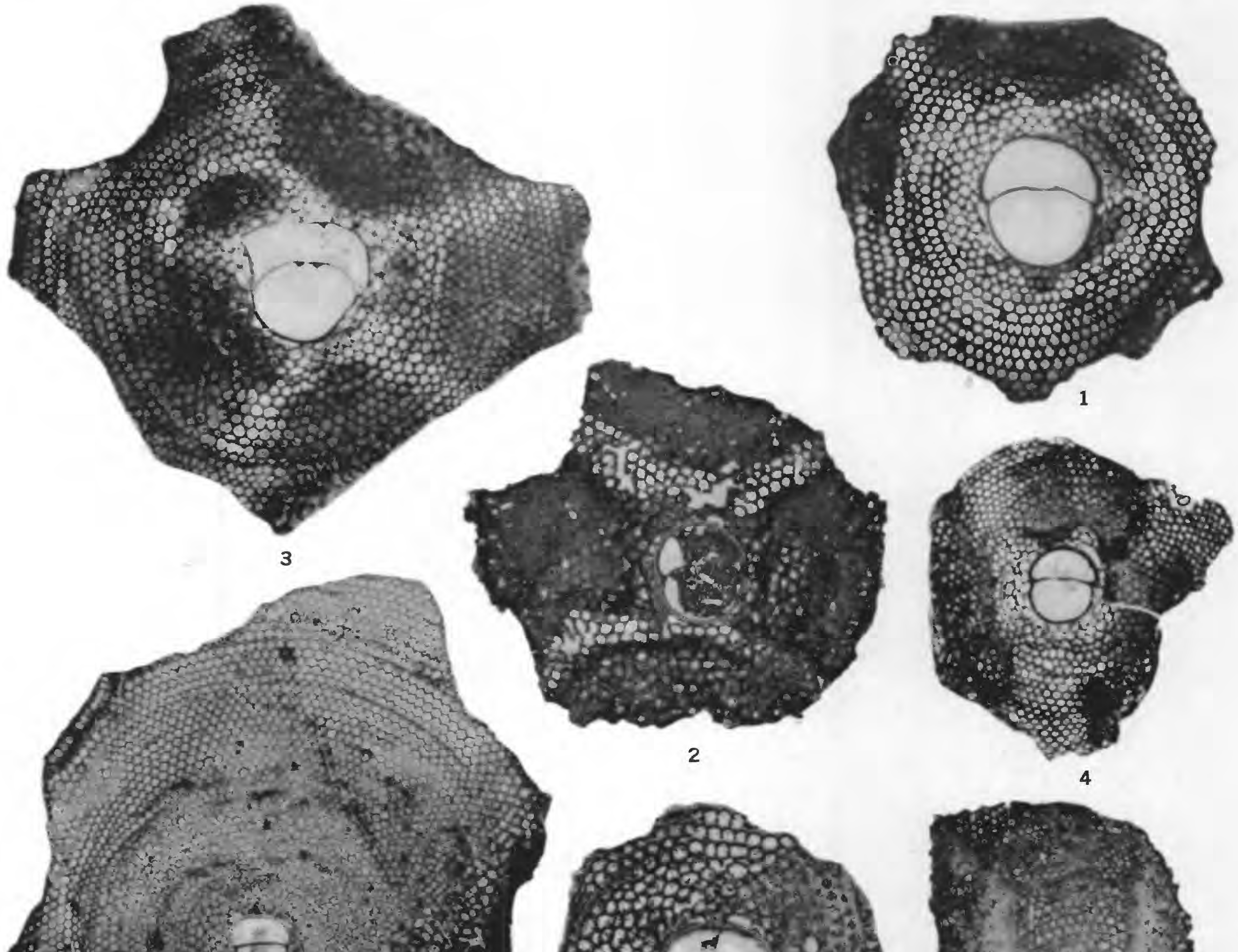


EOCENE *LEPIDOCYCLINA*

PLATE 10

FIGURES 1–10. *Lepidocyclina* (*Nephrolepidina*) *chaperi* Lemoine and R. Douvillé (p. 23).

1. Equatorial section, × 12.5, of a topotype of Cushman's "*L. fragilis*" with extremely large embryonic chambers in which the initial chamber is almost as large as the embracing second chamber; from Ocala limestone at a cave, 200 yards below old wagon bridge over the Chipola River near Marianna, Fla. U.S.N.M. 561065.
2. Equatorial section, × 12.5, of a topotype with smaller embryonic chambers than those possessed by the specimen illustrated as figure 1; from same locality as figure 1. U.S.N.M. 561066.
3. Equatorial section, × 12.5, of a specimen having large embryonic chambers with the second chamber only slightly embracing the initial chamber; locality 125. U.S.N.M. 561067.
4. Equatorial section, × 12.5, of a specimen with embryonic chambers which are virtually lepidocycline s. s.; locality 125. U.S.N.M. 561068.
5. Equatorial section, × 12.5, of a specimen with moderately nephrolepidine embryonic chambers; locality 125. U.S.N.M. 561069.
6. Equatorial section, × 20, of a specimen with rather small embryonic chambers; locality 125. U.S.N.M. 561070.
7. Equatorial section, × 12.5, of a specimen with small embryonic chambers; locality 125. U.S.N.M. 561071.
8. Equatorial section, × 12.5, of a specimen with embryonic chambers similar to those illustrated by H. Douvillé (1924, p. 45, fig. 37b); locality 23. U.S.N.M. 561072.
9. Equatorial section, × 12.5; locality 125. U.S.N.M. 561073.
10. Equatorial section, × 12.5, of a specimen whose second chamber strongly embraces the initial chamber; locality 23. U.S.N.M. 561074.



EOCENE *LEPIDOCYCLINA*

PLATE 11

FIGURES 1–8. *Lepidocyclina (Nephrolepidina) chaperi* Lemoine and R. Douvillé (p. 23).

1, 2. Equatorial sections, × 12.5, of inflated specimens of Cole's "*L. sanfernandensis tallahasseensis*"; from Ocala limestone, City of Tallahassee water well no. 6 at a depth of 406 feet. U.S.N.M. 561075.

3. Equatorial section, × 12.5, of a thin specimen illustrating the individual variation in the size of the embryonic chambers; from same locality as figure 1. U.S.N.M. 561076.

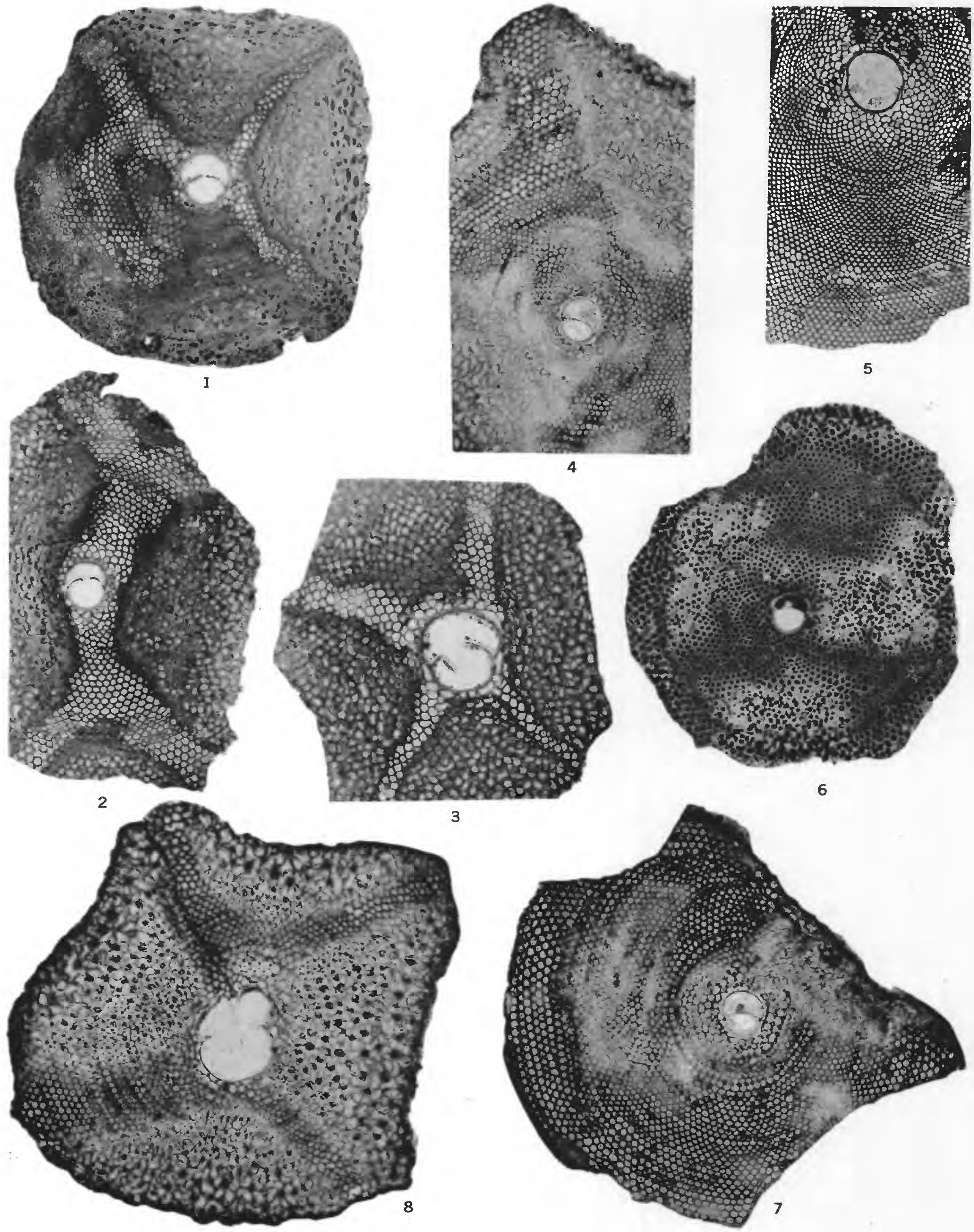
4–8. Equatorial sections, × 12.5, of Panamanian specimens to illustrate the variation which may occur in the size of the embryonic chambers.

4. Locality 125. U.S.N.M. 561077.

5. Locality 23. U.S.N.M. 561078.

6. Locality 140. U.S.N.M. 561079.

7, 8. Locality 125. U.S.N.M. 561080.



EOCENE *LEPIDOCYCLINA*

PLATE 12

FIGURES 1–15. *Lepidocyclina* (*Nephrolepidina*) *chaperi* Lemoine and R. Douvillé (p. 23).

1, 2. External views, × 5, of 2 topotypes of Cushman's "*L. fragilis*"; from Ocala limestone at a cave, 200 yards below the former wagon bridge over the Chipola River near Marianna, Fla. U.S.N.M. 561081.

3. Vertical section, × 12.5, of a specimen at first identified as *L. semmesi* Vaughan and Cole; locality 125. U.S.N.M. 561082.

4–6. Vertical sections, × 12.5, of specimens from the same sample showing individual variation; locality 125. U.S.N.M. 561083.

7. Vertical section, × 12.5, of a microspheric specimen; locality 125. U.S.N.M. 561084.

8. Part of an equatorial section, × 40, of a microspheric specimen showing the shape of the equatorial chambers; locality 125. U.S.N.M. 561085.

9. Vertical section, × 12.5; locality 140. U.S.N.M. 561086.

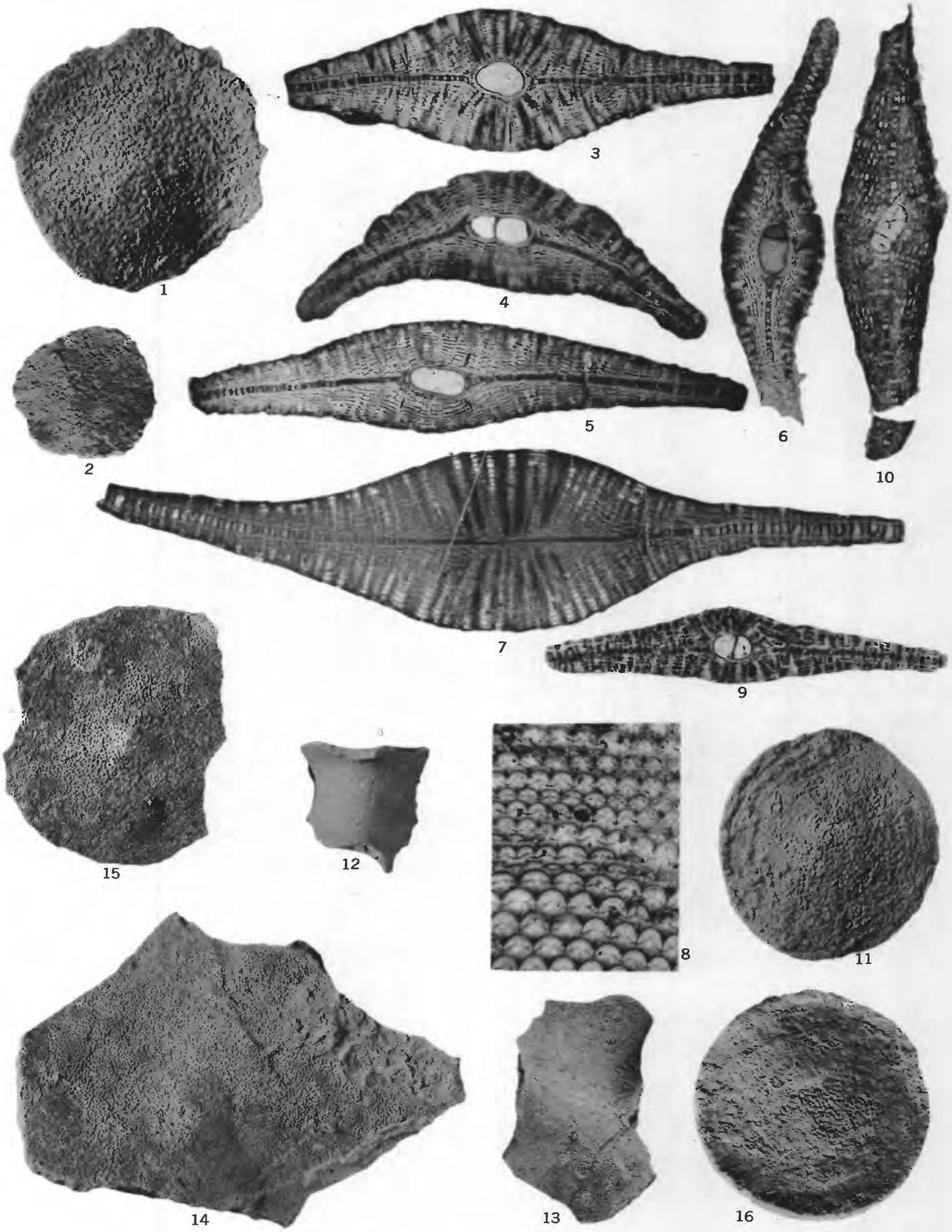
10. Vertical section, × 12.5; locality 137. U.S.N.M. 561087.

11. External view, × 5, of a megalospheric specimen; locality 23. U.S.N.M. 561088.

12, 13. External views, × 2, of two strongly selliform microspheric specimens; locality 23. U.S.N.M. 561089.

14, 15. External views, × 2, of two strongly papillate microspheric specimens; locality 23. U.S.N.M. 561090.

16. *Lepidocyclina* (*Pliolepidina*) *gubernacula* Cole, n. sp. (p. 15).
External view, × 5, of the holotype showing the inflated, elevated margin characteristic of this species; locality 23. U.S.N.M. 561091.



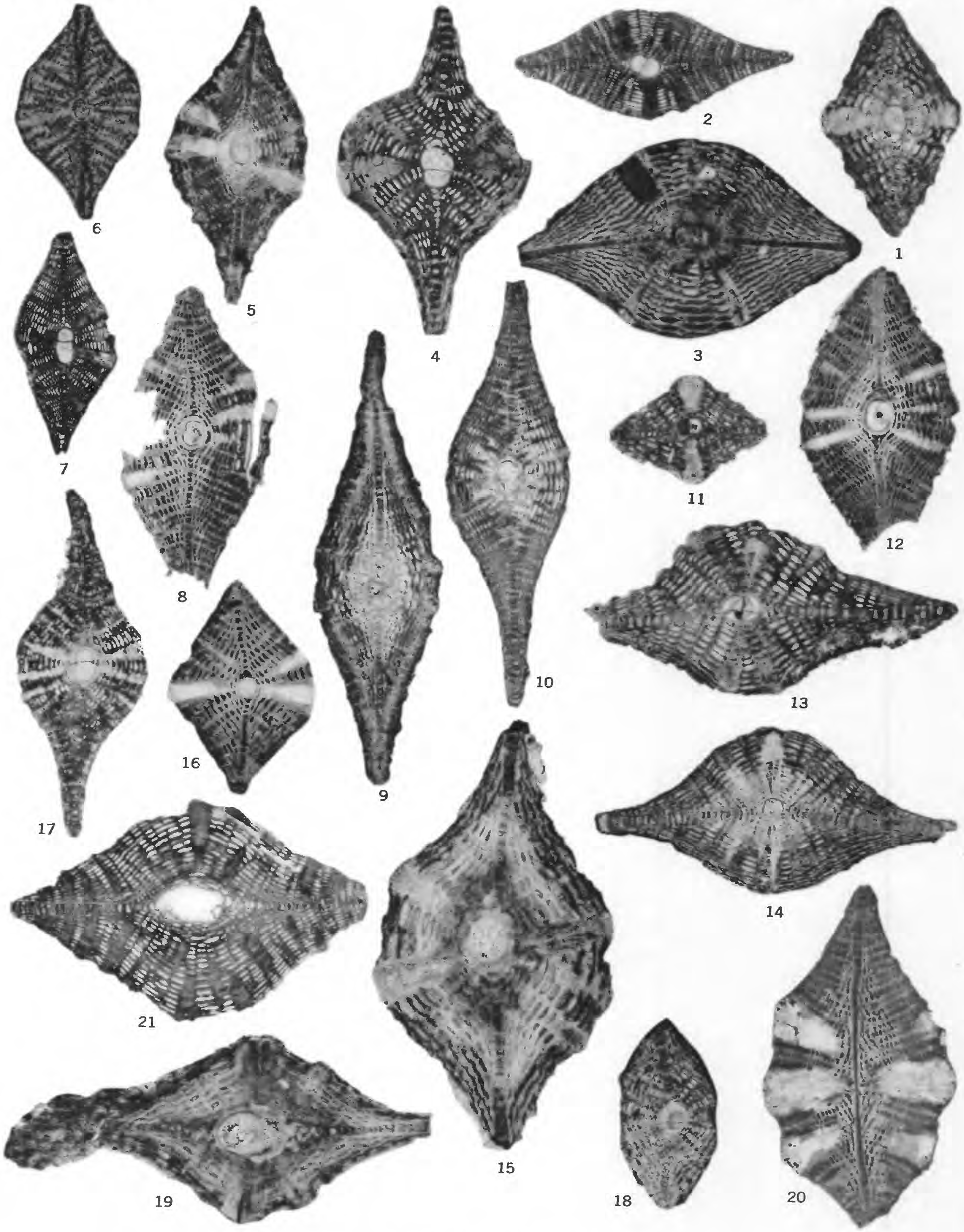
EOCENE *LEPIDOCYCLINA*

PLATE 13

FIGURES 1–20. *Lepidocyclina (Pliolepidina) pustulosa* H. Douvillé (p. 16).

1–19. Vertical sections of megalospheric individuals showing the great variation which may occur in this species.

1. × 20; locality 149b. U.S.N.M. 561092.
2. × 12.5; locality 137. U.S.N.M. 561093.
3. × 20; locality 150. U.S.N.M. 561094.
4. × 20; locality 15. U.S.N.M. 561097.
5. × 20; locality 140. U.S.N.M. 561095.
6. × 20; locality 131a. U.S.N.M. 561096.
7. × 12.5; locality 137. U.S.N.M. 561098.
8. × 20; locality 140. U.S.N.M. 561099.
9. × 20; locality 140. U.S.N.M. 561100.
10. × 20; locality 140. U.S.N.M. 561101.
11. × 20; locality 149b. U.S.N.M. 561102.
12. × 20; locality 140. U.S.N.M. 561103.
13. × 20; locality 15. U.S.N.M. 561104.
14. × 20; locality 140. U.S.N.M. 561105.
15. × 40; locality 22a. U.S.N.M. 561106.
16. × 20; locality 140. U.S.N.M. 561107.
17. × 20; locality 149b. U.S.N.M. 561108.
18. × 20; locality 15. U.S.N.M. 561109.
19. × 40; locality 22a. U.S.N.M. 561110.
20. Vertical section, × 20, of a microspheric individual showing the strong pillars which end in large surface pustules; locality 140. U.S.N.M. 561111.
21. *Lepidocyclina (Pliolepidina) pustulosa tobleri* H. Douvillé (p. 17).
    Vertical section, × 12.5, of a large, inflated specimen with the general configuration of typical *L. pustulosa* except for the embryonic chambers; introduced for comparison with *L. pustulosa;* locality 124. U.S.N.M. 561112.



EOCENE *LEPIDOCYCLINA*

PLATE 14

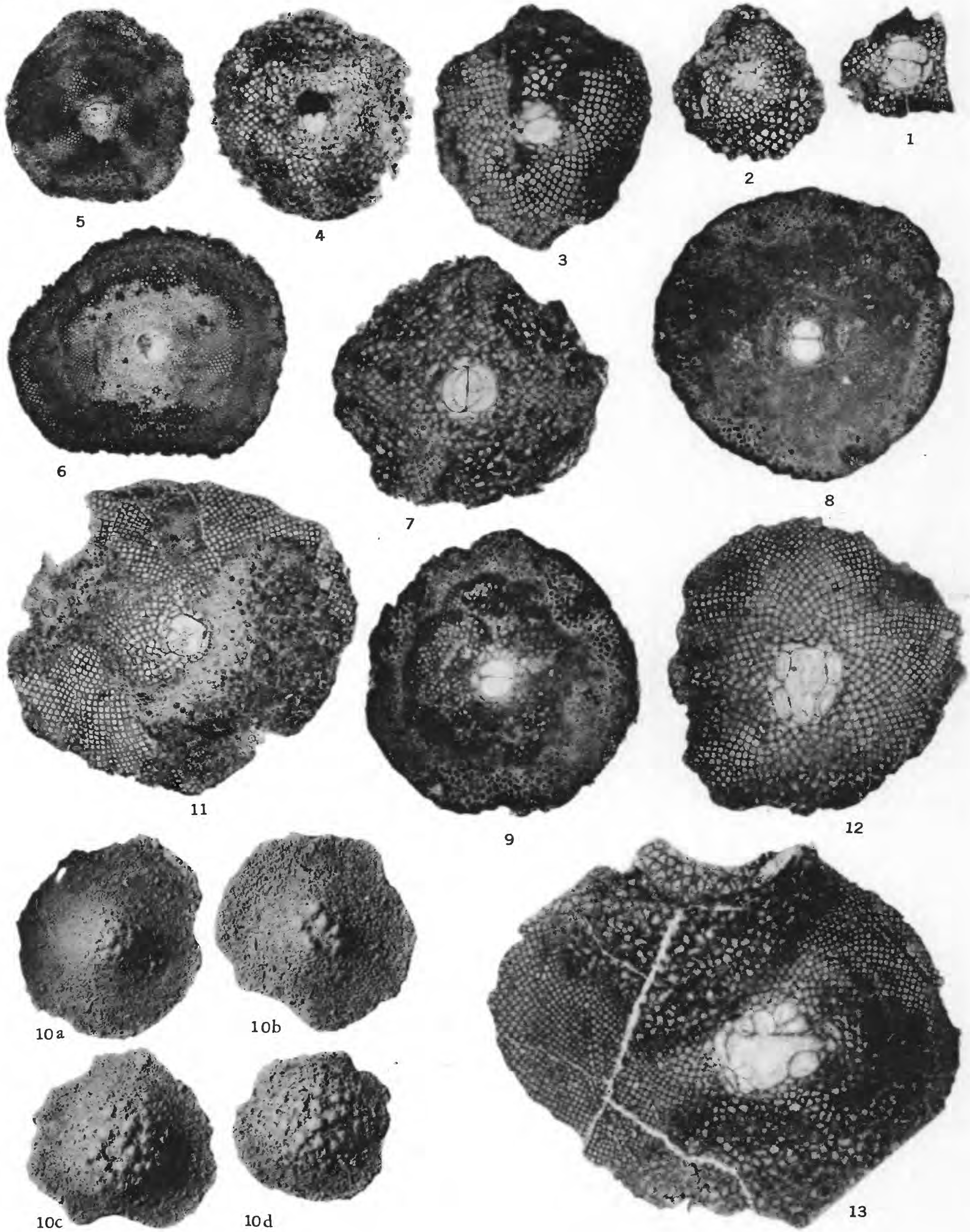
FIGURES 1–10. *Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé (p. 16).

1. Equatorial section, × 20; locality 22a. U.S.N.M. 561113.
2. Equatorial section, × 20; locality 22a. U.S.N.M. 561114.
3. Equatorial section, × 20; locality 15. U.S.N.M. 561115.
4. Equatorial section, × 20; locality 149b. U.S.N.M. 561116.
5. Equatorial section, × 12.5; locality 140. U.S.N.M. 561117.
6. Equatorial section, × 12.5; locality 140. U.S.N.M. 561118.
7. Equatorial section, × 20; locality 15. U.S.N.M. 561119.
8. Equatorial section, × 20; locality 140. U.S.N.M. 561120.
9. Equatorial section, × 20; locality 140. U.S.N.M. 561121.

10a–10d. External view, × 10, of 4 specimens showing individual differences; locality 140. U.S.N.M. 561122.

11. *Lepidocyclina* (*Pliolepidina*) *macdonaldi* Cushman (p. 16)
Equatorial section, × 12.5, showing the difference in shape of the equatorial chambers between this species and *L. pustulosa;* locality 149b. U.S.N.M. 561123.

12, 13. *Lepidocyclina* (*Pliolepidina*) *pustulosa tobleri* H. Douvillé (p. 17).
Equatorial sections, × 20; locality 132. U.S.N.M. 561124.



EOCENE *LEPIDOCYCLINA*

PLATE 15

FIGURES 1, 2, 4, 5. *Lepidocyclina (Lepidocyclina) yurnagunensis morganopsis* Vaughan (p. 23).

1, 2. Vertical sections, × 20, of megalospheric specimens showing the heavy pillars; locality 53. U.S.N.M. 561125.

4, 5. Vertical sections, × 20, of microspheric individuals showing the heavy pillars; locality 45. U.S.N.M. 561127.

3. *Lepidocyclina (Lepidocyclina) yurnagunensis* Cushman (p. 22). Vertical section × 12.5, showing the lateral chambers in regular tiers and the absence of pillars; locality 45. U.S.N.M. 561126.

6–10. *Lepidocyclina (Lepidocyclina) parvula* Cushman (p. 20)

6. Vertical section, × 20, of a megalospheric individual with heavy pillars; locality 11a. U.S.N.M. 561128.

7. Vertical section, × 20, of a microspheric individual with heavy pillars and thin floors and roofs to the lateral chambers; locality 11a. U.S.N.M. 561129.

8. Vertical section, × 20, of a microspheric specimen with low irregular lateral chambers between thick roofs and floors; locality 39. U.S.N.M. 561130.

9. Equatorial section, × 20, of a microspheric individual; locality 39. U.S.N.M. 561131.

10. Equatorial section, × 20, of a megalospheric individual; locality 11a. U.S.N.M. 561132.

11–13. *Lepidocyclina (Lepidocyclina) montgomeriensis* Cole (p. 20).

11. Equatorial section, × 12.5; locality 125. U.S.N.M. 561139.

12. Vertical section, × 20, of a specimen with large embryonic chambers and very few lateral chambers; locality 125. U.S.N.M. 561140.

13. Vertical section, × 20; locality 125. U.S.N.M. 561141.

14–16. *Lepidocyclina (Pliolepidina) pustulosa* H. Douvillé (p. 16).

14. Equatorial section, × 20, of a specimen of the type called *L. subglobosa* Nuttall; locality 131a. U.S.N.M. 561133.

15, 16. Vertical sections, × 20, of specimens of the type called *L. subglobosa* Nuttall; locality 131a. U.S.N.M. 561134.

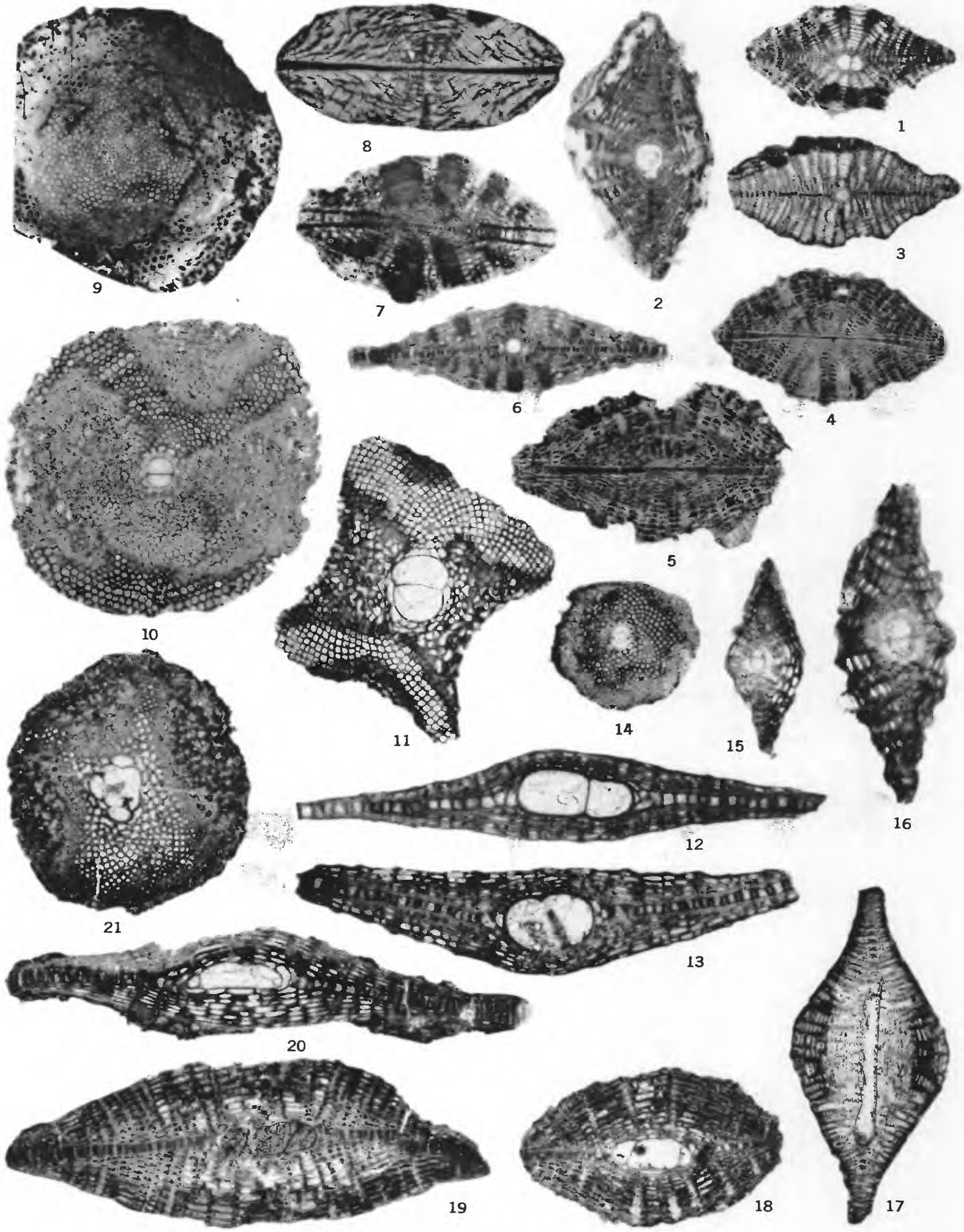
17–21. *Lepidocyclina (Pliolepidina) pustulosa tobleri* H. Douvillé (p. 17).

17. Vertical section, × 12.5, of an inflated specimen; locality 124. U.S.N.M. 561135.

18. Vertical section, × 20, of a small lenticular specimen, locality 149b. U.S.N.M. 561136.

19, 20. Vertical sections, × 20; locality 132. U.S.N.M. 561137.

21. Equatorial section, × 20; locality 149b. U.S.N.M. 561138.



EOCENE AND OLIGOCENE *LEPIDOCYCLINA*

PLATE 16

FIGURES 1–22. *Lepidocyclina (Lepidocyclina) canellei* Lemoine and R. Douvillé (p. 18.)

1. Vertical section, × 20; locality 53. U.S.N.M. 561142.
2. Vertical section, × 20; locality 11a. U.S.N.M. 561143.

3, 4. Vertical sections, × 20; locality 53. U.S.N.M. 561144.

5, 6. Vertical sections, × 20; locality 30. U.S.N.M. 561145.

7. Vertical section, × 20; locality 43. U.S.N.M. 561146.

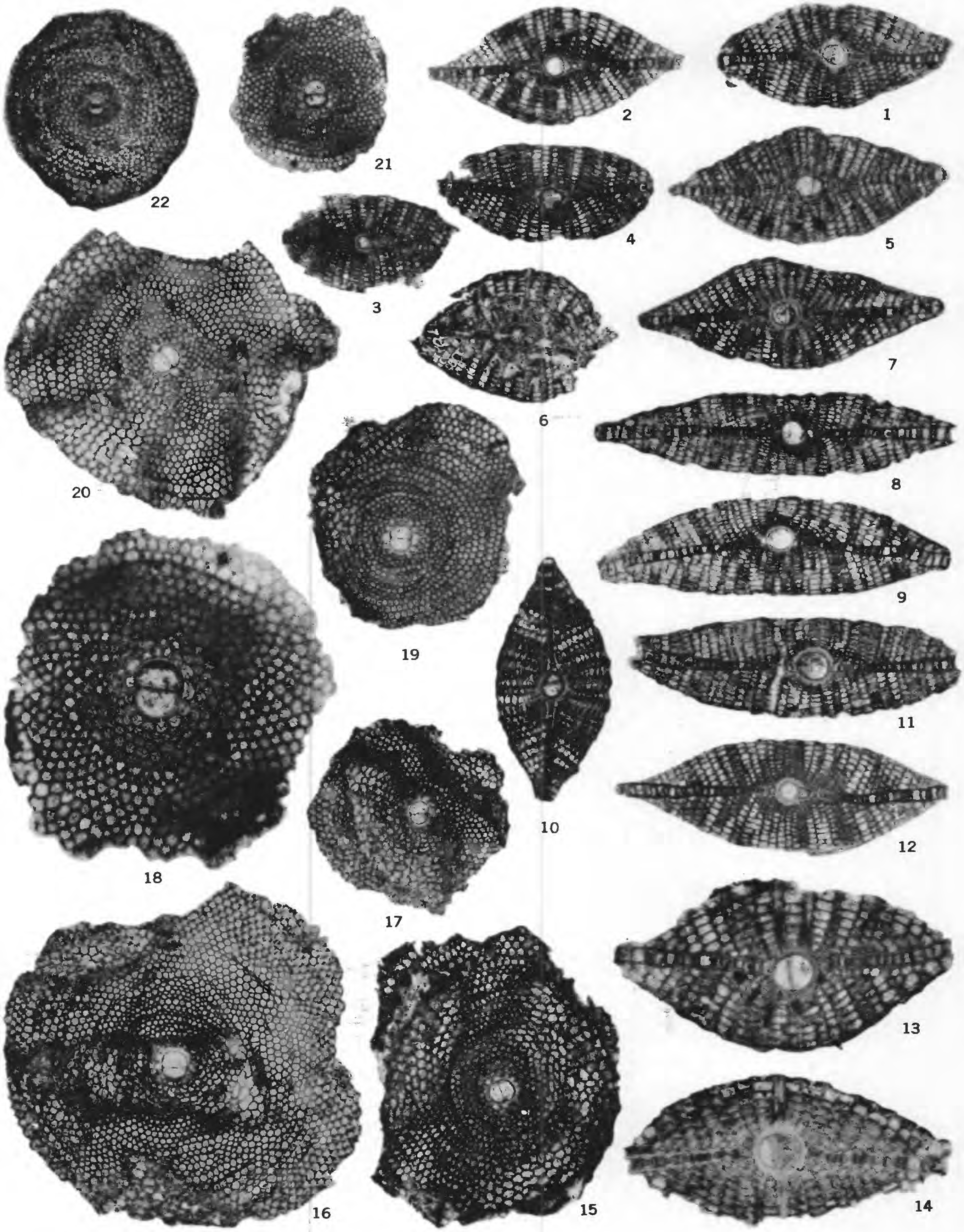
8, 9. Vertical sections, × 20; figure 9 is nearly an exact duplicate of the type vertical section given by Lemoine and R. Douvillé; locality 53. U.S.N.M. 561147.

10. Vertical section, × 20; locality 43. U.S.N.M. 561148.

11, 12. Vertical sections, × 20; station 53. U.S.N.M. 561149.

13, 14. Vertical sections, × 40, of topotypes of *L. pancanalis* Vaughan and Cole; U.S.G.S. locality 6025, Panama. U.S.N.M. 561150.

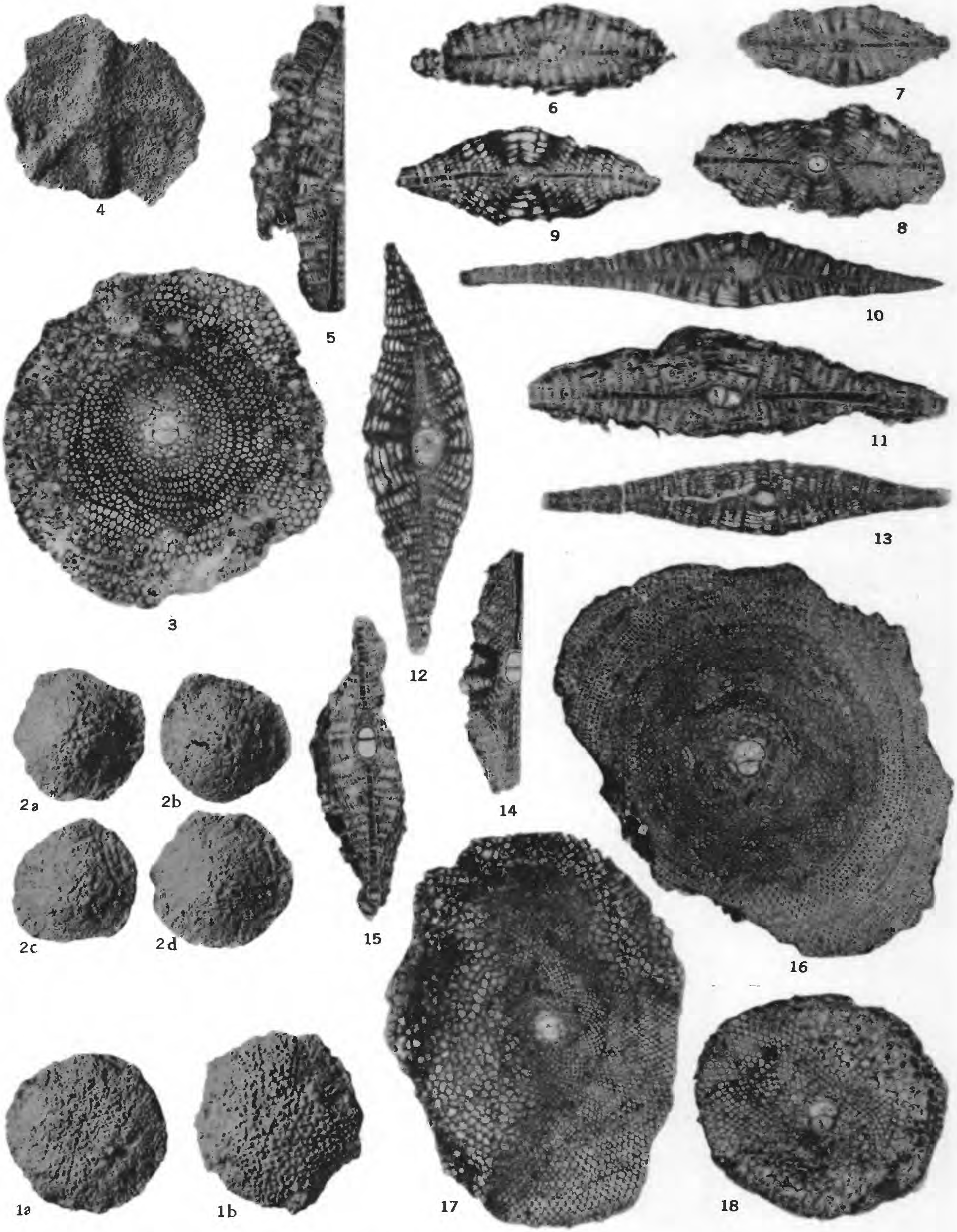
15. Equatorial section, × 20; locality 43. U.S.N.M. 561151.
16. Equatorial section, × 20; locality 53. U.S.N.M. 561152.
17. Equatorial section, × 20; locality 11a. U.S.N.M. 561153.
18. Equatorial section, × 40, of a topotype of *L. pancanalis* Vaughan and Cole; U.S.G.S. locality 6025, Panama. U.S.N.M. 561154.
19. Equatorial section, × 20; locality 43. U.S.N.M. 561155.
20. Equatorial section, × 20; locality 30. U.S.N.M. 561156.
21. Equatorial section, × 20, of the same specimen illustrated as figure 18; U.S.G.S. locality 6025, Panama. U.S.N.M. 561157.
22. Equatorial section, × 20; locality 55. U.S.N.M. 561158.



OLIGOCENE *LEPIDOCYCLINA*

PLATE 17

FIGURES 1–3. *Lepidocyclina* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé (p. 18).
1a–1b. External view, × 10, of 2 large specimens; locality 53. U.S.N.M. 561159.
2a–2d. External view, × 10, of 4 small specimens of the type called *L. pancanalis* Vaughan and Cole; locality 43. U.S.N.M. 561160.
3. Equatorial section, × 20, which is similar to the type section figured by Lemoine and R. Douvillé (1904, pl. 3, fig. 5); locality 53. U.S.N.M. 561161.
4. *Lepidocyclina* (*Lepidocyclina*) *asterodisca* Nuttall (p. 17). External view, × 5, of the only available specimen showing the radiate character of the test; locality 110. U.S.N.M. 561162.
5–18. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman (p. 22).
5–9. Vertical sections, × 20; locality 45. U.S.N.M. 561163.
10. Vertical section, × 20, of a very compressed specimen; locality 54. U.S.N.M. 561164.
11. Vertical section, × 20, of a strongly inflated specimen; locality 45. U.S.N.M. 561165.
12, 13. Vertical sections, × 20; locality 54. U.S.N.M. 561166.
14, 15. Vertical sections, × 20; locality 45. U.S.N.M. 561167.
16. Equatorial section, × 20; locality 39. U.S.N.M. 561168.
17. Equatorial section, × 20; locality 54. U.S.N.M. 561169.
18. Equatorial section, × 20; locality 45. U.S.N.M. 561170.



OLIGOCENE *LEPIDOCYCLINA*

PLATE 18

FIGURES 1–10, 16, 17. *Lepidocyclina (Lepidocyclina) waylandvaughani* Cole (p. 20).

1. Vertical section, × 20; locality 38. U.S.N.M. 561171.

2–4. Vertical sections, × 20; locality 11a. U.S.N.M. 561172.

5–7. Vertical sections of topotypes introduced for comparison with the Panamanian specimens; 5, 6, × 12.5; 7, × 20; collected by W. S. Cole, on the Huasteca Petroleum Company's golf course, Tampico, Mexico, from the Meson formation. U.S.N.M. 561173.

8. Vertical section, × 20, of a Panamanian specimen which has features identical to those shown by the Mexican specimen, fig. 7; locality 11a. U.S.N.M. 561174.

9. Part of a vertical section, × 40, of a Panamanian specimen showing the open, rectangular cavities of the lateral chambers; locality 11a. U.S.N.M. 561175.

10. Part of a vertical section, × 40, of the topotype illustrated as figure 6, introduced for comparison with the Panamanian specimen, figure 9; collected by W. S. Cole, on the Huasteca Petroleum Company's golf course, Tampico, Mexico, from the Meson formation. U.S.N.M. 561173.

16. Part of an equatorial section, × 12.5, of a topotype introduced for comparison; collected by W. S. Cole, on the Huasteca Petroleum Company's golf course, Tampico, Mexico, from the Meson formation. U.S.N.M. 561173.

17. Part of an equatorial section, × 20, showing the thick-walled, bilocular embryonic chambers and the short-spatulate to hexagonal equatorial chambers; locality 11a. U.S.N.M. 561176.

11. *Lepidocyclina (Lepidocyclina) forresti* Vaughan (p. 21).
Part of a vertical section, × 40, of a cotype which has lateral chambers similar to those found in *L. supera* (Conrad); photograph by Lloyd Henbest; specimen originally illustrated by Vaughan (1927, pl. 2, fig. 1); from the Antigua formation, east of Willoughby Bay, Antigua. U.S.N.M. 561177.

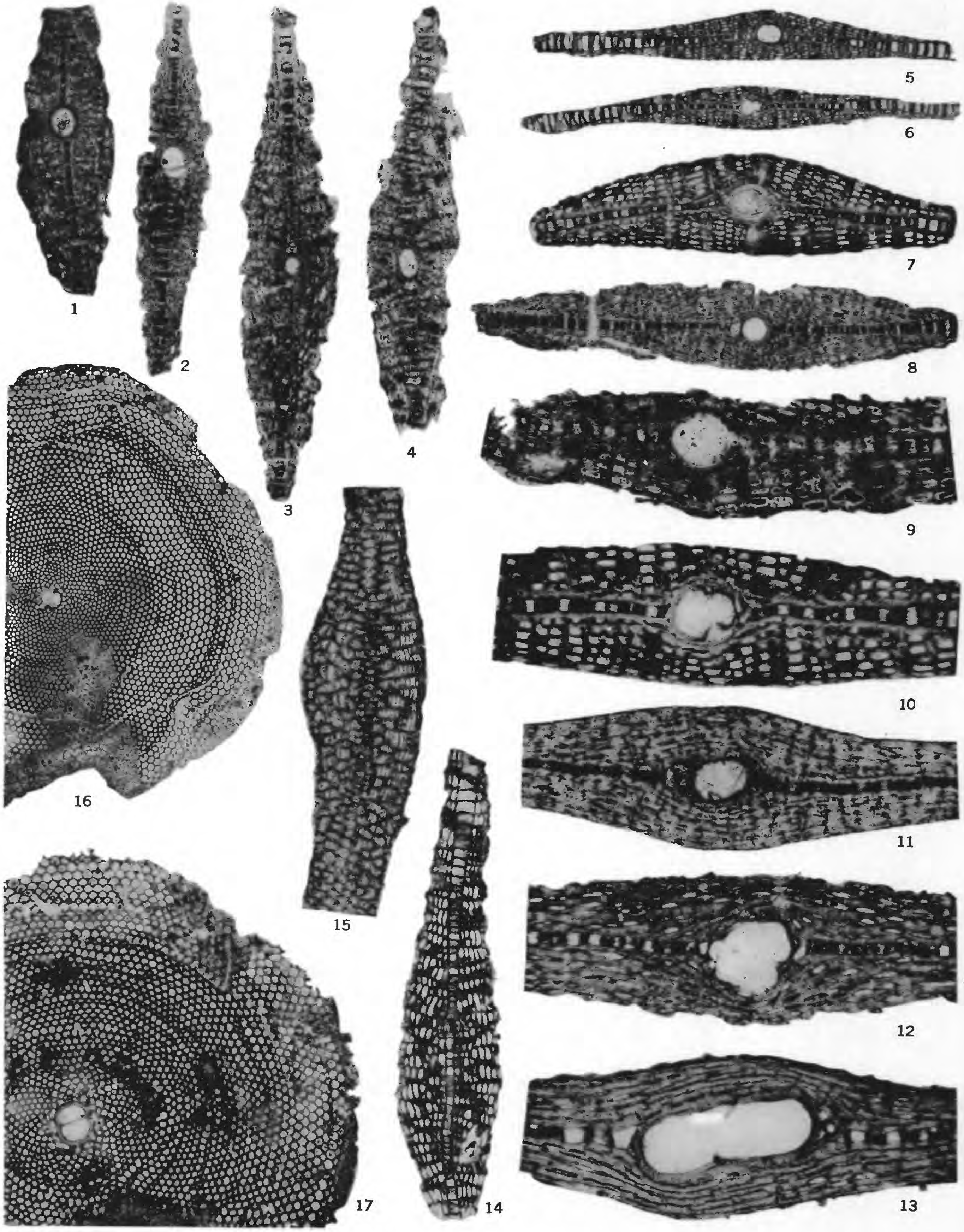
12. *Lepidocyclina (Lepidocyclina) supera* (Conrad) (p. 21).
Part of a vertical section, × 40, introduced to illustrate the differences in vertical section between it and *L. waylandvaughani* and the similarities between it and *L. forresti;* from the Byram formation, Vicksburg, Miss. U.S.N.M. 561178.

13. *Lepidocyclina (Lepidocyclina) mantelli* (Morton) (p. 21).
Part of a vertical section, × 40, to show the features of the vertical section; collected by W. S. Cole from the Marianna limestone on the Chipola River one-half mile east of Marianna, Fla. U.S.N.M. 561179.

14, 15. *Lepidocyclina (Nephrolepidina) vaughani* Cushman (p. 21).

14. Part of a vertical section, × 20, not centered, to show the open, rectangular lateral chambers with thin roofs and floors; locality 11a. U.S.N.M. 561180.

15. Part of an oblique "vertical" section, × 20, not centered, made to resemble Cushman's (1919a) illustration figure 5, plate 37, which Vaughan (1923) used as a cotype for *L. miraflorensis;* locality 30. U.S.N.M. 561181.



OLIGOCENE *LEPIDOCYCLINA*

PLATE 19

FIGURES 1–8. *Lepidocyclina* (*Nephrolepidina*) *dartoni* Vaughan (p. 27).

1, 2. External view, × 10, of 2 specimens showing the surface appearance and the radiate character of the test; locality 11a. U.S.N.M. 561182.

3–5. Vertical sections, × 20, showing the large, rectangular lateral chambers arranged in rather regular tiers; locality 11a. U.S.N.M. 561183.

6. Equatorial section, × 20, showing the equatorial chambers arranged in a stellate pattern; locality 11a. U. S. N. M. 561184.

7. Equatorial section, × 20, of a specimen whose radiate pattern is less distinct than that of figure 6 in which the shape of the equatorial chambers varies from diamond to elongate hexagonal; locality 11a. U.S.N.M. 561185.

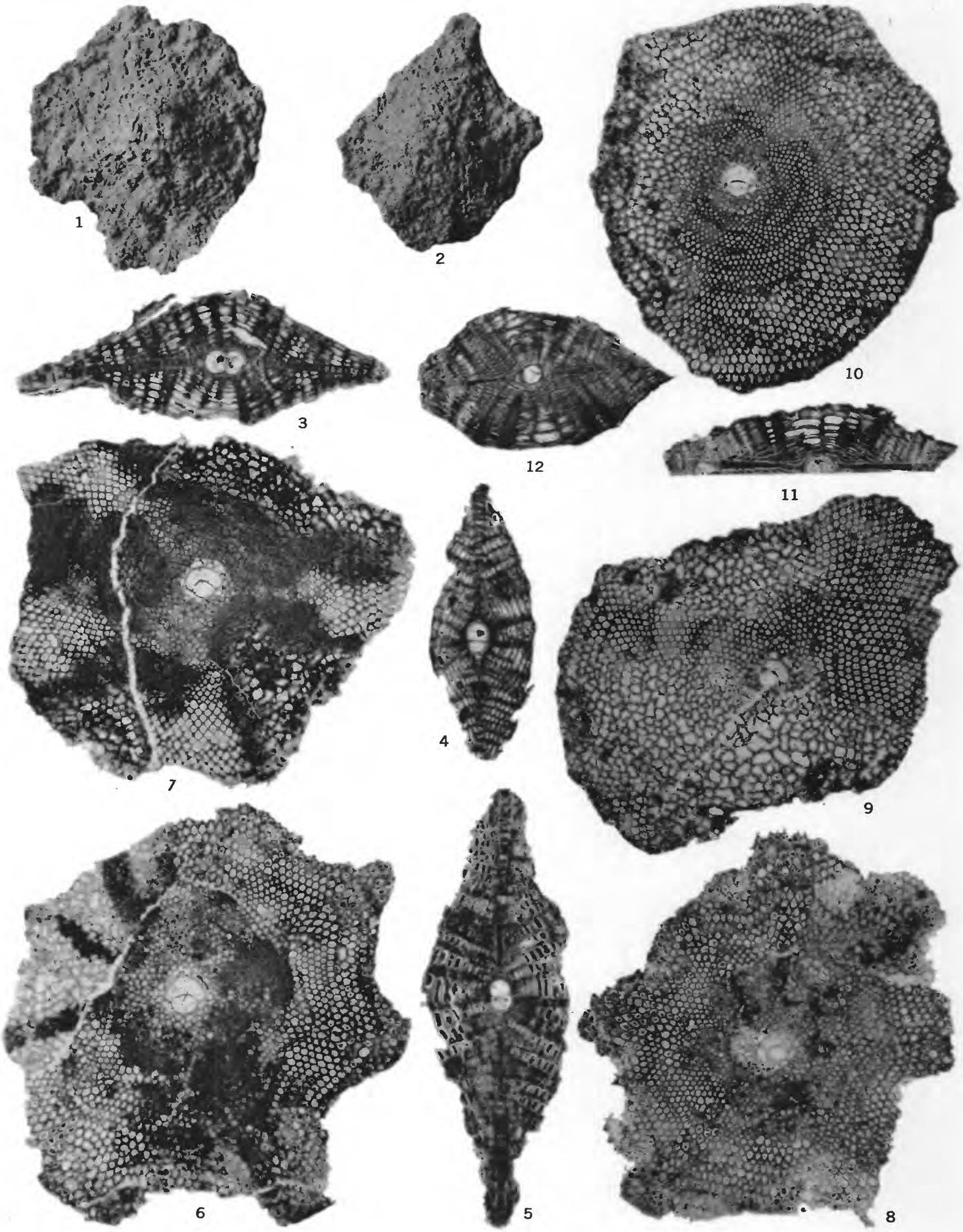
8. Equatorial section, × 20, of a specimen with very small embryonic chambers; locality 11a. U.S.N.M. 561186.

9–12. *Lepidocyclina* (*Nephrolepidina*) *tournoueri* Lemoine and R. Douvillé (p. 28).

9. Equatorial section, × 20, which has elongate hexagonal equatorial chambers to the right of the embryonic chambers of the type assumed to characterize *L. tempanii* Vaughan and Cole, and which has equatorial chambers of the type associated with typical *L. tournoueri* to the left of the embryonic chambers; locality 45. U.S.N.M. 561187.

10. Equatorial section, × 20; locality 45. U.S.N.M. 561188.

11, 12. Vertical sections, × 20; locality 45. U.S.N.M. 561189.



OLIGOCENE *LEPIDOCYCLINA*

PLATE 20

FIGURES 1–6. *Lepidocyclina* (*Nephrolepidina*) *vaughani* Cushman (p. 29).

1. Vertical section, × 20; locality 38. U.S.N.M. 561190.
2. Vertical section, × 20; locality 43. U.S.N.M. 561191.
3. Vertical section, × 20; locality 37. U.S.N.M. 561192.
4. Vertical section, × 12.5; locality 121. U.S.M.N. 561193.
5. Equatorial section, × 12.5; locality 121. U.S.N.M. 561194.
6. Part of an equatorial section, × 20; locality 30. U.S.N.M. 561195.
7. *Lepidocyclina* (*Lepidocyclina*) *montgomeriensis* Cole (p. 20).
   Vertical section, × 12.5, of a specimen with more open cavities to the lateral chambers than is usual for this species; locality 125. U.S.N.M. 561196.

8–10. *Lepidocyclina* (*Nephrolepidina*) *chaperi* Lemoine and R. Douvillé (p. 23).

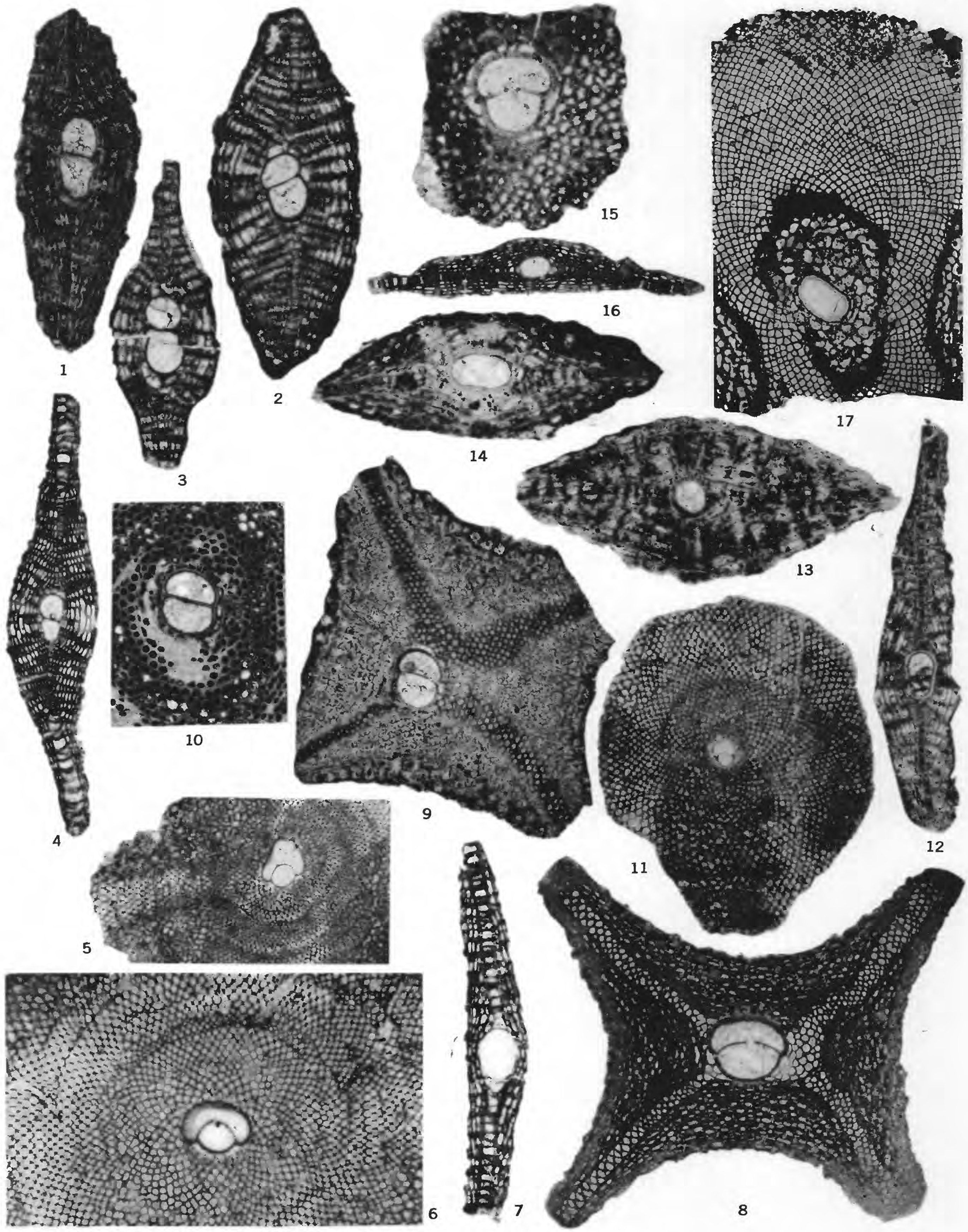
8. Equatorial section, × 12.5, of a strongly selliform individual; locality 23. U.S.N.M. 561197.
9. Equatorial section, × 12.5, of a specimen with embryonic chambers in which the second chamber does not embrace the initial chamber; locality 150. U.S.N.M. 561198.
10. Part of an equatorial section, × 20, in which the embryonic chambers are lepidocycline; locality 140. U.S.N.M. 561199.

11, 12. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman (p. 22).

11. Equatorial section, × 20, in which the embryonic chambers tend toward the nephrolepidine type; locality 54. U.S.N.M. 561200.
12. Vertical section, × 20; locality 45. U.S.N.M. 561201.
13. *Helicolepidina spiralis* Tobler (p. 30).
    Vertical section, × 40, of a small individual resembling certain small specimens of *L. pustulosa* except for its equatorial spire which is shown by an enlarged chamber at the place where it cuts the equatorial layer; locality 22a. U.S.N.M. 561202.

14, 15. *Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé (p. 17).

14. Vertical section, × 40, of a small individual with thin roofs and floors to the lateral chambers; locality 22a. U.S.N.M. 561203.
15. Equatorial section, × 40, showing the equatorial and embryonic chambers; locality 22a. U.S.N.M. 561204.
16. *Lepidocyclina* (*Pliolepidina*) *macdonaldi* Cushman (p. 16).
    Vertical section, × 12.5, of a specimen which probably should be assigned to this species; locality 132. U.S.N.M. 561205.
17. *Lepidocyclina* (*Pliolepidina*) *gubernacula* Cole, n. sp. (p. 15).
    Part of an equatorial section, × 12.5, showing the shape of the equatorial chambers; locality 23. U.S.N.M. 561206.



EOCENE AND OLIGOCENE *LEPIDOCYCLINA* AND EOCENE *HELICOLEPIDINA*

PLATE 21

FIGURES 1–15. *Lepidocyclina (Nephrolepidina) vaughani* Cushman (p. 29).

1. Part of an equatorial section, × 12.5, showing an abnormal development of the embryonic chambers; locality 123. U.S.N.M. 561207.

2, 3. Parts of equatorial sections, × 20; figure 2 shows the stoloniferous opening between the initial and the second embryonic chamber; locality 38. U.S.N.M. 561208.

4. Parts of an equatorial section, × 12.5, showing well-developed embryonic and equatorial chambers; locality 30. U.S.N.M. 561209.

5. Equatorial chambers, × 40, from the upper right part of the specimen illustrated as figure 4, showing details of their shape; locality 30. U.S.N.M. 561210.

6. Vertical section, × 12.5, showing the greatly increased height of the equatorial chambers in the inflated margin of the test; locality 30. U.S.N.M. 561211.

7. Vertical section, × 20, of the central part of an incomplete specimen; locality 11a. U.S.N.M. 561212.

8. Vertical section, × 12.5; locality 30. U.S.N.M. 561213.

9. Vertical section, × 12.5, of a specimen with few lateral chambers on each side of the embryonic chambers; locality 123. U.S.N.M. 561214.

10. Vertical section, × 12.5; locality 11a. U.S.N.M. 561216.

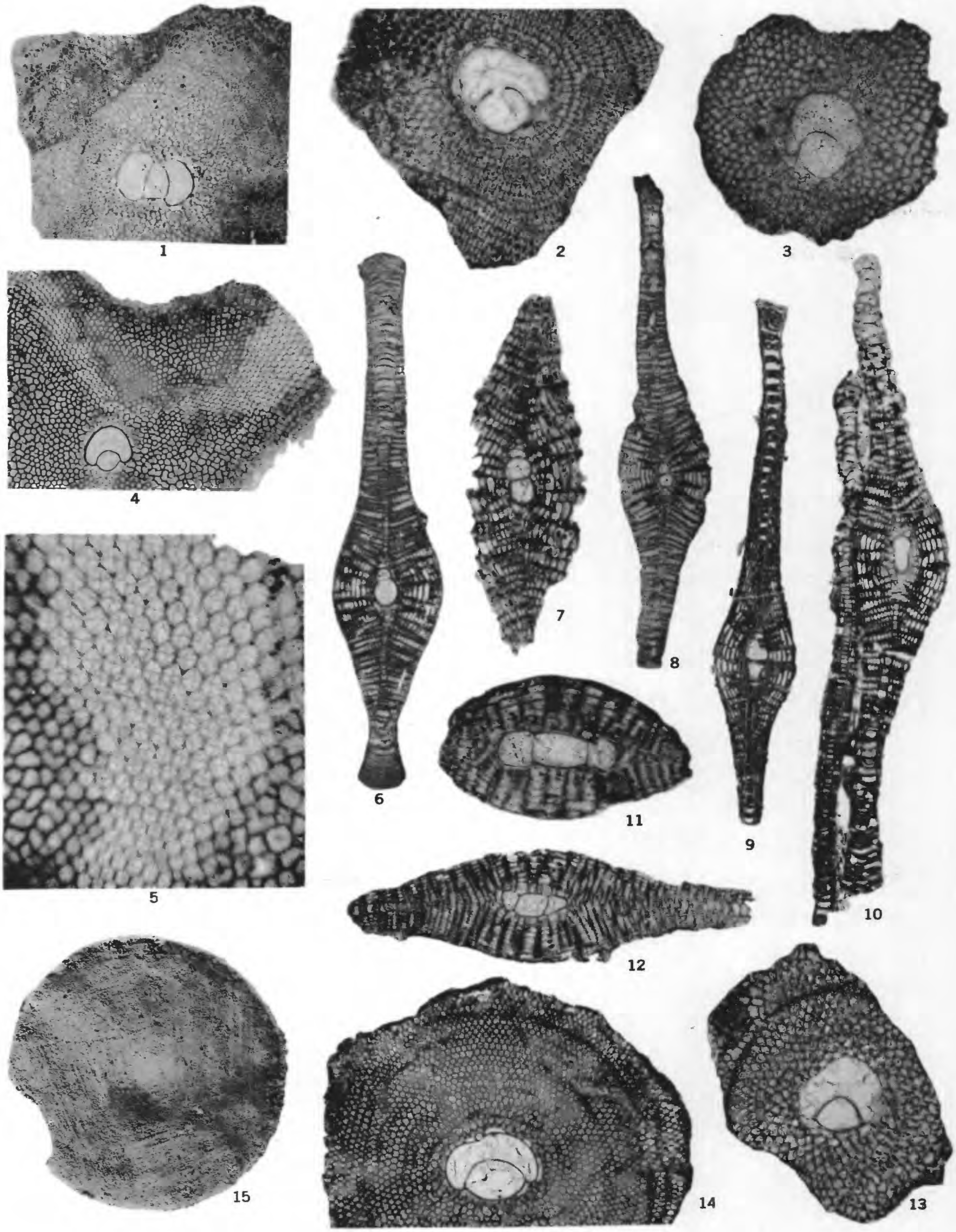
11. Vertical section, × 20, of the central, inflated part of an incomplete and broken specimen; locality 38. U.S.N.M. 561215.

12. Vertical section × 12.5; locality 43. U.S.N.M. 561217.

13. Part of an equatorial section, × 20; locality 37. U.S.N.M. 561218.

14. Part of an equatorial section, × 12.5, of a specimen with very large embryonic chambers; locality 43. U.S.N.M. 561219.

15. External view, × 5, showing the small but pronounced central umbo and the elevated edge of the test; locality 30. U.S.N.M. 561220.



OLIGOCENE *LEPIDOCYCLINA*

PLATE 22

FIGURES 1–5. *Lepidocyclina* (*Eulepidina*) *favosa* Cushman (p. 30).

1–3. Vertical sections, × 12.5, of microspheric individuals; locality 38. U.S.N.M. 561221.

4. Vertical section, × 12.5, of a megalospheric individual; locality 39. U.S.N.M. 561222.

5. Part of an equatorial section, × 12.5, of a megalospheric specimen; locality 39. U.S.N.M. 561223.

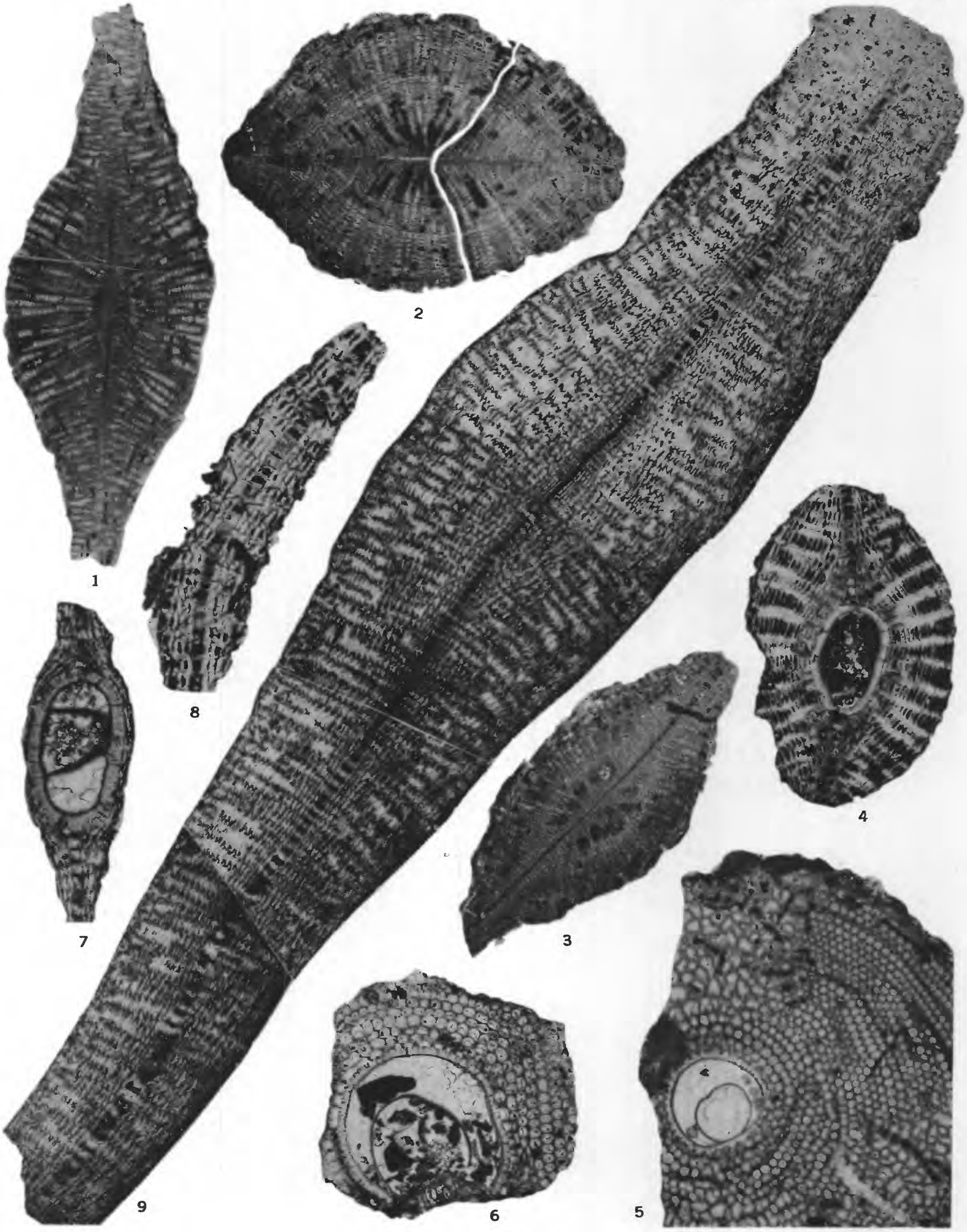
6–8. *Lepidocyclina* (*Eulepidina*) *undosa* Cushman (p. 30).

6. Part of an equatorial section, × 12.5, of a megalospheric specimen; locality 45. U.S.N.M. 561224.

7. Vertical section, × 20, of a megalospheric specimen whose surface is so eroded that the lateral chambers are largely missing; locality 45. U.S.N.M. 561225.

8. Vertical section, × 20, not centered, showing the equatorial layer and lateral chambers; locality 45. U.S.N.M. 561226.

9. *Lepidocyclina gigas* Cushman (p. 30).
Vertical section, × 12.5, virtually centered; locality 39. U.S.N.M. 561227.



OLIGOCENE *LEPIDOCYCLINA*

PLATE 23

FIGURES 1–3, 10. *Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé (p. 16).

1. External view, × 10, of a microspheric specimen with well-developed, raised, umbonal pustules; locality 140. U.S.N.M. 561228.
2. Equatorial section, × 20, of a microspheric specimen; locality 131a. U.S.N.M. 561229.
3. Detail of figure 2, × 40, showing the initial spire and the shape of the equatorial chambers; locality 131a. U.S.N.M. 561229.
10. Vertical section, × 12.5, of a microspheric specimen; locality 137. U.S.N.M. 561238.

4. *Lepidocyclina* (*Lepidocyclina*) *montgomeriensis* Cole (p. 20).
Detail, × 40, of equatorial chambers from part of the specimen illustrated on plate 15, figure 13; locality 125. U.S.N.M. 561230.

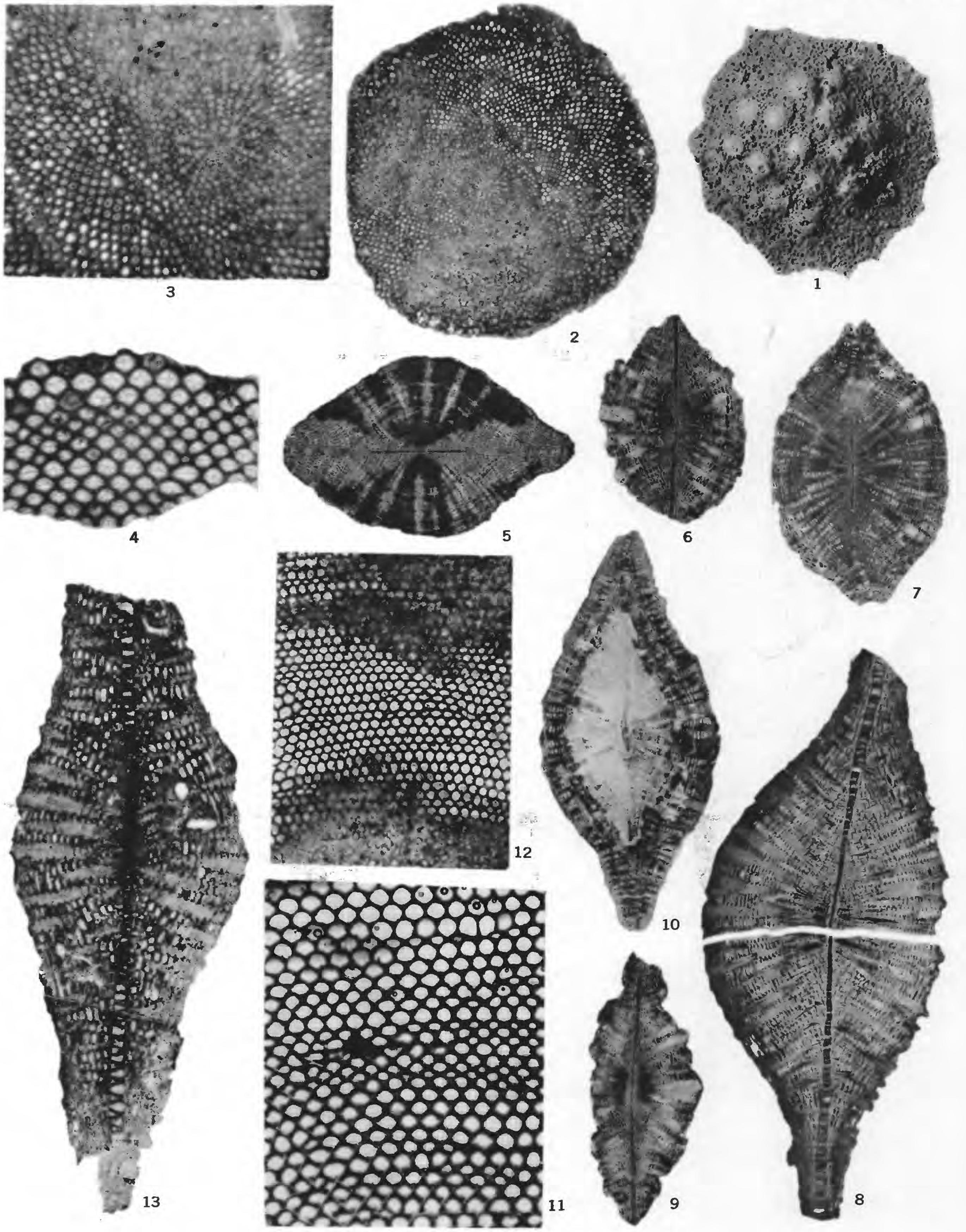
5–7, 9. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis morganopsis* Vaughan (p. 23).

5. Vertical section, × 12.5, of a microspheric specimen with very strong pillars; locality 39. U.S.N.M. 561231.
6. Vertical section, × 12.5, of a microspheric specimen with moderate pillars; locality 45. U.S.N.M. 561232.
7. Vertical section, × 12.5, of a specimen with few pillars near the center; locality 11a. U.S.N.M. 561233.
9. Vertical section, × 12.5, locality 45. U.S.N.M. 561235.

8, 11, 12. *Lepidocyclina* (*Nephrolepidina*) *chaperi* Lemoine and R. Douvillé (p. 23).

8. Vertical section, × 12.5, of a microspheric specimen of the type called *L. subraulinii;* locality 125. U.S.N.M. 561234.
11. Part of an equatorial section, × 20, of a microspheric topotype of Cushman's "*L. fragilis*" showing the shape of the equatorial chambers; from Ocala limestone at a cave 200 yards below old wagon bridge over the Chipola River near Marianna, Fla. U.S.N.M. 561236.
12. Part of an equatorial section, × 12.5, of a microspheric specimen from Panama showing the shape of the equatorial chambers; locality 23. U.S.N.M. 561237.

13. *Lepidocyclina* (*Pliolepidina*) *gubernacula* Cole, n. sp. (p. 15).
Vertical section, × 12.5, showing well-developed pillars in the umbonal area; locality 23. U.S.N.M. 561239.



EOCENE AND OLIGOCENE *LEPIDOCYCLINA*

PLATE 24

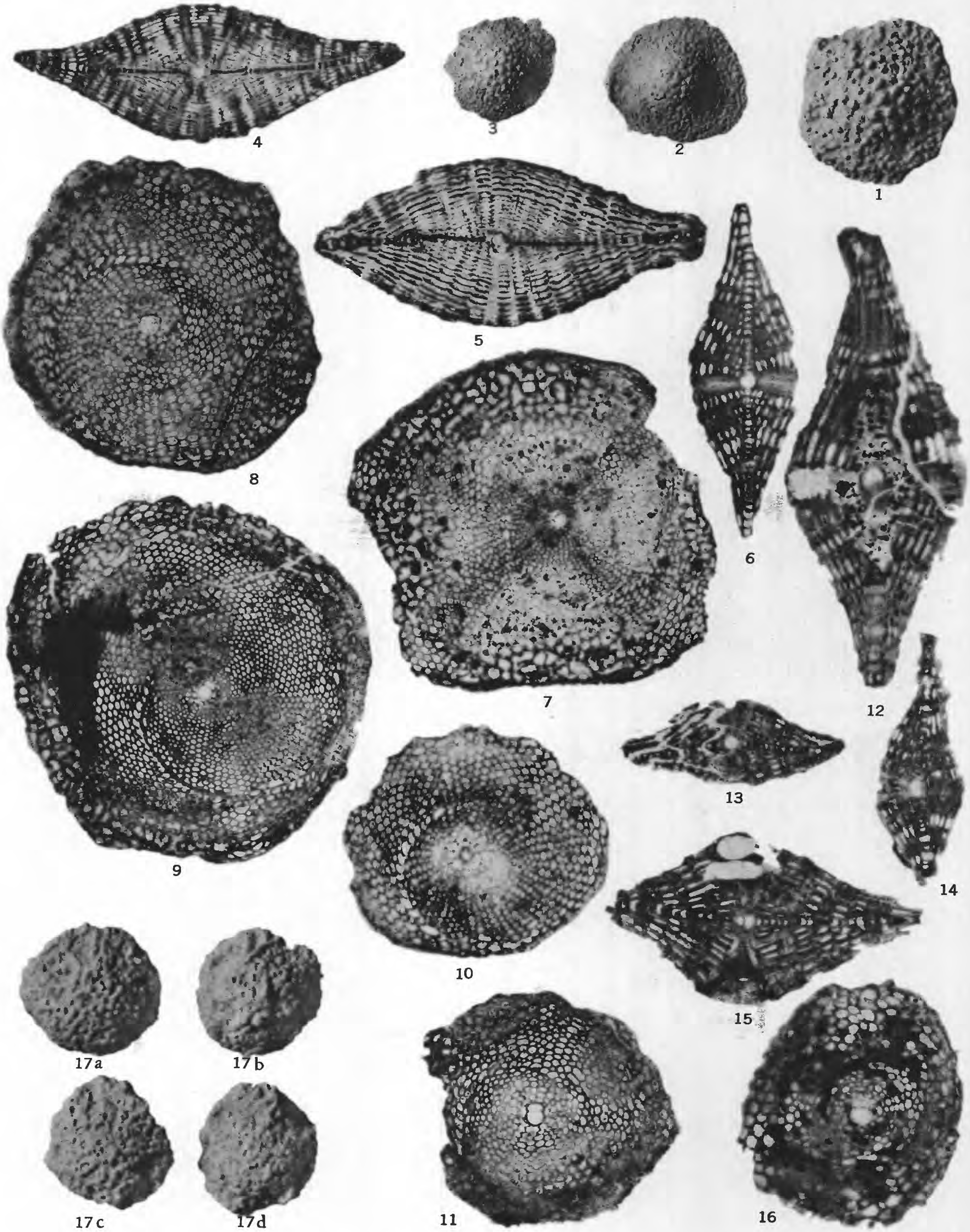
FIGURES 1–16. *Helicolepidina spiralis* Tobler (p. 30).

1. External view, × 10, of a slightly eroded specimen; locality 125. U.S.N.M. 561240.
2. External view, × 5, of a large specimen with a sharply inflated umbo and a distinct rim; locality 125. U.S.N.M. 561241.
3. External view, × 5, of a small specimen; locality 125. U.S.N.M. 561242.
4. Vertical section, × 12.5, of a typical large specimen; locality 125. U.S.N.M. 561243.
5. Vertical section, × 20, of a well-developed specimen; locality 150. U.S.N.M. 561244.
6. Vertical section, × 20, of a small specimen similar to Vaughan's "*H. nortoni*"; locality 125. U.S.N.M. 561245.
7. Equatorial section, × 12.5; locality 125. U.S.N.M. 561246.
8. Equatorial section, × 20, which shows the spiral chambers clearly; locality 125. U.S.N.M. 561247.
9. Equatorial section, × 12.5; locality 125. U.S.N.M. 561248.
10. Equatorial section, × 20; locality 125. U.S.N.M. 561249.
11. Equatorial section, × 20, of a specimen which does not show the spire clearly; the indistinct spire is supposed to be a characteristic of Vaughan's "*H. nortoni*"; locality 22a. U.S.N.M. 561250.
12. Vertical section, × 40, of a specimen similar to "*H. nortoni*" and also small *H. spiralis;* locality 22a. U.S.N.M. 561251.
13. Vertical section, × 20, of a specimen which is similar to the topotype of "*H. nortoni*" illustrated as figure 14; locality 22a. U.S.N.M. 561252.

14, 15. Vertical sections, × 20, of topotypes of "*H. nortoni*" introduced for comparison; from Jackson formation in well sample at a depth of 3611–3612 feet in sec. 20, T. 6S., R. 5E., St. Landry Parish, La. U.S.N.M. 561253.

16. Equatorial section, × 20, of a topotype of "*H. nortoni;*" same locality as above. U.S.N.M. 561254.

17a–17d. *Miogypsina* (*Miogypsina*) *antillea* (Cushman) (p. 35).
External view, × 15, of 4 specimens showing the shape and external sculpture; locality 53. U.S.N.M. 561255.



EOCENE *HELICOLEPIDINA* AND OLIGOCENE *MIOGYPSINA*

PLATE 25

FIGURES 1–8. *Miogypsina (Miolepidocyclina) panamensis* (Cushman) (p. 36).

1. Vertical section, × 40, of the inflated type; locality 55. U.S.N.M. 561256.
2. Equatorial section, × 40, showing embryonic, periembryonic, and equatorial chambers; locality 55. U.S.N.M. 561257.
3. Equatorial section, × 40, of an inflated specimen; locality 55. U.S.N.M. 561258.
4. Equatorial section, × 40; locality 55. U.S.N.M. 561259.
5. Equatorial section, × 40, of an inflated specimen; locality 55. U.S.N.M. 561260.
6. Transverse section, × 40, of a compressed specimen; locality 55. U.S.N.M. 561261.
7. Equatorial section, × 20, of a compressed specimen; locality 55. U.S.N.M. 561262.

8a–8d. External view, × 15, of 4 individuals showing varying degrees of inflation and the surface ornamentation; locality 55. U.S.N.M. 561263.

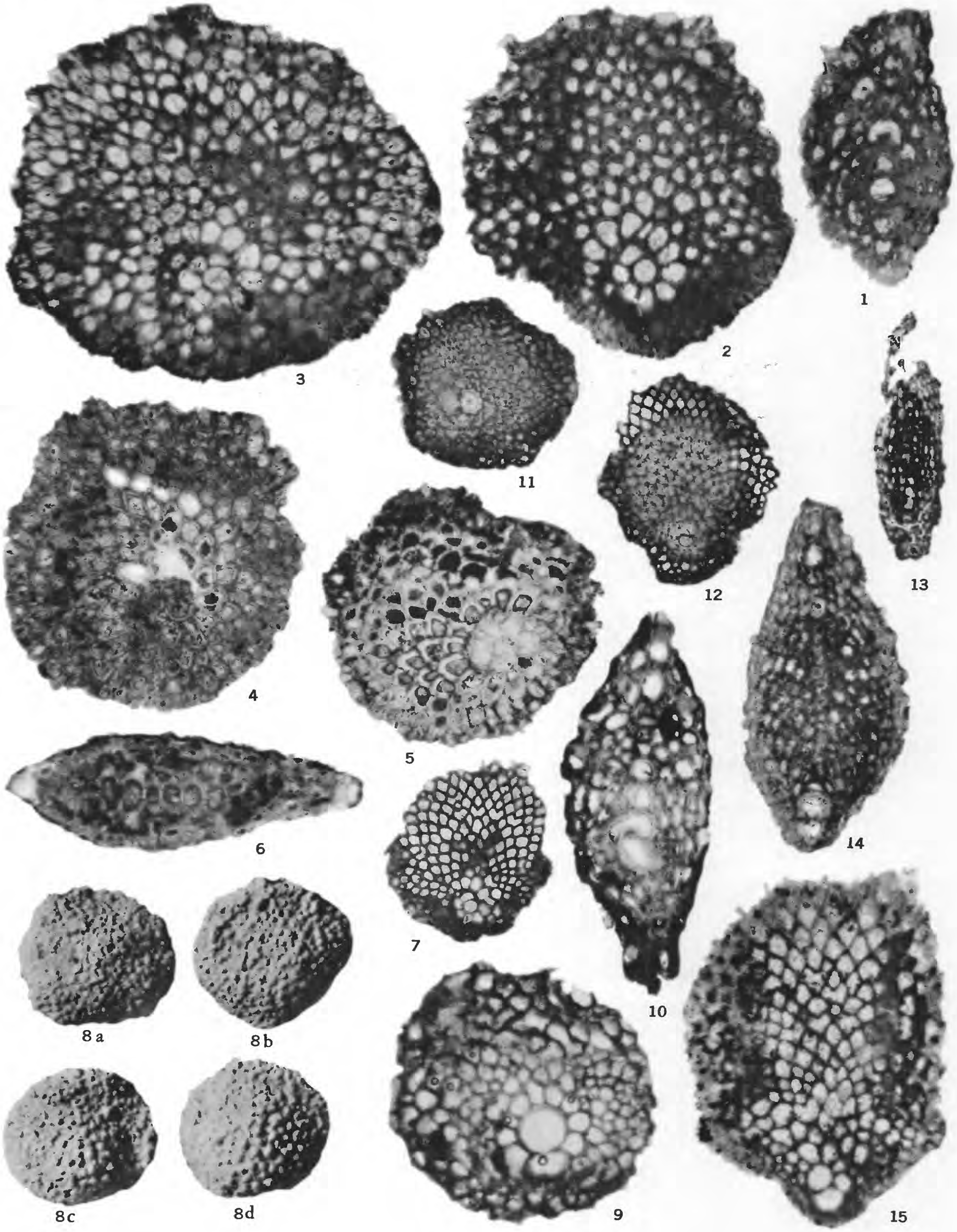
9–12. *Miogypsina (Miolepidocyclina) mexicana* Nuttall (p. 36).

9. Equatorial section, × 40, introduced for comparison with *M. panamensis*; from lower Oligocene, northeast of Finca de los Tremari, Veracruz, Mexico. U.S.N.M. 561264.
10. Vertical section, × 40, introduced for comparison with *M. panamensis*. U.S.N.M. 561265.

11, 12. Equatorial sections, × 20, introduced for comparison with *M. panamensis*. U.S.N.M. 561266.

13–15. *Miogypsina (Miogypsina) antillea* (Cushman) (p. 35).

13. Vertical section, × 20, not centered; locality 53. U.S.N.M. 561267.
14. Vertical section, × 40; locality 53. U.S.N.M. 561268.
15. Equatorial section, × 40; locality 53. U.S.N.M. 561269.

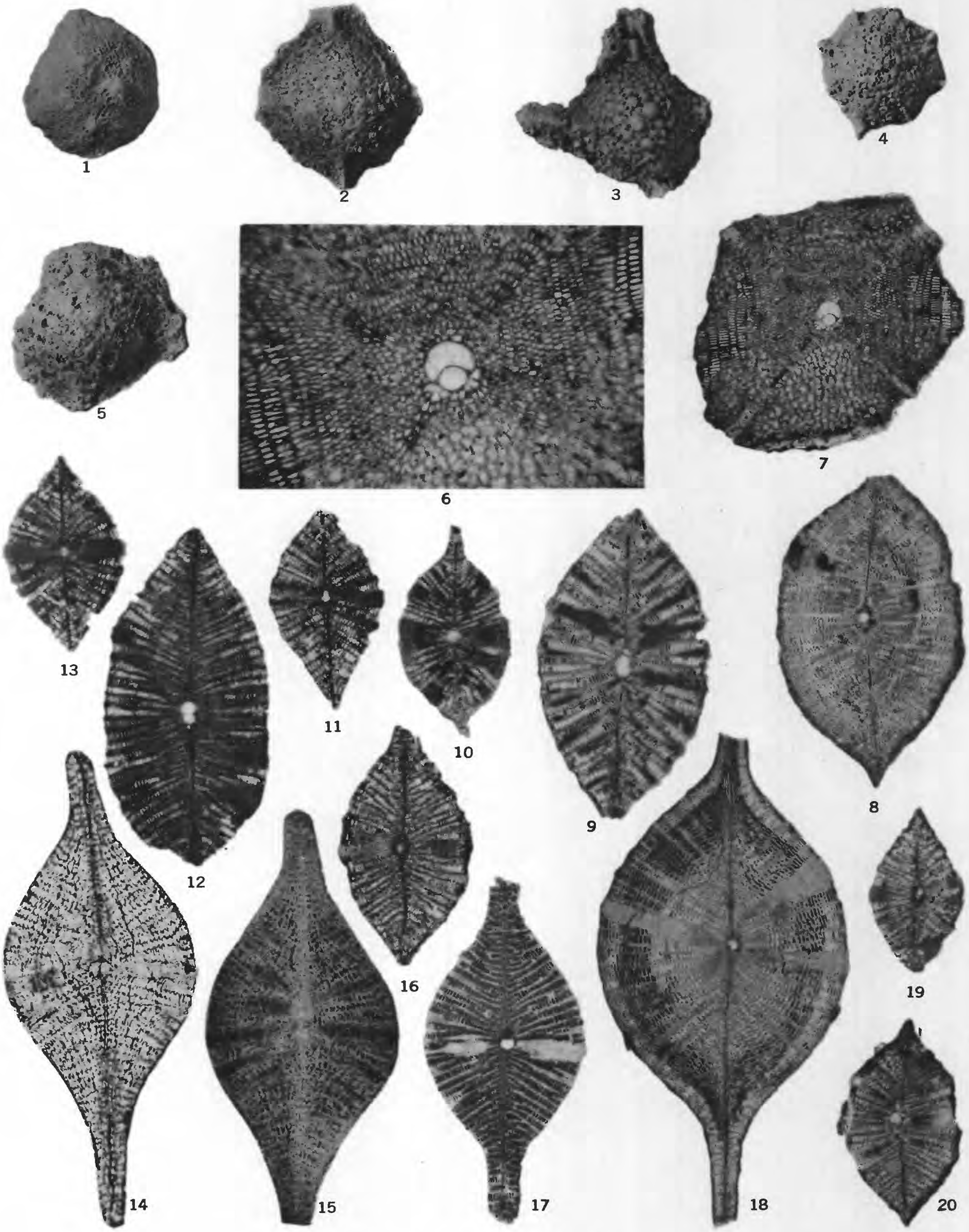


OLIGOCENE *MIOGYPSINA*

PLATE 26

FIGURES 1–20. *Asterocyclina minima* (Cushman) (p. 32).

1. External view, × 10, of a Cuban specimen of Vaughan's "*A. rutteni*" with a few raised large, umbonal pustules; from the upper Eocene at Palmer's locality 1102, 4.5 km west of Guanajay on the road to Mariel, Pinar del Rio Province, Cuba. U.S.N.M. 561270.
2. External view, × 10, of a Panamanian specimen with a few large umbonal pillar-heads which are flush with the surface of the test; locality 140. U.S.N.M. 561271.
3. External view, × 15, of a Panamanian specimen with projecting rays, a few large raised umbonal pustules, and many smaller pustules; locality 22a. U.S.N.M. 561272.
4. External view, × 10, of a Cuban specimen with many short rays and small pustules evenly distributed over the umbo; from upper Eocene, at same locality as figure 1. U.S.N.M. 561273.
5. External view, × 10, of a Panamanian specimen with a few large slightly raised umbonal pustules; locality 140. U.S.N.M. 561274.
6. Enlarged detail, × 40, of figure 7 showing the embryonic and equatorial chambers; locality 22a. U.S.N.M. 561275.
7. Equatorial section, × 20, of a specimen similar to the one illustrated as figure 3; locality 22a. U.S.N.M. 561275.
8. Vertical section, × 20, of a Cuban specimen similar to the one illustrated as figure 1; from upper Eocene, same locality as figure 1. U.S.N.M. 561276.
9. Vertical section, × 20, of a Cuban specimen similar to the one illustrated as figure 1 except the umbonal surface is devoid of pustules; from upper Eocene, same locality as figure 1. U.S.N.M. 561277.
10. Vertical section, × 20, of a Cuban specimen which is similar to the one called *A. sculpturata* (Cushman) by Vaughan (1945, pl. 31, fig. 2, the first specimen on the left); from upper Eocene, same locality as figure 1. U.S.N.M. 561278.
11. Vertical section, × 20, of a Cuban specimen similar in external appearance to the one illustrated as figure 4; upper Eocene, same locality as figure 1. U.S.N.M. 561279.
12. Vertical section, × 20, of a Cuban specimen similar in external appearance to the one illustrated as figure 1; from upper Eocene, same locality as figure 1. U.S.N.M. 561280.
13. Vertical section, × 20, of a Cuban specimen similar in external appearance to the one illustrated by Vaughan (1945, pl. 31, fig. 2, the third specimen from the left) under the name *A. sculpturata* (Cushman); from upper Eocene, same locality as figure 1. U.S.N.M. 561281.
14. Vertical section, × 20, of the holotype of *A. minima* (Cushman) photographed by transmitted light by Lloyd Henbest; U.S.G.S. locality 6512, David, Panama. U.S.N.M. 324745.
15. Vertical section, × 20, of the holotype of *A. minima* (Cushman) taken by dark field illumination by Lloyd Henbest to show the well-developed pillars, the thin roofs and floors of the lateral chambers, and the open, rectangular cavities of these chambers; U.S.G.S. locality 6512, David, Panama. U.S.N.M. 324745.
16. Vertical section, × 20, of a Panamanian specimen which was identified at first as *A. sculpturata* (Cushman); locality 22a. U.S.N.M. 561282.
17. Vertical section, × 20, of a Panamanian specimen which was identified as *A. minima* (Cushman); locality 140. U.S.N.M. 561283.
18. Vertical section, × 20, of a Panamanian specimen which was identified from external view as *A. rutteni* Vaughan; locality 140. U.S.N.M. 561284.
19. Vertical section, × 20; locality 22a. U.S.N.M. 561285.
20. Vertical section, × 20, of a Panamanian specimen which was identified by external characters as *A. sculpturata* (Cushman); locality 140. U.S.N.M. 561286.



EOCENE *ASTEROCYCLINA*

PLATE 27

FIGURES 1–5. *Asterocyclina mariannensis* (Cushman) (p. 31).

1. Vertical section, × 20, of a large specimen; locality 140. U.S.N.M. 561287.
2. Vertical section, × 20, of a small specimen; locality 140. U.S.N.M. 561288.
3. External view, × 10, of a Cuban specimen introduced for comparison; from upper Eocene, at Palmer's locality 1102. 4.5 km west of Guanajay on the road to Mariel, Pinar del Rio Province, Cuba. U.S.N.M. 561289.

4, 5. External views, × 10, of Panamanian specimens showing individual differences; locality 140. U.S.N.M. 561290.

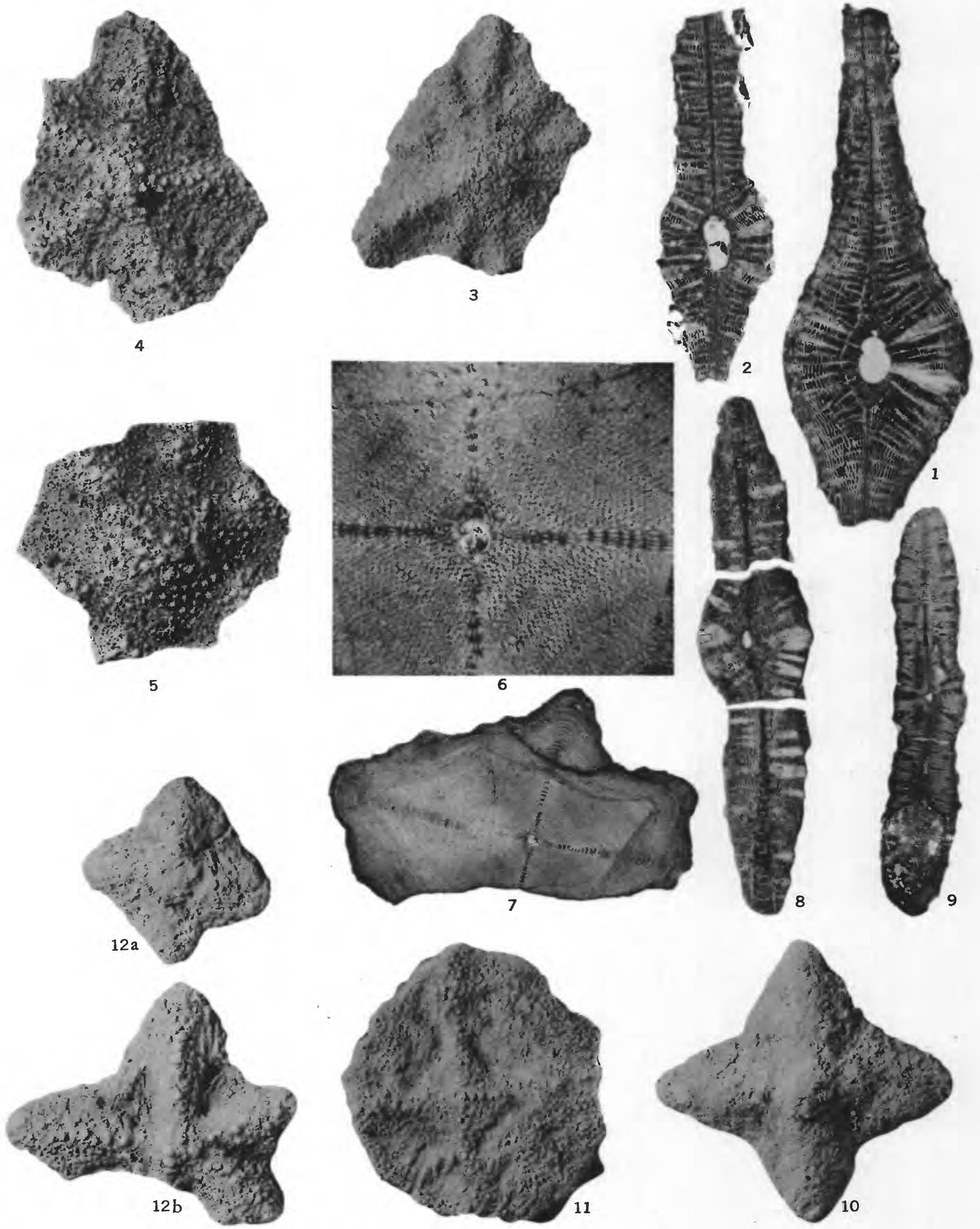
6–12. *Asterocyclina georgiana* (Cushman) (p. 31).

6. Detail of figure 7, × 40, showing the embryonic chambers and the elongate equatorial chambers of the rays; locality 125. U.S.N.M. 561291.
7. Equatorial section, × 12.5; locality 125. U.S.N.M. 561291.

8, 9. Vertical sections, × 20, showing individual differences; locality 125. U.S.N.M. 561292.

10. External view, × 10, showing well-developed rays and only slight interray areas; locality 124. U.S.N.M. 561293.
11. External view, × 10, showing well-developed interray areas; locality 145. U.S.N.M. 561294.

12a–12b. External views, × 10, of 2 specimens, the lower one of which has heavy pillars along the rays; locality 125. U.S.N.M. 561295.



EOCENE *ASTEROCYCLINA*

PLATE 28

FIGURES 1–4. *Asterocyclina mariannensis* (Cushman) (p. 31).

1. Vertical section, × 20, showing long, low lateral chambers in regular tiers and heavy umbonal pillars; locality 140. U.S.N.M. 561296.
2. Equatorial section, × 20; locality 140. U.S.N.M. 561297.
3. Equatorial section, × 12.5; locality 140. U.S.N.M. 561298.
4. Equatorial section, × 20; locality 140. U.S.N.M. 561299.

5, 6. *Asterocyclina minima* (Cushman) (p. 32).

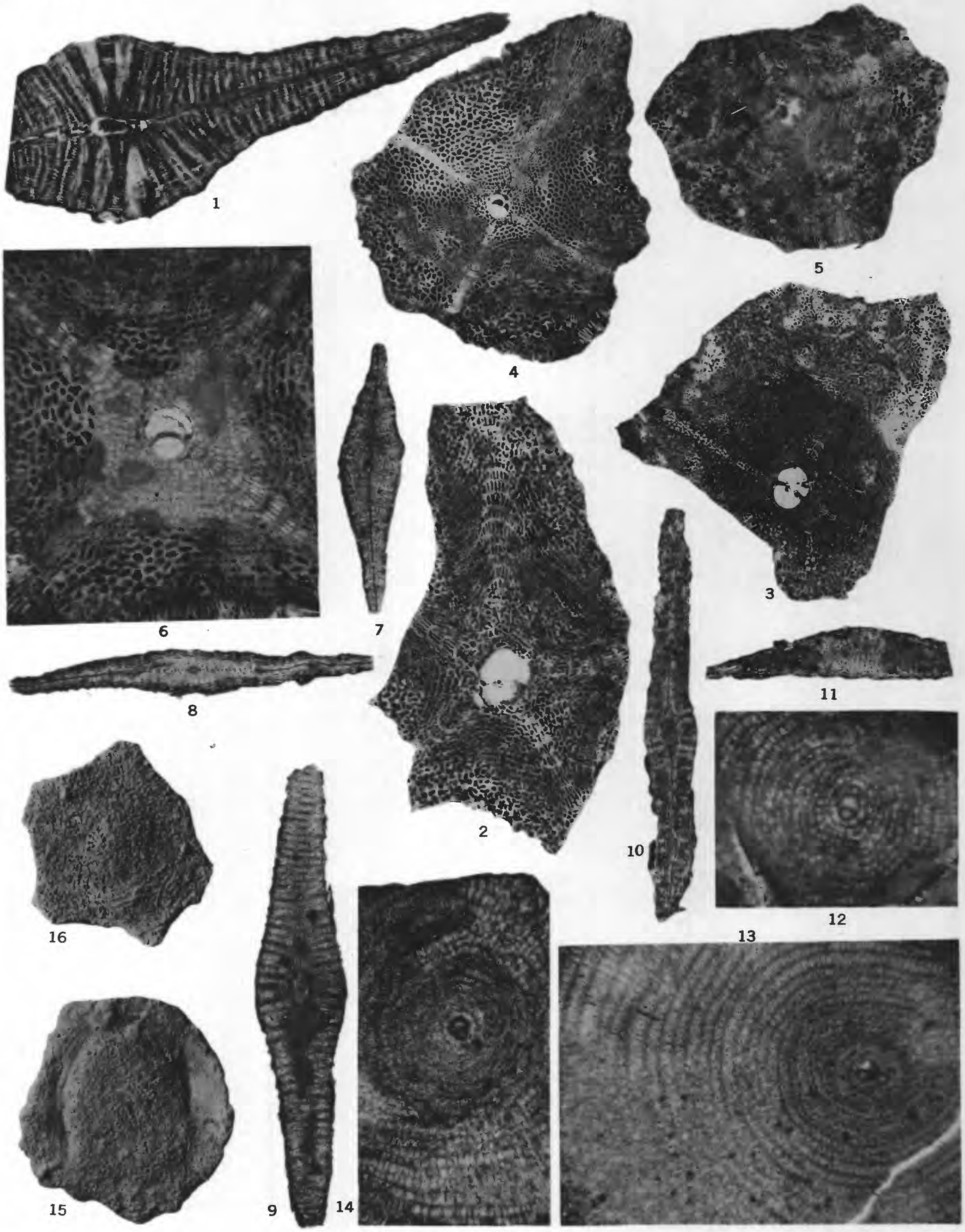
5. Equatorial section, × 20; locality 140. U.S.N.M. 561300.
6. Part of an equatorial section, × 40, showing embryonic chambers and the arrangement of the equatorial chambers to produce rays; locality 140. U.S.N.M. 561301.

7–16. *Pseudophragmina* (*Proporocyclina*) *flintensis* (Cushman) (p. 35).

7. Vertical section, × 20, showing a lenticular test of the type of *P. citrensis* (Vaughan); locality 125. U.S.N.M. 561302.
8. Vertical section, × 20, showing a nonumbonate test of the type of *P. mirandana* (Hodson); locality 140. U.S.N.M. 561303.
9. Vertical section, × 20, showing a lenticular test with a strong umbo; locality 125. U.S.N.M. 561304.
10. Vertical section, × 20, showing a compressed umbonate test of the type of *P. flintensis* (Cushman); locality 140. U.S.N.M. 561305.
11. Vertical section, × 20, not centered; locality 140. U.S.N.M. 561306.
12. Part of an equatorial section, × 40, showing the embryonic and periembryonic chambers; locality 140. U.S.N.M. 561307.

13, 14. Parts of equatorial sections, × 40, showing the embryonic and equatorial chambers; locality 125. U.S.N.M. 561308.

15. External view, × 10; locality 125. U.S.N.M. 561309.
16. External view, × 10; locality 140. U.S.N.M. 561310.



EOCENE *ASTEROCYCLINA* AND *PSEUDOPHRAGMINA*