# Geology of Saipan Mariana Islands

## Part 3. Paleontology

GEOLOGICAL SURVEY PROFESSIONAL PAPER 280-E-J

Chapter E. Calcareous Algae
*By* J. Harlan Johnson

Chapter F. *Discoaster* and Some Related Microfossils
*By* M. N. Bramlette

Chapter G. Eocene Radiolaria
*By* William R. Reidel

Chapter H. Smaller Foraminifera
*By* Ruth Todd

Chapter I. Larger Foraminifera
*By* W. Storrs Cole

Chapter J. Echinoids
*By* C. Wythe Cooke

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## CONTENTS OF PART 3


| | | Page |
|---|---|---|
| Chapter E. | Calcareous Algae | 209 |
| Chapter F. | *Discoaster* and Some Related Microfossils | 247 |
| Chapter G. | Eocene Radiolaria | 257 |
| Chapter H. | Smaller Foraminifera | 265 |
| Chapter I. | Larger Foraminifera | 321 |
| Chapter J. | Echinoids | 361 |

**GEOLOGICAL SURVEY PROFESSIONAL PAPER 280**

# Geology of Saipan, Mariana Islands

## Part 1. General Geology

A. General Geology
*By* PRESTON E. CLOUD, Jr., ROBERT GEORGE SCHMIDT, *and* HAROLD W. BURKE

## Part 2. Petrology and Soils

B. Petrology of the Volcanic Rocks
*By* ROBERT GEORGE SCHMIDT

C. Petrography of the Limestones
*By* J. HARLAN JOHNSON

D. Soils
*By* RALPH J. McCRACKEN

## Part 3. Paleontology

E. Calcareous Algae
*By* J. HARLAN JOHNSON

F. *Discoaster* and Some Related Microfossils
*By* M. N. BRAMLETTE

G. Eocene Radiolaria
*By* WILLIAM RIEDEL

H. Smaller Foraminifera
*By* RUTH TODD

I. Larger Foraminifera
*By* W. STORRS COLE

J. Echinoids
*By* C. WYTHE COOKE

## Part 4. Submarine Topography and Shoal-Water Ecology

K. Submarine Topography and Shoal-Water Ecology
*By* PRESTON E. CLOUD, Jr.

*Professional Paper 280 is being published in the foregoing sequence of parts and chapters*

# Larger Foraminifera

*By* W. STORRS COLE

GEOLOGICAL SURVEY PROFESSIONAL PAPER 280-I

*Describes and discusses range and associations of 20 species from the upper Eocene, 35 from the Miocene, and 7 from the Pleistocene; most are illustrated*

# CONTENTS

| | Page |
|---|---|
| Abstract | 321 |
| Introduction | 321 |
| Stratigraphic paleontology | 323 |
| Eocene | 323 |
| Miocene | 324 |
| Pleistocene | 327 |
| Reworked specimens | 327 |
| Comparison with identifications by Hanzawa | 327 |
| Systematic descriptions | 329 |
| Family Valvulinidae | 329 |
| Family Miliolidae | 329 |
| Family Camerinidae | 329 |
| Family Peneroplidae | 335 |
| Systematic descriptions—Continued | |
| Family Alveolinellidae | 336 |
| Family Calcarinidae | 336 |
| Family Cymbaloporidae | 336 |
| Family Planorbulinidae | 337 |
| Family Eorupertiidae | 337 |
| Family Rotaliidae | 338 |
| Family Miogypsinidae | 338 |
| Family Orbitoididae | 342 |
| Family Discocyclinidae | 347 |
| Localities and type numbers | 352 |
| Literature cited | 355 |
| Index | 357 |


# ILLUSTRATIONS

[Plates 94–118 follow index]

PLATE 2. Generalized geologic map and sections of Saipan, Mariana Islands — In pocket
4. Locality-finding map of Saipan — In pocket
94. Lower Miocene *Operculina* and *Operculinoides*.
95. Lower Miocene *Heterostegina* and *Spiroclypeus*.
96, 97. Upper Eocene *Pellatispira*.
98, 99. Upper Eocene *Biplanispira* and *Pellatispira*.
100. Upper Eocene *Biplanispira*.
101. Upper Eocene *Dictyoconus*, lower Miocene *Austrotrillina*, lower Miocene and Pleistocene *Cycloclypeus*.
102. Upper Eocene *Borelis*, *Camerina*, *Eorupertia*, *Fabiania*, *Halkyardia*, *Heterostegina*, *Operculinoides*, *Planorbulinella*, and *Spiroclypeus*.
103. Upper Eocene and lower Miocene *Eorupertia*, lower Miocene *Archaias*, *Marginopora*, *Streblus*, and *Gypsina*.
104–108. Lower Miocene *Lepidocyclina*.
109. Lower Miocene *Lepidocyclina* and *Spiroclypeus*.
110. Lower Miocene *Borelis*, *Flosculinella*, and *Miogypsinoides*.
111. Lower Miocene *Miogypsinoides*.
112–114. Lower Miocene *Miogypsina*.
115. Upper Eocene *Discocyclina*.
116, 117. Upper Eocene *Asterocyclina*.
118. Upper Eocene *Asterocyclina* and *Fabiania*, lower Miocene *Operculina*, Pleistocene *Baculogypsina* and *Calcarina*.


# TABLES

| | Page |
|---|---|
| TABLE 1. Distribution of Eocene Tertiary *b* species of larger Foraminifera on Saipan | 322 |
| 2. Distribution of Miocene lower Tertiary *e* species of larger Foraminifera on Saipan | Faces 324 |
| 3. Distribution of Miocene upper Tertiary *e* species of larger Foraminifera on Saipan | Faces 324 |
| 4. Distribution of Pleistocene species of larger Foraminifera on Saipan | 326 |


# CHART

Summary of the geologic units of Saipan — In pocket

GEOLOGY OF SAIPAN, MARIANA ISLANDS

# LARGER FORAMINIFERA

By W. Storrs Cole


## ABSTRACT

Sixty-two species of larger Foraminifera from the Eocene, Miocene, and Pleistocene of Saipan are discussed, and most of them are illustrated. Twenty species occur in the upper Eocene, Tertiary *b*; 35 in the Miocene, Tertiary *e*; and 7 in the Pleistocene.

The Eocene and the Pleistocene faunas are not subdivided, but the Miocene includes two faunal zones. Of the 33 Miocene species, 14 range throughout the Miocene, 6 are restricted to a lower zone, and 13 occur only in an upper zone. In the East Indies *Heterostegina borneensis* is believed to mark lower Tertiary *e*, whereas such species as *Flosculinella globulosa* and *Miogypsinoides dehaartii* (Van der Vlerk) are restricted to upper Tertiary *e*. As the ranges of these and associated species on Saipan are stratigraphically segregated in the same order of superposition, their stratigraphic distribution is assumed to be approximately that found in the East Indies, and the Miocene of Saipan is divided into upper and lower Tertiary *e*.

The range of *Cycloclypeus* (*Katacycloclypeus*) *transiens* Tan is extended downward into upper Tertiary *e*. Elsewhere, species of this subgenus are thought to be restricted to Tertiary *f*.


## INTRODUCTION

In a preliminary report (Cole and Bridge, 1953) describing the results of reconnaissance studies on Saipan, larger Foraminifera from 25 localities were recorded. After the manuscript for this preliminary report had been prepared, samples from an additional 650 localities were received in documentation of detailed mapping by Cloud, Schmidt, and Burke (1956). In most instances the study material consisted of three large random thin sections from hand specimens, but matrix-free specimens were utilized whenever available.

The distribution of the larger Foraminifera at 591 localities studied in detail is shown on tables 1–4. The Eocene is represented by 98 localities, the Miocene by 426, and the Pleistocene by 67. The Eocene and Pleistocene are not subdivided paleontologically, but the Miocene is divided into 2 faunal zones. Approximately 50 localities are without recognizable Foraminifera.

In the zonation of the Miocene, 170 localities represent lower Tertiary *e*, the stratigraphically lower zone of the Miocene, and 256 localities are assigned to upper Tertiary *e*.

The ranges of the genera of larger Foraminifera in the East Indies have been compiled by numerous workers. Glaessner (1943), Van der Vlerk (1948), and M. G. Rutten (*in* Bemmelen, 1949, p. 87) have published the most recent range charts. The genera of larger Foraminifera from Saipan are believed to have the same stratigraphic ranges as they do in the East Indies with the exception of *Cycloclypeus* (*Katacycloclypeus*), which occurs in association with distinctive Tertiary *e* species. Elsewhere this subgenus has heretofore been recorded only from Tertiary *f*.

The genera of larger Foraminifera are so distinctive that the field party was able to use accidental sections of them observed on the broken surfaces of the rocks to locate themselves stratigraphically. Very few changes of ages assigned in the field had to be made as a result of the detailed examination of the samples. However, the zonation of the Miocene was the result of the laboratory study.

The Eocene of Saipan is correlated with the upper Eocene, Tertiary *b*, of the East Indies time scale, and the Miocene is correlated with the lower Miocene, Tertiary *e*, of this same scale. Except for the Pleistocene, these are the only major divisions recognized by means of larger Foraminifera on Saipan, although an Oligocene age has been proposed for certain restricted deposits on the basis of smaller Foraminifera.

During the final stages of the preparation of this report, I had access to a manuscript titled "Cenozoic Foraminifera of Micronesia," by Dr. Shoshiro Hanzawa (1956).

It was expected at that time that the excellent report by Dr. Hanzawa would be published first and that my work would be published at a later date. In order to avoid confusion I have used wherever possible the new generic and specific names proposed by Hanzawa, and a summary is given on the points on which disagreement occurred. The localities are indexed and their positions shown on plate 4.

TABLE 1.—*Distribution of Eocene Tertiary* b *species of larger Foraminifera on Saipan*

[See pl. 4 for localities]

| Species | Localities |||||||||||||||||||||||||||||||||||||||||||||||||
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | S | | | | C | S | | | S | | | | | | | | | | | | | | | | | | | | | | | | | | C | S | | | | | | | | | B | | |
| | 64, The | 33, The | 103, The | 592, The | 631, The | 9, Tdeq | 212, Tdeq | 214, Tdq | 335, Tdeq | 79, Tdm | 88, Tdm | 90, Tdm | 100, Tdm | 101, Tdm | 125, Tdm | 132, Tdm | 133, Tdm | 134, Tdm | 150, Tdm | 163, Tdm | 170, Tdm | 188, Tdm | 189, Tdm | 190, Tdm | 191, Tdm | 194, Tdm | 201, Tdm | 217, Tdm | 208, Tdm | 219, Tdm | 222, Tdm | 223, Tdm | 227, Tdm | 258, Tdm | 259, Tdm | 10, Tmt | 202, Tmt | 247, Tmt | 248, Tmt | 253, Tmt | 282, Tmt | 286, Tmt | 287, Tmt | 288, Tmt | 349, Tmt | 211, Tmp | 221, Tmp | 251, Tmp |
| *Asterocyclina incisuricamerata* Cole, n. sp. ||||||||||||||||||||||||||||||||||X|||||||||||||||
| *matanzensis* Cole, n. sp. ||X|||||X|X||X||X||X|X|X|X|X||X|||X||X||X||X|X|||||X|X||X|X|X|X|X|X|X|X||||
| *penuria* Cole, nom. nov. ||||||||||X|X||X|X||||X||||X|||||X||||X||||X|X|||||||||X||||
| *Biplanispira fulgeria* (Whipple) |||||||||X||||||||||||X|X||X|||||||||||X|||X||||X||||X||X||X|
| *hoffmeisteri* (Whipple) ||X|||||||||||X|||||X||||||||||||X||||||X||||||||||||||
| *mirabilis* (Umbgrove) ||||||||X|X||||||||||||X|||||||||||||X|||X|X|X||||X|X|X||X||X|
| *Borelis pygmaeus* Hanzawa ||||||||||||X|||||||||||||||||||||||||||||||||||||
| *Camerina djokdjokarta* (Martin) |||||||||||||||||||||||||||||||||||||||||||||||||
| *saipanensis* Cole ||||||||X|X|X|X|X||X|X|X|X||X||X|||X|||X|||||||||||X||||X||X|X|X||||
| *Dictyoconus saipanensis* Cole, n. sp. |||||||||||||||||||||||||||||||||||||||||||||||||
| *Discocyclina omphala* (Fritsch) ||X||||||X|||X|X||X|X|X|X|X|X|X||X||||||||X|||||||X|X||||||X|X|X|X|X||||
| *Eorupertia plecte* (Chapman) ||X||||||X|||||||||||||X||X||||||||||X|||X|||X||||X|||||
| *Fabiania saipanensis* Cole ||X|||X||X||X|X|X|||||X||||X|||X|||X||X|X|X|X|X|||X|X|X||X||X||X|X|X|X|X|
| *Halkyardia bikiniensis* Cole |||||||||||||||||||||||||||||||||||||||||||||||||
| *Heterostegina saipanensis* Cole ||X|X||||X|||X||X||X|X||X||X|||||X|||||||||||X|X|X|||X||X|X|||X||X|
| *Operculinoides saipanensis* Cole, n. sp. |||||||X|||X|||||||||||||||||||||||||||||||X||||||||
| *Pellatispira orbitoidea* (Provale) ||X||X|||X||||X|X|||||X|X|X||X|||X|X|X|X||||X|||||||||X||X|||
| *provaleae* Yabe ||X|X|X|X|X|X|||X|X|||X|||X|X|X|X|X|||X|X|X|X|X|X|||||X|X|X|||||X|||X||X|||
| *Planorbulinella larvata* (Parker and Jones) ||||||||||X|||||||||||||||||||||||X|||||X|||X|||||||
| *Spiroclypeus vermicularis* Tan ||||||||||||||||X|||||X|||||||||||||X|||||||||||X|||X||X|

| Species | Localities—Continued |||||||||||||||||||||||||||||||||||||||||||||||||||
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | | S | | | | | | | | | | | | | | | | | | | | | | | | | B | | | | | | | | | | | | | | | S | | | | | | | |
| | 21, Tmp | 22, Tmp | 241, Tmp | 242, Tmp | 251, Tmp | 254, Tmp | 256, Tmp | 262, Tmp | 270, Tmp | 271, Tmp | 290, Tmp | 291, Tmp | 292, Tmp | 315, Tmp | 319, Tmp | 321, Tmp | 336, Tmp | 338, Tmp | 341, Tmp | 342, Tmp | 345, Tmp | 351, Tmp | 364, Tmp | 369, Tmp | 381, Tmp | 603, Tmp | 604, Tmp | 19, Tmw | 20, Tmw | 22, Tmw | 23, Tmw | 51, Tmw | 56, Tmw | 65, Tmw | 69, Tmw | 77, Tmw | 78, Tmw | 80, Tmw | 85, Tmw | 110, Tmw | 111, Tmw | 176, Tmw | 268, Tmw | 307, Tmw | 308, Tmw | 310, Tmw | 311, Tmw | 318, Tmw | 340, Tmw | 359, Tmw |
| *Asterocyclina incisuricamerata* Cole, n. sp. ||||||||||||||||||||||||||||||||||||||||||||||||||||
| *matanzensis* Cole, n. sp. ||X||X|X|X|X|X|X|X|X|X|X|X||X|X|X||||X||X|X||X||||||||||||||||||||X|X|X|||X||X|
| *penuria* Cole, nom. nov. ||X||X|||||X|||X|X||||X|||X|X|X||||||||||||||||||||||||||||
| *Biplanispira fulgeria* (Whipple) ||X|X||X|X|X||X|X||||||X|X|X|||||||X|X|||||||||||||||||||||||X|||
| *hoffmeisteri* (Whipple) ||||||||||||||||||||||||||||||||||||||||||||||||||||
| *mirabilis* (Umbgrove) |X|X|X||X|X|X|X|||||X||X||X||X||X||||X|||||||||||||||||||||X|X|X||X|X|||
| *Borelis pygmaeus* Hanzawa ||||||||||||||||||||||||||||||||||||||||||||||||||||
| *Camerina djokdjokarta* (Martin) |||||||||||||||||||X|||||||||||||||||||||||||||||||
| *saipanensis* Cole |X|X||X||X||X|X|X|||X|X||X|X||X|X|X|X|X||X|||X|X|X|X|X|X||X|X|X|X|X|X|X|||X||||||||
| *Dictyoconus saipanensis* Cole, n. sp. ||||||||||||||||||||||||||||||||||X||||||||X||||||||||
| *Discocyclina omphala* (Fritsch) |X|X|X||X||X|X||X|X||X|X|X|X||X|X||X|X|X||X|X||||||||||||||||||X|X|X|X||X|||
| *Eorupertia plecte* (Chapman) |||X||X|X||X||X||||X|X|X||X|||||X|X|||||X||X|X|X|X|||||||X|||X|X|X|X||X|||
| *Fabiania saipanensis* Cole ||X|X|X|X|X||X|X||X||X||X||X|X|X|X|||X|X|||||||X||||||||X|||||X||X||X|X|X|
| *Halkyardia bikiniensis* Cole ||X||||||||||||||||X||||||||||||||||X||||||||||||||X|||
| *Heterostegina saipanensis* Cole ||||||||X||X||||||||||X|X||||||||||||||||||||||||||||||
| *Operculinoides saipanensis* Cole, n. sp. ||X|||||||X||||||||X||||||||||||||||||||||||||||||||||
| *Pellatispira orbitoidea* (Provale) ||X|||X|||||X|||||||||X|X|||||||X|||||||||||||||||||||||
| *provaleae* Yabe ||||X|||||||||||X|||X||X||||X|X|X|||||||||||||||||||||||||
| *Planorbulinella larvata* (Parker and Jones) |||||X|X|X||||||X||||||||||||||||||X||||||||||||||||X||||
| *Spiroclypeus vermicularis* Tan |X|X||||||||X|X|||X||||X||X||||||||||||||||||||||||X|X|X|||X|||

## STRATIGRAPHIC PALEONTOLOGY

### EOCENE

Although the three Eocene formations, the Hagman and Densinyama formations and the Matansa limestone, have slightly variant assemblages of larger Foraminifera, they are here regarded as constituting a single faunal unit. The number of localities in each facies of the Eocene which contained larger Foraminifera is shown in the following table. Five samples were studied from the Hagman formation, 30 from the Densinyama formation, and 63 from the Matansa limestone. The distribution of the Eocene species is shown on table 1.

The samples from the five localities which represent the Hagman formation were not very fossiliferous with the exception of the one from locality S33, which had larger Foraminifera in moderate abundance. Therefore, many of the genera and species which occur in the Densinyama formation and Matansa limestone were not found in the Hagman formation.

The number of occurrences of each species in each facies of the Eocene is shown in the following table.

*Number of localities in each Eocene facies that contained larger Foraminifera*

| Formation | Facies | Localities | | | Total |
|---|---|---|---|---|---|
| | | B | C | S | |
| Matansa limestone | White | 15 | | 8 | 23 |
| | Pink | 3 | 2 | 25 | 30 |
| | Transitional | | 1 | 9 | 10 |
| Densinyama | Limestone-conglomerate | | | 26 | 26 |
| | Conglomerate-sandstone | | 1 | 3 | 4 |
| Hagman | Conglomerate-sandstone | | 1 | 4 | 5 |
| Total | | 18 | 5 | 75 | 98 |

*Number of occurrences of each species in each Eocene facies*

| Species | Matansa limestone | | | Densinyama formation | | Hagman formation | Total |
|---|---|---|---|---|---|---|---|
| | White | Pink | Transitional | Limestone-conglomerate | Conglomerate-sandstone | Conglomerate-sandstone | |
| *Asterocyclina incisuricamerata* Cole, n. sp. | | | | 1 | | | 1 |
| *A. matanzensis* Cole, n. sp. | 5 | 20 | 9 | 13 | 2 | 1 | 50 |
| *A. penuria* Cole, nom. nov. | | 9 | 2 | 9 | | | 20 |
| *Biplanispira fulgeria* (Whipple) | 1 | 14 | 3 | 4 | 1 | | 23 |
| *B. hoffmeisteri* (Whipple) | | | | 4 | | 1 | 5 |
| *B. mirabilis* (Umbgrove) | 5 | 15 | 6 | 2 | 2 | | 30 |
| *Borelis pygmaeus* Hanzawa | | | | 1 | | | 1 |
| *Camerina djokdjokarta* (Martin) | | 1 | | | | | 1 |
| *C. saipanensis* Cole | 14 | 17 | 5 | 11 | 2 | | 49 |
| *Dictyoconus saipanensis* Cole, n. sp. | 2 | | | | | | 2 |
| *Discocyclina omphala* (Fritsch) | 5 | 20 | 5 | 12 | 1 | 1 | 44 |
| *Eorupertia plecte* (Chapman) | 11 | 11 | 4 | 3 | 1 | 1 | 31 |
| *Fabiania saipanensis* Cole | 7 | 20 | 7 | 13 | 1 | 2 | 50 |
| *Halkyardia bikiniensis* Cole | 2 | 2 | | | | | 4 |
| *Heterostegina saipanensis* Cole | | 6 | 5 | 8 | 1 | 2 | 22 |
| *Operculinoides saipanensis* Cole, n. sp. | | 3 | 1 | 1 | 1 | | 6 |
| *Pellatispira orbitoidea* (Provale) | | 6 | 2 | 12 | 1 | 2 | 23 |
| *P. provaleae* Yabe | | 8 | 3 | 16 | 2 | 4 | 33 |
| *Planorbulinella larvata* (Parker and Jones) | 2 | 4 | 2 | 2 | | | 10 |
| *Spiroclypeus vermicularis* Tan | 4 | 8 | 1 | 3 | | | 16 |

Four species were found in all of the fossiliferous facies of the Eocene: *Asterocyclina matanzensis, Discocyclina omphala, Eorupertia plecte,* and *Fabiania saipanensis*. Three species were found in the three formations, but not in all the facies: *Heterostegina saipanensis, Pellatispira orbitoidea,* and *P. provaleae*. Seven species were found in the Densinyama formation and the Matansa limestone: *Asterocyclina penuria, Biplanispira fulgeria, B. mirabilis, Camerina saipanensis, Operculinoides saipanensis, Planorbulinella larvata,* and *Spiroclypeus vermicularis*. Three species were found only in the Matansa limestone: *Camerina djokdjokarta, Dictyoconus saipanensis,* and *Halkyardia bikiniensis*. Two species were found only in the Densinyama formation: *Asterocyclina incisuricamerata* and *Borelis pygmaeus*. And one species, *Biplanispira hoffmeisteri,* was found in the Densinyama and Hagman formations.

No species occurred at all of the 98 Tertiary *b* localities. *Fabiania saipanensis* was found at the greatest number of localities (50), whereas *Asterocyclina incisuricamerata, Camerina djokdjokarta,* and *Borelis pygmaeus* were found at single localities. Species which occurred either at single or few localities were represented by few specimens. There is only 1 specimen of *Borelis pygmaeus* and *Camerina djokdjokarta,* 2 of *Dictyoconus saipanensis,* 4 of *Halkyardia bikiniensis,* and 6 of *Operculinoides saipanensis*. Thus, 5 of the 20 Tertiary *b* species are extremely rare.

These rare species which appear to be restricted to a given formation or facies occur so infrequently that little stratigraphic importance is given them. The more abundantly occurring species are well distributed through the localities assigned to the three formations. Therefore, no species or group of species can be designated as stratigraphic markers for any of the Eocene formations, and the fauna is considered to be a unit.

Van der Vlerk (1948, p. 61, 62) concluded that the presence of *Biplanispira* and *Spiroclypeus* indicates a

388273—57——26

Tertiary *b* (upper Eocene) age. M. G. Rutten (*in* Bemmelen, 1949, p. 87) concluded that in most areas in the East Indies it was not possible to separate the Eocene into Tertiary *a* and *b*. However, Mohler (*in* Bemmelen, 1949, p. 86) postulated that this division could be made in southeast Borneo on the presence of *Biplanispira mirabilis* (Umbgrove) and a saddle-shaped *Discocyclina* which was named *D. omphala "selliformis."* This variety is here referred to typical *D. omphala*.

As the Saipan fauna contains abundant *Biplanispira, Discocyclina omphala*, and frequent specimens of *Spiroclypeus vermicularis* Tan, it is correlated with Tertiary *b* of the East Indies.

### MIOCENE

In a preliminary report on Saipan, Cole and Bridge (1953, p. 8–11) recognized four units in the Miocene: the Densinyama beds, Laulau limestone, and Donni beds of Miocene, Tertiary *e* (Aquitanian) age and the Tagpochau limestone of probable high Tertiary *e* or possible low Tertiary *f* (Burdigalian) age. Detailed mapping by Cloud, Schmidt, and Burke (1956) indicates that only one Miocene formation, the Tagpochau limestone, can be recognized in the field. This formation is subdivided by them into 8 facies, two of which, the Donñi sandstone member and the Machegit conglomerate member, have been given geographic names.

Although material from only 16 localities was available in the preliminary study, these localities were separated into two ages, one of which was assigned definitely to Tertiary *e* on the presence of *Lepidocyclina* (*Eulepidina*) and *Spiroclypeus* and the other either to high *e* or low *f* on the presence of *Miogypsina* (*Miogypsina*) and *Miogypsinoides*.

The present study is based on samples from 426 localities from the Tagpochau limestone. From these localities 33 species of larger Foraminifera were recognized, of which 14 species appear to range throughout the formation. Six species are confined to the lower part of the formation, and 13 species occur in the upper part.

In the analysis of the abundant material in the present collection, which represents a very comprehensive sampling of the Miocene of Saipan, the twofold faunal division proposed in the preliminary report is substantiated. However, the possibility that the upper stratigraphic zone might be Tertiary *f* had to be abandoned.

The critical species for the recognition of the stratigraphically lower part of the Tagpochau limestone are *Heterostegina borneensis* Van der Vlerk, *Lepidocyclina* (*Nephrolepidina*) *brouweri* L. Rutten, and *Spiroclypeus tidoenganensis* Van der Vlerk. The upper part has the following diagnostic species: *Flosculinella globulosa* L. Rutten, *Lepidocyclina* (*Nephrolepidina*) *verbeeki* Newton and Holland, *L.* (*N.*) *verrucosa* Scheffen, *Miogypsina* (*Miogypsina*) *thecideaeformis* (L. Rutten), *Miogypsinoides dehaartii* (Van der Vlerk), and *Spiroclypeus higginsi* Cole.

Van der Vlerk (1948, p. 61) stated that *Heterostegina borneensis* in the East Indies is confined to lower Tertiary *e* and that upper Tertiary *e* has "the same assemblage without *Heterostegina borneensis* but with *Flosculinella* and *Lepidocyclina* (*Multilepidina* and *Trybliolepidina*)." M. G. Rutten (*in* Bemmelen, 1949, p. 87) accepted these ranges. Hanzawa (1940, p. 776) placed *Miogypsinoides dehaartii* in the Aquitanian, whereas Mohler (1949, p. 526) considered that this species in Borneo ranged from upper Tertiary *e* into Tertiary *f*.

On Saipan, samples from 83 localities contained *Heterostegina borneensis*, and those from 113 localities contained *Miogypsinoides dehaartii*. Before any critical check was made of the known stratigraphic position of these localities, they were separated into two faunal groups. Subsequent check against the known field relationship demonstrated that the grouping and assumed stratigraphic relationship was correct.

Localities at which neither *Heterostegina borneensis* nor *Miogypsinoides dehaartii* occurred were assigned either to lower *e* or upper *e* on the species which did occur at these localities. In this preliminary assignment of such localities, those with *Lepidocyclina* (*Nephrolepidina*) *brouweri* and *Spiroclypeus tidoenganensis* were placed in lower *e*. This association proved to be correct when it was checked against the known stratigraphic position of the localities. A small number of localities which did not have any of these species were assigned to lower *e* on their general appearance. This group includes the only localities about whose correlation there was question when the paleontologic determinations were checked against the field relationships. The localities assigned to upper *e* were handled in a similar manner. Again, the difference between the paleontologic determination and the known stratigraphic relationships occurred only with those localities at which the critical species did not occur. The range charts (tables 2, 3) of the Miocene species have been prepared to show the various grouping of the diagnostic species which were used. Lower *e* (table 2) is divided first into localities at which *Heterostegina borneensis* was present, then those at which *Spiroclypeus tidoenganensis* was recognized, and finally those which were without either of these species. The localities assigned to upper *e* (table 3), which have *Miogypsinoides dehaartii*, are listed first, followed by those which have *Miogypsina* (*Miogypsina*) *thecideaeformis* and then by those without these species.

For a time it seemed that localities at which *Miogypsinoides bantamensis* occurred could be grouped together and placed either in lower *e* or upper *e*. Detailed study, however, proved that this species is associated with the critical species both of lower *e* and upper *e*. On the distribution chart of lower Tertiary *e* species, it was not practical to group together the localities at which *M. bantamensis* is found, because it occurred with *Heterostegina borneensis* and *Spiroclypeus tidoenganensis* as well as at localities where these species were not found. However, on the chart (table 3) of upper *e* associations, the localities at which *M. bantamensis* occurred are grouped together.

The only species which did not fit the known range of the species in the East Indies was *Cycloclypeus* (*Katacycloclypeus*) *transiens* Tan, which was found at two localities (B701, B704) in association with typical upper Tertiary *e* species. In the East Indies this subgenus has not been found in Tertiary *e* and is supposed to be restriced to Tertiary *f*.

Mohler (1949, p. 526) recently has suggested that upper Tertiary *e* should be removed from the Aquitanian and placed with Tertiary $f_1$, in the Burdigalian, largely on the discovery of *Flosculinella* in beds of Tertiary *e* age on Borneo.

Glaessner (1953, p. 654) disagreed with this separation of Tertiary *e* and wrote concerning the presence of *Flosculinella* in beds of upper Tertiary *e* age, "Its discovery in earlier beds containing the *Eulepidina-Spiroclypeus* fauna means only that *Flosculinella* existed elsewhere somewhat earlier than previously known, but not that the Burdigalian must now be extended downward." The same reasoning applies to the discovery of infrequent specimens of *Katacycloclypeus* on Saipan.

Inasmuch as lower Tertiary *e* and upper Tertiary *e* on Saipan contain *Eulepidina* and *Spiroclypeus*, it would appear that only one stage is represented. The infrequent occurrence of *Flosculinella* and *Katacycloclypeus* is not as important as the occurrence of *Eulepidina* and *Spiroclypeus* whose ranges are considered more reliably established on abundant and widely distributed material.

Glaessner (1953, p. 656) rejected the letter classification because it has "become defective and no improvement can be expected in the near future. . . ." He considered (p. 655) that there is "no evidence at present to show which part of the e-Stage is Chattian and which is Aquitanian. . . ."

Although it appears that the Aquitanian as a definite world stage cannot be recognized yet in the East Indies, the letter classification still serves a useful purpose. It has been possible in terms of this classification to correlate the faunas of Saipan with those of the East Indies. However, it is preferable to refer to the subdivisions of *e* in the general terms lower *e* and upper *e* rather than use the numerical subscripts which were proposed originally.

The question of whether this Tertiary *e* fauna on Saipan is Oligocene or Miocene cannot be decided with evidence available. However, because of its general unity it seems preferable to consider it either all Oligocene or all Miocene. For the present, Tertiary *e* on Saipan is considered to be lower Miocene.

The possibility was entertained that the various faunal associations at the localities within the Miocene could be explained by facies. The following table was prepared showing the number of localities at which the different specific associations were found are shown with the facies recognized in the field.

*Number of localities in each lower Miocene paleontologic association and facies*

| Facies or member of Tagpochau limestone | Lower Tertiary *e* | | | | | | | | | | Upper Tertiary *e* | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Heterostegina borneensis* from localities— | | | *Spiroclypeus tidoenganensis* from localities— | | | Others from localities— | | | Totals | *Miogypsinoides dehaartii* from localities— | | | *Miogypsina thecideaeformis* from localities— | | | *Miogypsinoides bantamensis* from localities— | | | Others from localities— | | | Totals |
| | B | C | S | B | C | S | B | C | S | | B | C | S | B | C | S | B | C | S | B | C | S | |
| Inequigranular | 38 | 6 | 27 | 30 | 5 | 14 | 16 | 3 | 3 | 142 | 74 | 16 | 7 | 32 | 2 | 4 | 24 | 5 | | 41 | 2 | 1 | 208 |
| Equigranular | | | | 2 | | | | | | 2 | | | | 7 | | | 1 | | | 3 | | | 11 |
| Rubbly | | 1 | | 6 | | | | | | 7 | | 3 | | 4 | | | | | | 1 | | | 8 |
| Marly | | | 4 | | 1 | | 1 | 1 | 1 | 8 | | 1 | 1 | 1 | 3 | | | | | | 2 | | 8 |
| Tuffaceous | | 1 | 1 | | | | | 1 | | 3 | 2 | 2 | | 1 | 1 | 1 | 1 | | | | | | 8 |
| Transitional | | 1 | 4 | | | | | | 1 | 6 | | | 1 | | 1 | | | | | | | | 2 |
| Machegit conglomerate | | | | | | | | | | | | | | | | | | | | | | | |
| Donni sandstone | | | | | | 1 | | | | 1 | 1 | | | | | | | | 1 | | | | 2 |
| Undifferentiated | | | | | 1 | | | | | 1 | | 5 | | | 3 | | | | | | 1 | | 9 |
| Totals | | 83 | | | 60 | | | 27 | | 170 | | 113 | | | 60 | | | 32 | | | 51 | | 256 |

TABLE 4.—*Distribution of Pleistocene species of larger Foraminifera on Saipan*

[See pl. 4 for localities]

B localities

| Species | 28, Qmm | 38, Qta | 64, Qmm | 179, Qmm | 181, Qmm | 188, Qmm | 192, Qmm | 193, Qmm | 215, Qmm | 226, Qmm | 227, Qmm | 229, Qmm | 230, Qmm [1] | 231, Qmm | 232, Qmm | 233, Qmm | 234, Qmm | 235, Qmm | 282, Qmm | 286, Qmm | 287, Qmm | 293, Qmm | 294, Qmm | 299, Qmm | 300, Qta | 317, Qmm | 318, Qmm | 321, Qmm | 324, Qmm | 328, Qmm | 331, Qmm | 334, Qta | 338, Qmr | 340, Qmm | 406, Qta |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Amphistegina madagascariensis* D'Orbigny | X | X | | X | X | X | | X | | X | X | | X | | | | | | | | | X | X | | X | | | | | X | X | | X | X | X |
| *Baculogypsina sphaerulata* (Parker and Jones) | X | X | X | | | X | X | | | X | X | X | X | X | X | X | X | X | X | X | X | | | | X | X | X | X | X | X | | | | X | X |
| *Calcarina spengleri* (Gmelin) | X | X | | | | | X | | | | | | | X | X | | X | X | | X | X | | | X | X | X | X | X | | X | | X | | | X |
| *Cycloclypeus (Cycloclypeus) carpenteri* Brady | | | | X | | | | | | | | | | | | | | | | | | X | X | | | | | | | | X | | | | |
| *Heterostegina suborbicularis* D'Orbigny | | | | | | X | | X | | | | | | | | | | X | | | | | | | | | | | | | | | X | | |
| *Marginopora vertebralis* Quay and Gaimard | | | | | | | | | X | | X | | | | X | | | | | | | | X | X | X | | | X | | | X | | | | |
| *Operculinoides venosus* (Fichtel and Moll) | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

C localities

| Species | 49, Qmh | 50, Qta | 52, Qmh | 54, Qmh | 59, Qmm | 61, Qmm | 65, Qmm | 66, Qrb | 67, Qmm | 68, Qmm | 75, Qmm | 77, Qmm | 78, Qmm | 80, Qmm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Amphistegina madagascariensis* D'Orbigny | X | X | X | X | | | | | X | X | | | | |
| *Baculogypsina sphaerulata* (Parker and Jones) | | | | | | | | X | | | | | | |
| *Calcarina spengleri* (Gmelin) | | | | X | | | | | | | | | | |
| *Cycloclypeus (Cycloclypeus) carpenteri* Brady | | | | | X | | | | | | | X | X | X |
| *Heterostegina suborbicularis* D'Orbigny | | X | | | | | | | | | | | | |
| *Marginopora vertebralis* Quay and Gaimard | | | | X | | X | X | | | | X | | | X |
| *Operculinoides venosus* (Fichtel and Moll) | | | X | | | | | | | | | | | |

S localities

| Species | 417, Qta | 430, Qmr | 452, Qmb | 564, Qmr | 568, Qmr | 611, Qta | 613, Qmm | 622, Qmm [1] | 630, Qmm | 670, Qmr [1] | 676, Qmr | 677, Qmr [1] | 678, Qmr [1] | 681, Qmr | 690, Qmm | 691, Qmh | 697, Qmr | 699, Qmh |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Amphistegina madagascariensis* D'Orbigny | X | X | | | X | | X | X | X | X | | | | | | X | | |
| *Baculogypsina sphaerulata* (Parker and Jones) | | | | | | | | | | | | | | | | | | |
| *Calcarina spengleri* (Gmelin) | | | | | | X | | | | | | X | | | | | | |
| *Cycloclypeus (Cycloclypeus) carpenteri* Brady | X | X | X | | X | | X | X | X | X | X | X | X | X | X | | | X |
| *Heterostegina suborbicularis* D'Orbigny | | X | | | | | | | | | | | | | | | | |
| *Marginopora vertebralis* Quay and Gaimard | | | | X | | | | | | | X | | X | | | | X | |
| *Operculinoides venosus* (Fichtel and Moll) | | | | | | | | | | | | X | | | | X | | |

[1] Locality at which reworked specimens were found (see text p. 327).

Of the 426 Miocene localities studied, 351 represent the inequigranular facies of the Tagpochau formation. As all of the paleontological associations of lower and upper Tertiary *e* are represented, there is apparently no correlation between the species of larger Foraminifera and the several limestone facies. No larger Foraminifera were found in the tuffaceous beds of the Donni member; however, at one Donni locality (B186) larger Foraminifera were obtained from limestone presumed to be in place; at the other two localities (S126 and S127) the Foraminifera were in erratic limestone blocks.

The echinoid *Sismondia* was collected at 18 localities. Eight of these localities were examined for larger Foraminifera. Seven of the localities represent lower Tertiary *e* and one (C122) upper Tertiary *e*. All of the lower Tertiary *e* localities (C109, C130, C141, S145, S536, S540 and S541) have *Spiroclypeus tidoenganensis* as the diagnostic Foraminifera. Although *Sismondia* was found most commonly with a lower Tertiary *e* foraminiferal assemblage, its occurrence at an unquestioned upper Tertiary *e* locality seriously qualifies its use as an index fossil.

The fauna of 16 Miocene localities is known from one small thin section only from each of the localities given below. As these small thin sections are not as representative as the large ones used for the localities on the distribution charts, these localities were not plotted there. They are as follows: Localities representing lower Tertiary *e* with *Heterostegina borneensis*, B47, B52, C18, C19, S12; with *Spiroclypeus tidoenganensis*, S8, S76; without either of these species, but with associated species, S11. Localities representing upper Tertiary *e* either with *Myogypsinoides dehaartii* or *Miogypsina thecideaeformis* or both, B24a, B34, B44, B46, C30, C32; without either of these species, but with associated species, B37, B40.

## PLEISTOCENE

In the younger formations the genera *Baculogypsina* and *Calcarina* occur frequently. At some stations there are abundant specimens of *Cycloclypeus* (*Cycloclypeus*) *carpenteri* Brady and occasionally specimens of *Heterostegina suborbicularis* D'Orbigny. Most of the stations have *Amphistegina madagascariensis* D'Orbigny.

All of the species recognized are still living. No larger Foraminifera were found which would be satisfactory to separate these formations. The concensus of evidence, summarized under the discussion of the Marina limestone by Cloud, Schmidt, and Burke (1956), appears to favor a Pleistocene age, and the evidence of the Foraminifera is consistent with this conclusion.

The distribution of the Pleistocene species is shown on table 4.

## REWORKED SPECIMENS

At a few localities the presence of reworked specimens from older deposits was established with certainty. This is particularly true in the case of certain Pleistocene localities. Sections of small pebbles were found in the thin sections from locality B230 in which there were abundant specimens of *Miogypsinoides bantamensis* Tan, a Miocene species, whereas in the surrounding limestone Pleistocene species occur.

At locality S622 a single specimen of *Miogypsinoides dehaartii* (Van der Vlerk) was found; at S670 four specimens of *Miogypsina* (*Miogypsina*) *thecideaeformis* (L. Rutten) and several specimens of *Austrotrillina howchini* (Schlumberger) occur; at S677 one specimen of *Lepidocyclina* (*Nephrolepidina*) *parva* Oppenoorth, another of *L.* (*N.*) *verbeeki* Newton and Holland, and several specimens of *A. howchini* were observed; and at S678 two specimens of *Miogypsina* (*Miogypsina*) *thecideaeformis* (L. Rutten) and one specimen of *A. howchini* occur. At all of these localities the abundant species in the thin sections were Pleistocene ones.

In the Miocene samples the evidence of reworking is not as good as it is for the Pleistocene. At three localities, C131, C140, and S239, rare specimens of *Spiroclypeus tidoenganensis* occur. This species is assumed to be restricted to lower Tertiary *e*. These three stations are placed in upper Tertiary *e* because of the other species found in the thin sections. As these are the only localities at which this species appears without its associated species and as the specimens are rare and somewhat abraded, it is believed that they probably represent reworked specimens.

At S667 specimens of *Fabiania saipanensis* Cole occur with specimens identified as *Eorupertia semiornata* (Howchin) and *Streblus saipanensis* Cole. As the latter species are assumed to be confined to the Miocene, the specimens of the Eocene genus *Fabiania* may be reworked. The species which are believed to be reworked are not plotted in the distribution charts, but all of the important instances of reworking are noted above.

## COMPARISON WITH IDENTIFICATIONS BY HANZAWA

A summary of the differences between my identifications and those made by Hanzawa is given. These differences are more apparent than real inasmuch as Hanzawa subdivided many of the species, whereas the writer prefers to group them.

*Species upon which there is agreement*

*Amphistegina radiata* (Fichtel and Moll)
*Austrotrillina howchini* (Schlumberger)
*Baculogypsina sphaerulata* (Parker and Jones)
*Biplanispira mirabilis* (Umbgrove)
*Borelis pygmaeus* Hanzawa
*Calcarina spengleri* (Linné)
*Fabiania saipanensis* Cole
*Flosculinella globulosa* L. Rutten
*Gypsina disca* Göes
*marianensis* Hanzawa
*Heterostegina borneensis* Van der Vlerk
*Lepidocyclina* (*Nephrolepidina*) *parva* Oppenoorth
*Marginopora vertebralis* Quoy and Gaimard
*Miogypsinoides bantamensis* Tan
*dehaartii* (Van der Vlerk)
*Operculinoides ammonoides* (Gronovius)
*Pellatispira orbitoidea* (Provale)
*Planorbulinella larvata* (Parker and Jones)
*Sorites martini* (Verbeek)
*Spiroclypeus higginsi* Cole
*tidoenganensis* Van der Vlerk
*vermicularis* Tan

*Species upon which different names are used*

| *Hanzawa's determinations* | *Names used in this report* |
|---|---|
| *Archaias angulatus* (Fichtel and Moll) | *A. vandervlerki* De Neve |
| *Biplanispira absurda* Umbgrove | *B. fulgeria* (Whipple) |
| *inflata* Hanzawa | *mirabilis* (Umbgrove) |
| *mirabilis depressa* Hanzawa | *hoffmeisteri* (Whipple) |
| *elliptica* Hanzawa | *mirabilis* (Umbgrove) |
| *Borelis parvulus* Hanzawa | *B. pygmaeus* Hanzawa (part) |
| *Carpenteria proteiformis* Goës | *Eorupertia plecte* (Chapman) |
| *Cycloclypeus guembelianus* H. B. Brady | *C. carpenteri* H. B. Brady |
| *neglectus eidae* Tan | *C. eidae* Tan |
| *Discocyclina* (*Asterocyclina*) *stellaris* (Brunner) | *Asterocyclina matanzensis* Cole |
| *Discocyclina* (*Discocyclina*) *dispansa* (Sowerby) | *Asterocyclina penuria* Cole |
| (*D.*) *indopacifica* Hanzawa | *D.* (*D.*) *omphala* (Fritsch) |
| (*D.*) cf. *D. molengraeffi* Henrici | *Asterocyclina penuria* Cole |
| *Halkyardia minima* (Liebus) | *Halkyardia bikiniensis* Cole |
| *Lepidocyclina* (*Eulepidina*) *bridgei* Cole | *L.* (*E.*) *badjirraensis* Crespin |
| (*Eulepidina*) *formosa* Schlumberger | (*E.*) *ephippioides* Jones and Chapman |
| *gibbosa* Yabe | *ephippioides* Jones and Chapman |
| *monstrosa* Yabe | *ephippioides* Jones and Chapman |
| *rotaensis* Hanzawa | *ephippioides* Jones and Chapman |
| (*Nephrolepidina*) *angulosa* Provale (part) | (*N.*) *angularis* Newton and Holland |
| *angulosa* Provale (part) | *brouweri* L. Rutten |
| *dekroesi* Van der Vlerk | *verbeeki* Newton and Holland |
| *ferreroi* Provale | *brouweri* L. Rutten |
| *flexuosa* L. Rutten | *verbeeki* Newton and Holland |
| *morgani* Lem. and R. Douvillé | *verrucosa* Scheffen |
| *nipponica* Hanzawa | *verbeeki* Newton and Holland |
| *inornata* L. Rutten | *sumatrensis* (Brady) |
| *Miogypsina* (*Mogypsina*) sp | *M. thecideaeformis* (L. Rutten) |
| *Miogypsinoides borodinensis* (Hanzawa) | *Miogypsinoides bantamensis* Tan |
| *complanatus* (Schlumberger) | *bantamensis* Tan |
| *formosensis* Yabe and Hanzawa | *dehaartii* Van der Vlerk |
| *lateralis* Hanzawa | *bantamensis* Tan |
| *mauretanicus* Bronnemann | *bantamensis* Tan |
| *saipanensis* Hanzawa | *bantamensis* Tan |
| *Nummulites striata* d'Archiac and Haime | *Camerina saipanensis* Cole |
| *Pellatispira crassicolumnata* (Umbgrove) | *P. provaleae* Yabe |
| *rutteni* Umbgrove | *orbitoidea* (Provale) |
| *Rotalia mecatepecensis* Nuttall | *Streblus saipanensis* Cole |
| *Spiroclypeus leupoldi* Van der Vlerk | *orbitoideus* H. Douvillé |
| *Sporadotrema cylindricum* Carter | *Eorupertia semiornata* (Howchin) |

*Species not found by Hanzawa*

*Asterocyclina incisuricamerata* Cole
*Camerina djokdjokarta* (Martin)
*Cycloclypeus* (*Cycloclypeus*) *indopacifica* Tan
(*Cycloclypeus*) *posteidae* Tan
(*Katacycloclypeus*) *transiens* Tan
*Dictyoconus saipanensis* Cole
*Heterostegina saipanensis* Cole
*Operculina bartschi* Cushman
*complanata* (Defrance)
*victoriensis* Chapman and Parr
*Operculinoides saipanensis* Cole
*venosus* (Fichtel and Moll)

*Species discussed by Hanzawa, but not described in this report*

*Acervulina inhaerens plana* Carter
*linearis* Hanzawa
(*Ladoronia*) *vermicularis* Hanzawa
*Alveolinella quoii* (D'Orbigny)
*Borelis vanderschmitti* (Schweighauser)?
*Borodina septentrionalis* Hanzawa
*Gypsina globulus* Reuss
*saipanensis* Hanzawa
*vesicularis* (Parker and Jones)
*Homotrema rubrum* (Lamarck)
*Kanakaia marianensis* Hanzawa
*Miniacina miniacea* (Pallas)
*Nummulites bagelensis* Verbeek
*pengaronensis* Verbeek
*Orbulina universa* D'Orbigny

Fundamentally, Hanzawa and the writer are in agreement concerning the correlation of the sediments. He recognized Tertiary *b*, *e*, and Pleistocene. However, he did not attempt a subdivision of Tertiary *e* as he considered that the fauna of Tertiary *e* was a unit. In this report Tertiary *e* is divided into two faunal zones.

## SYSTEMATIC DESCRIPTIONS

### Family VALVULINIDAE

#### Genus DICTYOCONUS Blanckenhorn, 1900

#### Dictyoconus saipanensis Cole, n. sp.

Plate 101, figure 3

The test is low conical with a flat base. The diameter at the base is 1.41 mm, and the height is 0.71 mm. The marginal chambers are large, about 200$\mu$ wide and 100$\mu$ high, with a single plate which has a thickness of about 20$\mu$ and projects about 50$\mu$ into the chamber. The outer wall of the test has a thickness of about 25$\mu$. The interior of the test is irregularly labyrinthic. The wall structure appears to be very finely arenaceous with an abundance of cement.

*Type material*.—Holotype: axial section from locality B176, USNM 624496.

*Remarks*.—This one accidental axial section at locality B176 was the best specimen found. The single projecting plate suggests that it is a very primitive type of *Dictyoconus* related to *D. cookei* (Moberg). *D. saipanensis* has fewer and much larger marginal chambers, and the interior is less complicated.

### Family MILIOLIDAE

#### Genus AUSTROTRILLINA Parr, 1942

#### Austrotrillina howchini (Schlumberger)

Plate 101, figures 4–6

1953. *Austrotrillina howchini* (Schlumberger). Cole, U. S. Geol. Survey Prof. Paper 253, p. 20, pl. 14, fig. 12.

Although Glaessner (1943, chart) gives the range of this species as *e* and $f_{1-2}$, Van der Vlerk (1948, fig. 1) believed it to be *e* and $f_1$. Miss Crespin (1948, p. 139) wrote concerning *A. howchini*, "The species has been recorded from '*e* stage' but has its greatest development in '*f* stage'. . . . Records indicate that *A. howchini* has not been found in the Indo-Pacific Region outside Australia in rocks younger than $f_2$."

The Indo-Pacific specimens have all been identified as *A. howchini*. There is some possibility that more than one species is present and that these species may have restricted ranges. However, the specimens commonly illustrated are from random thin sections of matrix material. It would be difficult to distinguish species with slight differences from this type of material.

### Family CAMERINIDAE

#### Genus CAMERINA Bruguière, 1792

#### Camerina djokdjokarta (Martin)

Plate 102, figure 21

1881. *Nummulina djokdjokartae* Martin, Geol. Reichs-Mus. Leiden Samml., ser. 1, v. 1, p. 109, 110, pl. 5, figs. 8–11.
1934. *Camerina djokdjokartae* (Martin). Caudri, Tertiary Deposits of Soemba, Amsterdam, p. 67–72, text fig. 19 [references].

This species is known in the present collection from a single transverse section. This section has a diameter of 4.15 mm and a thickness at the center of 2.2 mm. The surface would be ornamented by papillae with diameters of 180$\mu$ to 300$\mu$.

The embryonic chambers have a diameter of 500$\mu$ and a height of 450$\mu$.

There would be about six volutions if an oriented median section were available for study. Pillars are strongly developed and irregularly distributed. Two major pillars occur, one on either side of the embryonic apparatus.

*Remarks*.—The large size of the embryonic chambers and the form of the pillars are similar to illustrations given of this species (Verbeek and Fennema, 1896, pl. 8, fig. 119; Caudri, 1934, text fig. 19). However, without the median section, there must always be some doubt concerning the correct identification of the Saipan specimen.

**Camerina saipanensis Cole**

Plate 102, figure 20

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

This species was completely described from matrix-free specimens in the preliminary report on Saipan. One transverse section is illustrated for comparison with *C. djokdjokarta* (pl. 102, fig. 21).

**Genus OPERCULINA D'Orbigny, 1826**

**Operculina ammonoides (Gronovius)**

Plate 94, figures 12–14

1937. *Operculina ammonoides* (Gronovius) Chapman and Parr, Royal Soc. Victoria Proc., v. 50, pt. 1, n. ser., p. 290–292, pl. 17, figs. 12–16, text fig. 5 [references].

The test is thin, compressed, evolute, and the spiral suture is in a marked depression with the radial sutures raised and beaded at their proximal ends. Measurements of the four specimens which illustrate the external appearance follow:

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Height (mm) | 1. 96 | 2. 3 | 1. 7 | 1. 7 |
| Width (mm) | 1. 53 | 1. 9 | 1. 3 | 1. 27 |

The embryonic chambers are small, bilocular. The initial chamber has an internal diameter of about 30μ; the second chamber has internal diameters of about 25μ by 30μ.

A specimen with a height of 1.9 mm and a width 1.6 mm has 3½ coils with 46 chambers. There are 7 chambers in the first volution and 18 chambers in the final volution.

The chambers increase regularly in height as they are added. Chambers in the final volution near the apertural end have a height of about 500μ. The chamber walls are straight and radial for about one-third their length and then recurved.

In transverse section the thickness through the center is about 0.25 mm. At either end of the nearly straight-sided central part, there are inflated areas representing the final volution.

*Remarks.*—Through the courtesy of the late Dr. Vaughan, the writer has abundant specimens described by Yabe and Hanzawa (1925, p. 49) from Nakôshi, Haneji-mura, Okinawa-jima. Yabe and Hanzawa have given excellent illustrations of these specimens which they identified as *Operculina venosa* (Fichtel and Moll).

Later Hanzawa (1939, p. 229) reclassified these specimens, placing them in the species *O. ammonoides* (Gronovius) a revision which had been made earlier by Chapman and Parr (1938, p. 290). Hanzawa (1939, p. 225) believed that *Nautilus venosus* Fichtel and Moll, 1798, was a synonym of *Operculina ammonoides* (Gronovius), but Chapman and Parr recognized separate species.

In the collection from Saipan certain specimens are similar to the ones from the Ryukyu Islands and are identified as *O. ammonoides*. Other specimens are similar to *O. venosus*. *O. ammonoides* is always evolute to some degree and, therefore, belongs in the genus *Operculina*, whereas *O. venosus* is always involute and should be placed in the genus *Operculinoides*.

**Operculina bartschi Cushman**

Plate 94, figures 16–21

1950. *Operculina bartschi* Cushman. Cole, U. S. Geol. Survey Prof. Paper 221–B, p. 22–23, pl. 5, figs. 3–5 [references].

The test is evolute, thin, and compressed with a very slightly elevated central part which is surrounded by the thinner peripheral part. There is either a single, very slightly raised, papilla or a group of smaller papillae over the embryonic chambers. The diameter of this central ornamentation is from 200μ to 400μ. The spiral suture is depressed and more strongly so as the periphery is approached. The radial sutures are very slightly raised and normally not beaded except those of the initial coils which may have faint beading. The following are measurements of the two specimens which illustrate the external appearance:

| | 1 | 2 |
|---|---|---|
| Height mm | 3. 05 | 3. 2 |
| Width mm | 2. 8 | 2. 6 |

The embryonic chambers are bilocular. The initial chamber has an internal diameter of about 80μ; the second chamber has internal diameters of about 25μ by 75μ.

A specimen with a height of 2.4 mm and a width of 2.3 mm has 3¾ coils with 60 chambers. There are 8 chambers in the first volution and 23 chambers in the final volution.

The chamber walls normally are straight, radial, except a few have a slight recurvature at their distal ends.

The thickness at the center in transverse section is about 0.75 mm. Marked axial plugs occur on either side of the embryonic apparatus. The surface diameter of these plugs is from 400μ to 500μ. The marginal cord is well developed and prominent.

*Remarks.*—This species is normally larger than *O. ammonoides*, the ornamentation is less pronounced, and the transverse shape is different. The axial plugs are well developed and large.

**Operculina complanata (Defrance)**

Plate 94, figure 15; plate 118, figures 19, 20

1822. *Lenticulites complanata* Defrance, Dict. Sci. Nat., v. 5, p. 453.

Abundant specimens of a thin, fragile *Operculina* are found in the thin sections from a few localities.

As these specimens are present as transverse sections only, it was impossible to study all the features necessary for exact identification. As the transverse sections are similar to those of this species from localities elsewhere, they are assigned to this species.

**Operculina victoriensis Chapman and Parr**

Plate 94, figures 1–3

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

Measurements of median and transverse sections from locality C145 follow.

| | Specimen, from loc. C145, shown on pl. 94— | | |
|---|---|---|---|
| | Fig. 2 | Fig. 3 | Fig. 1 |
| Height mm | 1.5 | 1.95 | 2.05 |
| Width mm | 1.23 | | |
| Thickness mm | | | 0.40 |
| Embryonic chambers: | | | |
| Diameter of initial chamber μ | 60 x 70 | 50 x 40 | |
| Diameter of second chamber μ | 50 x 80 | 40 x 70 | |
| Number of coils | 2½ | 3½ | |
| Chambers in first volution | 7 | 7 | |
| Chambers in final volution | 15 | 19 | |
| Total number of chambers | 31 | 47 | |

**Genus OPERCULINOIDES Hanzawa, 1935**

**Operculinoides saipanensis Cole, n. sp.**

Plate 102, figures 15, 16

Very infrequent specimens of this species are found in the Eocene thin sections. The best median and transverse sections are described.

Test is small, compressed, and slightly umbonate with a fairly broad rim.

The median section which is incomplete has a height of 1.64 mm and a width of 1.25 mm. The initial chamber with an internal diameter of 30μ is small. The second chamber has internal diameters of 30μ by 50μ. The distance across both chambers is 65μ. There are 3½ coils with 7 chambers in the first volution, 23 in the last, and 56 in all.

An incomplete transverse section has a height of 1.92 mm and a thickness of 0.54 mm. One axial plug shows and has a surface diameter of 120μ.

*Type material.*—Holotype: median section from locality S271, USNM 624521; paratype: transverse section from locality S79*b*, USNM 624522.

*Remarks.*—The specimens which most nearly resemble this new species are described by Provale (1908, p. 71) from Borneo under the name *Operculina pyramidum* Ehrenberg. As she figures only a median section, it is impossible to decide whether this specimen belongs to *Operculina* or *Operculinoides*. The Borneo specimen is slightly larger, has fewer chambers in the final volution, and the chamber walls are straighter.

**Operculinoides venosus (Fichtel and Moll)**

Plate 94, figures 4–11

1937. *Operculinella venosa* (Fichtel and Moll.) Chapman and Parr, Royal Soc. Victoria Proc., v. 50 pt. 1, new ser., p. 293, pl. 17, figs. 21, 22, text fig. 7 [references].

1950. *Operculina ammonoides* Cole [not Gronovius], U. S. Geol. Survey Prof. Paper 221–B, p. 22, pl. 5, figs. 6, 7.

The test is small and completely involute with a diameter of 1.3 to 1.9 mm and a thickness of about 0.9 mm.

There are about 3⅛ coils with 20 chambers in the final volution. The first volution has about 7 chambers, and the total number of chambers in all the volutions is about 40.

The chamber walls are nearly straight except at their distal ends where they recurve slightly.

*Remarks.*—Hanzawa (1939, p. 226) combined *O. venosa* and *O. ammonoides*, but study of the Saipan and other specimens demonstrates that not only are there two species, but they belong to different genera. *O. ammonoides* is evolute and belongs to the genus *Operculina* (Cole, 1953, p. 28), whereas the involute *O. venosus* should be assigned to the genus *Operculinoides*.

**Genus HETEROSTEGINA D'Orbigny, 1826**

**Heterostegina borneensis Van der Vlerk**

Plate 95, figures 16–20

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

Several additional illustrations are given to supplement those previously published.

**Heterostegina saipanensis Cole**

Plate 102, figures 17–19

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

This species was described from two median sections. Three additional matrix-free specimens were found in the present collection, of which two were made into median sections and one into a transverse section. Measurements are given of the best median section and the transverse section in the following table.

| | Specimen, from loc. S259, shown on pl. 102— | |
|---|---|---|
| | Fig. 18 | Fig. 19 |
| Height mm | 3.0 | 2.9 |
| Width mm | 2.75 | |
| Thickness mm | | 1.08 |
| Diameter of umbo mm | | 1.9 |
| Width of flange mm | | 1.0 |
| Thickness of flange mm | | 0.17 |
| Embryonic chambers: | | |
| Diameters of initial chamber μ | 80 x 85 | |
| Diameters of second chamber μ | 40 x 140 | |
| Distance across both chambers μ | 150 | |
| Number of operculine chambers | 4 | |
| Number of coils | 2½ | |
| Surface diameter of axial plug μ | | 500 |

### Genus SPIROCLYPEUS H. Douvillé, 1905

#### Spiroclypeus higginsi Cole

Plate 95, figures 1–5; plate 109, figure 16

1939. *Spiroclypeus higginsi* Cole, Jour. Paleontology, v. 13, p. 185, 186, pl. 23, figs. 10–15; pl. 24, fig. 13.
1953. *Spiroclypeus higginsi* Cole, U. S. Geol. Survey Prof. Paper 253, p. 24–25, pl. 4, figs. 1–3, 13, 14, 19; pl. 5, figs 10–12; pl. 8, figs. 16, 17.

Typical specimens (pl. 95, figs. 3, 5) have lateral chambers with slitlike openings between thick roofs and floors. Other specimens (pl. 95, figs. 1, 2) have lateral chambers with open cavities between thin roofs and floors. These specimens superficially resemble *S. leupoldi* Van der Vlerk.

The typical specimens are the kind most frequently found in the samples from Saipan. The other type occurs in only a few samples, and in these they are always in association with the typical form with which there is complete intergradation.

Only one microspheric specimen (pl. 109, fig. 16) was found.

*Remarks.*—Cole (1939, p. 186) stated in the original description of *S. higginsi* that it resembled *S. leupoldi* in size and shape but it differed in possessing thick roofs and floors of the lateral chambers and pillars. These may not be valid criteria for the separation of these species. Therefore, eventually it may be proved that *S. higginsi* is a synonym of *S. leupoldi*.

#### Spiroclypeus orbitoideus H. Douvillé

Plate 95, figures 6–12

1905. *Spiroclypeus orbitoideus* H. Douvillé, Soc. géol. France Bull., sér. 4, v. 5, p. 460–462, pl. 14, figs. 1–6.
1953. *Spiroclypeus orbitoideus* H. Douvillé. Cole, U. S. Geol. Survey Prof. Paper 253, p. 26, pl. 4, figs. 4, 5 [references].

Measurements of transverse sections from four localities follow.

*Remarks.*—This species is characterized in transverse section by having long open rectangular lateral chambers with thin floors and roofs which are arranged in regular tiers. It is always associated on Saipan with *S. tidoenganensis* Van der Vlerk. Although it is not as abundant as that species, it occurs commonly at certain localities.

*Measurements of transverse sections of* Spiroclypeus orbitoideus

| | Specimen from locality— | | | | | |
|---|---|---|---|---|---|---|
| | B429, shown on— | B392, shown on— | | B354, shown on— | B355, shown on— | |
| | Pl. 95, fig. 10 | Pl. 95, fig. 7 | Pl. 95, fig. 6 | Pl. 95, fig. 8 | Pl. 95, fig. 11 | Pl. 95, fig. 12 |
| Diameter mm | 4.8 | 3.5+ | 2.2+ | 5.8+ | 4.6+ | 8.3 |
| Thickness mm | 1.81 | 1.78 | 1.5 | 1.65 | 1.66 | 2.3 |
| Diameter of umbo mm | 2.3 | 2.3 | 2.0 | 2.6 | 2.8 | 2.7 |
| Width of flange mm | 1.3 | ------ | ------ | 2.0 | 1.0+ | 4.2 |
| Thickness of flange mm | 0.13 | ------ | ------ | 0.12 | 0.14 | 0.27 |
| Embryonic chambers: | | | | | | |
| Length μ | 380 | 420 | 290 | 390 | 320 | 500 |
| Height μ | 190 | 240 | 240 | 410 | 320 | 340 |
| Median layer: | | | | | | |
| Height at center μ | 130 | 140 | 190 | 110 | 100 | 150 |
| Height at periphery μ | 130 | ------ | ------ | 110 | 140 | 210 |
| Lateral chambers: | | | | | | |
| Number | 13 | 14 | 12 | 11 | 12 | 10 |
| Length μ | 140–440 | 100–200 | 180–240 | 170–350 | 200–240 | 140–400 |
| Height μ | 40 | 20–30 | 15 | 20–30 | 40 | 40–60 |
| Thickness of floors and roofs μ | 10 | 20 | 20 | 10 | 20–40 | 20–50 |

#### Spiroclypeus tidoenganensis Van der Vlerk

Plate 95, figures 13–15

1925. *Spiroclypeus tidoenganensis* Van der Vlerk, Nederlandsche Akad. Wetensch. Meded., no. 3, p. 16, pl. 1, fig. 12; pl. 5, figs. 42, 47.
1953. *Spiroclypeus tidoenganensis* Cole, U. S. Geol. Survey Prof. Paper 253, p. 25–26, pl. 3, figs. 1–12; pl. 4, figs. 6–12; pl. 7, figs. 7–11 [references].

This species, of which a complete description and numerous illustrations were given in the preliminary report on Saipan, is abundant at many of the localities. Its comparatively large size, slitlike lateral chambers between thick roofs and floors, and the heavy pillars of the transverse section made it easy to recognize.

*Remarks.*—Certain large thin specimens with a small umbo, from station B435, are assigned to this species because of the shape of the lateral chambers and the presence of pillars. These specimens somewhat resemble the illustration of *S. tidoenganensis* given by Tan (1937b, pl. 4, fig. 5) although his specimen was much smaller. A description of these specimens is given:

The test is large with a diameter from 9.0 to 10.0 mm. The umbo is small with diameter from 1.0 to 1.7 mm, and a thickness of 1.0 to 1.7 mm, and is surrounded by a wide, fragile rim with a thickness near the umbo of about 0.4 mm and a thickness at the periphery of 0.15 mm.

The embryonic chambers are large with a diameter of 460$\mu$ to 480$\mu$ and a height of 210$\mu$ to 300$\mu$.

The lateral chambers are arranged in moderately regular tiers with some overlapping with 4 to 6 chambers in each tier on either side of the embryonic chambers. They are long and low with a length of 150$\mu$ to 270$\mu$, a height of 20$\mu$ to 30$\mu$, and floors and roofs 20$\mu$ to 40$\mu$ thick. Small but distinct pillars with surface diameters of 150$\mu$ to 180$\mu$ are distributed irregularly throughout the umbo.

**Spiroclypeus vermicularis Tan**

Plate 102, figures 12–14

1937. *Spiroclypeus vermicularis* Tan, De Ingenieur in Nederlandsch—Indië—IV Mijnbouw en Geologie, Jaarg. 4, no. 10, p. 187–190, pl. 1, figs. 7, 8; pl. 2, figs. 6–10; pl. 3, figs. 13–23; pl. 4, figs. 11–18.
1953. *Spiroclypeus* sp. Cole, U. S. Geol. Survey Prof. Paper 253, p. 18, pl. 14, fig. 7.

Matrix-free specimens of this species were not available. Several transverse sections of specimens from the limestone thin sections are illustrated. These sections show all the features which characterize this species in transverse section.

The floors and roofs of the lateral chambers are thick. The chamber openings are slitlike and irregular in development. Strong pillars are present and irregularly scattered throughout the inflated part of the test.

The median section is similar to that of *Heterostegina*. In the material available it was impossible to distinguish median sections of this species from those of *Heterostegina saipanensis*, therefore this type of section is not illustrated.

*Distribution elsewhere.*—Koetai, East Borneo.

**Genus PALLATISPIRA Boussac, 1906**

**Pellatispira orbitoidea (Provale)**

Plate 96, figures 3–5, 7–9; plate 97, figures 1–12; plate 99, figures 7–11

1908. *Assilina madaraszi orbitoidea* Provale, Riv. italiana paleont., v. 14, p. 71, pl. 5, fig. 5.
1928. *Pellatispira orbitoidea* (Provale). Umbgrove, Nederlandsche Akad. Wetensch. Meded., no. 10, p. 18, 19, figs. 2, 3, 5, 7, 9, 11–26, 34–41.
1928. *Pellatispira rutteni* Umbgrove, idem, p. 20, 21, figs. 57–61.
1928. *Pellatispira inflata* Umbgrove, idem, p. 21, figs. 42–56.
1953. *Pellatispira rutteni* Umbgrove. Cole, U. S. Geol. Survey Prof. Paper 253, p. 22, pl. 6, figs. 1–8.

Examination of several hundred specimens in the present collection proves that the external shape of the test and the size of the individuals is extremely variable. In the preliminary inspection several species were recognized, but detailed study of thin sections demonstrates that the internal structure in all of these specimens is the same.

The name *P. orbitoidea* has been given to compressed lenticular individuals. More inflated individuals have been called *P. inflata*, and larger individuals with an umbonate central area which is surrounded by a rim have been termed *P. rutteni*. All of these form an integrated series and are grouped together.

*Distribution elsewhere.*—Borneo and Eua, Tonga.

**Pellatispira provaleae Yabe**

Plate 96, figures 1, 2, 6; plate 98, figures 1–12

1908. *Assilina madaraszi* Provale, Riv. italiana paleont., v. 14, p. 66–70, pl. 4, figs. 21–24; pl. 5, figs. 1–4. [*Not Nummulites madaraszi* von Hankten, 1875.]
1928. *Pellatispira madaraszi provalei* Yabe. Umbgrove, Nederlandsche Akad. Wetetnsch. Meded., no. 10, p. 17, 18, figs. 27–33 [synonymy].
1941. *Pellatispira madaraszi provalei* Yabe. Heinrici, Palaeontographica, supp.; v. 4, p. 33, 34, pl. 2, figs. 10, 11.
1941. *Pellatispira crassicolumnata* Umbgrove. Heinrici, idem, p. 35, pl. 2, fig. 8.
1953. *Pellatispira crassicolumnata* Umbgrove. Cole, U. S. Geol. Survey Prof. Paper 253, p. 21–22, pl. 15, figs. 3–7.

The only observable distinction between *P. provaleae* and *P. crassicolumnata* is the development in the latter species of a thin fibrous keel beyond the main part of the test. This fragile structure is easily broken and, therefore, is not present in most matrix-free specimens or specimens that were slightly abraided before fossilization.

*P. provaleae* differs from *P. orbitoidea* in possessing pillars of two different sizes, the larger of which project irregularly above the surface of the test.

*Distribution elsewhere.*—Bonin Islands; Ryukyu Islands; Japan; Borneo; Timor.

**Genus BIPLANISPIRA UMBGROVE, 1937**

**Biplanispira fulgeria (Whipple)**

Plate 98, figures 13–18

1932. *Pellatispira fulgeria* Whipple, Bernice P. Bishop Mus. Bull. 96, p. 82, pl. 20, figs. 2, 3, 5, 6, 7.
1938. *Biplanispira absurda* Umbgrove, Leidsche geol. Meded., v. 10, p. 82–89, text figs. 1–17.

Comparison of Umbgrove's illustrations of *B. absurda* with those given by Whipple of *P. fulgeria* indicate that only one species is represented. The specimens in this collection are similar in all respects to those previously illustrated.

*Distribution elsewhere.*—Borneo and Eua, Tonga.

*Remarks.*—The degree of development of the marginal cord in this species is extremely variable. The other features are constant.

**Biplanispira hoffmeisteri (Whipple)**

Plate 100, figures 4–11

1932. *Pellatispira hoffmeisteri* Whipple, Bernice P. Bishop Mus. Bull. 96, p. 82, pl. 20, fig. 4; pl. 21, figs. 4, 5.
1956. *Biplanispira mirabilis* (Umbgrove) var. *depressa* Hanzawa, Geol. Soc. America Mem. 66 (in press).

The transverse sections show a single layer of equatorial chambers except near the periphery where subdivision into chamberlets occurs. Median sections have a bilocular embryonic apparatus. In one section the initial chamber has internal diameters of 240$\mu$ by 260$\mu$, and the second chamber has internal diameters of 190$\mu$ by 260$\mu$. The distance across both chambers is 440$\mu$. There are about 2½ coils of *Pellatispira*-like chambers after which the equatorial chambers are subdivided into chamberlets. The following table gives the measurements of four transverse sections.

| | Specimens from locality— | | | |
|---|---|---|---|---|
| | S100, shown on— | S259, shown on— | S134, shown on— | |
| | Pl. 100, fig. 8 | Pl. 100, fig. 9 | Pl. 100, fig. 10 | Pl. 100, fig. 11 |
| Height mm | 7.8 | 4.7 | 8.55 | 8.6 |
| Thickness mm | 1.4 | 1.0 | 1.07 | 1.4 |
| Embryonic chambers: | | | | |
| Length $\mu$ | 490 | 300 | 480 | 420 |
| Height $\mu$ | 490 | 220 | 300 | 290 |
| Surface diameter of pillars $\mu$ | 160–200 | 150–200 | 120–180 | 150–250 |
| Diameter of vertical canals $\mu$ | 5–30 | 5–20 | 10–20 | 5–30 |

*Distribution elsewhere.*—Eua, Tonga.

*Remarks.*—At the time this specific name was given, the genus *Biplanispira* was not recognized. Through the courtesy of Dr. Evitt, of the University of Rochester, the writer was able to examine the types of *P. hoffmeisteri*. There is no question that this species is *Biplanispira*, not *Pellatispira*.

*B. hoffmeisteri* is not only much larger and more compressed than *B. mirabilis* but also has more *Pellatispira*-like chambers surrounding the embryonic apparatus.

Hanzawa gives a varietal name, *B. mirabilis depressa*, to specimens which resemble *B. hoffmeisteri*. He apparently overlooked Whipple's species. Although *B. hoffmeisteri* has many of the features of *B. mirabilis*, there are sufficient differences to retain the specific name *B. hoffmeisteri*.

**Biplanispira mirabilis (Umbgrove)**

Plate 99, figures 1–6; plate 100, figures 1–3

1953. *Biplanispira mirabilis* (Umbgrove). Cole, U. S. Geol. Survey Prof. Paper 253, p. 22–23, pl. 6, figs. 9–19 [synonymy].
1956. *Biplanispira mirabilis* (Umbgrove) var. *elliptica* Hanzawa, Geol. Soc. America Mem. 66 (in press).
1955. *Biplanispira inflata* Hanzawa, idem.

The illustrations of the type (Umbgrove, 1936, figs. 1–11) are drawings, but two distinct transverse sections are shown, compressed lenticular and umbonate with a pronounced rim. These two forms of test are associated on Saipan. There are other specimens which have thick lenticular tests with or without a rim. As there is complete gradation, only one species is recognized.

*Distribution elsewhere.*—Borneo and New Guinea.

*Remarks.*—Specimens that would be included as Hanzawa's *B. mirabilis elliptica* are illustrated as figures 2, 3, plate 100, and one that would be included as his *B. inflata* is shown as figure 6, plate 99.

**Genus CYCLOCLYPEUS W. B. Carpenter, 1856**

**Subgenus CYCLOCLYPEUS W. B. Carpenter, 1856**

**Cycloclypeus (Cycloclypeus) carpenteri Brady**

Plate 101, figures 1, 2

1953. *Cycloclypeus (Cycloclypeus) carpenteri* Brady. Cole, U. S. Geol. Survey Prof. Paper 253, p. 26–27, pl. 14, figs. 5, 6.

This species is a common form at many of the localities of Pleistocene age. It is still living in the Indo-Pacific region.

**Cycloclypeus (Cycloclypeus) eidae Tan**

Plate 101, figure 15

1953. *Cycloclypeus (Cycloclypeus) eidae* Tan. Cole, U. S. Geol. Survey Prof. Paper 253, p. 27, pl. 5, figs. 13–19 [references].

The equatorial section illustrated has an initial chamber with internal diameters of 55$\mu$ by 60$\mu$ and a second chamber with internal measurements of 40$\mu$ by 120$\mu$. There are 19 nepionic chambers arranged in 2 volutions.

**Cycloclypeus (Cycloclypeus) indopacificus Tan**

Plate 101, figures 7, 8

1932. *Cycloclypeus indopacificus* Tan, Nederlandsche Akad. Wetensch. Meded., no. 19, p. 65–67, pl. 15, fig. 7; pl. 18, fig. 3; pl. 19, fig. 1; pl. 22, fig. 10; pl. 23, figs. 1, 2.

As the material on which this determination is based was not sufficiently abundant for a complete analysis, the assignment of these specimens to this species is tentative.

**Cycloclypeus (Cyclocylpeus) posteidae Tan**

Plate 101, figures 9–11

1932. *Cycloclypeus posteidae* Tan, Nederlandsche Akad. Wetensch. Meded., no. 19, p. 59–62, pl. 13, fig. 3; pl. 14, figs. 1–6; pl. 15, figs. 1–4; pl. 17, figs. 2, 7; pl. 22, figs. 3, 4, 8.

The test is small with a slightly raised umbo surrounded by a thinner rim. Papillae with a diameter of about 120$\mu$ are irregularly scattered over the umbo. Smaller papillae with a diameter of about 60$\mu$ are arranged in concentric circles on the rim. The diameter is from 1.8 to 2.5 mm; thickness at the center, about 0.6 mm.

The initial chamber has internal diameters of 70μ by 100μ, and the second chamber has internal measurements of 50μ by 130μ. The distance across both chambers is 130μ. The thickness of the outer wall is about 30μ.

There are about 11 nepionic chambers arranged in 1⅛ volutions.

The vertical section has laminar walls on either side of the equatorial layer.

*Remarks.*—The Saipan specimens resemble the variety which Tan named *C. posteidae dodekasepta* (compare Tan's fig. 5, pl. 14 with pl. 10, fig. 11). It is doubtful if the varieties which Tan recognized serve any useful purpose inasmuch as all larger Foraminifera show considerable variation between individuals.

### Subgenus KATACYCLOCLYPEUS Tan, 1932

#### Cycloclypeus (Katacycloclypeus) transiens Tan

Plate 101, figures 12–14

1950. *Cycloclypeus* (*Katacycloclypeus*) *transiens* Tan. Cole, U. S. Geol. Survey Prof. Paper 221–B, p. 23–24, pl. 5, figs. 9–11 [synonymy].

The test has a lenticular central area with a diameter of about 1.6 mm around which there is a depressed zone which in turn is followed by an inflated annulus. The diameter of the entire specimens is from 3.3 to 3.8 mm. The entire surface has small indistinct papillae arranged in concentric circles. The thickness at the center is about 0.75 mm, at the depressed zone about 0.25 mm, and at the inflated annulus about 0.5 mm.

In the one median section available the initial chamber has an internal diameter of 90μ, and the second chamber has internal diameters of 60μ by 160μ. The distance across both chambers is 160μ. The embryonic chambers are followed by one operculinelike chamber and 13 partial rings of heterosteginelike chambers before the annular rings of chamberlets are developed.

*Distribution elsewhere.*—Java; Lau, Fiji; Palau Islands.

### Family PENEROPLIDAE

### Genus ARCHAIAS Montfort, 1808

#### Archaias vandervlerki De Neve

Plate 103, figures 5–9

1947. *Archaias vandervlerki* De Neve, Bull. Bureau Mines and Geol. Survey in Indonesia, v. 1, no. 1, p. 14–16, text figs. 1–4.

The earliest record of *Archaias* in the Miocene of the Malay Archipelago is that of Rutten (1917, pl. 5, fig. 142) from the Miocene of Java. He compared these specimens with *A. aduncus* (Fichtel and Moll). Later, Van der Vlerk (1924, pl. 5, fig. 25) figured a specimen from the Njalindoeng beds of Java without specific designation.

De Neve described and illustrated the external appearance of specimens from East Borneo to which he gave the name *A. vandervlerki.* These specimens of *Archaias* were found with *Flosculinella globulosa* L. Rutten, *Miogypsina*, and species of *Lepidocyclina.* This association is similar to the one on Saipan in which *Archaias* occurs.

Although De Neve did not publish sections, it would appear from his description that the Saipan specimens represent the same species and, therefore, are assigned to De Neve's species.

It should be noted, however, that Drooger (1951, text fig. 1) illustrates by a drawing a transverse section of *A. angulatus* (Fichtel and Moll), from the Leeward Islands, which is similar to certain transverse sections (pl. 103, fig. 8) of *Archaias* from Saipan. It may be that all of these specimens represent only one species, the recent *A. angulatus.*

*Occurrence elsewhere.*—Java; East Borneo.

### Genus SORITES Ehrenberg, 1840

#### Sorites martini (Verbeek)

1953. *Sorites martini* (Verbeek). Cole, U. S. Geol. Survey Prof. Paper 253, p. 27, pl. 12, fig. 11; pl. 14, figs. 1, 2.

This species is known in the present collection only from random thin sections of the matrix material.

### Genus MARGINOPORA Quoy and Gaimard, in Blainville, 1830

#### Marginopora vertebralis Quoy and Gaimard

Plate 103, figures 19, 20

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

1834. *Marginopora vertebralis* Quoy and Gaimard *in* Blainville's Manuel d'Actinologie, p. 412, 413, pl. 69, figs. 6; 6a–c.

1954. *Marginopora vertebralis* Quoy and Gaimard. Cole, U. S. Geol. Survey Prof. Paper 260–O, p. 582–583, pl. 210, figs. 10–13; pl. 211, figs. 3–29.

Rare specimens of this species were found. The writer has discussed this genus and species in the report on the Bikini test holes. Similar specimens occurred abundantly in the Miocene of these holes.

*Remarks.*—In accidental sections it is very easy to confuse this species with *Sorites martini* (Verbeek), particularly when only a part of the equatorial plane is exposed.

### Family ALVEOLINELLIDAE

### Genus BORELIS Montfort, 1808

#### Borelis pygmaeus Hanzawa, 1930

Plate 102, figure 1; plate 110, figures 5–7

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

1951. *Alveolina pygmaea* (Hanzawa). Ritsema, K. Nederlandse Akad. Wetensch. Proc., ser. B, v. 54, no. 2, p. 179, figs. 2D, 3D.

1956. *Borelis parvulus* Hanzawa, Geo. Soc. America Mem. 66 (in press).

Hanzawa (1947a) has given a complete description of this species based on specimens from Saipan.

*Remarks.*—Hanzawa named certain small specimens *B. parvulus* and compared this new species with *B. melo* (Fichtel and Moll). Similar specimens in the present collection are considered to be small *B. pygmaeus.*

One specimen (pl. 102, fig. 1) which appears to be this species was found at locality S88 with an undoubted Eocene fauna. Bakx (1932, p. 254) gave the range of *B. pygmaeus* from upper Tertiary *a* through *b*, *c*, and *e*. Reichel (1937, p. 130) stated that its presence in the Eocene of the Sunda Islands needs confirmation. Caudri (1934, p. 134) stated, "This species could be identified on Soemba in Tertiary-*a* . . . and further in a number of later rocks from Tertiary-*c* age."

### Genus FLOSCULINELLA Schubert, 1910

#### Flosculinella globulosa L. Rutten

Plate 110, figures 1–4

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

1922. *Alveolinella globulosa* L. Rutten. Van der Vlerk, Geol.–mijnb. genootsch. Nederland en Kolonien, Verh., Geol. ser., v. 5, p. 395, pl. 2, figs 12, 12a.

1937. *Flosculinella globulosa* L. Rutten. Reichel, Soc. Paléont. Suisse, Mém., v. 59, p. 113.

The test is small, globular to subspherical with a diameter of about 1.1 mm.

The embryonic chambers in axial sections are bilocular, the initial chamber with internal diameters of about $100\mu$ and the second chamber with internal diameters of about $25\mu$ by $110\mu$.

There are about 3 undivided coils of chambers around the embryonic chambers beyond which occur about 6 subdivided annuli, each consisting of a row of major openings on the distal side of which are a row of minor openings. A typical annulus near the periphery of the test has a height of $210\mu$. The major openings have internal diameters of about $100\mu$ by $120\mu$, and the secondary openings have internal diameters of about $20\mu$ by $20\mu$.

*Remarks.*—The specimens in the present collection are somewhat larger than the types whose diameter was given as 0.5 to 0.9 mm. Otherwise they are similar. Mohler (1949, p. 521) has named small specimens from the Tertiary $e_5$ of Borneo *F. reicheli.* Specimens from Saipan identified by Hanzawa (1942, figs. 1–3) as *F. globulosa* are referred by Mohler to *F. reicheli.*

The Saipan specimens are larger than those named *F. reicheli* and have a greater number of coils and a larger number of primary chambers in the final volution. In all respects, however, the two species are similar. It is entirely possible that the name *F. reicheli* was applied to specimens from a population of small individuals of *F. globulosa.*

### Family CALCARINIDAE

### Genus CALCARINA D'Orbigny, 1826

#### Calcarina spengleri (Gmelin)

Plate 118, figures 1, 2

This species occurs in great abundance on the shallow-water reef flats in the present seas. The fossils are morphologically the same as the living ones, and presumably lived under similar conditions.

### Genus BACULOGYPSINA Sacco, 1893

#### Baculogypsina sphaerulata (Parker and Jones)

Plate 118, figures 3–7

1952. *Baculogypsina sphaerulata* (Parker and Jones). Hanzawa, Short papers, Inst. Geol. and Paleont., Tōhoku Imp. Univ., Sendai, Japan, no. 4, p. 1–22, 2 pls., 3 text figs. [references].

The habitat of this species is similar to that of *Calcarina spengleri,* described above, and on Saipan they are commonly associated.

### Family CYMBALOPORIDAE

### Genus HALKYARDIA Heron-Allen and Earland, 1919

#### Halkyardia bikiniensis Cole

Plate 102, figures 10, 11

1954. *Halkyardia bikiniensis* Cole, U. S. Geol. Survey Prof. Paper 260–0, p. 584–585, pl. 210, figs. 1–5.

Three axial sections, one of which exposes the embryonic chambers, were found. The best section represents a specimen with a diameter of 0.95 mm and a total height of 0.4 mm. The thickness of the test at the center is 0.31 mm, and the height of the umbilicus is 0.09 mm.

There are three zones to the test, an upper and a lower zone of coarsely tubulated shell material between which occurs a zone of chambers which start at the embryonic chambers and expand slowly as they approach the base of the test.

The upper tubulated zone has a thickness of 60μ above the embryonic chambers and thins progressively toward the base of the test. The lower tubulated zone has a thickness of 180μ below the embryonic chambers, and it thins toward the periphery of the test.

Only one of the embryonic chambers is exposed. This chamber has internal diameters of 60μ by 80μ. The wall of this embryonic chamber is about 8μ thick.

The chambers of the middle zone expand from the embryonic chambers and appear in the base of the test as a wide zone without a covering of tubulated shell material, but elsewhere they are enclosed between this material. The chambers at the base of the test have a length of about 180μ and a height of about 60μ. There are about 12 chambers on each side of the embryonic chambers.

The other sections were not centered, and therefore measurements were not made.

*Remarks.*—These specimens are very similar to those recovered from the Bikini test wells and represent the same species.

### Genus FABIANIA A. Silvestri, 1926

#### Fabiania saipanensis Cole

Plate 102, figures 7–9; plate 118, figure 8

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

The illustration of the type is a transverse section· Three additional illustrations are given: one (pl. 102, fig. 8) is similar to the type; a second (pl. 102, fig. 9) is a transverse section which shows the form of the major chambers; and the third (pl. 102, fig. 7) is a tangential section which parallels the surface of the test, so that the chamberlets into which the chambers near the surface of the test are divided are exposed.

A few specimens from locality S253 appear to have the form of *Gunteria*. A part of one of these specimens is illustrated (pl. 118, fig. 8). It may be that *Gunteria* is only compressed *Fabiania*. Unfortunately, there were not enough well-preserved specimens available to prove this relationship, but the structural details of the two genera are remarkably similar.

### Family PLANORBULINIDAE

### Genus PLANORBULINELLA Cushman, 1927

#### Planorbulinella larvata (Parker and Jones)

Plate 102, figures 2, 3

In the matrix of both the Eocene and Miocene rocks, specimens similar to those illustrated are commonly found. They may represent the Recent species to which most fossil specimens of this type have been referred, or they may be new species. From the material available, it is impossible to state.

### Genus GYPSINA Carter, 1877

#### Gypsina disca Goës

1947. *Gypsina disca* Goës. Bursch, Schweizer. Palaeont. Gesell Abh., v. 65, p. 40–42, pl. 3, figs. 2, 4, 13, 17, 22; pl. 5, figs. 6, 7; text figs: 15, 20 [references].

Infrequent specimens which are similar to descriptions and illustrations of this species occur rarely in lower and upper Tertiary *e*.

The localities for this species are S687, B145, B152, B168, B303, B432.

#### Gypsina marianensis Hanzawa

Plate 103, figures 1–4

1956. *Gypsina marianensis* Hanzawa, Geol. Soc. America Mem. 66 (in press).

As this species is described completely by Hanzawa, it is necessary only to give illustrations of the specimens in this collection. They are in every respect identical with the types.

### Family EORUPERTIIDAE, n. family name [1]

### Genus EORUPERTIA Yabe and Hanzawa, 1925

1914. *Carpenteria* L. Rutten [not Gray, 1858], Nova Guinea, Géol., v. 6, p. 47, pl. 7, figs. 6–9.

1930. *Victoriella* Chapman and Crespin, Royal Soc. Victoria Proc., v. 42, pt. 2, p. 110–112, pl. 7, figs. 1–4.

1931. *Hofkerina* Chapman and Parr, Royal Soc. Victoria Proc., v. 50, pt. 2, p. 237, 238, pl. 9, figs. 1–5.

#### Eorupertia plecte (Chapman)

Plate 102, figures 4–6

1921. *Carpenteria proteiformis* var. *plecte* Chapman, Reconn. Geol. Survey Victoria, v. 4, p. 320, pl. 51, fig. 3.

1930. *Victoriella plecte* (Chapman). Chapman and Crespin, Royal Soc. Victoria Proc., v. 42, p. 110–112, pl. 7, figs. 1–4.

A new illustration (pl. 103, fig. 10) of a topotype of *Eorupertia boninensis* Yabe and Hanzawa, made available through the courtesy of Dr. S. Hanzawa, is given to demonstrate the similarities between it and specimens from Saipan.

The Saipan specimens have slightly thicker walls, and the structure of the walls is much coarser. In these respects the Saipan specimens resemble *E. plecte*

[1] Under article 5, of the presently effective International Rules of Zoological Nomenclature, a change in family name is mandatory with this suppression of the generic name *Victoriella*. It is a recommendation of the Copenhagen Decisions on Zoological Nomenclature that this rule be reversed, but this recommendation is not a rule, and the author prefers to follow the practice called for by article 5.

(Chapman) and, therefore, are referred to that species. However, thickness and coarseness of wall structure may be the result of differences in individuals or environment rather than specific differences. At some future time it may be found that *E. boninensis* and *E. plecte* represent only one species, but this decision will depend upon study of more specimens.

*Remarks.*—According to Chapman and Crespin (1930, p. 112), *Victoriella* differs from *Eorupertia* "in having larger and fewer chambers, a much thicker shell wall and less pronounced hollow center." These differences are specific rather than generic, therefore the two genera are combined.

At the time the genus *Victoriella* was proposed, it was assumed to be restricted to the Miocene, whereas *Eorupertia* was known to occur only in the Eocene. Recently, Raggatt and Crespin (1952, p. 145, 146) have stated that *V. plecte* is restricted to the Jan Juc formation of the Janjukian stage (upper Eocene). Glaessner (1951, p. 274) placed the *V. plecte* zone in the Chattian, an opinion which is not accepted by Crespin (1952b, p. 225, 226), who maintained it is Eocene in age.

**Eorupertia semiornata (Howchin)**

Plate 103, figures 11–16

1899. *Pulvinulina semiornata* Howchin, Royal Soc. South Australia, Trans., v. 12, p. 14, pl. 1, figs. 12a–c.
1930. *Hofkerina semiornata* (Howchin). Chapman and Parr, Proc. Royal Soc. Victoria, v. 43, pt. 2, new ser., p. 237 238, pl. 9, figs. 1–5.
1953. *Victoriella plecte* Cole [not Chapman 1921], U. S. Geol. Survey Prof. Paper 253, p. 28, pl. 14, fig. 4.

The original illustrations of this species are drawings which show only the external appearance. Chapman and Parr presented photomicrographs of the external appearance and one thin section. This illustration (Chapman and Parr, 1931, pl. 9, fig. 5) should be compared with plate 103, figure 12.

*Remarks.*—Chapman and Parr stated, "*Hofkerina* differs from *Victoriella* in the rotaline form of the test and the cribrate apertures." Chapman and Crespin (1930, p. 111) in the description of *Victoriella* wrote, "It is distinguished by the great development of the earlier series of chambers, plaited together and forming almost a rotaline coil. . . ." Finally, Yabe and Hanzawa (1922, p. 72) stated in their description of *Eorupertia* that "the chambers are arranged spirally in some two convolutions. . . ." From these statements it would appear that the initial development at least is the same in *Hofkerina, Victoriella,* and *Eorupertia.*

Although there is supposed to be apertural differences in the three genera, the general plan of the test and the structure of the walls is so similar that it is doubtful if they can be separated.

*E. semiornata* has thicker walls with a coarser structure than does *E. plecte.* The initial chambers of *E. semiornata* are larger, and the final chambers are smaller and more numerous.

Specimens from New Guinea described by L. Rutten (1914. p. 47) as *Carpenteria conoidea* probably are *E. semiornata,* but the illustrations are too poor for exact comparison. Hanzawa (1930, p. 94) has presented excellent illustrations of *E. semiornata* from the Miocene of Pabeasan, Java, under the name *Sporadotrema cylindricum* Carter.

**Family ROTALIIDAE**

**Genus STREBLUS Fischer, 1817**

**Streblus saipanensis Cole**

Plate 103, figures 17, 18

1953. *Streblus saipanensis* Cole, U. S. Geol. Survey Prof. Paper 253, p. 27–28, pl. 5, figs. 8, 9.

The internal features of this species were illustrated in the preliminary report on Saipan by a median section. Another median and transverse section are illustrated.

*Remarks.*—The specimens illustrated by Cole (1939, pl. 24, figs. 10–12) and Hanzawa (1931, pl. 26, figs. 6–8) as *Rotalia schroeteriana* Parker and Jones are not that species. Although there is a superficial resemblance to *S. saipanensis,* the specimens from Guam are larger, much coarser, and more strongly papillate.

**Family MIOGYPSINIDAE**

**Genus MIOGYPSINOIDES Yabe and Hanzawa, 1928**

**Miogypsinoides bantamensis Tan**

Plate 110, figures 8–18; plate 111, figures 1–4

1936. *Miogypsinoides complanata* forma *bantamensis* Tan, De Ingenieur in Nederlandsch-Indië—IV Mijnbouw en Geologie, de Jaarg. 3, no. 3, p. 48–50, pl. 1, fig. 13.
1940. *Miogypsinoides bantamensis* Tan. Hanzawa, Jubilee Pub. in Commemoration of Prof. H. Yabe's 60th Birthday, p. 782–783, pl. 39, figs. 15–19; pl. 41, figs. 24–26.
1940. *Miogypsinoides lateralis* Hanzawa, idem, p. 783, pl. 39, figs. 10–14.

These small *Miogypsinoides* were observed only in thin section. Well-oriented equatorial sections were scarce, but a sufficient number were found to give the statistics of this species. The following table presents measurements of 5 equatorial sections.

*Measurements of equatorial sections of* Miogypsinoides bantamensis *Tan*

| | Specimens from locality— | | | | |
|---|---|---|---|---|---|
| | B391, shown on— | | | | B316, shown on— |
| | Pl. 110, fig. 12 | Pl. 111, fig. 2 | Pl. 111, fig. 3 | Pl. 110, fig. 15 | Pl. 110, fig. 13 |
| Length, mm | 1.26 | 1.5 | 1.56 | 1.9 | 1.55 |
| Width, mm | 0.86 | 1.68 | 1.62 | 1.95 | 1.5 |
| Embryonic chambers: | | | | | |
| Diameters of initial chamber, μ | 120 x 110 | 90 x 90 | 80 x 80 | 140 x 130 | 120 x 100 |
| Diameters of second chamber, μ | 105 x 80 | 90 x 60 | 95 x 60 | 150 x 110 | 100 x 60 |
| Distance across both chambers, μ | 195 | 160 | 150 | 250 | 190 |
| Periembryonic chambers: | | | | | |
| Number of whorls | 1⅛ | 1¼ | 1¼ | 1 | 1⅛ |
| Number of chambers | 13 | 13 | 14 | 11 | 12 |
| Number of chambers in first volution | 10 | 10 | 10 | 11 | 10 |
| Equatorial chambers: | | | | | |
| Radial diameter, μ | 110 | 130 | 110 | 100 | 130 |
| Tangential diameter, μ | 130 | 140 | 140 | 110 | 120 |

Well-oriented vertical sections which cut the embryonic chambers were extremely rare; therefore, measurement of only two of these are given in the following table.

*Measurements of vertical sections of* Miogypsinoides bantamensis *Tan*

| | Specimens from locality— | |
|---|---|---|
| | B316, shown on pl. 110, fig. 8 | B395 |
| Length, mm | 1.75 | 2.15 |
| Thickness, mm | 0.75 | 0.72 |
| Embryonic chambers: | | |
| Length, μ | 230 | 160 |
| Height, μ | 150 | 130 |
| Thickness of outer wall, μ | 30 | 10 |
| Equatorial layer: | | |
| Height near embryonic chambers, μ | 150 | 130 |
| Height at periphery, μ | 150 | 130 |
| Surface diameter of pillars, μ | 100–200 | 80–150 |

The walls over the equatorial layer are composed of pillarlike structures between which are small vertical pores that extend from the equatorial layer to the surface of the test.

*Remarks.*—Hanzawa (1940, p. 773) considered that the position of the periembryonic chambers in the coils of these chambers, with respect to the apical part of the test, is a constant character in the miogypsinoids. It is in this character that he distinguished *M. lateralis* from *M. bantamensis* Tan. He states, "In its external form and transverse section alone, the present form is almost indistinguishable from *Miogypsinoides bantamensis* Tan Sin Hok . . . . But, the former is easily distinguishable from the latter by the characteristics of its juvenarium."

Although the number of coils and the number of periembryonic chambers are significant in specific identification, it does not appear that the position of the periembryonic chambers, with regard to the apical part of the test, has any special significance. Therefore, *M. lateralis* Hanzawa is combined with *M. bantamensis* Tan.

The illustration of the type of *M. bantamensis* is an equatorial section. No illustration of the vertical section is given. The equatorial sections of specimens from Saipan are identical with the type, and the vertical sections of these specimens are very similar to those identified as *M. bantamensis* by Hanzawa in the North Borodino Island test hole.

**Miogypsinoides dehaartii (Van der Vlerk)**

Plate 111, figures 5–16

1924. *Miogypsina dehaartii* Van der Vlerk, Eclogae geol. Helvetiae, v. 18, no. 3, p. 429–432, text figs. 1–3.
1927. *Miogypsina abunensis* Tobler, idem, v. 20, no. 2, p. 323–330, text figs. 3, 5.
1928. *Miogypsina (Miogypsinoides) dehaartii* Van der Vlerk var. *formosensis* Yabe and Hanzawa, Imp. Acad. Japan Proc., v. 4, no. 9, p. 535–536, text fig. 1.
1928. *Miogypsina verrucosa* Zuffardi-Comerci, Soc. geol. italiana Boll., v. 47, no. 2, p. 143, pl. 9, figs. 8–10, 14, 15.
1930. *Miogypsina (Miogypsinoides) dehaartii* Van der Vlerk var. *formosensis* Yabe and Hanzawa, Tōhoku Imp. Univ., Sci. Repts., 2d ser. (Geol.), v. 14, no. 1, p. 32–33, pl. 3, figs. 4, 5; pl. 4, figs. 3, 4; pl. 7, fig. 12; pl. 9, fig. 9; pl. 11, figs. 1–6, 12.
1936. *Conomiogypsinoides* cf. *C. abunensis* Tobler. Tan, De Ingenieur in Nederlandsch-Indië—IV Mijnbouw en Geologie, de Jaarg. 3, no. 3, p. 51–52, pl. 1, figs. 8–10.
1939. *Miogypsinoides dehaartii* Van der Vlerk, var. *formosensis* Yabe and Hanzawa. Cole, Jour. Paleontology, v. 13, no. 2, p. 187, pl. 24, figs. 1–7.
1940. *Miogypsinoides formosensis* Yabe and Hanzawa. Hanzawa, Jubilee Pub. in Commemoration of Prof. H. Yabe's 60th Birthday, p. 773.
1940. *Miogypsinoides dehaartii* (Van der Vlerk) var. *pustulosa* Hanzawa, idem, p. 780–782, pl. 40, figs. 9–29; pl. 42, fig. 13.

1953. *Miogypsinoides abunensis* (Tobler). Cole, U. S. Geol. Survey Prof. Paper 253, p. 38, pl. 13, figs. 8, 9; pl. 14, figs. 9, 10 [additional references].
1953. *Miogypsinoides formosensis* Yabe and Hanzawa. Cole, idem, p. 38, 39, pl. 8, figs. 18, 19; pl. 13, figs. 1–3, 10, 11, 15, 16; pl. 14, fig. 8.
1953. *Miogypsina dehaartii* Van der Vlerk. Drooger, K. Nederlandse Akad. Wetensch. Proc., ser. B, v. 56, no. 1, p. 110–114, pl. 1, figs. 15–19.
1953. *Miogypsina verrucosa* Zuffardi-Comerci. Drooger, idem, p. 116, pl. 1, figs. 24–26.
1953. *Miogypsina abunensis* Tobler. Drooger, idem, p. 116–117.

Two circumstances have caused the tangled nomenclature of this species: (1) poor, incomplete, inadequate descriptions and illustrations and (2) doubt concerning the value and stability of certain of the characters used to distinguish the various species.

Certain authors have believed that the presence or absence of pillars was a specific feature, whereas others have placed considerable reliance on the position of the periembryonic chambers with respect to the apical part of the test. Still others have used the shape of the test as a means of defining not only species but also subgenera.

Van der Vlerk adequately described and illustrated "*Miogypsina*" *dehaartii*, but Tobler illustrated "*Miogypsina*" *abunensis* by a drawing of an unoriented vertical section and a poor photograph of numerous sections surrounded by matrix material. Yabe and Hanzawa distinguished *Miogypsinoides formosensis* from *M. dehaartii* "by the features of the juvenarium, namely the apical part of the test is occupied by the 8th chamber, and not by the second." (Hanzawa, 1940, p. 773.)

The writer (Cole and Bridge, 1953, p. 38, 39) in a previous discussion of Saipan specimens of *Miogypsinoides*, identified *M. abunensis* and *M. formosensis*. He believed that specimens with large distinct pillars with fibrous intervening zones could be separated from specimens with lamellar structure in which small pillars might or might not occur.

However, the examination of a large number of thin sections since that time has demonstrated that such separation is impossible. It has been discovered that certain specimens are devoid of pillars but others have strong pillars. In every other respect, however, these specimens are identical. Moreover, the thickness of the thin section plays an important role. In very thick sections the lamellar structure is pronounced, whereas in thinner sections the pillars and the fibrous intervening zones show clearly.

The position of the periembryonic chambers is variable. In one of the specimens illustrated (pl. 111, fig. 7), there are no periembryonic chambers between the embryonic chambers and the apex of the test; in another (pl. 111, fig. 6) there is one; and in a third (pl. 111, fig. 8) there are several.

Three topotypes of *M. formosensis* Yabe and Hanzawa are illustrated. One of the vertical sections (pl. 111, fig. 16) shows marked lamellar structure, a second (pl. 111, fig. 14) has small pillars, and the third (pl. 111, fig. 15) has neither pillars nor lamellar structure. All of these types are duplicated in specimens which occur together in samples from Saipan.

Drooger (1953, p. 115) believed that *Miogypsina cupulaeformis* Zuffardi-Comerci (1929, p. 142) is a conical variety of *M. dehaartii* (Van der Vlerk). Although he may be correct, there is not sufficient evidence at this time for this conclusion. Cole (1954, p. 601) referred certain specimens from the Bikini test holes to *Miogypsinoides cupulaeformis* because of their very coarse papillae and size. Equatorial sections of these Bikini specimens compare favorably with the equatorial section illustrated by Zuffardi-Comerci.

As Hanzawa (1940, p. 772) has demonstrated in his criticism of Tan's subgenus *Conomiogypsinoides*, a low conical shape with the embryonic chambers situated at the apex of the cone is not a distinguishing feature either for subgeneric or specific purposes. Many of the random thin sections have individuals with this shape in association with the normal type, and all gradations occur. One of the low conical individuals is illustrated (pl. 111, fig. 9) for comparison with the normal types.

### Genus MIOGYPSINA Sacco, 1893

#### Miogypsina (Miogypsina) thecideaeformis (L. Rutten)

Plate 112; plate 113; plate 114

1911. *Lepidosemicyclina thecideaeformis* L. Rutten, K. Akad. Wetensch. Amsterdam Proc., p. 1135, 1136.
1912. *Miogypsina thecideaeformis* (L. Rutten). Rutten, Geol. Reichs-Mus. Leiden Samml., ser. 1, v. 9, p. 204–207, pl. 12, figs. 1–5.
1927. *Miogypsina tuberosa* Tobler, Eclogae geol. Helvetiae, v. 20, no. 2, p. 323–330, text figs. 1, 2, 4.
1930. *Miogypsina* (s. s.) *inflata* Yabe and Hanzawa, Tōhoku Imp. Univ., Sci. Repts., 2d ser. (Geol.), v. 14, p. 33, pl. 3, fig. 6; pl. 10, fig. 7?; pl. 12, figs. 6, 7; pl. 14, fig. 6; pl. 16, fig. 9.
1930. *Miogypsina* (s. s.) *irregularis* Yabe and Hanzawa [not Michelotti, 1841], idem, p. 35, pl. 11, fig. 11; pl. 12, figs. 2–5.
1930. *Miogypsina* (s. s.) *mamillata* Yabe and Hanzawa, idem, p. 34, pl. 1, fig. 11; pl. 3, figs. 7, 8; pl. 4, fig. 6; pl. 6, fig. 13; pl. 11, figs. 7, 8; pl. 12, fig. 1; pl. 13, fig. 8.
1931. *Miogypsina kotoi* Hanzawa, idem, v. 12, no. 2 A, p. 154, pl. 25, figs. 14–18.
1931. *Miogypsina ozawai* Hanzawa, idem, p. 155, pl. 24, fig. 12; pl. 25, figs. 10–13; pl. 26, fig. 3.
1935. *Miogypsina kotoi* Hanzawa, idem, v. 18, no. 1, p. 23–25, pl. 3.
1937. *Miogypsina kotoi* Hanzawa. Tan, De Ingenieur in Nederlandsch-Indië—IV Mijnbouw en geologie, Jaarg. 4, no. 2, p. 31, 32, 6 figs.

1953. *Miogypsina thecidaeformis* (L. Rutten). Drooger, K. Nederlandse Akad. Wetensch. Proc., ser. B, v. 56, no. 1, p. 109, 110, pl. 1, figs. 10–14, 32.

1953. *Miogypsina* (*Miogypsina*) *inflata* Yabe and Hanzawa. Cole, U. S. Geol. Survey Prof. Paper 253, p. 37, 38, pl. 13, figs. 12–14.

1953. *Miogypsina* (*Miogypsina*) *irregularis* (Michelotti) [teste Yabe and Hanzawa]. Cole, idem, p. 38, pl. 14, fig. 11.

1953. *Miogypsina* (*Miogypsina*) *mamillata* Yabe and Hanzawa. Cole, idem, p. 38, pl. 13, fig. 16.

The external views and equatorial and vertical sections show most of the characteristics of this species. To supplement the illustrations measurements of equatorial and vertical sections are given in the following two tables.

*Measurements of equatorial sections of* Miogypsina thecideaeformis

| | Specimens from locality— | | | | | |
|---|---|---|---|---|---|---|
| | Balik Papan, East Borneo, shown on pl. 112, fig. 10 | Inokosi, Japan, shown on— | | S701, shown on— | | B413, shown on pl. 112, fig. 4 |
| | | Not illustrated | Pl. 112, fig. 11 | Pl. 112, fig. 2 | Pl. 112, fig. 3 | |
| Length ........ mm | 1. 7 | 2. 3 | 2. 65 | 2. 4 | 2. 85 | 2. 2 |
| Width ........ mm | 1. 7 | 2. 1 | 2. 43 | 2. 7 | 2. 9 | 1. 9 |
| Embryonic chambers: | | | | | | |
| Diameters initial chamber ........ μ | 140 x 140 | 180 x 185 | 180 x 160 | 130 x 145 | 120 x 120 | 100 x 100 |
| Diameters second chamber ........ μ | 90 x 170 | 100 x 160 | 90 x 200 | 110 x 180 | 110 x 180 | 85 x 130 |
| Distance across both ........ μ | 240 | 290 | 290 | 260 | 250 | 190 |
| Thickness of outer wall ........ μ | 20–30 | 10–20 | 10–25 | 10–40 | 20–40 | 20 |
| Equatorial chambers: | | | | | | |
| Radial diameter ........ μ | 80–120 | 80–190 | 100–160 | 70–110 | 100–180 | 80–140 |
| Tangential diameter ........ μ | 90–120 | 60–120 | 80–140 | 60–100 | 70–130 | 60–140 |

*Measurements of vertical sections of* Miogypsina thecideaeformis

| | Specimens from locality— | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Balik Papan, East Borneo, shown on— | | | Inokosi, Japan, shown on— | | | S701, shown on— | | | B413, shown on pl. 114, fig. 1 |
| | Pl. 114, fig. 13 | Pl. 114, fig. 14 | Pl. 114, fig. 12 | Pl. 114, fig. 17 | Pl. 114, fig. 11 | Pl. 114, fig. 10 | Pl. 114, fig. 3 | Pl. 114, fig. 20 | Pl. 114, fig. 5 | |
| Diameter ........ mm | 1. 87 | 1. 88 | 1. 92 | 2. 35 | 2. 8 | 2. 15 | 2. 3+ | 2. 25 | 2. 35 | 2. 5 |
| Thickness ........ mm | 0. 55 | 0. 65 | 0. 66 | 0. 75 | 1. 0 | 0. 95 | 0. 83 | 1. 06 | 1. 05 | 0. 54 |
| Embryonic chambers: | | | | | | | | | | |
| Diameter ........ μ | 230 | 220 | 240 | 225 | 320 | 270 | 250 | 260 | 210 | 190 |
| Height ........ μ | 115 | 120 | 150 | 130 | 210 | 150 | 150 | 150 | 150 | 130 |
| Thickness of outer wall ........ μ | 50 | 40–60 | 30–70 | 20–50 | 20–50 | 35–50 | 30 | 30 | 15–50 | 20 |
| Equatorial layer: | | | | | | | | | | |
| Height near embryonic chambers ........ μ | 140 | 120 | 140 | 150 | 180 | 160 | 140 | 140 | 140 | 100 |
| Height near periphery ........ μ | 130 | 120 | 130 | 150 | 150 | 150 | 140 | 100 | 130 | 150 |
| Lateral chambers: | | | | | | | | | | |
| Number ........ | 4 | 5 | 5 | 4 | 6 | 5 | 5 | 8 | 9 | 5 |
| Length ........ μ | 50–110 | 50–120 | 40–150 | 40–90 | 50–210 | 60–130 | 40–200 | 50–140 | 50–130 | 50–70 |
| Height ........ μ | 20–50 | 20–50 | 20–40 | 20–40 | 20–50 | 10–40 | 30–60 | 15–40 | 20–40 | 20–30 |
| Thickness of floors and roofs ........ μ | 10–25 | 10–40 | 10–30 | 10–40 | 10–40 | 10–40 | 20–40 | 10–20 | 10–50 | 10–35 |
| Surface diameter of pillars ........ μ | 30–60 | 50–150 | 30–50 | 50–90 | 70–110 | 60–100 | 50 | 50–90 | 80–150 | 20–50 |

*Remarks.*—The late Helen Jeanne Plummer gave the writer specimens which are labeled *Miogypsina thecideaeformis* (L. Rutten) from Balik-Papan Bay, east coast of Borneo. This is the type locality of the species, but Rutten also described *M. polymorpha* from this general locality from beds which were supposed to be stratigraphically higher. Drooger (1953, p. 53) recently has restudied Rutten's specimens. From his description and figures the conclusion was reached that the specimens are *M. thecideaeformis*. Thin sections of these specimens are illustrated on plate 112, figure 10, and plate 114, figures 12–14.

Dr. Hanzawa kindly supplied me with abundant specimens of *M. kotoi*, from Inokosi, Koyamaiti, Koyama-mura, Kawakanir-gun, Okayama Prefecture, Japan. Although this is not the type locality of the species, Hanzawa (1935, p. 23) has discussed specimens from this locality and presented an excellent series of illustrations. Later, Tan (1937a, p. 31) restudied specimens from this locality and gave more details concerning the embryonic apparatus.

Tan (1936, p. 58; 1937a, p. 32) stated both of these species have "*bifida*-type" nepionic chambers. Rutten (1912, pl. 12, figs. 2–4) demonstrated that the distal equatorial chambers of *M. thecideaeformis* are hexagonal, a fact which Drooger (1953, p. 110) substantiated. Although Hanzawa did not mention that *M. kotoi* possessed any hexagonal equatorial chambers, Tan (1937a, p. 32) wrote, "Hexagonal shapes are very exceptional." Thus, it would appear that *M. thecideaeformis* and *M. kotoi* may develop hexagonal equatorial chambers, but chambers of this shape are more commonly found in *M. thecideaeformis.*

In the thin sections of these species available for this study, there does not appear to be sufficient differences in either equatorial or vertical section to separate them.

Hanzawa (1947b, p. 569) stated that strata in Japan containing "*Nephrolepidina* and/or *Miogypsina* . . . can certainly be regarded as belonging to stage *f* of the Netherlands East Indies Tertiary sequence." Van Bemmelen (1949, p. 134) wrote concerning the age of Pulubalang beds from which *M. thecideaeformis* came: "The age of the Pulubalang Stage is generally accepted as T. $f_1$. Beets . . . remarked on the age of the type locality of Pulu Balang, an island in the northwestern part of Balikpapan Bay, that the range of the concerning molluscan species does not justify to say any more about its age than that for the moment it may be correlated with the T. $f_1$ or $f_2$ until more complementary material has been collected." It would appear, therefore, that these two species occur in strata which have approximately the same age.

Van der Vlerk (1948, p. 61, 62) gave the range of *Miogypsina* (*Miogypsina*) as *e* through $f_3$, a vertical distribution which is generally accepted in the East Indies. *Miogypsinoides dehaartii* (Van der Vlerk) is assigned to Tertiary *e*, but *Cycloclypeus* (*Katacycloclypeus*) is restricted to Tertiary *f*. *Lepidocyclina* (*Eulepidina*) ranges through *d* and *e*. Thus, *Miogypsina thecideaeformis* on Saipan is associated with subgenera and species which elsewhere in the East Indies occur only in upper Tertiary *e* or *f*.

If the rare specimens of *Katacycloclypeus* are discounted, *M. thecideaeformis* would be associated on Saipan with subgenera and species which would indicate an $e_5$ age. Tan (1937a, p. 32) has reported previously that specimens he identified as *M. kotoi* occur in Java in association with *Eulepidina*, which would place these beds in Tertiary *e*. Therefore, *M. thecideaeformis* would appear to be a Tertiary *e* species, but it may extend into Tertiary $f_1$.

Certain specimens (pl. 114, fig. 15) have very strong pillars. These specimens resemble *M.* (*M.*) *tuberosa* Tobler (1927, p. 323). However, they occur with and appear to intergrade with specimens which are identified as *M.* (*M.*) *thecideaeformis;* therefore, they are considered one of the possible variants.

### Family ORBITOIDIDAE

#### Genus LEPIDOCYCLINA Gümbel, 1870

#### Subgenus NEPHROLEPIDINA H. Douvillé, 1911

#### Lepidocylina (Nephrolepidina) angularis Newton and Holland

Plate 107, figures 13, 14

1902. *Orbitoides* (*Lepidocyclina*) *angularis* Newton and Holland, Jour. College of Sci., Tokyo Imp. Univ., v. 17, pt. 3, p. 10, 11, pl. 1, figs. 1, 6; pl. 3, fig. 7.

1930. *Lepidocyclina* (*Nephrolepidina*) *angularis* Newton and Holland. Yabe and Hanzawa, Tōhoku Imp. Univ., Sci. Repts., 2d ser. (Geol.), v. 14, no. 1, p. 27, 28, pl. 10, fig. 7; pl. 11, figs. 2, 4.

Rare vertical sections appear to represent this species. A specimen (pl. 107, fig. 13) from Sekihekiryô in Daianryo, Taihoku Prefecture, Formosa, given me by the late Dr. T. Wayland Vaughn is illustrated for comparison with the Saipan specimens.

It is possible that specimens similar to plate 107, figure 12, identified as small specimens of *L.* (*N.*) *verbeeki*, may be *L.* (*N.*) *angularis.*

#### Lepidocyclina (Nephrolepidina) brouweri L. Rutten

Plate 105, figures 1–10

1924. *Lepidocyclina brouweri* L. Rutten, Jaar. Mijnwezen in Nederlandsch Oost-Indië, p. 182, figs. 22–29.

The test has an inflated central part bounded by a narrow flat rim. There is an apical crown of large, prominent papillae.

The embryonic chambers (pl. 105, fig. 9) are nephrolepidine. The initial chamber is subspherical with internal diameters of 180$\mu$ by 210$\mu$. The second chamber, with internal diameters of 100$\mu$ by 360$\mu$, embraces about half of the periphery of the initial chamber. The internal distance across both chambers is 290$\mu$. The thickness of the outer wall is about 50$\mu$.

In another specimen (pl. 105, fig. 8) the initial chamber has internal diameters of 120$\mu$ by 160$\mu$. The second chamber, with internal diameters of 140$\mu$ by 260$\mu$ does not embrace the initial chamber. The internal distance across both chambers is 270$\mu$. The thickness of the outer wall is about 40$\mu$.

The equatorial chambers are rhombic to short spatulate. Those near the periphery have radial diameters from 40$\mu$ to 70$\mu$. The tangential diameter is from 60$\mu$ to 70$\mu$. Measurements of the vertical sections are given in the following table.

*Measurements of vertical sections of* Lepidocyclina (Nephrolepidina) brouweri

| | Specimens from locality— | | | | | |
|---|---|---|---|---|---|---|
| | B361, not illustrated | C102b, shown on— | | B420, shown on pl. 105, fig. 7 | B357, shown on pl. 105, fig. 4 | B419, shown on pl. 105, fig. 2 |
| | | Pl. 105, fig. 1 | Pl. 105. fig. 6 | | | |
| Diameter mm | 3. 2 | 3. 9 | 3. 14 | ---------- | 3. 1 | 3. 5 |
| Thickness mm | 1. 8 | 1. 46 | 1. 65 | 1. 34 | 1. 75 | 1. 37 |
| Embryonic chambers: | | | | | | |
| Length μ | 200 | 270 | 340 | 320 | 280 | 250 |
| Height μ | 110 | 170 | 210 | 190 | 190 | 150 |
| Thickness of outer wall μ | 50 | 25 | 40 | 40 | 50 | 30 |
| Equatorial layer: | | | | | | |
| Height at center μ | 80 | 75 | 80 | 120 | 80 | 80 |
| Height at periphery μ | 130 | 150 | 150 | 160 | 180 | 160 |
| Lateral chambers: | | | | | | |
| Number | 15 | 12 | 12 | 9 | 12 | 11 |
| Length μ | 110–260 | 130–150 | 140–210 | 110–200 | 100–140 | 130–170 |
| Height μ | 40 | 20–40 | 40 | 20–35 | 10–40 | 20–40 |
| Thickness of floors and roofs μ | 20 | 10–20 | 10–20 | 10–25 | 15–25 | 10–20 |
| Surface diameter of pillars μ | 130–340 | 230–480 | 180–300 | 170–450 | 200–400 | 700 |

The lateral chambers are arranged in regular tiers except near the periphery of the test where overlapping occurs. The chamber cavities are open, long, and rather high. The floors and roofs are moderately thick and slightly arched.

The pillars are heavy, prominent, and irregularly scattered.

*Remarks.*—Specimens of this type have been identified commonly as *L.* (*N.*) *angulosa* Provale. *L.* (*N.*) *angulosa* has elongate hexagonal equatorial chambers; the floors and roofs of the lateral chambers are straight; and the chamber cavity is very long. The specimens from Saipan typically have rhombic to short spatulate equatorial chambers; the floors and roofs of the lateral chambers are arched; and the chamber cavities are not as long as those of *L.* (*N.*) *angulosa.*

Although the type figures of *L.* (*N.*) *brouweri* are drawings, the internal structure of the species is shown clearly. The specimens from Saipan have the same internal structure as that illustrated for *L.* (*N.*) *brouweri.*

At its type locality near Patoenoeang Asoe (Maros, Celebes), *L.* (*N.*) *brouweri* occurs in association with *Spiroclypeus orbitoideus* H. Douvillé and *Heterostegina* sp., an association similar to that on Saipan.

#### Lepidocyclina (Nephrolepidina) parva Oppenoorth

Plate 104, figures 10–17; plate 107, figure 17

1953. *Lepidocyclina* (*Nephrolepidina*) *parva* Oppenoorth. Cole, U. S. Geol. Survey Prof. Paper 253, p. 30–32, pl. 7, fig. 6; pl. 9, figs. 5–12, 15–18; pl. 10, figs. 11–18; pl. 11, figs. 1, 2; pl. 12, fig. 6 [references].

1953. *Lepidocyclina* (*Nephrolepidina*) *brouweri* L. Rutten. Cole, idem, p. 28–29, pl. 8, fig. 1; pl. 9, fig. 1; pl. 11, fig. 3, pl. 12, figs. 5, 14.

Additional illustrations are given to supplement those previously published. These illustrations demonstrate that the size of the pillars differs between specimens.

*Remarks.*—*L. parva* is very similar to the American species *L. yurnagunensis* Cushman. At some future time and with more study, it may be found that these two species can be combined. For the present, however, this is not done (see remarks under *L. ephippioides*) for the same reasons that *L. favosa* and *L. ephippioides* are not combined.

Microspheric specimens with heavy pillars and rhombic equatorial chambers similar to plate 107, figure 17, are referred commonly to *L. morgani* Lemoine and R. Douvillé. As this type of microspheric specimen is always associated with megalospheric specimens of *L. parva,* the two generations are associated under this specific name.

#### Lepidocyclina (Nephrolepidina) sumatrensis (Brady)

Plate 104, figures 1–9; plate 105, figure 18; plate 106, figure 5; plate 109, figures 1–3

1953. *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* (Brady). Cole, U. S. Geol. Survey Prof. Paper 253, p. 32–33, pl. 10, figs. 7–10; pl. 11, figs. 4, 5 [references].

This is a variable species as shown by the illustrations. Some specimens have lateral chambers with thick roofs and floors; others have thin roofs and floors. Three varietal names have been proposed: *L. sumatrensis minor* L. Rutten (1911), *L. sumatrensis inornata* L. Rutten (1913), and *L. sumatrensis umbilicata* L. Rutten (1913). As there is complete intergradation, these subspecies designations are without value.

Basically, this species consists of specimens with short spatulate equatorial chambers and lateral chambers with arched roofs and floors arranged in regular tiers. The presence or absence of pillars and the degree of thickness of the roofs and floors of the lateral chambers are individual rather than specific differences.

**Lepidocyclina (Nephrolepidina) verbeeki Newton and Holland**

Plate 106, figures 1–3, 6, 7, 9, 10; plate 107, figures 1–12, 16; plate 109, figures 7, 8

1899. *Orbitoides* (*Lepidocyclina*) *verbeeki* Newton and Holland, Annals and Mag. Nat. History, ser. 7, v. 3, p. 257–259, pl. 9, figs. 7–11; pl. 10, fig. 1.

1953. *Lepidocyclina* (*Nephrolepidina*) *verbeeki* Newton and Holland. Cole, U. S. Geol. Survey Prof. Paper 253, p. 33–34, pl. 11, figs. 6–14; pl. 12, figs. 7, 12, 13.

The test has an umbonate central part which is surrounded by a relatively wide, fragile rim. Moderately heavy papillae are irregularly scattered over the umbonate part. The rim shows the equatorial chambers because it is not covered by lateral chambers.

The embryonic chambers are nephrolepidine, rather large, and bounded by a moderately thick outer wall. Several large periembryonic chambers occur irregularly spaced on the periphery of the embryonic chambers. These are shown clearly in plate 106, figure 9.

Measurements of three equatorial sections appear in the following table.

*Measurements of equatorial sections of* Lepidocyclina (Nephrolepidina) verbeeki

| | Specimen from locality— | | |
|---|---|---|---|
| | B138, shown on pl. 106, figs. 6, 9 | B136, shown on pl. 106, fig. 1 | B373, shown on pl. 106, fig. 2 |
| Diameter mm | 2. 5 | 1. 75 | 1. 9 |
| Embryonic chambers: | | | |
| Diameters of initial chamber μ | 160 x 240 | 120 x 200 | 210 x 300 |
| Diameters of second chamber μ | 140 x 350 | 150 x 320 | 200 x 440 |
| Distance across both chambers μ | 310 | 280 | 420 |
| Thickness of outer wall μ | 30 | 30 | 35 |
| Equatorial chambers: | | | |
| Radial diameter μ | 60–80 | 50–70 | 50–60 |
| Tangential diameter μ | 40 | 30–50 | 40 |

The equatorial chambers are either rhombic or short spatulate. The radial diameter is always greater than the tangential diameter. The chambers are arranged in rather regular, concentric circles.

The following table contains measurements of five vertical sections.

*Measurements of vertical sections of* Lepidocyclina (Nephrolepidina) verbeeki

| | Specimens from locality— | | | | |
|---|---|---|---|---|---|
| | B135, shown on pl. 107, fig. 4 | B161, shown on pl. 107, fig. 5 | B131, shown on pl. 107, fig. 1 | B138, shown on— | |
| | | | | Pl. 107, fig. 7 | Pl. 107, fig. 9 |
| Diameter mm | 4. 55 | 5. 65 | 2. 9+ | 2. 92+ | 2. 95+ |
| Thickness mm | 1. 4 | 1. 45 | 1. 4 | 1. 0 | 0. 82 |
| Diameter of umbo mm | 2. 8 | 2. 4 | 2. 1 | 2. 2 | 2. 4 |
| Width of rim mm | 0. 8 | 2. 1 | ------ | ------ | 0. 3 |
| Thickness of rim mm | 0. 2 | 0. 21 | ------ | ------ | 0. 11 |
| Embryonic chambers: | | | | | |
| Length μ | 400 | 200 | 310 | 160 | 190 |
| Height μ | 260 | 110 | 190 | 120 | 110 |
| Thickness of outer wall μ | 30 | 25 | 30 | 20 | 25 |
| Equatorial layer: | | | | | |
| Height at center μ | 100 | 80 | 80 | 60 | 60 |
| Height at periphery μ | 220 | 210 | 120 | 110 | 110 |
| Lateral chambers: | | | | | |
| Number | 11 | 10 | 12 | 11 | 11 |
| Length μ | 140–300 | 100–320 | 70–120 | 100–140 | 90–140 |
| Height μ | 30–50 | 30–50 | 25–30 | 20–30 | 20 |
| Thickness of floors and roofs μ | 10 | 10–25 | 10–15 | 10 | 10 |
| Surface diameter of pillars μ | 60–140 | 80–200 | 120–200 | 40–90 | 40 |

The lateral chambers are arranged in regular tiers. In some specimens the lateral chambers near the periphery overlap, but this is the exceptional rather than normal condition. The cavities of the lateral chambers are open, rectangular in shape. The floors and roofs are straight and thin.

Moderately heavy pillars are irregularly scattered throughout the umbonal part of the test. The number of the pillars differ from specimen to specimen.

*Remarks.*—In the Vaughan collection of larger Foraminifera in the U. S. National Museum, there are matrix-free specimens of this species from Sumatra which apparently are topotypes from the "coral-limestone, Padang Highlands, West-Coast District, Sumatra" (Brady, 1875, p. 536). A vertical section (pl. 107, fig. 11) and an equatorial section (pl. 106, fig. 7) are illustrated for comparison with the specimens from Saipan.

Dr. S. Hanzawa generously had sent me specimens from Pinaiko, Taihoku Prefecture, Formosa which he (1943, p. 129) had identified as *L.* (*N.*) *verbeeki*. Sections (pl. 106, fig. 10; pl. 107, fig. 8) were prepared from these specimens for comparison with the specimens in the present collection.

As Hanzawa (1943, p. 129) stated, *L.* (*N.*) *verbeeki* is similar to his *L.* (*N.*) *nipponica*. Dr. H. G. Schenck had sent me abundant specimens of this species from Shimo-shiroiwa, Shizuoka Prefecture, Japan. Sections (pl. 106, figs. 4, 8; pl. 107, fig. 15) are illustrated for comparison with the Saipan specimens assigned to *L.* (*N.*) *verbeeki*.

Although the vertical sections of *L.* (*N.*) *nipponica* and *L.* (*N.*) *verbeeki* are similar, the equatorial chambers are different. These chambers are elongate hexagonal to elongate spatulate in *L.* (*N.*) *nipponica*, but rhombic to short spatulate in *L.* (*N.*) *verbeeki*.

**Lepidocyclina (Nephrolepidina) verrucosa Scheffen**

Plate 105, figures 11–17; plate 109, figures 4–6

1932. *Lepidocyclina verrucosa* Scheffen, Nederlandsche Akad. Wetensch. Meded., no. 21, p. 33, 34, pl. 7, figs. 2–4.

1939. *Lepidocyclina verrucosa* Scheffen. Caudri, Geol.-Mijnb. genootsch. v. Nederland en Kolonien, Verh., Geol. ser., v. 12, p. 179–185, figs. 26–30, 42, 46.

1954. *Lepidocyclina* (*Nephrolepidina*) *verrucosa* Scheffen. Cole, U. S. Geol. Survey Prof. Paper 260–0, p. 593–594, pl. 213, figs. 1–9.

The embryonic chambers are nephrolepidine. The initial chamber is subspherical with internal diameters of 180$\mu$ by 240$\mu$. The second chamber, with internal diameters of 110$\mu$ by 380$\mu$, very slightly embraces the initial chamber. The internal distance across both chambers is 320$\mu$. The thickness of the outer wall is 20$\mu$.

Two distinct periembryonic chambers are present, lying at either end of the dividing partition between the embryonic chambers. These chambers have internal diameters of about 35$\mu$ by 100$\mu$.

The equatorial chambers were not satisfactorily exposed in any of the thin sections available. Some that could be seen indistinctly appear to be small and rhombic in shape. Measurements of vertical sections from four localities are given below.

*Measurements of vertical sections of* Lepidocyclina (Nephrolepidina) verrucosa

| | Specimens from locality— | | | |
|---|---|---|---|---|
| | B177, shown on pl. 105, fig. 16 | C132, shown on pl. 105, fig. 15 | C140, shown on pl. 105, fig. 13 | B320, shown on pl. 105, fig. 14 |
| Diameter……mm | 1.75 | 2.36 | 3.2 | 2.85 |
| Thickness……mm | 1.22 | 1.18 | 1.9 | 1.53 |
| Embryonic chambers: | | | | |
| Length……$\mu$ | 310 | 330 | 400 | 240 |
| Height……$\mu$ | 210 | 210 | 270 | 165 |
| Thickness of outer wall……$\mu$ | 40 | 40 | 20 | 40 |
| Equatorial layer: | | | | |
| Thickness at center……$\mu$ | 100 | 120 | 90 | 90 |
| Thickness at periphery……$\mu$ | 100 | 130 | 115 | 130 |
| Lateral chambers: | | | | |
| Number…… | 11 | 10 | 15 | 11 |
| Length……$\mu$ | 100–130 | 100–140 | 110–220 | 120–160 |
| Height……$\mu$ | 20–30 | 40 | 30–40 | 30–40 |
| Thickness of floors and roofs……$\mu$ | 10–20 | 10 | 20 | 20–30 |
| Surface diameter of pillars……$\mu$ | 100–250 | 150–300 | 200–450 | 150–180 |

The lateral chambers are arranged in rather regular tiers. The floors and roofs of the lateral chambers either are straight or slightly arched. The chamber cavity is open, nearly rectangular.

The pillars are strong, rather numerous, and irregularly scattered throughout the central part of the test.

**Subgenus EULEPIDINA H. Douvillé, 1911**

**Lepidocyclina (Eulepidina) badjirraensis Crespin**

Plate 108, figures 1–3; plate 109, figures 9, 10

1952. *Lepidocyclina* (*Eulepidina*) *badjirraensis* Crespin, Contr. Cushman Found. Foram. Research, v. 3, pt. 1, p. 29, 30, pl. 6, figs. 1, 2, 5; pl. 7, figs. 1, 2; pl. 8, figs. 1–5.

1952. *Lepidocyclina* (*Eulepidina*) *manduensis* Crespin, idem, p. 30, 31, pl. 6, figs. 3, 4; pl. 7, figs. 3, 5, 6; pl. 8, figs. 6, 7.

1953. *Lepidocyclina* (*Eulepidina*) *bridgei* Cole, U. S. Geol. Survey Prof. Paper 253, p. 34, pl. 9, figs. 2–4, 13, 14, 19–21.

1953. *Lepidocyclina* (*Eulepidina*) *saipanensis* Cole, idem, p. 37, pl. 8, figs. 8–15.

1953. *Lepidocyclina* (*Eulepidina*) *badjirraensis* Crespin. Crespin, Australia, Bur. Mineral Res., Geol. and Geophysics Bull. 21, p. 61, pl. 7, figs. 2, 3; pl. 8, fig. 4; pl. 10, fig. 3.

1953. *Lepidocyclina* (*Eulepidina*) *manduensis* Crespin, idem, p. 63, pl. 8, figs. 2, 3.

Matrix-free specimens of *Lepidocyclina badjirraensis* were not found on Saipan, but both equatorial and vertical cuts were observed in mislabeled sections whose exact locality on the island is unknown. Measurements of vertical sections of selected specimens follow.

*Measurements of vertical sections of* Lepidocyclina badjirraensis

| | Pl. 108, fig. 2 | Pl. 108, fig. 1 | Not illustrated | Pl. 109, fig. 10 | Pl. 109, fig. 9 |
|---|---|---|---|---|---|
| Diameter ... mm | 7.2 | 9.7 | 6.15 | 2.55+ | 3.1 |
| Diameter of umbo ... mm | 2.0 | 1.8 | 2.0 | 1.6 | 2.1 |
| Thickness of umbo ... mm | 0.92 | 0.76 | 0.86 | 0.72 | 1.13 |
| Thickness of rim near umbo ... mm | 0.46 | 0.42 | 0.40 | 0.25 | 0.45 |
| Thickness of rim at periphery ... mm | 0.25 | 0.13 | 0.14 | ---- | ---- |
| Embryonic chambers: | | | | | |
| Diameter ... μ | 430 | 390 | 360 | 350 | 320 |
| Height ... μ | 140 | 140 | 150 | 120 | 160 |
| Thickness of outer wall ... μ | 30 | 30 | 40 | 50 | 30 |
| Equatorial layer: | | | | | |
| Height at center ... μ | 50 | 40 | 50 | 30 | 35 |
| Height at periphery ... μ | 60 | 60 | 60 | ---- | ---- |
| Lateral chambers: | | | | | |
| Number ... no | 7 | 7 | 7 | 6 | 9 |
| Length ... μ | 90–150 | 70–120 | 50–120 | 100–120 | 90–140 |
| Height ... μ | 10–20 | 10 | 10 | 10 | 10–25 |
| Thickness of floors and roofs ... μ | 30 | 20 | 20–30 | 30 | 20–30 |
| Surface diameter of pillars ... μ | 150 | 60–150 | 60–150 | 80–110 | 140–250 |

*Remarks.*—*L.* (*E.*) *bridgei* and *L.* (*E.*) *saipanensis* were described as new species in the preliminary report on Saipan (Cole and Bridge, 1953, p. 34, 37) where they were found associated at a single locality. After the manuscript of that report was in press, Crespin (1952a, p. 28) published two new species, *L.* (*E.*) *badjirraensis* and *L.* (*E.*) *manduensis*, which occur together in the Miocene, Tertiary *e*, of Australia. As *L.* (*E.*) *bridgei* appeared to be similar to, if not identical with *L.* (*E.*) *badjirraensis*, a footnote to this effect was inserted in the preliminary report.

*L.* (*E.*) *bridgei* and *L.* (*E.*) *saipanensis* differed from each other largely in the size and thickness of the wall of the embryonic chambers. These same differences occur between the two Australian species.

The measurements of the maximum diameters of the embryonic chambers of these four species follow:

| Species | Locality | Maximum diameter of embryonic chambers |
|---|---|---|
| *Lepidocyclina* (*Eulepidina*) *saipanensis* | Saipan | 200μ–250μ |
| (*Eulepidina*) *bridgei* | Saipan | 720μ–1,480μ |
| *manduensis* | Australia | 500μ–800μ |
| *badjirraensis* | Australia | 1,200μ–1,300μ |

Specimens in the present collection which were identified first as *L.* (*E.*) *saipanensis* have embryonic chambers with a diameter of 360μ to 430μ. Thus, these specimens are intermediate between *L.* (*E.*) *bridgei* and *L.* (*E.*) *saipanensis*.

In a study of the American species, *L.* (*N.*) *chaperi* Cole (1953, p. 25) demonstrated that the range in diameter of the embryonic chambers of this species is 640μ to 1,420μ. The size and thickness of the wall of the embryonic chambers is apparently not a specific character.

As the Saipan specimens and the Australian ones have essentially the same form and internal structure, they are all combined under the name *L.* (*E.*) *badjirraensis*.

Unfortunately, the most complete vertical sections occur on slides mislabeled as coming from a known Eocene locality. However, illustrations are used from these slides, because they include the most complete vertical sections available.

**Lepidocyclina (Eulepidina) ephippioides Jones and Chapman**

Plate 108, figures 4–13; plate 109, figures 11–15

1900. *Orbitoides* (*Lepidocyclina*) *ephippioides* Jones and Chapman, *in* C. W. Andrews, A monograph of Christmas Island (Indian Ocean), British Mus. (Nat. History), London, p. 251, 252, 256, pl. 20, fig. 9; pl. 21, fig. 15.
1952. *Lepidocyclina ephippioides* Jones and Chapman. Grimsdale, Bull. British Mus. (Nat. History) Geol., London, v. 1, no. 8, p. 240–244, pl. 23, figs. 8, 17, 18 [references].
1953. *Lepidocyclina* (*Eulepidina*) *formosa* Schlumberger. Cole, U. S. Geol. Survey Prof. Paper 253, p. 34–35, pl. 7, figs. 4, 5; pl. 10, figs. 1–6.
1953. *Lepidocyclina* (*Eulepidina*) *gibbosa* Yabe. Cole, idem, p. 35–36, pl. 8, figs. 2–7.
1953. *Lepidocyclina* (*Eulepidina*) *planata* Oppenoorth. Cole, idem, p. 36, pl. 7, figs. 1–3 [references].
1953. *Lepidocyclina* (*Nephrolepidina*) *newtoni* Yabe and Hanzawa. Cole, idem, p. 29–30, pl. 12, figs. 8–10, 15; pl. 14, fig. 3.

The various species *L. formosa*, *L. gibbosa*, *L. planata*, and *L. newtoni*, here considered variants of *L. ephippioides*, were described and illustrated in the preliminary report on Saipan. Additional illustrations are given which in conjunction with the illustrations previously published show the variation which may occur within this species and prove the interconnection of all these individuals.

*Remarks.*—Grimsdale (1952, p. 240–244) has made a study recently of the species most commonly called *L.* (*E.*) *formosa* Schlumberger. He believed that the earliest name given to this species was *Orbitoides* (*Lepidocyclina*) *ephippioides* Jones and Chapman and that this specific name should have priority. He placed in the synonymy of *L.* (*E.*) *ephippioides* numerous Indo-Pacific species, all of which have "hexagonal or spatulate equatorial chambers, eulepidine nucleoconch, lack of pillars, but thickening of the lateral chamber walls visible in varying degree." He believed, also, that the American Oligocene species *L.* (*E.*) *favosa* Cushman should be a synonym of *L. ephippioides*.

Earlier, Hanzawa and Asano (1942, p. 121), after a comparative study of *L. favosa* and *L. formosa*, decided that the species were closely related but could be separated. Grimsdale (1952, p. 244) in commenting on the opinion of Hanzawa and Asano stated: "From this I would infer that the distinction between these species is not proven and is better not maintained. There remains, however, the possibility that geographical or stratigraphical races may eventually be found to merit recognition in a varietal status only."

Although there is parallel development in *L. formosa* and *L. favosa* and it is possible that only one species is represented, the author agrees with a statement made by Vaughan (1933, p. 4): " . . . I wish to say that I sympathize with Douvillé's comparison of American with European species. I feel, however, that the time is not quite ripe for extensive critical comparisons."

Eventually, a worldwide comparison of the species of larger Foraminifera must be made, but the information on most of the species is still too fragmental. In the case of the species under consideration, it is believed that they can be separated, admittedly with difficulty, but if this be true it appears that the separate specific names should be retained because of stratigraphical and geographical implications.

It is certain, however, that Grimsdale is correct in placing in synonymy most of the names which have been given to various specimens of *L. formosa* within the Indo-Pacific province and that the first name used was *L. ephippioides* Jones and Chapman. This name is accepted for the Saipan specimens.

In the preliminary report (Cole and Bridge, 1953, p. 35, 36) the name *L. gibbosa* Yabe (1919, p. 46) was retained for certain specimens associated with *L. ephippioides* (*L. formosa*) because "The specimens from Saipan have the thickened wall surrounding the lateral chambers which is the outstanding characteristic of *L. gibbosa*. . . ." After studying the abundant material from Saipan which is available at present, this position can not be maintained. There is complete gradation between specimens of the *L. ephippioides* and the *L. gibbosa* type.

Certain aberrant specimens (pl. 109, figs. 12–15) which have a depressed central part surrounded by an inflated ring were found in the thin sections from a few localities. The specimens have all the internal features of *L. ephippioides* except the cross section shape. They are found only rarely and always in association with normal specimens of *L. ephippioides*. Therefore, these specimens are believed to be an unusual, perhaps pathological, form of this species.

388273—57——27

*L. monstrosa* Yabe (1919, p. 42), a variant of *L. ephippioides*, which is found at certain of the stations on Saipan combines the characters of "*L. gibbosa*" and "*L. formosa*" types.

Previously, Cole (Cole and Bridge, 1953, p. 29, 36) recognized the species *L.* (*N.*) *newtoni* Yabe and Hanzawa and *L.* (*E.*) *planata* Oppenoorth on Saipan. He wrote concerning *L. planata*, "The relationship and association of *L. formosa* and *L. planata* is the same as that of *L. favosa* and *L. undosa* from the American Oligocene." Since that time, Cole (1952, p. 23) studied abundant and well-preserved material of *L.* (*N.*) *chaperi* Lemoine and R. Douvillé from Panama. In this species he proved the wide variation which may occur in a given species.

Inasmuch as the variation between individuals in a single population of *L. chaperi* is no greater than that between *L. planata* and *L. ephippioides*, these two species are combined. As the illustrations (pl. 108, figs. 5–13) demonstrate, the thin specimens of the *L. planata* type merge with thicker specimens which are called "*L. ephippioides*.

Although certain Saipan specimens (Cole and Bridge, 1953, pl. 12, fig. 8) appeared to have nephrolepidine embryonic chambers and therefore were assigned to *L.* (*N.*) *newtoni* Yabe and Hanzawa, it is doubtful if this assignment was correct. Cole (1945, p. 43) among others has long recognized that in *L. favosa* and *L. undosa* (probably comprising a single gradational species) the embryonic chambers grade from nephrolepidine to eulepidine. The same gradation occurs in *L. ephippioides*.

### Family DISCOCYCLINIDAE

#### Genus DISCOCYCLINA Gümbel, 1870

#### Subgenus DISCOCYCLINA Gümbel, 1870

##### Discocyclina (Discocyclina) omphala (Fritsch)

Plate 115, figures 1–12

1875. *Orbitoides omphalus* Fritsch, Palaeontographica, supp. 3, p. 142, 143, pl. 18, fig. 13; pl. 19, fig. 5.

1905. *Orthophragmina umbilicata* Deprat, Soc. géol. France, Bull., sér. 4, v. 5, p. 497–501, pl. 16, figs. 2–11.

1905. *Orthophragmina umbilicata* Deprat, var. *fournieri* Deprat, idem, p. 501, 502, pl. 17, fig. 12.

1905. *Orthophragmina javana* Verbeek var. *minor* Verbeek, idem, p. 502, 503, pl. 17, figs. 13, 14. [Not *Orbitoides papyracea* var. *javana minor* Verbeek, 1896.]

1905. *Orthophragmina* cf. *O. stella* D'Archiac. Deprat, idem, p. 504, 505, pl. 17, figs. 15–18. [Not *Orbitolites stella* D'Archiac, 1848.]

1905. *Orthophragmina* cf. *O. dispansa* Sowerby. Deprat, idem, p. 505, pl. 17, fig. 19. [Not *Lycophris dispansus* Sowerby, 1837.]

1905. *Orthophragmina* cf. *varians* Kaufmann. Deprat, idem, p. 505, 506, pl. 18, figs. 20–22. [Not *Orbitoides varians* Kaufmann, 1867.]

1905. *Orthophragmina omphala* (Fritsch). Douvillé, Soc. géol. France Bull., sér. 4, v. 5, p. 440, 441, text figs. 1, 2.

1914. *Orthophragmina umbilicata* Deprat. L. Rutten, Nova Guinea, v. 6, géol. 2, Leiden, p. 49, pl. 9, figs. 4–7.

1947. *Discocyclina umbilicata* Deprat. Bursch, Schweizer. palaeont. Gesell. Abh., v. 65, p. 57–59, pl. 3, figs. 18, 21, 24.

1953. *Discocyclina* sp. A, Cole, U. S. Geol. Survey Prof. Paper 253, p. 37, pl. 12, fig. 3.

1956. *Discocyclina* (*Discocyclina*) *indopacifica* Hanzawa, Geol. Soc. America Mem. 66 (in press).

The test is moderate size with or without a central umbo. The umbonate forms have the inflated central area bordered by a wide rim. The umbo is either gently arched, flat-topped, or slightly depressed in the center. The nonumbonate forms are lenticular. The surface is covered with small, very slightly raised papillae.

The embryonic chambers are bilocular with the larger chamber embracing the initial chamber except for a distance of about 100μ along their common boundary. The initial chamber is subspherical with an internal diameter of about 180μ. The second chamber is large with diameters of 680μ by 530μ. The outer wall of the embryonic chamber is 15μ thick. Distinct periembryonic chambers do not appear, and the embryonic chambers are followed by the normal rectangular equatorial chambers.

The equatorial chambers are radially elongated with radial diameters of 50μ to 70μ and tangential diameters of 20μ to 25μ. The annular stolon is situated on the proximal side of the radial chamber walls. The radial chamber walls are well developed and straight, and those of one annulus alternate in position with those of the next adjacent annuli.

The following table contains measurements of five vertical sections.

*Measurements of vertical sections of* Discocyclina omphala

| | Specimens from locality— | | | | |
|---|---|---|---|---|---|
| | S100, shown on— | | | S259, shown on— | |
| | Pl. 115, fig. 3 | Pl. 115, fig. 9 | Pl. 115, fig. 5 | Pl. 115, fig. 8 | Pl. 115, fig. 6 |
| Diameter ... mm | 8. 3 | 5. 2+ | 5. 1+ | 3. 8+ | 5. 3+ |
| Thickness ... mm | 1. 45 | 1. 75 | 1. 1 | 1. 1 | 1. 8 |
| Diameter of umbo ... mm | 3. 0 | 2. 8 | 2. 6 | 2. 3 | 3. 0 |
| Width of flange ... mm | 3. 0 | 1. 8+ | 1. 5+ | 1. 0+ | 1. 8+ |
| Thickness of flange ... mm | 0. 55 | 0. 65 | 0. 35 | 0. 35 | 0. 65 |
| Equatorial chambers: | | | | | |
| Length ... μ | 380 | 510 | 380 | 730 | 470 |
| Height ... μ | 140 | 160 | 120 | 180 | 200 |
| Thickness of outer wall ... μ | 10 | 10 | 10 | 5 | 10 |
| Equatorial layer: | | | | | |
| Height at center ... μ | 50 | 60 | 50 | 40 | 60 |
| Height at periphery ... μ | 70 | 60 | 40 | 40 | 60 |
| Lateral chambers: | | | | | |
| Number | 26 | 28 | 22 | 17 | 33 |
| Length ... μ | 50–80 | 50–90 | 60–100 | 40–100 | 80–120 |
| Height ... μ | 10 | 10 | 10 | 10 | 10 |
| Thickness of floors and roofs ... μ | 10 | 10 | 20 | 10 | 10 |
| Surface diameter of pillars ... μ | 150 | 100 | 120–150 | 100 | 50–140 |

The lateral chambers are not arranged in regular tiers, but irregularly overlap. The chamber cavities are low, slitlike between relatively thick floors and roofs.

Heavy pillars are irregularly scattered throughout the vertical sections with the greatest concentration of pillars in the umbo.

*Occurrence elsewhere.*—Borneo; New Caledonia; New Guinea; Gross Kei, Moluccas.

*Remarks.*—The type description and illustrations are inadequate. However, the external view shows a depressed area within the umbo although the internal features are not clearly characterized. Later, Douvillé (1905, p. 440) gave better illustrations of the external view. Fortunately, Dr. A. Tobler had sent Vaughan specimens from Douvillé's Borneo locality; therefore, the internal structure of the species could be investigated. These specimens have the same internal structure as that of the Saipan specimens.

Deprat (1905, p. 497) described a new species from New Caledonia to which he gave the name *Orthophragmina umbilicata*. He illustrated this species with photomicrographs showing the internal structure. As the internal features of the specimens identified by Douvillé with *D. omphala* (Fritsch) appear to be the same as those of Deprat's *D. umbilicata*, these species are combined.

The external shape of *D. omphala* is similar to that of *Pseudophragmina* (*Proporocyclina*) *peñonensis* Cole and Gravell (1952, p. 723). Examination of many matrix-free specimens of this species showed that there is great variation in external shape. Although some specimens have a marked central depression, others are without this feature. This same variation occurs in *P.* (*P.*) *advena* (Cushman), another American species in which certain individuals have a marked central depression and others do not.

External shape is not a criterion upon which a species may be based, as this character is variable. Internal structure is constant, and the main reliance for the definition of species of larger Foraminifera should be based on the internal structures.

Although most of the Saipan specimens do not have a depressed center, certain individuals (pl. 115, fig. 4) do. The internal structure of the Saipan specimens, however, compares favorably with that of the East Indies specimens.

Bemmelen (1949, fig. 40) figures specimens to which the name *Discocyclina omphalus* (v. Fritsch) var. "*selliformis*" is given. Although only the external appearance is shown, these specimens appear to be the same as those from Saipan.

### Genus ASTEROCYCLINA Gümbel, 1870

#### Asterocyclina incisuricamerata Cole, n. sp.

Plate 117, figures 1–5

The test is small, with the central part inflated. There are 4 rays which are short with blunted rounded ends and merge imperceptibly into the central part. Small papillae, slightly raised, occur on the inflated part.

The embryonic chambers are bilocular. The initial chamber is subspherical slightly embraced by a reniform second chamber. The dividing partition between the two chambers is curved.

There appear to be four principal periembryonic chambers, one lying at each end of the dividing partition between the embryonic chambers. The other two are situated so that one is on the outer edge of the initial chamber and the other is on the outer edge of the second chamber. These chambers have diameters of about 25μ by 60μ. Measurements of horizontal sections are given below.

| | Specimen shown on— | |
|---|---|---|
| | Pl. 117, fig. 3 | Pl. 117, fig. 4 |
| Diameter (mm) | 2.1 | 2.0 |
| Embryonic chambers: | | |
| Diameter of initial chamber (μ) | 50 x 50 | 45 x 40 |
| Diameter of second chamber (μ) | 80 x 40 | 50 x 40 |
| Distance across both chambers (μ) | 95 | 90 |
| Thickness of outer wall (μ) | 10 | 10 |
| Equatorial chambers: | | |
| In rays: | | |
| Radial diameter (μ) | 50 | 55 |
| Tangential diameter (μ) | 20 | 20 |
| In interrays: | | |
| Radial diameter (μ) | 35 | 20–35 |
| Tangential diameter (μ) | 35 | 30 |

The four rays show prominently in all of the equatorial sections. The chambers in the rays are tangentially elongate, whereas the interray chambers are nearly square. Measurements of vertical sections are given below.

| | Specimens from locality S259, shown on— | |
|---|---|---|
| | Pl. 117, fig. 1 | Pl. 117, fig. 2 |
| Diameter (mm) | 2.2+ | 2.35 |
| Thickness (mm) | 0.77 | 0.65 |
| Embryonic chambers: | | |
| Diameter (μ) | 60 | 80 |
| Height (μ) | 30 | 50 |
| Thickness of outer wall (μ) | 5 | 20 |
| Equatorial layer: | | |
| Height at center (μ) | 50 | 50 |
| Height at periphery (μ) | 60 | 60 |
| Lateral chambers: | | |
| Number | 10 | 11 |
| Length (μ) | 50–60 | 50 |
| Height (μ) | 5–10 | 10 |
| Thickness of floors and roofs (μ) | 10–25 | 20–25 |
| Surface diameter of pillars (μ) | 60–160 | 60–130 |

The lateral chambers are not arranged in regular tiers. The chamber cavities are low, slitlike between thick floors and roofs.

Heavy pillars are irregularly scattered throughout the test, with the greatest concentration in the central area.

*Type material.*—Holotype, USNM 624717; paratype, USNM 624719, from locality S–259.

*Remarks.*—The small embryonic chambers, the slitlike lateral chambers with thick floors and roofs, and their overlapping arrangement distinguish this species from the others found on Saipan.

The equatorial chambers are nearly square, but some of them have a faint hexagonal shape. This type of equatorial chamber was found in *Orthocyclina soeroeanensis* Van der Vlerk (1923, p. 93). Although Van der Vlerk based the genus *Orthocyclina* on the shape of the equatorial chambers, it is doubtful if this is a sufficiently well-defined characteristic on which to base a genus.

Many of the discocyclinids have certain of the chambers in the equatorial section with a faint hexagonal shape, but other chambers in the same section are square or rectangular.

*A. soeroeanensis* (Van der Vlerk) is incompletely described, as the only illustration given is the one of the equatorial section. The embryonic chambers are very different from those of *A. incisuricamerata.*

### Asterocyclina matanzensis Cole, n. sp.

Plate 117, figures 6–10; plate 118, figures 9–18

The test is small, compressed, consisting of a central umbonate area from which radiate four slightly elevated rays; interray areas are thin, flat; the surface is covered by small, projecting papillae.

In all of the specimens available the embryonic apparatus has been destroyed by replacement with calcite. Typical equatorial sections are illustrated (pl. 117, figs. 6, 7) but not described.

The following table contains measurements of four vertical sections made from matrix-free specimens.

| | Specimens from locality— | | | |
|---|---|---|---|---|
| | S259, shown on— | | | S134, shown on pl. 118, fig. 16 |
| | Pl. 117, fig. 9 | Pl. 117, fig. 8 | Pl. 118, fig. 17 | |
| Diameter mm | 2. 65+ | 2. 25+ | 2. 1+ | 2. 55+ |
| Thickness mm | 0. 88 | 0. 85 | 1. 03 | 1. 18 |
| Embryonic chambers: | | | | |
| Diameter μ | 160 | 140 | 150 | 150 |
| Height μ | 120 | 70 | 60 | 90 |
| Thickness of outer wall μ | 10 | 5 | 5 | ---------- |
| Equatorial layer: | | | | |
| Height at center μ | 35 | 30 | 35 | 40 |
| Height at periphery μ | 30 | 20 | 30 | 40 |
| Lateral chambers: | | | | |
| Number | 17 | 20 | 20 | 24 |
| Length μ | 70 | 50 | 70 | 50–70 |
| Height μ | 10 | 5 | 10 | 10 |
| Thickness of floors and roofs μ | 10 | 10 | 10 | 10 |
| Surface diameter of thickened areas between lateral chambers μ | 80–100 | 50–70 | 50–90 | 80 |

The lateral chambers are in regular tiers. The chamber cavities are low, slitlike between floors and roofs which are about as thick as the height of the chamber cavity. Thickened areas occur between the tiers of lateral chambers which resemble pillars.

*Type material.*—Holotype, vertical section from locality S259, USNM 624723; paratype, median section from locality S259, USNM 624721.

*Remarks.*—Although the matrix-free specimens are small and apparently represent only the central portion, vertical sections in the thin sections made from the limestone are much larger because of the preservation of a wide but very fragile rim. Several of these are illustrated (pl. 118, figs. 9–18), and the measurements of the best one are listed below.

| | | |
|---|---|---|
| Diameter | mm | 6. 41+ |
| Thickness at center | mm | 1. 12 |
| Diameter of umbo | mm | 1. 1 |
| Rim: | | |
| Width | mm | 3. 65 |
| Thickness near the umbo | mm | 0. 5 |
| Thickness at the periphery | mm | 0. 21 |
| Embryonic chambers: | | |
| Diameter | μ | 150 |
| Height | μ | 120 |
| Height of equatorial layer: | | |
| Near center | μ | 40 |
| Near periphery | μ | 35 |
| Lateral chambers: | | |
| Length | μ | 50 |
| Height | μ | 10 |
| Thickness of roofs and floors | μ | 10 |
| Number | | 21 |
| Surface diameter of pillars | μ | 50 |

The features of these specimens compare favorably with specimens from the East Indies which have been commonly referred to *Asterocyclina lanceolata* (Schlumberger). Deprat (1905, p. 509) referred certain specimens from New Caledonia to this species, but his specimens appear to be similar to those of the present collection.

All of the specimens, however, differ from the types of *A. lanceolata* and should be given a new name.

### Asterocyclina penuria Cole, nom. nov.

Plate 116, figures 1–10

1905. *Orthophragmina pentagonalis* Deprat, Soc. géol. France Bull., ser. 4, v. 5, p. 507, 508, pl. 18, figs. 24, 25; pl. 19, fig. 27. [Not *Asterodiscus pentagonalis* Schafhäult, 1863, Sud-Bayerns Lethaea Geog., p. 107, pl. 15, fig. 2.]

1905. *Orthophragmina nummulitica* (Gümbel) (?). Deprat, idem, p. 506, pl. 18, fig. 23. [Not *Orbitoides* (*Rhipidocyclina*) *nummulitica* Gümbel, 1868.]

1934. *Asterocyclina* aff. *A. pentagonalis* Deprat. Caudri, Tertiary Deposits of Soemba, Amsterdam, p. 97–99, pl. 3, figs. 1, 9.

1953. *Discocyclina* sp. B. Cole, U. S. Geo. Survey Prof. Paper 253, p. 37, pl. 12, fig. 4.

The test is moderate size with an inflated central area surrounded by a narrow brim on which there are 4 slightly elevated areas at right angles to each other representing rays. The rays are not at all distinct. The surface of the test is covered by shallow polygonal pits which are bounded by elevated walls of clear shell material. The largest specimen has a diameter of more than 5 mm.

The embryonic chambers are bilocular consisting of an initial chamber with diameters of 220μ by 140μ and a second chamber with diameters of 310μ by 160μ. The distance across both chambers is 300μ. The outer wall of the embryonic chambers is 18μ thick. The dividing partition between the chambers is gently curved.

There are 4 large, prominent periembryonic chambers which completely surround the embryonic chambers. The 2 larger chambers are situated so that their point of juncture is at the apex of the initial chamber from which they extend on either side of the initial chamber to a point on the second embryonic chamber about 80μ beyond the dividing partition between the chambers. The 2 smaller chambers extend from their juncture with the larger chambers around the second embryonic chamber and meet at the apical point. The larger chambers have diameters of about 300μ by 50μ, and the smaller chambers have diameters of about 240μ by 50μ.

The equatorial chambers are radially elongate. The chambers in the interray areas have radial diameters of 70μ to 90μ and tangential ones of 20μ to 30μ. The chambers which compose the 4 rays have radial diameters of 120μ and tangential diameters of 15μ to 20μ.

*Measurements of vertical sections of* Asterocyclina penuria

| | Specimens from locality— | | | | | |
|---|---|---|---|---|---|---|
| | S259, shown on— | | | S188, shown on pl. 116, fig. 5 | S259, shown on pl. 116, fig. 2 | S134, not illustrated |
| | Pl. 116, fig. 1 | Pl. 116, fig. 3 | Pl. 116, fig. 4 | | | |
| Diameter ---- mm | 3. 4 | 3. 55 | 3. 6+ | 3. 7+ | 1. 9 | 5. 4 |
| Thickness ---- mm | 1. 36 | 2. 2 | 1. 8 | 3. 15 | 0. 85 | 2. 5 |
| Embryonic chambers: | | | | | | |
| Length ---- μ | 260 | 270 | 320 | 270 | 210 | 340 |
| Height ---- μ | 160 | 180 | 130 | 190 | 170 | 190 |
| Thickness of outer wall ---- μ | 10 | 10 | 15 | 10 | 20 | 15 |
| Equatorial layer: | | | | | | |
| Height at center ---- μ | 60 | 40 | 80 | 60 | 70 | 60 |
| Height at periphery ---- μ | 50 | 50 | 60 | 60 | 40 | 60 |
| Lateral chambers: | | | | | | |
| Number ---- | 20 | 22 | 20 | 44 | 16 | 28 |
| Length ---- μ | 50–150 | 200–260 | 70–200 | 150 | 70 | 100–200 |
| Height ---- μ | 10–20 | 25–40 | 20–30 | 20–30 | 10 | 10–30 |
| Thickness of floors and roofs ---- μ | 10–25 | 20 | 10 | 10 | 10 | 10–25 |
| Surface diameter of thickened areas between the lateral chambers ---- μ | 50–150 | 200–300 | 100–200 | 100–170 | 40–140 | 140–300 |

The lateral chambers are in regular tiers. The lateral chambers over the embryonic apparatus have slitlike openings between thick floors and roofs. Those toward the periphery have open rectangular cavities between straight moderately thick floors and roofs.

Between the tiers of lateral chambers, there are thickened areas which resemble pillars.

*Occurrence elsewhere.*—New Caledonia; Soemba.

*Remarks.*—Although the types are smaller than the average Saipan specimen, certain specimens compare favorably in size with the types. The internal features of the New Caledonian and the Saipan specimens are similar.

The figures demonstrate that in vertical section there is considerable variation between individuals in the degree of inflation, number of lateral chambers, and thickness of floors and roofs. However, all the specimens have the lateral chambers arranged in regular tiers. The chambers over the embryonic apparatus have low slitlike cavities, whereas those near the periphery have open rectangular cavities.

Miss Caudri (1934, p. 97) compared specimens from Soemba with *A. pentagonalis* Deprat. The description which she gave of these specimens demonstrates that they are similar to the Saipan specimens. Although she hesitated to assign her specimens to Deprat's species, it appears from the variation shown by the Saipan specimens that they should be.

Hanzawa refers similar Saipan specimens to *Discocyclina* cf. *D. molengraaffi* Henrici.

## LOCALITIES AND TYPE NUMBERS

*Localities and type numbers*

[See pl. 4 for locality data]

| USGS permanent locality numbers | Field locality numbers | USNM type numbers |
|---|---|---|
| **Eocene** | | |
| f11471 | B19 | |
| f11472 | B20 | |
| f21021 | B22 | |
| f21022 | B23 | |
| f21023 | B51 | |
| f21024 | B56 | |
| f21025 | B65 | |
| f21026 | B69 | |
| f21027 | B77 | |
| f21028 | B78 | |
| f21029 | B80 | |
| f21030 | B85 | |
| f21031 | B110 | |
| f21032 | B111 | |
| f21033 | B176 | 624496 |
| f21034 | B211 | |
| f21035 | B221 | |
| f21036 | B251 | |
| f21037 | C9 | 624466, 624468 |
| f21038 | C10 | |
| f21039 | C21 | |
| f21040 | C22 | 624476 |
| f21041 | C64 | |
| f21043 | S33 | 624454, 624470 |
| f21044 | S74 | |
| f21045 | S79 | 624522 |
| f21046 | S88 | 624464, 624508 |
| f21047 | S90 | |
| f21048 | S100 | 624449, 624458, 624459, 624483, 624491, 624698 to 624702, 624706, 624707, 624709 |
| f21049 | S101 | |
| f21050 | S103 | |
| f21051 | S125 | 624732, 624734 |
| f21052 | S132 | 624525 |
| f21053 | S133 | 624514, 624736 |
| f21054 | S134 | 624452, 624455, 624461, 624489, 624490, 624493, 624739 |
| f21055 | S150 | |
| f21056 | S163 | |
| f21057 | S170 | 624511, 624520 |
| f21058 | S188 | 624448, 624450, 624453, 624456, 624482, 624485, 624712, 624714 |
| f21059 | S189 | 624746 |
| f21060 | S190 | |
| f21061 | S191 | 624445, 624446, 624460, 624467, 624469 |
| f21062 | S194 | |
| f21063 | S201 | |
| f21064 | S202 | 624741 |
| f21065 | S208 | |
| f21067 | S212 | |
| f21069 | S214 | 624513 |
| f21071 | S217 | |
| f21072 | S219 | |
| f21073 | S222 | |
| f21074 | S223 | 624515 |
| f21075 | S227 | 624480, 624509 |
| f21076 | S241 | 624477 |
| f21077 | S242 | |
| f21078 | S247 | |
| f21079 | S248 | |
| f21080 | S251 | 624471, 624475, 624478 |
| f21081 | S253 | 624731 |
| f21082 | S254 | 624479, 624487, 624512 |
| f21083 | S256 | |
| f21084 | S258 | |
| f21085 | S259 | 624447, 624451, 624457, 624463, 624484, 624492, 624523, 624524, 624703–624705, 624708, 624710, 624711, 624713, 624715–624724, 624740, 624745 |
| f21086 | S262 | |
| f21087 | S268 | |
| f21088 | S270 | 624474, 624488 |
| f21089 | S271 | 624518, 624521 |
| f21091 | S282 | |
| f21093 | S286 | 624737 |
| f21094 | S287 | |
| f21095 | S288 | 624465, 624472 |
| f21096 | S290 | 624519 |
| f21097 | S291 | |
| f21098 | S292 | 624733 |
| f21099 | S307 | |
| f21100 | S308 | |
| f21101 | S310 | |
| f21102 | S311 | 624510 |
| f21103 | S315 | |
| f21104 | S318 | 624517 |
| f21105 | S319 | 624481 |
| f21106 | S321 | 624473 |
| f21107 | S335 | |
| **Eocene—Continued** | | |
| f21108 | S336 | 624486 |
| f21109 | S338 | 624516 |
| f21110 | S340 | |
| f21111 | S341 | 624462, 624526 |
| f21112 | S342 | |
| f21114 | S345 | |
| f21117 | S349 | |
| f21118 | S351 | |
| f21119 | S359 | |
| f21121 | S364 | |
| f21123 | S369 | |
| f21124 | S381 | |
| f21127 | S592 | |
| f21130 | S603 | |
| f21131 | S604 | 624735, 624738 |
| f21132 | S631 | |
| **Miocene** | | |
| f21135 | B1 | 624616 |
| f21136 | B2 | 624649 |
| f21137 | B3 | 624592, 624615 |
| f21138 | B4 | |
| f21139 | B5 | |
| f21140 | B6 | |
| f21141 | B7 | |
| f21142 | B8 | |
| f21143 | B9 | |
| f21144 | B10 | |
| f21145 | B11 | |
| f21146 | B12 | |
| f21147 | B13 | |
| f21148 | B14 | |
| f21149 | B15 | 624648 |
| f21150 | B16 | |
| f21151 | B24a | |
| f21152 | B27 | |
| f21153 | B29 | 624591 |
| f21154 | B34 | |
| f21155 | B35 | |
| f21156 | B37 | |
| f21157 | B40 | |
| f21158 | B42 | |
| f21159 | B44 | |
| f21160 | B46 | |
| f21161 | B47 | |
| f21162 | B49 | |
| f21163 | B50 | 624538 |
| f21164 | B52 | |
| f21165 | B55 | 624620 |
| f21166 | B57 | |
| f21167 | B59 | |
| f21168 | B60 | |
| f21169 | B61 | |
| f21170 | B66 | |
| f21171 | B73 | |
| f21172 | B76 | |
| f21173 | B79 | 624540 |
| f21174 | B82 | |
| f21175 | B84 | |
| f21176 | B86 | |
| f21177 | B88 | |
| f21178 | B89 | |
| f21179 | B90 | |
| f21180 | B91 | |
| f21181 | B92 | |
| f21182 | B93 | |
| f21183 | B94 | |
| f21184 | B95 | |
| f21185 | B96 | |
| f21186 | B98 | |
| f21187 | B99 | |
| f21188 | B101 | 624550 |
| f21189 | B103 | 624555 |
| f21190 | B104 | |
| f21191 | B016 | |
| f21192 | B108 | |
| f21193 | B109 | |
| f21194 | B112 | |
| f21195 | B113 | |
| f21196 | B114 | |
| f21197 | B115 | |
| f21198 | B116 | |
| f21199 | B117 | |
| f21200 | B118 | |
| f21201 | B119 | |
| f21202 | B120 | |
| f21203 | B121 | |
| f21204 | B122 | |
| f21205 | B123 | |
| f21206 | B124 | |
| f21207 | B125 | |

*Localities and type numbers*—Continued

| USGS permanent locality numbers | Field locality numbers | USNM type numbers |
|---|---|---|
| **Miocene—Continued** | | |
| f21208 | B126 | 624556 |
| f21209 | B127 | |
| f21210 | B128 | |
| f21211 | B129 | |
| f21212 | B130 | |
| f21213 | B131 | |
| f21214 | B132 | |
| f21215 | B133 | |
| f21216 | B134 | |
| f21217 | B135 | 624585 |
| f21218 | B136 | 624577, 624623 |
| f21219 | B137 | |
| f21220 | B138 | 624558, 624579, 624588, 624590, 624593 |
| f21221 | B139 | |
| f21222 | B140 | |
| f21223 | B141 | |
| f21224 | B143 | |
| f21225 | B144 | |
| f21226 | B145 | |
| f21227 | B146 | |
| f21228 | B147 | |
| f21229 | B148 | |
| f21230 | B149 | |
| f21231 | B150 | |
| f21232 | B151 | |
| f21233 | B152 | |
| f21234 | B153 | |
| f21235 | B154 | |
| f21236 | B155 | 624619 |
| f21237 | B156 | |
| f21238 | B157 | 624432 |
| f21239 | B158 | |
| f21240 | B159 | |
| f21241 | B160 | |
| f21242 | B161 | 624586 |
| f21243 | B162 | 624416, 624595 |
| f21244 | B163 | |
| f21245 | B164 | |
| f21246 | B165 | |
| f21247 | B166 | 624600, 624601 |
| f21248 | B167 | |
| f21249 | B168 | |
| f21250 | B169 | |
| f21251 | B170 | 624497, 624628 |
| f21252 | B171 | |
| f21253 | B172 | |
| f21254 | B173 | |
| f21255 | B174 | |
| f21256 | B175 | |
| f21257 | B177 | 624574 |
| f21258 | B178 | |
| f21259 | B183 | |
| f21260 | B186 | |
| f21261 | B187 | 624670, 624688 |
| f21262 | B195 | |
| f21263 | B197 | |
| f21264 | B198 | |
| f21265 | B200 | |
| f21266 | B201 | |
| f21267 | B202 | |
| f21268 | B203 | |
| f21269 | B204 | |
| f21270 | B205 | |
| f21271 | B206 | |
| f21272 | B207 | |
| f21273 | B208 | |
| f21274 | B209 | |
| f21275 | B210 | |
| f21276 | B212 | |
| f21277 | B213 | |
| f21278 | B214 | 624546 |
| f21279 | B216 | |
| f21280 | B217 | |
| f21281 | B218 | |
| f21282 | B219 | |
| f21283 | B220 | |
| f21284 | B222 | |
| f21285 | B223 | |
| f21286 | B224 | 624536, 624633, 624637, 624640, 624642 |
| f21287 | B225 | 624644 |
| f21288 | B228 | |
| f21289 | B236 | |
| f21290 | B237 | 624527 |
| f21291 | B238 | 624530 |
| f21292 | B239 | |
| f21293 | B240 | |
| f21294 | B241 | |
| f21295 | B242 | |
| f21296 | B243 | |
| f21297 | B244 | 624529 |
| f21298 | B245 | |
| f21299 | B246 | 624547 |
| f21300 | B247 | 624548, 624552 |
| f21301 | B248 | |
| f21302 | B249 | |

*Localities and type numbers*—Continued

| USGS permanent locality numbers | Field locality numbers | USNM type numbers |
|---|---|---|
| **Miocene—Continued** | | |
| f21303 | B252 | |
| f21304 | B254 | 624528, 624682, 624689 |
| f21305 | B255 | |
| f21306 | B258 | |
| f21307 | B260 | |
| f21308 | B261 | 624569, 624611 |
| f21309 | B262 | |
| f21310 | B264 | |
| f21311 | B265 | |
| f21312 | B270 | |
| f21313 | B276 | |
| f21314 | B277 | |
| f21315 | B278 | |
| f21316 | B279 | 624554 |
| f21317 | B281 | 624606, 624621 |
| f21318 | B283 | |
| f21319 | B284 | 624617 |
| f21320 | B290 | 624622 |
| f21321 | B291 | 624433 |
| f21322 | B295 | |
| f21323 | B296 | |
| f21324 | B298 | |
| f21325 | B301 | 624632, 624634 |
| f21326 | B302 | |
| f21327 | B303 | 624597, 624604 |
| f21328 | B304 | |
| f21329 | B305 | |
| f21330 | B306 | |
| f21331 | B307 | |
| f21332 | B308 | |
| f21333 | B309 | |
| f21334 | B310 | 624549 |
| f21335 | B311 | |
| f21336 | B312 | 624584, 624630 |
| f21337 | B313 | |
| f21338 | B314 | |
| f21339 | B315 | 624412, 624418, 624561 |
| f21340 | B316 | 624631, 624636 |
| f21341 | B320 | 624572, 624576 |
| f21342 | B322 | |
| f21343 | B323 | 624499 |
| f21344 | B325 | |
| f21347 | B341 | 624553 |
| f21348 | B342 | 624623 |
| f21349 | B343 | |
| f21350 | B344 | |
| f21351 | B345 | |
| f21352 | B346 | |
| f21353 | B347 | |
| f21354 | B348 | |
| f21355 | B349 | |
| f21356 | B350 | |
| f21357 | B351 | |
| f21358 | B352 | |
| f21359 | B353 | |
| f21360 | B354 | 624436 |
| f21361 | B355 | 624437–624440 |
| f21362 | B356 | |
| f21363 | B357 | 624562 |
| f21364 | B358 | |
| f21365 | B359 | |
| f21366 | B360 | |
| f21367 | B361 | |
| f21368 | B362 | 624567 |
| f21369 | B363 | |
| f21370 | B364 | 624419 |
| f21371 | B365 | |
| f21372 | B366 | |
| f21373 | B367 | |
| f21374 | B368 | |
| f21375 | B369 | |
| f21376 | B370 | |
| f21377 | B371 | |
| f21378 | B372 | |
| f21379 | B373 | 624578, 624587 |
| f21380 | B375 | |
| f21381 | B376 | |
| f21382 | B377 | |
| f21383 | B378 | |
| f21384 | B380 | |
| f21385 | B382 | |
| f21386 | B383 | |
| f21387 | B385 | |
| f21388 | B386 | |
| f21389 | B387 | |
| f21390 | B388 | |
| f21391 | B389 | |
| f21392 | B390 | |
| f21393 | B391 | 624612, 624613, 624635, 624638, 624639, 624643 |
| f21394 | B392 | 624435 |
| f21396 | B394 | 624570 |
| f21397 | B395 | 624614, 624641 |
| f21398 | B396 | |

*Localities and type numbers*—Continued

| USGS permanent locality numbers | Field locality numbers | USNM type numbers |
|---|---|---|
| **Miocene—Continued** | | |
| f21399 | B397 | |
| f21400 | B398 | |
| f21401 | B399 | |
| f21402 | B400 | b24500, 624557 |
| f21403 | B402 | |
| f21404 | B403 | |
| f21405 | B404 | |
| f21406 | B408 | |
| f21407 | B410 | |
| f21408 | B411 | |
| f21409 | B412 | |
| f21410 | B413 | 624424–624426, 624582, 624626, 624627, 624657, 624662, 624663, 624673–624675, 624681, 624695 |
| f21411 | B414 | |
| f21412 | B415 | |
| f21413 | B416 | |
| f21414 | B417 | |
| f21415 | B418 | |
| f21416 | B419 | 624560 |
| f21417 | B420 | 624563, 624565 |
| f21418 | B421 | |
| f21419 | B422 | |
| f21420 | B423 | 624629 |
| f21421 | B424 | |
| f21422 | B425 | |
| f21423 | B426 | |
| f21424 | B427 | |
| f21425 | B428 | |
| f21426 | B429 | 624744 |
| f21427 | B431 | |
| f21428 | B432 | |
| f21429 | B433 | 624423, 624742, 624743 |
| f21430 | B434 | |
| f21431 | B435 | 624441 |
| f21432 | C1 | |
| f21433 | C14 | |
| f21434 | C16 | 624430, 624431, 624539 |
| f21435 | C18 | |
| f21436 | C19 | |
| f21437 | C23 | |
| f21438 | C24 | |
| f21439 | C27 | |
| f21440 | C30 | |
| f21441 | C32 | |
| f21442 | C36 | |
| f21445 | C55 | |
| f21446 | C56 | |
| f21448 | C62 | |
| f21451 | C71 | |
| f21452 | C72 | |
| f21453 | C73 | |
| f21454 | C74 | |
| f21455 | C76 | |
| f21456 | C82 | |
| f21457 | C87 | |
| f21458 | C88 | |
| f21459 | C89 | 624625 |
| f21460 | C90 | |
| f21461 | C91 | |
| f21462 | C92 | |
| f21463 | C93 | |
| f21464 | C95 | |
| f21465 | C96 | |
| f21466 | C97 | |
| f21467 | C98 | |
| f21468 | C100 | |
| f21469 | C102b | 624559, 624564, 624566, 624568 |
| f21470 | C103 | |
| f21471 | C104 | |
| f21472 | C105 | |
| f21473 | C106 | |
| f21474 | C107 | |
| f21475 | C109 | |
| f21476 | C111 | |
| f21477 | C112 | |
| f21478 | C113 | 624544, 624545 |
| f21479 | C115 | |
| f21480 | C117 | 624434 |
| f21481 | C118 | |
| f21482 | C119 | |
| f21483 | C120 | |
| f21484 | C121 | 624427–624429, 624671 |
| f21485 | C122 | |
| f21486 | C123 | |
| f21487 | C125 | |
| f21488 | C126 | |
| f21489 | C127 | |
| f21490 | C128 | |
| f21491 | C129 | |
| f21492 | C130 | |
| f21493 | C131 | 624583 |
| f21494 | C132 | 624573 |
| f21495 | C133 | |

*Localities and type numbers*—Continued

| USGS permanent locality numbers | Field locality numbers | USNM type numbers |
|---|---|---|
| **Miocene—Continued** | | |
| f21496 | C135 | |
| f21498 | C137 | |
| f21499 | C138 | |
| f21500 | C139 | |
| f21501 | C140 | 624542, 624571 |
| f21502 | C141 | |
| f21503 | C142 | |
| f21504 | C143 | |
| f21505 | C144 | |
| f21506 | C145 | 624410, 624411 |
| f21507 | C146 | |
| f21508 | C147 | |
| f21509 | C148 | |
| f21510 | S6 | |
| f21511 | S8 | |
| f21512 | S11 | |
| f21513 | S12 | |
| f21515 | S61 | |
| f21516 | S62 | |
| f21517 | S64 | |
| f21518 | S65 | |
| f21520 | S85 | 624531, 624532 |
| f21521 | S126 | |
| f21522 | S127 | |
| f21523 | S145 | |
| f21526 | S149 | |
| f21527 | S164 | 624602 |
| f21528 | S165 | 624413, 624415, 624533, 624534 |
| f21529 | S166 | |
| f21530 | S168 | |
| f21531 | S203 | 624605 |
| f21532 | S204 | |
| f21533 | S205 | |
| f21534 | S206 | |
| f21535 | S224 | |
| f21536 | S228 | |
| f21537 | S239 | |
| f21538 | S240 | |
| f21539 | S243 | |
| f21540 | S244 | |
| f21541 | S246 | |
| f21542 | S249 | |
| f21543 | S250 | |
| f21544 | S255 | |
| f21545 | S257 | |
| f21546 | S260 | |
| f21547 | S263 | |
| f21548 | S264 | 624414, 624417 |
| f21549 | S289 | |
| f21550 | S309 | |
| f21551 | S312 | 624498 |
| f21552 | S320 | |
| f21553 | S323 | |
| f21554 | S328 | |
| f21555 | S339 | |
| f21556 | S360 | |
| f21557 | S371 | |
| f21558 | S378 | |
| f21559 | S386 | |
| f21560 | S416 | |
| f21561 | S421 | |
| f21562 | S422 | |
| f21565 | S470 | |
| f21566 | S471 | |
| f21567 | S478 | |
| f21568 | S511 | |
| f21569 | S536 | |
| f21570 | S540 | 624420–624422 |
| f21571 | S541 | |
| f21574 | S585 | 524603 |
| f21575 | S589 | |
| f21576 | S616 | |
| f21577 | S619 | |
| f21579 | S651 | |
| f21580 | S656 | |
| f21581 | S664 | |
| f11473 | S667 | 624537, 624541, 624543 |
| f21583 | S668 | |
| f21584 | S669 | |
| f21585 | S671 | |
| f21586 | S672 | 624442–624444, 624507, 624608, 624618 |
| f21587 | S674 | 624607 |
| f21589 | S683 | |
| f21590 | S684 | |
| f21591 | S685 | |
| f21592 | S686 | |
| f21593 | S687 | |
| f21594 | S701 | 624501–624504, 624506, 624551, 624575, 624609, 624610, 624645–624647, 624651, 624652, 624654–624656, 624658, 624659, 624, 664 to 624669, 624672, 624676–624679, 624683–624687, 624697 |
| f21595 | S704 | 624505 |

*Localities and type numbers*—Continued

| USGS permanent locality numbers | Field locality numbers | USNM type numbers |
|---|---|---|
| **Pleistocene** | | |
| f21597 | B28 | |
| f21598 | B38 | 624726, 624729 |
| f21599 | B64 | |
| f21600 | B179 | |
| f21601 | B181 | |
| f21602 | B188 | |
| f21603 | B192 | |
| f21604 | B193 | |
| f21605 | B215 | |
| f21606 | B226 | |
| f21607 | B227 | 624730 |
| f21608 | B229 | |
| f21609 | B230 | |
| f21610 | B231 | 624725, 624727 |
| f21611 | B232 | |
| f21612 | B233 | |
| f21613 | B234 | |
| f21614 | B235 | 624728 |
| f21615 | B282 | |
| f21616 | B286 | |
| f21617 | B287 | |
| f21618 | B293 | |
| f21619 | B294 | 624494, 624495 |
| f21620 | B299 | |
| f21621 | B300 | |
| f21622 | B317 | |
| f21623 | B318 | |
| f21624 | B321 | |
| f21625 | B324 | |
| f21626 | B328 | |
| f21627 | B331 | |
| f21628 | B334 | |
| f21629 | B338 | |
| f21630 | B340 | |
| f21631 | B406 | |
| f21632 | C49 | |
| f21633 | C50 | |
| f21634 | C52 | |
| f21635 | C54 | |
| f21636 | C59 | |
| f21637 | C61 | |
| f21638 | C65 | |
| f21639 | C66 | |
| f21640 | C67 | |
| f21641 | C68 | |
| f21642 | C75 | |
| f21643 | C77 | |
| f21644 | C78 | |
| f21645 | C80 | |
| f21646 | S417 | |
| f21647 | S430 | |
| f21648 | S452b | |
| f21649 | S564 | |
| f21650 | S568 | |
| f21651 | S611 | |
| f21652 | S613 | |
| f21653 | S622 | |
| f21654 | S630 | |
| f21655 | S670 | |
| f21656 | S676 | |
| f21657 | S677 | |
| f21658 | S678 | |
| f21659 | S681 | |
| f21660 | S690 | |
| f21661 | S691 | |
| f21662 | S697 | |
| f21663 | S699 | |

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# INDEX

[Italic numbers indicate descriptions


A

Page

Abstract 321
*absurda, Biplanispira* 333
*abunensis, Conomiogypsinoides* 339
*Miogypsina* 339, 340
*Miogypsinoides* 340
*aduncus, Archaias* 335
*advena, Pseudophragmina (Proporocyclina)* 349
*Alveolina pygmaea* 336
*Alveolinella globulosa* 336
*(Flosculinella) glotulosa* 336
*ammonoides, Operculina* *330*, 331, pl. 94
*Amphistegina madagascariensis* 327
*angularis, Lepidocyclina (Nephrolepidina)* *342*, pl. 107
*Orbitoides (Lepidocyclina)* 342
*angulatus, Archaias* 335
*angulosa, Lepidocyclina (Nephrolepidina)* 343
*Archaias aduncus* 335
*angulatus* 335
*vandervlerki* *335*, pl. 103
*Assilina madarazi orbitoidea* 333
*Asterocyclina incisuricamerata* 323, *349*, pl. 117
*lanceolata* 350
*matanzensis* 323, *350*, pls. 117, 118
*penuria* 323, *350*, pl. 116
*pentagonalis* 350, 351
*soeroeanensis* 350
*Austrotrillina howchini* 327, *329*, pl. 101

*Baculogypsina* 327
*sphaerulata* *336*, pl. 118
*badjirraensis, Lepidocyclina (Eulepidina)* *345*, pls. 108, 109
*bantamensis, Miogypsinoides* 325, 327, *338*, pls. 110, 111
*Miogypsinoides complanata* 338
*bartschi, Operculina* *330*, pl. 94
Bibliography 355–356
*bikiniensis, Halkyardia* 323, *336*, pl. 102
*Biplanispira absurda* 333
*fulgeria* 323, *333*, pl. 98
*hoffmeisteri* 323, *334*, pl. 100
*inflata* 334
*miratilis* 323, *334*, pls. 99, 100
*depressa* 334
*elliptica* 334
*boninensis, Eorupertia* 337, pl. 103
*Borelis melo* 336
*parvulus* 336
*pygmaeus* 323, *336*, pls. 102, 110
*borneensis, Heterostegina* 324, 325, 327, *331*, pl. 95
*bridgei, Lepidocyclina (Eulepidina)* 345
*brouweri, Lepidocyclina* 342
*Lepidocyclina (Nephrolepidina)* 324, *342*, 343, pl. 105

C

*Calcarina* 327
*spengleri* *336*, pl. 118
*Camerina djokdjokarta* 323, *329*, pl. 102
*djokdjokartae* 329
*saipanensis* 233, *330*, pl. 102
Camerinidae 329
*carpenteri, Cycloclypeus (Cycloclypeus)* 327, *334*, pl. 101
*Carpenteria* 337
*conoidea* 338
*proteiformis plecte* 337
*chaperi, Lepidocyclina (Nephrolepidina)* 346, 347

Page

*complanata, Lenticulites* 330
*Operculina* *330*, pls. 94, 118
*complanata bantamensis, Miogypsinoides* 338
*conoidea, Carpenteria* 338
*Conomiogypsinoides* 340
*abunensis* 339
*cookei, Dictyoconus* 329
*crassicolumnata, Pellatispira* 333
*cupulaeformis, Miogypsina* 340
*Cycloclypeus posteidae dodekasepta* 335
*(Cycloclypeus) carpenteri* 327, *334*, pl. 101
*eidae* *334*, pl. 101
*indopacificus* *334*, pl. 101
*posteidae* *334*, pl. 101
*(Katacycloclypeus)* 321, 342
*transiens* 325, *335*, pl. 101
*(Cycloclypeus) carpenteri, Cycloclypeus* 327, *334*, pl. 101
*(Cycloclypeus) eidae, Cycloclypeus* *334*, pl. 101
*(Cycloclypeus) indopacificus, Cycloclypeus* *334*, pl. 101
*(Cycloclypeus) posteidae, Cycloclypeus* *334*, pl. 101
*cylindricum, Sporadotrema* 338

D

*dehaartii, Miogypsina* 339, 340
*Miogypsina (Miogypsinoides)* 339
*Miogypsinoides* 324, 327, *339*, pl. 111
*dehaartii formosensis, Miogypsinoides* 339
*depressa, Biplanispira mirabilis* 334
*Dictyoconus cookei* 329
*saipanensis* 323, *329*, pl. 101
*disca, Gypsina* *337*
*Discocyclina molengraaffi* 351
*omphala* 323
*omphalus selliformis* 324, 349
*umbilicata* 348
sp. A 348
sp. B 350
*(Discocyclina) indopacifica* 348
*omphala* *347*, pl. 115
*(Discocyclina) indopacifica, Discocyclina* 348
*(Discocyclina) omphala, Discocyclina* *347*, pl. 115
*dispansa, Orthophragmina* 348
Distribution of larger Foraminifera on Saipan, Eocene 322 (tab.)
Miocene 324 (tab.)
Pleistocene 326 (tab.)
*djokdjokarta, Camerina* 323, *329*, pl. 102
*djokdjokartae, Camerina* 329
*Nummulina* 329
*dodekasepta, Cycloclypeus posteidae* 335

E

*eidae, Cycloclypeus (Cycloclypeus)* *334*, pl. 101
*elliptica, Biplanispira mirabilis* 334
Eocene, distribution of Foraminifera in 322 (tab.)
number of occurrences of species in 323 (tab.)
stratigraphic paleontology 323, 324
type numbers and localities 352
*Eorupertia* 337
*boninensis* 337, pl. 103
*plecte* 323, *337*, pl. 102
*semiornata* 327, *338*, pl. 103
*ephippioides, Lepidocyclina* 343, 346, 347
*Lepidocyclina (Eulepidina)* *346*, pls. 108, 09
*Orbitoides (Lepidocyclina)* 346
*Eulepidina* 342
*(Eulepidina), Lepidocyclina* 324, 342

Page

*(Eulepidina) badjirraensis, Lepidocyclina* ... *345*, pls. 108, 109
*(Eulepidina) bridgei, Lepidocyclina* ... 345
*(Eulepidina) ephippioides, Lepidocyclina* ... *346*, pls. 108, 109
*(Eulepidina) formosa, Lepidocyclina* ... 346
*(Eulepidina) gibbosa, Lepidocyclina* ... 346
*(Eulepidina) manduensis, Lepidocyclina* ... 345
*(Eulepidina) planata, Lepidocyclina* ... 346
*(Eulepidina) saipanensis, Lepidocyclina* ... 345
*Eulepidina-Spiroclypeus* fauna ... 325

F

*Fabiania saipanensis* ... 323, 327, *337*, pls. 102, 118
*favosa, Lepidocyclina* ... 343, 347
*Flosculinella* ... 325
  *globulosa* ... 324, 335, *336*, pl. 110
  *reicheli* ... 336
*(Flosculinella) globuloso, Alveolinella* ... 336
*formosa, Lepidocyclina* ... 347
  *Lepidocyclina (Eulepidina)* ... 346
*formosensis, Miogypsinoides* ... 339, 340
  *Miogypsinoides dehaartii* ... 339
*fulgeria, Biplanispira* ... 323, *333*, pl. 98
  *Pellatispira* ... 333

G

*gibbosa, Lepidocyclina* ... 347
  *Lepidocyclina (Eulepidina)* ... 346
*globulosa, Alveolinella* ... 336
  *Alveolinella (Flosculinella)* ... 336
  *Flosculinella* ... 324, 335, *336*, pl. 110
*Gunteria* ... 337
*Gypsina disca* ... *337*
  *marianensis* ... *337*, pl. 103

H

*Halkyardia bikiniensis* ... 323, *336*, pl. 102
Hanzawa identifications, comparison with ... 327-329
*Heterostegina borneensis* ... 324, 325, 327, *331*, pl. 95
*saipanensis* ... 323, *331*, 333, pl. 102
*suborbicularis* ... 327
  sp ... 343
*higginsi, Spiroclypeus* ... 324, *332*, pls. 95, 109
*hoffmeisteri, Biplanispira* ... 323, *334*, pl. 100
  *Pellatispira* ... 334
*Hofkerina* ... 337
  *semiornata* ... 338
*howchini, Austrotrillina* ... 327, *329*, pl. 101

I

*incisuricamerata, Asterocyclina* ... 323, *349*, pl. 117
*indopacifica, Discocyclina (Discocyclina)* ... 348
*indopacificus, Cycloclypeus (Cycloclypeus)* ... *334*, pl. 101
*inflata, Biplanispira* ... 334
  *Miogypsina* ... 340
  *Miogypsina (Miogypsina)* ... 341
  *Pellatispira* ... 333
*inornata, Lepidocyclina sumatrensis* ... 343
Introduction ... 321
*irregularis, Miogypsina* ... 340
  *Miogypsina (Miogypsina)* ... 341

J

*javana, Orthophragmina* ... 347

K

*Katacycloclypeus* ... 342
*(Katacycloclypeus), Cycloclypeus* ... 321, 342
*(Katacycloclypeus) transiens, Cycloclypeus* ... 325, *335*, pl. 101
*kotoi, Miogypsina* ... 340

L

*lanceolata, Asterocyclina* ... 350
*larvata, Planorbulinella* ... 323, *337*, pl. 102
*lateralis, Miogypsinoides* ... 338
*Lenticulites complanata* ... 330
*Lepidocyclina brouweri* ... 342
  *ephippioides* ... 343, 346, 347
  *favosa* ... 343, 347
  *formosa* ... 347
  *gibbosa* ... 347

Page

*Lepidocyclina brouweri*—Continued
  *monstrosa* ... 347
  *morgani* ... 343
  *parva* ... 343
  *sumatrensis inornata* ... 343
    *minor* ... 343
  *undosa* ... 347
  *verrucosa* ... 345
  *yurnagunensis* ... 343
*(Eulepidina)* ... 324, 342
  *badjirraensis* ... *345*, pls. 108, 109
  *bridgei* ... 345
  *ephippioides* ... *346*, pls. 108, 109
  *formosa* ... 346
  *gibbosa* ... 346
  *manduensis* ... 345
  *planata* ... 346
  *saipanensis* ... 345
(Nephrolepidina) *angularis* ... *342*, pl. 107
  *angulosa* ... 343
  *brouweri* ... 324, *342*, 343, pl. 105
  *chaperi* ... 346, 347
  *newtoni* ... 346
  *nipponica* ... 345, pls. 106, 107
  *parva* ... 327, *343*, pls. 104, 107
  *sumatrensis* ... *343*, pls. 104, 105, 106, 109
  *verbeeki* ... 324, 327, 342, *344*, pls. 106, 107, 109
    *verrucosa* ... 324, *345*, pls. 105, 109
*(Lepidocyclina) angularis, Orbitoides* ... 342
*(Lepidocyclina) ephippioides, Orbitoides* ... 346
*(Lepidocyclina) verbeeki, Orbitoides* ... 344
*Lepidosemicyclina thecideaeformis* ... 340
*leupoldi, Spiroclypeus* ... 332
Localities ... 352-355
Localities, Eocene ... 323 (tab.)
Localities, Miocene ... 325 (tab.)

M

*madagascariensis, Amphistegina* ... 327
*madaraszi orbitoidea, Assilina* ... 333
*madaraszi provalei, Pellatispira* ... 333
*mamillata, Miogypsina* ... 340
  *Miogypsina (Miogypsina)* ... 341
*manduensis, Lepidocyclina (Eulepidina)* ... 345
*Marginopora vertebralis* ... *335*, pl. 103
*marianensis, Gypsina* ... *337*, pl. 103
*martini, Sorites* ... *335*
*matanzensis, Asterocyclina* ... 323, *350*, pls. 117, 118
*melo, Borelis* ... 336
Miliolidae ... 329
*minor, Lepidocyclina sumatrensis* ... 343
  *Orthophragmina umbilicata* ... 347
Micocene, distribution of Larger Foraminifera in ... 324 (tab.)
  localities, number of in each paleontologic association ... 325 (tab.)
  stratigraphic paleontology ... 324-327
  type numbers and localities ... 352-354
*Miogypsina abunensis* ... 339, 340
  *cupulaeformis* ... 340
  *dehaartii* ... 339, 340
  *inflata* ... 340
  *irregularis* ... 340
  *kotoi* ... 340
  *mamillata* ... 340
  *ozawai* ... 340
  *polymorpha* ... 341
  *thecideaeformis* ... 340, 341
  *tuberosa* ... 340
  *verrucosa* ... 339, 340
  *(Miogypsina)* ... 324
    *inflata* ... 341
    *irregularis* ... 341
    *mamillata* ... 341
    *thecideaeformis* ... 324, 325, 327, *340*, pls. 112, 113, 114
  (Miogypsinoides) *dehaartii* ... 339
*(Miogypsina), Miogypsina* ... 324
*(Miogypsinoides) dehaartii, Miogypsina* ... 339
*(Miogypsina) inflata, Miogypsina* ... 341
*(Miogypsina) irregularis, Miogypsina* ... 341

Page

*(Miogypsina) mamillata, Miogypsina* 341
*(Miogypsina) thecideaeformis, Miogypsina* 324, 325, 327, *340*, pls. 112, 113, 114
*Miogypsinoides* 324
*abunensis* 340
*bantamensis* 325, 327, *338*, pls. 110, 111
*complanata bantamensis* 338
*dehaartii* 324, 327, *339*, pl. 111
*formosensis* 339
*formosensis* 339, 340
*lateralis* 338
*mirabilis, Bisplanispira* 323, *334*, pls. 99, 100
*mirabilis depressa, Biplanispira* 334
*mirabilis elliptica, Biplanispira* 334
*molengraaffi, Discocyclina* 351
*monstrosa, Lepidocyclina* 347
*morgani, Lepidocyclina* 343
*Multilepidina* 324

N

*Nautilus venosus* 330
*Nephrolepidina* 342
*(Nephrolepidina) angularis, Lepidocyclina* *342*, pl. 107
*(Nephrolepidina) angulosa, Lepidocyclina* 343
*(Nephrolepidina) brouweri, Lepidocyclina* 324, *342*, 343, pl. 105
*(Nephrolepidina) chaperi, Lepidocyclina* 346, 347
*(Nephrolepidina) newtoni, Lepidocyclina* 346
*(Nephrolepidina) nipponica, Lepidocyclina* 345, pls. 106, 107
*(Nephrolepidina) parva, Lepidocyclina* *343*, pls. 104, 107
*(Nephrolepidina) sumatrensis, Lepidocyclina* *343*, pls. 104, 105, 106, 109
*(Nephrolepidina) verbeeki, Lepidocyclina* 324, 327, 342, *344*, pls. 106, 107, 109
*(Nephrolepidina) verrucosa, Lepidocyclina* 324, *345*, pls. 105, 109
*newtoni, Lepidocyclina (Nephrolepidina)* 346
*nipponica, Lepidocyclina (Nephrolepidina)* 3455, pls. 106, 107
*Nummulina djokdjokartae* 329
*nummulitica, Orthophragmina* 350

O

Occurrences of species, number of in Eocene facies 323 (tab.)
*omphala, Discocyclina* 323
*Discocyclina (Discocyclina)* *347*, pl. 115
*Orthophragmina* 348
*omphalus, Orbitoides* 347
*omphalus selliformis, Discocyclina* 324, 349
*Operculina ammonoides* *330*, 331, pl. 94
*bartschi* *330*, pl. 94
*complanata* *330*, pls. 94, 118
*pyramidum* 331
*venosa* 330
*victoriensis* *331*, pl. 94
*Operculinella venosa* 331
*Operculinoides saipanensis* 323, *331*, pl. 102
*venosus* *331*, pl. 94
*orbitoidea, Assilina madarazi* 333
*Pellatispira* 323, *333*, pls. 96, 97, 99
*Orbitoides omphalus* 347
*(Lepidocyclina) angularis* 342
*ephippioides* 346
*verbeeki* 344
*orbitoideus, Spiroclypeus* *332*, 343, pl. 95
Orbitoididae 342
*Orthocyclina soeroeanensis* 349
*Orthophragmina dispansa* 348
*javana* 347
*nummulitica* 350
*omphala* 348
*pentagonolis* 350
*stella* 347
*umbilicota* 348, 349
*minor* 347
*varians* 348
*ozawai, Miogypsina* 340

P

*parva, Lepidocyclina* 343
*(Nephrolepidina)* 327, *343*, pls. 104, 107
*parvulus, Borelis* 336

Page

*Pellatispira crassicolumnata* 333
*fulgeria* 333
*hoffmeisteri* 334
*inflata* 333
*madaraszi provalei* 333
*orbitoidea* 323, *333*, pls. 96, 97, 99
*provaleae* 323, *335*, pls. 96, 98
*rutteni* 333
*peñonensis, Pseudophragmina (Proporocyclina)* 349
*pentagonalis, Asterocyclina* 350, 351
*Orthophragmina* 350
*penuria, Asterocyclina* 323, *350*, pl. 116
*planata, Lepidocyclina (Eulepidina)* 346
*Planorbulinella larvata* 323, *337*, pl. 102
*plecte, Carpenteria proteiformis* 337
*Eorupertia* 323, *337*, pl. 102
*Victoriella* 337, 338
Pleistocene, distribution of Foraminfera in 326 (tab.)
stratigraphic paleontology 327
type numbers and localities 355
*polymorpha, Miogypsina* 341
*posteidae, Cycloclypeus (Cycloclypeus)* *334*, pl. 101
*posteidae dodekasepta, Cycloclypeus* 335
*(Proporocyclina) advena, Pseudophragmina* 349
*(Proporocyclina) peñonensis, Pseudophragmina* 349
*proteiformis plecte, Carpenteria* 337
*provaleae, Pellatispira* 323, *333*, pls. 96, 98
*provalei, Pellatispira madaraszi* 333
*Pseudophragmina (Proporocyclina) advena* 349
*(Proporocyclina) peñonensis* 349
*Pulvinulina semiornata* 338
*pygmaea, Alveolina* 336
*Borelis* 323, *336*, pls. 102, 110
*pyramidum, Operculina* 331

R

*reicheli, Flosculinella* 336
*Reworked specimens* 327
*Rotalia schroeteriana* 338
*rutteni, Pellatispira* 333

S

*saipanensis, Camerina* 323, *330*, pl. 102
*Dictyoconus* 323, *329*, pl. 101
*Fabiania* 323, 327, *337*, pls. 102, 118
*Heterostegina* 323, *331*, pl. 102
*Lepidocyclina (Eulepidina)* 345
*Operculinoides* 323, *331*, pl. 102
*Streblus* 327, *338*, pl. 103
*schroeteriana, Rotalia* 338
*selliformis, Discocyclina omphalus* 324, 349
*semiornata, Eorupertia* 327, *338*, pl. 103
*Hofkerina* 338
*Pulvinulina* 338
*Sismondia* 327
*soeroeanensis, Asterocyclina* 350
*Orthocyclina* 349
*Sorites martini* 535
*spengleri, Calcarina* *336*, pl. 118
*sphaerulata, Baculogypsina* *336*, pl. 118
*Spiroclypeus* 324
*higginsi* 324, *332*, pls. 95, 109
*leupoldi* 332
*orbitoideus* *332*, 343, pl. 95
*tidoenganensis* 324, 325, 327, *332*, pl. 95
*vermicularis* 323, 324, *333*, pl. 102
sp. 333
*Spiroclypeus-Eulepidina* fauna 325
*Sporadotrema cylindricum* 338
*stella, Orthophragmina* 347
Stratigraphic paleontology 323–327
Eocene 323–324
Miocene 324–327
Pleistocene 327
*Streblus saipanensis* 327, *338*, pl. 103
*suborbicularis, Heterostegina* 327
*sumatrensis, Lepidocyclina (Nephrolepidina)* *343*, pls. 104, 105, 106, 109
*sumatrensis inornata, Lepidocyclina* 343
*sumatrensis minor, Lepidocyclina* 343
Systematic descriptions 329–351

T

Page

*thecideaeformis, Lepidosemicyclina* 340
*Miogypsina* 340, 341
(*Miogypsina*) 324, 325, 327, *340*, pls. 112, 113, 114
*tidoenganensis, Spiroclypeus* 324, 325, 327, *332*, pl. 95
*transiens, Cycloclypeus* (*Katacycloclypeus*) 325, *335*, pl. 101
*Trybliolepidina* 324
*tı berosa, Miogypsina* 340
Type numbers and localities 352-355

U

*umbilicata, Discocyclina* 348
*Orthophragmina* 348, 349
*umbilicata minor, Orthophragmina* 347
*undosa, Lepidocyclina* 347

V

Valvulinidae 329
*vandervlerki, Archaias* *335*, pl. 103

Page

*varians, Orthophragmina* 348
*venosa, Operculina* 330
*Operculinella* 331
*venosus, Nautilus* 330
*Operculinoides* *331*, pl. 94
*verbeeki, Lepidocyclina* (*Nephrolepidina*) 324, 327, 342, *344*, pls. 106, 107, 109
*Orbitoides* (*Lepidocyclina*) 344
*vermicularis, Spiroclypeus* 323, 324, *333*, pl. 102
*verrucosa, Lepidocyclina* 345
*Lepidocyclina* (*Nephrolepidina*) 324, *345*, pls. 105, 109
*Miogypsina* 339, 340
*vertebralis, Marginopora* *335*, pl. 103
*Victoriella* 337
*plecte* 337, 338
*victoriensis, Operculina* *331*, pl. 94

Y

*yurnagunensis, Lepidocyclina*

PLATES 94–118

## PLATE 94

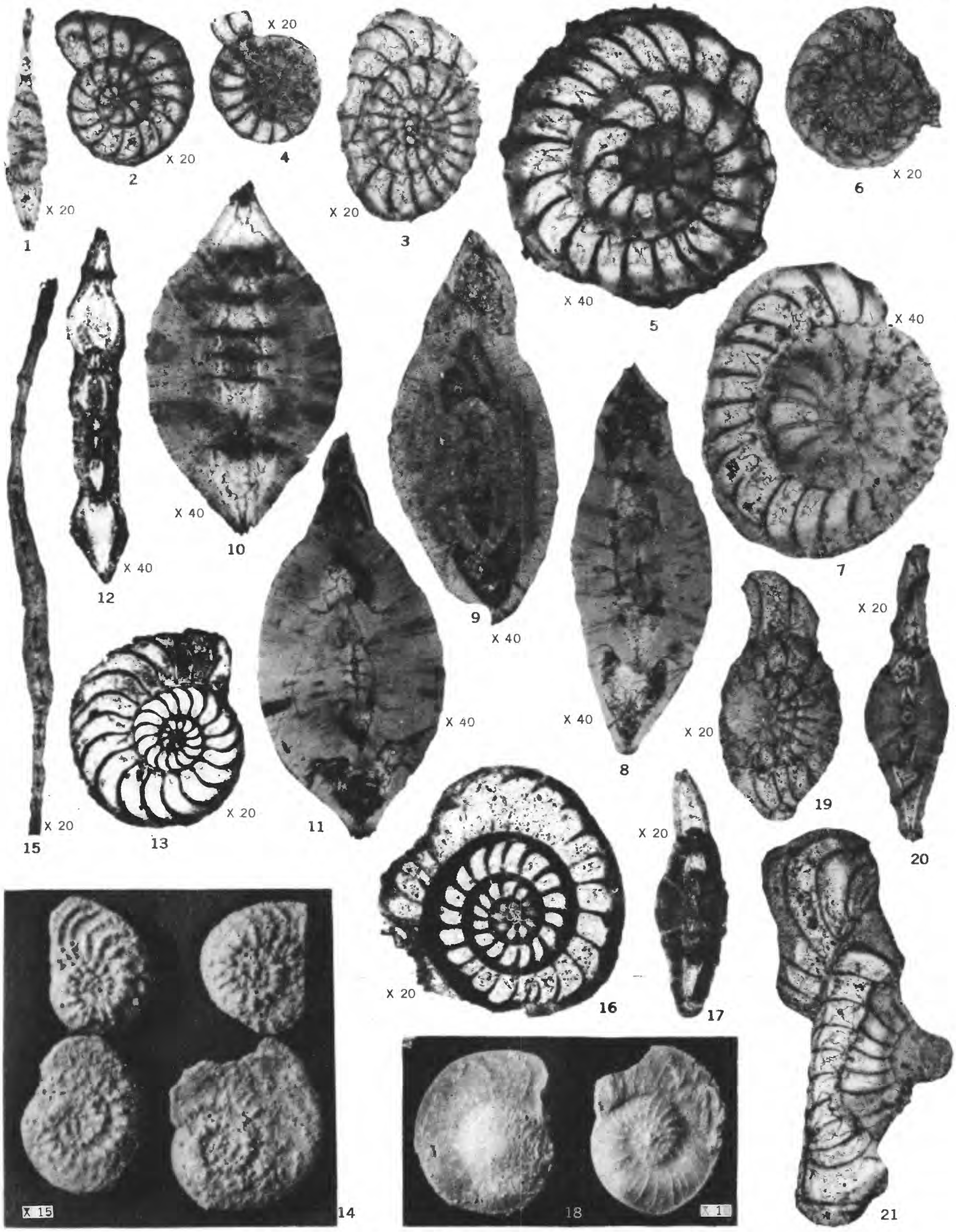
FIGURES 1–3. *Operculina victoriensis* Chapman and Parr (p. 331).
1. Transverse section; locality C145. USNM 624410.
2, 3. Median sections; locality C145. USNM 624411.

4–11. *Operculinoides venosus* (Fichtel and Moll) (p. 331).
4. Oblique median section; locality B315. USNM 624412.
5. Median section; locality S165. USNM 624413.
6. Median section; locality S264. USNM 624414.
7. Oblique median section; locality S165. USNM 624415.
8. Transverse section; locality B162. USNM 624416.
9. Transverse section; locality S264. USNM 624417.
10. Transverse section; locality B315. USNM 624418.
11. Transverse section; locality B364. USNM 624419.

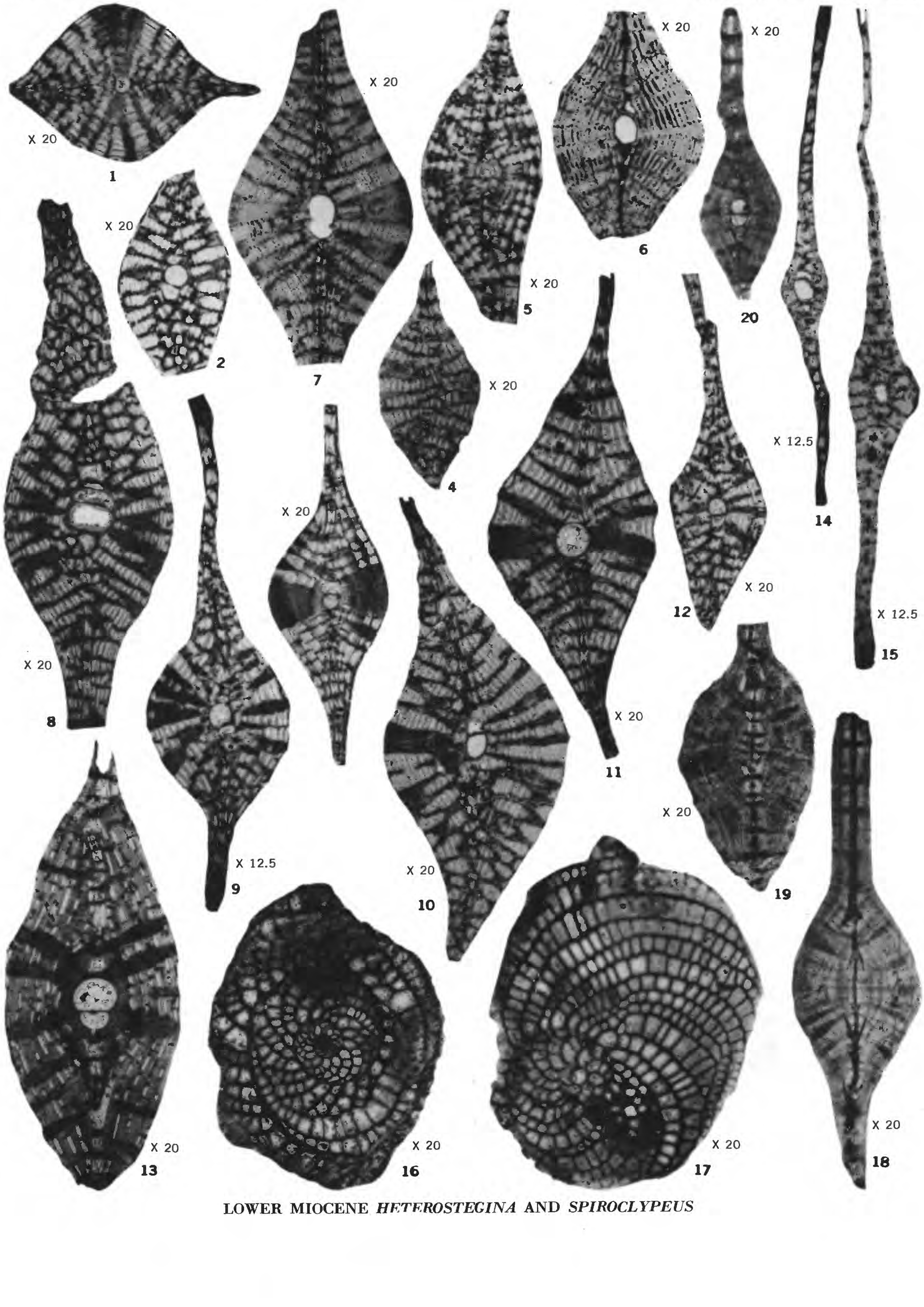
12–14. *Operculina ammonoides* (Gronovius) (p. 330).
12. Transverse section; locality S540. USNM 624420.
13. Median section; locality S540. USNM 624421.
14. External views; locality S540. USNM 624422.

15. *Operculina complanata* (Defrance) (p. 330).
Transverse section of an apparent microspheric individual; locality B433. USNM 624423.

16–21. *Operculina bartschi* Cushman (p. 330).
16. Median section; locality B413. USNM 624424.
17. Transverse section; locality B413. USNM 624425.
18. External views; locality B413. USNM 624426.
19. Oblique median section; locality C121. USNM 624427.
20. Transverse section; locality C121. USNM 624428.
21. Part of a median section of an apparent microspheric individual; locality C121. USNM 624429.




LOWER MIOCENE *OPERCULINA* AND *OPERCULINOIDES*




LOWER MIOCENE *HETEROSTEGINA* AND *SPIROCLYPEUS*

## PLATE 95

FIGURES 1–5. *Spiroclypeus higginsi* Cole (p. 332).

1. Transverse section of a globular specimen with thin floors and roofs of the lateral chambers; locality C16. USNM 624430.
2. Transverse section of a compressed specimen with very thin floors and roofs of the lateral chambers; locality C16. USNM 624431.
3. Transverse section of an umbonate specimen with strong central pillars; locality B157. USNM 624432.
4. Transverse section not centered; locality B291. USNM 624433.
5. Transverse section of a typical specimen; locality C117. USNM 624434.

6–12. *Spiroclypeus orbitoideus* H. Douvillé (p. 332).

6, 7. Transverse sections of specimens with inflated umbos; locality B392. USNM 624435.
8. Transverse section of a large specimen; locality B354. USNM 624436.
9. Transverse section of a specimen with a wide, fragile rim; locality B355. USNM 624437.
10. Transverse section; locality B429. USNM 624744.
11. Transverse section; locality B355. USNM 624438.
12. Transverse section of a compressed specimen; locality B355. USNM 624439.

13–15. *Spiroclypeus tidoenganesis* Van der Vlerk (p. 332).

13. Transverse section of a typical specimen; locality B355. USNM 624440.
14, 15. Transverse sections of thin, compressed fragile specimens; locality B435. USNM 624441.

16–20. *Heterostegina borneensis* Van der Vlerk (p. 331).

16. Median section of a microspheric specimen; locality S672. USNM 624442.
17. Median section of a megalospheric specimen; locality S672. USNM 624443.
18–20. Transverse sections; locality S672. USNM 624444.

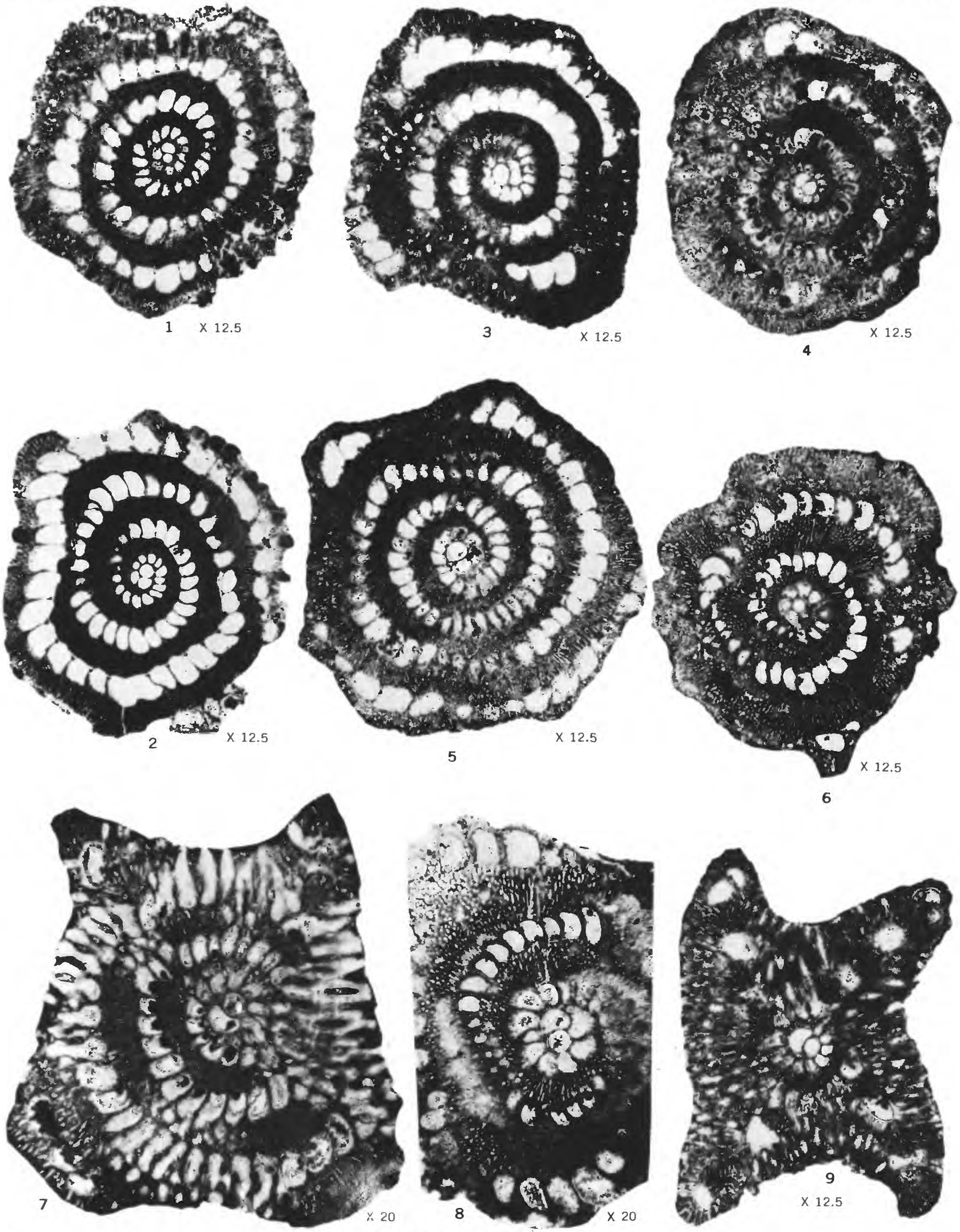
## PLATE 96

FIGURES 1, 2, 6. *Pellatispira provaleae* Yabe (p. 333).

1. Median section; locality S191. For the transverse section made from a similar specimen see plate 98, figure 11. USNM 624445.
2. Median section; locality S191. For the transverse section made from a similar specimen see plate 98, figure 9. USNM 624446.
6. Median section; locality S259. For the transverse section made from a similar specimen see plate 98, figure 5. USNM 624447.

3–5, 7–9. *Pellatispira orbitoidea* (Provale) (p. 333).

3. Median section; locality S188. For the transverse section made from a similar specimen see plate 97, figure 7. USNM 624448.
4. Median section; locality S100. For the transverse section made from a similar specimen see plate 97, figure 9. USNM 624449.
5. Median section; locality S188. For the transverse section made from a similar specimen see plate 97, figure 3. USNM 624450.
7. Median section; locality S259. For the transverse sections made from similar specimens see plate 97, figures 8, 10. USNM 624451.
8. Median section; locality S134. For the transverse section made from a similar specimen see plate 97, figure 2. USNM 624452.
9. Median section; locality S188. For the transverse section made from a similar specimen see plate 97, figure 11. USNM 624453.




UPPER EOCENE *PELLATISPIRA*


UPPER EOCENE *PELLATISPIRA*

## PLATE 97

FIGURES 1–12. *Pellatispira orbitoidea* (Provale) (p. 333).

Vertical sections to show individual variation and progressive gradation from flat, compressed, lenticular to thick, selliform individuals.

1. Locality S33. USNM 624454.
2. Locality S134. USNM 624455.
3, 7, 11. Locality S188. USNM 624456.
4–6, 8, 10. Locality S259. USNM 624457.
9. Locality S100. USNM 624458.
12. Locality S100. USNM 624459.

## PLATE 98

FIGURES 1–12. *Pellatispira provaleae* Yabe (p. 333).

1–3. External views to show differences in shape and the prominent papillae.

1, 3. Locality S191. USNM 624460.

2. Locality S134. USNM 624461.

4–12. Transverse sections

4. Locality S341. USNM 624462.

5. Locality S259. USNM 624463.

6. Locality S88. USNM 624464.

7. Locality S288. USNM 624465.

8. Locality C9*a*. USNM 624466.

9. Locality S191. USNM 624467.

10. Locality C9*a*. USNM 624468.

11. Locality S191. USNM 624469.

12. Locality S33. USNM 624470.

13–18. *Biplanispira fulgeria* (Whipple) (p. 333).

Parts of transverse sections to show the variable development of the marginal cord.

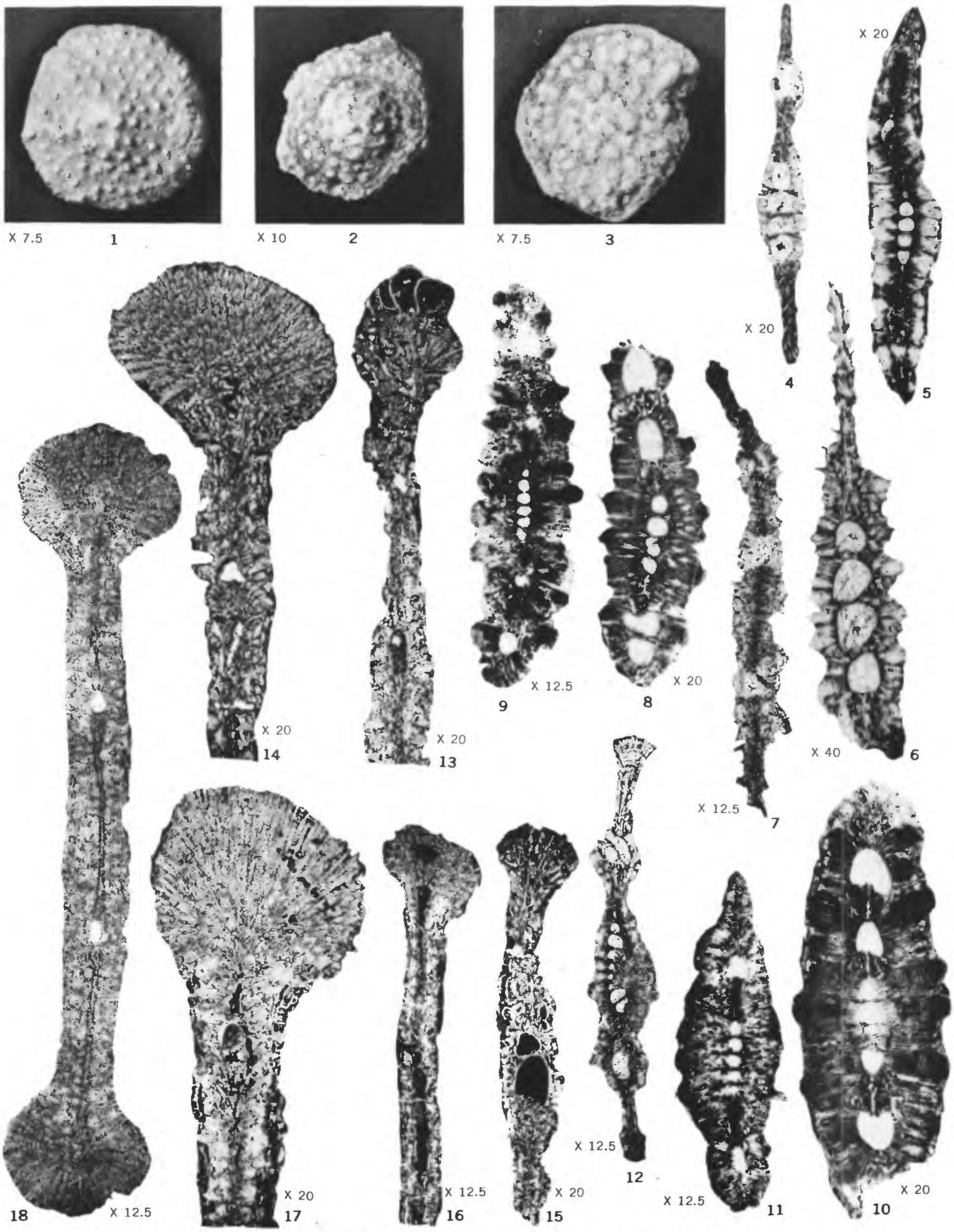
13, 14. Locality S251. USNM 624471.

15. Locality S288. USNM 624472.

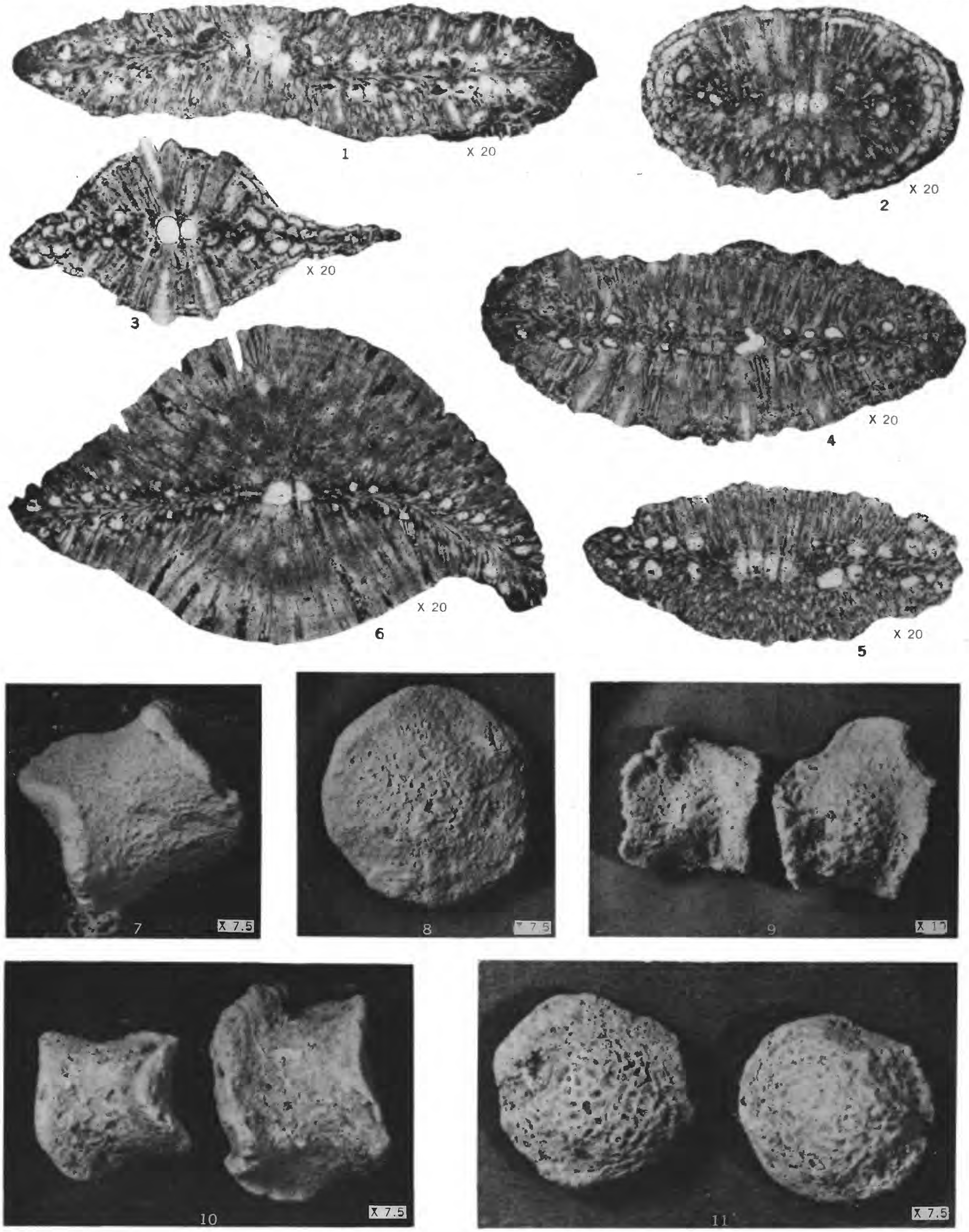
16. Locality S321. USNM 624473.

17. Locality S270. USNM 624474.

18. Locality S251. USNM 624475.




UPPER EOCENE *BIPLANISPIRA* AND *PELLATISPIRA*




UPPER EOCENE *BIPLANISPIRA* AND *PELLATISPIRA*

## PLATE 99

FIGURES 1–6. *Biplanispira mirabilis* (Umbgrove) (p. 334).

1. Transverse section of a compressed specimen; locality C22. USNM 624476.
2. Transverse section of an inflated specimen; locality S241. USNM 624477.
3. Transverse section of an umbonate specimen; locality B251. USNM 624478.
4. Transverse section of a moderately inflated specimen; locality S254. USNM 624479.
5. Transverse section of a moderately inflated specimen; locality S227. USNM 624480.
6. Transverse section of a highly inflated specimen; locality S319. USNM 624481.

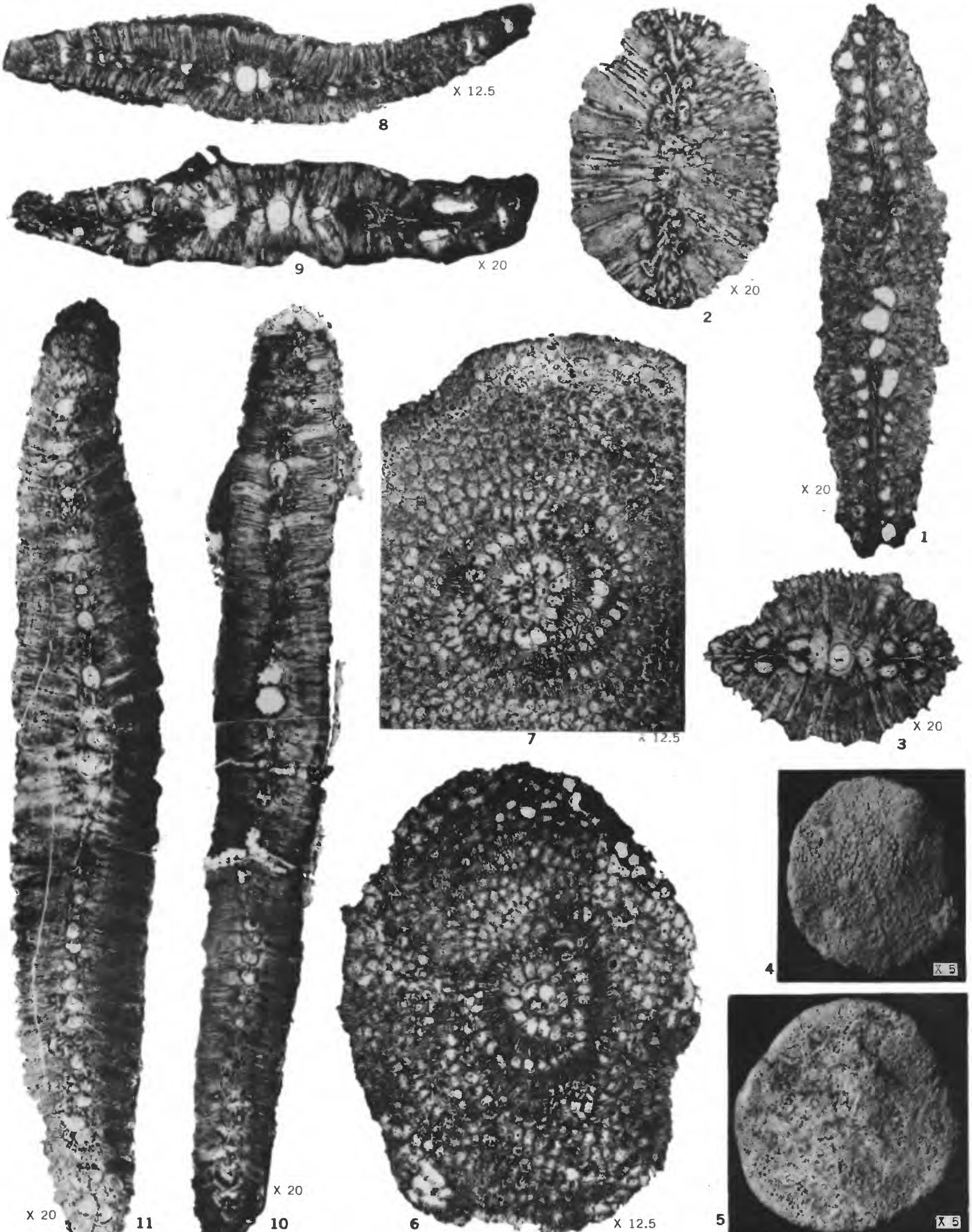
7–11. *Pellatispira orbitoidea* (Provale) (p. 333).

7. External view of a selliform specimen; locality S188. USNM 624482.
8. External view of a flat, moderately inflated specimen; locality S100. USNM 624483.
9. External views of umbonate, selliform specimens; locality S259. USNM 624745.
10. External views of selliform specimens; locality S259. USNM 624484.
11. External views of highly inflated specimens; locality S188. USNM 624485.

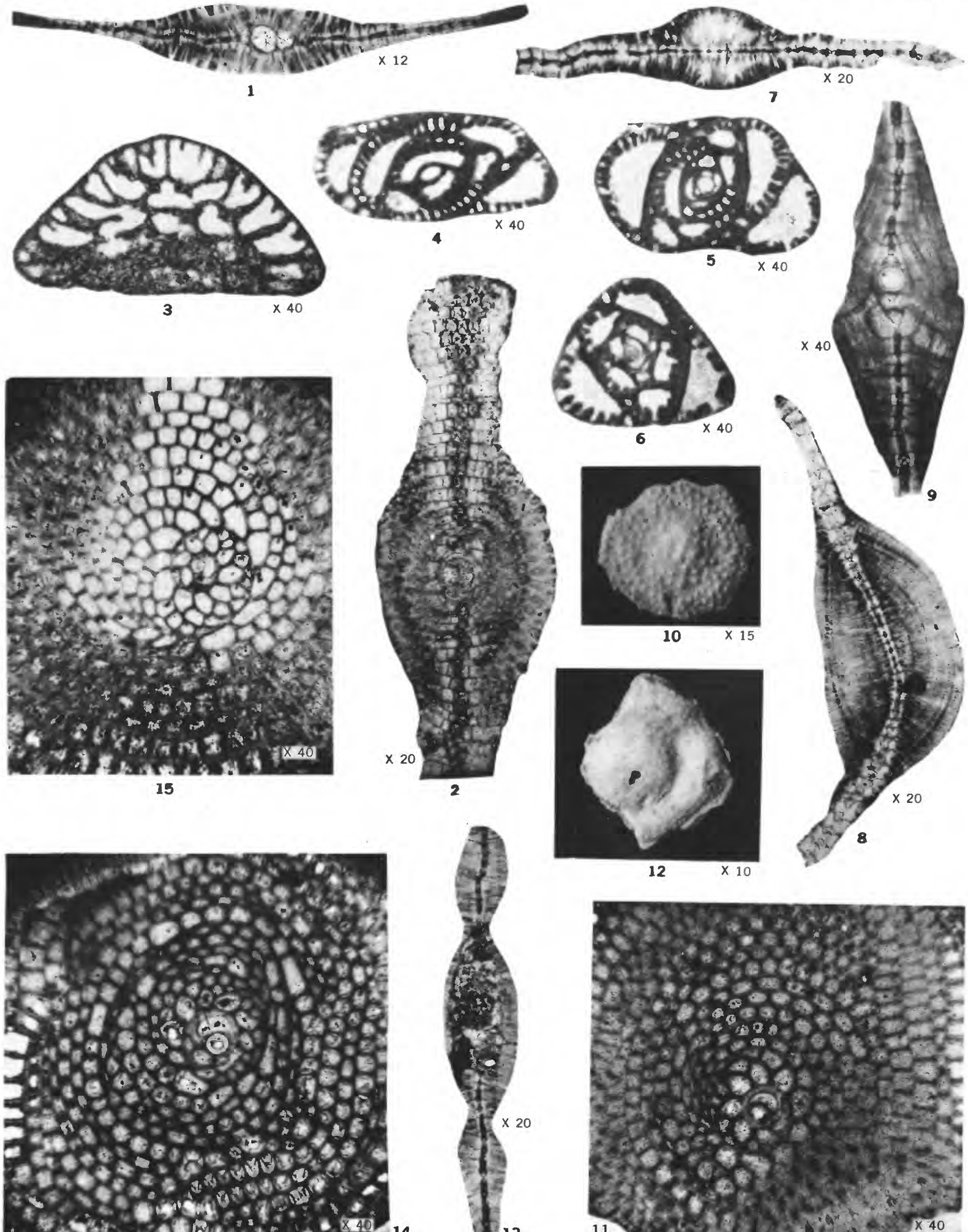
## PLATE 100

FIGURES 1–3. *Biplanispira mirabilis* (Umbgrove) (p. 334).
1. Transverse section of a compressed lenticular specimen; locality S336. USNM 624486.
2. Transverse section of a thick lenticular specimen; locality S254. USNM 624487.
3. Transverse section of a thick lenticular specimen with strong pillars; locality S270. USNM 624488.

4–11. *Biplanispira hoffmeisteri* (Whipple) (p. 334).
4, 5. External views; locality S134. USNM 624489.
6, 7. Equatorial sections; locality S134. USNM 624490.
8–11. Transverse sections.
8. Locality S100. USNM 624491.
9. Locality S259. USNM 624492.
10, 11. Locality S134. USNM 624493.




UPPER EOCENE *BIPLANISPIRA*




UPPER EOCENE *DICTYOCONUS*, LOWER MIOCENE *AUSTROTRILLINA*, AND LOWER MIOCENE AND PLEISTOCENE *CYCLOCLYPEUS*

## PLATE 101

FIGURES 1, 2. *Cycloclypeus* (*Cycloclypeus*) *carpenteri* Brady (p. 334).
1. Vertical section; locality B294. USNM 624494.
2. Oblique equatorial section; locality B294. USNM 624495.

3. *Dictyoconus saipanensis* Cole, n. sp. (p. 329).
Axial section of the holotype; locality B176. USNM 624496.

4–6. *Austrotrillina howchini* (Schlumberger) (p. 329).
4, 5. Locality B170. USNM 624497.
6. Locality S312. USNM 624498.

7, 8. *Cycloclypeus* (*Cycloclypeus*) *indopacificus* Tan (p. 334).
7. Vertical section nearly centered; locality B323. USNM 624499.
8. Oblique equatorial section; locality B400. USNM 624500.

9–11. *Cycloclypeus* (*Cycloclypeus*) *posteidae* Tan (p. 334).
9. Vertical section; locality S701. USNM 624501.
10. External view; locality S701. USNM 624502.
11. Part of an equatorial section to show the embryonic and periembryonic chambers; locality S701. USNM 624503.

12–14. *Cycloclypeus* (*Katacycloclypeus*) *transiens* Tan (p. 335).
12. External view; locality S701. USNM 624504.
13. Vertical section; locality S704. USNM 624505.
14. Part of an equatorial section to show the embryonic and periembryonic chambers; locality S701. USNM 624506.

15. *Cycloclypeus* (*Cycloclypeus*) *eidae* Tan (p. 334).
Part of an equatorial section; locality S672. USNM 624507.

## PLATE 102

FIGURE 1. *Borelis pygmaeus* Hanzawa (p. 336).
Longitudinal section; locality S88. USNM 624508.

2, 3. *Planorbulinella larvata* (Parker and Jones) (p. 337).
2. Transverse section; locality S227. USNM 624509.
3. Transverse section; locality S311. USNM 624510.

4–6. *Eorupertia plecte* (Chapman) (p. 337).
4. Longitudinal section of an elongate specimen; locality S170. USNM 624511.
5. Longitudinal section of a specimen with inflated terminal chambers; locality S254. USNM 624512.
6. Part of a specimen to show the wall structure; locality S214. USNM 624513.

7–9. *Fabiania saipanensis* Cole (p. 337).
7. Section parallel to the outer surface to show the chamberlets; locality S133. USNM 624514.
8. Transverse section through the embryonic chambers; locality S223. USNM 624515.
9. Transverse section not centered; locality S189. USNM 624746.

10, 11. *Halkyardia bikiniensis* Cole (p. 336).
10. Transverse section not centered; locality S338. USNM 624516.
11. Transverse section through the embryonic chambers; locality S318. USNM 624517.

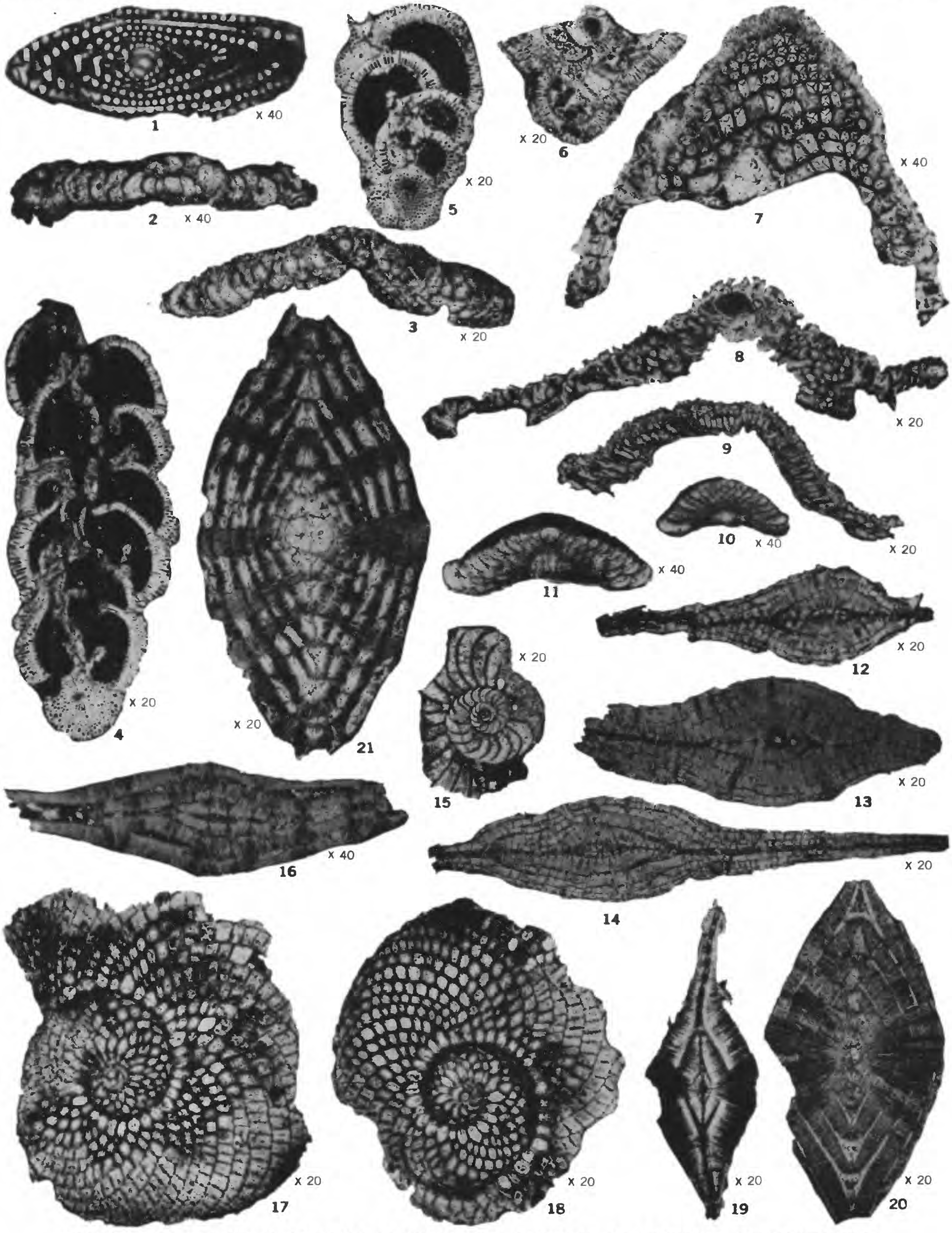
12–14. *Spiroclypeus vermicularis* Tan (p. 333).
12. Transverse section; locality S271. USNM 624518.
13. Transverse section; locality S290. USNM 624519.
14. Transverse section; locality S170. USNM 624520.

15, 16. *Operculinoides saipanensis* Cole, n. sp. (p. 331).
15. Median section of the holotype; locality S271. USNM 624521.
16. Transverse section of a paratype; locality S79*b*. USNM 624522.

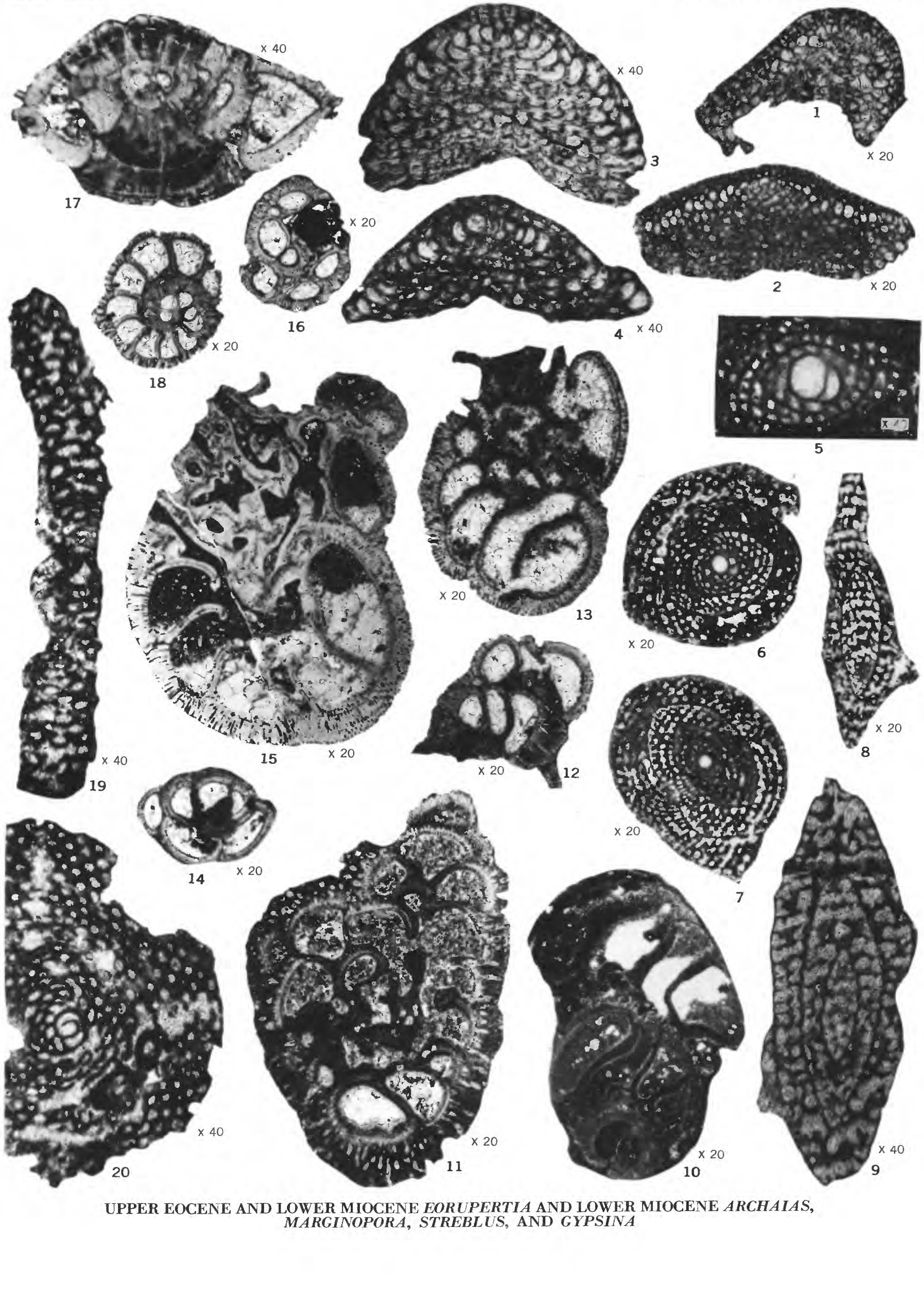
17–19. *Heterostegina saipanensis* Cole (p. 331).
17, 18. Median sections; locality S259. USNM 624523.
19. Transverse section; locality S259. USNM 624524.

20. *Camerina saipanensis* Cole (p. 330).
Transverse section; locality S132. USNM 624525.

21. *Camerina djokdjokarta* (Martin) (p. 329).
Transverse section; locality S341. USNM 624526.




UPPER EOCENE *BORELIS, CAMERINA, EORUPERTIA, FABIANIA, HALKYARDIA, HETEROSTEGINA, OPERCULINOIDES, PLANORBULINELLA,* AND *SPIROCLYPEUS*




UPPER EOCENE AND LOWER MIOCENE *EORUPERTIA* AND LOWER MIOCENE *ARCHAIAS*, *MARGINOPORA*, *STREBLUS*, AND *GYPSINA*

## PLATE 103

FIGURES 1–4. *Gypsina marianensis* Hanzawa (p. 337).
All transverse sections.
1. Locality B237. USNM 624527.
2. Locality B254. USNM 624528.
3. Locality B244. USNM 624529.
4. Locality B238. USNM 624530.

5–9. *Archaias vandervlerki* De Neve (p. 335).
5. Embryonic chambers; locality S85. USNM 624531.
6, 7. Median section; locality S85. USNM 624532.
8. Transverse section; locality S165. USNM 624533.
9. Transverse section; locality S165. USNM 624534.

10. *Eorupertia boninensis* (Yabe and Hanzawa) (p. 337).
Longitudinal section of a topotype specimen from Oki-mura, Haha-jima (Hillsborough island), Bonin group, introduced for comparison with the Saipan specimens; gift of Dr. S. Hanzawa. USNM 624535.

11–16. *Eorupertia semiornata* (Howchin) (p. 338).
11. Locality B224. USNM 624536.
12. Locality S667. USNM 624537.
13. Locality B50. USNM 624538.
14. Locality C16. USNM 624539.
15. Locality B79. USNM 624540.
16. Locality S667. USNM 624541.

17, 18. *Streblus saipanensis* Cole (p. 338).
17. Transverse section; locality C140. USNM 624542.
18. Median section; locality S667. USNM 624543.

19, 20. *Marginopora vertebralis* Quoy and Gaimard (p. 335).
19. Transverse section; locality C113. USNM 624544.
20. Part of a median section; locality C113. USNM 624545.

## PLATE 104

FIGURES 1–9. *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* (Brady) (p. 343).

1, 2. Vertical sections of microspheric individuals; locality B214. USNM 624546.

3. Vertical section of a small, nearly globular megalospheric individual; locality B246. USNM 624547.

4. Oblique vertical section; locality B247. USNM 624548.

5. Vertical section of a specimen with a wide rim; locality B310. USNM 624549.

6. Vertical section to show pillars which are present in some specimens; locality B101. USNM 624550.

7. Vertical section of a specimen with thin floor and roofs to the lateral chambers; locality S701. USNM 624551.

8. Vertical section of a compressed specimen; locality B247. USNM 624552.

9. Vertical section of a specimen with thin, strongly arched roofs and floors to the lateral chambers; locality B341. USNM 624553.

10–17. *Lepidocyclina* (*Nephrolepidina*) *parva* Oppenoorth (p. 343).

Vertical sections of megalospheric individuals showing the different degrees that pillars are developed.

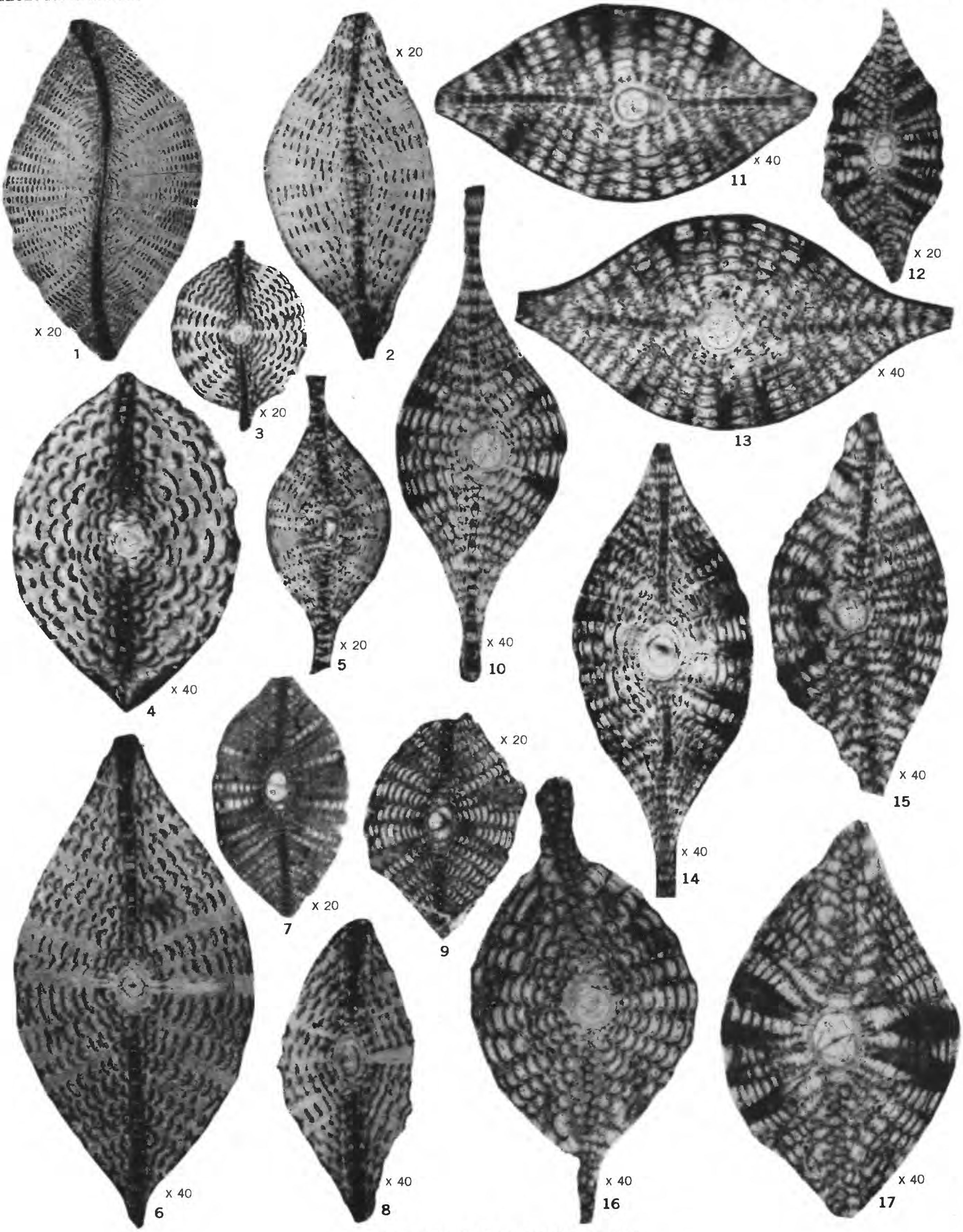
10. Locality B279. USNM 624554.

11, 13–15. Locality B103. USNM 624555.

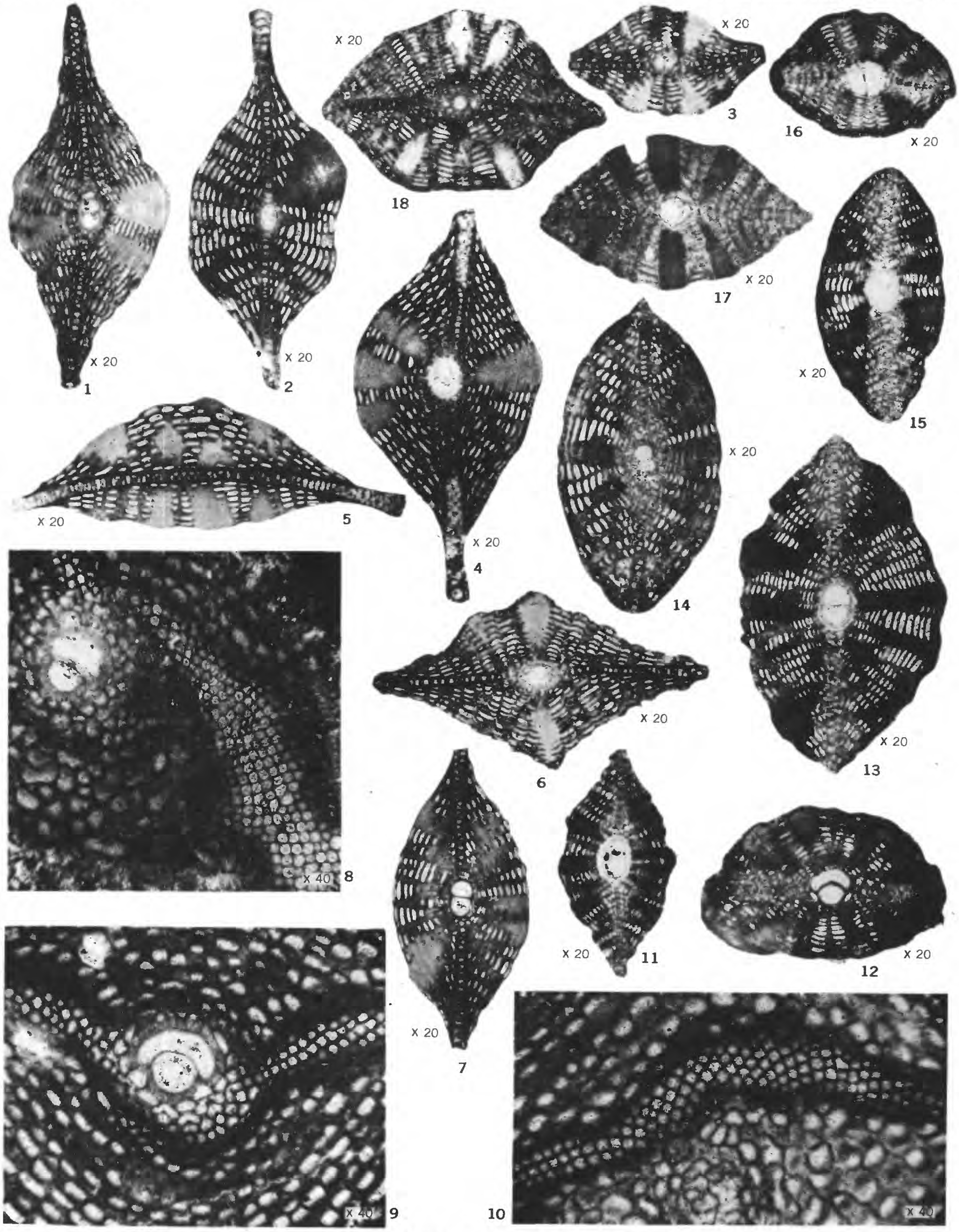
12. Locality B126. USNM 624556.

16. Locality B400. USNM 624557.

17. Locality B138. USNM 624558.




LOWER MIOCENE *LEPIDOCYCLINA*




LOWER MIOCENE *LEPIDOCYCLINA*

## PLATE 105

FIGURES 1–10. *Lepidocyclina (Nephrolepidina) brouweri* L. Rutten (p. 342).

1–7. Vertical sections of megalospheric specimens showing the variation which occurs in this species.

1. Locality C102. USNM 624559.
2. Locality B419. USNM 624560.
3. Locality B315. USNM 624561.
4. Locality B357. USNM 624562.
5. Locality B420. USNM 624563.
6. Locality C102. USNM 624564.
7. Locality B420. USNM 624565.

8–10. Parts of slightly oblique equatorial sections to show the embryonic and equatorial chambers.

8. Locality C102. USNM 624566.
9. Locality B362. USNM 624567.
10. Locality C102. USNM 624568.

11–17. *Lepidocyclina (Nephrolepidina) verrucosa* Scheffen (p. 345).

11–17. Vertical sections of megalospheric specimens showing the variation which occurs in this species.

11. Locality B261. USNM 624569.
12. Locality B394. USNM 624570.
13. Locality C140. USNM 624571.
14. Locality B320. USNM 624572.
15. Locality C132. USNM 624573.
16. Locality B177. USNM 624574.
17. Locality S701. USNM 624575.

18. *Lepidocyclina (Nephrolepidina) sumatrensis* (Brady) (p. 343).

Vertical section of specimen introduced for comparison with the other species; locality B320. USNM 624576.

## PLATE 106

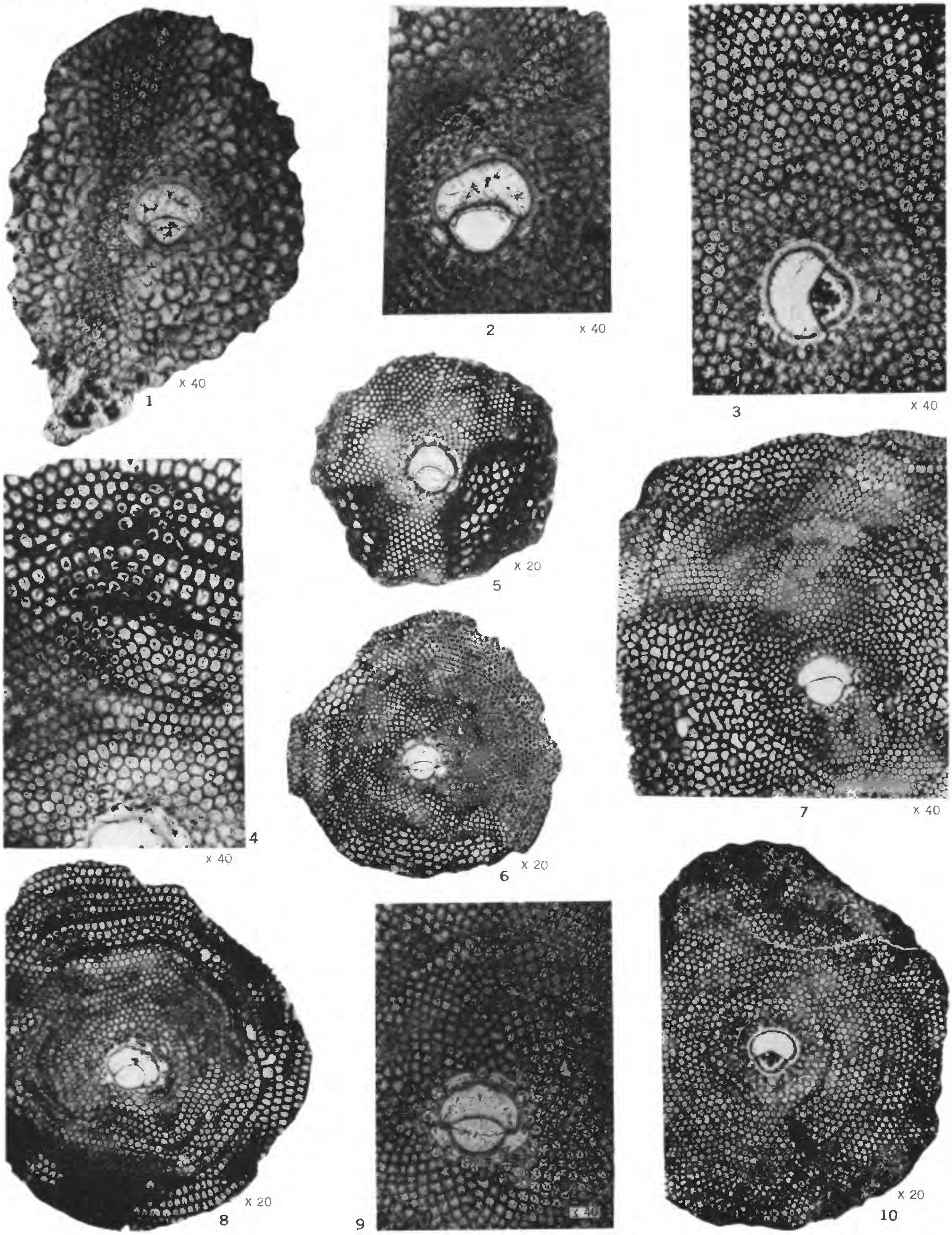
FIGURES 1–3, 6, 7, 9, 10. *Lepidocyclina* (*Nephrolepidina*) *verbeeki* Newton and Holland (p. 344).

1. Slightly oblique equatorial section; locality B136. USNM 624577.
2. Part of an equatorial section showing the embryonic and equatorial chambers; locality B373. USNM 624578.
3. Enlargement of the central part of the equatorial section, figure 10, to show the embryonic and equatorial chambers, introduced for comparison with the Saipan specimens; same locality as figure 10. USNM 624580.
6. Equatorial section; locality B138. USNM 624579.
7. Part of an equatorial section of a topotype specimen from the U. S. National Museum collection from the "coral-limestone, Padang Highlands, West-Coast District, Sumatra" introduced for comparison. USNM 544990.
9. Enlargement of the central portion of the specimen illustrated as figure 6. USNM 624579.
10. Part of an equatorial section of a specimen identified by Dr. S. Hanzawa and presented by him to the writer; Kaizan beds, Pinaikô, Sansikyaku, Ôka-syô, Kaizan-gun, Taihoku Prefecture, Formosa. USNM 624580.

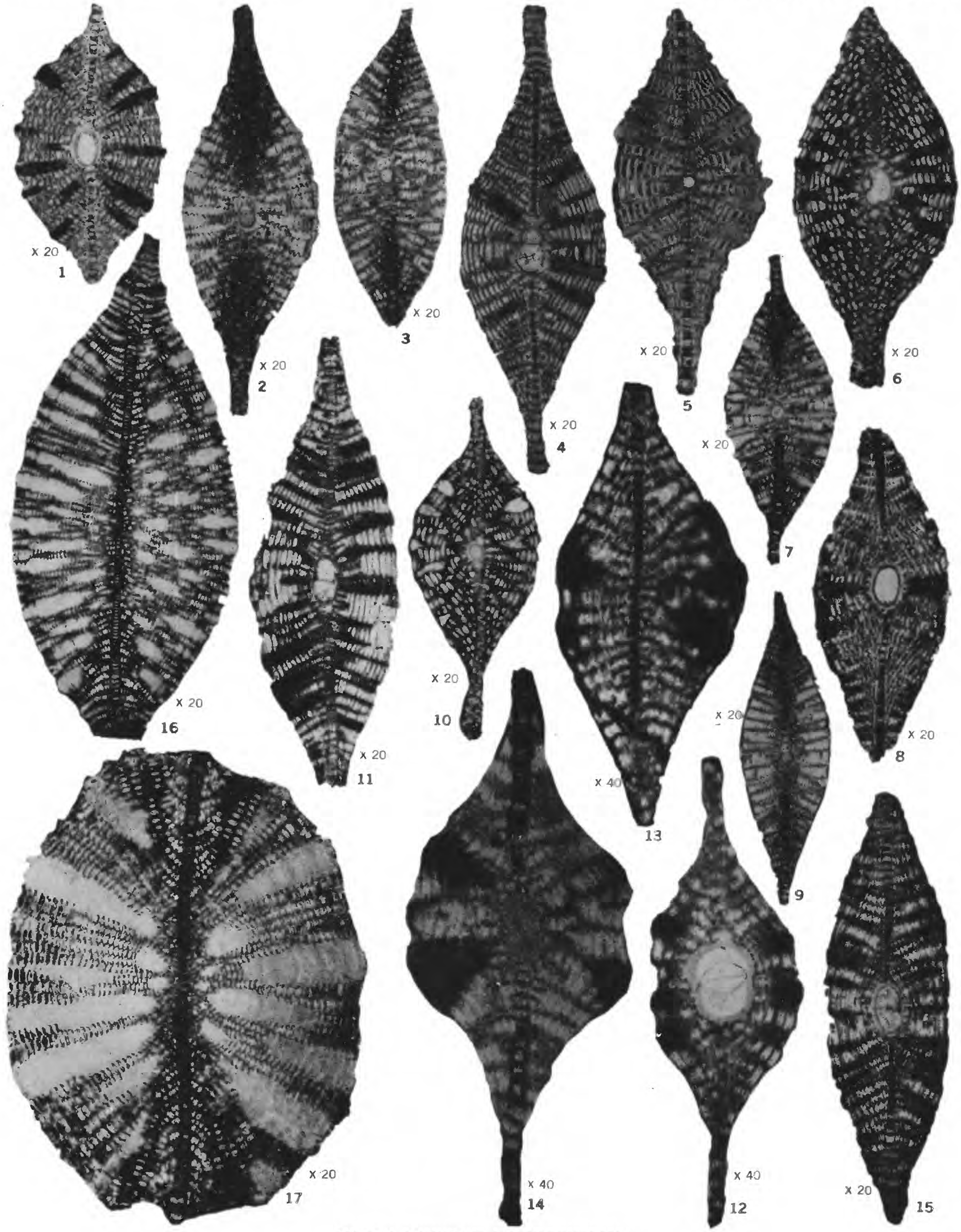
4, 8. *Lepidocyclina* (*Nephrolepidina*) *nipponica* Hanzawa (p. 345).

4. Enlargement of a part of the equatorial section, figure 8, showing the shape of the equatorial chambers, introduced for comparison with *L. verbeeki*. USNM 624581.
8. Part of an equatorial section collected and presented by Dr. H. Schenck; Shimo-shiraiwa, Shimo-omimura, Takota-gun, Shizuoka Prefecture, Japan. USNM 624581.

5. *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* (Brady) (p. 343).
Equatorial section; locality B413. USNM 624582.




LOWER MIOCENE *LEPIDOCYCLINA*




LOWER MIOCENE *LEPIDOCYCLINA*

## PLATE 107

FIGURES 1–12, 16. *Lepidocyclina* (*Nephrolepidina*) *verbeeki* Newton and Holland p. 344).

1. Vertical section; locality C131. USNM 624583.
2, 3. Vertical sections; locality B312. USNM 624584.
4. Vertical section; locality B135. USNM 624585.
5. Vertical section; locality B161. USNM 624586.
6. Slightly oblique vertical section; locality B373. USNM 624587.
7. Vertical section; locality B138. USNM 624588.
8. Vertical section of a specimen identified by Dr. S. Hanzawa and presented to the writer, introduced for comparison; Kaizan beds, Pinaikô, Sansikyaku, Ôka-syô, Kaizan-gun, Taihoku Prefecture, Formosa. USNM 624589.
9. Vertical section; locality B138. USNM 624590.
10. Vertical section of a specimen with extremely thin floors and roofs to the lateral chambers; locality B29*a*. USNM 624591.
11. Vertical section of a topotype specimen from "coral-limestone, Padang Highlands, West-Coast District, Sumatra," introduced for comparison. USNM 544990.
12. Vertical section of small, not fully developed specimen; locality B3. USNM 624592.
16. Vertical section of a microspheric specimen with numerous, rather strong pillars; locality B138. USNM 624593.

13, 14. *Lepidocyclina* (*Nephrolepidina*) *angularis* Newton and Holland (p. 342).

13. Vertical section of specimen presented to the writer by the late Dr. Vaughan, introduced for comparison; Sekihekiryô in Daiamryô, Dojô-shô, Kaizan-gun, Taihoku Prefecture, Formosa. USNM 624594.
14. Vertical section; locality B162. USNM 624595.

15. *Lepidocyclina* (*Nephrolepidina*) *nipponica* Hanzawa (p. 345).

Vertical section introduced for comparison with *L. verbeeki*, collected and presented by Dr. H. Schenck; Shimo- shiroiwa, Shimo-ômi-mura, Tagata-gun, Shizuoka Prefecture, Japan. USNM 624596.

17. *Lepidocyclina* (*Nephrolepidina*) *parva* Oppenoorth (p. 343).

Vertical section of a microspheric individual; locality B303. USNM 624597.

## PLATE 108

FIGURES 1–3. *Lepidocyclina* (*Eulepidina*) *badjirraensis* Crespin (p. 345).

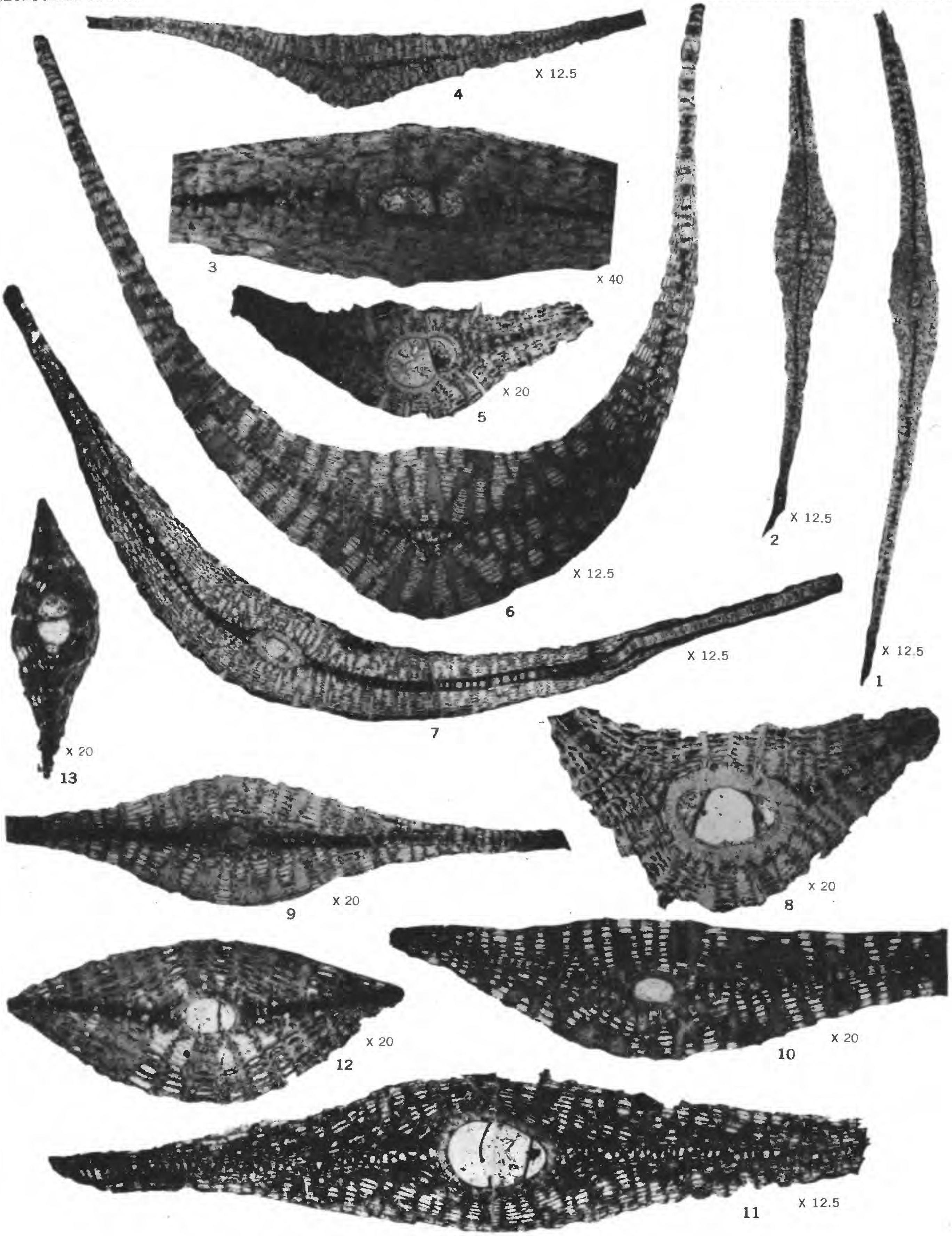
1, 2. Vertical sections; Saipan, locality unknown. USNM 624598.

3. Part of a vertical section showing the embryonic chambers and the low oppressed lateral chambers; Saipan, locality unknown. USNM 624599.

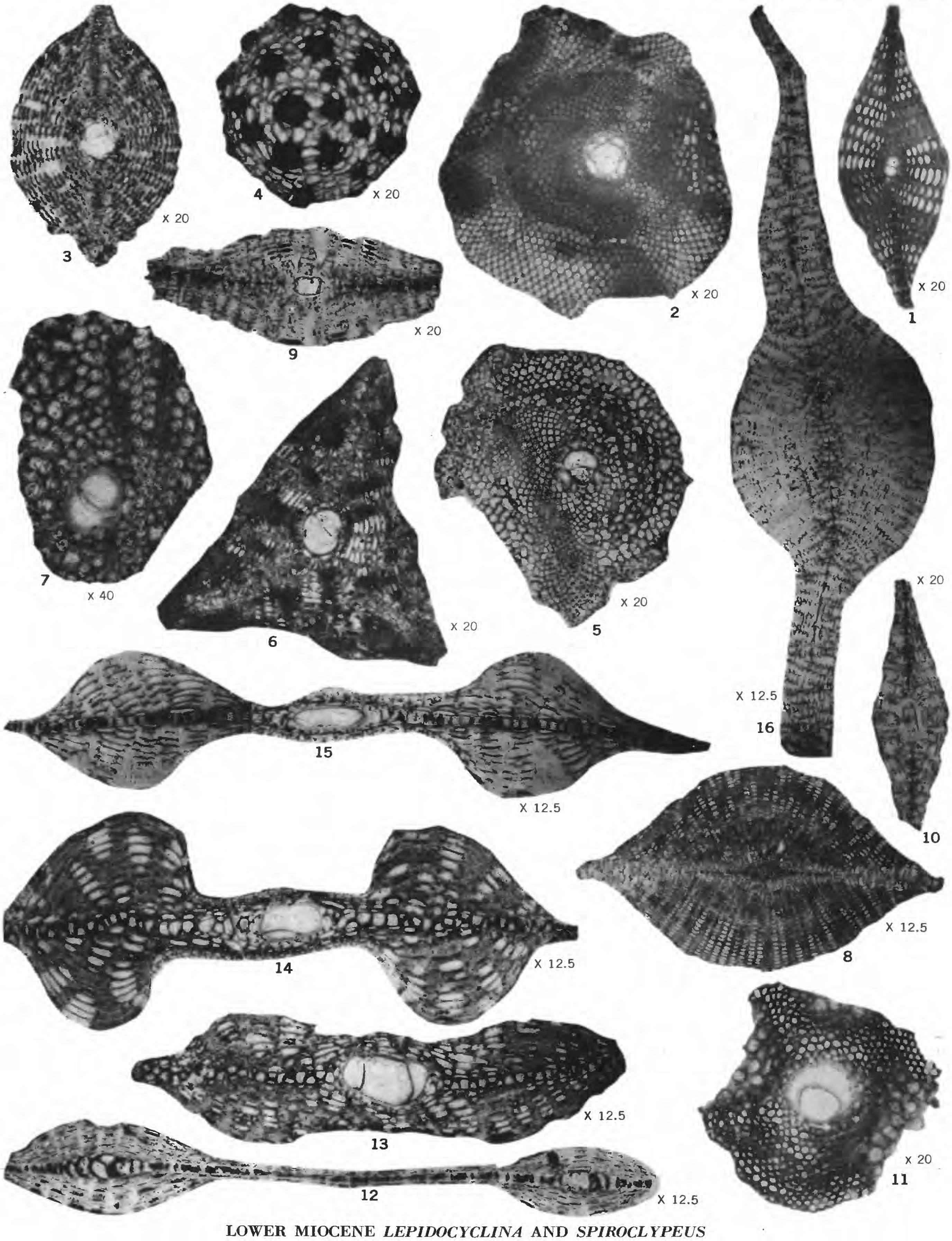
4–13. *Lepidocyclina* (*Eulepidina*) *ephippioides* Jones and Chapman (p. 346).

Vertical sections to show the great variation in size and shape.

4. Locality B166. USNM 624600.
5. Locality B166. USNM 624601.
6. Locality S164. USNM 624602.
7. Locality S585. USNM 624603.
8. Locality B303. USNM 624604.
9. Locality S203. USNM 624605.
10. Locality B281. USNM 624606.
11. Locality S674. USNM 624607.
12, 13. Locality S672. USNM 624608.




LOWER MIOCENE *LEPIDOCYCLINA*




LOWER MIOCENE *LEPIDOCYCLINA* AND *SPIROCLYPEUS*

## PLATE 109

FIGURES 1–3. *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* (Brady) (p. 343).

1. Vertical section of a compressed specimen with open lateral chambers; locality S701. USNM 624609.
2. Equatorial section; locality S701. USNM 624610.
3. Vertical section of an inflated specimen with low lateral chambers; locality B261. USNM 624611.

4–6. *Lepidocyclina* (*Nephrolepidina*) *verrucosa* Scheffen (p. 345).

4. Section parallel to the equatorial plane showing distribution of the pillars; locality B391. USNM 624612.
5. Equatorial section slightly oblique; locality B391. USNM 624613.
6. Vertical section of a trigonal specimen; locality B395. USNM 624614.

7, 8. *Lepidocyclina* (*Nephrolepidina*) *verbeeki* Newton and Holland (p. 344).

7. Equatorial section of a specimen of the type illustrated by figure 12, plate 107; locality B3. USNM 624615.
8. Vertical section of a microspheric specimen; locality B1. USNM 624616.

9, 10. *Lepidocyclina* (*Eulepidina*) *badjirraensis* Crespin (p. 345).

Vertical sections; locality B284. USNM 624617.

11–15. *Lepidocyclina* (*Eulepidina*) *ephippioides* Jones and Chapman (p. 346).

11. Equatorial section of a small specimen; locality S672. USNM 624618.

12–15. Vertical sections of irregularly developed specimens.

12. Locality B155. USNM 624619.
13. Locality B55. USNM 624620.
14. Locality B281. USNM 624621.
15. Locality B290. USNM 624622.

16. *Spiroclypeus higginsi* Cole (p. 332).

Transverse section of a microspheric specimen; locality B136. USNM 624623.

## PLATE 110

FIGURES 1–4. *Flosculinella globulosa* L. Rutten (p. 336).

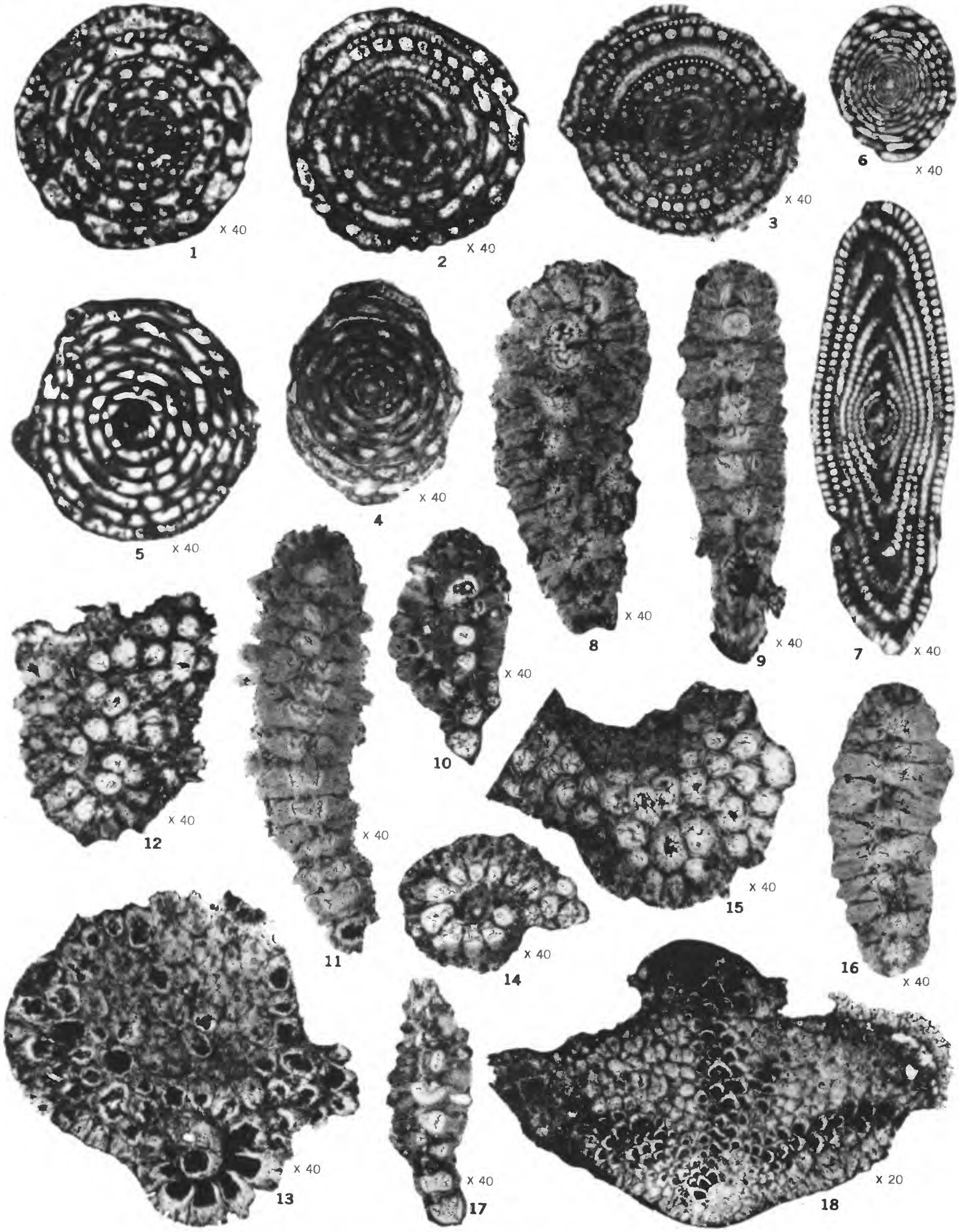
1. Transverse section; locality B342. USNM 624624.
2. Axial section; locality C89. USNM 624625.
3. Axial section; locality B413. USNM 624626.
4. Transverse section; locality B413. USNM 624627.

5–7. *Borelis pygmaeus* Hanzawa (p. 336).

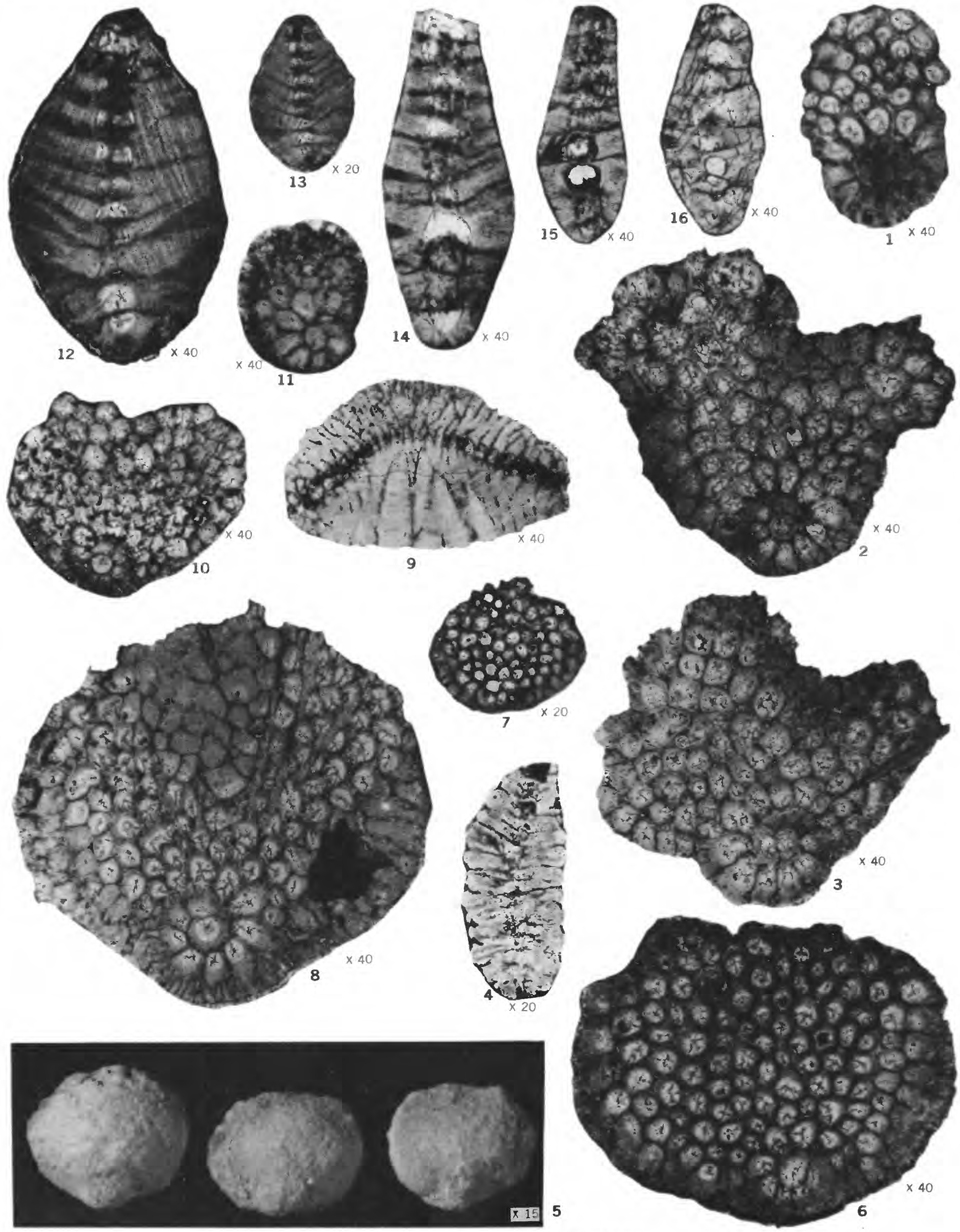
5. Transverse section; locality B170. USNM 624628.
6. Transverse section; locality B423. USNM 624629.
7. Axial section; locality B312. USNM 624630.

8–18. *Miogypsinoides bantamensis* Tan (p. 338).

8. Vertical section; locality B316. USNM 624631.
9. Vertical section; locality B301. USNM 624632.
10. Vertical section; locality B224. USNM 624633.
11. Vertical section; locality B301. USNM 624634.
12. Equatorial section to show the embryonic, periembryonic and equatorial chambers; locality B391. USNM 624635.
13. Equatorial section; locality B316. USNM 624636.
14. Equatorial section; locality B224. USNM 624637.
15. Equatorial section; locality B391. USNM 624638.
16. Vertical section; locality B391. USNM 624639.
17. Vertical section; locality B224. USNM 624640.
18. Equatorial section of a microspheric specimen; locality B395. USNM 624641.




LOWER MIOCENE *BORELIS*, *FLOSCULINELLA*, AND *MIOGYPSINOIDES*




LOWER MIOCENE *MIOGYPSINOIDES*

## PLATE 111

FIGURES 1–4. *Miogypsinoides bantamensis* Tan (p. 338).

1. Equatorial section of a microspheric specimen; locality B224. USNM 624642.

2, 3. Equatorial sections of megalospheric specimens to illustrate the embryonic, periembryonic, and equatorial chambers; locality B391. USNM 624643.

4. Vertical section, not centered, to illustrate the pillars; locality B225. USNM 624644.

5–16. *Miogypsinoides dehaartii* (Van der Vlerk) (p. 339).

5. External views of three megalospheric specimens; locality S701. USNM 624645.

6. Equatorial section of a megalospheric specimen; locality S701. USNM 624646.

7. Equatorial section of a megalospheric specimen; locality S701. USNM 624647.

8. Equatorial section of a megalospheric specimen; locality B15. USNM 624648.

9. Oblique vertical section of a probable microspheric specimen to illustrate strong pillars; locality B2. USNM 624649.

10, 11. Equatorial sections of topotype specimens of *Miogypsinoides formosensis* Yabe and Hanzawa illustrating embryonic and equatorial chambers; Sekihekiryo in Taihoku Prefecture, Formosa. USNM 624650.

12. Vertical section of a megalospheric specimen; locality S701. USNM 624651.

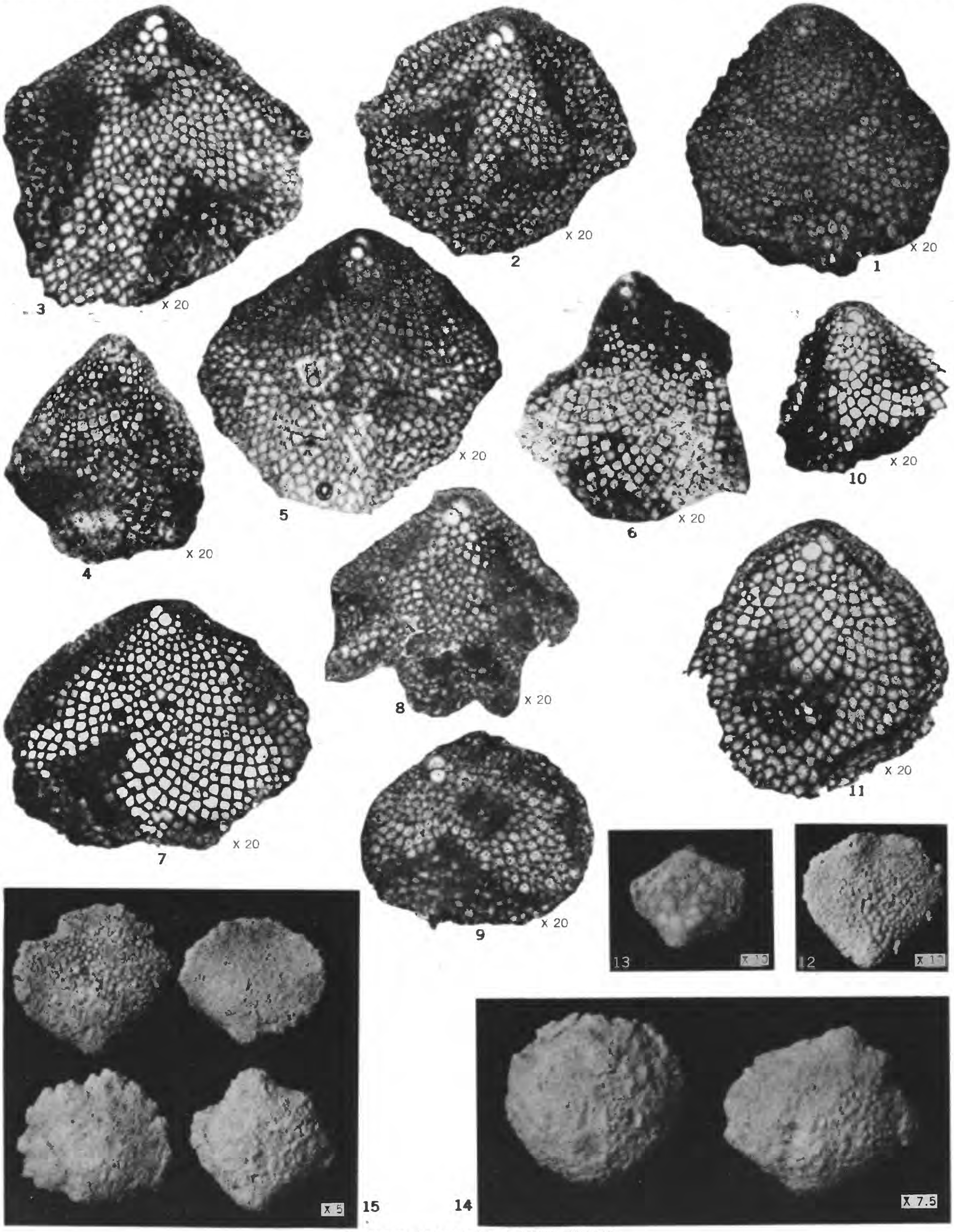
13. Vertical section of a megalospheric specimen; locality S701. USNM 624652.

14–16. Vertical sections of topotype specimens of *Miogypsinoides formosensis* Yabe and Hanzawa; same locality as figures 10, 11. USNM 624653.

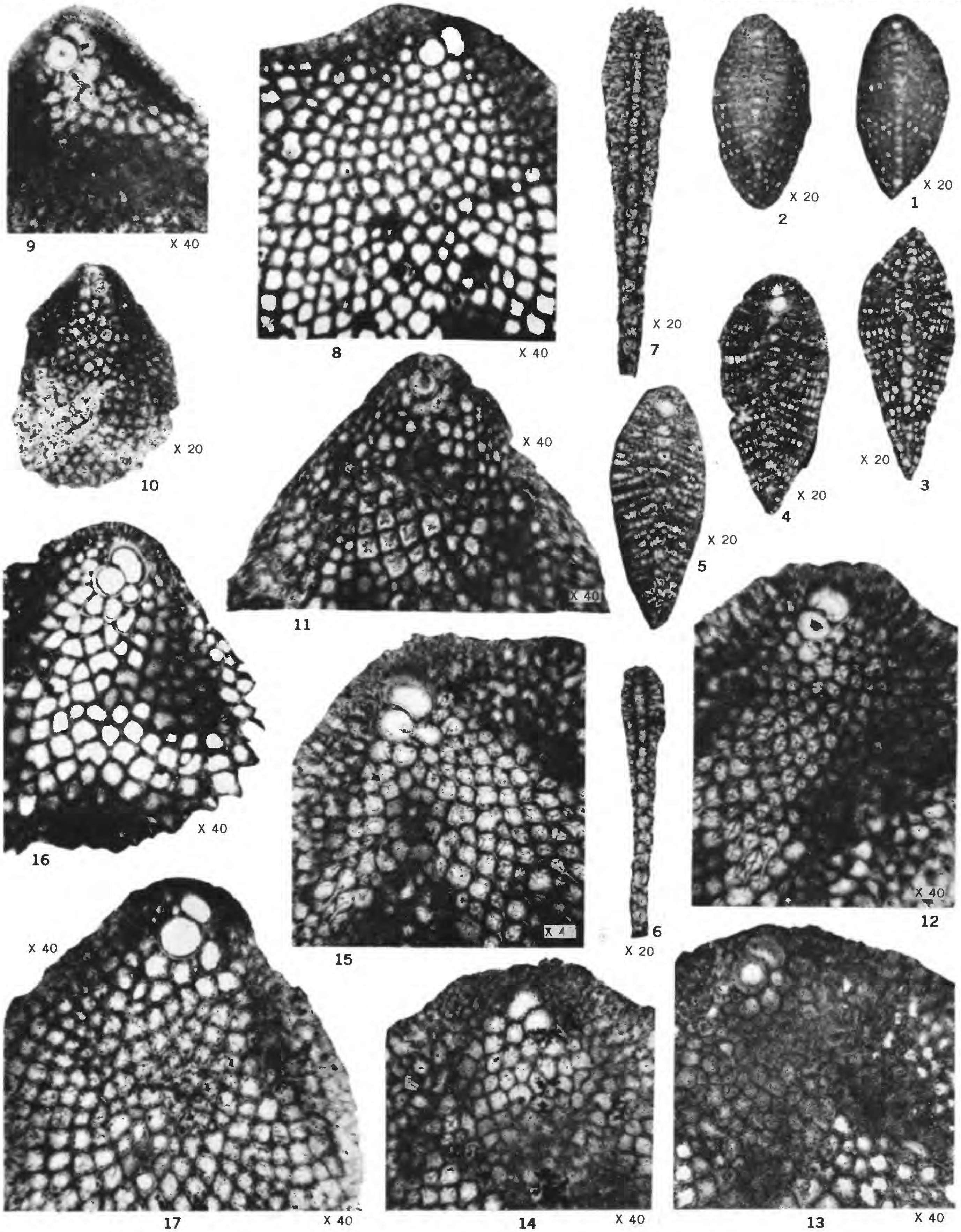
## PLATE 112

FIGURES 1–15. *Miogypsina* (*Miogypsina*) *thecideaeformis* (L. Rutten) (p. 340).

1. Equatorial section of a specimen with rudely hexagonal equatorial chambers near the distal margin; locality S701. USNM 624654.
2. Equatorial section, an enlargement of part of which is illustrated as figure 15, plate 113; locality S701. USNM 624679.
3. Equatorial section illustrating the shape of the equatorial chambers; locality S701. USNM 624655.
4. Equatorial section, an enlargement of part of which is illustrated as figure 11, plate 113; locality B413. USNM 624675.
5. Equatorial section; locality S701. USNM 624656.
6. Equatorial section to illustrate the shape of the distal equatorial chambers; locality B413. USNM 624657.
7. Equatorial section, an enlargement of part of which is illustrated as figure 8, plate 113; locality S701. USNM 624672.
8. Equatorial section of a specimen with a digitate distal margin; locality S701. USNM 624658.
9. Equatorial section of a specimen with a rounded proximal margin; locality S701. USNM 624659.
10. Equatorial section of a probable topotype specimen of *M.* (*M.*) *thecideaeformis*, an enlargement of part of which is illustrated as figure 16, plate 113; Balik-Papan, East Borneo. USNM 624660.
11. Equatorial section of a specimen called *M.* (*M.*) *kotoi* Hanzawa for comparison; Inokosi, Kayamaiti, Koyamamur, Kawakanir-gun, Okayama Prefecture, Japan. USNM 624661.
12. External view of a specimen with small pillars; locality B413. USNM 624662.
13. External view of a specimen with few, large pillars; locality B413. USNM 624663.
14. External view of two weathered, rather thick specimens; locality S701. USNM 624664.
15. External view of four thin specimens; locality S701. USNM 624665.




LOWER MIOCENE *MIOGYPSINA*




LOWER MIOCENE *MIOGYPSINA*

## PLATE 113

FIGURES 1–17. *Miogypsina (Miogypsina) thecideaeformis* (L. Rutten) (p. 340).

1–5. Vertical sections of megalospheric specimens.

1, 2, 4, 5. Locality S701. USNM 624666–624669.

3. Locality B187. USNM 624670.

6, 7. Vertical sections not centered, of probable microspheric specimens; locality C121. USNM 624671.

8. Part of an equatorial section illustrating the embryonic, periembryonic, and equatorial chambers; locality S701. USNM 624672.

9. Part of an equatorial section of a specimen similar to the one whose vertical section is illustrated as figure 1, plate 114; locality B413. USNM 624673.

10. Part of an equatorial section of a specimen similar to the one whose vertical section is illustrated as figure 15, plate 114; locality B413. USNM 624674.

11. Part of an equatorial section; locality B413. USNM 624675.

12–15. Parts of equatorial sections; locality S701. USNM 624676–624679.

16. Part of an equatorial section of a probable topotype specimen of *M.* (*M.*) *thecideaeformis* for comparison with the Saipan specimens; Balik-Papan, East Borneo. USNM 624660.

17. Part of an equatorial section of a specimen called *M.* (*M.*) *kotoi* Hanzawa for comparison; Inokosi, Kayamaiti, Koyama-mur, Kawakanir-gun, Okayama Prefecture, Japan. USNM 624680.

## PLATE 114

FIGURES 1–20. *Miogypsina* (*Miogypsina*) *thecideaeformis* (L. Rutten) (p. 340).

1. Vertical section of a compressed specimen; locality B413. USNM 624681.
2. Slightly oblique vertical section of a specimen similar to those previously identified with *M.* (*M.*) *inflata* Yabe and Hanzawa (see Cole and Bridge, 1953, pl. 13, figs. 12–14); locality B254. USNM 624682.
3. Vertical section of a specimen with intermediate thickness; locality S701. USNM 624683.

4–9. Vertical sections of thick specimens.

4, 5, 7, 9. Locality S701. USNM 624684–624687.

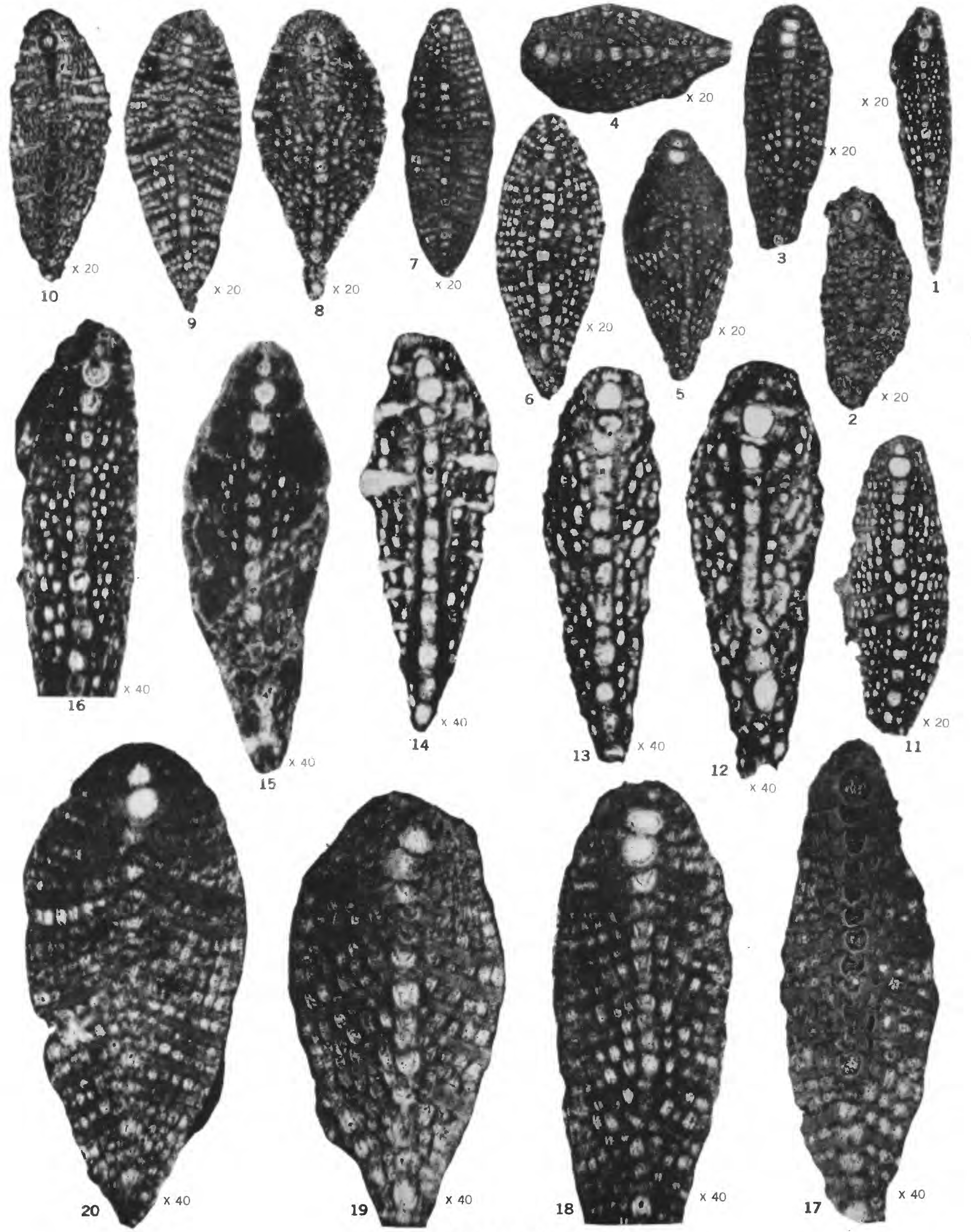
6. Locality B187. USNM 624688.

8. Locality B254. USNM 624689.

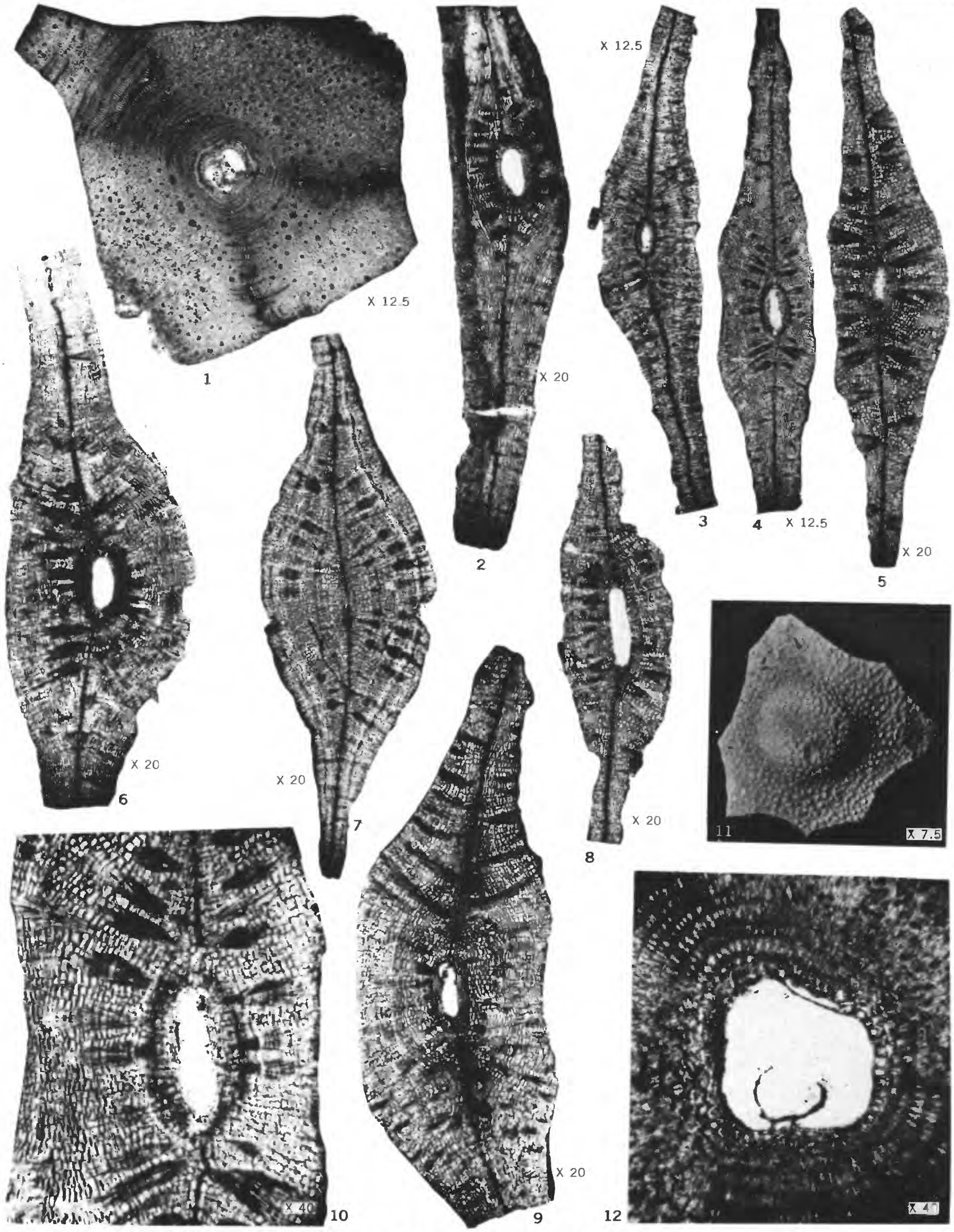
10, 11. Vertical sections of specimens called *M.* (*M.*) *kotoi* Hanzawa; Inokosi, Kayamaiti, Koyama-mur, Kawakanir-gun, Okayama Prefecture, Japan. USNM 624690, 624691.

12–14. Vertical sections of probable topotype specimens of *M.* (*M.*) *thecideaeformis* illustrating the variable development of pillars; Balik-Papan, East Borneo. USNM 624692–624694.

15. Vertical section of a specimen with strong pillars similar to specimens called *M. tuberosa* Tobler; locality B413. USNM 624695.
16. Part of the vertical section of the specimen illustrated as figure 1 for comparison with figure 13. USNM 624681.
17. Vertical section of a specimen called *M.* (*M.*) *kotoi* Hanzawa; same locality as figures 10, 11. USNM 624696.
18. Part of the vertical section of the specimen illustrated as figure 3 for comparison with figure 17. USNM 624683.
19. Part of the vertical section of the specimen illustrated as figure 4 for comparison with figures 12, 17, 18. USNM 624684.
20. Vertical section to illustrate the structures developed by another specimen; locality S701. USNM 624697.




LOWER MIOCENE *MIOGYPSINA*




UPPER EOCENE *DISCOCYCLINA*

## PLATE 115

FIGURES 1–12. *Discocyclina* (*Discocyclina*) *omphala* (Fritsch) (p. 347).

1. Equatorial section of a megalospheric specimen illustrating embryonic and equatorial chambers; locality S100. USNM 624698.
2. Vertical section of a megalospheric specimen; locality S100. USNM 624699.
3. Vertical section of a megalospheric specimen showing a well-developed umbo; locality S100. USNM 624700.
4. Vertical section of a megalospheric specimen showing a marked umbonal depression; locality S100. USNM 624701.
5. Vertical section of a megalospheric specimen with a pronounced umbo; locality S100. USNM 624702.
6. Vertical section of a megalospheric specimen with the umbonal area distinctly separated from the rim; locality S259. USNM 624703.
7. Vertical section of a microspheric specimen; locality S259. USNM 624704.
8. Vertical section of a megalospheric specimen with very large embryonic chambers; locality S259. USNM 624705.
9. Vertical section of a megalospheric specimen showing a marked umbonal depression; locality S100. USN 624706.
10. Part of the vertical section illustrated in figure 4 illustrating the embryonic chambers, lateral chambers and pillars; locality S100. USNM 624707.
11. External view of a specimen with a slightly depressed umbonal area; locality S259. USNM 624708.
12. Central part of an equatorial section illustrating the embryonic and periembryonic chambers; locality S100. USNM 624709.

## PLATE 116

FIGURES 1–10. *Asterocyclina penuria* Cole, nom. nov. (p. 350).

1–5. Vertical sections.

1, 3, 4. Locality S259. USNM 624710.

2. Locality S259. USNM 624711.

5. Locality S188. USNM 624712.

6–9. Equatorial sections.

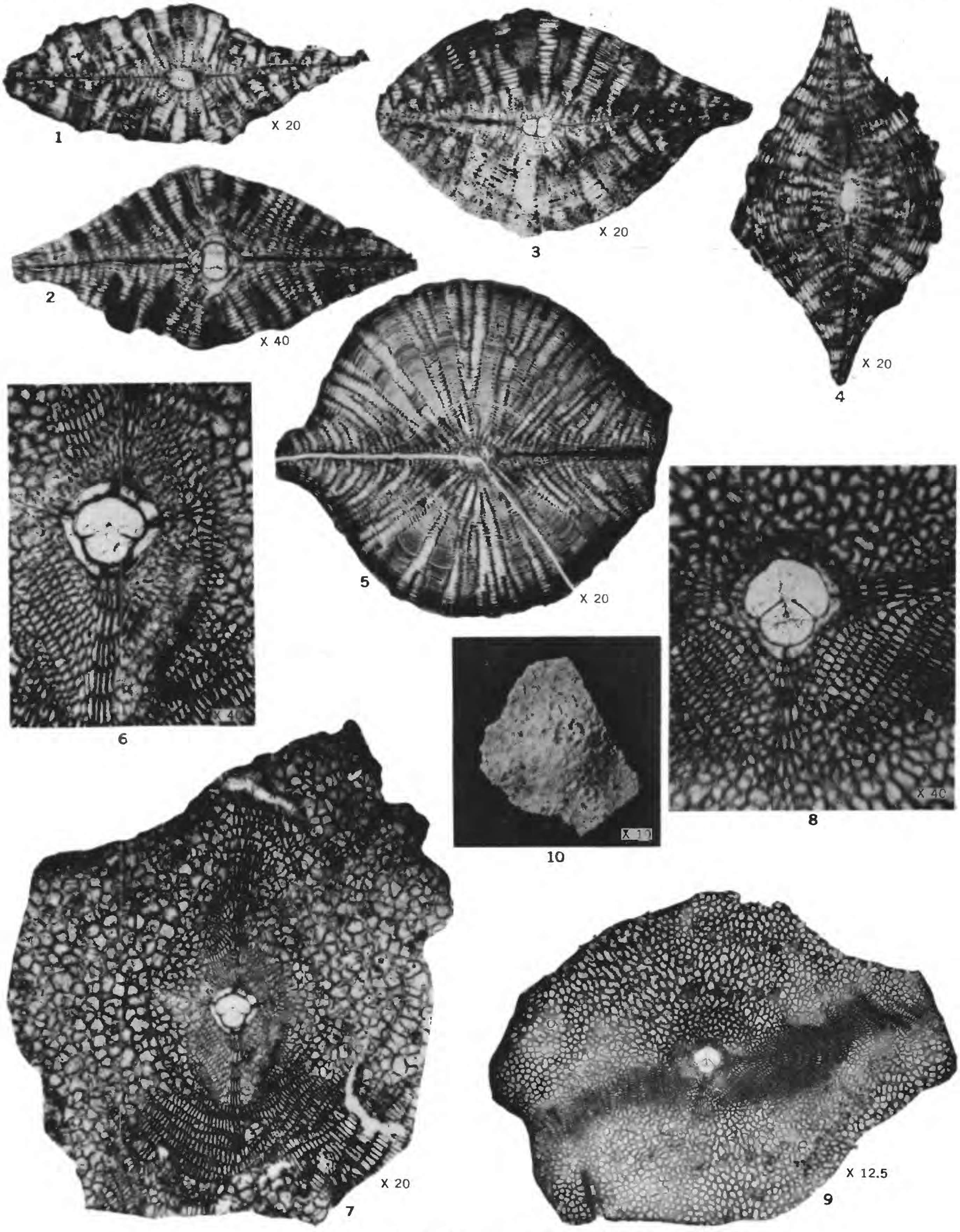
6. Enlargement of the embryonic chambers of figure 7; locality S259. USNM 624713.

7. Entire equatorial section; locality S259. USNM 624713.

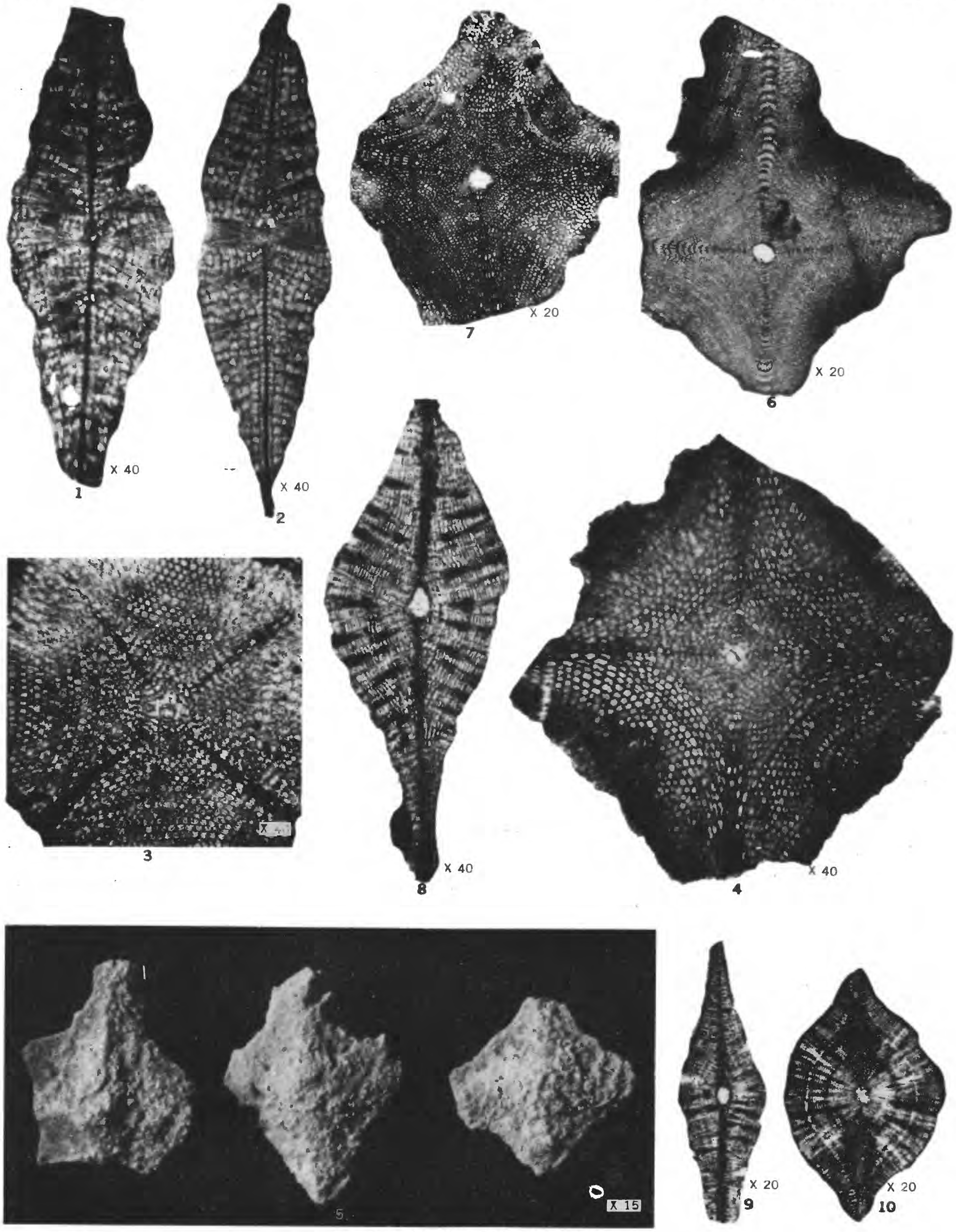
8. Enlargement of the embryonic chambers of figure 9; locality S188. USNM 624714.

9. Entire equatorial section; locality S188. USNM 624714.

10. External view; locality S259. USNM 624715.




UPPER EOCENE *ASTEROCYCLINA*




UPPER EOCENE *ASTEROCYCLINA*

## PLATE 117

FIGURES 1–5. *Asterocyclina incisuricamerata* Cole, n. sp. (p. 349).
1. Vertical section; locality S259. USNM 624716.
2. Vertical section of the holotype; locality S259. USNM 624717.
3. Part of an equatorial section; locality S259. USNM 624718.
4. Equatorial section of a paratype; locality S259. USNM 624719.
5. External views; locality S259. USNM 624720.

6–10. *Asterocyclina matanzensis* Cole, n. sp. (p. 350).
6, 7. Equatorial sections; locality S259. USNM 624721.
8. Vertical section; locality S259. USNM 624722.
9. Vertical section of a compressed specimen; locality S259. USNM 624723.
10. Vertical section of an inflated specimen; locality S259. USNM 624724.

## PLATE 118

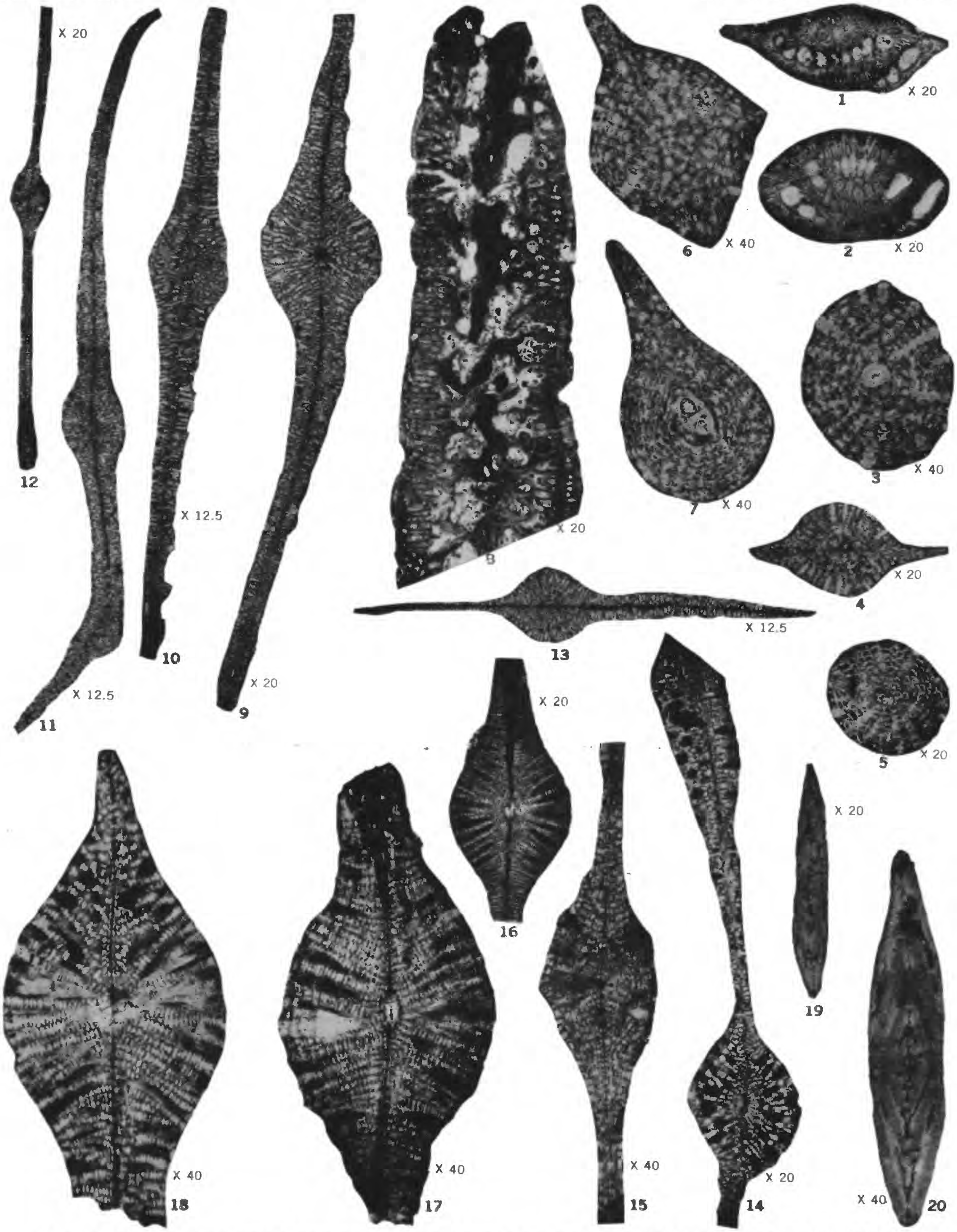
FIGURES 1, 2. *Calcarina spengleri* (Gmelin) (p. 336).
- 1. Transverse section showing peripheral spines; locality B231. USNM 624725.
- 2. Transverse section; locality B38. USNM 624726.

3–7. *Baculogypsina sphaerulata* (Parker and Jones) (p. 336).
- 3, 6. Locality B231. USNM 624727.
- 4. Locality B235. USNM 624728.
- 5. Locality B38. USNM 624729.
- 7. Locality B227. USNM 624730.

8. *Fabiania saipanensis* Cole (p. 337).
Transverse section of a compressed specimen which is similar in form to *Gunteria;* locality S253. USNM 624731.

9–18. *Asterocyclina matanzensis* Cole, n. sp. (p. 350).
All vertical sections showing variation in form and size.
- 9. Locality S125. USNM 624732.
- 10. Locality S292. USNM 624733.
- 11. Locality S125. USNM 624734.
- 12. Locality S604. USNM 624735.
- 13. Locality S133. USNM 624736.
- 14. Locality S286. USNM 624737.
- 15. Locality S604. USNM 624738.
- 16. Locality S134. USNM 624739.
- 17. Locality S259. USNM 624740.
- 18. Locality S202. USNM 624741.

19, 20. *Operculina complanata* (Defrance) (p. 330).
- 19. Transverse section; locality B433. USNM 624742.
- 20. Transverse section; locality B433. USNM 624743.




UPPER EOCENE *ASTEROCYCLINA* AND *FABIANIA*, LOWER MIOCENE *OPERCULINA*, AND PLEISTOCENE *BACULOGYPSINA* AND *CALCARINA*