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PLANKTIC FORAMINIFERA AND CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY OF THE NEOGENE OF MEXICO

PART I — MIDDLE PLIOCENE

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I. ABSTRACT

Calcareous nannofossils and planktic foraminifera that are diagnostic for precise geologic ages have been identified in some marine Tertiary formations in Mexico. The original age assignments of these formations have persisted in the literature and some revisions are necessary for the Mexican sections to conform with the chronostratigraphy that has been developed for the rest of the world. New planktic evidence now affords assignment of the Mexican beds to precise trans-oceanic Neogene zones. Part I of this report is concerned with the middle Pliocene (Zone N.20) to which the following formations at designated localities are referred: Agueguexquite, Filisola, Concepcion Inferior, Concepcion Superior, and several unnamed formations. Subsequent studies will deal with the successively older formations, including the Encanto, Deposito, La Laja, Tuxpan, Guajalote, Escolin, Anahuac, Coatzintla, Meson, Alazan, and Palma Real formations.

II. INTRODUCTION

The objective of this report is to document the calcareous planktic microfossils in some Pliocene formations of Mexico. Planktic foraminifera and calcareous nannoplankton have been particularly useful in understanding the chronology of depositional events in the deep seas and in many stratigraphic sections on land. The recognition of key taxa should materially assist the correlation of stratigraphic successions in the subject area with marine rocks in other parts of the world. The same fossil successions are to be seen in the Mexican Cenozoic as in other marine sequences throughout the middle and low latitudes.

Planktic foraminiferal zonations defined by Banner and Blow (1965), Blow (1969), and Berggren and Van Couvering (1974), as well as nannoplankton zones proposed by Martini (1971) are recognized in Mexico. Biostratigraphic interpretations of some of the Mexican Tertiary units with reference to standard intercontinental zonation systems have been recorded by Blow (1969), Akers (1972, 1974a, 1974b), Akers and Koeppel (1973), and Barker and Blow (1976). Recognition of planktic foraminiferal and nannoplankton zones in the Mexican succession is the basis, in turn, of correlation of these units with radiometric and chronostratigraphic time-scales, such as that proposed by Berggren and Van Couvering (1974, fig. 1).

Obviously there are advantages in using a multiplicity of faunal and floral groups for age-dating. The biostratigrapher must consider the absence of particular species in the light of both paleoecology and total ranges in geologic time, and he must be able to recognize recycled organisms. In some cases, planktic foraminifera alone were not sufficiently definitive for the purpose of assigning a formation to a precise Neogene zone and the same restrictions sometimes applied to the calcareous nannofossils. Some biostratigraphic knowledge of both planktic foraminifera and calcareous nannofossils has been useful in the zonation of the Mexican Neogene. The repudiation of former assignments does not invalidate the use of benthic organisms as guides to time but, rather, documents the incompleteness of early data relating the benthic fossils to time and facies.

Data for the present report are derived from rocks that have been referred in the literature or by geological mapping to the following formations:

Agueguexquite
Filisola
Concepcion Superior
Concepcion Inferior

In addition to the above units, material has been studied from several sequences to which rock-stratigraphic names have not been applied.

This report will deal with the formations that belong to Zone N. 20. Subsequent studies will include the Encanto, Deposito, La Laja, Tuxpan, Guajalote, Escolin, Anahuac, Coatzintla, Meson, Alazan, and Palma Real formations. The oldest rocks eventually to be included in the overall project are assignable to the Palma Real Formation, which has been referred, in part, to Zone N. 1 (Barker and Blow, 1976, text-fig. 2; p. 47). Thus, planktic foraminifera and calcareous nannoplankton will eventually be identified, illustrated, and reviewed for biostratigraphic significance for most of the Neogene Zones (N. 1 to N. 20) of the Mexican Tertiary.

It should be emphasized that the age assignments to be proposed and correlations with other formations, both in Mexico and elsewhere, are applicable only to that part of a formation as seen at the designated exposure (locality). Some formations, such as the Tuxpan, span long intervals of geologic time and represent several Neogene zones (N. 8 to N. 12). Others, such as the Agueguexquite Formation (N. 20), represent short time intervals. A complete marine depositional record does not exist at any single locality for either the entire Neogene or for the time represented by some of the formations.

The marine Neogene of Mexico is in marked contrast with the Neogene of the northern Gulf of Mexico. Surface exposures in Texas, Louisiana, and Alabama of marine beds younger than Neogene Zone 4 are of negligible extent. In Florida, marine rocks of middle Miocene age, with the exception of the Yellow River Formation, are not found at the surface (Akers, 1972, fig. 4). On the other hand, subsurface rocks of Texas and Louisiana thicken seaward and are correlatable by means of subsurface samples with the thick equivalents exposed in the Mexican Gulf Coast.

Standard methods of preparation of foraminiferal concentrations and nannofossil slides (also stubs for the scanning electron microscope) were used. These methods are described elsewhere in the literature by the writer as well as by others. All foraminiferal samples were boiled in solutions of "Quaternary O" (see Zingula, 1968, p. 1092).

All of the fossils studied for this report were collected from outcrops by the writer, or by Dr. Harold E. Vokes and Dr. Emily H. Vokes.

III. ACKNOWLEDGMENTS

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IV. BIOSTRATIGRAPHY, NEOGENE ZONE 20

A. AGUEGUEXQUITE FORMATION

The Agueguexquite Formation was defined by Thalmann (1935a, p. 592; 1935b, p. 116), as follows:

> "The type locality of the Agueguexquite formation is the series of outcrops at the crossing of the road from Puerto Mexico to Santa Rosa, dipping 5° towards N. W., in the Agueguexquite Creek, 11 kms. azimuth 100° from Puerto Mexico Church (Coatzacoalcos, State of Vera Cruz, Mexico).
>
> The average thickness of this highly fossiliferous (Foraminifera and Mollusca) beds is about 200 ms. At the base, indicating a marine transgression, are layers of quartz pebbles, from hazelnut to walnut in size, which are embedded in a matrix of coarse sand and bluish-grey, micaceous, brown-weathering clay. The sediments consist principally of bluish-grey sandy clays, mostly micaceous, with intercalations of grit and sand, poorly bedded, containing a rich fauna of gastropods and lamellibranchiata and scattered plant remains, chiefly in the lower part of the formation.
>
> The geological age, judged from faunal evidences is upper Lower Miocene or lower Middle Miocene (Helvetian or Tortonian). The foraminiferal association includes over a hundred different species and is characterized by the presence of unusually large specimens of *Cuneolina* and *Textulariella*. The fauna is closely connected with that from the Choctawhatchee formation in Florida; apparently it was deposited in shallow warm water within the neritic zone.
>
> The Agueguexquite formation represents the youngest Miocene deposition as yet found in the Coatzacoalcos basin, and approximately can be correlated with the Mid-Upper Gatun formation of Panama or with the basal Bowden formation of Jamaica" (Thalmann, 1935b, p. 116).

The precise locality described by Thalmann has not been relocated and collected, but material from an exposure approximately ½ mile from the type was studied (TU 1046). The foraminiferal assemblage at TU 1046 is not so rich as that described by Thalmann for the type locality, and it may represent a different horizon of the formation. Perrilliat Montoya (1960, 1963) described mollusks from the exposure designated here as TU 1046. The beds at locality TU 638 are richly fossiliferous and have been referred to the Agueguexquite Formation by E. H. Vokes (1970 and earlier reports). It should be pointed out that the field work for this report has thus far failed to disclose foraminiferal associations characterized by the "unusually large specimens of *Cuneolina* and *Textulariella*" mentioned by Thalmann, although the number of species at TU 638 is of the order described by him. Although all of the foraminiferal associations observed in the area are representative of warm water, data on foraminiferal ecology amassed since 1935 would indicate depths greater than the neritic zone. Thalmann's description of the lithology and mollusks, however, fits the section at TU 638.

Contreras Velazquez (1956, p. 52) and Salas (1967, p. 13) have followed Thalmann in referring these beds to the Miocene. Their reasoning was based on faunal similarities in mollusks and benthic foraminifera with the Choctawhatchee beds of Florida and the Bowden Formation of Jamaica. Subsequent studies on planktic foraminifera (Akers, 1972, p. 14-28) have shown that the Agueguexquite Formation and the Jackson Bluff Formation of the Choctawhatchee Stage are of middle Pliocene age. Studies on the calcareous nannofossils of the Agueguexquite and Jackson Bluff formations support this conclusion (Akers and Koeppel, 1973, p. 82-83). Similarly, planktic foraminifera now indicate a post-Miocene age for the Bowden Formation (Lamb and Beard, 1972, p. 31-32).

The sparse calcareous planktic assemblage at TU 1046 includes the following:

Planktic foraminifera
- *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny)
- *Globigerinoides ruber* (d'Orbigny)
- *Orbulina universa* d'Orbigny

Calcareous nannofossils
- *Ceratolithus cristatus* Kamptner
- *Discoaster brouweri* Tan Sin Hok
- *Discoaster surculus* Martini and Bramlette
- *Gephyrocapsa caribbeanica* Boudreaux and Hay
- *Pseudoemiliania lacunosa* (Kamptner)
- Reworked Eocene species

The following planktic foraminifera were identified from a dark gray clay in the lower part of an exposure in the roadcut and quarry on Mexico Highway 180, 14 miles east of the junction with the road to Coatzacoalcos, Veracruz (TU 638):

- *Globigerina bulloides apertura* Cushman
- *Globigerina bulloides bulloides* d'Orbigny
- *Globigerina juvenilis* Bolli
- *Globigerinoides obliquus extremus* Bolli and Bermúdez
- *Globigerinoides obliquus obliquus* Bolli
- *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny)
- *Globigerinoides ruber* (d'Orbigny)
- *Globorotalia (Globorotalia) cultrata limbata* (Fornasini)
- *Globorotalia (Turborotalia) acostaensis acostaensis* Blow
- *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito
- *Hastigerina (Hastigerina) siphonifera siphonifera* (d'Orbigny)
- *Orbulina universa* d'Orbigny
- *Sphaeroidinella dehiscens dehiscens* forma *immatura* (Cushman)

In the basal part of the section at TU 638, the total number of planktic specimens exceeds the total number of benthic specimens of foraminifera greater than 64 microns in size. This high ratio of planktic to benthic forms is especially interesting in view of the gravel and coarse sands that are in and interbedded with the clay component of these beds. Reworking is suggested by such an association and is further indicated by the presence of Eocene discoasters, although recycled foraminiferal tests were not seen.

Akers and Koeppel (1973, p. 83) listed and discussed the calcareous nannofossils that they identified in the Agueguexquite Formation. The list should now include the following for locality TU 638:

- *Coccolithus doronicoides* Black and Barnes
- *Cyclococcolithina leptopora* (Murray and Blackman)
- *Cyclococcolithina macintyrei* (Bukry and Bramlette)
- *Discoaster brouweri* Tan Sin Hok
- *Discoaster pentaradiatus* Tan Sin Hok
- *Discoaster surculus* Martini and Bramlette
- *Discoaster variabilis* Martini and Bramlette
- *Gephyrocapsa reticulata* Nishida
- *Helicopontosphaera kamptneri* Hay and Mohler
- *Helicopontosphaera* sp.
- *Lithostromation perdurum* Deflandre
- *Pseudoemiliania lacunosa* (Kamptner)

Geologic Age of the Agueguexquite Formation and Correlation with Other Formations.

The absence of the calcareous nannoplankton species, *Sphenolithus abies* Deflandre, may be significant in fixing the age of these beds. This species is ubiquitous in upper Miocene to middle Pliocene sediments of marine and low latitude origin. The species and also the genus became extinct during the middle Pliocene within Zone N. 20 at the approximate middle of that zone (Akers, 1974a, fig. 1). *Pseudoemiliania lacunosa* (Kamptner) does occur in the Agueguexquite beds, and it is also significant to the age of this formation, since it first appeared within Zone N. 20 (Gartner, 1969, p. 592, fig. 7; Akers, 1974a, fig. 1). *Globigerina bulloides apertura* Cushman probably ranges to the approximate middle of Zone N. 20. Blow's experience with this form was inadequate for him to fix the exact time of extinction (Blow, 1969, p. 317). Rare specimens of *Sphaeroidinella dehiscens dehiscens* forma *immatura* (Cushman) were found, but they may be pseudomorphs with arrested ontogenetic development, as described by Blow (1969, p. 336). Thus, the Agueguexquite Formation must be considered to be of middle Pliocene age, and it probably belongs just above the precise middle of Zone N. 20.

Calcareous nannoplankton indicate a close time equivalence with the following formations in the Atlantic and Gulf coasts of the United States:

Yorktown Formation at Rice's Pit, Virginia

Yorktown Formation in the Lee Creek Mine, North Carolina

Jackson Bluff Formation at Beds 4 and 10 of Alum Bluff, Florida

A slightly younger age is indicated by the calcareous nannofloras for the Agueguexquite Formation than for the Pinecrest Formation of southern Florida, the Jackson Bluff Formation at Watson's Landing and at Darling Slide, Florida. Akers and Koeppel (1973) present discussions of the calcareous nannoplankton in the Yorktown and Jackson Bluff formations, and Akers (1974a, p. 119-120) has documented the age of the Pinecrest Formation.

B. FILISOLA FORMATION

Thalmann referred the Filisola beds of the Coatzacoalcos Basin to the lower Miocene and described them as follows:

"The upper section of the Lower Miocene shows a succession of strata of gray marl, in part strongly sandy, in places with green to blue-green clays with plant remains and Pleurotomas. Towards the top, there appears blue or greenish-gray micaceous sandstone and chalk concretions. The sandstone weathers yellowish and alternates locally with violet sand-marl. Because of the great sand content, the fossil content found in Ixhuatlan and Concepcion strata has been greatly impoverished, yet the following important species occur for the first time:

Amphistegina lessoni d'Orbigny var.
Cibicides americanus (Cushman)
Cristellaria vaughani (Cushman)
C. rotulata (Lamarck)

Fauna and lithology permit recognition of coastal formation and sedimentation in which delta formation is already noticeable. For a time the Filisola correlates with the upper section of the Tuxpan stage (Tuxpan strata s.s.) of East Mexico" (Thalmann, 1935a, p. 592; translation by Gail P. Kohl).

Contreras Velazquez (1956, p. 54-56) has further defined the Filisola Formation and refers it to the middle Miocene (p. 48). Viniegra *et al.* (1956, p. 163) refer beds in a roadcut on the north side of Mexico Highway 180, 13 kilometers west of San Andreas Tuxtla, State of Veracruz, to the Filisola Formation. This is the same locality as stop 10 of the 20th International Geological Congress. For reasons discussed below, these beds are considered to be of middle Pliocene age. Thalmann's original description is applicable to the beds at this locality, and, in the absence of a formal designation by Thalmann or others, this locality (designated as locality TU 1141) is proposed as the type locality for the Filisola Formation.

The following planktic foraminifera were identified at TU 1141:

Globigerina bulloides apertura Cushman
Globigerinoides obliquus extremus Bolli and Bermúdez
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny)
Globigerinoides ruber (d'Orbigny)
Globorotalia (Globorotalia) cultrata limbata (Fornasini)
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito
Globorotalia (Turborotalia) scitula scitula (Brady)
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny)
Orbulina universa d'Orbigny
Prosphaeroidinella parkerae Ujiié

Calcareous nannofossils are not so abundant or well preserved in the Filisola Formation at TU 1141 as they are in other middle Pliocene assemblages of Mexico. The following identifications were confirmed by electron microscopy:

Coccolithus doronicoides Black and Barnes
Coccolithus pelagicus (Wallich)
Discoaster sp. (only fragments were observed)
Gephyrocapsa sp. cf. *G. reticulata* Nishida
Helicopontosphaera sp.
Reticulofenestra pseudoumbilica (Gartner)
Reworked nannofossils of Eocene age

The following species were identified by light microscopy but were not observed in preparations for electron microscopy:

Gephyrocapsa caribbeanica Boudreaux and Hay
Pseudoemiliania lacunosa (Kamptner)
Sphenolithus abies Deflandre (heavily calcified)

Geologic Age of the Filisola Formation and Correlation with Other Formations.

The conjunction of *Globigerina bulloides apertura* Cushman, *Sphenolithus abies* Deflandre, *Gephyrocapsa caribbeanica* Boudreaux and Hay, and *Pseudoemiliania lacunosa* (Kamptner) fixes the age of the Filisola Formation at the proposed type locality as middle Pliocene, Neogene Zone 20 (Akers, 1974, fig. 1). The absence of *Sphenolithus abies* Deflandre in the Agueguexquite Formation (also Zone N. 20) indicates that the Aquequexquite Formation is stratigraphically higher than the Filisola Formation. In general, this relationship has been known by many Mexican geologists, although the precise age of the two formations has not been determined previously.

Nannoplankton floras indicate that the Filisola Formation was deposited contemporaneously with the Jackson Bluff Formation, *Ecphora* Faunizone, at Watson's Landing and at Darling Slide, northern Florida. The Filisola Formation is also contemporaneous with the Pinecrest Formation of southern Florida. The Filisola Formation, then, is slightly older than the Jackson Bluff Formation at beds 4 and 10 of Alum Bluff, Florida. It is also slightly older than the Yorktown Formation at Rice's Pit, Virginia, and the Yorktown Formation at Lee Creek Mine, North Carolina. These slightly older beds contain *Sphenolithus abies*, as does the Filisola Formation at the proposed type locality (see Akers and Koeppel, 1973, for a discussion of the calcareous nannoplankton of these formations).

C. CONCEPCION FORMATION

Thalmann (1935a, p. 592) described the Concepcion Formation as follows:

> "These middle Lower Miocene deposits also have an especially rich, small foraminiferal fauna. Lithologically we are dealing here primarily with a blue-gray marl and clay with sand lenses, chalk concretions, and rich *Pleurotoma* fauna in the upper part. The weathered color of the marl is mostly brownish. Index fossils are:
>
> *Cibicides filisolaensis* Nuttall
> *Chilostomella mexicana* Nuttall
> *Bolivina subaenariensis* Cushm.
> *Epistomina elegans* d'Orb.
> *Gyroidina soldanii* d'Orb.
> *Marginulina pecketi* Schrodt
> *M. pecketi* var. *spinosa* Schrodt
> *M. hirsuta* d'Orb. var.
> *Nodosaria hispida* d'Orb.
> *Siphogenerina transversa* Cushm.
> *Textularia mississippiensis* Cushm.
>
> Facies: deeper neritic zone to shallower bathyal region (*Pleurotoma* clay) in the sense of L. Strausz. In age, it agrees with the strata series of the Papantla strata of the Tuxpan Stage of East Mexico (Burdigalian to older Vindobonian)".

Thalmann did not specify a type locality for the Concepcion Formation. The type area (type depositional basin), as for the Agueguexquite Formation, is "the southeastern part of Mexico, especially in the Coatzacoalcos Basin on the Atlantic side of the Isthmus of Tehuantepec" (Thalmann, 1935a, p. 592, as translated by Gail P. Kohl).

Subsequent to Thalmann's observations, subsurface beds in this area have been referred to the "Concepcion Inferior" and the "Concepcion Superior" formations by industrial micropaleontologists. Although no clear lithological basis has been offered for this subdivision, or, indeed, for the separation of the Concepcion from the Aqueuexquite Formation, the Concepcion Inferior and the Concepcion Superior are said to be recognized by characteristic suites of benthic foraminifera (Sansores and Flores-Covarrubias, 1972, vol. 1, p. 5; Contreras Velazquez, 1956, p. 56-59).

Contreras Velazquez *et al.* (1956, p. 176) designated the exposure at stop 5 of the 20th International Geological Congress Excursion C-7 as Concepcion Inferior. This is TU 1025 of Vokes (1970, p. 49) who described the locality as follows:

> "Concepcion Fm., roadcut on east side of road from Nuevo Teapa to Ixhuatlan, 0.5 mile south of junction with Mexico Highway 180, Veracruz, Mexico."

Material collected by the writer in May, 1972, from this locality contains the following planktic foraminifera:

Biorbulina bilobata (d'Orbigny)
Candeina nitida nitida d'Orbigny
Globigerina bulloides bulloides d'Orbigny
Globigerinita uvula (Ehrenberg)
Globigerinoides conglobatus conglobatus (Brady)
Globigerinoides obliquus extremus Bolli and Bermúdez
Globigerinoides obliquus obliquus Bolli
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny)
Globigerinoides quadrilobatus sacculifer (Brady)
Globigerinoides ruber (d'Orbigny)
Globoquadrina altispira altispira (Cushman and Jarvis)
Globoquadrina altispira globosa Bolli
Globoquadrina conglomerata (Schwager)
Globoquadrina venezuelana (Hedberg)
Globorotalia (Globorotalia) crassula conomiozea Kennett
Globorotalia (Globorotalia) cultrata limbata (Fornasini)
Globorotalia (Globorotalia) margaritae Bolli and Bermúdez
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito
Globorotalia (Turborotalia) acostaensis pseudopima Blow
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny)

Orbulina universa d'Orbigny
Sphaeroidinellopsis subdehiscens subdehiscens (Blow)

The calcareous nannofossils at TU 1025 have been illustrated and discussed in a previous publication (Akers and Koeppel, 1973, p. 82, pl. 1, 3). The following species have been identified:

Ceratolithus cristatus Kamptner
Discoaster asymmetricus Gartner
Discoaster brouweri Tan Sin Hok
Discoaster pentaradiatus Tan Sin Hok
Discoaster surculus Martini and Bramlette
Discoaster variabilis Martini and Bramlette
Pseudoemiliania lacunosa (Kamptner)
Reticulofenestra pseudoumbilica (Gartner)
Sphenolithus abies Deflandre

Geologic Age of the Concepcion Inferior Beds at TU 1025 and Correlation with Other Formations

Both Contreras Velazquez (1956, p. 48) and Sansores and Flores-Covarrubias (1972, p. 4) perpetuate the older concept of an early Miocene age for the Concepcion Inferior beds. This concept was proposed without benefit of our present information on planktic biostratigraphy. Both planktic foraminifera and calcareous nannoplankton indicate a younger age for these strata than that proposed by earlier investigators.

The concurrence of *Globorotalia (Turborotalia) acostaensis pseudopima* Blow, *Reticulofenestra pseudoumbilica* (Gartner), *Pseudoemiliana lacunosa* (Kamptner), and *Sphenolithus abies* Deflandre dates the Concepcion Inferior beds at TU 1025 as middle Pliocene Zone N. 20. This association is also evidence that deposition here was precisely contemporaneous with the Filisola Formation at the proposed type locality (TU 1141), the Pinecrest Formation in southern Florida, the Jackson Bluff Formation, *Ecphora* Faunizone, at Watson's Landing and at Darling Slide, Florida. The Concepcion Inferior strata, then, like the Filisola Formation, is slightly older than the Jackson Bluff Formation at beds 4 and 10 of Alum Bluff, Florida, the Yorktown Formation at Rice's Pit, Virginia, and the Yorktown Formation at Lee Creek Mine, North Carolina (see Akers and Koeppel, 1973, for a discussion of the calcareous nannoplankton in these formations).

The Concepcion Superior Formation is represented in a road metal quarry (State of Veracruz) on Mexico Highway 175, about one mile north of the bridge over the Tonto River (just above confluence with the Papaloapan River), near Tuxtepec, Oaxaca, Mexico (Contreras Velazquez, 1956, p. 56-58). The locality is designated in this report as TU 1026. The general lithologic aspect and the profusion of megafossils in the rocks are so reminiscent of the Chipola Formation of northwestern Florida that one wonders if the superficial similarities were not influential in the early assignment of the Concepcion beds to the Miocene. The benthic genus *Amphistegina*, moreover, is conspicuous in both formations. The microplankton of the two formations, however, are quite different (see Akers, 1972, p. 9-12, for the Chipola Formation), as are most of the benthic foraminifera.

The following planktic foraminifera have been identified in the Concepcion Superior beds at TU 1026:

Biorbulina bilobata (d'Orbigny)
Globigerina bulloides bulloides d'Orbigny
Globigerina nepenthes Todd
Globigerinita uvula (Ehrenberg)
Globigerinoides conglobatus conglobatus (Brady)
Globigerinoides obliquus extremus Bolli and Bermúdez
Globigerinoides obliquus obliquus Bolli
Globigerinoides quadrilobatus quadrilobatus (d'Orbigny)
Globigerinoides quadrilobatus sacculifer (Brady)
Globigerinoides ruber (d'Orbigny)
Globoquadrina altispira globosa Bolli
Globorotalia (Globorotalia) cultrata limbata (Fornasini)
Globorotalia (Globorotalia) margaritae Bolli and Bermúdez
Globorotalia (Globorotalia) cf. *Globorotalia multicamerata* Cushman and Jarvis
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny)
Orbulina universa d'Orbigny
Sphaeroidinellopsis subdehiscens subdehiscens (Blow)

The calcareous nannofossils at locality TU 1026 have been illustrated and discussed in a previous publication (Akers and Koeppel, 1973, p. 82-83, pl. 1, 3, 4). The following species have been identified here:

Cyclococcolithina leptopora (Murray and Blackman)
Cyclococcolithina macintyrei (Bukry and Bramlette)
Discoaster brouweri Tan Sin Hok

Discoaster pentaradiatus Tan Sin Hok
Discoaster surculus Martini and Bramlette
Pseudoemiliania lacunosa (Kamptner)
Reticulofenestra pseudoumbilica (Gartner)
Sphenolithus abies Deflandre

Geologic Age of the Concepcion Superior Formation at TU 1026 and Correlation with Other Formations

The concurrence of *Pseudoemiliania lacunosa* (Kamptner), *Reticulofenestra pseudoumbilica* (Gartner), and *Sphenolithus abies* Deflandre in the Concepcion Superior Formation at TU 1026 fixes the age as middle Pliocene Zone N. 20. Little, if any, difference in age can be shown for the Concepcion Inferior beds at TU 1025 and the Concepcion Superior strata at TU 1026, and the same relationships described above for the Concepcion Inferior Formation at TU 1025 with other formations would apply equally for the Concepcion Superior locality at TU 1026.

D. UNNAMED FORMATIONS

Microfossils of middle Pliocene age were collected from two localities (TU 1083 and TU 1136) for which the rock stratigraphic nomenclature is not clear. Whether such beds can be assigned correctly to an existing formally designated unit must be determined by lithologic study in the field. The outcrops fall within areas designated on published maps as "lower Miocene" and "upper Miocene" (Contreras Velazquez *et al.*, 1956, fig. 21).

Locality TU 1083.

These beds are exposed in a roadcut on Mexico Highway 185, 3.0 miles north of Sayula, State of Veracruz, Mexico. The locality is within an area designated as "lower Miocene" on map 21 of Excursion C-7, Congreso Geologico Internacional (Contreras Velazquez *et al.*, 1956, map 21). The Concepcion Inferior Formation as designated by Contreras Velazquez *et al.*, (1956, p. 176) at stop 5 of the 20th International Geological Congress also falls within the area indicated by map legend as "lower Miocene." Stop 5 (TU 1025) is approximately 80 kilometers east of TU 1083.

Hand samples from this formation are marked by a profusion of echinoid spines. The planktic microfauna and microflora, however, are extremely rich. Calcareous nannoplankton from the locality were discussed by Akers and Koeppel (1973, p. 83), and the beds were referred to Zone N. 20.

The following planktic foraminifera were identified at TU 1083:

Biorbulina bilobata (d'Orbigny)
Globigerina bulloides bulloides d'Orbigny
Globigerinita uvula (Ehrenberg)
Globigerinoides conglobatus conglobatus (Brady)
Globigerinoides obliquus extremus Bolli and Bermúdez
Globigerinoides obliquus obliquus Bolli
Globigerinoides quadrilobatus sacculifer (Brady)
Globoquadrina altispira altispira (Cushman and Jarvis)
Globoquadrina altispira globosa Bolli
Globoquadrina venezuelana (Hedberg)
Globorotalia (Globorotalia) cultrata menardii (Parker, Jones and Brady)
Globorotalia (Globorotalia) margaritae Bolli and Bermúdez
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito
Globorotalia (Turborotalia) crassacrotonensis Conato and Follador
Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny)
Orbulina universa d'Orbigny
Prosphaeroidinella parkerae Ujiié
Sphaeroidinellopsis subdehiscens subdehiscens (Blow)

The calcareous nannoplankton at locality TU 1083 were illustrated and reviewed by Akers and Koeppel (1973, p. 83) and were useful in the precise dating of the formation. The following species were identified:

Ceratolithus rugosus Bukry and Bramlette
Coccolithus doronicoides Black and Barnes
Coccolithus pelagicus (Wallich)
Cristallolithus multiporus (Kamptner)
Cyclococcolithina leptopora (Murray and Blackman)
Cyclococcolithina macintyrei (Bukry and Bramlette)
Discoaster asymmetricus Gartner
Discoaster brouweri Tan Sin Hok
Discoaster exilis Martini and Bramlette
Discoaster pentaradiatus Tan Sin Hok
Discoaster perplexus Bramlette and Riedel
Discoaster surculus Martini and Bramlette
Discoaster variabilis Martini and Bramlette
Emiliania annula (Cohen)
Gephyrocapsa caribbeanica Boudreaux and Hay
Helicopontosphaera kamptneri Hay and Mohler
Pontosphaera sp.
Pseudoemiliania lacunosa (Kamptner)
Reticulofenestra pseudoumbilica (Gartner)
Sphenolithus abies Deflandre
Umbilicosphaera mirabilis (Lohmann)

Geologic Age of the Beds at TU 1083

These species constitute a typical Pliocene nannoflora, and their overlapping stratigraphic ranges indicate a precise position for the beds at TU 1083 in Zone N. 20. *Sphenolithus abies* Deflandre and *Reticulofenestra pseudoumbilica* (Gartner) indicate that the age cannot be younger than Zone N. 20. *Pseudoemiliania lacunosa* (Kamptner) and *Gephyrocapsa caribbeanica* Boudreaux and Hay establish an age no older than Zone N. 20.

Locality TU 1136

Beds are exposed in a roadcut at K 15 on Mexico Highway 185, south of Acayucan, State of Veracruz. The locality lies within an area designated as "middle Miocene" on Excursion C-7, Congreso Geologico Internacional (Contreras Velazquez *et al.*, 1956, fig. 21).

The following planktic foraminifera were identified at TU 1136:

Biorbulina bilobata (d'Orbigny)
Globigerina bulloides bulloides d'Orbigny
Globigerina calida praecalida Blow
Globigerina decoraperta Takayanagi and Saito
Globigerinoides obliquus extremus Bolli and Bermúdez
Globigerinoides obliquus obliquus Bolli
Globigerinoides quadrilobatus sacculifer (Brady)
Globorotalia (Globorotalia) cultrata menardii (Parker, Jones and Brady)
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito
Orbulina universa d'Orbigny
Prosphaeroidinella parkerae Ujiié

The following calcareous nannofossils were identified at TU 1136 by scanning electron microscopy:

Coccolithus pelagicus (Wallich)
Cristallolithus macroporus (Deflandre)
Cyclococcolithina macintyrei (Bukry and Bramlette)
Discoaster brouweri Tan Sin Hok
Discoaster pentaradiatus Tan Sin Hok
Discoaster perplexus Bramlette and Riedel
Discoaster variabilis Martini and Bramlette
Gephyrocapsa reticulata Nishida
Helicopontosphaera sp.
Lithostromation perdurum Deflandre
Pseudoemiliania lacunosa (Kamptner)
Reticulofenestra pseudoumbilica (Gartner)
Sphenolithus abies Deflandre

Geologic Age of the Beds at TU 1136

The overlapping ranges of *Pseudoemiliania lacunosa* (Kamptner) with *Reticulofenestra pseudoumbilica* (Gartner) and *Sphenolithus abies* Deflandre fix the age of this formation within Zone N. 20.

Correlation of the Unnamed Formation(s) at TU 1083 and TU 1136 with Other Formations

Sphenolithus abies Deflandre and *Reticulofenestra pseudoumbilica* (Gartner) occur at both of these localities. These species become extinct within Zone N. 20. The occurrence of these species with other species, such as *Gephyrocapsa caribbeanica* Boudreaux and Hay and *Pseudoemiliania lacunosa* (Kamptner) that are known to have their first evolutionary occurrence within Zone N. 20, would seem to offer a reliable basis for the correlation of the formations wherein such a concurrence is observed (Akers, 1974, fig. 1). On this premise, the unnamed formation(s) at TU 1083 and TU 1136 would be precisely contemporaneous with the Concepcion Inferior Formation at TU 1025, the Concepcion Superior Formation at TU 1026, the Filisola Formation at TU 1141, the Jackson Bluff Formation at Watson's Landing and Darling Slide, northern Florida, and the Pinecrest Formation in southern Florida.

All of the above formations are approximately correlatable with the Agueguexquite Formation at TU 638 and TU 1046, the Yorktown Formation at Rice's Pit, Virginia, and at Lee Creek Mine, North Carolina, and the Jackson Bluff Formation, beds 4 and 10 of Alum Bluff, northern Florida. The absence of the ubiquitous species, *Sphenolithus abies* Deflandre and *Reticulofenestra pseudoumbilica* (Gartner), suggests that this latter group of formations, though also referable to Zone N. 20 by the association of other species (Akers and Koeppel, 1973, p. 80-83), are slightly younger than the former group.

V. TAXONOMY

The taxonomic concept adopted for this series of reports is similar to that followed by Thierstein (1976, p. 348-353) in which age dating and correlations in geologic time are the main objectives. This section presents the planktic foraminifera and the calcareous nannofossils in separate groups and alphabetically by specific epithet in each respective group. References to original descriptions, subsequent combinations, and synonyms are given. Remarks are included when pertinent. Additional references for the calcareous nannofossils may be found in Loeblich and Tappan (1966, 1968, 1969, 1970a, 1970b, 1971, 1973). The plates for this report are organized alphabetically by genus, space permitting, in order to facilitate comparison of similar forms. The species lists for the various formations are also arranged alphabetically by genus. The plate and figure references immediately following each author's name in the following alphabetized list of specific or subspecific epithets are to the illustrations in this study.

A. PLANKTIC FORAMINIFERA

Globorotalia (Turborotalia) acostaensis acostaensis Blow. Pl. 4, fig. 11

Globorotalia acostaensis BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 208-210, pl. 17, fig. 106a-c, 107.

Globoquadrina acostaensis (Blow), PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 164-165, pl. 24, fig. 3-9.

Globorotalia (Turborotalia) acostaensis acostaensis Blow, BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 344-345, pl. 9, fig. 13-15; pl. 33, fig. 1, 2.

Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito. Pl. 5, fig. 1, 6

Globorotalia humerosa TAKAYANAGI and SAITO, 1962, Sci. Repts., Tohoku Univ., ser. 2 (Geology), Spec. Vol. no. 5, p. 78, pl. 28, fig. 1, 2.

Globoquadrina humerosa (Takayanagi and Saito), PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 169-170, pl. 24, fig. 10, 11; pl. 25, fig. 1-6.

Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito, BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 345-346, pl. 33, fig. 3-9; pl. 34, fig. 1-3.

Globorotalia (Turborotalia) acostaensis pseudopima Blow. Pl. 5, fig. 3

Globorotalia (Turborotalia) acostaensis pseudopima BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 387-388, pl. 35, fig. 1-7.

Globoquadrina altispira altispira (Cushman and Jarvis). Pl. 3, fig. 8

Globigerina altispira CUSHMAN and JARVIS, 1936, Cushman Lab. Foram. Res., Contr., vol. 12, pt. 1, p. 5, pl. 1, fig. 13a-c, 14.

Globoquadrina altispira altispira (Cushman and Jarvis), BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 111, pl. 24, fig. 7a-8b.

Globoquadrina altispira globosa Bolli. Pl. 3, fig. 10

Globoquadrina altispira globosa BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 111, pl. 24, fig. 9, 10.

Biorbulina bilobata (d'Orbigny). Pl. 2, fig. 1

Globigerina bilobata D'ORBIGNY, 1846, Foraminifères du bassin tertiaire de Vienne, p. 164, pl. 9, fig. 11-14.

Orbulina bilobata (d'Orbigny), PALMER, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, p. 286, pl. 28, fig. 3.

Biorbulina bilobata (d'Orbigny), BLOW, 1956, Micropaleontology, vol. 2, no. 1, p. 69-70, text-fig. 2, no. 16.

Globigerina bulloides apertura Cushman. Pl. 2, fig. 2-3.

Globigerina apertura CUSHMAN, 1918, U. S. Geol. Surv., Bull. 676, p. 57, pl. 12, fig. 8a-c.

Globigerina riveroae BOLLI and BERMÚDEZ, 1965, Bol. Informativo, Asociacion Venezolana de Geologia, Min. y Pet., vol. 8, no. 5, p. 137, 138, pl. 1, fig. 1-6.

Globigerina bulloides apertura Cushman, BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 317, pl. 12, fig. 8.

Remarks: Some of the specimens from the Agueguexquite Formation (pl. 2, fig. 2, 3) resemble *Globigerinoides obliquus obliquus* Bolli. However, close examination does not disclose supplementary apertures.

Globigerina bulloides bulloides d'Orbigny. Pl. 2, fig. 4-6

"Polymorphium tuberosum et globiferum" SOLDANI, 1791 (part), Testaceogr. ac Zoophytogr., vol. 1, pt. 2, p. 117, pl. 123, fig. 0 (not figs. H, I, and P, *fide* Banner and Blow, 1960, p. 3).

Globigerina bulloides D'ORBIGNY, 1826, Ann. Sci. Nat., (ser. 1) vol. 7, p. 277, list no. 1.

Globigerina bulloides bulloides d'Orbigny, BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 316-317, pl. 14, fig. 1, 2.

Globigerina calida praecalida Blow. Pl. 2, fig. 7

Globigerina calida PARKER, 1962, *partim*, Micropaleontology, vol. 8, no. 2, p. 221, pl. 1, fig. 12 (not pl. 1, fig. 9a-c, 10a-b, 11).

Globigerina calida PARKER, 1967, *partim*, Bull. Amer. Paleontology, vol. 52, no. 235, pl. 18, fig. 6a-c, 7, 8a-b, 9, 10 (not fig. 11, ? 12).

Globigerina calida praecalida BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 380-381, pl. 13, fig. 6, 7; pl. 14, fig. 3.

Globigerinoides conglobatus conglobatus (Brady). Pl. 2, fig. 10

Globigerina conglobata BRADY, 1879, Quart. Jour. Micr. Science, (new ser.) vol. 19, p. 286.

Globigerinoides conglobatus (Brady), PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 229, pl. 3, fig. 1-5.

Globigerinoides conglobatus conglobatus (Brady), AKERS, 1972, Tulane Stud. Geol. Paleont., vol. 9, no. 1-4, p. 56, 58, pl. 24, fig. 1, 2; pl. 58, fig. 1, 2.

Globoquadrina conglomerata (Schwager). Pl. 3, fig. 9

Globigerina conglomerata SCHWAGER, 1866, *Novara* Exped. 1857-1859, Geol. Theil., vol. 2, pt. 2, p. 255, pl. 7, fig. 113.

Globoquadrina conglomerata (Schwager), PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 165-166, pl. 27, fig. 4.

Globorotalia (Turborotalia) crassacrotonensis Conato and Follador. Pl. 5, fig. 2

Globorotalia crassacrotonensis CONATO and FOLLADOR, 1967, Bol. Soc. Geol. Italy, vol. 86, p. 557-558, fig. 2a-c; fig. 4, no. 3.

Globorotalia (Globorotalia) crassula conomiozea Kennett. Pl. 4, fig. 2

Globorotalia conomiozea KENNETT, 1966, Micropaleontology, vol. 12, p. 235, pl. 1, fig. 8-18, pl. 2, fig. 6-13; text-fig. 10.

Globorotalia (Globorotalia) crassula conomiozea Kennett, BLOW, 1969 Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 360-361, pl. 41, fig. 5-8.

Globorotalia (Globorotalia) cultrata limbata (Fornasini). Pl. 4, fig. 3

Rotalia limbata D'ORBIGNY, 1826, Tableau Méthodique de la classe des Céphalopodes, Ann. Sci. Nat., vol. 7, p. 274, list no. 30. *Nomen nudum.*

Rotalia limbata D'ORBIGNY, *in* FORNASINI, 1902, R. Accad. Sci., Ist. Bologna, Mem. Sci. Nat., Bologna, (ser. 5) vol. 10, p. 56, text-fig. 55.

Globorotalia pseudomiocenica BOLLI and BERMÚDEZ, 1965, Bol. Informativo, Assoc. Venezolana de Geol., Min. y Pet., vol. 8, no. 5, p. 140-141, pl. 1, fig. 13-15.

Globorotalia (Globorotalia) cultrata limbata (Fornasini), BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 359, pl. 7, fig. 4-6; pl. 42, fig. 2, 3.

Globorotalia (Globorotalia) cultrata menardii (Parker, Jones and Brady). Pl. 4, fig. 4-5, 9

Rotalia menardii PARKER, JONES and BRADY, 1865, Ann. Mag. Nat. Hist., (ser. 3) vol. 16, p. 20, pl. 3, fig. 81.

Globorotalia (Globorotalia) cultrata menardii (Parker, Jones and Brady), BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 359-360, pl. 6, fig. 9-11.

Globigerina decoraperta Takayanagi and Saito. Pl. 2, fig. 8

Globigerina druryi Akers *decoraperta* TAKAYANAGI and SAITO, 1962, Sci. Repts. Tohoku Univ., ser. 2 (Geology), Spec. Vol. no. 5, p. 85, pl. 28, fig. 10.

Globigerina decoraperta Takayanagi and Saito, PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 149, pl. 19, fig. 1a-c (not fig. 2).

Sphaeroidinella dehiscens dehiscens forma *immatura* (Cushman). Pl. 5, fig. 7

Sphaeroidina dehiscens Parker and Jones var. *immatura* CUSHMAN, 1919, Carnegie Inst. Washington, Publ. no. 291, p. 40, pl. 14, fig. 2.

Sphaeroidinella dehiscens dehiscens forma *immatura* (Cushman), BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 336, pl. 29, fig. 6-8.

Remarks: The specimens referred here may be pseudomorphs with arrested ontogenetic development, as described by Blow (1969, p. 336).

Globigerina juvenilis Bolli. Pl. 1, fig. 3

Globigerina juvenilis BOLLI, 1957, U.S. Natl. Mus., Bull. 215, p. 110, pl. 24, fig. 5a-6.

Globorotalia (Globorotalia) margaritae Bolli and Bermúdez. Pl. 4, fig. 6-8

Globorotalia margaritae BOLLI and BERMÚDEZ, 1965, Bol. Informativo, Asociacion Venezolana de Geologia, Min. y Pet., vol. 8, no. 5, p. 139-140, pl. 1, fig. 16-18.

Globorotalia (Globorotalia) cf. *Globorotalia multicamerata* Cushman and Jarvis. Pl. 4, fig. 10

Globorotalia menardii (d'Orbigny) var. *multicamerata* CUSHMAN and JARVIS, 1930, Jour. Paleontology, vol. 4, p. 367, pl. 34, fig. 8.

Remarks: The specimen figured in this report has fewer chambers than typical forms.

Globigerina nepenthes Todd. Pl. 1, fig. 2

Globigerina nepenthes TODD, 1957, U.S. Geol. Survey, Prof. Paper 280-H, p. 301, pl. 78, fig. 7a-b.

Sphaeroidinellopsis nepenthes (Todd) var. *constricta* BERMÚDEZ, 1961, Mem. III Congr. Geol. Venezolano, vol. 3, Bol. Geol. Publ. Esp. 3, (1960), p. 1278, pl. 10, fig. 2a-b.

Candeina nitida nitida d'Orbigny, Pl. 1, fig. 1

Candeina nitida D'ORBIGNY, 1839, Foraminifères, *in* DE LA SAGRA, Hist. Phys. Pol. Cuba, p. 108, pl. 2, fig. 27-28.

Candeina nitida nitida d'Orbigny, BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 335, pl. 23, fig. 1-4.

Globigerinoides obliquus extremus Bolli and Bermúdez. Pl. 3, fig. 1

Globigerinoides obliquus extremus BOLLI and BERMÚDEZ, 1965, Bol. Informativo, Assoc. Venezolana de Geol., Min. y Pet., vol. 8, no. 5, p. 139, pl. 1, fig. 10-12.

Globigerinoides obliquus obliquus Bolli. Pl. 3, fig. 2-3

Globigerinoides obliqua BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 113, pl. 25, fig. 9, 10, text-fig. 21, no. 5.

Globigerinoides obliquus obliquus Bolli, BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 324.

Prosphaeroidinella parkerae Ujiie. Pl. 5, fig. 8

Sphaeroidinella disjuncta Finlay, TODD, 1964, U.S. Geol. Surv., Prof. Paper 260-CC, p. 1089, pl. 290, fig. 2, 4.

Sphaeroidinella seminulina (Schwager), PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 161-162, pl. 23, fig. 3, 5 (not 1, 2, 4).

Sphaeroidinellopsis subdehiscens subdehiscens Blow, AKERS, 1972, Tulane Stud. Geol. Paleont., vol. 9, no. 1-4, p. 86, pl. 20, fig. 2-4; pl. 34, fig. 2; pl. 35, fig. 3-4; pl. 39, fig. 1, 3; pl. 49, fig. 3.

Prosphaeroidinella parkerae UJIIÉ, 1976, Bull. Natl. Sci. Mus., ser. C (Geol.), vol. 2, no. 1, p. 14-19, pl. 3, fig. 4; pl. 4, fig. 1, 2, 4; pl. 5, fig. 1-4; pl. 12, fig. 5; pl. 13, fig. 1.

Globigerinoides quadrilobatus quadrilobatus (d'Orbigny). Pl. 3, fig. 4

Globigerina quadrilobata D'ORBIGNY, 1846, Foraminifères fossiles du bassin tertiaire de Vienne, p. 164, pl. 9, fig. 7-10.

Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 325.

Globigerinoides quadrilobatus sacculifer (Brady). Pl. 3, fig. 5-6

Globigerina sacculifera BRADY, 1877, Geol. Mag., (new ser.) Decade 2, vol. 4, no. 12, p. 535.

Globigerinoides quadrilobatus sacculifer (Brady), BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 326.

Globigerinoides ruber (d'Orbigny). Pl. 3, fig. 7

Globigerina rubra D'ORBIGNY, 1839, Foraminifères, *in* DE LA SAGRA, Hist. Phys., Pol., Nat. Cuba, p. 82, pl. 4, fig. 12-14.

Globigerinoides ruber (d'Orbigny), CORDEY, 1967, Paleontology, vol. 10, pt. 4, p. 647-659, pl. 103, fig. 7-14; text-fig. 1a-d, text-fig. 3 (fig. 3a-5b).

Globorotalia (Turborotalia) scitula scitula (Brady)

Pulvinulina scitula BRADY, 1882, Roy. Soc. Edinburgh, Proc., vol. 11 (1880-1882), no. 111, p. 716-717.

Globorotalia scitula (Brady), CUSHMAN and HENBEST, 1940, U.S. Geol. Surv., Prof. Paper 196-A, pt. 2, p. 36, pl. 8, fig. 5a-c.

Globorotalia scitula scitula (Brady), BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 219, pl. 19, fig. 126a-c.

Globorotalia (Turborotalia) scitula scitula (Brady), BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 356, pl. 39, fig. 7.

Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny). Pl. 5, fig. 4

Globigerina siphonifera D'ORBIGNY, 1839, Foraminifères, *in* DE LA SAGRA, Hist. Phy., Pol., Nat. Cuba, p. 83, pl. 4, fig. 15-18.

Globigerina aequilateralis BRADY, 1879, Quart, Jour. Micr. Science, (new ser.) vol. 19, p. 285.

Globigerina aequilateralis Brady var. *involuta* CUSHMAN, 1917, U.S. Natl. Mus., Proc., vol. 51, no. 2172, p. 662.

Hastigerina (Hastigerina) siphonifera (d'Orbigny), BANNER and BLOW, 1960, Micropaleontology, vol. 6, no. 1, p. 22, text-fig. 2, 3.

Globigerinella siphonifera (d'Orbigny) PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 152-153, pl. 22, fig. 5.

Hastigerina (Hastigerina) siphonifera siphonifera (d'Orbigny), BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 375.

Sphaeroidinellopsis subdehiscens subdehiscens (Blow). Pl. 5, fig. 9

Sphaeroidinella dehiscens subdehiscens BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 195, pl. 12, fig. 71, 72.

Sphaeroidinellopsis subdehiscens subdehiscens (Blow), BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 338, pl. 30, fig. 1-3; pl. 31, fig. 1-3; pl. 32, fig. 1-3.

Orbulina universa d'Orbigny. Pl. 5, fig. 5

Orbulina universa D'ORBIGNY, 1839, Foraminifères, *in* DE LA SAGRA, Hist. Phys., Pol., Nat. Cuba, p. 2, pl. 1, fig. 1.

Globigerinita uvula (Ehrenberg). Pl. 2, fig. 9

Pylodexia uvula EHRENBERG, 1861, K. Preuss. Akad. Wiss. Berlin, Monatsber., p. 276, 277, 308.

Globigerina sp. BRADY, 1884, Rept. Voy.

Challenger, Zoology, vol. 9, p. 603, pl. 82, fig. 8, 9.
Globigerina bradyi WIESNER *in* DRYGALSKI, 1931, Deutsche Südpolar Exped. 1901-1903, vol. 20, (Zoology, vol. 12), p. 133.
Globigerinoides minuta NATLAND, 1938, Univ. Calif., Scripps Inst. Oceanography, Bull., Tech. Ser., vol. 4, no. 5, p. 150, pl. 7, fig. 2, 3.
Globigerinia uvula (Ehrenberg), PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 252, pl. 8, fig. 14-26.

Globoquadrina venezuelana (Hedberg). Pl. 4, fig. 1
Globigerina venezuelana HEDBERG, 1937, Jour. Paleontology, vol. 11, p. 681, pl. 92, fig. 7.
Globoquadrina venezuelana (Hedberg), BLOW, 1959, Bull. Amer. Paleontology, vol. 39, p. 186, pl. 11, fig. 58-59.

B. CALCAREOUS NANNOFOSSILS

Sphenolithus abies Deflandre. Pl. 8, fig. 18-19.
Sphenolithus abies DEFLANDRE, 1954, *in* DEFLANDRE and FERT, Ann. Paléontologie, vol. 40, p. 164, pl. 10, fig. 1-4.
Sphenaster metula WILCOXON, 1970, Tulane Stud. Geol. Paleont., vol. 8, no. 2, p. 80, pl. 1, fig. 1-8; pl. 2, fig. 1-6.

Remarks: Wilcoxon's illustrations are views of the basal apparatus of *Sphenolithus abies* Deflandre.

Emiliania annula (Cohen). Pl. 7, fig. 14-15
Coccolithites annulus COHEN, 1964, Micropaleontology, vol. 10, p. 237, pl. 3, fig. 1a-e.
Cyclolithella annulus (Cohen), McINTYRE and BÉ, 1967, Deep-Sea Research, vol. 14, p. 568, pl. 5, fig. A-C.
Emiliania annula (Cohen), BUKRY, 1971, Initial Reports Deep Sea Drilling Project, fol. 8, p. 1514.

Discoaster asymmetricus Gartner. Pl. 7, fig. 17
Discoaster asymmetricus GARTNER, 1969, Gulf Coast Assoc. Geol. Soc., Trans., vol. 19, p. 598, pl. 1, fig. 1-3.

Discoaster brouweri Tan Sin Hok. Pl. 7, fig. 16, 20-22
Discoaster brouweri TAN SIN HOK, 1927, Jaarb. Mijnw. Nederl.-Indie, vol. 55, p. 120, text-fig. 2, 8a, b.

Gephyrocapsa caribbeanica Boudreaux and Hay. Pl. 8, fig. 5
Gephyrocapsa caribbeanica BOUDREAUX and HAY, 1967, *in* HAY *et al.*, Gulf Coast Assoc. Geol. Soc., Trans., vol. 17, p. 447, pl. 12, fig. 1-4; pl. 13, fig. 1-4.

Ceratolithus cristatus Kamptner. Pl. 6, fig. 1
Ceratolithus cristatus KAMPTNER, 1954, Archiv. Protistenk., vol. 100, p. 43, text-fig. 44-55.

Coccolithus doronicoides Black and Barnes. Pl. 6, fig. 4-7
Coccolithus doronicoides BLACK and BARNES, 1961, Roy. Micros. Soc., Jour., (ser. 3) vol. 80, pt. 2, p. 142, pl. 25, fig. 3.
Ellipsoplacolithus galenis KAMPTNER, 1967, Naturh. Mus. Wien, Ann., vol. 71, p. 140, pl. 6, fig. 41.

Remarks: In pre-Pliocene formations and even in rocks of middle and lower Pliocene age, specimens referred to this species may be pseudomorphs. Fragmentation or solution of the bridge in the central area of species of *Gephyrocapsa*, for example, can pose problems in speciation. Validity of biostratigraphic use of the taxon remains to be established.

Discoaster exilis Martini and Bramlette. Pl. 7, fig. 18
Discoaster exilis MARTINI and BRAMLETTE, 1963, Jour. Paleontology, vol. 37, p. 852, pl. 104, fig. 1-3.

Helicopontosphaera kamptneri Hay and Mohler. Pl. 8, fig. 9
Coccolithus carteri (Wallich), KAMPTNER, 1941, Naturh. Mus. Wien, Ann., vol. 51, p. 93, 111, pl. 13, fig. 136 (not *Coccosphaera carteri* Wallich, 1877, Ann. Mag. Nat. Hist., ser. 4, vol. 19, p. 348, pl. 17, fig. 3, 4, 6, 7, 17).
Helicosphaera carteri (Wallich), KAMPTNER, 1954, Archiv. Protistenk., vol. 100, no. 1, p. 21, text-fig. 17-19.
Helicopontosphaera kamptneri HAY and MOHLER, 1967, *in* HAY *et al.*, Gulf Coast Assoc. Geol. Soc., Trans., vol. 17, p. 448, pl. 10, 11, fig. 5.

Pseudoemiliania lacunosa (Kamptner). Pl. 8, fig. 11, 17
Ellipsoplacolithus exsectus KAMPTNER, 1963, Naturh. Mus. Wien, Ann., vol. 66, p. 171, pl. 9, fig. 51, 52 (fig. 52 is incorrectly labelled).
Ellipsoplacolithus lacunosus KAMPTNER, 1963, Naturh. Mus. Wien, Ann., vol. 66, p. 172, pl. 9, fig. 50.
Coccolithus doronicoides Black *partim*, McINTYRE, BÉ, and PREIKSTAS, 1967, Progress in Oceanography, vol. 4, p. 8, pl. 3, fig. A.
Umbilicosphaera cricota (Gartner), COHEN and REINHARDT, 1968, Nueves Jahrb. Geologie Paläontologie Abh., vol. 131, p. 296, pl. 21, fig. 3.
Pseudoemiliania lacunosa (Kamptner), GART-

NER, 1969, Gulf Coast Assoc. Geol. Soc., Trans., vol. 19, p. 598, pl. 2, fig. 9, 10.

Cyclococcolithina leptopora (Murray and Blackman). Pl. 7, fig. 9-13

Coccosphaera leptopora MURRAY and BLACKMAN, 1898, Roy. Soc. London, Phil. Trans., (ser. B) vol. 190, p. 430, pl. 15, fig. 1-7.

Coccolithophora leptopora (Murray and Blackman), LOHMANN, 1902, Archiv. Protistenk., vol. 1, p. 138, pl. 5, fig. 52, 61-64.

Coccolithus leptoporus (Murray and Blackman), SCHILLER, 1930, *in* L. RABENHORST, Kryptogamen-Flora, vol. 10, p. 245, text-fig. 10.

Cyclococcolithus leptoporus (Murray and Blackman), KAMPTNER, 1954, Archiv. Protistenk., vol. 100, p. 23, fig. 20.

Cyclococcolithina leptopora (Murray and Blackman), WILCOXON, 1970, Tulane Stud. Geol. Paleont., vol. 8, no. 2, p. 82.

Cyclococcolithina macintyrei (Bukry and Bramlette). Pl. 7, fig. 6-8

Coccolithus leptoporus (Murray and Blackman), McINTYRE, BÉ, and PREIKSTAS, 1967, Progress in Oceanography, vol. 4, p. 9 *(partim)*, pl. 2, fig. A, B (not pl. 4, fig. C, D; pl. 5, fig. A, C, D).

Cyclococcolithus macintyrei BUKRY and BRAMLETTE, 1969, Tulane Stud. Geol. Paleont., vol. 7, no. 3, p. 132, pl. 1, fig. 1-3.

Cyclococcolithina macintyrei (Bukry and Bramlette), GARTNER, 1973, Geol. Soc. America, Bull., vol. 84, no. 6, p. 2021.

Cristallolithus macroporus (Deflandre). Pl. 7, fig. 4

Discolithus macroporus DEFLANDRE, 1954, *in* DEFLANDRE and FERT, Ann. Paléontologie, vol. 40, p. 24, pl. 11, fig. 5.

Discolithina macroporus (Deflandre), LEVIN and JOERGER, 1967, Micropaleontology, vol. 13, p. 167, pl. 2, fig. 5.

Cristallolithus macroporus (Deflandre), SACHS and SKINNER, 1973, Tulane Stud. Geol. Paleont., vol. 10, no. 3, p. 154-155, pl. 5, fig. 1-4.

Umbilicosphaera mirabilis Lohmann. Pl. 8, fig. 20

Umbilicosphaera mirabilis LOHMANN, 1902, Archiv. Protistenk., vol. 1, p. 139, pl. 5, fig. 66, 66a.

Cyclococcolithus mirabilis (Lohmann), KAMPTNER, 1954, Archiv. Protistenk., vol. 100, p. 24, text-fig. 21-23.

Cristallolithus multiporus (Kamptner), new combination. Pl. 7, fig. 5

Discolithus multiporus Kamptner, 1948, Sitz Ber. Österr. Akad. Wiss., Math.-Naturw. Kl., vol. 157, pt. 1, p. 5, pl. 1, fig. 9.

Discolithina multipora (Kamptner), MARTINI, 1965, Proc. 17th Symp. Colston. Res. Soc., London, p. 400.

Coccolithus pelagicus (Wallich). Pl. 7, fig. 1-3

Coccosphaera pelagica WALLICH, 1877, Ann. Mag. Nat. Hist., (ser. 4) vol. 19, p. 348, pl. 17, fig. 1, 2, 5, 11, 12.

Coccolithus pelagicus (Wallich) SCHILLER, 1930, *in* L. RABENHORST, Kryptogamen-Flora, Leipzig, vol. 10, p. 246.

Discoaster pentaradiatus Tan Sin Hok. Pl. 7, fig. 19

Discoaster pentaradiatus TAN SIN HOK, 1927, Jaarb. Mijnw. Nederl.-Indie, vol. 55, p. 120, fig. 2.

Lithostromation perdurum Deflandre. Pl. 8, fig. 10

Lithostromation perdurum DEFLANDRE, 1942, Acad. Sci. (Paris), C. R., vol. 214, p. 919, fig. 1-9.

Discoaster perplexus Bramlette and Riedel. Pl. 7, fig. 23-24

Discoaster perplexus BRAMLETTE and RIEDEL, 1954, Jour. Paleontology, vol. 28, p. 400, pl. 39, fig. 9.

PLATE 1

Figures

1. *Candeina nitida nitida* d'Orbigny
   Concepcion Inferior Formation, TU 1025
   a. Spiral view, ×188
   b. Side view, ×188
2. *Globigerina nepenthes* Todd
   Concepcion Superior Formation, TU 1026
   Umbilical view, ×234
3. *Globigerina juvenilis* Bolli
   Agueguexquite Formation, TU 638
   a. Umbilical view, ×283
   b. Spiral view, ×283

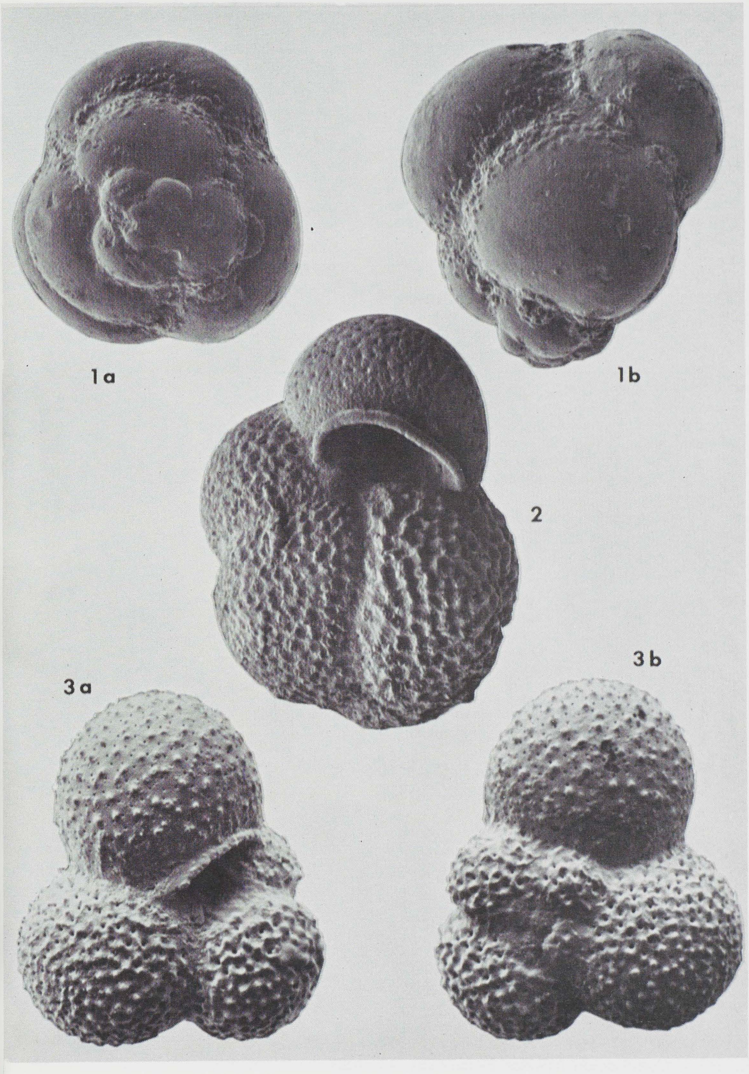

PLATE 1

Reticulofenestra pseudoumbilica (Gartner). Pl. 8, fig. 12-16

Coccolithus pseudoumbilicus GARTNER, 1967, Kans. Univ. Paleontological Contr., Paper 29, p. 4, pl. 6, fig. 1-4.

Reticulofenestra pseudoumbilica (Gartner), GARTNER, 1969, Gulf Coast Assoc. Geol. Soc., Trans., vol. 19, p. 598, pl. 2, fig. 4.

Gephyrocapsa reticulata Nishida. Pl. 8, fig. 6-7

Gephyrocapsa reticulata NISHIDA, 1971, Palaeontological Soc. Japan, Trans. Proc., (new ser.) vol. 83, p. 150, pl. 17, fig. 1-3.

Ceratolithus rugosus Bukry and Bramlette. Pl. 6, fig. 2-3

Ceratolithus rugosus BUKRY and BRAMLETTE, 1968, Tulane Stud. Geol. Paleont., vol. 6, no. 4, pl. 152, pl. 1, fig. 5-9.

Discoaster surculus Martini and Bramlette. Pl. 8, fig. 1-2

Discoaster surculus MARTINI and BRAMLETTE, 1963, Jour. Paleontology, vol. 37, p. 854, pl. 104, fig. 10-12.

Discoaster variabilis Martini and Bramlette. Pl. 8, fig. 3-4

Discoaster variabilis MARTINI and BRAMLETTE, 1963, Jour. Paleontology, vol. 37, p. 854, pl. 104, fig. 4-9.

VI. SUPPLEMENTARY LOCALITY DATA

The following are Tulane University fossil locality numbers:

638. Agueguexquite Formation.
Roadcut, pipeline cut, and quarry on both

PLATE 2

Figures

1. *Biorbulina bilobata* (d'Orbigny)
   Concepcion Superior Formation, TU 1026
   ×99
2. *Globigerina bulloides apertura* Cushman
   Agueguexquite Formation, TU 638
   a. Apertural view, ×127
   b. Spiral view, ×127
3. *Globigerina bulloides apertura* Cushman
   Filisola Formation, TU 1141
   Apertural view, ×104
4. *Globigerina bulloides bulloides* d'Orbigny
   Concepcion Superior Formation, TU 1026
   Spiral view, ×115
5. *Globigerina bulloides bulloides* d'Orbigny
   Concepcion Inferior Formation, TU 1025
   Umbilical view, ×91
6. *Globigerina bulloides bulloides* d'Orbigny
   Agueguexquite Formation, TU 638
   a. Spiral view, ×110
   b. Umbilical view, ×117
7. *Globigerina calida praecalida* Blow
   Unnamed formation, TU 1136
   Umbilical view, ×121
8. *Globigerina decoraperta* Takayanagi and Saito
   Unnamed formation, TU 1136
   Umbilical view, ×134
9. *Globigerinita uvula* (Ehrenberg)
   Concepcion Inferior Formation, TU 1025
   a. Umbilical view, ×250
   b. Spiral view, ×250
10. *Globigerinoides conglobatus conglobatus* (Brady)
   Concepcion Inferior Formation, TU 1025
   a. Spiral view, ×96
   b. Umbilical view, ×96

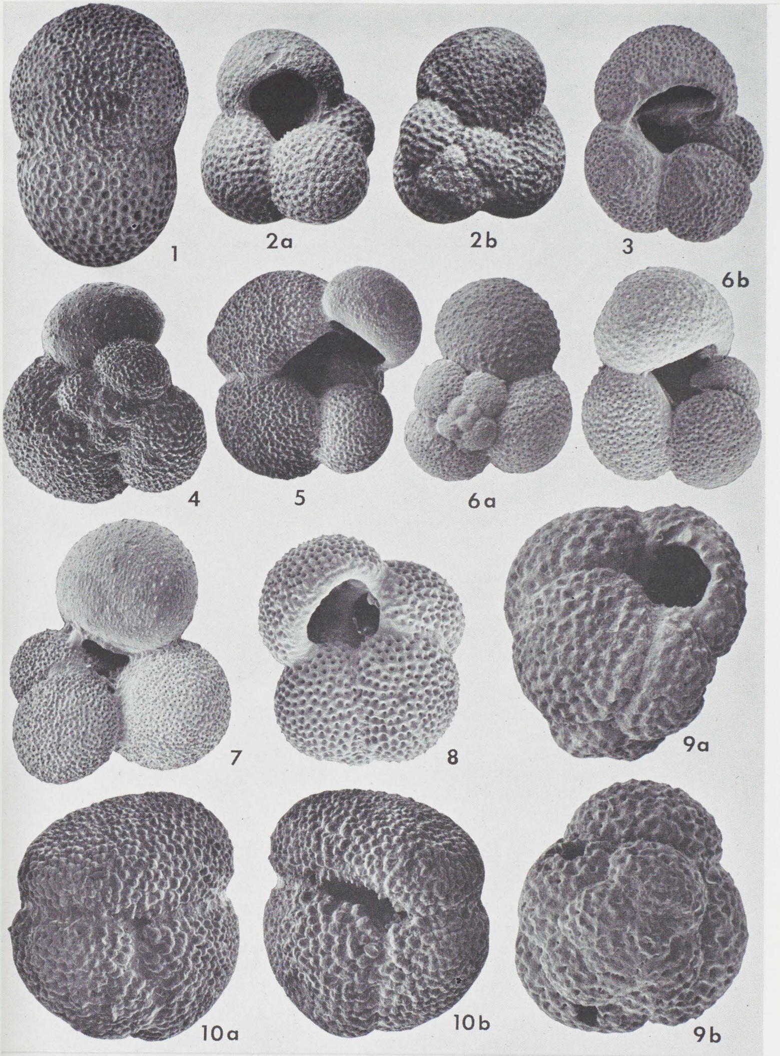

PLATE 2

sides of Mexico Highway 180, 14 miles east of the junction with the side road to Coatzacoalcos, Veracruz. Sampled May, 1972, by H. E. and E. H. Vokes and W. H. Akers. Material for this report was taken from the pipe line cut, north of the highway. Nineteen samples were collected at one-meter intervals from the base to the top of the exposure by Ronald Parsley and W. H. Akers. The latter outcrop subsequently has been removed by additional construction, but a representative sample sequence is deposited in the Tulane University Department of Earth Sciences.

1025. Concepcion Inferior Formation.
Roadcut on east side of road from Nuevo Teapa to Ixhuatlan, 0.5 mile south of junction with Mexico Highway 180, State of Veracruz, Mexico. Stop no. 5 of the 20th International Geological Congress, Excursion C-7 (see Contreras Velazquez *et al.*, 1956, p. 176; Vokes, 1970, p. 49). Collected by W. H. Akers, with H. E. and E. H. Vokes, May, 1972.

1026. Concepcion Superior Formation.
Road metal quarry (State of Veracruz) on Mexico Highway 175, about one mile north of the bridge over the Tonto River (just above confluence with the Papaloapan River), near Tuxtepec, Oaxaca, Mexico. See Contreras Velazquez (1956, p. 56-58). Collected by W. H. Akers with H. E. and E. H. Vokes, May, 1972.

1046. Agueguexquite Formation.
Roadcuts, both sides of Mexico Highway 180, 7½ miles east of the junction with side road into Coatzacoalcos, Veracruz; within ½ mile of the type locality. See Perrilliat Montoya (1963). Sample collected by W. H. Akers with H. E. and E. H. Vokes, May, 1972.

1083. Unnamed formation.
Roadcut on Mexico Highway 185, 3.0 miles north of Sayula, Veracruz, Mexico. Collected

PLATE 3

Figures

1. *Globigerinoides obliquus extremus* Bolli and Bermúdez
Concepcion Inferior Formation, TU 1025
a. Spiral view, ×103
b. Umbilical view, ×103

2. *Globigerinoides obliquus obliquus* Bolli
Concepcion Inferior Formation, TU 1025
Umbilical view, ×103

3. *Globigerinoides obliquus obliquus* Bolli
Concepcion Superior Formation, TU 1026
Spiral view, ×94

4. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny)
Concepcion Superior Formation, TU 1026
a. Spiral view, ×95
b. Umbilical view, ×95

5. *Globigerinoides quadrilobatus sacculifer* (Brady)
Concepcion Inferior Formation, TU 1025
Spiral view, ×64

6. *Globigerinoides quadrilobatus sacculifer* (Brady)
Unnamed formation, TU 1083
Umbilical view, ×69

7. *Globigerinoides ruber* (d'Orbigny)
Concepcion Inferior Formation, TU 1025
a. Umbilical view, ×94
b. Spiral view, ×94

8. *Globoquadrina altispira altispira* (Cushman and Jarvis)
Concepcion Inferior Formation, TU 1025
Side view, ×107

9. *Globoquadrina conglomerata* (Schwager)
Concepcion Inferior Formation, TU 1025
a. Spiral view, ×94
b. Umbilical view, ×94

10. *Globoquadrina altispira globosa* Bolli
Unnamed formation, TU 1083
Umbilical view, ×70

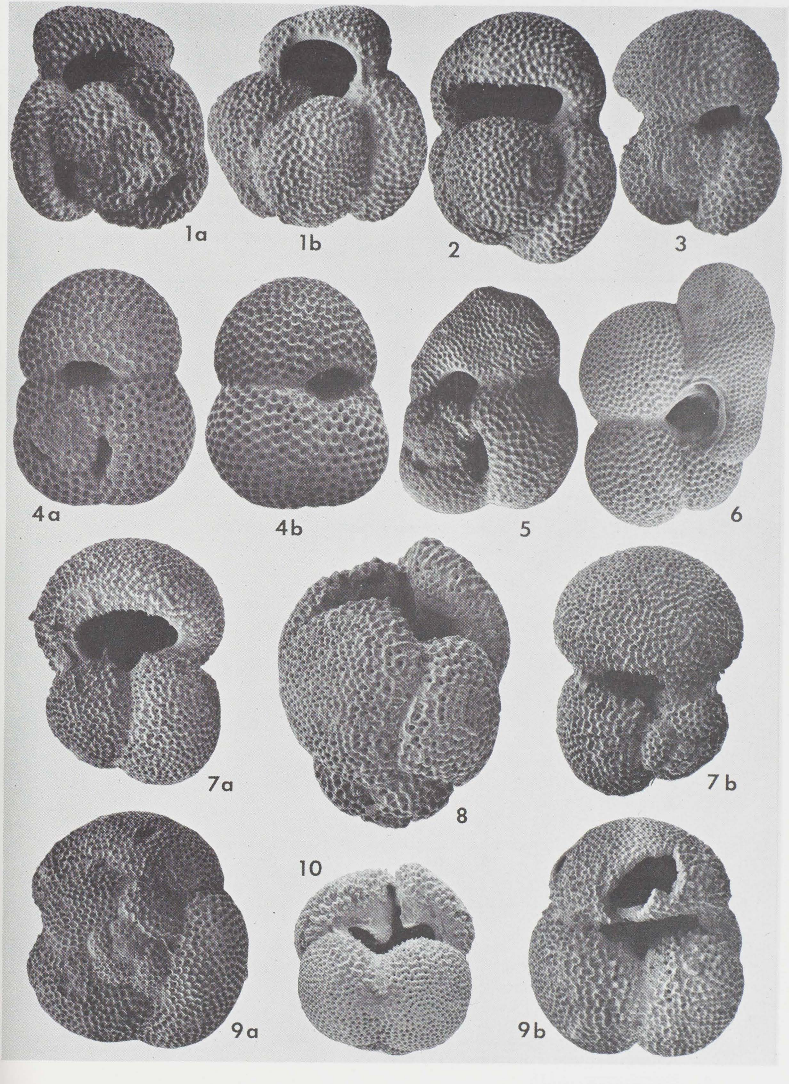

PLATE 3

by W. H. Akers with H. E. and E. H. Vokes, May, 1972.

1136. Unnamed formation.
Roadcut at K 15 on Mexico Highway 185, south of Acayucan, Veracruz, Mexico. Collected by W. H. Akers with H. E. and E. H. Vokes, May, 1972.

1141. Filisola Formation.
Roadcut on the north side of Mexico Highway 180, 13 kilometers west of San Andreas Tuxtla, Veracruz. Stop no. 10 of the 20th International Geological Congress, Excursion C-7 (see Viniegra *et al.*, 1956, p. 163). Collected by W. H. Akers with H. E. and E. H. Vokes, May, 1972.

VII. LITERATURE CITED

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PLATE 4

Figures

1. *Globoquadrina venezuelana* (Hedberg)
   Concepcion Inferior Formation, TU 1025
   a. Spiral view, ×113
   b. Umbilical view, ×113
2. *Globorotalia (Globorotalia) crassula conomiozea* Kennett
   Concepcion Inferior Formation, TU 1025
   a. spiral view, ×97
   b. Umbilical view, ×97
3. *Globorotalia (Globorotalia) cultrata limbata* (Fornasini)
   Agueguexquite Formation, TU 638
   a. Spiral view, ×125
   b. Umbilical view, ×125
4. *Globorotalia (Globorotalia) cultrata menardii* (Parker, Jones and Brady)
   Unnamed formation, TU 1136
   Umbilical view, ×121
5. *Globorotalia (Globorotalia) cultrata menardii* (Parker, Jones and Brady)
   Unnamed formation, TU 1136
   Edge view, ×105
6. *Globorotalia (Globorotalia) margaritae* Bolli and Bermúdez
   Unnamed formation, TU 1083
   Umbilical view, ×108
7. *Globorotalia (Globorotalia) margaritae* Bolli and Bermúdez
   Unnamed formation, TU 1083
   Spiral view, ×109
8. *Globorotalia (Globorotalia) margaritae* Bolli and Bermúdez
   Unnamed formation, TU 1083
   Edge view, ×108
9. *Globorotalia (Globorotalia) cultrata menardii* (Parker, Jones and Brady)
   Unnamed formation, TU 1083
   Spiral view, ×58
10. *Globorotalia (Globorotalia)* cf. *Globorotalia multicamerata* Cushman and Jarvis
    Concepcion Superior Formation, TU 1026
    a. Spiral view, ×57
    b. Umbilical view, ×57
11. *Globorotalia (Turborotalia) acostaensis acostaensis* Blow
    Agueguexquite Formation, TU 638
    a. Spiral view, ×118
    b. Umbilical view, ×118

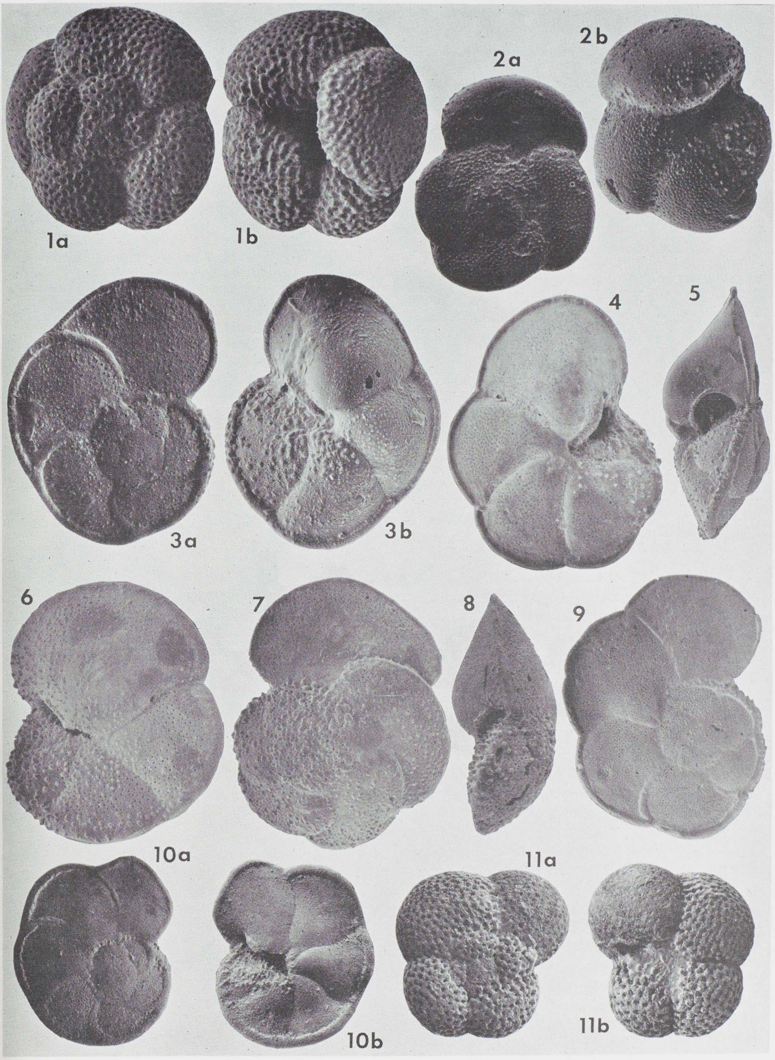

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PLATE 5

Figures

1. *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito
   Concepcion Inferior Formation, TU 1025
   a. Spiral view, ×98
   b. Umbilical view, ×98
2. *Globorotalia (Turborotalia) crassacrotonensis* Conato and Follador
   Unnamed formation, TU 1083
   a. Edge view, ×105
   b. Spiral view, ×106
   c. Umbilical view, ×107
3. *Globorotalia (Turborotalia) acostaensis pseudopima* Blow
   Concepcion Inferior Formation, TU 1025
   a. Umbilical view, ×96
   b. Spiral view, ×96
4. *Hastigerina (Hastigerina) siphonifera siphonifera* (d'Orbigny)
   Agueguexquite Formation, TU 638
   a. Edge view, ×95
   b. Umbilical view, ×95
5. *Orbulina universa* d'Orbigny
   Concepcion Superior Formation, TU 1026
   ×100
6. *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito
   Filisola Formation, TU 1141
   Umbilical view, ×104
7. *Sphaeroidinella dehiscens dehiscens forma immatura* (Cushman)
   Agueguexquite Formation, TU 638
   a., b. Opposite views, ×116
8. *Prosphaeroidinella parkerae* Ujiié
   Filisola Formation, TU 1141
   Umbilical view, ×104
9. *Sphaeroidinellopsis subdehiscens subdehiscens* (Blow)
   Concepcion Inferior Formation, TU 1025
   Umbilical view, ×97

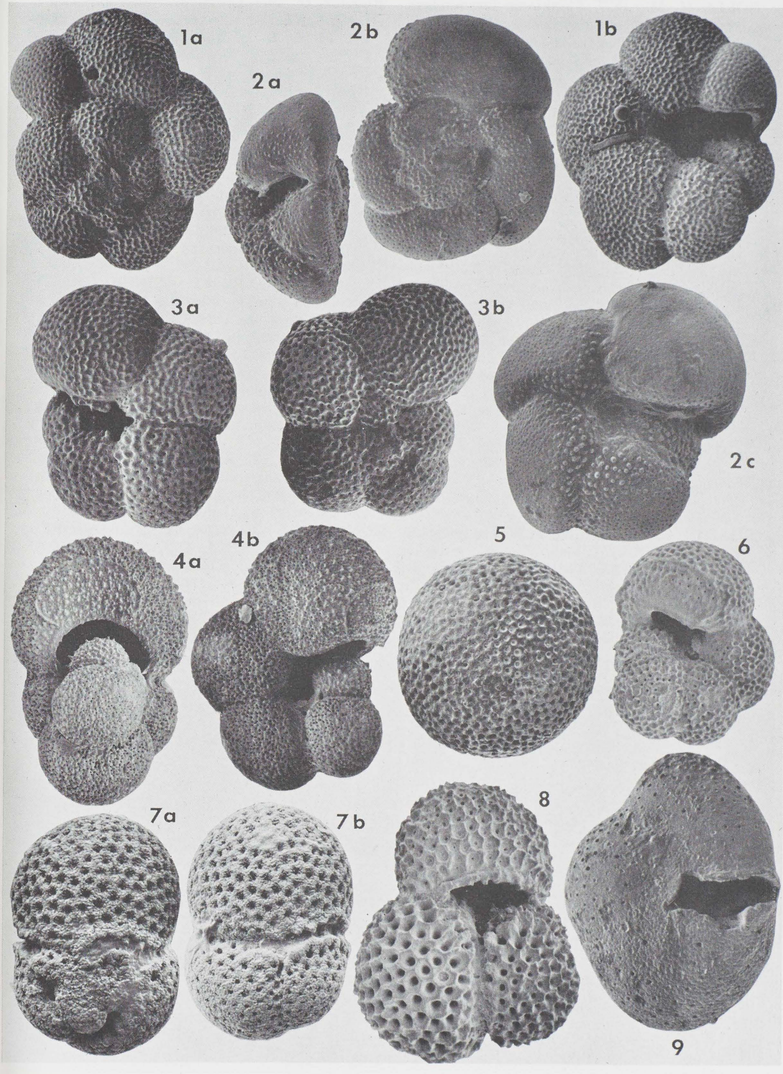

PLATE 5

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PLATE 6

Figures

1. *Ceratolithus cristatus* Kamptner, Stereoscan micrograph, ×10,000
   Concepcion Inferior Formation, TU 1025
2. *Ceratolithus rugosus* Bukry and Bramlette, light micrograph, polarized light, ×3150
   Unnamed formation, TU 1083
3. *Ceratolithus rugosus* Bukry and Bramlette, light micrograph, plain light, ×3150
   Unnamed formation, TU 1083
4. *Coccolithus doronicoides* Black and Barnes, light micrograph, polarized light ×3150
   Unnamed formation, TU 1083
5. *Coccolithus doronicoides* Black and Barnes, light micrograph, polarized light, ×3150
   Agueguexquite Formation, TU 638
6. *Coccolithus doronicoides* Black and Barnes, Stereoscan micrograph, ×20,000
   Unnamed formation, TU 1083
7. *Coccolithus doronicoides* Black and Barnes, Stereoscan micrograph, ×10,000
   Agueguexquite Formation, TU 638

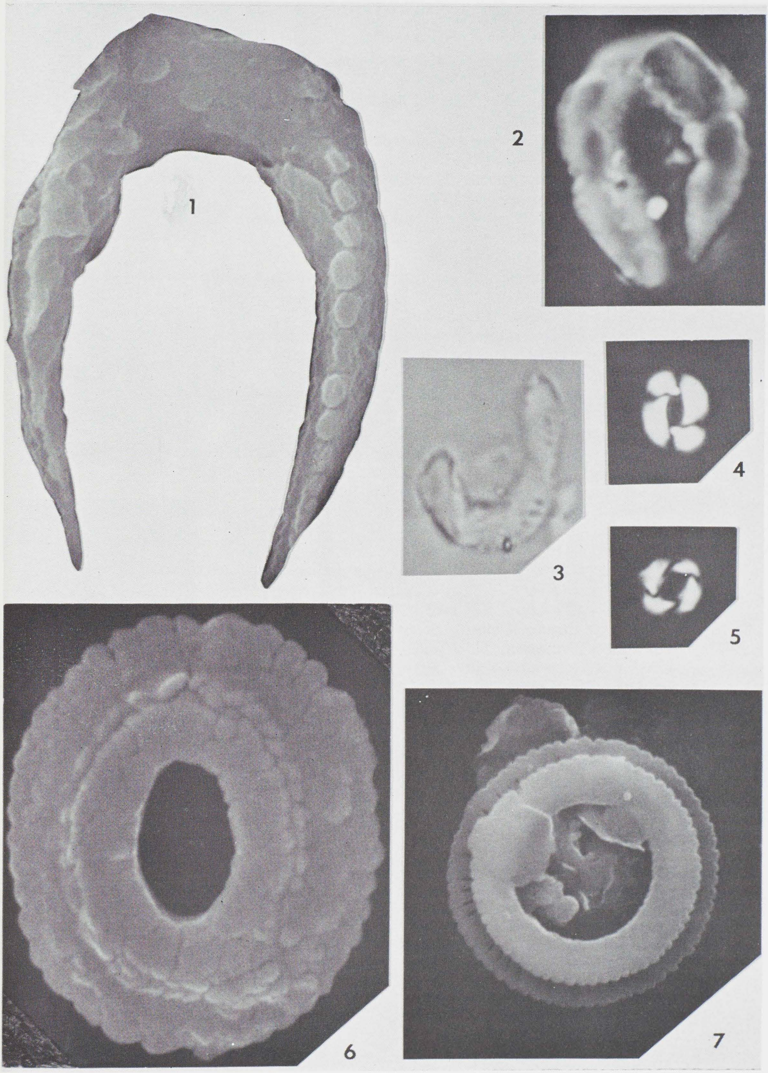

PLATE 6

PLATE 7

Figures

1. *Coccolithus pelagicus* (Wallich), Stereoscan micrograph, ×5000
Unnamed formation, TU 1083

2. - 3. *Coccolithus pelagicus* (Wallich), light micrographs, polarized light, ×1575
Unnamed formation, TU 1083

4. *Cristallolithus macroporus* (Deflandre), Stereoscan micrograph, ×10,000
Unnamed formation, TU 1136

5. *Cristallolithus multiporus* (Kamptner), Stereoscan micrograph, ×2500
Unnamed formation, TU 1083

6. *Cyclococcolithina macintyrei* (Bukry and Bramlette), Stereoscan micrograph, ×2500
Unnamed formation, TU 1083

7. *Cyclococcolithina macintyrei* (Bukry and Bramlette), Stereoscan micrograph, ×2500
Concepcion Superior Formation, TU 1026

8. *Cyclococcolithina macintyrei* (Bukry and Bramlette), light micrograph, plain light, ×1575
Unnamed formation, TU 1083

9. *Cyclococcolithina leptopora* (Murray and Blackman), light micrograph, polarized light, ×1575
Agueguexquite Formation, TU 638

10. *Cyclococcolithina leptopora* (Murray and Blackman), Stereoscan micrograph, ×5000
Concepcion Superior Formation, TU 1026

11. - 12. *Cyclococcolithina leptopora* (Murray and Blackman), light micrographs, plain light, ×1575
Unnamed formation, TU 1083

13. *Cyclococcolithina leptopora* (Murray and Blackman), Stereoscan mirograph, ×5000
Unnamed formation, TU 1083

14. *Emiliania annula* (Cohen), Stereoscan micrograph, ×5000
Unnamed formation, TU 1083

15. *Emiliania annula* (Cohen), light micrograph, polarized light ×1575
Unnamed formation, TU 1083

16. *Discoaster brouweri* Tan Sin Hok, Stereoscan micrograph, ×2500
Concepcion Superior Formation, TU 1026

17. *Discoaster asymmetricus* Gartner, Stereoscan micrograph, ×5000
Concepcion Inferior Formation, TU 1025

18. *Discoaster exilis* Martini and Bramlette, Stereoscan micrograph, ×2500
Unnamed formation, TU 1083

19. *Discoaster pentaradiatus* Tan Sin Hok, Stereoscan micrograph, ×2500
Agueguexquite Formation, TU 638

20. *Discoaster brouweri* Tan Sin Hok, Stereoscan micrograph, ×2500
Unnamed formation, TU 1136

21. *Discoaster brouweri* Tan Sin Hok, Stereoscan micrograph, ×2500
Unnamed formation, TU 1083

22. *Discoaster brouweri* Tan Sin Hok, light micrograph, plain light, ×1575
Unnamed formation, TU 1083

23. *Discoaster perplexus* Bramlette and Riedel, light micrograph, plain light, ×1575
Unnamed formation, TU 1083

24. *Discoaster perplexus* Bramlette and Riedel, Stereoscan micrograph, ×5000
Unnamed formation, TU 1136

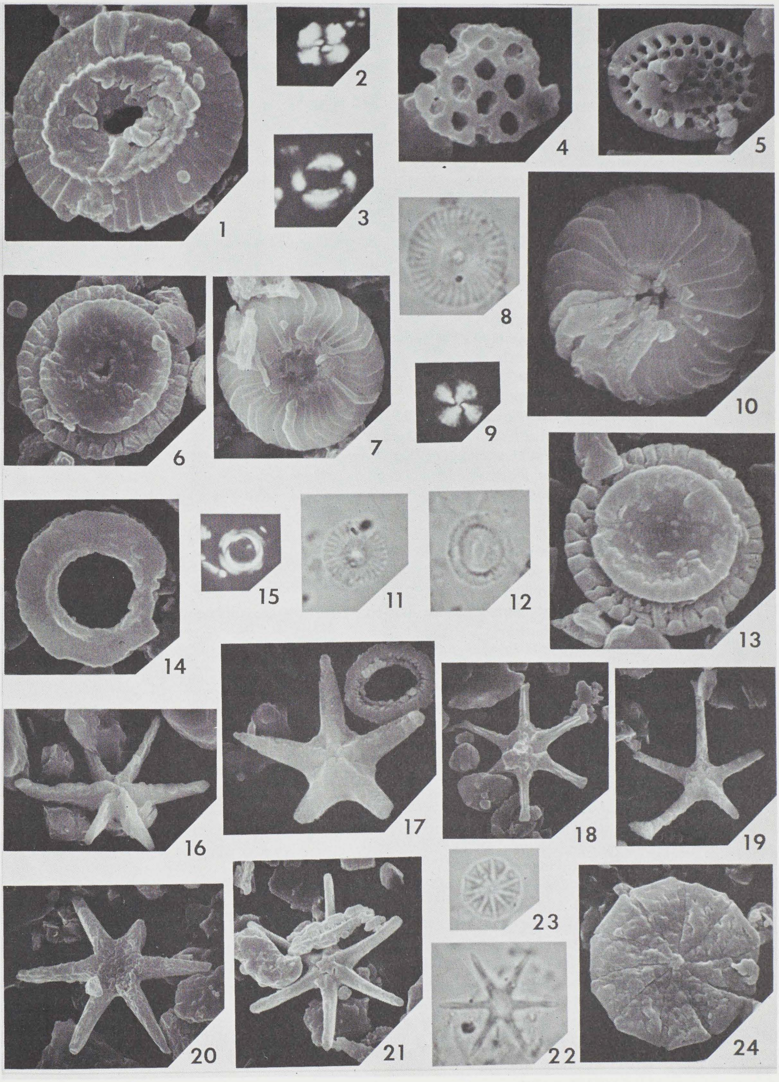

PLATE 7

PLATE 8

Figures

1. *Discoaster surculus* Martini and Bramlette, Stereoscan micrograph, ×2500
Concepcion Superior Formation, TU 1026
2. *Discoaster surculus* Martini and Bramlette, light micrograph, plain light, ×1575
Unnamed formation, TU 1083
3. *Discoaster variabilis* Martini and Bramlette, light micrograph, plain light, ×1575
Unnamed formation, TU 1083
4. *Discoaster variabilis* Martini and Bramlette, Stereoscan micrograph, ×5000
Unnamed formation, TU 1083

5a. *Gephyrocapsa* cf. *G. caribbeanica* Boudreaux and Hay, Stereoscan micrograph, ×10,000
Unnamed formation, TU 1083

5b. *Gephyrocapsa caribbeanica* Boudreaux and Hay, light micrograph, polarized light, ×2520
Unnamed formation, TU 1083

6. *Gephyrocapsa reticulata* Nishida, Stereoscan micrograph, ×10,000
Unnamed formation, TU 1136
7. *Gephyrocapsa reticulata* Nishida, Stereoscan micrograph, ×5000
Agueguexquite Formation, TU 638
8. *Pseudoemiliania lacunosa* (Kamptner), Stereoscan micrograph, ×5000
Agueguexquite Formation, TU 638
9. *Helicopontosphaera kamptneri* Hay and Mohler, Stereoscan micrograph, ×5000
Agueguexquite Formation, TU 638
10. *Lithostromation perdurum* Deflandre, Stereoscan micrograph, ×2500
Unnamed formation, TU 1136

11., 17. *Pseudoemiliania lacunosa* (Kamptner), Stereoscan micrograph, ×10,000
Unnamed formation, TU 1136

12., 16. *Reticulofenestra pseudoumbilica* (Gartner), Stereoscan micrograph, ×2500
Concepcion Inferior Formation, TU 1025

13. *Reticulofenestra pseudoumbilica* (Gartner), light micrograph, polarized light, ×1575
Concepcion Superior Formation, TU 1026

14. *Reticulofenestra pseudoumbilica* (Gartner), Stereoscan micrograph, ×5000
Concepcion Superior Formation, TU 1026

15. *Reticulofenestra pseudoumbilica* (Gartner), light micrograph, plain light, ×1575
Concepcion Superior Formation, TU 1026

18. *Sphenolithus abies* Deflandre, Stereoscan micrograph, ×5000
Unnamed formation, TU 1083

19. *Sphenolithus abies* Deflandre, Stereoscan micrograph, ×5000
Concepcion Inferior Formation, TU 1025

20. *Umbilicosphaera mirabilis* Lohmann, Stereoscan micrograph, ×5000
Unnamed formation, TU 1083

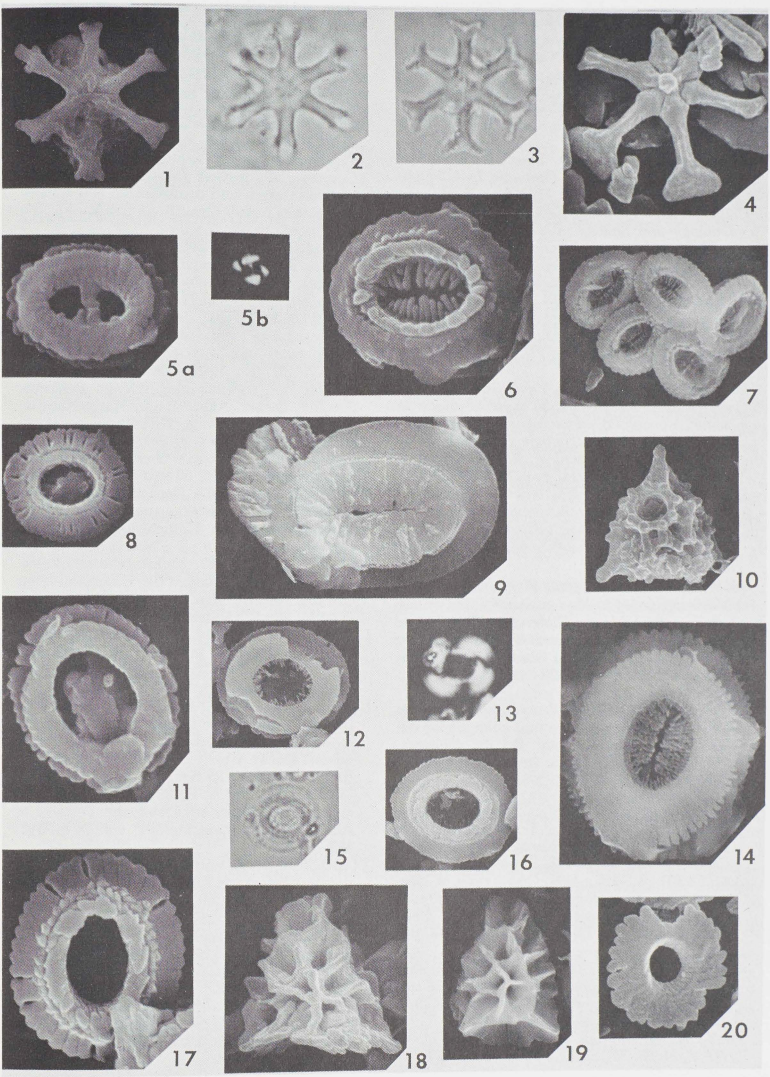

PLATE 8

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REVIEW

INTRODUCTION TO MARINE MICROPALEONTOLOGY, edited by Bilal U. Haq and Anne Boersma. Published by Elsevier North-Holland, Inc., New York and Oxford, 1978, viii + 376 pp., illustrated, ... $24.00

This volume will be agreeably received by those involved in the study of marine micro-organisms, expecially those confronted with the formidable task of teaching a course on this subject to beginning students. There is no other comprehensive book on marine microfossils available.

Each of fourteen major groups of microfossils is surveyed by a leading expert or specialist for that group. The marine micro-organisms are arranged in four categories based on composition: Calcareous Microfossils, Siliceous Microfossils, Phosphatic Microfossils, and Organic-walled Microfossils.

Obviously, it is impossible to treat each of the fourteen in depth and to contain the work in a single volume. However, the authors have done an excellent job of introducing each subject and the book provides an adequate base on which to build for classroom study or research purposes. It is highly recommended for both geologists and paleontologists who need a survey of microfossil morphology. classification, and paleoecology.

—H.C.S.