PLANKTIC FORAMINIFERA AND CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY OF THE NEOGENE OF MEXICO PART II – LOWER PLIOCENE

W. H. AKERS
CHEVRON OIL FIELD RESEARCH COMPANY
LA HABRA, CALIFORNIA

CONTENTS

ILLUSTRATIONS

I. ABSTRACT

Six outcrop localities in the Isthmus of Tehuantepec, Mexico, are assigned to the Lower Pliocene Zones N. 18 or N. 19 on the basis of concurrent range zones of planktic foraminifera and calcareous nannofossils. Beds at one of the localities have been referred to the Encanto "Formation" by Mexican geologists. Microfossil lists for the localities follow the taxonomic procedures of Kennett and Srinivasan (1983) or Haman *et al.* (1980), differing only when inconsistent with the experience or interpretations of this writer. Illustrations have been included for taxa that were not identified from the Middle Pliocene of Mexico in this series (Akers, 1979).

II. INTRODUCTION

This is the second part in a series of reports on calcareous nannofossils and planktic foraminifera from some Neogene beds of Mexico. Part 1 (Akers, 1979) and the addendum to Part 1 (Akers, 1981) dealt

EDITORIAL COMMITTEE FOR THIS PAPER:
DREW HAMAN, Chevron Oil Field Research Company, La Habra, California
KENNETH L. FINGER, Chevron Oil Field Research Company, La Habra, California

with the Middle Pliocene "formations" (Neogene Zone 20) to which the names Agueguexquite, Filisola, Concepcion Superior, and Concepcion Inferior have been applied.

The introductory remarks for Part 1 of this series are also appropriate for Part 2 and should be reviewed for the objectives of documenting the calcareous microplankton of the Mexican Tertiary. In general, it may be repeated that the fossil groups considered in this project afford assignment of the Mexican beds to transoceanic Neogene Zones 18 and 19 (Blow, 1969; Berggren and Van Couvering, 1974) and that the proposed geochronologic revisions for these sections are necessary, if Mexican successions are to conform stratigraphically with the rest of the world.

The stratigraphic ranges of index species, as determined by data from the Deep Sea Drilling Program, as well as data from land based sections, are the bases of chronologic assignments. Unlike material from tropical deep sea sites, the Mexican outcrops do not contain a high diversity of planktic microfossils. The forms recorded herein were found only after relatively prolonged microscopic examination, rather than after only a few minutes, as in the case of highly fossiliferous material from deep sea cores. Thus, chronostratigraphic interpretations are offered for assemblages that are less than ideal for this purpose.

Several index fossils are illustrated herein as well as in the previous report (Akers, 1979) on the Middle Pliocene of Mexico. In general, however, the plan was to include taxa not figured in Part 1. Useful species for chronostratigraphic purposes are charted in Figure 2 with their respective occurrences in tropical Neogene zones recognized by the Deep Sea Drilling Program.

PLATE 1

Figures

1. *Globigerina* cf. *G. incisa* (Bronnimann and Resig)
   Locality TU 1153
   a. Edge view, −107
   b. Umbilical view, ×105
   c. Spiral view, ×100
2. *Globigerina nepenthes* Todd
   Locality TU 1323
   a. Spiral view, ×135
   b. Edge view, ×135
   c. Umbilical view, ×135
3. *Globigerina* cf. *G. nepenthes* Todd, juvenile(?)
   Locality TU 1324
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   Locality TU 1153
   a. Edge view, ×72
   b. Umbilical view, ×70
   c. Spiral view, ×72
5. *Globigerina glutinata* (Egger)
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   a. Edge view, ×145
   b. Umbilical view, ×140
   c. Spiral view, ×145
6. *Globigerina conglobatus conglobatus* (Brady)
   Locality TU 1153
   a. Spiral view, ×65
   b. Umbilical view, ×62
   c. Edge view, ×65

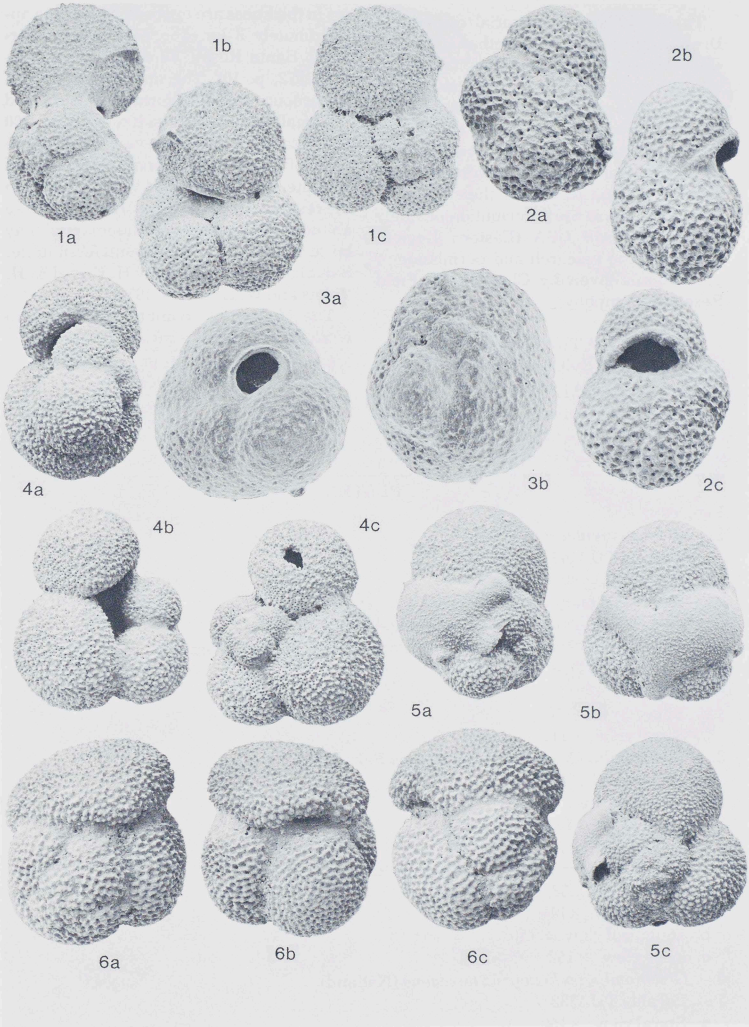

PLATE 1

III. ACKNOWLEDGMENTS

Thanks go to the editorial committee: Drew Haman and Kenneth L. Finger, Chevron Oil Field Research Company. The Mexican sites would not have been studied, and the manuscript would not have been written without the field guidance and the constant encouragement of Emily and Harold Vokes. Figure 1, showing the location of five of the six Lower Pliocene sites, is the contribution of Emily Vokes. Chevron USA (Eastern Region) supported the research and permission to publish was given by Chevron Oil Field Research Company.

IV. BIOSTRATIGRAPHY, NEOGENE ZONES 18 AND 19

A. LOCALITY TU 1144

An unnamed formation is exposed at locality TU 1144 in roadcuts on Mexico Highway 185, about 42 km south of Acayucan, state of Veracruz. Beds three to four meters in thickness are exposed in the area approximately 3 km due east of Istal (formerly Santa Rosa), Veracrux (see Perrilliat, 1972, p. 10). The lithology is a hard, calcareous clay of uniform buff color, and the small amount of residue on a No. 200 U.S. Standard Series Sieve consists of the tests of foraminifera and aggregates of limonite. No quartz sand was observed in the residue. Calcareous nannofossils are so abundant in the clay that the material may be termed a calcareous nannofossil lutite. Samples were collected by H. E. and E. H. Vokes and W. H. Akers, 1979.

The following planktic foraminifera were found in residues from TU 1144:

Biorbulina bilobata (d'Orbigny)
Candeina nitida nitida d'Orbigny
Globigerina bulloides bulloides d'Orbigny
G. decoraperta Takayanagi and Saito
G. nepenthes Todd
Globigerinita glutinata (Egger)

PLATE 2

Figures

1. *Globigerinoides mitra* Todd
   Locality TU 1144
   a. Side view, ×90
   b. View of primary aperture, ×90
   c. Side view showing supplementary aperture, ×90
2. *Globorotalia (Truncorotalia) crassiformis* (Galloway and Wissler)
   Locality TU 1153
   a. Umbilical view, ×110
   b. Edge view, ×110
   c. Spiral view, ×115
3. *Globorotalia (Menardella) miocenica* Palmer
   Locality TU 1144
   a. Umbilical view, ×105
   b. Edge view, ×105
   c. Spiral view, ×105
4. *Globorotaloides hexagona hexagona* (Natland)
   Locality TU 1153
   a. Spiral view, ×147
   b. Umbilical view, ×150
   c. Edge view, ×152
5. *Globorotaloides hexagona hexagona* (Natland)
   Locality TU 1332
   a. Spiral view, ×150
   b. Umbilical view, ×147
   c. Edge view, ×150

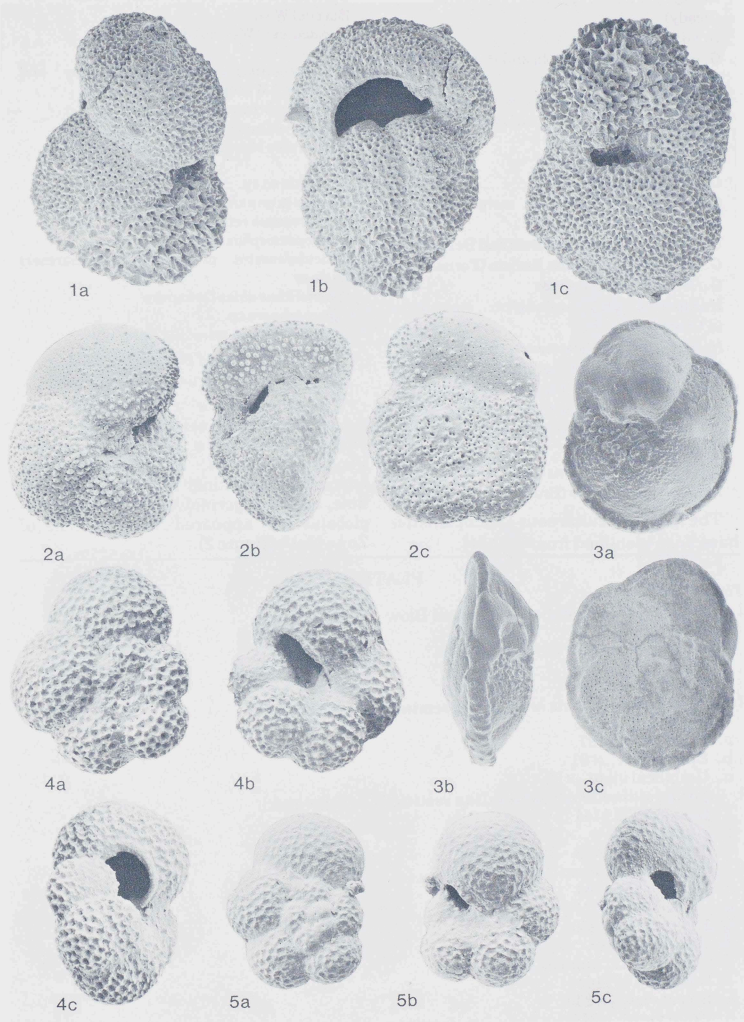

PLATE 2

Globigerinoides conglobatus conglobatus (Brady)
G. mitra Todd
G. obliquus extremus Bolli and Bermudez
G. obliquus obliquus Bolli
G. quadrilobatus quadrilobatus (d'Orbigny)
Globoquadrina altispira altispira (Cushman and Jarvis)
G. altispira globosa Bolli
G. venezuelana (Hedberg)
Globorotalia (Obandyella) margaritae Bolli and Bermudez
G. cf. *G. (O.) margaritae* Bolli and Bermudez
G. (Menardella) cultrata limbata (Fornasini)
G. (M.) miocenica Palmer
Hastigerina (H.) siphonifera siphonifera (d'Orbigny)
Neogloboquadrina acostaensis (Blow)
N. humerosa (Takayanagi and Saito)
Orbulina universa d'Orbigny
Prosphaeroidinella parkerae Ujiie
Sphaeroidinellopsis seminulina seminulina (Schwager)
S. subdehiscens subdehiscens (Blow)
Turborotalita humilis (Brady)

The following calcareous nannoplankton have been identified from TU 1144:

Cyclicargolithus doronicoides (Black and Barnes) Wise
C. pelagicus (Wallich) Schiller
C. sp.
Cyclococcolithina leptopora (Murray and Blackman) Wilcoxon
Discoaster brouweri Tan
D. pentaradiatus Tan
D. surculus Martini and Bramlette
D. sp.
Discolithina sp.
Emiliania annula (Cohen) Bukry
Gephyrocapsa reticulata Nishida
Helicopontosphaera sp.
Reticulofenestra pseudoumbilica (Gartner) Gartner
Sphenolithus abies Deflandre
Syracosphaera sp.
Umbilicosphaera mirabilis Lohmann

Geologic Age of Beds at TU 1144 and Correlation with Other Strata

The concurrence of *Globigerinoides mitra* and *Globigerinoides conglobatus conglobatus* indicates a position in Lower Pliocene, Zone N. 18. *Globigerinoides mitra* became extinct by the end of that time, and *Globigerinoides conglobatus conglobatus* first appeared near the base of Zone N. 18 (Figure 2).

PLATE 3

Figures

1. *Pulleniatina primalis* Banner and Blow
   Locality TU 1153
   a. Umbilical view, ×100
   b. Edge view, ×95
   c. Spiral view, ×98
2. *Sphaeroidinellopsis seminulina seminulina* (Schwager)
   Locality TU 1323
   a. Edge view, ×97
   b. Spiral view, ×91
   c. Umbilical view, ×91
3. *Sphaeroidinellopsis seminulina seminulina* (Schwager)
   Locality TU 1144
   a. Umbilical view, ×69
   c. Spiral view, ×69
4. *Turborotalita humilis* (Brady)
   Locality TU 1144
   a. Spiral view, ×240
   b. Edge view, ×250
   c. Umbilical view, ×240
5. *Turborotalita humilis* (Brady)
   Locality TU 1144
   a. Spiral view, ×240
   b. Edge view, ×245
   c. Umbilical view, ×240

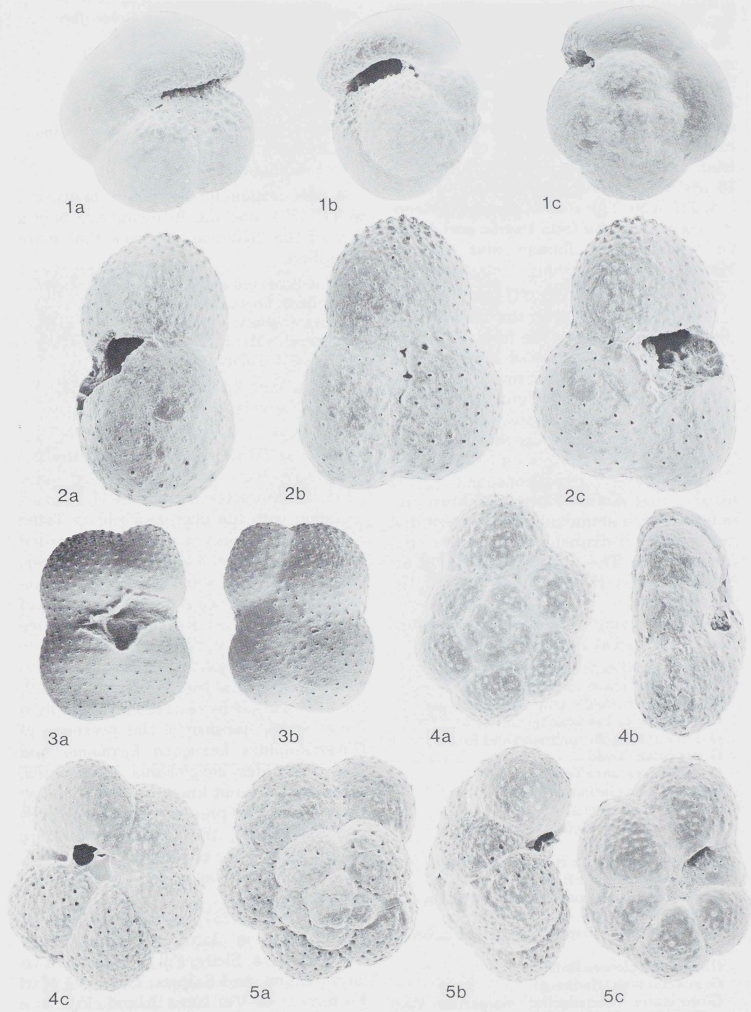

PLATE 3

Blow (1969, p. 254) has referred the following land based sections to Zone N. 18 as follows: Donni Sandstone of Saipan, Janum Formation of Guam, Bowden Formation (median part) of Jamaica, and Trubi Marl (lowest part) of Sicily. He recognized N. 18 also on Vanua Levu Island (Fiji), in Papua, Java, Borneo, and Venezuela. The Lami Limestone of Viti Levu Island, Fiji, has been referred to Zone N. 18 (Adams, Rodda and Kiteley, 1979, p. 324, 327, 329). The zone is present in deep-sea cores from the Indo-Pacific and Atlantic (including Caribbean and Gulf of Mexico provinces).

B. LOCALITY TU 1324

Locality TU 1324 is on the road to Istal (Santa Rosa), which is the former railroad right-of-way, 5 km west of Mexico Highway 185, at a point 16 km north of the side road to Jesus Carranza, Veracruz, Mexico. The lithology at this exposure, as at TU 1144, is a hard, calcareous clay of uniform buff color. The residue on a No. 200 U.S. Standard Series Sieve is conspicuously the tests of foraminifera, both planktics and benthics, with abundant quartz grains that are smaller in diameter than most of the foraminifera. The material was collected by E. H. and H. E. Vokes and W. H. Akers, 1979.

The following planktic foraminifera were identified at TU 1324:

Biorbulina bilobata (d'Orbigny)
Candeina nitida nitida d'Orbigny
Globigerina bulloides bulloides d'Orbigny
G. decoraperta Takayanagi and Saito
G. cf. *G. incisa* (Bronnimann and Resig)
G. nepenthes Todd
G. cf. *G. nepenthes* Todd, juvenile(?)
Globigerinita glutinata (Egger)
G. uvula (Ehrenberg)
Globigerinoides conglobatus conglobatus (Brady)
G. obliquus extremus Bolli and Bermudez
G. obliquus obliquus Bolli
G. quadrilobatus quadrilobatus (d'Orbigny)
G. ruber (d'Orbigny)
Globoquadrina altispira altispira (Cushman and Jarvis)
G. altispira globosa Bolli
G. venezuelana (Hedberg)
Globorotalia (Obandyella) margaritae Bolli and Bermudez
G. (O.) scitula (Brady)
G. (Menardella) cultrata limbata (Fornasini)
G. (M.) miocenica Palmer
Globorotaloides hexagona hexagona (Natland)
Hastigerina (H.) siphonifera siphonifera (d'Orbigny)
Neogloboquadrina acostaensis (Blow)
N. humerosa (Takayanagi and Saito)
Orbulina universa d'Orbigny
Prosphaeroidinella parkerae Ujiie
Sphaeroidinellopsis seminulina seminulina (Schwager)
Turborotalita humilis (Brady)

A rich calcareous nannoflora is present at TU 1324, and the following are only a few of the significant species that were identified:

Ceratolithus rugosus Bukry and Bramlette
Discoaster brouweri Tan
D. pentaradiatus Tan
D. surculus Martini and Bramlette
Sphenolithus abies Deflandre

Geologic Age of Beds at TU 1324 and Correlations with Other Strata

Globigerina nepenthes is typically developed at TU 1324, and, although this development has been observed in older beds, it is characteristic of Zone N. 19 in association with the microassemblage listed above. *Ceratolithus rugosus* was recorded in low frequency. Calcification of other, more slender forms creates a close resemblance to *C. rugosus*. If the identification of the species here is correct, the occurrence with *Globigerina nepenthes* indicates Zone N. 19. If the *Ceratolithus* species is in actuality an older one that is highly calcified, the beds can still be referred no lower than Zone N. 18, because of the presence of *Globorotaloides hexagona hexagona* and *Globigerinoides conglobatus conglobatus*, forms that are not known to occur below Zone N. 18. The precise age of these beds notwithstanding, the microplankton are quite similar to the assemblage at TU 1144, and both assemblages are typical of the Lower Pliocene.

Blow (1969, p. 257) has referred Zone N. 19 to beds in Jamaica, Papua (New Guinea), Java, Sicily, Fiji (Vanua Levu Island), Guam, and Saipan. The Suva Marl Formation of Viti Levu Island, Fiji, is a highly fossiliferous sequence that only recently has been studied thoroughly and assigned to Zone N. 19 (Adams, Rodda and

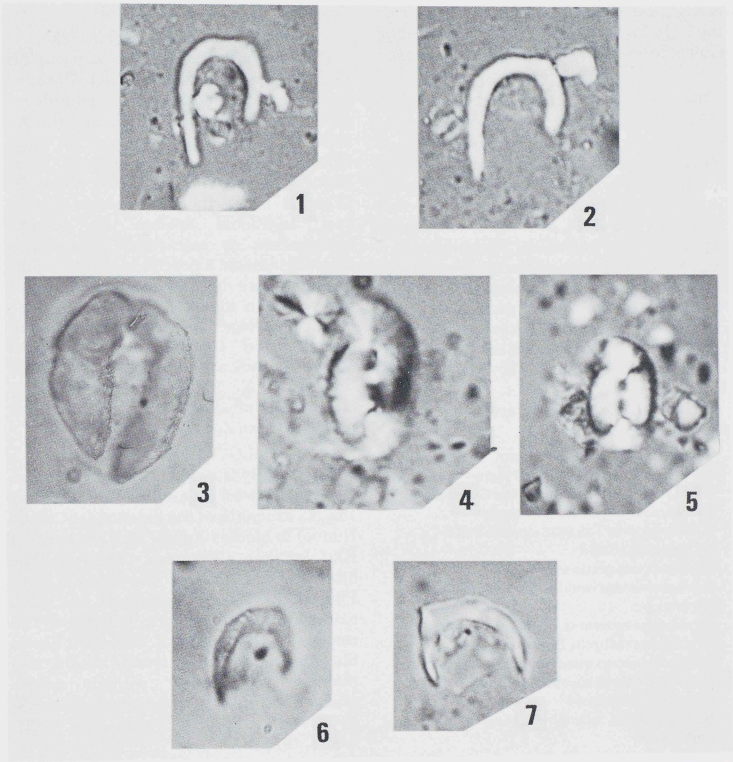

PLATE 4

Figures

1. *Amaurolithus delicatus* Gartner and Bukry, ×2100
   Locality TU 1332
2. *Amaurolithus delicatus* Gartner and Bukry, ×2626
   Locality TU 1332
3. *Ceratolithus rugosus* Bukry and Bramlette, ×2500
   Locality TU 1324
4. *Helicopontosphaera sellii* Bukry and Bramlette, ×3150
   Locality TU 1332
5. *Helicopontosphaera sellii* Bukry and Bramlette, ×2100
   Locality TU 1332

6, 7. *Amaurolithus primus* (Bukry and Percival) Gartner and Bukry, 1975, ×2100
   Locality TU 1333

Kiteley, 1979, p. 327). The zone has been recognized in many deep-sea cores from the Indo-Pacific and the Atlantic (including Gulf of Mexico and Caribbean provinces).

C. LOCALITY TU 1323

This locality is a roadcut at Istal (Santa Rosa), on the side road that was the old railroad right-of-way, 10 km west of Mexico Highway 185, at a point 16 km north of the side road to Jesus Carranza, Veracruz, Mexico. The lithology, like that at nearby TU 1324, is a hard, calcareous clay of uniform buff color. The residue on a No. 200 U.S. Standard Series Sieve is different in general appearance from that at TU 1324 in lacking quartz grains (conspicuous at TU 1324) and in having abundant fragments of mollusks. Beds here were collected by H. E. and E. H. Vokes and W. H. Akers.

The planktic foraminiferal assemblage includes the following:

Biorbulina bilobata (d'Orbigny)
Candeina nitida nitida d'Orbigny
Globigerina bulloides apertura Cushman
G. bulloides bulloides d'Orbigny
G. decoraperta Takayanagi and Saito
G. nepenthes Todd
Globigerinita glutinata (Egger)
Globigerinoides conglobatus conglobatus (Brady)
G. obliquus extremus Bolli and Bermudez
G. obliquus obliquus Bolli
G. quadrilobatus quadrilobatus (d'Orbigny)
G. quadrilobatus sacculifer (Brady)
G. ruber (d'Orbigny)
Globoquadrina altispira altispira (Cushman and Jarvis)
G. altispira globosa Bolli
G. venezuelana (Hedberg)
Globorotalia (Obandyella) margaritae Bolli and Bermudez
G. (O.) scitula (Brady)
G. (Menardella) cultrata limbata (Fornasini)
Globorotaloides hexagona hexagona (Natland)
Hastigerina (H.) siphonifera siphonifera (d'Orbigny)
Neogloboquadrina acostaensis (Blow)
Orbulina universa d'Orbigny
Prosphaeroidinella parkerae Ujiie
Sphaeroidinellopsis seminulina seminulina (Schwager)
S. subdehiscens subdehiscens (Blow)
Turborotalita humilis (Brady)

The nannoflora at TU 1323 is a typical Lower Pliocene assemblage resembling those from TU 1144 and TU 1324.

Geologic Age of Beds at TU 1323

The rich microfossil assemblages at TU 1323 are typical of the Lower Pliocene biota of bathyal middle and low latitude regions in both the Indo-Pacific and the Atlantic-Caribbean-Gulf of Mexico provinces. The age of the beds is Early Pliocene, somewhere between Zones N. 18 and N. 19. Further examination may reveal additional species of planktic foraminifera or calcareous nannofossils that will indicate a precise biostratigraphic position. More definitive index fossils have not yet been identified. The occurrence here of *Globigerinoides conglobatus conglobatus* and *Globorotaloides hexagona hexagona* indicates a position no lower than Zone N. 18, and the presence of *Globigerina nepenthes* indicates a position no higher than Zone N. 19.

D. LOCALITY TU 1332

This locality is behind the power substation on the west side of Mexico Highway 185, 8.2 km north of the junction (at Campo Nuevo) to Medias Aguas; 47.3 km north of Rio Jaltepec, Veracruz, Mexico. The lithology, like that at the other Lower Pliocene localities of this report, is a hard, calcareous clay of uniform buff color. The residue on a No. 200 U.S. Standard Series Sieve is predominantly tests of benthic and planktic foraminifera without quartz grains and mollusk fragments. Collected by E. H. and H. E. Vokes and W. H. Akers, 1979.

The following planktic foraminifera were identified at TU 1332.

Biorbulina bilobata (d'Orbigny)
Globigerina bulloides bulloides d'Orbigny
G. decoraperta Takayanagi and Saito
Globigerinita glutinata (Egger)
Globigerinoides conglobatus conglobatus (Brady)
G. obliquus extremus Bolli and Bermudez
G. obliquus obliquus Bolli
G. quadrilobatus quadrilobatus (d'Orbigny)
G. quadrilobatus sacculifer (Brady)
Globoquadrina altispira altispira (Cushman and Jarvis)
G. altispira globosa Bolli
Globorotalia (Obandyella) margaritae Bolli and Bermudez

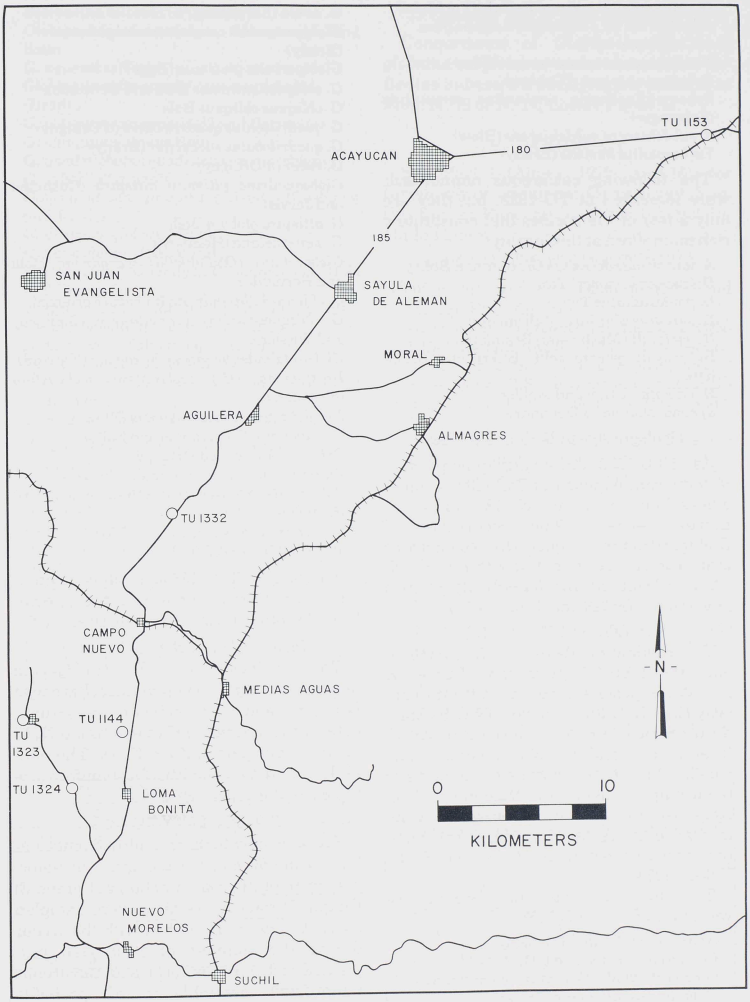

Figure 1. Lower Pliocene exposures discussed in this report, Isthmus of Tehuantepec, Mexico.

G. (Menardella) cultrata limbata (Fornasini)
Hastigerina (H.) siphonifera siphonifera (d'Orbigny)
Neogloboquadrina acostaensis (Blow)
Orbulina universa d'Orbigny
Sphaeroidinellopsis seminulina seminulina (Schwager)
S. subdehiscens subdehiscens (Blow)
Turborotalita humilis (Brady)

The following calcareous nannofossils were identified at TU 1332, but they are only a few of the species that constitute a rich nannoflora at this locality:

Amaurolithus delicatus Gartner and Bukry
Discoaster brouweri Tan
D. pentaradiatus Tan
D. surculus Martini and Bramlette
D. variabilis Martini and Bramlette
Helicopontosphaera sellii Bukry and Bramlette
H. kamptneri Hay and Mohler
Sphenolithus abies Deflandre

Geologic Age of Beds at TU 1332

As at TU 1323, the stratigraphic position of the strata exposed at TU 1332 is somewhere between Zones N. 18 and N. 19, Lower Pliocene. The occurrence of *Globigerinoides conglobatus conglobatus* indicates a position not lower than Zone N. 18, and *Amaurolithus delicatus* suggests a position not higher than Zone N. 19.

E. LOCALITY TU 1153

This roadcut on Mexico Highway 180, at Km 16, east of Acayucan, Veracruz, Mexico, exposes a mottled, buff and light gray clay. Residue on a No. 200 U.S. Standard Series Sieve is largely tests of foraminifera and acicular limonite. The locality is on the Potrerillos Dome and has been mapped as Lower Miocene and referred to the Encanto Formation (Contreras Velazquez *et al.*, 1956, map). Samples were collected by H. E. and E. H. Vokes, 1974.

The following planktic foraminifera were identified at TU 1153:

Biorbulina bilobata (d'Orbigny)
Candeina nitida nitida d'Orbigny
Globigerina bulloides apertura Cushman
G. bulloides bulloides d'Orbigny
G. decoraperta Takayanagi and Saito
G cf. *G. incisa* (Bronnimann and Resig)
G. nepenthes Todd
G. nepenthes Todd, juvenile(?)
Globigerinerlla calida (Parker)
G. uvula (Ehrenberg)
Globigerinoides conglobatus conglobatus (Brady)
Globigerinita glutinata (Egger)
G. obliquus extremus Bolli and Bermudez
G. obliquus obliquus Bolli
G. quadrilobatus quadrilobatus (d'Orbigny)
G. quadrilobatus sacculifer (Brady)
G. ruber (d'Orbigny)
Globoquadrina altispira altispira (Cushman and Jarvis)
G. altispira globosa Bolli
G. venezuelana (Hedberg)
Globorotalia (Obandyella) margaritae Bolli and Bermudez
G. (Menardella) cultrata limbata (Fornasini)
G. (Truncorotalia) crassaformis (Galloway and Wissler)
Globorotaloides hexagona hexagona (Natland)
Hastigerina (H.) siphonifera siphonifera (d'Orbigny)
Neogloboquadrina acostaensis (Blow)
N. humerosa (Takayanagi and Saito)
Orbulina universa d'Orbigny
Pulleniatina primalis Banner and Blow
Sphaeroidinellopsis seminulina seminulina (Schwager)
S. subdehiscens subdehiscens (Blow)
Turborotalita humilis (Brady)

The beds at TU 1153 are rich in calcareous nannofossils, containing the species listed for other Lower Pliocene sites.

Geologic Age of Beds at TU 1153

The coincidence of *Globigerina nepenthes* with *Globorotaloides hexagona hexagona* and *Globigerinella calida* indicates a stratigraphic position in Zone N. 19 or the upper part of Zone N. 18. The nannoflora and the planktic foraminifera are typical of the Lower Pliocene.

F. LOCALITY TU 1333

Fresh excavations in railroad cuts behind a newly constructed grain elevator, just north of the road junction at Campo El Chapo, Veracruz, Mexico, were sampled by H. E. and E. H. Vokes with the writer during the summer of 1980. Soft clay yielded rich foraminiferal and calcareous nannofossil assemblages of probable bathyal origin. *Melonis affinis* (Reuss), *Uvigerina hispida* Schwager, and *Amphimorphina stainforthi* (Cushman and Renz) are prominent benthics. The following planktic foraminifera occur at this site:

Biorbulina bilobata (d'Orbigny)
Globigerina decoraperta Takayanagi and Saito
G. nepenthes Todd
Globigerinoides conglobatus conglobatus (Brady)
G. obliquus extremus Bolli and Bermudez
G. obliquus obliquus Bolli
G. quadrilobatus quadrilobatus (d'Orbigny)
G. ruber (d'Orbigny)
Globoquadrina altispira altispira (Cushman and Jarvis)
G. altispira globosa (Bolli)
G. venezuelana (Hedberg)
Globorotalia (Obandyella) margaritae Bolli and Bermudez
G. (Menardella) cultrata limbata (Fornasini)
Neogloboquadrina acostaensis (Blow)
N. humerosa (Takayanagi and Saito)
Orbulina universa d'Orbigny
Sphaeroidinellopsis seminulina seminulina (Schwager)
S. subdehiscens subdehiscens (Blow)

The following calcareous nannoplankton were identified at TU 1333:

Amaurolithus delicatus Gartner and Bukry
A. primus (Bukry and Percival) Gartner and Bukry
A. tricorniculatus (Gartner) Gartner and Bukry
Ceratolithus acutus Gartner and Bukry
Discoaster brouweri Tan
D. pentaradiatus Tan
D. surculus Martini and Bramlette
Helicopontosphaera sellii Bukry and Bramlette
Reticulofenestra pseudoumbilica (Gartner) Gartner
Sphenolithus abies Deflandre

Geologic Age of Beds at TU 1333

Concurrence of *Globigerinoides conglobatus conglobatus* and *Amaurolithus delicatus* indicates a stratigraphic position in Zone N. 18 or N. 19, Lower Pliocene.

V. TAXONOMY

See Part 1 (Akers, 1979, p. 9-16), for taxonomy of additional forms listed from the Lower Pliocene localities but not included below.

A. PLANKTIC FORAMINIFERA

Globigerina incisa (Bronnimann and Resig). Pl. 1, fig. 1a-c

Globorotalia (Turborotalia) incisa BRONNIMANN and RESIG, 1971, Initial Reports of the Deep Sea Drilling Project, vol. 7, Washington (U.S. Government Printing Office), p. 1278-1279, pl. 45, fig. 5, 7; pl. 46, fig. 1-8.

Globigerina fossulata POAG, *in* POAG and SWEET, 1972, Contr. Geol. Geophys. Oceanogr. Gulf of Mexico, vol. 3, p. 257, fig. 8-12e.

Remarks: The species may have become extinct in the Caribbean-Gulf of Mexico region later than it disappeared from the Pacific, as Bronnimann and Resig (1971, p. 1278-1279) do not record it above Zone N. 20 in deep-sea cores from the southwestern Pacific. Many specimens from the Lower Pliocene of Mexico do not have sutures so deeply incised as seen in specimens from the northern Gulf Coast and elsewhere.

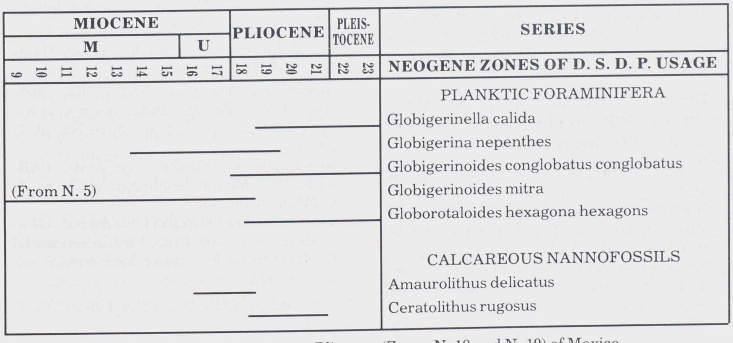

Figure 2. Index Microfossils for the Lower Pliocene (Zones N. 18 and N. 19) of Mexico.

Specimens illustrated from TU 1153 show secondary calcification in the sutures. They are assigned tentatively here.

Globigerina nepenthes Todd. Pl. 1, fig. 2a-c
Globigerina nepenthes TODD, 1957, U.S. Geol. Survey, Prof. Paper 280-H, p. 301, pl.78, fig. 7a-b.
Sphaeroidinellopsis nepenthes (Todd) var. *constricta* BERMUDEZ, 1961, Mem. III Congr. Geol. Venezolano, vol. 3, Bol. Geol. Publ. Esp. 3, (1960), p. 1278, pl. 10, fig. 2a-b.

Remarks: Forms listed and illustrated as *G.* cf. *G. nepenthes* Todd, juvenile(?) have been found by the writer in fine sieve fractions (pl. 1, fig. 3a-b). The maximum diameter of most specimens is 200 microns. The writer has found these forms in beds that yield typical adults of *G. nepenthes* including TU 1324 and TU 1153 of Mexico, the Bowden Formation of Jamaica (Blow's "Holotype" beds for his Zones N. 18 and N. 19), the Suva Marl Formation of Fiji (Zone N. 19), and the Lower Pliocene of several continental slope core holes in the northern Gulf of Mexico.

Globigerinella calida (Parker). Pl. 1, fig. 4a-c
Globigerina calida PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 221, pl. 1, fig. 9-13, 15.
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. AKERS, 1979, Tulane Stud. Geol. Paleont., vol. 15, no. 1, p. 10, pl 2, fig. 7.
Globigerinella calida (Parker), KENNETT and SRINIVASAN, 1983, Neogene Planktonic Foraminifera, Hutchinson Ross Publ. Co., p. 240, pl. 60, fig. 7-9.

Remarks: Kennett and Srinivasan (1983, p. 240) consider this form to range from N. 19 to the Holocene.

Globigerinita glutinata (Egger). Pl. 1, fig. 5a-c
Globigerina glutinata EGGER, 1893, Abh. K. Bayer. Akad. Wiss. München, CL II, vol. 18, p. 371, pl. 13, fig. 19-21.
Tinophodella ambitacrena LOEBLICH and TAPPAN, 1957, Washington Acad. Sci., Jour., vol. 47, no. 4, p. 114, fig. 2, 3.
Globigerinoides parkerae BERMUDEZ, 1961, Bol. Geologia, Pub. Esp. no. 3; Mem. Terc. Congr. Geol. Venezolano, tom. 3, p. 1.232, pl. 10, fig. 10, 11.
Globigerinita glutinata (Egger), PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 246, pl. 9, fig. 1-16.

Globigerinoides conglobatus conglobatus (Brady). Pl. 1, fig. 6a-c
Globigerina conglobata BRADY, 1879, Quart. Jour. Micr. Science (new ser.), vol. 19, p. 286.
Globigerinoides conglobatus conglobatus (Brady), PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 229, pl. 3, fig. 1-5.

Globigerinoides mitra Todd. Pl. 2, fig. 1a-c
Globigerinoides mitra TODD, 1957, U.S. Geol. Survey, Prof. Paper 280-H, p. 302, pl. 78, fig. 3, 6.

Remarks: Saito *et al.* (1976) placed *G. mitra* in a new genus, *Globicuniculus*, but Kennett and Srinivasan (1983, p. 76) retained the species in *Globigerinoides*.

Globorotalia (Truncorotalia) crassaformis (Galloway and Wissler). Pl. 2, fig. 2a-c
Globigerina crassaformis GALLOWAY and WISSLER, 1927, Jour. Paleontology, vol. 1, p. 41, pl. 7, fig. 12.
Globorotalia crassaformis (Galloway and Wissler), PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 235, pl. 4, fig. 17, 18, 20, 21.

Remarks: Specimens from the Pliocene of Mexico are rare and small and are referred here, *sensu lato*.

Globorotalia (Menardella) miocenica Palmer. Pl. 2, fig. 3a-c
Globorotalia menardii (d'Orbigny) *miocenica* PALMER, 1945, Bull. Amer. Paleontology, vol. 29, no. 115, p. 70, pl. 1, fig. 10

Globorotaloides hexagona hexagona (Natland). Pl. 2, fig. 4a-c, 5a-c
Globigerina hexagona NATLAND, 1938, Univ. Calif., Scripps Inst. Oceanography, Bull. Tech. Ser., vol. 4, no. 5, p. 149, pl. 7, fig. 1.
Globoquadrina hexagona (Natland), PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 244, pl. 8, fig. 5-13.
Globorotaloides hexagona hexagona (Natland), BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 373-374.

Pulleniatina primalis Banner and Blow. Pl. 3, fig. 1a-c

Pulleniatina primalis BANNER and BLOW, 1967, Micropaleontology, vol. 13, no. 1, p. 142, pl. 1, fig. 3-8; pl. 3, fig. 2.

Sphaeroidinellopsis seminulina seminulina (Schwager). Pl. 3, fig. 2a-c, 3a-b
Globigerina seminulina SCHWAGER, 1866, *Novara* Exped., 1857-1859, Geol. Theil., vol. 2, pt. 2, p. 256, pl. 7, fig. 112. BANNER and BLOW, 1960, Contr. Cushman Found. Foram. Res., vol. 11, p. 24, pl. 7, fig. 2 (neotype).
Sphaeroidinellopsis seminulina seminulina (Schwager), BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 337, pl. 30, fig. 7.

Turborotalita humilis (Brady). Pl. 3, fig. 4a-c, 5a-c
Truncatulina humilis BRADY, 1884, Rept. Voy. *Challenger,* Zoology, vol. 9, p. 665, pl. 94, fig. 7.
Globigerina cristata HERON-ALLEN and EARLAND, 1929, Jour. Roy. Micr. Soc., ser. 3, vol. 49, pt. 4, art. 27, p. 331, pl. 4, fig. 33-39.
Globigerinita parkerae LOEBLICH and TAPPAN, 1957, Washington Acad. Sci., Jour., vol. 47, no. 4, p. 113, fig. 1.
Globigerinita humilis (Brady), PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 249, pl. 10, fig. 1-25.
Turborotalita humilis (Brady), PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, pl. 146-147, pl. 17, fig. 10. BLOW, 1969, Proc. First International Conference on Planktonic Microfossils, vol. 1, p. 373, pl. 51, fig. 4 *(Turborotalia [sic]* cf. *humilis* (Brady)). SEIGLIE AND CUCURULLO, 1971, Carib. Jour. Sci., vol. 11, no. 3-4, p. 110, pl. 4, fig. 64a, b, 66a-67b.
Globorotalia sp. cf. *Turborotalita humilis* (Brady), SEIGLIE and CUCURULLO, 1971, Carib. Jour. Sci., vol. 11, no. 3-4, p. 110, pl. 4, fig. 61a-63b, 65a, b.

Remarks: The writer agrees with Seiglie and Cucurullo (1971, p. 110) that forms having a less complex bulla and fewer infralaminal apertures are probably ancestral to those forms cited as typical of the species. These authors may also be correct in referring the less complex form to *Globanomalina pumilio* Parker, 1962.

B. CALCAREOUS NANNOFOSSILS

Amaurolithus delicatus Gartner and Bukry, Pl. 4, Fig. 1, 2
Amaurolithus delicatus GARTNER and BUKRY, 1975, Jour. Research, U.S. Geol. Survey, vol. 3, no. 4, p. 456-457, fig. 7a-f.

Amaurolithus primus (Bukry and Percival) Gartner and Bukry, Pl. 4, fig. 6, 7
Ceratolithus primus Bukry and Percival, 1971, Tulane Stud. Geol. Paleont., vol. 8, p. 126, pl. 1, fig. 12-14.
Amaurolithus primus (Bukry and Percival) Gartner and Bukry, 1975, Jour. Research, U.S. Geol. Survey, vol. 8, no. 4, p. 457, fig. 7g-l.

Helicopontosphaera sellii Bukry and Bramlette. Pl. 4, fig. 4, 5
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