

## Late Cretaceous (Maastrichtian) foraminiferal assemblage from the inoceramid beds, Ocozocoautla Formation, central Chiapas, SE Mexico

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### ABSTRACT

*Foraminifera from samples collected in the lower part of the Ocozocoautla Formation were studied. This sequence crops out north-west of Tuxtla Gutiérrez in central part of Chiapas state in south-eastern Mexico. The lower part of the unit consists mostly of argillaceous and marly sandstone with inoceramids. This horizon yields a poorly preserved but biostratigraphically useful foraminiferal assemblage.*

*The upper part of the Gansserina gansseri zone is defined on the basis of the planktic foraminiferal association. An early Maastrichtian age has been assigned, rather than late Campanian-Maastrichtian as previously determined in the literature.*

*The environment was interpreted as outer shelf-upper slope with Tethyan affinities, on the basis of the benthic and planktic foraminiferal association.*

*Key words: foraminiferal assemblage, Maastrichtian, Ocozocoautla Formation, Chiapas, Mexico.*

### RESUMEN

*Se realizó un estudio de foraminíferos en muestras colectadas de la parte inferior de la Formación Ocozocoautla. Esta secuencia aflora al noroeste de la ciudad de Tuxtla Gutiérrez, en la parte central del Estado de Chiapas en el sureste de México. La parte inferior de esta unidad está compuesta de arenisca arcillosa y arenisca margosa que contiene inocerámidos; este horizonte presenta una asociación de foraminíferos pobremente preservada pero bioestratigráficamente útil.*

*La parte superior de la Zona de Gansserina gansseri fue definida con base en la asociación de foraminíferos planctónicos. La edad asignada es Maastrichtiano temprano más bien que Campaniano-Maastrichtiano como fue previamente expresado en la literatura.*

*Se sugiere un ambiente de plataforma externa-talud superior, de aguas cálidas de la Provincia del Tethys, tomando en cuenta la asociación de foraminíferos bentónicos y planctónicos.*

*Palabras clave: asociación de foraminíferos, Maastrichtiano, Formación Ocozocoautla, Chiapas, México.*

## INTRODUCTION

The Ocozocoautla Formation is a terrigenous, highly fossiliferous unit with a varied macrofossil assemblage dominated by rudists (Müllerried, 1931, 1934; Chubb, 1959, Alencáster, 1971; Alencáster and Pons, 1992); inoceramids (Michaud, 1984; Bolaños and Buitrón, 1984; Alencáster and Omaña, in press); gastropods (Buitrón *et al.*, 1995) and corals (Filkorn, 2005).

The larger foraminifera are abundant and have been reported by Ayala-Castañares (1963) and Michaud (1987). Planktic and arenaceous benthic foraminifera were observed to occur with *Inoceramus* prisms by Brönnimann (*in* Chubb, 1959) in the basal part of the Piedra Parada Formation (Ocozocoautla Series). Michaud (1984) studied the inoceramids of the Ocuilapa and Ocozocoautla sections and recorded some planktic foraminifera from washed samples of these rocks. Subsequently, Omaña (1998) reported a foraminiferal assemblage from the inoceramid beds.

The objective of this paper is to report the occurrence of planktic and benthic foraminifera recovered from samples with inoceramids. The biostratigraphic significance of planktic foraminifera, considered to be an important tool for dating marine sedimentary sequences, has allowed us to assign an age to these samples. Analysis of the benthic foraminifera has also provided a valuable means of inferring the depositional environment. The study of the planktic foraminiferal assemblage has been useful for biogeographic differentiation and definition of the bioprovinces.

## GEOLOGICAL SETTING AND LOCAL STRATIGRAPHY

The studied section is located in the state of Chiapas in southeastern Mexico (Figure 1). The area belongs to the Maya Block, which is bounded on the south by the Polochic-Motagua sinistral fault system, the boundary between the North American and Caribbean Plates (Fourcade *et al.*, 1999). The geological evolution and depositional framework of this region is considered to be closely related to the opening of the Atlantic Ocean and the Gulf of Mexico in the Middle Jurassic.

According to Michaud and Fourcade (1989), the Jurassic sedimentation is interpreted within the rift model. The first marine sediments (San Ricardo Formation) deposited in the Oxfordian correspond to the synrift phase. A postrift phase occurred during the Kimeridgian, with the development of a carbonate platform (Scott, 1984; Salvador, 1987).

A subsident basin, present during the Tithonian, was filled until the Neocomian. After the Neocomian regression, a new marine transgression flooded the Chiapas batholith, forming a broad Albian-Cenomanian carbonate platform (Sierra Madre Formation). Michaud and Fourcade (1989) stated that sedimentation in the upper Campanian–Maastrichtian began

with the fragmentation of the middle Cretaceous platform, which gave origin to the Tuxtla Gutiérrez basin. This basin was limited by a fault that separated the Angostura platform from an emergent zone that supplied terrigenous material to the Ocozocoautla submarine detrital cone. Various lithological units were consequently deposited (Ocozocoautla and Angostura Formations).

The terrigenous rocks located in the environs of the town of Ocozocoautla were first documented when Sapper (1894) made a geological reconnaissance of the Chiapas region. Page and Pike (1921) were the first to use the term Gravas Ocozocoautla for the sandstone conglomeratic outcrops located to the west of Ocozocoautla. This succession was subsequently defined by Gutierrez-Gil (1956) as “the Ocozocoautla Series”. Chubb (1959) divided it into five formations: Piedra Parada beds, San Luis Conglomerate, Nuevo beds, Campeche beds and Carretera Formation. Sánchez-Montes de Oca (1969) claimed that the division proposed by Chubb (1956) is questionable because the lithological variation corresponds to different facies within the same formation.

Sánchez-Montes de Oca (1973) measured the Turipache section of the Ocozocoautla Formation, which is composed of a lower part of mostly argillaceous sandstone, overlain by gray to reddish and greenish gray marly sandstone (245 m). Inoceramids, echinoids, and a few ammonites were collected in this level. Above these lies light brown

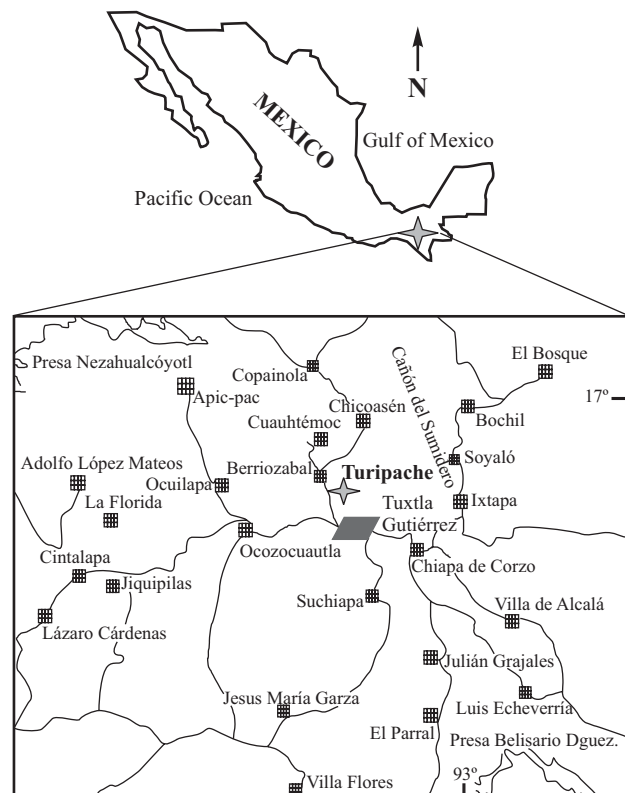


Figure 1. Geographic setting of the studied section, NW of Tuxtla Gutiérrez, Chiapas.

bioclast packstone containing red algae, echinoids and some rudists in living position; this limestone is interbedded with shale (75 m). Above these strata, marl alternates with shale (25 m), which is capped by a packstone (22 m) followed by 100 m of marl and shale. The final layers consist of a deposit of Angostura limestone (Figure 2).

## MATERIAL AND METHODS

The samples analysed range from gray to greenish and reddish gray marly sandstone beds with inoceramids from the lower Ocozocoautla Formation. The material was collected and measured, as noted above, by Sánchez-Montes de Oca (1973) from the Turipache section (16° 46'N 93° 5'W) located northwest of the town of Ocozocoautla (Figure 1)

The hardened samples were chemically treated with a boiling phosphate trisodium solution to facilitate removal of the sediment particles (Kohl, 1985). The samples were then washed repeatedly in water and passed through a 63 µm screen. The washed residue was dried and the foraminifera separated and identified (see Appendix). Although the foraminifera are poorly preserved, some species were reported and illustrated by SEM photos for first time in this work (Figures. 3, 4).

## AGE

Exhaustive analysis of the studied samples allowed to identify 27 planktic foraminifera species. The planktic foraminiferal assemblage is abundant and biostratigraphically useful. The most prominent species are *Gansserina gansseri* (Bolli), *Plummerita reicheli* (Brönnimann), *Rugoglobigerina macrocephala* Brönnimann, *R. hexacamerata* Brönnimann, *Globotruncana aegyptiaca* Nakkady, *G. falsostuarti* Sigal, *Contusotruncana plicata* (White), *Pseudoguembelina excolata* (Cushman), *P. kempensis* Esker, and *Pseudotextularia intermedia* de Klantz.

In addition, further planktic foraminifera recorded include *Globotruncana arca* (Cushman), *G. bulloides* Vogler, *Globotruncanita stuarti* (de Lapparent), *G. stuartiformis* (Dalbiez), *G. subspinosa* (Pessagno), *Contusotruncana fornicata* (Plummer), *Rugotruncana subpenny* (Gandolfi), *Pseudotextularia elegans* (Rzehak), *Heterohelix globulosa* (Ehrenberg), and *Globigerinelloides prairiehillensis* Pessagno.

The presence of *Gansserina gansseri*, as well as *Rugoglobigerina hexacamerata*, *R. macrocephala* and *Plummerita reicheli*, suggests that this association can be assigned to the upper part of the *Gansserina gansseri* Zone of early Maastrichtian age, according to the zonal scheme proposed by Robaszynski and Caron (1995) and Premoli Silva and Sliter (1995, 1999).

The age of this interval has been controversial because Brönnimann (*in* Chubb, 1959) assigned a probable

Campanian age to the microfauna of basal Piedra Parada beds with inoceramids. Michaud (1987) subsequently dated these strata with inoceramids as late Campanian-Maastrichtian. The inoceramids reported in a recent study (Alencaster and Omaña, *in press*) are, however, typical of early Maastrichtian age.

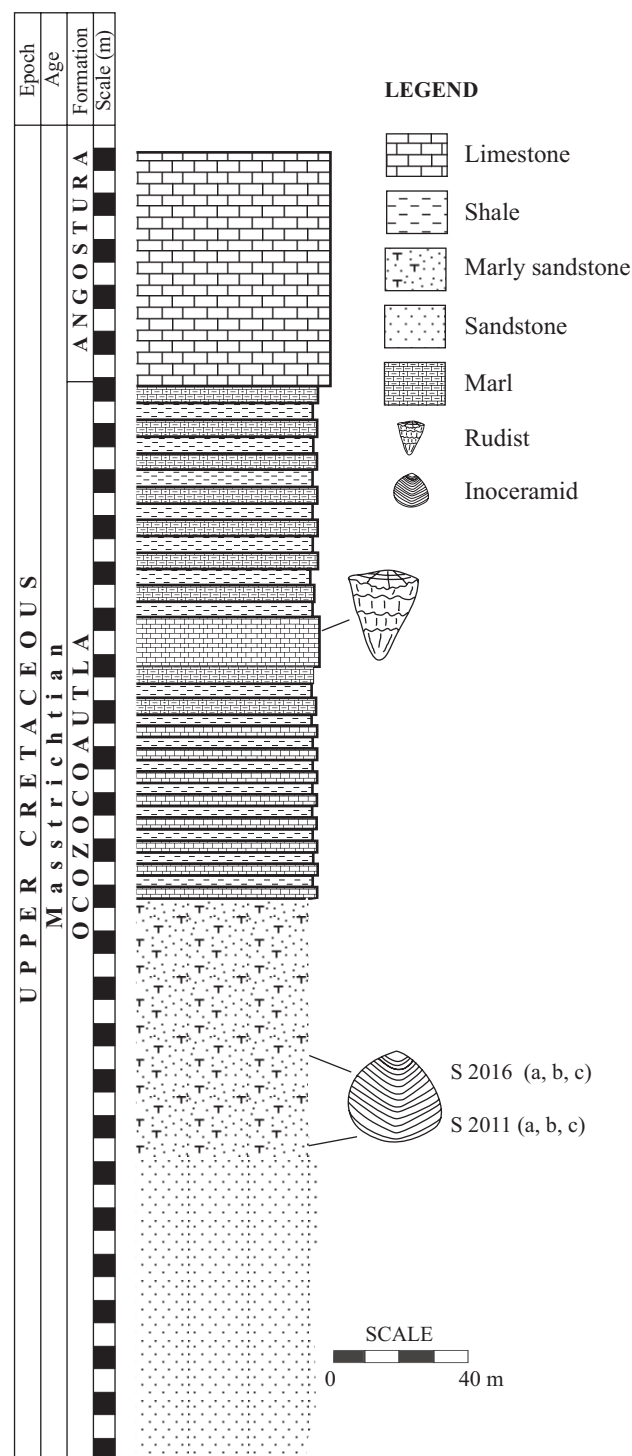


Figure 2. Stratigraphic section of the Ocozocoautla Formation in the Turipache region. Location of studied samples is indicated.

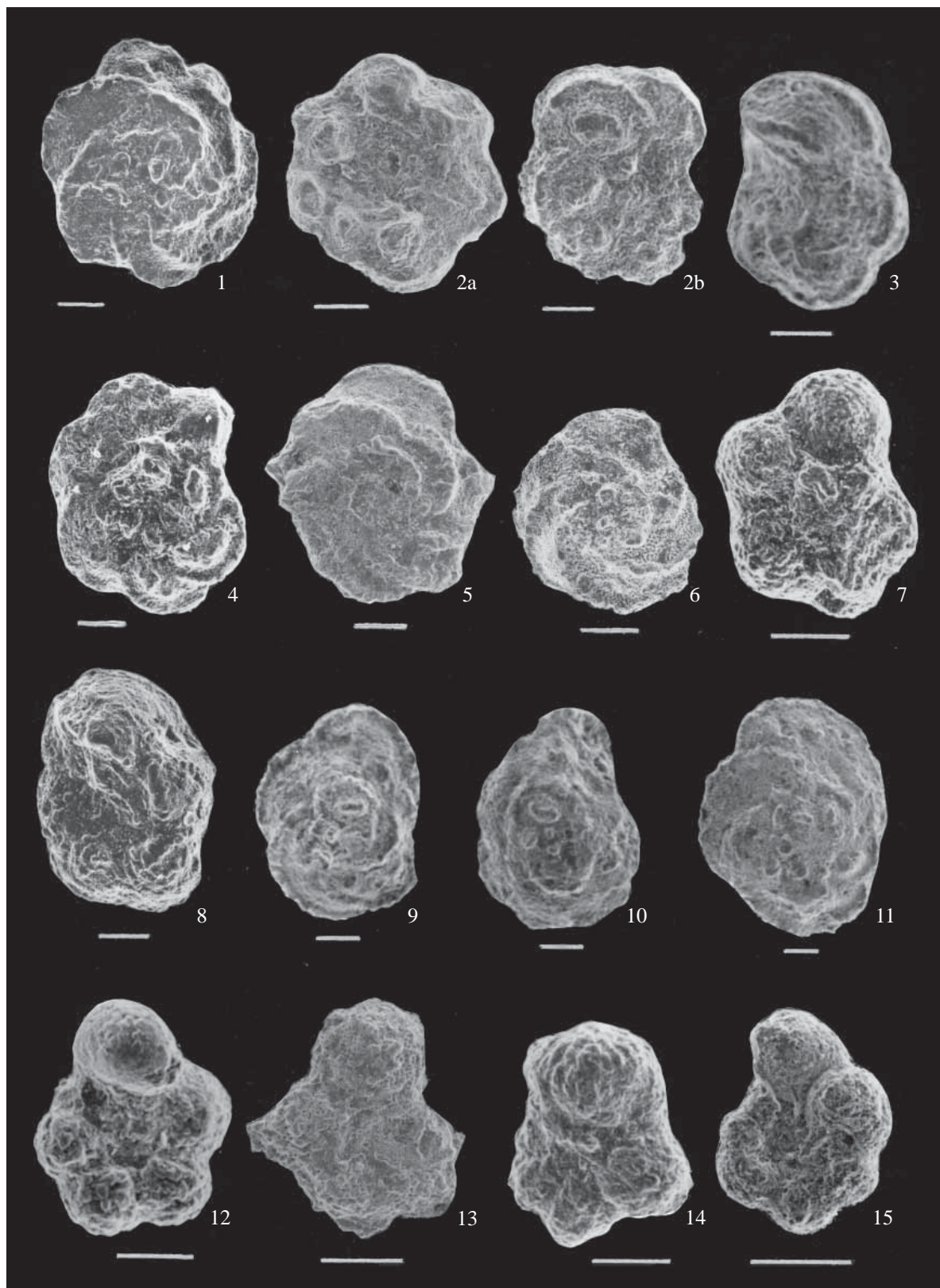


Figure 3. Planktic foraminifera from the Ocozocoautla Formation (early Maastrichtian). Scale bar 100 $\mu$ m. 1: *Globotruncana falsostuarti* Sigal (S-2016 a); 2 a,b: *Globotruncana bulloides* Vogler (S-2011 a); 3: *Globotruncana aegyptiaca* Nakkady (S-2011 a); 4: *Globotruncana arca* (Cushman) (S-2011 a); 5: *Globotruncanita subspinoso* (Pessagno) (S-2011 a); 6: *Globotruncanita insignis* Gandolfi (S-2016 b); 7: *Rugotruncana subpenny* (Gandolfi) (S-2016 b); 8: *Gansserina gansseri* (Bolli) (S-2016 a); 9: *Contusotruncana plummerae* (Gandolfi) (S-2011 b); 10: *Contusotruncana plicata* (White) (S-2011a); 11: *Contusotruncana fornicata* (Plummer) (S-2011 b); 12: *Rugoglobigerina hexacamerata* Brönnimann (S-2011 a); 13: *Plummerita reicheli* Brönnimann (S-2011a); 14: *Rugoglobigerina rugosa* (Plummer) (S-2011b); 15: *Globigerinelloides praerihillensis* Pessagno (S-2011 b).

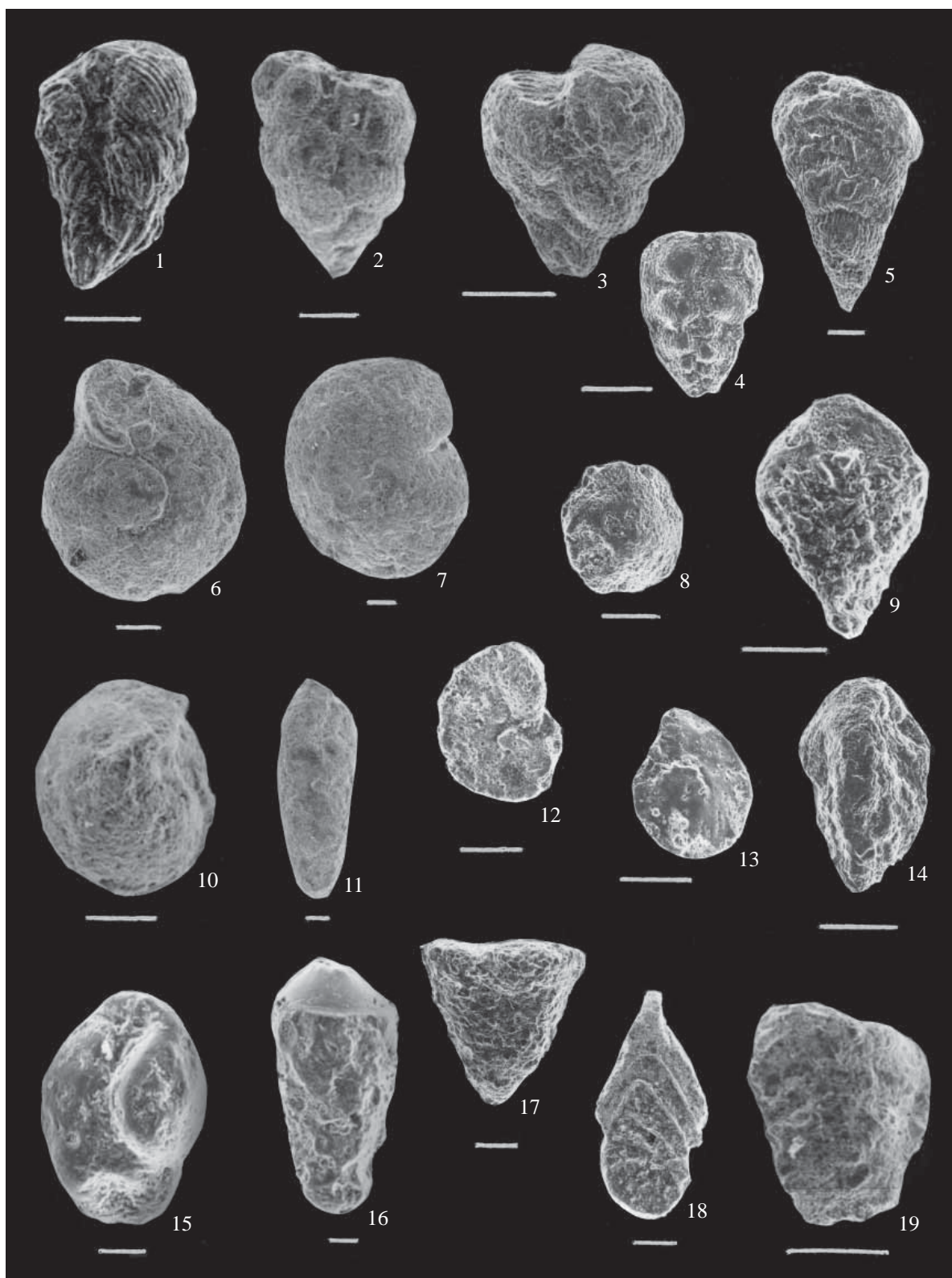


Figure 4. Planktic (1–5) and benthic (6–19) foraminifera from the Ocozocoautla formation (early Maastrichtian). Scale bar 100µm. 1: *Pseudoguembelina excolata* (Cushman) (S-2011 a); 2: *Pseudotextularia intermedia* De Klasz (S- 2016 a); 3: *Heterohelix globulosa* (Ehrenberg) (S-2016 b); 4: *Pseudoguembelina kempensis* Esker (S-2011 b); 5: *Pseudotextularia elegans* (Rzehak) (S-2016 a); 6, 7: *Gavellinella dayi* (White) (S-2011 a); 8: *Siphonina prima* Plummer (S- 2011 a); 9: *Bolivinoides draco* (Marsson) (S-2011 a); 10: *Globorotalites conicus* (Carsey) (S-2011 a); 11: *Bolivina incrassata* Reuss (S-2011 a); 12: *Planulina texana* Cushman (S-2011 b); 13: *Cibicides harperi* (Sandidge) (S-2016b); 14: *Pseudovigenerina plummerae* Cushman (S-2011 b); 15: *Praebulimina carseyae* (Plummer) (S-2011 b); 16: *Pseudonodosaria manifesta* (Reuss) (S-2011 b); 17: *Dorothia oxycona* (Reuss) (S-2016 a); 18: *Neoflabellina* sp (S-2011 b); 19: *Spiroplectammina laevis* (Roemer) (S-2011 b).

## PALEOENVIRONMENT

The foraminiferal assemblage recovered from the samples with inoceramids contains a great variety of benthic foraminifera; *Pseudovigerina*, *Bolivina*, *Loxostomun*, *Saracenaria*, *Lenticulina*, *Bolivinooides*, *Marginulina*, *Globorotalites*, as well as nodosarids. *Gyroidina*, *Gavelinella*, and some arenaceous foraminifers such as *Dorothia*, *Verneulina* and *Spiroplectammina* were also identified.

The paleobathymetric interpretation of the depositional environment is defined by depth restricted genera, several of which are homeomorphs of modern indicators (Sliter and Baker, 1972). The genus *Pseudovigerina* has been considered a homeomorph of the modern *Trifarina*, which typically inhabits a region ranging from the outer shelf to upper continental slope. In addition, on the basis of morphological similarity to modern large bolivinids, *Bolivina incrassata* should be indicative of an outer shelf-upper slope environment (Schnitker, 1972).

The various *Gyroidinoides* and *Gavelinella* species observed appear to be restricted to deeper environment. The overlapping bathymetric ranges of the shelf and slope forms suggests an outer shelf-upper slope deposit for this interval of the Ocozocoautla sequence.

The planktic foraminiferal diversity, including keeled forms, confirms a relatively greater depth for this deposit, since globotruncanids lived farther down in the water column and were excluded from shallow water environments (Douglas and Savin, 1975; Hart, 1980; Huber, 1992). This foraminiferal assemblage may correspond to biofacies 3 proposed by Olsson and Nyong (1984).

Brönnimann (*in* Chubb, 1959) reported planktic foraminifera, some arenaceous benthic foraminifera and inoceramid prisms in the Piedra Parada beds. The environment was interpreted to be moderately deep water.

Michaud and Fourcade (1989) postulated that basal arenaceous marl with planktic foraminifera in the Ocozocoautla detrital system occupied a deltaic frontal position within a deep-sea environment, deposited in the subsident basin.

## PALEOBIOGEOGRAPHY

A latitudinal distribution of marine fauna as determined by climates and currents shows a regional pattern from the equator to the poles that defines bioprovinces characterised by a marked decrease in species diversity from the equator toward the high latitudes, in which the assemblages consist basically of opportunistic species with simple morphologies (Bé, 1982).

Late Cretaceous planktic foraminifera generally have been assigned to the boreal and austral provinces, intermediate and equatorial Tethyan realm (Sliter, 1968, 1977; Huber, 1992; Koutsoukos, 1992).

According to Douglas (1972), in the Americas the Tethyan province comprises the Caribbean, Central America, northern South America, Mexico, and the Gulf and Atlantic coastal plains and the southern half of California. The Tethyan realm includes the largest diversity of planktic foraminiferal species; all single and double keeled globotruncanids, the rugoglobigerinids and the heterohelicids (Sliter, 1968, 1977). The region studied in the present work should be thus included in this province, due to the geographic location of the Chiapas region.

The planktic foraminiferal association studied consists of a great diversity of species including keeled forms, rugoglobigerinids, and heterohelicids characteristic of the low latitudes as cited by Sliter (1968, 1977), Malmgren (1991) and Premoli Silva and Sliter (1999).

## CONCLUSIONS

The upper part of the *Gansserina gansseri* Zone was identified from the lower part of the Ocozocoautla Formation which contains inoceramids. The age assigned is early Maastrichtian, in contrast to the view frequently expressed in the literature that the interval is Campanian (Brönnimann *in* Chubb, 1959) or Campanian-Maastrichtian (Michaud, 1987). For this reason the present study contributes to a better definition of the biostratigraphical position of this part of the Ocozocoautla deposit.

The benthic foraminiferal association and the occurrence of keeled planktic forms suggest that the interval studied was deposited in an outer shelf-upper slope environment.

The warm-water planktic foraminifera of the lower portion of the Ocozocoautla unit is characteristic of the tropical Tethyan realm.

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## APPENDIX

This section includes an alphabetical list of the most prominent species identified in the interval studied. Some generic definitions proposed by Loeblich and Tappan (1988) have been used in the paper. All specimens are housed in the Paleontological Collection of the Instituto de Geología (Universidad Nacional Autónoma de México).

**Planktic foraminifera**

*Contusotruncana fornicata* (Plummer, 1931)  
*Contusotruncana plicata* (White, 1928)  
*Contusotruncana plummerae* (Gandolfi, 1955)  
*Gansserina gansseri* (Bolli, 1951)  
*Globigerinelloides praeiehillensis* Pessagno, 1967  
*Globotruncana aegyptiaca* Nakkady, 1950  
*Globotruncana arca* (Cushman, 1926)  
*Globotruncana bulloides* Vogler, 1941  
*Globotruncana falsostuarti* Sigal, 1952  
*Globotruncanita insignis* Gandolfi, 1955  
*Globotruncanella havanensis* (Voorwijk, 1937)  
*Globotruncanella minuta* Caron and González-Donoso, 1984  
*Globotruncanita stuarti* (de Lapparent, 1918)  
*Globotruncanita stuartiformis* (Dalbiez, 1955)  
*Globotruncanita subspinosa* (Pessagno, 1960)  
*Heterohelix globulosa* (Ehrenberg, 1840)  
*Heterohelix navarroensis* Loeblich, 1951  
*Plummerita reicheli* Brönnimann, 1952  
*Pseudoguembelina costulata* (Cushman, 1938)  
*Pseudoguembelina excolata* (Cushman, 1926)  
*Pseudoguembelina kempensis* Esker, 1968  
*Pseudotextularia elegans* (Rzehak, 1891)  
*Pseudotextularia intermedia* De Klasz, 1953  
*Rugoglobigerina hexacamerata* Brönnimann, 1952  
*Rugoglobigerina macrocephala* Brönnimann, 1952  
*Rugoglobigerina rugosa* (Plummer, 1926)  
*Rugotruncana subpenny* (Gandolfi, 1952)

**Benthic foraminifera**

*Allomorphina cretacea* Reuss, 1851  
*Bolivina incrassata* Reuss, 1851  
*Bolivinoides draco* (Marsson, 1878)  
*Cibicides harperi* (Sandidge, 1932)  
*Clavulina trilatera* Cushman, 1926  
*Dorothia oxycona* (Reuss, 1860)  
*Gavelinella dayi* (White, 1928)  
*Globorotalites conicus* (Carsey, 1926)  
*Globorotalites spineus* (Cushman, 1926)  
*Gyroidinoides cretacea* (Carsey, 1926)  
*Gyroidina deppresa* (Alth, 1850)  
*Lagena semiinterrupta* Berry, 1929  
*Lenticulina muensteri* (Roemer, 1839)  
*Loxostomum eleyi* (Cushman, 1927)  
*Nonionella cretacea* Cushman, 1931  
*Planulina texana* Cushman, 1938  
*Praebulimina carseyae* (Plummer, 1931)  
*Pseudonodosaria manifesta* (Reuss, 1851)  
*Pseudowigenerina plummerae* Cushman, 1927  
*Pullenia coryelli* White, 1929  
*Saracenaria triangularis* (d'Orbigny, 1840)  
*Siphonina prima* Plummer 1926  
*Spiroplectammina laevis* (Roemer, 1841)  
*Vaginulina plummerae* (Cushman, 1937)