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A MIDDLE ALBIAN BIOTA (ALGAE, FORAMINIFERA AND GASTROPODA) FROM AHUACATLÁN, STATE OF QUERÉTARO, MEXICO

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ABSTRACT

In the northeastern part of the State of Querétaro, central Mexico, Cretaceous carbonate rocks are extensively exposed. Samples of algae (*Acicularia elongata* Carozzi, *Linoporella* cf. *L. elliotti* [Praturlon], *Cayeuxia kurdistanensis* Elliott and *Neomeris* cf. *N. cretacea* Steinmann), foraminifers (*Barkerina barkerensis* Frizzel and Schwartz, *Dictyoconus walnutensis* [Carsey] and *Cuneolina* sp.), gastropods (*Neoptyxis pre-olisiponensis* [Delpey] and *Diptyxis castilli* [Bárcena]) and rudists (*Caprinuloidea perfecta* Palmer and *Coalcomana* sp.) were collected along a segment of the edge of San Luis Potosí carbonate platform nearby the town of Ahuacatlán. The age of the identified fauna has been assigned to the middle Albian.

The area of study is located in the forelimb of the Ahuacatlán syncline that averages 2.5 km in width. This structural unit is flanked to the west by the Bonanza fold-nappe and to the east by the Puente de Dios thrust. Toward the north, these units end abruptly against a salient of the Valles-San Luis Potosí platform in Arroyo Hondo. The structural distribution of these units can be correlated with the Bonanza fold-nappe, flanked in its eastern limb by the El Volantín thrust, the El Fraile syncline and the Jiliapan thrust located within the San Francisco region in the State of Hidalgo, southeast of the area of study.

Key words: Algae, foraminifera, gastropoda, middle Albian, Querétaro, Mexico.

RESUMEN

En la región nororiental del Estado de Querétaro, están expuestas en forma extensiva rocas carbonatadas cretácicas. Muestras de algas (*Acicularia elongata* Carozzi, *Linoporella* cf. *L. elliotti* [Praturlon], *Cayeuxia kurdistanensis* Elliot y *Neomeris* cf. *N. cretacea* [Steinmann]), foraminíferos (*Barkerina barkerensis* Frizzel and Schwartz, *Dictyoconus walnutensis* [Carsey] y *Cuneolina* sp.), gasterópodos (*Neoptyxis pre-olisiponensis* [Delpey] y *Diptyxis castilli* [Bárcena]) y rudistas (*Caprinuloidea perfecta* Palmer y *Coalcomana* sp.) fueron recolectadas a lo largo de un segmento del borde de la plataforma carbonatada de Valles-San Luis Potosí, cerca del poblado de Ahuacatlán. La fauna identificada es del Albiano medio.

El área de estudio está localizada en el flanco oriental del sinclinal de Ahuacatlán, estructura que promedia 2.5 km en anchura. Esta unidad estructural está limitada al oeste por el pliegue-napa Bonanza y hacia el oriente por la cabalgadura Puente de Dios. Hacia el norte, estas unidades estructurales terminan abruptamente contra la saliente de la plataforma carbonatada de Valles-San Luis Potosí en Arroyo Hondo. Esta distribución estructural se correlaciona con el pliegue-napa Bonanza, limitado al noreste por la cabalgadura El Volantín, el sinclinal El Fraile y la cabalgadura de Jiliapan; localizados en la región de San Francisco, Hidalgo, al sureste del área de estudio.

Palabras clave: Algas, foraminíferos, gasterópodos, Albiano medio, Querétaro, México.

INTRODUCTION

The Sierra Madre Oriental fold and thrust belt is typically constituted of Cretaceous carbonate platforms and adjacent Upper Jurassic to Upper Cretaceous basinal rocks. The region is located in east-central Mexico, in the vicinity of Ahuacatlán, State of Querétaro (Figure 1). It represents a transition zone between the southwestern edge of the Valles-San Luis Potosí carbonate platform (Carrillo-Bravo, 1971) and the northeastern zone of what is known as the epicontinental Zimapán basin (Carrillo-Martínez and Suter, 1982).

The carbonate platform beds in the studied area contain extensive deposits of a well-preserved biota (Carrillo-Martínez, 1993), that includes algae, foraminifers, gastropods (that are described in this paper) and rudists (that are in the process of being studied and therefore will only be discussed). With the paleontological information derived from this biotic association the basic facies pattern will be established and used as a reference framework for correlation with other areas within the general region, that includes this part of the state of Querétaro and a portion of northern Hidalgo (Suter, 1987).

The aim of this paper is to describe this important assemblage and use the bioestratigraphical and paleoecological information obtained from this study for a better undestanding of the compressing processes and other structural features between the Ahuacatlán area and other regions of this portion of the Sierra Madre Oriental.

GEOLOGIC SETTING

STRATIGRAPHIC FRAMEWORK

The Ahuacatlán area has been divided into four Mesozoic lithostratigraphic units ranging from Upper Jurassic to

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Upper Cretaceous: Las Trancas (Upper Jurassic-Lower Cretaceous), Tamaulipas (?Aptian-Cenomanian), Soyatal (Turonian-Campanian) and El Abra (Aptian-Cenomanian) Formations. Among these sedimentary rocks the Tamaulipas and El Abra Formations are characterized by their carbonate nature and by a marked pattern of changes in their depositional conditions that range from basinal to platform facies (Segerstrom, 1961; Carrillo-Martínez and Suter, 1982; Carrillo-Martínez, 1989) (Figure 1).

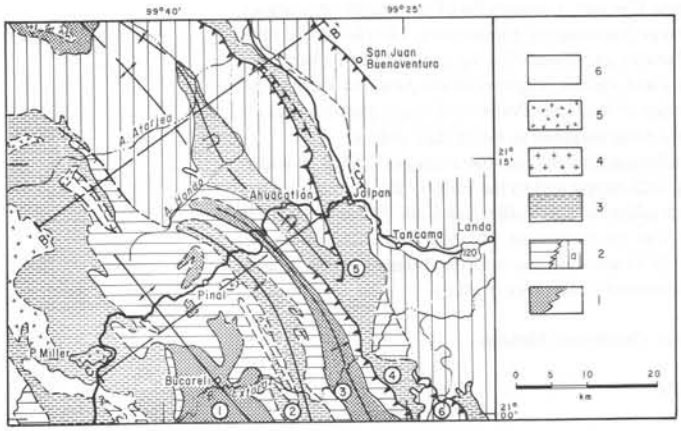


Figure 1. Tectonic map of the southwestern portion of the Cretaceous Valles-San Luis Potosí carbonate platform, between the states of Querétaro and Hidalgo. The numbers shown in the map correspond to the following formations: *1,* San Juan de la Rosa, La Peña Azul and Las Trancas Formations; *2,* El Abra and Tamaulipas Formations; *3,* Soyatal Formation; *4,* Cenozoic intrusive rocks; *5,* Cenozoic volcanic rocks; *6,* Undifferentiated Quaternary rocks. The numbers on the structural units correspond to *1,* El Piñón anticline; *2,* El Aguacate syncline; *3,* the Bonanza fold-nappe; *4,* El Volantín thrust; *5,* Puente de Dios thrust; *6,* Jiliapan thrust. Letters BB' and CC' represented two cross sections that encompass all the stratigraphic units studied in the area.

In the northeastern portion of the studied area, known by the Mexican geologists as the Zimapán basin, Las Trancas Formation (Segerstrom, 1961) is exposed. This Upper Jurassic-Lower Cretaceous unit—the oldest within the Ahuacatlán area—consists mainly of marl and shale beds, with subordinated graywackesand pyroclastic intercalations. Overlying Las Trancas Formation without any sharp discontinuity, is the Tamaulipas Formation. This intermediate unit consits of a well-bedded sequence of mudstone-wackestone limestones of ?Aptian to Cenomanian age (Suter, 1987).

The Tamaulipas Formation changes laterally to El Abra Formation, which is represented by a thick (1,500-2,000 m) sequence of carbonate sediments. Two major facies can be recognized within the El Abra Formation. One is represented by a thick to massive series of bioclastic grainstone-rudist limestone beds, that correspond to a bank edge facies (Wilson, 1975; Suter, 1987), and the other consists mainly of thick beds of well-stratified micritic limestone, where the interesting fossil assemblage described herein was collected. This biota includes abundant grass-green algae (Chlorophyta), several genera of benthonic foraminifers, two species of nerineid gastropods and specially some well-represented patches of rudists.

The Soyatal Formation—Turonian-Campanian age—is the youngest Mesozoic unit found in the Ahuacatlán area. It is constituted at its base by 100-200 m of thick pelagic limestone, intercalated with thin shale beds, and higher in the section, there is an 800 m thick sequence of marly-shale sediments. From all the Mesozoic units in the Ahuacatlán area, the Soyatal Formation was the last one to be affected by the Cordilleran deformation. This is expressed locally where soft sedimentary structures can be appreciated (Figures 2 and 3), suggesting that the Valles-San Luis Potosí platform have been still active during the Late Cretaceous.

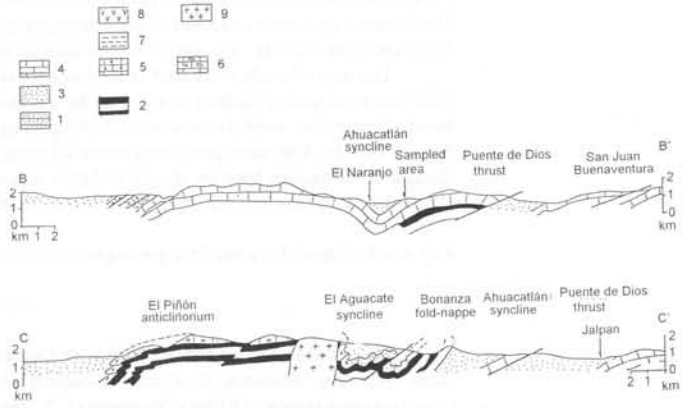


Figure 2. Cross sections BB' and CC' from the southern portion of the Cretaceous Valles-San Luis Potosí carbonate platform, as represented in the map of Figure 1.

REGIONAL TECTONIC ASPECTS

A major structural feature in the area of study is represented by the Bonanza fold-nappe (Segerstrom, 1961, 1962; Suter, 1987), which embodies rocks of the Zimapán basin overriding the Valles-San Luis Potosí platform marginal strata. This structure runs from the southeast to the northwest, and it is partially confined by El Aguacate and the Ahuacatlán synclines (Sergestrom, 1961; Carrillo-Martínez and Suter,

Figure 3. Soft sediment structures in rocks of the Soyatal Formation. The location is the vicinity of the village of Alejandría, State of Querétaro.

1982; Carrillo-Martínez, 1989); nevertheless, most of this fold-nappe is bounded to the northeast by the El Volantín thrust—as shown in Figure 4—that decreases its translation axially toward the northwest and possibly transfers its shortening into the Puente de Dios thrust (Carrillo-Martínez and Suter, 1982; Suter, 1987). Three kilometers southwest from the town of Ahuacatlán, the northeastern limb of the Bonanza anticline displays only minor thrusting and ends abruptly juxtaposed against a projection of the Valles-San Luis Potosí platform at Arroyo Hondo (Figures 1, 4 and 5). Also, more to the northeast this anticline is bounded by the Ahuacatlán syncline, cored by the Soyatal Formation and flanked to the northeast by a backlimb of the Puente de Dios thrust sheet, as it is shown in Figures 4 and 5 (Carrillo-Martínez, 1989). This structural configuration is similar to that of the southeastern region of San Francisco, Hidalgo, where field work in two areas has shown that the Ahuacatlán syncline and the Puente de Dios thrust (this paper), can be correlated with Suter's (1987) El Fraile syncline and Jiliapan thrust, respectively.

However, the platform sediments of the San Francisco area—in Hidalgo—were more extensively overrided by the Zimapán basin than those of Ahuacatlán, describing a deformation style similar to what was studied by Tardy (1975) in the State of Coahuila.

The large area of platform-edge facies exposed in Ahuacatlán did yield a large biota—described in this paper—that correlates favorably with what Suter (1987) has reported for the San Francisco area, as well as with others within the Valles-San Luis Potosí platform.

FAUNISTIC ASSOCIATION

The studied biota from the Ahuacatlán area was collected along the backlimb of the Puente de Dios thrust sheet, close to the contact between the massive carbonate rocks at the edge of the Valles-San Luis Potosí platform and the Soyatal Formation. The rocks containing an abundant and diverse biota consist of fine grained massive limestone with: algae (*Acicularia elongata* Carozzi, *Linoporella* cf. *L. elliotti* [Praturlon], *Cayeuxia kurdistanensis* Elliott, *Neomeris* cf. *N. cretacea* [Steinmann]), benthonic foraminifers (*Barkerina barkerensis* Frizell and Schwartz, *Dictyoconus walnutensis* [Carsey] and *Cuneolina* sp.); rudists (*Caprinuloidea perfecta* Palmer and *Coalcomana* sp.); and nerineid gastropods of the species *Neoptyxis pre-olisiponensis* (Delpey) and Diptyxis *castilli* (Bárcena).

Regarding the lithological and other faunistic features, the present evidence suggests that the depositional environment had been that of a tropical calcareous platform, having a well-oxigenated and shallow water community with such a high productivity that allowed the development of large rudistid banks.

FAUNAL AGE

From the Ahuacatlán assemblage, the presence of the rudists *Coalcomana* sp. (Plate 3, figure 4) and *Caprinuloidea perfecta* (Plate 3, figure 5) (Alencáster, 1987) and the algae *Linoporella* cf. *elliotti* (Praturlon, 1965) indicates that these sediments may range from the Albian to the Cenomanian. Nevertheless, the stratigraphic range of the associated nerineid *Neoptyxis pre-olisiponensis* (Delpey, 1940, p. 20-21) and *Diptyxis castilli* (Bárcena, 1875, p. 379) is restricted to the Albian.

Other taxa present in the Ahuacatlán outcrops seem to corroborate the Albian assignment for this fossil biota. The algae *Acicularia elongata, Cayeuxia kurdistanensis* and

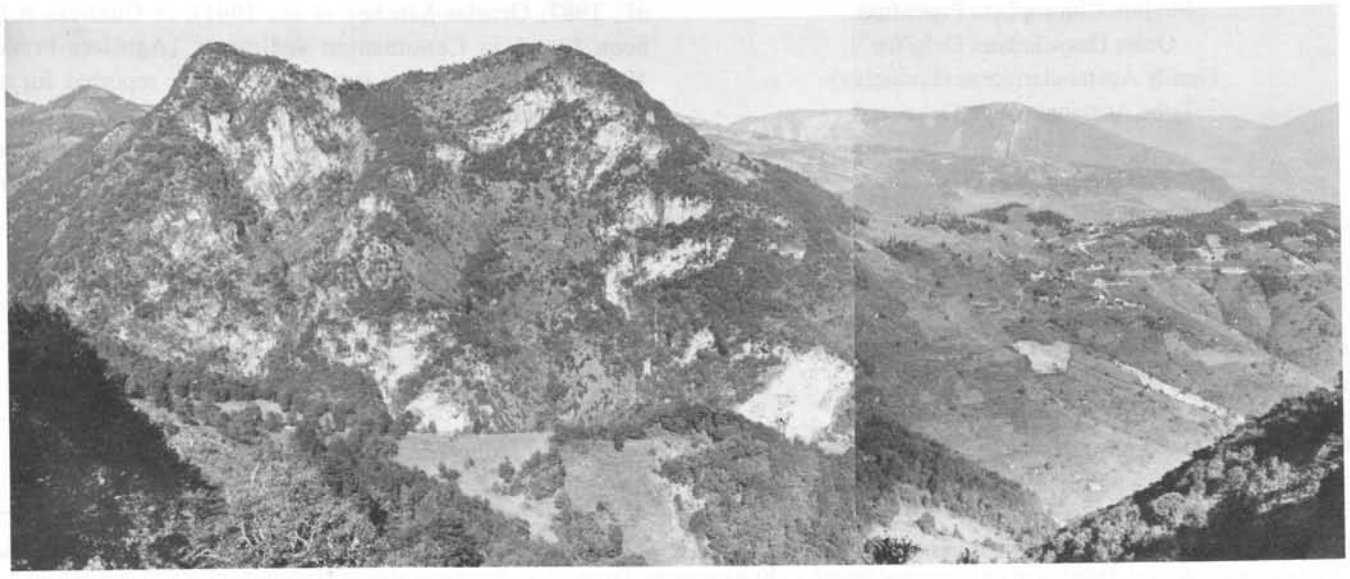


Figure 4. Panoramic view of the northern slope of Arroyo Hondo, close to the town Alejandría. Note the folding associated to the thrust. The fault juxtaposes the carbonate platform (to the left of the picture) against the marl and shale sequence of the Soyatal Formation.

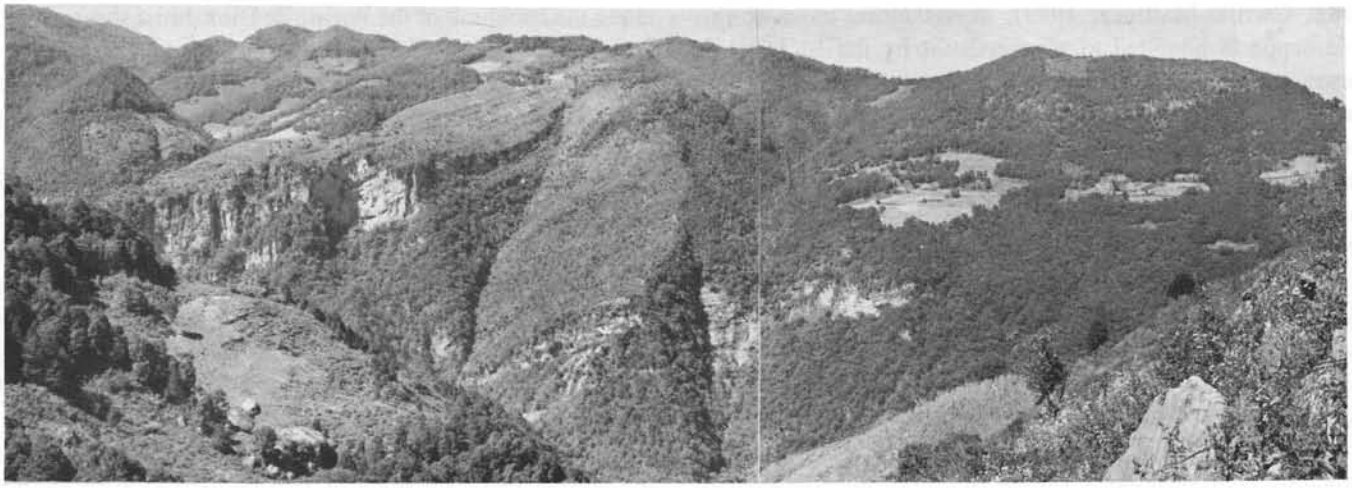


Figure 5. South view, seen from the northern slope of a gorge at Arroyo Hondo. Notice the west-southwest low dipping of the carbonate Valles-San Luis Potosí platform beds, contrasting with the nearly vertical strata of the Tamaulipas Formation (Zimapán basin), represented by limbs of El Aguacate syncline. Besides the gently dipping beds of El Abra Formation is the westerly continuation of the folding related to the thrust of the Figure 4.

Neomeris cf. *cretacea* seem to be common in Albian deposits of several places in the world, particularly *Cayeuxia kurdistanensis* that has been extensively reported of the Aptian-Albian from Lebanon (Basson and Edgell, 1971).

The benthic foraminifers *Cuneolina* and *Dictyoconus walnutensis*, also present in the Ahuacatlán assemblage, are well-known from El Abra Formation and other Cretaceous (middle Albian) formations in Mexico (Bonet, 1956; Aguayo-Camargo, 1993; Basáñez-Loyola *et al.*, 1993).

Therefore, from the biostratigraphical information derived from the taxa present in this Cretaceous biota, the middle Albian age assignment seems to be the most precise.

SYSTEMATIC PALEONTOLOGY

Phylum Chlorophyta Papenfuss
Order Dasycladales Deloffre
Family Acetabulariaceae (Endlicher)
Tribe Acetabularieae (Decaisne)

Genus *Acicularia* d'Archiac

Acicularia elongata Carozzi, 1947

(Plate 1, figures 1, 2)

Acicularia elongata Carozzi, 1947, p. 13, pl.1, figs. 2-3; pl. 2, figs. 1, 2, 4.

Description—Generally, these algae are shown as spicules in transversal section, whereas longitudinally have an elongated shape. Within the group, the spicules diameter and the number of sporangial cavities are key characters in separating the species. The diameter of the spicules reported herein ranges from 180 to 200 micrometers and the sporangium bears between 11 and 13 cavities, measuring 30 micrometers in diameter. The sporangian cavities are located toward the periphery of the spicules.

Remarks—*Acicularia elongata* has been reported for the Oxfordian-Valanginian of Switzerland (Bouroullec and Deloffre, 1970); in Poland, Iran, England, Spain, and Lebanon it is known from the Oxfordian-Berriasian (Bouroullec and Deloffre, 1970). In Mexico, it has been collected in outcrops and wells from Campeche, Chiapas, Tabasco, and Veracruz, in Kimmeridgian-Valanginian facies (Ponce de León-Obregón *et al.*, 1987; Ornelas-Sánchez *et al.*, 1991); in Guerrero it has been found in Cenomanian sediments (Aguilera-Franco, 1995), and for the first time this taxon is reported for any Albian locality.

These algae belong to very shallow marine waters, less than 10 m deep, where the sediments are mainly muddy. Their distribution in lagoonal reefs is generally post-reefal.

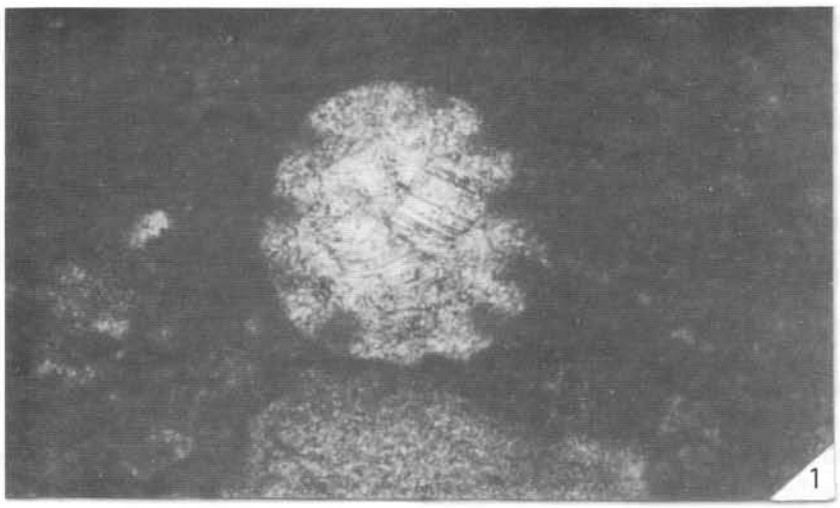
Family Dasycladaceae Kützing orth. mut. Stizenberger
Tribe Neomereae (Pia, 1920) Bassoullet and others, 1979

Genus *Linoporella* Steinmann, 1899

Linoporella cf. *L. elliotti* Praturlon, 1965

(Plate 1, figures 3, 4)

Plate 1. Figures 1, 2—*Acicularia elongata* in transversal and longitudinal sections, respectively. *1*, Shows the sporangial cavities located toward the periphery; *2*, shows a spicule in detail. Diameter of the transversal section = 450 micrometers. Figures 3, 4—Panoramic view of *Linoporella* cf. *elliotti* in longitudinal and transversal sections, respectively. In the figures a portion of the unsegmented cylindric thallus is observed, as well as the calcified spores that correspond to the pores within the branches can be observed. The structures measured 950 and 3,350 micrometers, respectively. Figure 5—A poorly preserved fragment of *Neomeris* cf. *cretacea* forming an algalclast. The specimen measured 900 micrometers in its longer axis. Figure 6—*Linoporella* sp., 6.3 mm. Transversal section of the thallus, where the primary branching can be observed.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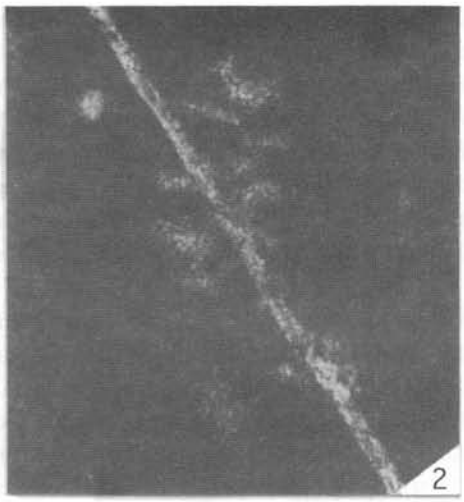
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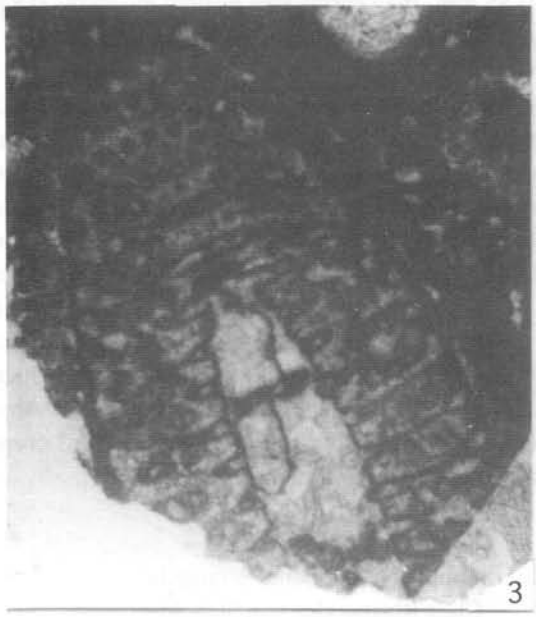
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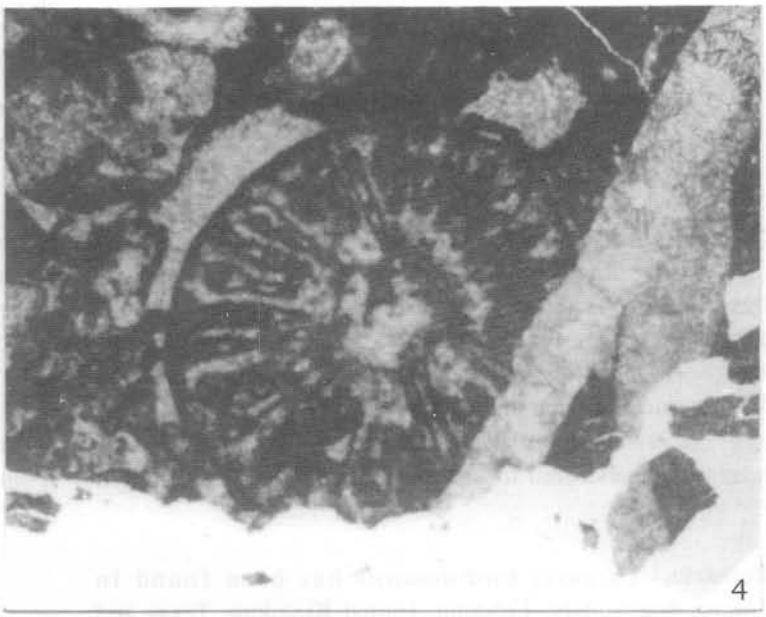
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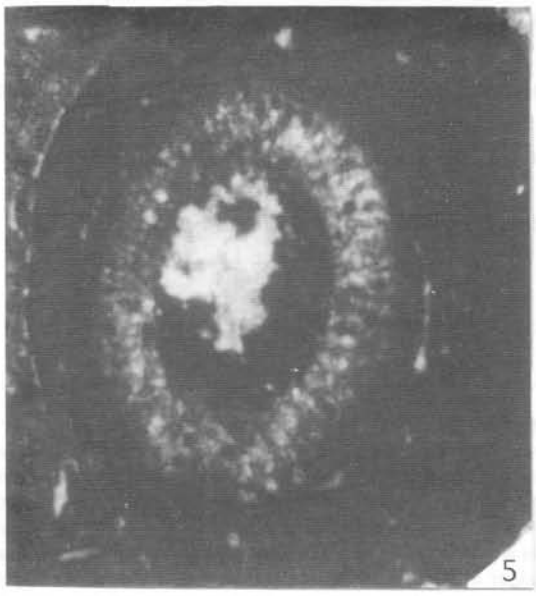
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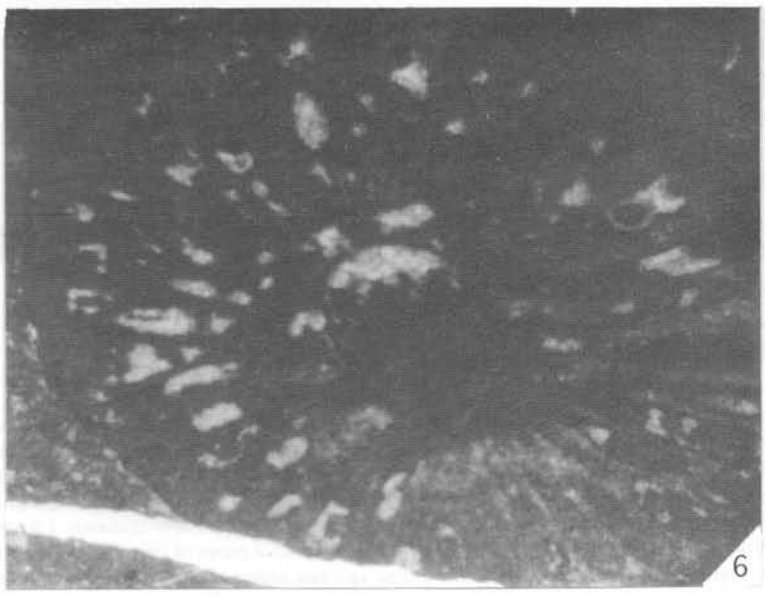
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Description—Cylindrical calcified and unsegmented. The primary branches are bent upwards towards the periphery and show a constant ratio. Also, the primary branches are subdivided and the branching points are swollen and distended. Within the branches, some small pores have been observed; these have been interpreted as calcified spores. The measurements of the studied are as follows: thallus length = 1 mm, thallus diameter = 1.04 mm, and internal diameter = 0.567 mm.

Remarks—*Linoporella elliotti* has been mainly reported in post-reefal muddy facies from Italy (Praturlon, 1965), being the present paper the first known report of this species in America. From what has been reported from outcrops of the southern Latium-Abruzzi province, in Italy (Praturlon, 1966), the stratigraphic range of *L. elliotti,* encompasses the Albian and the Cenomanian.

Family Udoteaceae Bassoullet
Genus *Cayeuxia* Frollo, 1938

***Cayeuxia kurdistanensis* Elliot, 1956**
(Plate 3, figure 1)

Cayeuxia kurdistanensis Elliot, 1956, p. 2, pl. 2, 4, figs. 5, 6.

Description—Thallus formed by fine joined tubes, whose number increases according to the divisions of the parallel branches; the thallus length is around 0.1 to 3.0 mm, 0.18 to 3.5 mm wide; and the diameter of the tubes is 0.025 to 0.035 mm. The branching pattern, which is the most important character to be considered for taxonomic purposes, is oriented in 45° angles.

Remarks—*Cayeuxia kurdistanensis* has been found in France, Spain, Italy, Lebanon, United Kingdom, Texas and Cuba (Bouroullec and Deloffre, 1970; Basson and Edgell, 1971; Johnson, 1968). In Mexico, this species has been reported for the southeast, especially in the marine sediments of Campeche, Chiapas, and Tabasco (Ponce de León-Obregón *et al.*, 1987; Ponce de León and Viñas, 1988).

In the Aquitaine region (France), the stratigraphic range of the genus is Oxfordian-Kimmeridgian when it is associated to *Cayeuxia piae.* In Lebanon, Basson and Edgell (1971, p. 415, pl. 1-7, figs. 4-7) assigned it to the Aptian-Albian, when associated to *Carpathoporella occidentalis*, and in other areas of Europe, its range goes from Tithonian to Albian (Dragastan, 1969). In Texas, USA, Johnson (1968) had assigned the genus to the Aptian-Cenomanian. In southeast Mexico (Chiapas and Tabasco) it had been previously found only in the Oxfordian-Kimmeridgian (Ponce de León-Obregón, 1987; Ponce de León-Obregón and Viñas, 1988; Ornelas-Sánchez *et al.*, 1991) and this work represents the first report of *Cayeuxia kurdistanensis* in Albian sediments.

Environment of deposition—Found in peri-reefal environments, in locally oolitic and pelletoidal muddy facies.

***Neomeris* cf. *N. cretacea* (Steinmann, 1899)**
(Plate 1, figure 5)

Description—Cylindric thallus with a diameter that measured 1.3 mm. The central part of the thallus is hollow and from it the primary branches stem. The diameter of the branches is about 0.24-0.55 mm, the central area hollow measures 0.825 mm; and the thickness of the wall is 0.33 mm.

Remarks—This taxon is known from Irak, Lebanon, Libia, Oman, Yugoslavia, France, Portugal and Texas, USA (Elliott, 1956; Johnson, 1968; Basson and Edgell, 1971; Berthou, 1974). In Mexico, *N. cretacea* was firstly described for the Cerro de Escamela locality, in the State of Veracruz (Steinmann, 1899, p. 149, text-figs. 14-18) and later its presence was reported in the State of Guerrero. Regarding the stratigraphic range of *N. cretacea,* it has been recognized for the Cenomanian-Turonian of Irak. It also was reported for the upper Albian of France, as well as for the upper Aptian-Albian of Lebanon and in Mexico the record from the State of Guerrero corresponds to the Cenomanian (Aguilera-Franco, 1995).

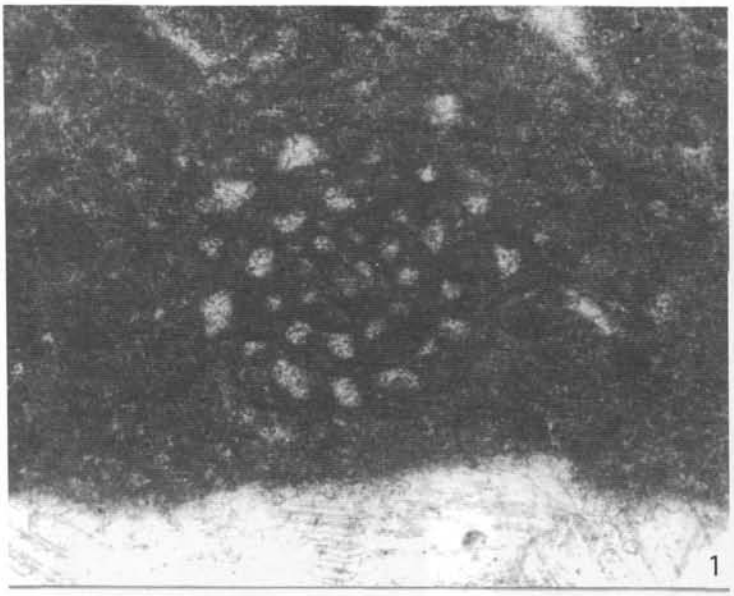
Phylum Protozoa
Subphylum Sarcodina Schmarda
Class Rhizopodea von Siebold
Order Foraminiferida Eichwald
Suborder Textulariina Delage and Herouard
Superfamily Lituolacea de Blainville
Family Barkerinidae Smout emend. Hamaoui and Saint-Marc

Genus *Barkerina* Frizzel and Schwartz, 1950

Barkerina barkerensis Frizzel and Schwartz, 1950
(Plate 2, figure 1)

1950 *Barkerina barkerensis* Frizzel and Schwartz, p. 6, pl. 1, figs. 1-6.

Plate 2. Figure 1—*Barkerina barkerensis* in equatorial section showing the subdivision of the chambers into chamberlets. Diameter = 480 microns.
Figure 2—Panoramic view where several axial sections of *Dictyoconus walnutenis* can be observed. The tests of the specimens measured approximately 1.5 mm. Figure 3—Subaxial section of *Dictyoconus walnutensis*. In this view it can be observed that the conical shape is almost as tall as wide. Also the specimen shows a marginal zone with clearly differentiated horizontal plates that bifurcate the margin of each chamber. The central zone depicts the pillars that form the endoskeleton. As for figure 2, the test of the specimen measured approximately 1.5 mm. Figure 4—Part of a transversal section of *Dictyoconus walnutensis.* Within the marginal zone, the generic key characters, radial plates of first, second, and third order are observed. Measurements are the same as for figures 2 and 3. Figure 5—Subaxial section of *Cuneolina* sp., that shows the pillars that extend from chamber to chamber, forming well-defined square to rectangular chamberlets, that together form a conspicuous latticed pattern. The size of the specimen was less than 1 mm long. Figure 6—Oblique section of *Cuneolina* sp.,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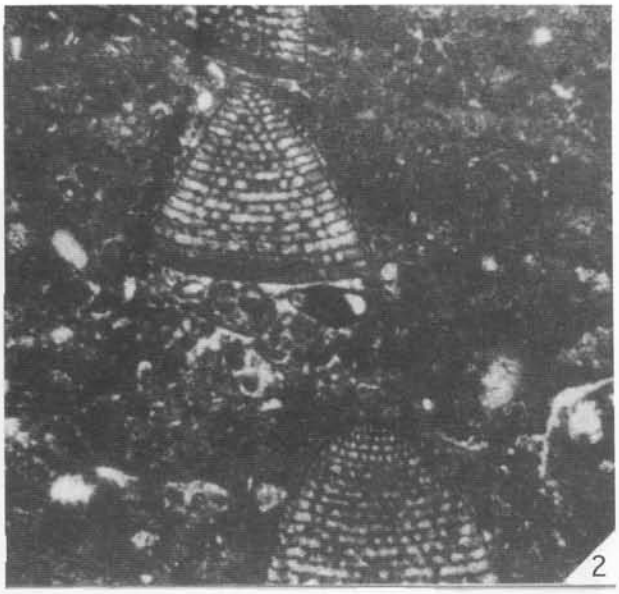
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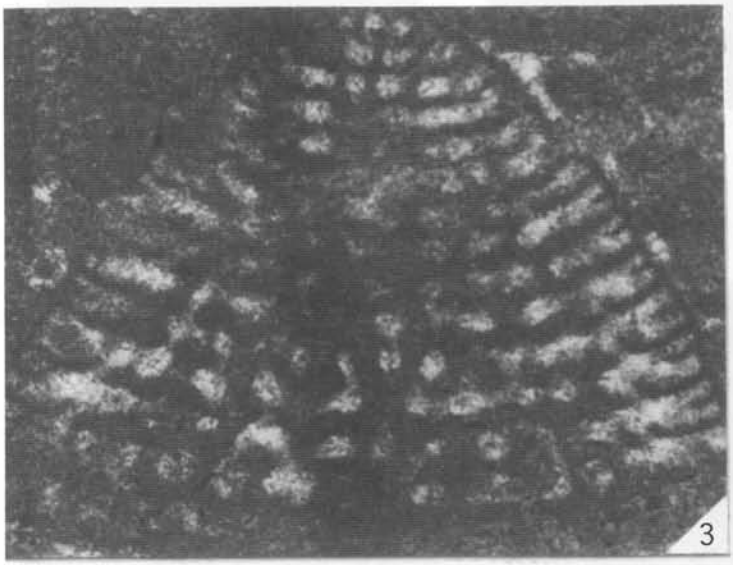
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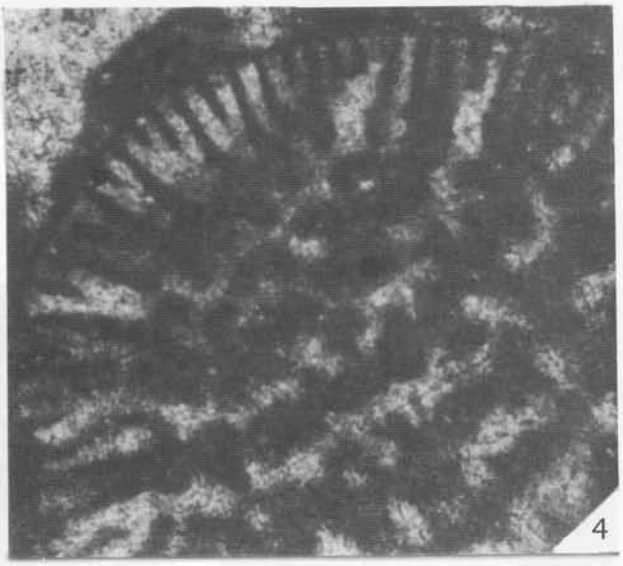
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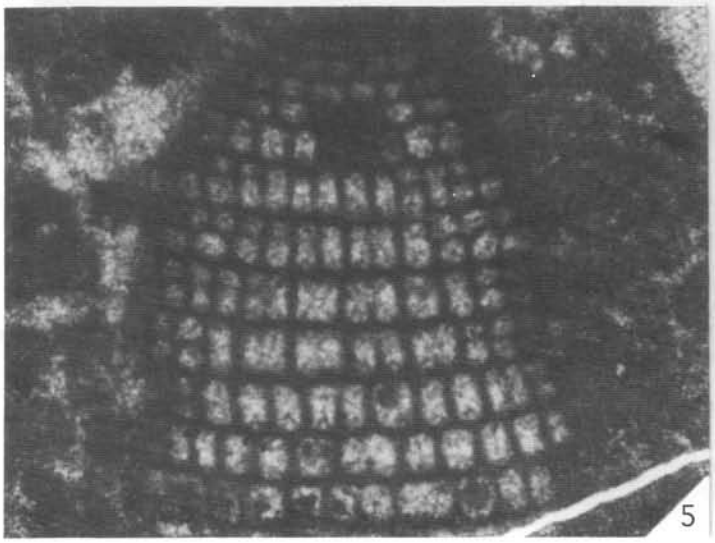
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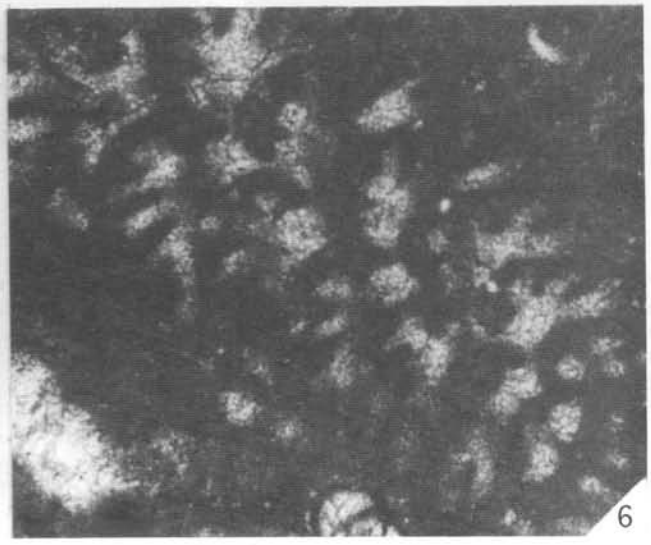
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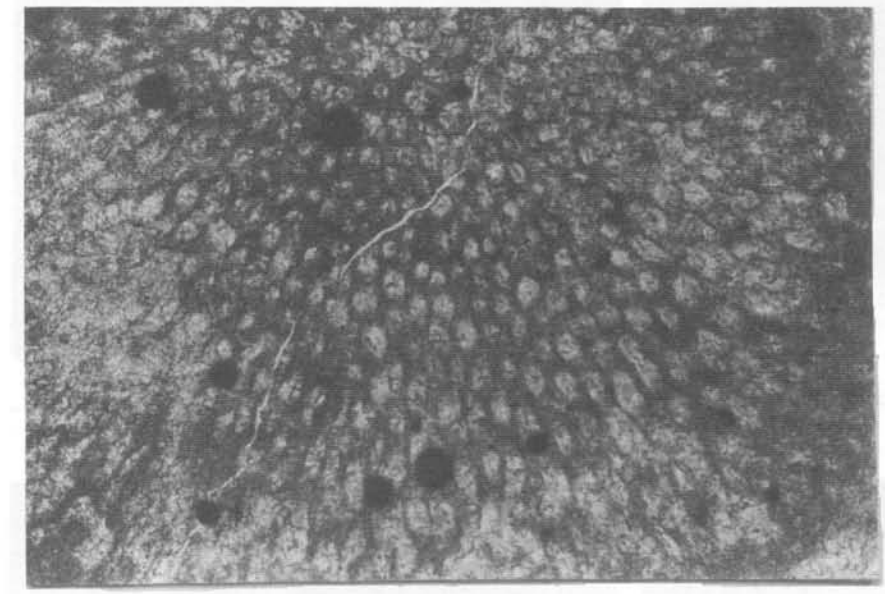

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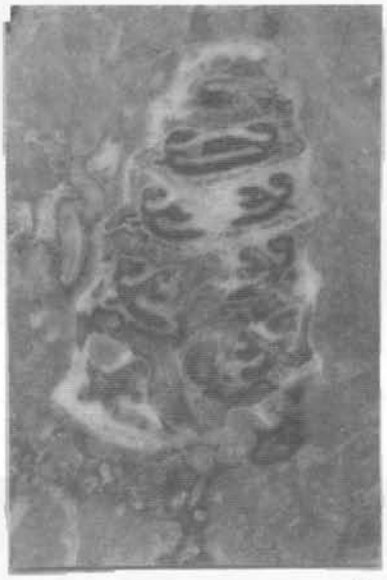

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Plate 3. Figure 1—Cross section of the thallus of *Cayeuxia kurdistanensis*, in which the tube-like branching is shown. The diameter of the tubes measured 45 microns and the total diameter of the thallus was 1,160 microns long. Figure 2—Axial section of the shell of *Neoptyxis pre-olisiponensis* (specimen IGM-7391 x 1.5), in which the folds and the lobes are shown. Figure 3—Axial section of the shell of *Diptyxis castilli* (specimen IGM-7392 x 1.5), in which the folds and the lobes are shown. Figure 4—Cross section of the left valve of *Coalcomana* sp., showing the pallial canals. Natural size. Figure 5—Cross section of *Caprinuloidea perfecta*, showing the pallial canals. Natural size.

Description—Ovoid small test, with a planispiral and involute coiling; the wide and low chambers are subdivided by transverse partitions giving way to small chamberlets; micritic wall. The specimen found in this locality corresponds to an equatorial section, with a spiral diameter measuring 480 micrometers.

Remarks—*Barkerina barkerensis* is a benthonic foraminifera that generally is not found in large numbers, however, it has been reported (Scott and González-León, 1991) from several localities in Texas, Greece, Sardinia and Mexico (in the states of Sonora and Coahuila).

The scarce specimens of *B. barkerensis* reported so far have always been associated to shallow water environments related to rudist banks and other benthonic foraminifera species.

In the Old World, *B. barkerensis* has generally been assigned to the Cretaceous, with no more precise assessment in its stratigraphical range; however, in America, this species is recognized sometimes as a good index for the middle Albian if it does coexist with *Coskinolinoides texanus* (Scott and González-León, 1991).

Family Orbitolinidae Martin
Genus *Dictyoconus* Blanckenhorn

***Dictyoconus walnutensis* (Carsey, 1926)**
(Plate 2, figures 2-4)

Orbitolina walnutensis Carsey, 1926, p. 23, pl. 7, figs. 11, a-b; pl. 8, fig. 3.
Dictyoconus walnutensis (Carsey), Bonet, 1956, p. 21, pl. 8, 9.

Description—Conical test that measured 1.5 mm of width and 1.15 mm of height; the base of the cone is slightly concave; the apex is sligthly rounded because the sections do not pass exactly through it; between 16 to 20 low chambers and in most of the chambers the horizontal plate that divides them can be observed.Transversal sections of the specimens showed the circular edge of the tests, and within the central zone, the pillars—so characteristic of the genus—were present; also, the marginal zone bears radial partition plates of first, second, and third order arranged in a pattern that is shaped like a letter "Y".

Remarks—*Dictyoconus walnutensis* is basically a tethysian form, frequently found in France and Switzerland; in America it is known from Florida, Texas, Mexico, Cuba, and Venezuela (Bonet, 1956).Particularly in Mexico, this species has been reported previously from the El Abra limestones, as well as from other Cretaceous formations, as in the case of the Espinazo del Diablo, in Sonora (Scott and González-León, 1991).

The presence of *Dictyoconus walnutensis* and *Cuneolina* sp. has been associated with muddy reefal facies or in the calcarenites formed nearby the rudistid banks.

Generally, in America *D. walnutensis* has been considered as a middle Albian species (Bonet, 1956); nevertheless, recent and more precise biostratigraphic studies complemented with radiometric datings, indicate that *D. walnutensis* may range throughout all the Albian (Bermúdez-Santana, 1994).

Family Ataxophragmiidae Schwager
Subfamily Ataxophragmiinae Schwager

***Cuneolina* sp. d'Orbigny, 1839**
(Plate 2, figures 5-6)

1839 *Cuneolina* d'Orbigny, p. 150.
1967 *Cuneolina* Neumann, pl. 53, figs. 3-5; pl. 54, figs. 1-4.
1988 *Cuneolina* Loeblich and Tappan, p. 148, pl. 155, figs. 1-3.

Remarks—This taxon was recognized only to a generic level because discrimination between its species is based on external morphological characters which were not observed in the thin sections prepared for this study. The specimens reported herein correspond to a conical form that is wider than higher, and with a micritic wall. Oblique sections clearly show a labyrinthic appearance described by their internal structures; axial sections are distinguished by the division of the chambers, which form small square and well defined chamberlets. The size of several specimens that were measured never exceeded 1 mm long.

The geographic distribution and the environment of deposition discussed mentioned for *D. walnutensis* can also be applied to *Cuneolina* sp.

Phylum Mollusca Linnaeus, 1758
Class Gastropoda Cuvier, 1797
Order Entomotaeniata Cossmann, 1896
Family Nerineidae Zittel, 1873

Genus *Neoptyxis* Pchelintsev, 1934

***Neoptyxis pre-olisiponensis* (Delpey, 1940)**
(Plate 3, figure 2)

1940 *Nerinea pre-olisiponensis* Delpey, p. 20-21, pl. 4, figs. 8-9.

Description—Shell of average size, impressed suture and with a slightly conical shape due to a gradual increase of the whorl. The axial section of the shell has four conspicuous folds, one in the parietal side, two are columellar and the fourth is labial.

The primary columellar fold is wide, deep and straight; the secondary, columellar, is small with a triangular shape and this fold separates two large, straight lobes, bended toward the base.

The shell measures 57.5 mm in height and the body whorl is 34.0 mm wide, only seven whorls were preserved.

The studied material has been deposited in the Museum of Paleontology of the Institute of Geology, Universidad Nacional Autónoma de México, Ciudad Universitaria, Delegación Coyoacán, 04510 D.F., with the catalogue number IGM-7391.

Remarks—*Neoptyxis pre-olisiponensis* is an Albian species that was described originally from the western region of Madagascar (Delpey, 1948). Therefore, the information reported here expands the distribution of this taxon, because its presence is recorded for the first time in the New World.

There are three Cretaceous species closely related, the first is *Ptygmatis galatea,* from the Aptian of Spain (Coquand, 1865, p. 65, pl. 5, fig. 3), Lebanon (Delpey, 1940, p. 184, pl. 3, figs. 9, 10, p. 205, fig. 158) and Mexico (Alencáster, 1956, pl. 6, figs. 3, 4). The second is *Nerinea pre-olisiponensis* (Delpey, 1940, p. 20-21, pl. 4, figs. 8, 9) from the Albian of Madagascar, and the third one is *Neoptyxis pre-olisiponensis* (Carbone, Praturlon and Sirna, 1971, p. 153, fig. 24; Accordi, Carbone and Sirna, 1982, p. 776, fig. 12, a) of the Cenomanian from Istria, Lebanon, Syria and Italy, as well as from the Cenomanian-Turonian from Portugal and Egypt. However, the differences among these species do not seem to be as striking as it has been thought, particularly when the three are analyzed in sequence or forming a series from the oldest (*Ptygmatis galatea)* to the youngest (*Neoptyxis olisiponensis*). Regarding the close relationship that exists between these taxa, Delpey (1940) discussed the similarities among them, based on the same number and design of the axial section of the shell folds. Nevertheless, it must be noticed that *P. galatea* and *N. pre-olisiponensis* show an excavated whorl profile, whereas in *N. olisiponensis* this structure tends to be almost plane or slightly concave. Also, when the three species were compared in detail, it was observed that in *N. pre-olisiponensis* (the intermediate form), the design of the folds is coarser than in *N. pre-olisiponensis* (the younger form), as it is shown in Plate 3, figure 1 (notice that only this feature can be appreciated in the portion of the body whorl). Therefore from this study it is evident that according to Delpey (1940, p. 21) these taxa must be kept as separate entities.

Genus *Diptyxis* Oppenheim, 1889

***Diptyxis castilli* (Bárcena)**
(Plate 3, figure 3)

Nerinea castilli Bárcena, 1875, p. 379, figs. 7, 8, 9, 10.

Description—Turrited shaped shell, with seven wide and low whorls that slightly increase their size. The whorl profile is gently rounded and bears an impressed suture. In a longitudinal section of the shell, the whorl shows two folds, one is columellar, short, with a broad base and an acute ending, and the other is parietal although it shares with the columellar fold a broad base and acute ending is curved towards the external lip.

The shell measures 30 mm in height and the body whorl is 20 mm wide, only seven whorls were preserved.

The specimen has been deposited in the Museum of Paleontology of the Institute of Geology, Universidad Nacional Autónoma de México, with the catalogue number IGM-7392.

Remarks—The description of the especies herein reported was based on a single specimen embedded in the rock matrix; yet, with this limitation, it was possible to determine the species. The structures observed correspond mainly to the internal folding patterns of the shell.

Bárcena (1875, p. 379, figs. 7, 8, 9, 10) portraits *Nerinea castilli* as a gastropod of variable size, that is common in Cretaceous rocks of the El Doctor Formation, widely distributed in the states of Querétaro and San Luis Potosí.

Discussion—The faunal association, collected in the backlimb of the Puente de Dios thrust sheet near Ahuacatlán, corresponds to the edge of Valles-San Luis Potosí carbonate platform. This belt facies has also been observed by Suter (1987) in the San Francisco region to the southeast.

To fully understand the tectonic evolution and the sedimentary history of this important province of east central Mexico, and even to compare the Ahuacatlán area and other similar regions of this portion of the Sierra Madre Oriental, it is necessary to establish a basic biostratigraphic and paleoecological framework for comparison and correlation. As a preliminary study on this Albian assemblage from Ahuacatlán, the first step has been set up, regarding the micro and macro fossils present in these sediments. With this information, in future studies the synchronic or diachronic nature of the outcrops can be determined, as well as the paleoecological conditions in which they were formed, reaching the finest possible detail all the different facies or sedimentary environments present in the Sierra Madre Oriental region (*e. g.,* rudistid reefs, lagoons, open sea, etc.).

The study of the Ahuacatlán area shows clearly, as in other Albian areas in east central México, *e. g.,* the San Francisco-El Fraile area (Suter, 1987) and the Actopan bank (Carrasco-Velázquez, 1971), that the depositional environment corresponds to that of a tropical calcareous platform, with a shallow water community, and suitable conditions for the development of extensive rudistid banks (*e. g.,* well oxigenated and with high productivity patterns).

Also, with the exception of the associated microflora that has a comparative wide stratigraphic range and one species of gastropod that ranges as high as the Cenomanian, with no question, the age of the rest of the fauna corresponds to the Albian. A close examination of the microfauna (*e. g., Dictyoconus walnutensis, Barkerina barkerensis* and *Cuneolina* sp.) places the Ahuacatlán assemblage more precisely within the middle part of the Albian.

The consistency of the bioestratigraphic and paleoecologic information obtained in this study, in combination with past and present works related to the rudists, indicate that it is possible to establish a reference framework for correlation (including age and depositional environment) among several important areas of this major tectonic province of east central Mexico.

The structural relationship between the Ahuacatlán sediments and what has been reported from the San Francisco area in the State of Hidalgo has been reinforced by the results of this work and all future geologic work in this area will have to be performed with a strong paleontologic and sedimentologic support.

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BIBLIOGRAPHICAL REFERENCES

Accordi, Giovanni; Carbone, Federico; and Giuseppe, Sirna, 1982, Relationships among tectonic setting, substratum and benthonic communities in the Upper Cretaceous of northeastern Matese (Molise, Italy): Geologica Romana Estratto, v. 21, p. 755-793, 5 pls.

Aguayo-Camargo, J.E., 1993, The middle Cretaceous El Abra limestone at its type locality and Laguna Colorada, east-central Mexico: Universidad Nacional Autónoma de México, Instituto de Geología, Third International Conference on Rudists, México D.F., Guidebook for field trip "A", 43 p.

Aguilera-Franco, Noemí, 1995, Litofacies, paleoecología y dinámica sedimentaria del Cenomaniano-Turoniano del área de Zotoltitlán-La Esperanza en el Estado de Guerrero: México, D.F., Universidad Nacional Autónoma de México, Facultad de Ingeniería, M. Sci. thesis, 137 p. (unpublished).

Alencáster, Gloria, 1956, Pelecípodos y gasterópodos del Cretácico Inferior de la región de San Juan Raya-Zapotitlán, Estado de Puebla: Universidad Nacional Autómoma de México, Instituto de Geología, Paleontología Mexicana 2, 47 p., 7 pls.

———1987, Moluscos bentónicos de la mitad meridional de México durante el Cretácico: Revista de la Sociedad Mexicana de Paleontología, v. 1, núm. 1, p. 1-23.

Bárcena, Mariano, 1875, Datos para el estudio de las rocas mesozoicas de México y sus fósiles característicos: Boletín de la Sociedad de Estadística de la República Mexicana, 3a. época, v. 2, p. 368-385.

Basáñez-Loyola, M.A.; Fernández-Turner, R.; and Rosales-Domínguez, M.C., 1993, Cretaceous platform of Valles-San Luis Potosí, northeastern central Mexico, *in* Simo, J.A.T.; Scott, R.W.; and Masse, J.P., eds., Cretaceous Carbonate Platforms: American Association of Petroleum Geologists, Memoir 56, p. 51-59.

Basson, P.W., and Edgell, H.S., 1971, Calcareous algae from the Jurassic and Cretaceous of Lebanon: Micropaleontology, v. 17, p. 411-433, pl. 1-7.

Bassoullet, J.P.; Bernier, Paul; Deloffre, Raoul; Genot, P.; Jaffrezo, Michel; and Vachard, Daniel, 1979, Essai de classification des Dasycladales en tribus: Bulletin des Centres de Recherches, Exploration, Production, Elf-Aquitaine, v. 2, no. 2, p. 429-442.

Bermúdez-Santana, J.C., 1994, Estratigrafía de una secuencia volcanosedimentaria del Cretácico de la región de Tepalcatepec-Coalcomán, Michoacán—integrando métodos bioestratigráficos y radiométricos: Mexico, D.F., Instituto Politécnico Nacional, Escuela Superior de Ingeniería y Arquitectura, M. Sci. thesis, 103 p., 12 pl. (unpublished).

Berthou, P.Y., 1974, Repartition stratigraphique actualisée des principaux foraminifères du Cretacé moyen et Supérieur du Bassin occidental Portugais, *in* Oertli, H.J., ed., Benthos 83: Symposium International sur les Foraminifera, Mémoire, p. 45-54.

Bonet, M.F., 1956, Zonificación microfaunística de las calizas cretácicas del este de México: Congreso Geológico Internacional, 20, Mexico, D.F., 102 p., 31 pls.

Bouroullec, Jacqueline, and Deloffre, Raoul, 1970, Les algues du Jurassique Aquitain: Bulletin des Centres de Recherches, Exploration, Production, Elf-Aquitaine, v. 4, núm. 1, p. 79-127, 11 pls.

Carbone, Federico; Praturlon, Antonio; and Sirna, Giuseppe, 1971, The Cenomanian shelf-edge facies of Rocca di Cave (Prenestini Mts., Latium): Geologica Romana Estratto, v. 10, p. 131-198, 53 figs., 1 table.

Carozzi, Albert, 1947, La microflore du Purbeckien du Jura Suisse: Genève, C. R. Soc. Phys. et Hist. Natur., v. 64, p. 13-15.

Carrasco-Velázquez, Baldomero, 1971, Litofacies de la Formación El Abra en la Plataforma de Actopan, Hgo.: Revista del Instituto Mexicano del Petróleo, v. 3, no. 1, p. 5-26.

Carrillo-Bravo, José, 1971, La plataforma Valles-San Luis Potosí: Asociación Mexicana de Geólogos Petroleros, Boletín, v. 23, p. 1-113.

Carrillo-Martínez, Miguel, 1989, Estratigrafía y tectónica de la parte centroorientaldel Estado de Querétaro: Universidad Nacional Autónoma de México, Instituto de Geología, Revista, v. 8, no. 2, p. 188-193.

———1993, Regional geological setting of an early Albian fauna in Ahuacatlán, State of Querétaro: Universidad Nacional Autónoma de México, Instituto de Geología, Third International Conference on Rudists, Mexico, D.F., Proceedings, p. 14 (abstract).

Carrillo-Martínez, Miguel, and Suter, Max, 1982, Tectónica de los alrededores de Zimapán, Hidalgo y Querétaro: Sociedad Geológica Mexicana, Convención Geológica Nacional, 6, Excursión geológica al área de Zimapán, Field guide book, 120 p.

Carsey, D.O., 1926, Foraminifera of the Cretaceous of central Texas: Texas, University of Texas Bulletin, no. 2612, 56 p., 8 pls.

Coquand, Honore, 1865, Monoghraphie paléontologique de l'étage Aptien de l'Espagne: Marseille, France, Tipographie et Litographie Arnaud et Cie., 221 p., 28 pls.

Cossmann, Maurice, 1896, Essais de Paléoconchologie comparée: Paris, Presses Universitaires de France, no. 2, 179 p., 8 pls.

Cuvier, Georges, 1797, Tableau élémentaire de l'histoire naturelle des animaux: Paris, Baudouin, 710 p.

Delpey, Genevieve, 1940, Les gastéropodes mésozoïques de la région libanaise: Haut. Comm. Syrie et Liban, Notes et Mémoires, v. 3, p. 5-324, pl. 1-11.

———1948, Gastéropodes mésozoïques de l'ouest de Madagascar: Madagascar Annales Géologiques de Service des Mines, no. 15, p. 1-35, 7 pls.

Dragastan, Ovidíu, 1969, Algues calcaires du Jurassique Supérieur et du Crétacé Inférieur de Roumanie: Paris, France, Revue de Micropalaeontologie, v. 12, no. 1, p. 53-62, 3 pls.

Elliott, G.F., 1956, Fossil calcareous algae from the Middle East: Micropaleontology, v. 1, p. 125-131, 1 pl.

Frizzell, D.L., and Schwartz, Ely, 1950, A new lituolid foraminiferal genus from the Cretaceous, with an emendation of *Cribrostomoides* Cushman: University of Missouri, School of Mines and Metallurgy Bulletin, Technical Series, v. 76, 12 p.

Frollo, M.M., 1938, Sur un nouveau genre de codiacée du Jurassique Supérieur des Carpates Orientales: Société Géologique Française, Bulletin, series 5, v. 8, p. 269-272, 1 pl.

Johnson, J.H., 1968, Lower Cretaceous Algae from Texas—Pt. 2, Pre-buda lower Cretaceous algae from Texas: Colorado School of Mines Professional Contr. pt. 2, no. 4, p. 29-71, 12 pls.

Linnaeus, Carl von, 1758, Systema naturae per regna tria naturae: Regnum animale, Holmiae, Editio decima reformata, 824 p.

Loeblich, A.R., and Tappan, Helen, 1988, Foraminiferal genera and their classification: Van Nostrand Reinhold 2, 970 p, 847 pl.

Neumann, Madeleine, 1967, Manual de Micropaléontologie des foraminifères (Systématique, Stratigraphie): Paris, Gauthier-Villars, v. 1, 297 p.

Oppenheim, Paul, 1889, Beiträge zur Geologie der Insel Capri und der Halbinsel Sorrent: Zeitschrift der Deutschen Geologischen, Gesellschaft, Bd. 41, p. 442-490.

Orbigny, Alcide d', 1839, Foraminifères in Sabra, Ramón de la—Histoire physique, politique et naturelle de l'île de Cuba: Paris, France, Arthus Bertrand, ed., Atlas de Zoología, 230 p.

Ornelas-Sánchez, María; Aguilera-Franco, Noemí; Franco, Sonia; Granados, Mónica; and Bello-Montoya, Ricardo, 1991, Determinación de los límites Oxfordiano-Kimmeridgiano-Titoniano en pozos de la zona marina de Campeche, plataforma continental de México: Instituto Mexicano del Petróleo, Subdirección de Exploración, Internal report, 183 p. (unpublished).

Pchelintsev, V.F., 1934, Some data on the Mesozoic faune of the western Georgia: Transactions Geol. Prosp. Service U.S.S.R., v. 252, p. 3-67 (in Russian with English summary).

Pia, Julius von, 1920, Die Siphoneae verticillatae von Karbon bis zur Kreide: Abhandlungen Zool-Bot. Gesellschaft Wien, v. 11, 263 p., 8 pl.

Ponce de León-Obregón, Álvaro; Viñas, Fidelia; and Rodríguez, J.L., 1987, Estudio bioestratigráfico del Jurásico en pozos profundos de la zona sureste: Instituto Mexicano del Petróleo, Subdirección de Tecnología de Exploración, Internal report, 150 p., 55 pls. (unpublished).

Ponce de Léon-Obregón, Álvaro, and Viñas, Fidelia, 1988, Estudio bioestratigráfico de las rocas del Jurásico en el prospecto Uech-Pek de la zona marina de Campeche: Instituto Mexicano del Petróleo, Subdirección de Tecnología de Exploración, Internal report, 166 p., 46 pls. (unpublished).

Praturlon, Antonio, 1965, A new *Linoporella* (Dasycladaceae) from middle Cretaceous of Marsica (central Appennines): Geologica Romana Estratto, v. 3, p. 171-202, 34 figs.

——— 1966, Algal assemblages from Lias to Paleocene in southern Latium-Abruzzi, a review: Società Geologica Italiana, Bollettino, pt. 1, v. 85, p. 167-194, 16 figs.

Scott, R.W., and González-León, Carlos, 1991, Paleontology and biostratigraphy of Cretaceous rocks, Lampazos area, Sonora, Mexico: Geological Society of America, Special Paper 254, p. 51-68.

Segerstrom, Kenneth, 1961, Geology of the Bernal-Jalpan area, State of Querétaro, Mexico: U.S. Geological Survey, Bulletin 1104-B, p. 19-85.

——— 1962, Geology of south-central Hidalgo and northeastern Mexico: U.S. Geological Survey, Bulletin 1104-C, p. 87-162.

Steinmann, Gustav, 1899, Über fossile Dasycladaceen vom Cerro Escamela, Mexico, *in* Felix, Johannes, and Lenk, Hans, eds., Beiträge zur Geologie und Paläontologie der Republik Mexico: Leipzig, Berlin, Bot. Zeitung, Bd. 2, p. 137-154.

Suter, Max, 1987, Structural traverse across the Sierra Madre Oriental fold-thrust belt in east-central Mexico: Geological Society of America Bulletin, v. 98, p. 249-264.

Tardy, Marc, 1975, La nappe de Parras; un trait essentiel de la structure Laramienne du secteur transverse de la Sierra Madre Orientale, Mexique: Société Géologique de France Bulletin, series 7, v. 17, p. 77-87.

Wilson, J.L., 1975, Carbonate facies in geologic history: Berlin, Springer-Verlag, 471 p.

Zittel, K.A. von, 1873, Die Gastropoden der Stranberger Schichten, *in* Beiträge zur Naturgeschichte der Vorwelt: Palaeontographica, Abh., Bd. 2, p. 193-373.

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