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LATE JURASSIC-CRETACEOUS MOLLUSCAN PALEOGEOGRAPHY OF THE SOUTHERN HALF OF MEXICO

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ABSTRACT

The paleogeography of the southern half of Mexico, reconstructed on the basis of the distribution of molluscan faunas, indicates that near the beginning of the Late Jurassic a gradual and progressive marine transgression advanced from the east toward the west covering high-relief topography. Islands, platforms, and basins were inhabited by pelagic and benthic, neritic and littoral molluscs. The deeper facies with ammonites were abundant from Late Jurassic to Early Cretaceous. Since the Late Jurassic, the Mexican Sea was connected with oceans to the east and west. Molluscs genera and even species have affinities with the Mediterranean Province of the Tethys Realm, and also with the northern and southern part of the Circumpacific Geosyncline. During Neocomian and Aptian times, the benthic communities of nearshore facies are very widespread. During Albian and Cenomanian times, the sea reached its maximum extent. Shallow platforms were very extensive where reefs, banks and patches of diverse communities of rudists and other molluscs proliferated. During the Turonian the slow regression of the sea toward the east began. The biocenosis of hippuritids and inoceramids thrived in a shallow sea. In Maastrichtian time, only a shallow platform extended around the southern Mexican Gulf Coast, with a rich endemic fauna in Chiapas and the Caribbean region.

Subsurface studies of the Yucatan Peninsula show that it was a low-relief platform covered by a shallow sea since at least the Albian to the end of the Tertiary, when it was again above sea level. Cretaceous limestone lenses with rudists are intercalated with evaporites.

RÉSUMÉ

La paléogeographie de la moitié sud du Méxique, établie sur la distribution des localités marines portant des mollusques, révele que, aux cours du commencement du Jurassique Supérieur, une mer transgressive a venu a envahir le continent, de maniere graduelle et progressive des l'est jusqu'a l'ouest. Dans le bassin, les iles et les plateformes resultantes ont veçu mollusques péllagiques et benthoniques. Le facies de profondeur modérée avec ammonites a dominé pendant le Jurassique Supérieur jusqu'a le Cretacique Inférieur. La communication entre la mer mexicaine et les mers de l'ouest et de l'est depuis le Jurassique Supérieur, est indéniable, a cause des affinités que presentent les mollusques, en genres et méme en especes, tant entre la Province Mediterraniénne du Tethys, comme des parties Nord et Sud du Géosynclinal Circumpacifique. Au Néocomien et Aptien, on remarque par leur abondance des faunes littorales près des cotes. A l'Albien et au Cénomanien, la mer atteignait son amplitude maxime. Les plateformes étaient tres étendues et permettait le développement des récifs et des bancs du rudistes et d'autres mollusques. Au Turonien la mer commence a se retirer lentement vers l'est. Les biocenosis des hippuritides et des inocéramides fleurirent dans eaux peu profondes. Au Maastrichtien la mer se limite a une frange bordant la Cote du Golfe, tres large au Chiapas, ou se développe une faune endémique de rudistes que s'étend jusqu'au les Caraibbes.

Les études du sous-sol de la Presqu'ile de Yucatán, indiquent qui une plateforme s'est formée depuis l'Albien, quand sont deposées couches marines avec rudistes intercalés d'evaporites. Cette terre a emergait a nouveau a la fin du Tertiare.

INTRODUCTION

The purpose of this paper is to present the Late Jurassic to Cretaceous paleogeography of southern Mexico, reconstructed on the basis of the distribution of molluscan faunas. The time interval selected corresponds to the principal period of marine sedimentation in Mexico, starting with the progressive flooding of the country and ending with the gradual withdrawal of the seas.



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Molluscs are the most abundant marine megafossils in the Mesozoic rocks in Mexico. Among these, the ammonites are the most numerous and reasonably well preserved both in the Jurassic and the Cretaceous rocks. The rudistids are numerous and well distributed only in the Cretaceous. In addition, other pelecypods and the gasteropods are widespread and offer valuable information concerning paleoenvironmental conditions. It is worthy to note, however, that in many localities the molluscs are indeed poorly preserved, scarce or fragmented. These are generally associated with other fossils of known age, such as tintinnids, nannoconids, radiolarids, echinoids and foraminifers. Localities with this kind of fossil material were also studied in order to be able to complete the record, specially among the Gulf Coast of Mexico where information has been obtained by drilling for oil.

Although, in the past, excellent paleogeographic reconstructions for the Mesozoic of Mexico have been presented by Burckhardt (1930), Imlay (1943, 1944, 1953, 1980) and Erben (1956b, 1957a) the new geological information gathered through drilling in east and south Mexico by Petroleos Mexicanos (PEMEX), in my opinion, deserves certain reconsiderations of southern Mexico. Consequently, I have concentrated my research on this part of the country during the past few years.

The localities shown on the maps in this paper are not all that have been cited in the geological literature, but are the most important ones from paleontological, stratigraphical and paleoenvironmental stand points. The numerous citations of the papers of Burckhardt and Imlay show clearly that these contain the most information to the subject of this paper.

When two or more stages are shown together on a map, it is because these occur together at most of the localities and thus their separate presentation would lengthen the paper but would not change the interpretation substantially.

DATA BANK OF FOSSIL LOCALITIES

The complete set of locality references for Figures 1 to 7 is available from the Departamento de Paleontologia, Instituto de Geologia, Universidad Nacional de México, Ciudad Universitaria, 04510 México, D.F. México.

PRE-OXFORDIAN

During the Early and Middle Jurassic most of Mexico was a landmass and in its southern half there were only two regions that received marine sediments. One of these was the central part of the present Gulf Coastal Plain where Lower Jurassic marine deposition occured (the Huayacocotla Embayment) (Burckhardt, 1930, p. 12-20; Erben, 1956a) and the other (the Guerrero-Oaxaca Embayment) was in south-central Mexico where the marine Middle Jurassic interfingers with continental coal and plant bearing strata (Burckhardt, 1927) (Fig. 1). It is worthy to note that in the Huayacocotla Embayment, Lower Jurassic marine beds are overlain unconformably by Middle Jurassic plant-bearing continental deposits which are in turn covered by marine Callovian sediments, whereas in the Oaxaca-Guerrero Embayment the Middle Jurassic marine deposition continued without interruption into the Late Jurassic. These embayments, although apparently separated in time and space, could have been isolated either from each other or

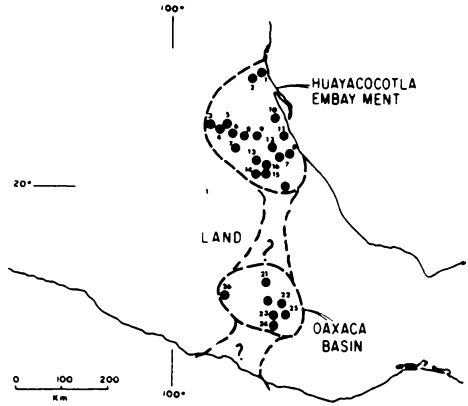


Figure 1. Pre-Oxfordian molluscan localities and paleogeography of Mexico.

connected. However, they probably had connections with the Pacific for there are sufficient arguments against the existence of the Gulf of Mexico at that time (Imlay, 1980; Viniegra, 1971, 1981).

Along the Gulf Coastal Plain, ammonites and oysters are abundant, with the more typical Callovian forms *Reineckeia*, *Neuqueniceras neogaeum* (Burckhardt) and *Liogryphaea nebrascensis* (Meek and Hayden) (Cantu Chapa, 1969; Westermann in Taylor *et al.*, this volume). This last species is present in the west of the United States of America and is similar to species of Argentina, while *Neuqueniceras* only exists in South and Middle America (Cantu Chapa, 1971, p. 19; Westermann *et al.*, this volume).

In northwestern Oaxaca (Fig. 1, locs. 21-24) Westermann (1983) has distinguished two ammonite faunas, named the *Parastrenoceras* and the *Zigzagiceras* assemblages, of late-Bajocian and supposed early Bathonian ages respectively which are more closely affiliated to the West-Tethyan than to the circum-Pacific fauna and are good evidence for a "Central Atlantic" marine sporadic connection between the Pacific and Tethys. The alleged *Zigzagiceras* subgenus *Duashnoceras* Westermann, however, has presently been recognized as a Late Bajocian stephanoceratid, so that Bathonian remains unknown (Westermann in Taylor *et al.*, this volume). In contrast, in the near-by Cualac area (Fig. 1, loc. 26) of northeastern Guerrero, the late Bathonian-early Callovian *Neuqueniceras* assemblage, shows a closer conspecific affinity with the Andean ammonite fauna of Argentina and Chile than with the Tethyan ammonites (Westermann *et al.*, this volume).

OXFORDIAN

The distribution of marine Oxfordian outcrops in southern Mexico (Fig. 2) shows the location and extent of the epicontinental seas at that time. There is as yet no faunal evidence to suppose that these marine areas were connected.

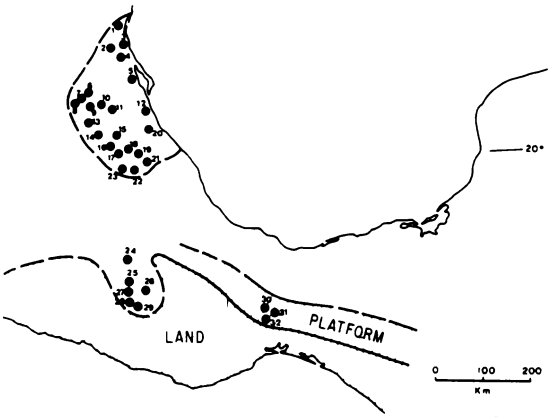


Figure 2. Oxfordian molluscan localities and paleogeography of Mexico.

In the lower and middle Oxfordian rocks, as in the upper Callovian, the fossils are absent or very scarce. *Fehlmannites* from northeastern Puebla (Cantu Chapa, 1971, p. 23) and *Creniceras renggeri* (Oppel) from Huayacocotla, Veracruz. (Erben, 1957a, p. 47) are the only two records of an early Oxfordian fauna. Imlay (1980, p. 50) and Viniegra (1971) assume that the major evaporitic sequences in the Gulf region were deposited during this time. This would explain the scarcity of life in a hypersaline environment. In contrast with the lower and middle Oxfordian, the upper Oxfordian rocks contain a very abundant fauna. *Discosphinctes, Dichotomosphinctes, Campylites* and *Euaspidoceras* are some of the common genera in these strata, which are found in the subsurface of the Tampico Embayment (Fig. 2, locs. 1-5), the Poza Rica area (Fig. 2, locs. 12-20) and in the subsurface and surface of the Huasteca region (Fig. 2, locs. 6-14) and the adjacent area of northern Puebla (Fig. 2, locs. 15-23) (Cantu Chapa, 1969, 1971, 1979).

The middle and late Oxfordian ammonite faunas of Cuba (Wierzbovski, 1976) are closely related to the Oxfordian faunas of Mexico. Some taxa which were considered as endemic of Cuba are now known from Mexico and from South America (*Cubaochetoceras mexicanum* (Burckhardt), *Discoscaphites caribeanus* (Jaworski), *Vinalesphinctes*, etc.). After Wierzbovski (1976, p. 163) the whole area of Middle and South America should be treated as biogeographically uniform.

In California and Oregon, as in the southern United States, the late Oxfordian is represented by species of *Dichotomosphinctes* and *Discosphinctes* that are similar to species in Mexico and Cuba (Imlay, 1980, p. 30). The same genera are present also in the contemporaneous strata of the Mediterranean region (Cantu Chapa, 1979, p. 19).

In southern Puebla and northern Oaxaca (Fig. 2, locs. 24-29) Oxfordian faunas which include bivalves, gastropods, brachiopods and spines of cidarid echinoids (Alencaster and Buitron, 1965) are closely related to species of the West Tethys.

The upper Oxfordian rocks of the Huasteca region and adjacent areas pertain to a marine sequence with middle Callovian beds at the base and upper Tithonian rocks at the top. The sequence was deposited during gradual and successive advances of the sea from the Gulf region toward the west. The land that was progressively being covered had rather abrupt relief in places, and was formed by granitic, metamorphic and sedimentary rocks of different composition and ages. Thus the Callovian strata have an unconformable relation with the underlying units and their basal terrigenous interval is of different ages from place to place due to the geometry of the transgression. The chronostratigraphic package that was deposited during this transgression forms the Huasteca Series (Cantu Chapa, 1969, 1971).

In the Huayacocotla area, the upper Oxfordian deposits are transgressive over the continental Liassic rocks; here, over a basal conglomerate and red shales, is a black compact limestone with *Nerinea* and above this is a thin bed with brackish water molluscs and coal denoting the proximity of a landmass (Burckhardt, 1930, p. 91).

The Oxfordian beds of southern Puebla and Oaxaca as well as of the Isthmus of Tehuantepec (Fig. 2, locs. 30-32) probably were deposited in a sea that transgressed northward or northeastward from the Pacific Ocean (Imlay, 1980, p. 51).

KIMMERIDGIAN

The area that became covered by marine Kimmeridgian sediments is considerably greater than that covered by marine Oxfordian sediments. The sea extended farther to the west, south and southeast (Fig. 3). In the northeastern part of the map the most widespread lithology is that of the Taman Formation (Heim, 1926) which consists of well bedded black, fine-grained limestone that alternates with black shale. Ammonites are abundant in this formation. Cantu Chapa (1969, p. 7; 1971, p. 25-28) recognized three lower Kimmeridgian biozones in this unit, which from the base upward includes: 1) the *Ataxioceras* Zone characterized by various species of this genus, as well as *Taramelliceras, Rasenia, Parataxioceras* and other genera, 2) the *Idoceras* Zone, widely recognized in east-central Mexico, contains many species of this genus, and rare species of *Aspidoceras;* and 3) the *Glochiceras* gr. *fialar* (Oppel) Zone, is very widespread throughout Mexico, and is associated mainly with the genera *Ochetoceras, Taramelliceras* (*Metahaploceras*), *Aspidoceras* and *Subdichotomoceras.*

The species of the *Ataxioceras* Zone are closely related to species of lower Kimmeridgian strata of western Europe, mainly from the south of Germany (Cantu Chapa, 1971, p. 37). As to *Idoceras*, Mexico is considered the dispersal centre of the genus, due to the great abundance and diversity that are present in the country. Outside Mexico it is found in Lower Kimmeridgian rocks of the southeastern United States, together with *Ataxioceras, Metahaploceras* and *Glochiceras* (Imlay, 1980, p. 31). It is also common in California, Argentina, Chile and Bolivia (Cantu Chapa, 1979, p. 20) as well as in the early Kimmeridgian of Italy and Germany (Cantu Chapa, 1971, p. 39).

In the Gulf Coastal Plain between the Tampico region and the areas of Tuxpan and Poza Rica (Fig. 3, locs. 1-16, 28-30) subsurface studies revealed the presence of a variety of facies of

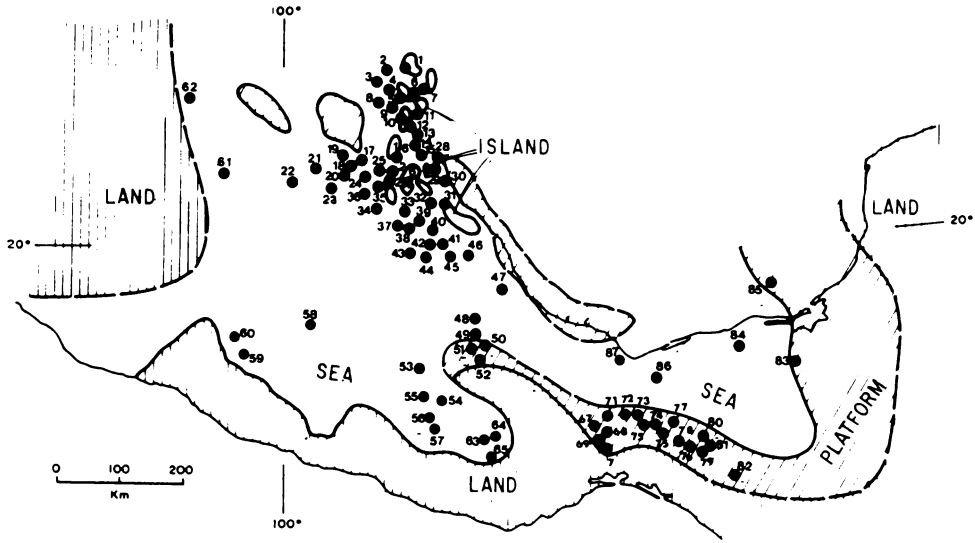


Figure 3. Kimmeridgian-Tithonian molluscan localities and paleogeography of Mexico.

the Kimmeridgian Stage included in several formations. Microfacies studies coupled with electric log correlations contributed a great deal of information about the shape and size of the islands that formed the Tampico-Tuxpan archipelago during this age. Several greater islands were located near Tampico (Stabler, 1972; Sánchez-Rosas, 1972) (Fig. 3). These studies show that some of the higher land areas were not covered yet by the sea during this time, which influenced the development of 11 facies in this region (Aguilera, 1972).

The localities in eastern Oaxaca and Chiapas (Fig. 3 locs. 66-82) contain a fauna of bivalves and gastropods, whose species show a clear relation with forms of the West Tethys (Alencaster, 1977, 1978).

TITHONIAN

During the Tithonian the sea extended farther to the west and to the south. Localities shown in the west and southwest of the map (Fig. 3, locs. 21-23, 58-62) consist of Tithonian deposits only.

The ammonites of south Zacatecas (Fig. 3, loc. 62) are scarce and badly preserved; nevertheless, early Tithonian beds are present with *Virgatosphinctes mexicanus* Burckhardt, *Suplanites* and *Pseudolissoceras* (Imlay, 1980, p. 31). In central Guanajuato (Fig. 3, loc. 61) *Himalayites* (*Micracanthoceras*) is present (López-Ramos, 1979a, p. 428; 1979b, p. 352).

In the southwest the Tithonian deposits consist of marine shales, sandstones and conglomerates (Fig. 3, locs. 59, 60) of metasediments and metavolcanics (Fig. 3, loc. 58), with poorly preserved *Gervillia* and probably *Gryphaea mexicana* Felix (Fig. 3, loc. 60), and very poorly preserved himalayitids *Micracanthoceras*, *Wichmanniceras* and other forms similar to *Durangites* and *Corongoceras* (Campa *et al.*, 1974).

At the localities in the east (Fig. 3, locs. 21-23), the sequence of Tithonian-Neocomian age includes *Parodontoceras* and *Protancyloceras*, and consists of calcareous shales, greywackes and thin beds of chert, and represents a deep water facies.

In the Huasteca region, Cantu Chapa (1969, 1971) selected several species as zone markers. At the base of the Tithonian, he defined the *Virgatosphinctes mexicanus* (Burckhardt) Zone with *Aulacomyella neogaea* Burckhardt (Cantu Chapa, 1971, p. 27). Other species of *Aulacomyella* occur elsewhere in Mexico in beds with *Idoceras* and also in beds with *Glochiceras* gr. *fialar* (Oppel), but the genus ranges higher into beds containing the lowest occurrence of *Virgatosphinctes* (Imlay, 1980, p. 31). The zone of *V. mexicanus* which contains the early Tithonian *Taramelliceras* and *Subdichotomiceras*, is correlated with the upper part of the Taman Formation (Heim, 1926, 1940).

The *Kossmatia victoris* and *Pseudolissoceras zitteli* Zone, of middle Tithonian age, is correlated with the Pimienta Formation of Heim (1926). The *Suarites bituberculatum* Zone, which is of late Tithonian age, has a wide distribution and contains *Mazapilites*, *Kossmatia*, *Haploceras*, *Aulacosphinctoides*. The upper Tithonian is marked by the *Parodontoceras* aff. *callistoides* Zone.

In this region, the Upper Jurassic rocks are represented by a deep facies (Taman Formation), by a shallow water and lagoonal facies (San Andres Member) and by an open sea neritic facies (Pimienta Formation).

In general, there is a strong resemblance between the Titho-

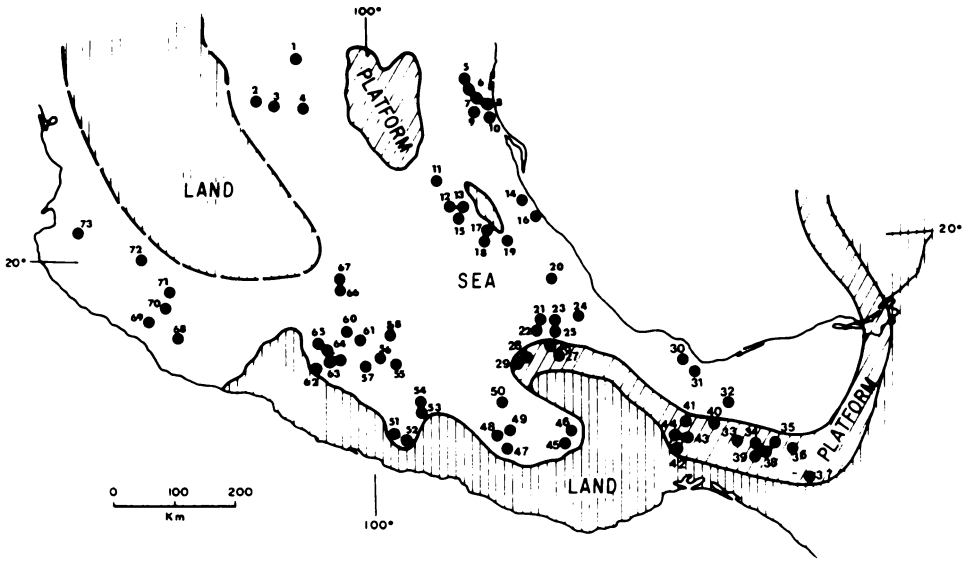


Figure 4. Neocomian-Aptian molluscan localities and paleogeography of Mexico.

nian ammonite faunas of Mexico and Cuba. The similarity is still more remarkable with the faunas located in the Gulf region and in the Sierra Madre Oriental, where the Pimienta Formation can be compared with the Artemisa Formation of Cuba. Both formations have the same lithological and faunistic sequences and in their tops are tintinnids in the Zone of *Parodontoceras* aff. *callistoides* (Cantu Chapa, 1976, p. 68).

In the southern parts of the Gulf Coastal Plain, the Upper Jurassic rocks have been referred to the Chinameca Limestone (Burckhardt, 1930, p. 97) and Mogoñé Limestone (Böse, 1905). In this southernly region, during the Late Jurassic there were several massifs formed by granitic, metamorphic and volcanic rocks which remained above sea level. In the west, apparently, a considerable region was not covered by the sea during this time, as deduced by the absence of marine sedimentary rocks or fossils (Fig. 3).

In southeastern Mexico, a thick sequence of Kimmeridgian-Tithonian rocks covers a vast region that includes the western half of Chiapas and parts of Oaxaca and Veracruz. These strata contain abundant faunas which include among many other species *Inoperna plicata, Pinna suprajurensis, Placunopsis suprajurensis, Myophorella clavellata, M. hudlestoni, "Cyprina" brongniarti,* and many species of *Pholadomya, Pleuromya, Gresslya, Anisocardia,* as well as *Harpagodes oceani* and other gastropods. These are benthic forms of neritic to litoral environments. The species of this fauna are identical to those of the Tethyan Mediterranean Province, indicating the presence of the same biozones in this region in similar stratigraphic position (Alencaster, 1977, 1978; Alencaster and Quezada, in prep.) and in a direct and close relation to that province. The shallow platform over which the sediments were deposited that contains this fauna deepens gradually to the north (Sánchez-Montes de Oca, 1969), as detected by the lithology and by the ammonite fauna of Cerro Pelón and Chinameca (Fig. 3, locs. 86, 87) as well as those close to the City of Oaxaca (Fig. 3, loc. 64). The presence of abundant fossil fish remains at these localities as well as the Tampico region within this stratigraphic interval is especially noteworthy.

The Mexican sea at this time had a direct and effective communication with the Tethys, as shown by the molluscs present in these localities. The fauna, to a lesser extent, contain some Andean and Californian elements also, implying certain communication with the Circum-Pacific Geosyncline toward the north and south (Cantu Chapa, 1969, 1971).

NEOCOMIAN-APTIAN

The gradual flooding of Mexico continued during the Early Cretaceous and an intracratonic geosyncline developed (Fig. 4). The ammonites are very abundant and widely distributed, as shown by their presence in almost all localities. The areas devoid of fossils were probably positive areas, like the western landmass of Mexico. In the south, the massifs of Guerrero, Oaxaca and Chiapas remained as positive areas and formed a barrier preventing the extending of the sea in that region. The Late Jurassic islands of the northeast became flooded by this Early Cretaceous transgression; however, like the one that existed in the Huayacocotla-Huachinango region (Imlay, 1944, Fig. 2), some still remained above sea level.

In the Neocomian-Aptian sequence a variety of depositional

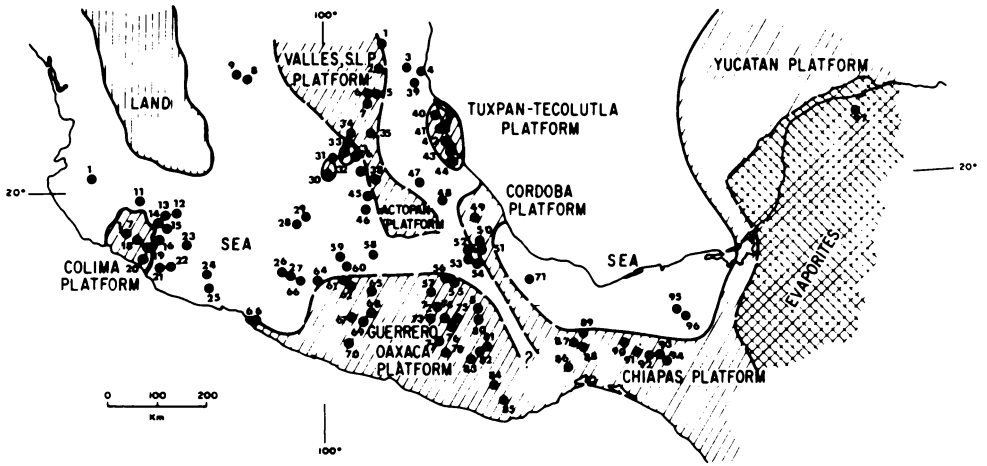


Figure 5. Albian-Cenomanian molluscan localities and paleogeography of Mexico.

environments can be recognized, as evidenced by the lithology and fauna. The localities shown within the geosyncline correspond (Fig. 4) to basin facies of thin-bedded limestones, commonly with chert interbedded with shales, and commonly containing ammonites. Thus, at Mazatepec (Cantu Chapa, 1967) (Fig. 4, loc. 19) the Berriasian is represented by limestones of the Lower Tamaulipas Formation, containing several species of *Subthurmannia, Groebericeras, Berriasella, Taraisites, Spiticeras* and tintinnids; it is a deep-water community related to Berriasian faunas from Argentina, France and India (Cantu Chapa, 1967). Similar associations are present in the north of Mexico (San Pedro del Gallo, Dgo.) as well as in the Oaxaca localities.

Deep-water localities (Fig. 4, locs. 1-4) in the north-central area, in the Tampico region (Fig. 4, locs. 5-10), in central Veracruz (Fig. 4, locs. 20-21) and in central Oaxaca (Fig. 4, locs. 45-46) contain *Hoplites, Astieria, Acanthodiscus, Crioceratites, Parahoplites, Olcostephanus, Neocomites*, etc.

The shallow-water facies has a wide distribution in the Huasteca region (Fig. 4, locs. 11-15), consisting of calcareous and carbonaceous shales with ammonites, and coal beds and ostreids near Huayacocotla (Imlay, 1944, p. 1079).

The rich Neocomian-Aptian faunas of southern Puebla deserve a special comment (Fig. 4, locs. 28-29). The Hauterivian and Barremian deposits consist of nearshore clastics, carbonaceous shale and limestone, with corals, monopleurid rudists, gastropods and bivalves. Similar lithology and fauna are found in localities 61-65 (Fig. 4), with *Nerinea titania* Felix in all outcrops. At some of these localities (Huetamo, Fig. 4, loc. 65 and Coyuca de Catalan, Fig. 4, loc. 62), a pelagic Barremian fauna is suggested by the presence of *Pulchellia, Holcodiscus, Barremites*, etc. (Burckhardt and Müllerried, 1936). The late Aptian rocks at San Juan Raya (Fig. 4, loc. 29) consist of near-shore facies, shaly marl, thin-bedded limestone, some conglomerate, and locally, beds of salt and gypsum. Bivalves and gastropods (Müllerried, 1933, 1934; Alencaster, 1956), as well as echinoids (Buitrón, 1970), ostreid banks and coral reefs are extraordinarily abundant. Remarkable is the strong affinity of the fauna with Aptian faunas of the Mediterranean Province of the Tethys - many species are common to both regions. There is also some relation with species of Lebanon and Japan.

In the southwest, a large region comprising the States of Colima and the southern part of the State of Jalisco and Michoacán (Fig. 4, locs. 68-73), the late Aptian benthic communities formed primarily by gastropods of the genera *Cassiope, Nerinea, Uchauxia* and *Craginia*, and monopleurid and requienid rudists, suggest that the region was covered by shallow seas.

Subsurface information from the Yucatán Peninsula indicates the absence of Neocomian-Aptian marine deposits, implying that at that time this region was probably a flat land area or a very shallow platform over which evaporites precipitated (López-Ramos, 1973, 1979b).

ALBIAN-CENOMANIAN

During the Albian-Cenomanian the sea reached its maximum extent in Mexico (Fig. 5). The massifs of Chiapas, Oaxaca and Guerrero became flooded by the sea that advanced gradually toward the south-southwest, covering older terrains that were not inundated earlier. The epicontinental sea was relatively shallow and the organisms lived mostly in a neritic to littoral environment. The western landmass became more reduced and the sea invaded its western and southern margins (Fig. 5).

The rudists attained their maximum development during this time. They were the dominant invertebrates and with them abundant shallow-water benthic faunas flourished. The ideal conditions for this type of biota were the large platforms that

had their widest development at this time. Thus, the southern half of the Valles-San Luis Platform (Carrillo, 1971) and its narrow southern prolongation called the Actopan Platform (Carrasco, 1971) are in the region discussed in this paper. To the west of this, two small platforms, Toliman and El Doctor (Segerstrom, 1961b), were sites of reef-facies limestones. Another great elliptical platform extended between Tuxpan and Tecolutla (Pedrazzini, 1978) upon which the oil fields of the Golden Lane are located, and farther south was the Cordoba Platform (González-Alvarado, 1976). This last one possibly continued to Chiapas, bordering the more or less deeper Veracruz Basin and the Gulf of Chiapas (Sánchez-Montes de Oca, 1969) (Fig. 5).

In south-central Mexico, the Morelos-Guerrero Platform extended roughly east of the meridian of Taxco, whereas toward the west a basin separated this platform from that of the Huetamo area (de Cserna *et al.*, 1978).

For the early Albian, *Coalcomana ramosa* (Boehm) is a very valuable guide fossil, for it has a very wide distribution. It is present in different faunal assemblages with monopleurids (Scott, 1981), caprotinids (Alencaster, 1984) being the most frequent faunal community made up of *Caprinuloidea and Toucasia*, as well as *Nerinea*, *Actaeonella* and *Orbitolina texana*. This assemblage is present at all shallow-water localities shown on the map as well as in Sinaloa (Bonneau, 1971), Baja California (Allison, 1955), Texas (Coogan, 1977), and in the Caribbean region (MacGillavry, 1937). For a long time this rudist facies was considered as Cenomanian (Boehm, 1898; Douvillé, 1900; Burckhardt, 1930), and even Cenomanian-Turonian (Palmer, 1928). Müllerried (1939) placed it into the middle Albian, whereas Imlay (1944, p. 1098) expressed his doubts as to its Cenomanian consideration because of the presence of *Orbitolina texana* in the same beds. The accepted age, presently, of the beds carrying this fauna is early Albian; it is based on the correlation of the *Coalcomana* beds with other strata of an age well established by microfossils, ostreids and ammonites (Bonet, 1956b, 1969; Coogan, 1973).

Toucasia is a very abundant requienid rudist, which forms part of various Albian assemblages or forms banks of one single species (Alencaster, 1973).

The basin facies deposits of Albian-Cenomanian age are generally present in areas between platforms and around them (Fig. 5). They contain pelagic faunas, principally ammonites together with planktonic microfossils, for instance, in the subsurface of the Tampico region (Fig. 5, locs. 3, 4, 39), in the Zimapan Basin (Carrasco, 1977) (Fig. 5, locs. 36, 37), and in the Apizaco-Zongolica Basin (Fig. 5, loc. 54) (Ontiveros, 1973). In those areas the presence of ammonites suggests a depositional environment transitional from neritic to moderately deep for the Upper Tamaulipas Formation (Muir, 1936; Ontiveros, 1973; Carrasco, 1977). Generally, the Albian beds are transitional with the Cenomanian. However, at a few localities the lithologies are indicative of a late Albian-Cenomanian deepening of the sea. At Orizaba (Fig. 5, loc. 53) and Coquimatlán (Fig. 5, loc. 18), the lower Albian rudist limestones are overlain by marly limestones containing banded chert and carrying *Mantelliceras*, *Mortoniceras* and *Uhligella*. In central Oaxaca (Fig. 5, locs. 81-84), the basin facies deposits of the upper Albian-Ceno-

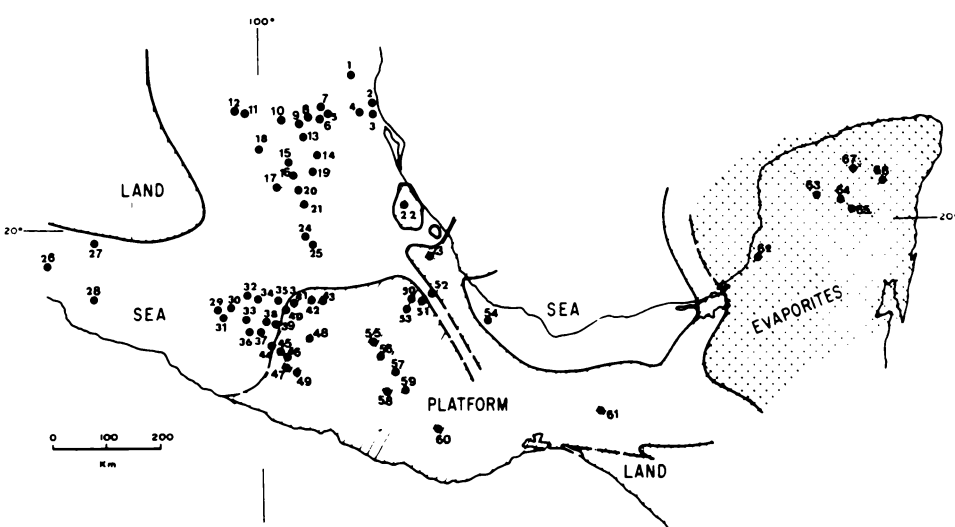


Figure 6. Turonian molluscan localities and palegeography of Mexico.

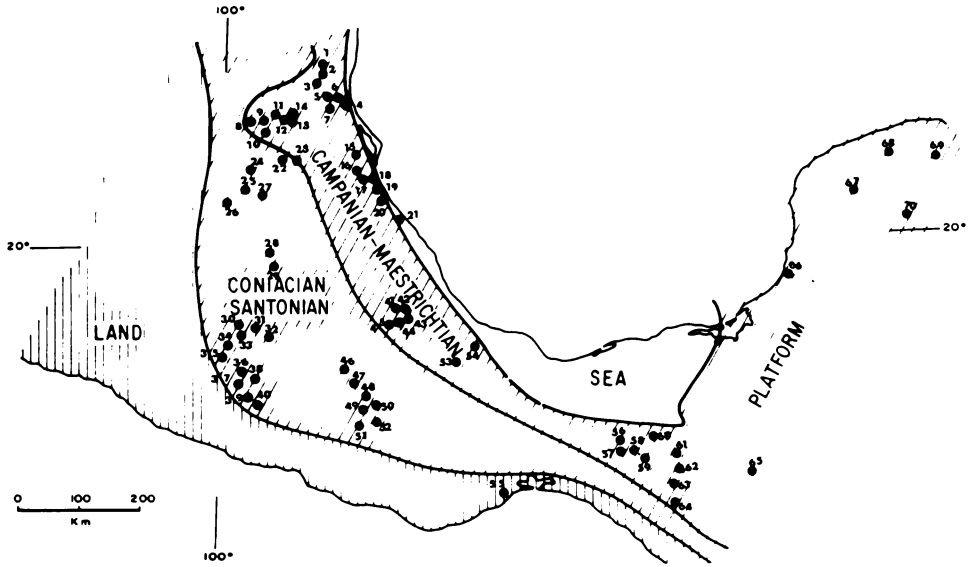


Figure 7. Senonian-Maastrichtian molluscan localities and paleogeography of Mexico.

manian contains *Hamites*, *Acanthoceras* and *Mantelliceras*, whereas in nearby localities (Fig. 5, locs. 72-80) of the lower and middle Albian, the faunal assemblages indicate littoral conditions of deposition of a shallow platform, similar to those that prevailed around the Chiapas Platform. In southwestern Mexico, the deposition upon the Colima Platform and nearby areas (Fig. 5, locs. 10-25) took place in shallow waters, as deduced by the presence of rudist banks with *Coalcomana*. In this latter region the carbonate rocks are interbedded with volcanics, indicating clearly eugeosynclinal conditions (Pantoja *et al.*, 1978).

TURONIAN

The distribution of the Turonian localities (Fig. 6) shows that the sea became somewhat reduced in extent in the west, as compared with the Cenomanian. This reduction becomes even more noticeable if it is kept in mind that localities 26-28 (Fig. 6) in the southwest are doubtfully Turonian. To date no certain Turonian fauna has been found in that region. The faunas reported (Palmer, 1928; Müllerried, 1950; López-Ramos, 1979b, p. 361) pertain to the Cenomanian.

The Turonian faunas show two wide-spread associations which are characterized by uniform and little varied composition. The inoceramid assemblage includes the characteristic *Inoceramus labiatus* Schlotheim, *I. hercynicus* (Petraschek), as well as other species of this genus, other bivalves and gastropods. This assemblage is found at eastern localities (Fig. 6, locs. 1-10, 13, 14, 20, 21) and in south-central Mexico (Fig. 6, locs. 55-59). The other assemblage is of hippuritids, whose principal form is *Hippurites resectus mexicanus* Bárcena (Müllerried, 1930, 1949). There are also other species of this genus in this assemblage, as well as various genera of radiolitids, such as *Durania* and *Sauvagesia*. This assemblage is found in the most eastern localities (Fig. 6, locs. 11, 12, 15-17, 24, 25, 29-44). It should be noted, however, that although these two facies generally occur separately, they do occur together in the Tampico region and north of Oaxaca.

In the central part of the State of Guerrero (Fig. 6, locs. 45-49), gastropods and pelecypods are very abundant, and *Actaeonella* forms banks at the top of the Turonian which are concordantly overlain by beds containing ammonites of early Coniacian age (Burckhardt, 1930, p. 237).

Solely because of the characteristics of the faunas, one can deduce that the seas during the Turonian were shallow to moderately deep, and that the animals inhabited the neritic and littoral zones. The hippuritids, just like all rudists, required a warm climate, well-oxygenated waters of high enery and shallow depths - conditions which are present in the littoral zone of a shallow platform (Fig. 6).

As to the inoceramids, Kauffman (1965, p. 213, 214) showed that these occur in all major different lithologies of the Western Interior Basin of the United States, but that the shallow shelf areas are the principal inoceramid habitats throughout the world. In the case of the Turonian sea of Mexico, the proximity of the hippuritid and inoceramid localities and also their association in some places show that they lived in a similar habitat.

SENONIAN-MAASTRICHTIAN

The Coniacian, Santonian, Campanian and Maastrichtian localities were grouped together and are shown on one single map (Fig. 7) in spite of the fact that these do not form complete sequences. This was done to show in a contrasting manner the extent of the Coniacian-Santonian seas with respect to the Campanian-Maastrichtian seas. As can be observed on the map (Fig. 7), the localities of these stages are toward the east and the region on the west is devoid of outcrops of marine rocks of these ages. In other words, the eastward migration of the coast that started toward the end of the Turonian continued advancing.

The Senonian-Maastrichtian faunas have a highly varied composition of rudists, ammonites, gastropods, and bivalves. However, it should be kept in mind that Upper Cretaceous outcrops at many localities are devoid of fossils and thus their more precise age assignment is very difficult at times. In general, the Upper Cretaceous fossils of this interval, where they are present, are abundant and well preserved.

The important Coniacian-Santonian faunas are those that occur in the westernmost parts of the paleogeographic map (Fig. 7). They consist of rudists of the same genera as in the Turonian, but different species. There are also *Inoceramus* like *I. undulatoplicatus* and some very large species of this genus. Ammonites are present at many localities, but generally they are not abundant. *Texanites* and *Nowakites* are indicative of the Coniacian-Campanian in the Zimapan region (Fig. 7, loc. 27; Segerstrom, 1956) and in northwestern Oaxaca (Fig. 7, loc. 48; Ferrusquia, 1976, p. 27).

The most important Coniacian fauna is in the central part of the State of Guerrero at Zumpango del Rio and Tixtla (Fig. 7, locs. 39, 40). It contains ammonites, gastropods, bivalves, echinoids, rare inoceramids, and *Didymotis* (Burckhardt, 1921; 1930, p. 237, 238). The ammonites are the most numerous and are represented by various species of *Barroisiceras, Peroniceras* and *Otoscaphites;* the latter was thought to be *Scaphites* of late Turonian age, until Imlay (*in* Fries, 1960, p. 84) showed that it was a different genus belonging to the lower Coniacian, just like the rest of the fauna.

In Central Guerrero, at the end of the Santonian the marine rocks became covered by continental deposits, indicating the withdrawal of the sea eastward.

As to the environments, the faunas are composed of benthic and pelagic molluscs, that lived in the littoral and neritic zones.

During the Campanian-Maastrichtian the withdrawal of the sea continued, and the sea occupied mainly the areas adjacent to the Gulf of Mexico (Fig. 7). It was probably somewhat deeper in its eastern parts. The faunas are isolated, but very abundant where they are preserved. In the region of Cárdenas (Fig. 7, loc. 8) the abundant fauna of the Maastrichtian contains gastropods of which *Actaeonella* is the most numerous, bivalves with *Exogyra costata* Say and *Arctostrea aguilerae* (Böse), and rudists with species in common with the fauna of Chiapas (Myers, 1968). Most of the fauna consists of benthic forms which lived in the infralittoral zone. The shallow depth of the sea is suggested by the presence of corals together with rudists and by the presence of ostreid banks and mud cracks in some of the beds (Myers, 1968, p. 26).

Another important fossiliferous region of the Campanian-Maastrichtian stages is located in the west-central part of the State of Chiapas. The fauna of these ages are very abundant and are found at many localities (Fig. 7, locs. 56-65). Here the rudists predominate, however, there are gastropods (*Actaeonella*) and bivalves including some inoceramids. Ammonites are very scarce at some localities, but the foraminiferal fauna is rich. Among the rudists, the most frequent are species of *Durania, Titanosarcolites, Barretia monilifera, Praebarrettia, Plagyoptichus, Chiapasella* and many other forms. Many of the genera attained gigantic sizes and the major part of the fauna is endemic (Alencaster, 1971). The fauna constitutes the Caribbean-Subprovince which is an extension of the Mediterranean Province of the Tethys Realm (Kauffman, 1973). It comprises the south of Mexico, the Antilles (MacGillavry, 1937; Chubb, 1971), and the northern parts of Central America. Toward the north it extends to the region of Cardenas; however, to date no intermediate localities have been found between these two regions.

In the Chiapas region, apparently the faunas were very scarce from the Turonian until the Campanian, since only a few specimens have been found so far indicating certain doubts as to these ages. It appears that in this region there is an unconformity between the "middle" and Upper Cretaceous and the corresponding discordant relations have been observed only at a few localities (Sánchez-Montes de Oca, 1969, p. 13). What is really surprising is that a scarce and impoverished as well as little varied fauna at a few localities was succeeded suddenly by an abundant, varied and very specialized endemic fauna that developed and became distributed in a relatively large region.

As to the environmental conditions, it was a sea of high energy with warm and well-oxygenated waters which permitted the development of gigantic rudists on banks and reefs, in shallow waters, over the internal and marginal portions of a platform. To the north of this region, the oil wells of the southern parts of Tabasco and Veracruz yielded information regarding the northerly progradation of this platform which bordered a sea of moderate depth (Sánchez-Montes de Oca, 1969; López-Ramos, 1979b, p. 367). The planktonic and benthic foraminiferal faunas are very abundant in this region as well as in the entire belt that surrounds this platform.

Subsurface studies in the Yucatán Peninsula show that this region was a lowland until the Albian, when it started to be covered by marine deposits consisting of a few beds and lenses of limestone with rudists and foraminifera, interbedded with thick intervals of evaporites which range from the Albian to the Turonian. The shallow platform conditions of this region lasted until the end of the Tertiary, when it began to rise to form a positive lowland.

In summation, throughout the Cretaceous, the molluscan faunas of the southern half of Mexico belong to a tropical biotic province characterized by "assemblages rich in nerineid and actaeonellid gastropods, associated with rudist reef facies" (Sohl, 1971, p. 1631). The predominant affinity of the faunas during most of the period with the Mediterranean Tethyan region is evident.

Paleogeographic interpretation are contingent on stratigraphy and paleontology which in turn depend on new geological information from the field. As geologic mapping progresses

in the country, and as new fossil material is studied the interpretation will be updated, modified or corrected. Therefore, the present approach to this problem should be considered with an open mind, and as a preliminary step.

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REFERENCES

Aguilera, E.H., 1972, Ambientes de Depósito de las Formaciones del Jurásico Superior de Tampico, Tamps.: Boletin de la Asociación Mexicana de Geólogos Petroleos, v. 24, p. 129-146.

Alencaster, Gloria, 1956, Pelecipodos y Gasterópodos del Cretácico Inferior de la Región de San Juan Raya-Zapotitlán, Estado de Puebla: Universidad Nacional Autónoma de México, Instituto de Geologia, Paleontologia Mexicana 2, 47 p.

_____, 1971, Rudistas del Cretácico Superior de Chiapas, México: Universidad Nacional Autónoma de México, Instituto de Geologia, Paleontologia Mexicana 34, 91 p.

_____, 1973, Una nueva especie de *Toucasia* en el Albiano de Oaxaca y Puebla: Universidad Nacional Autónoma de México, Instituto de Geologia, Paleontologia Mexicana 37, 18 p.

_____, 1977, Moluscos y Braquiópodos del Jurásico Superior de Chiapas: Universidad Nacional Autónoma de México, Instituto de Geologia, Revista, v. 1 p. 151-166.

_____, 1978, Presencia del Tethys en el Sureste de México durante del Jurásico Superior: Actas, II Congreso Argentino de Paleontologia y Bioestratigrafia y I Congreso Latinoamericano de Paleontologia, Buenos Aires, v. 5, p. 9-14.

_____, 1984, Rudista Caprotinido (Bivalvia Hippuritacea) del Cretácico Inferior de Pihuamo, Jalisco: Universidad Nacional Autónoma de México, Instituto de Geologia, in press.

Alencaster, Gloria and Buitrón, B.E., 1965, Fauna del Jurásico Superior de la Región de Petlalcingo, Estado de Puebla: Universidad Nacional Autónoma de México, Instituto de Geologia, Paleontologia Mexicana 21, p. 1-53.

Alencaster, Gloria and Quezada-Muñetón, J.M. in preparation, Bioestratigrafia del Mesozoico de la Parte Occidental del Estado de Chiapas y del la Parte Oriental de los Estados de Veracruz y Oaxaca: Universidad Nacional Autónoma de México, Instituto de Geologia, Paleontologia Mexicana.

Allison, Edwin, C., 1955, Middle Cretaceous Gastropoda from Punta China, Baja California, México: Journal of Paleontology, v. 29, p. 400-432.

Boehm, G., 1898, Ueber Caprinidenkalke aus Mexico: Zeitschrift der Deutschen Geologischen Gesellschaft, v. 50, p. 323-332.

Bonet, Federico, 1956b, Zonificación Microfaunistica de las Calizas Cretácicas del Este de México: Congreso Geológico Internacional, Sesión 20, México, D.F., Sistema Cretácico T. III, 102 p.

_____, 1969, Microfacies de las Calizas Cretácicas de la Región de Córdoba y Orizaba: Seminario sobre Exploración Petrolera, Instituto Mexicano del Petróleo, Mesa Redonda 4, 24 p.

Bonneau, M., 1971, Una nueva área fosilifera en el Estado de Sinaloa: Boletin de la Sociedad Geológica Mexicana, v. 32, p. 159-167.

Böse, Emil, 1905, Algunos datos sobre la Geologia del Istmo de Tehuantepec: Boletin del Instituto Geologico de México, v. 20, p. 75-85.

Buitrón, B.E., 1970, Equinoides del Cretácico Inferior de la Región de San Juan Raya-Zapotitlán, Estado de Puebla: Universidad Nacional Autónoma de México, Instituto de Geologia, Paleontologia Mexicana 30, 46 p.

Buitrón, B.E., 1983, Gasterópodos del Cretácico Inferior del Cerro de Tuxpan, Jalisco: Universidad Nacional Autónoma de México, Instituto de Geologia, Revista, in press.

Burckhardt, C., 1921, Faunas Jurásicas de Symon (Zacatecas) y Faunas Cretácicas de de jZumpango del Rio (Guerrero): Boletin del Instituto Geológico de México, v. 13, 135 p.

_____, 1927, Cefalópodos del Jurásico Medio de Oaxaca y Guerrero: Boletin del Instituto Geológico de México, v. 47, 108 p.

_____, 1930, Etude Synthétique Sur le Mésozoique Mexicain: Mémoire Societé Paléontologique Suisse, v. 49-50, 280 p.

Burckhardt, Carl and Müllerried, F.K.G., 1936, Neue Funde in Jura und Kreide Ost- und Süd- Mexicos: Eclogae Geologicae Helvetiae, v. 29, p. 309-324.

Campa, M.F.; Campos, Mario; Flores, Roberto and Oviedo, Ramón, 1974, La Secuencia Mesozoica Volcánico-Sedimentaria Metamorfizada de Ixtapan de la Sal, México-Teloloapan, Guerrero: Boletin de la Sociedad Geológica Mexicana, v. 35, p. 7-28.

Cantu Chapa, A., 1967, El Limite Jurásico-Cretácico en Mazatepec, Puebla (México): Instituto Mexicano del Petróleo, Sección Geologia, p. 3-24, pl. 1-7; also *in* 1968, Ingenieria del Petróleo, v. 8, p. 5-26.

_____, 1969, Estratigrafia del Jurásico Medio-Superior del Subsuelo de Poza Rica, Ver. (Area de Soledad-Miquetla): Revista del Instituto Mexicano del Petróleo, v. 1, p. 3-9.

_____, 1976, El Contacto Jurásico-Cretácico, la Estratigrafia del Neocomiano, el Hiato Hauteriviano Superior-Eoceno Inferior y las Amonitas del Pozo Bejuco 6 (Centro-Este de México): Boletin de la Sociedad Geológica Maxicana, v. 37, p. 60-83.

Cantú Chapa, A., 1976, Bioestratigrafia de la Serie Huasteca (Jurásico Medio) y Superior en el subsuelo de Poza Rica, Veracruz: Revista del Instituto Mexicana, v. 37, p. 60-83.

_____, 1971, La Serie Huasteca (Jurásico Medio-Superior) del Centro Este de México: Revista del Instituto Mexicano del Petróleo, v. 3, p. 17-39.

Carrasco, V., Baldomero, 1971, Litofacies de la Formación El Abra en la Plataforma de Actopan, Hgo.: Revista del Instituto Mexicano del Petróleo, v. 3, p. 5-26.

_____, 1977, Albian Sedimentation of Submarine Autochthonous and Allochthonous Carbonates, East Edge of the Valles-San Luis Potosi Platform, México: *in* Cook, H.E. and Enos, Paul, eds., Deep-Water Carbonate Environments: Society of Economic Paleontologist and Mineralogists, Special Publication No. 25, p. 263-272.

Carrillo, B.J., 1971, La Plataforma Valles-San Luis Potosi: Boletin de la Asociación Mexicana de Geólogos Petroleros, v. 23, 102 p.

Coogan, A.H., 1973, Nuevos Rudistas del Albiano y Cenomaniano de México y del Sur de Texas: Instituto Mexicano del Petróleo, v. 5, p. 51-83.

_____. 1977. Early and Middle Cretaceous Hippuritacea (Rudists) of the Gulf Coast: *in* Bebout, D.G. and Loucks, R.G., eds., Cretaceous Carbonates of Texas and Mexico, Applications to Subsurface Exploration: Report Investigations No. 89, Bureau of Economic Geology, University of Texas, Austin, p. 32-70.

Cserna, Zoltan de, 1978, Notas sobre la Geologia comprendida entre Iguala, Ciudad Altamirano y Temascaltepec, Estado de Guerrero, México: Sociedad Geológica Mexicana, Libro-Guia de la Excursión a Tierra Caliente, Estados de Guerrero y México, p. 1-25.

Chubb, L.J., 1971, Rudists of Jamaica: Paleontographica Americana, v. 7, p. 161-257.

Douvillé, H., 1900, Sur Quelques Rudistes Américains: Bulletin Societé Geologique de France, Ser. 3, v. 28, p. 205-221.

Erben, H.K., 1956a, El Jurásico Inferior de México y sus Amonitas: Universidad Nacional Autónoma de México, Instituto de Geologia, Congreso Geológico Internacional, Sesión 20, 393 p.

_____. 1956b, El Jurásico Medio y el Calloviano de México: Universidad Nacional Autónoma de México, Instituto de Geologia, Congreso Geológico Internacional, Sesión 20, 140 p.

_____. 1957, Paleogeographic Reconstruction for the Lower and Middle Jurassic and for the Callovian of México: *in* El Mesozoico del Hemisferio Occidental y sus Correlaciones Mundiales: Congreso Geologógico Internacional, Sesión 20, México, D.F., Sección 2, p. 35-41.

Ferrusquia-V., Ismael, 1976, Estudio Geológico-Paleontológico de la Región Mixteca: Universidad Nacional Autónoma de México, Instituto de Geologia, Boletin 97, 106 p.

Fries, Carl, 1960, Geologia del Estado de Morelos y Partes Adyacentes de México y Guerrero, Región Central Meridional de México: Universidad Nacional Autónoma de México, Instituto de Geologia, Boletin 60, 236 p.

González-Alvarado, J., 1976, Resultados Obtenidos en la Exploración de la Plataforma Córdoba y Principales Campos Productores: Boletin de la Sociedad Geológica Mexicana, v. 37, p. 53-59.

Heim, A., 1926, Notes on the Jurassic of Tamazunchale (Sierra Madre Oriental, México): Eclogae Geologicae Helvetiae, v. 20, p. 84-89.

_____. 1940, The Front Ranges of Sierra Madre Oriental, from Ciudad Victoria to Tamazunchale: Eclogae Geologicae Helvetiae, v. 33, p. 313-362.

Imlay, R.W., 1943, Jurassic Formations of the Gulf Region: Bulletin of the American Association of Petroleum Geologists, v. 27, p. 1407-1533.

_____. 1944, Cretaceous Formations of Central America and México: Bulletin of the American Association of Petroleum Geologists, v. 28, p. 1077-1195.

_____. 1953, Las Formaciones Jurásicas de México: Boletin de la Sociedad Geológica Mexicana, v. 16, 65 p.

_____. 1980, Jurassic Paleobiogeography of the Conterminous United States in its Continental Setting: United States Geological Survey, Professional Paper 1062, 134 p.

Kauffman, E.G., 1965, The Upper Cretaceous *Inoceramus* of Puerto Rico: Fourth Caribbean Geological Conference, Trinidad, p. 203-218.

_____. 1973, Cretaceous Bivalvia: Atlas of Paleobiogeography: Elsevier, Amsterdam, p. 353-383.

López-Ramos, Ernesto, 1973, Estudio Geológico de la Peninsula de Yucatán, México: Boletin de la Asocación Mexicana de Geólogos Petroleros, v. 25, p. 24-76.

_____. 1979a, Geologia de México, Tomo II: Second Edition, México, D.F., 454 p.

_____. 1979b, Geologia de México, Tomo III: Second Edition, México, D.F., 446 p.

MacGillavry, H.J., 1937, Geology of the Province of Camagüey, Cuba, with Revisional Studies in Rudist Paleontology: Ph.D. Thesis, University of Utrecht, 168 p.

Muir, J.M., 1936, Geology of the Tampico Region, México: American Association of Petroleum Geologists: Tulsa, Oklahoma, 280 p.

Müllerried, F.K.G., 1930, El *Hippurites calamitiformis* Bárcena: Universidad Nacional Autónoma de México, Anales del Instituto de Biologia, v. 1, p. 169-174.

_____. 1933-1934, Estudios Paleontológicos y Estratigráficos en la Región de Techuacán, Puebla: Universidad Nacional Autónoma de México, Anales del Instituto de Biologia, v. 4, p. 33-46, 79-93, 309-330; v. 5, p. 55-79.

_____. 1939, Apuntes Paleontológicos y Estratigráficos sobre el Valle de Mezquital, Estado de Hidalgo: Anales de la Escuela Nacional de Ciencias Biológicas, México, v. 1, p. 225-252.

_____. 1949, Estratos del Cretácico Medio y Superior en la Región de Apaxco, Estado de México, y Terrenos Litmitrofes de Hidalgo: Memorias de la Comisión Impulsora para la Coordinación de la Investigación Cientifica, p. 31-34.

_____. 1950, La Facies Arrecifal de Paquiodontos del Cretácico Superior, en el Sur de México, de Chiapas a Colima: Memorias de la Comisión Impulsora para la Coordinación de la Investigación Cientifica, p. 13-16.

Myers-L., Ralph, 1968, Biostratigraphy of the Cardenas Formation (Upper Cretaceous), San Luis Potosi, México: Universidad Nacional Autónoma de México, Instituto de Geologia, Paleontologia Mexicana 24, p. 1-89.

Ontiveros, T.G., 1973, Estudio Estratigráfico de la Porción Nororiental de la Cuenca Morelos-Guerrero: Boletin de la Asociación Mexicana de Geólogos Petroleros, v. 25, p. 190-234.

Palmer-H., Robert, 1928, The Rudistids of Southern Mexico: California Academy of Sciences, San Francisco, Occasional Paper N° 14, 137 p.

Pantoja-Alor, Jerjes; Estrada-B; Samuel, and Alencaster, Gloria, 1978, Estratigrafia del Cretácico Inferior de la Mina El Encino, Mpio. de Pihuamo, Jalisco: Boletin de la Sociedad Geológica Mexicana, IV Convención Geológica Nacional, Resúmenes, Tomo 39, p. 28.

Pedrazzini, Carmen, 1978, Facies Ambientales, Desarrollo de la Plataforma Cretácica de Tuxpan-Tecolutla (Faja de Oro): Boletin de la Sociedad Geológica Mexicana, v. 39, p. 118-125.

Sánchez Montes de Oca, Rafael, 1969, Estratigrafia y Paleogeografia del Mesozoico de Chiapas: Seminario sobre Exploración Petrolera, Mesa Redonda No. 5, Problemas de Exploración de la Zona Sur, Instituto Mexicano del Petróleo, p. 23-29.

Sánchez-Rosas, G.J., 1972, Estudio Estratigráfico del Area Los Cues-Salinas, SE de Tamaulipas y N de Veracruz: Boletin de la Asociación Mexicana de Geólogos Petroleros, v. 24, p. 65-81.

Scott, R.W., 1981, Biotic relations in Early Cretaceous coralalgal-rudist reefs, Arizona: Journal of Paleontology, v. 55, p. 463-478.

Segerstrom, Kenneth, 1956, Estratigrafia y Tectónica del Cenozoico entre México, D.F. y Zimapán, Hidalgo: Congreso Geológico Internacional, Sesión 20, México, D.F., Excursiones A-14 y C-6, p. 311-323.

Stabler, C.L., 1972, Secuencia de una Trampa Estratigráfica en el Jurásico Superior, Campo Tamaulipas-Constituciones: Boletin de la Asociación Mexicana de Geólogos Petroleros, v. 24, p. 165-178.

Viniegra-O., Francisco, 1971, Age and Evolution of Salt Basins of South-Eastern México: American Association of Petroleum Geologists Bulletin, v. 55, p. 478-494.

_____. 1981, Carbonate Bank of Yucatán, Southern México: Journal of Petroleum Geology, v. 3, No. 3, p. 247-278.