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THE RUDIST FAUNA OF THE CÁRDENAS FORMATION, MAASTRICHTIAN, SAN LUIS POTOSÍ STATE, MEXICO

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ABSTRACT—A Maastrichtian rudist fauna composed of the radiolitids *Biradiolites aguilerae* Böse, *B. Cárdenasensis* Böse, *Huasteca ojanchalensis* (Myers), *Tampsia floriformis* Myers, and *Trechmannites rudissimus* (Trechmann), the hippuritids *Caribbea muellerriedi* (Vermunt) and *Praebarrettia sparcilirata* (Whitfield) sensu lato, and the plagioptychids *Coralliochama gbohemi* Böse and *Mitrocaprina tschoppi* (Palmer) is described from the Cárdenas Formation in San Luis Potosí State, Mexico. Abundant fossil material and excellent preservation of a number of specimens allowed observation of both the internal and external shell characters and their ontogenetic and eco-phenotypic variability. The description of some hitherto insufficiently known species has been enhanced and/or completed, making easier their subsequent identification and allowing their unequivocal generic assignation. Two new genera, *Huasteca* and *Trechmannites*, are proposed for two already known species of radiolitids. The Cárdenas Formation exhibits a continuously exposed sequence in the vicinity of Cárdenas. Thus, precise stratigraphic location of all fossil localities and their rudist associations, ranging from the early to the early late Maastrichtian, has been possible.

INTRODUCTION

THE LITERATURE on American Late Cretaceous rudists is extensive (e.g., Woodward, 1862; White, 1885; Whitfield, 1897; Böse, 1906; Stephenson, 1922; Trechmann, 1922, 1924; Adkins, 1930; Palmer, 1933; MacGillavry, 1937; Chubb, 1955, 1956a, 1956b, 1967, 1971; Myers, 1968; Alencáster, 1971, 1990; van Dommelen, 1971; Mitchell, 2003, 2007; Grubić, 2004; Oviedo, 2005; Pons et al., 2010). Rudists are considered good biostratigraphic markers, allowing reasonably high resolution in the shallow water platform sediments of the margins of the Tethys. Nevertheless, many American rudist taxa are still insufficiently known concerning both the internal and external shell characters and their ontogenetic and eco-phenotypic variability, and for that reason, their subsequent identification in different localities may become doubtful. Moreover, several species are based on specimens collected in single isolated localities whose precise stratigraphic position and correlation with other rudist localities is uncertain.

The main objective of this study is the complete description of the rudist fauna from several localities of the Cárdenas Formation. The abundance of specimens and the excellent preservation of a number of them allow enhancing and/or completing the knowledge of the shell characters of some species, describing ontogenetic and eco-phenotypic variability, recognizing synonymies, and identifying unequivocal generic attributions. The relative stratigraphic position of the different localities may be easily recognized thanks to the continuously exposed sequence of the Cárdenas Formation around Cárdenas. Published data on chronostratigraphically relevant fossils (ammonites and planktic foraminifers) and Sr-isotope stratigraphy help date the different units of the sequence.

LOCALITIES AND STRATIGRAPHY

The studied area is located in San Luis Potosí State, East-Central Mexico, about 100 km east of San Luis Potosí City. Localities (Fig. 1) are in the municipalities of Cárdenas ('Arroyo la Atarjea', 'Cárdenas 1′, 'Cárdenas 2′, and 'Cárdenas 3′) and Rayón ('Amoladeras', 'Cuchilla Las Palomas', 'Arroyo Los Terrerillos', and 'Arroyo el Terrero').

The stratigraphy of the Upper Cretaceous rocks around Cárdenas, known as 'division Cárdenas' or 'Cárdenas beds', was first attempted by Böse (1906), Böse and Cavins (1927), Burckhardt (1930), Heim (1940), Müllerried (1941), and Wade in Imlay (1944), where the term 'Cárdenas formation' was used. Myers (1968), after producing a detailed map of the region evidencing its structure, collecting fossils, and measuring sections, showed that previously published sections contained a repetition of lithologic units, a partly inverted sequence, or both.

Myers (1968) defined the Cárdenas Formation, divided it into three informally designated members, and subsequently recognized three assemblage zones. The Cárdenas Formation (Fig. 2) is a thick unit predominantly of fine clastic sedimentary rocks, overlying the thick to medium-bedded Tamasopo limestones, and unconformably overlain by the red and tan unfossiliferous siltstone, shale, sandstone, and conglomerate of the Tabaco Formation. The lower member of the Cárdenas Formation consists of alternating shale, sandstone and limestone, the middle member of shale and siltstone, and the upper member of siltstone, sandstone and limestone. The lowermost zone in the Cárdenas Formation is the *Durania ojanchalensis* Zone, characterized by a long list of bivalve species, but also gastropods, echinoids, and serpulids. The middle zone is the *Arctostrea aguilerae* Zone, less fossiliferous, only ostreids are abundant, and is coincident with the local range of *Exogyra costata*. The *Tampsia floriformis* Zone is the highest zone and has by far the richest fauna. These zones are not coincident with the members of the Cárdenas Formation nor are the boundaries of the members and zones parallel.

cárdenasensis Böse, 1906 is confirmed, as well as the fact that *B. potosianus* Böse, 1906 and *B. barretti* Trechmann, 1924 are junior synonyms of the latter. *Biradiolites aguilerae* is a small and very simple *Biradiolites* that, like similar American representatives of the genus, has uncertain affinities. *Biradiolites cárdenasensis* is clearly distinguished from *B. cancellatus*, although some specimens of the former species from Jamaica were attributed to *B. cancellatus* in literature. *Biradiolites cárdenasensis* shells show close similarities with the European *B. acuticostatus* and related species, but it is still not clear if these similarities correspond to phylogenetic relationships or are only convergent traits.

The new genus *Huasteca*, type species *Durania ojanchalensis* Myers, 1968, differs from *Durania* by its radial structures, evident at the outer shell surface as smooth radial bands, and by its very short myophores with striated outer margin. Both genera have normal cellular outer shell layer structure and lack a ligament ridge. Several American radiolitid species with normal cellular outer shell layer structure and without a ligament ridge have been ascribed to genus *Durania* without taking into account other important shell characters. Similarly, other species having a ligament ridge were attributed to genus *Sauvagesia*. As a result, the stratigraphic and paleogeographic distribution of these genera might have been overestimated, with *Durania* ranging from the Turonian to the Maastrichtian, *Sauvagesia* from the Albian to the Maastrichtian, and both genera having a worldwide distribution.

Tampsia floriformis Myers, 1968 and *Trechmannites rudissimus* (Trechmann, 1924), belonging to different genera, share the same type of outer shell layer structure: normal cellular and/or discontinuous cellular. Discontinuous cellular structure has been observed only in American radiolitids. Both species also share with *Huasteca ojanchalensis* a similar myocardinal apparatus, having very short myophores with striated outer margin

The herein provided description of the shell characters of *Praebarrettia* from the Cárdenas Formation is by far the most complete among all available *Praebarrettia* descriptions. Nevertheless, it is placed in *P. sparcilirata* (Witfield, 1897) sensu lato until the issue of *Praebarrettia* species distinction is cleared up. Most of the *Praebarrettia* species in literature are only known by a single poorly informative, more or less transverse section of the RV; further research is needed before confirming these species although the existence of different species within *Praebarrettia* is not formerly excluded.

The hippuritid genera *Caribbea* and *Praebarrettia*, being completely different and presumably not related, share the same type of outer shell layer structure. This is a modification of the current compact structure of hippuritids, in which the successive radially folded growth lamellae are in contact with each other in up-folds, while leaving voids in between them in down-folds, resulting in a non-compact outer shell layer structure. This has been observed only in American hippuritids.

Two species ascribed to different genera of plagioptychids are described and figured, *Coralliochama gbohemi* Böse, 1906 and *Mitrocaprina tschoppi* (Palmer, 1933). The relationships among plagioptychids, both European and American, are still not well understood.

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