

Upper Cretaceous microfauna of the Cárdenas Formation, San Luis Potosí, NE Mexico. Biostratigraphical, palaeoecological, and palaeogeographical significance

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ABSTRACT

The study of the microfauna of the lower member of the Cárdenas Formation occurring in the Cárdenas Basin (San Luis Potosí, NE México) has been carried out at the type-locality of *Lepidorbitoides minima* Douvillé. A re-examination of the larger foraminifera sampled in this locality, in addition to the study of the associated planktonic foraminifera and ostracodes, suggest a deposition in an open marine environment with terrigenous input during the middle-upper Campanian (*Globotruncana ventricosa* Zone and/or *calcarata* Zones). These preliminary results might be useful to precise the geological setting of the Cárdenas Formation. Moreover, the comparison of the studied microfauna with other Upper Cretaceous Tethyan ones have led to establish its strong similarities with the microfauna found in the Caribbean realm and the U.S. Gulf Coastal Plain but its tenuous European affinities.

Keywords: foraminifera, ostracoda, Upper Cretaceous, biostratigraphy, palaeogeography

RESUMEN

Se realizó el estudio de la microfauna de la localidad tipo de *Lepidorbitoides minima* Douvillé proveniente del miembro inferior de la Formación Cárdenas que aflora en la Cuenca de Cárdenas (San Luis Potosí, NE de México). Una revisión de los "macroforaminíferos" colectados en esta localidad, además del estudio de los foraminíferos planctónicos y ostrácodos asociados, sugieren sedimentación en un ambiente marino de plataforma abierta con influencia terrígena durante el Campaniano medio-superior (Zonas de *Globotruncana ventricosa* y/o *calcarata*). Los resultados preliminares aquí presentados podrían ser útiles para precisar el entorno geológico de la Formación Cárdenas. Además, la comparación de la microfauna con otras faunas del Cretácico Superior del Tethys ha permitido establecer fuertes similitudes con la microfauna encontrada en el área del Caribe y la Planicie Costera del Golfo de los Estados Unidos, así como poca afinidad con las faunas europeas.

Palabras clave: foraminíferos, ostrácodos, Cretácico Superior, bioestratigrafía, paleogeografía.

GEOLOGICAL SETTING OF THE SAMPLED FORMATION

Paleontological works in the Mesozoic Basin of San Luis Potosí (Mesa Central and Sierra Madre Oriental) started with the petroleum exploration, at the beginning of the century: larger foraminifera were found by Böse (1906) and studied by Douvillé (1927), who described a new species *Lepidorbitoides minima*. Its type-locality occurs at the Km. 419-420 on the railway side Tampico-San Luis Potosí, between Canoas and Cárdenas (Figure 1). It belongs to the lower member of the Upper Cretaceous Cárdenas Formation, predominantly composed of interbedded silty limestone and argillaceous marl with some intercalations of limestone rich in rudists or other molluscs (Aguilar, 1998, p. 44). It is still premature to present a precise biostratigraphical scheme of the whole Cárdenas Formation until the structural problems have not been solved. A re-examination of the larger foraminifera and a study of the associated microfauna: planktonic foraminifera, smaller benthic foraminifera and ostracods, have been carried out in order to clarify the stratigraphic setting of this part of the Cárdenas For-

mation, their depositional environment and to provide correlative ties with other Tethyan successions, either regional or European ones.

FORAMINIFERA

The larger foraminifera are mainly represented by *Lepidorbitoides minima* associated to *Sulcoperculina dickersoni* (Palmer), *S. globosa* Cizancourt, scarce *Smoutina?* sp., and *Vaughanina* cf. *cubensis* Palmer (Plate 1, figures 1-3). The porcellaneous genus *Ayalaina* is only represented in the type locality of *Lepidorbitoides minima* by fragments but it is abundant in the other Cárdenas facies not far from the sampled locality. The specimens belonging to the genus *Orbitoides* are rare and appear frequently fragmented, so the specific determinations have not been possible. Therefore, two kinds of larger foraminifera genera have been identified:

1) The cosmopolitan ones, represented by the orbital genera: *Lepidorbitoides* and *Orbitoides*; the abundance of one or other is function of the type of facies (environment). The parallel study of the morphology and

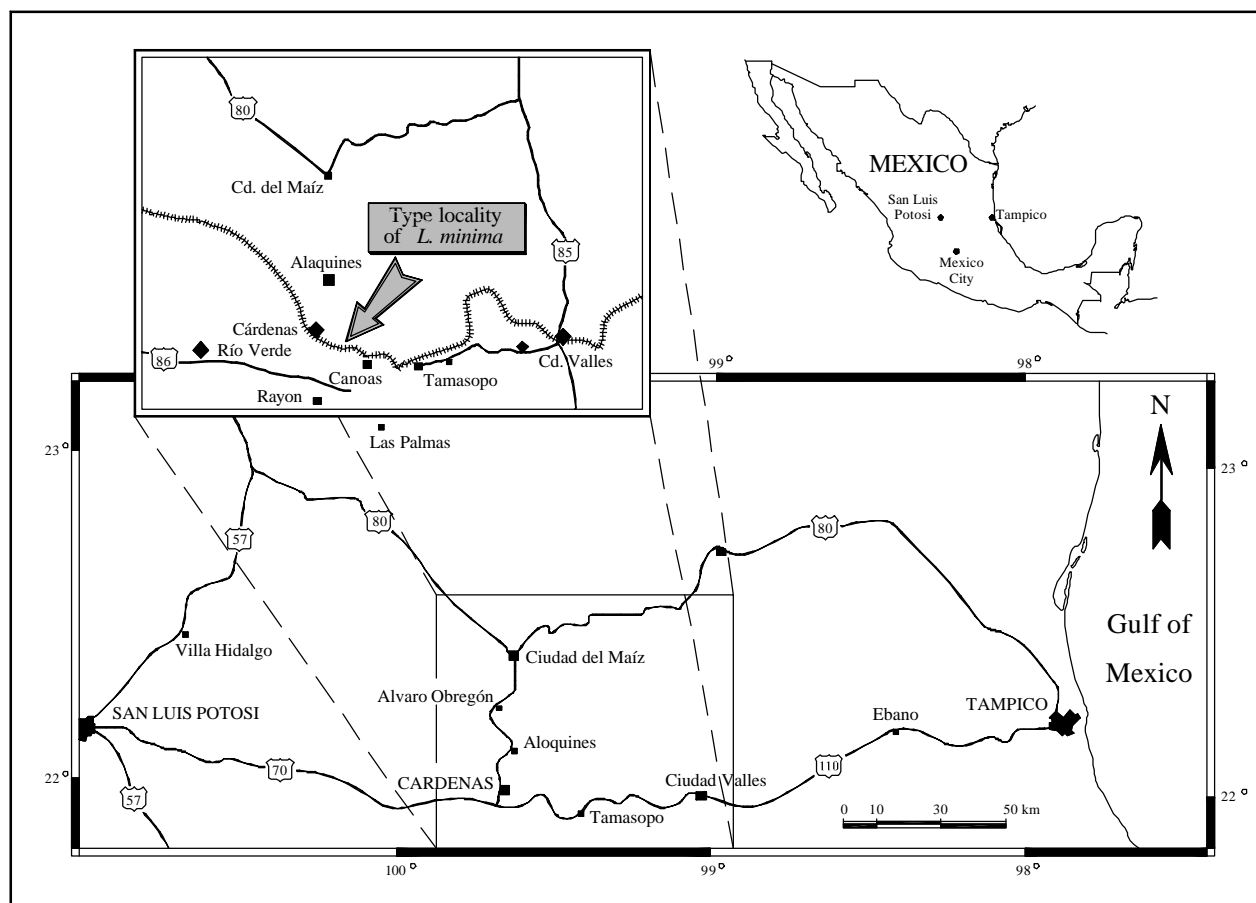


Figure 1. Location of *Lepidorbitoides minima* type locality on the railway side Tampico-San Luis Potosí, between Cárdenas and Canoas (Km. 419-420).

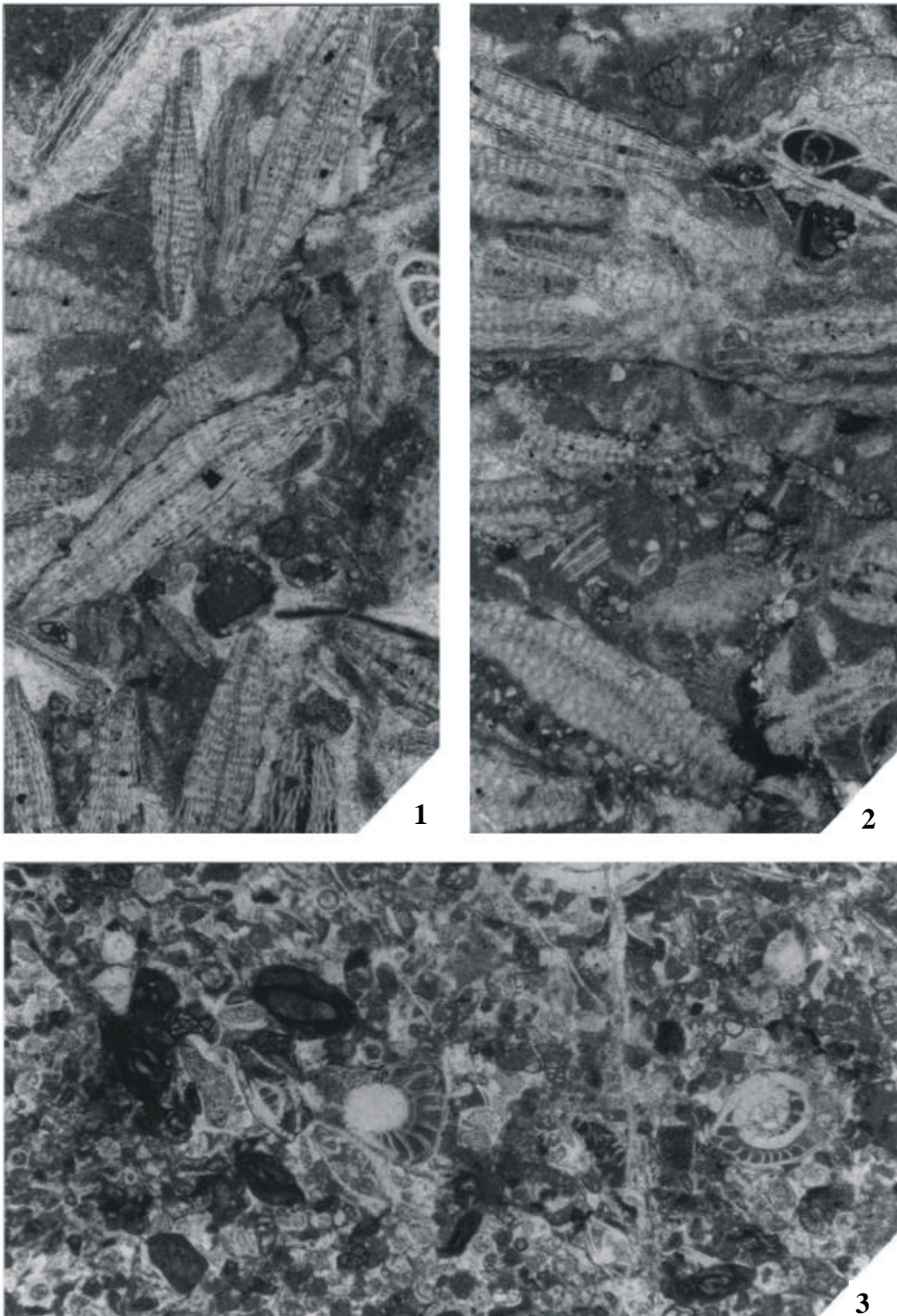


Plate 1. Figures 1-2: Microfacies containing abundant *Lepidorbitoides minima* Douvillé and some Nodosariidae. X 30. Figure 3: Microfacies containing *Sulcoperculina dickersoni* (Palmer), miliolids and textularids. X 30.

shell structure of *Lepidorbitoides minima* Douvillé (*Orbitocyclina minima* Vaughan) (Aguilar et al., in press) allows to establish the relationship between the American specimens and the "primitive" members of the European genus *Lepidorbitoides*: *L. pembergeri* Papp and *L. campaniensis* van Gorsel.

2) The restricted American ones, represented by the rotaliform genus *Sulcoperculina* and the pseudorbitoidiform *Vaughanina*, that permit to characterize a Tethyan Caribbean Province. The study carried out from well preserved Turkish Upper Cretaceous material allows to confirm that the specimens that have been reported in the literature to the genus *Sulcoperculina* in the Old World do not belong to this genus; they must be included in the non canaliferous genus *Goupillaudina*. Moreover, the specimens attributed by Hottinger (1966) to *Sulcoperculina* aff. *cubensis* in the Pyrenees correspond to a primitive representative of the *Siderolitinae* (Wannier, 1980) and those attributed to this genus by Azéma et al. (1979) must be probably included within the genus *Sirtina*. The presence of other genera belonging to the *Pseudorbitoides* group have not been detected, but it might be a problem of facies or stratigraphical distribution. Probably, in the European Province, the *Pseudorbitoides* group is substituted in the same environments by the representatives of larger foraminifera belonging to the *Siderolites* group.

The relationship between the American genus *Ayalaina* and the European *Meandropsininae* is not yet studied.

The smaller foraminifera are not abundant in the studied samples with the exception of Nodosariidae: *Lenticulina* and *Nodosaria* (Plate 1, figure 2). Few Cibicides and Textulariidae are also present.

The planktonic foraminifera contained in the same samples are not well preserved but some of them have been identified at the specific level. The recognized species are: *Globotruncana arca* (Cushman), *G. linneiana* (d'Orbigny), *Contusotruncana fornicata* (Plummer), *Globotruncanita stuartiformis* (Dalbiez) and *Heterohelix* sp. ranging from Lower Campanian (*Globotruncana elevata* Zone) to lower Maastrichtian (*Globotruncana falsostuarti* Zone); but their relative abundance and the degree of evolution of the found specimens suggest that the assemblages are from the upper part of the *Globotruncana ventricosa* and/or *Rodotruncana calcarata* Zones.

The foraminiferal content showing the co-occurrence of larger foraminifera assemblages dominated by *Lepidorbitoides* and of planktonic forms associated with some Nodosariidae suggests a deposition in the deeper part of the photic zone, in an open marine environment with terrigenous input. The planktonic assemblages found in the same strata as *L. minima* indicate a middle-upper Campanian age while earlier representatives of the genus *Lepidorbitoides* in Europe: *L. pembergeri* and *L. campaniensis*, are dated middle-late Campanian (van Gorsel, 1978; Wannier, 1980).

OSTRACODS

Besides the works of Van den Bold (1946, 1950) on the Upper Cretaceous of Cuba and British Honduras, of Ljubimova and Sánchez-Arango (1974), and Diaz-Collell et al. (1998) on the Campanian-Maastrichtian of Cuba, and Hazel (1971) and Hazel and Kamiya (1993) on the Maastrichtian of Jamaica, very little is known about Mesozoic ostracode faunas from Central America, and only the work of Lozo (1943) deals with the ostracodes from the Upper Cretaceous of Mexico. Our preliminary examination of the ostracodes from the Cárdenas Formation suggests that additional studies might provide useful stratigraphical and palaeogeographical information.

Ostracode assemblages

The studied samples, collected at the *Lepidorbitoides minima* type locality, have yielded moderately rich and diverse ostracode assemblages. Unfortunately, due to the fair to poor stage of preservation, most species had to be left in open nomenclature.

About a quarter of the ostracode assemblages belong to cosmopolitan and long ranging genera. The genus *Cytherella* is relatively rare and represented by two different species (Plate 2, figures 1, 2) and the genus *Cytherelloidea* by only one species (Plate 3, figure 10). Bairdiidae are common with the genera *Neonesidea* (Plate 2, figures 7, 8, 9) and *Bairdoppilata* (Plate 2, figure 12). It must be also noticed the presence of very rare specimens of *Xestoleberis* (Plate 2, figure 5) and *Bythoceratina* (Plate 2, figure 11).

Among the more significant forms, the genus *Brachycythere* is by far the most common (Plate 3, figures 1-9). It is represented by three species, the most frequent being *Brachycythere* sp. 1 (Plate 3, figures 1-5). This species shows strong affinities with *Brachycythere* sp. 1, *Brachycythere* sp. 2 and *Brachycythere* sp. 6 of Hazel and Kamiya, 1993 from the Maastrichtian of Jamaica as well as with several species known from the Upper Cretaceous of the U.S. Gulf Coastal Plain such as *Brachycythere ovata* (Berry, 1925), *Brachycythere crenulata* Crane, 1965 and *Brachycythere acuminata* Hazel and Paulson, 1964.

Five other significant species have been identified, the two first ones being relatively common in the assemblages:

1) *Haplocytheridea* cf. *dilatipuncta* Crane 1965 (Plate 2, figure 4), known from the middle Tayloran-early Navarroan (middle Campanian-lower Maastrichtian) of the U.S. Gulf Coastal Plain;

2) *Antibythocypris* sp. (Plate 2, figure 8). This genus is common in the upper Cretaceous of the U.S. Gulf Coastal Plain;

3) *Polylophus asper* Crane 1965, (Plate 2, figure 6), described from the upper Navarroan (upper Maas-

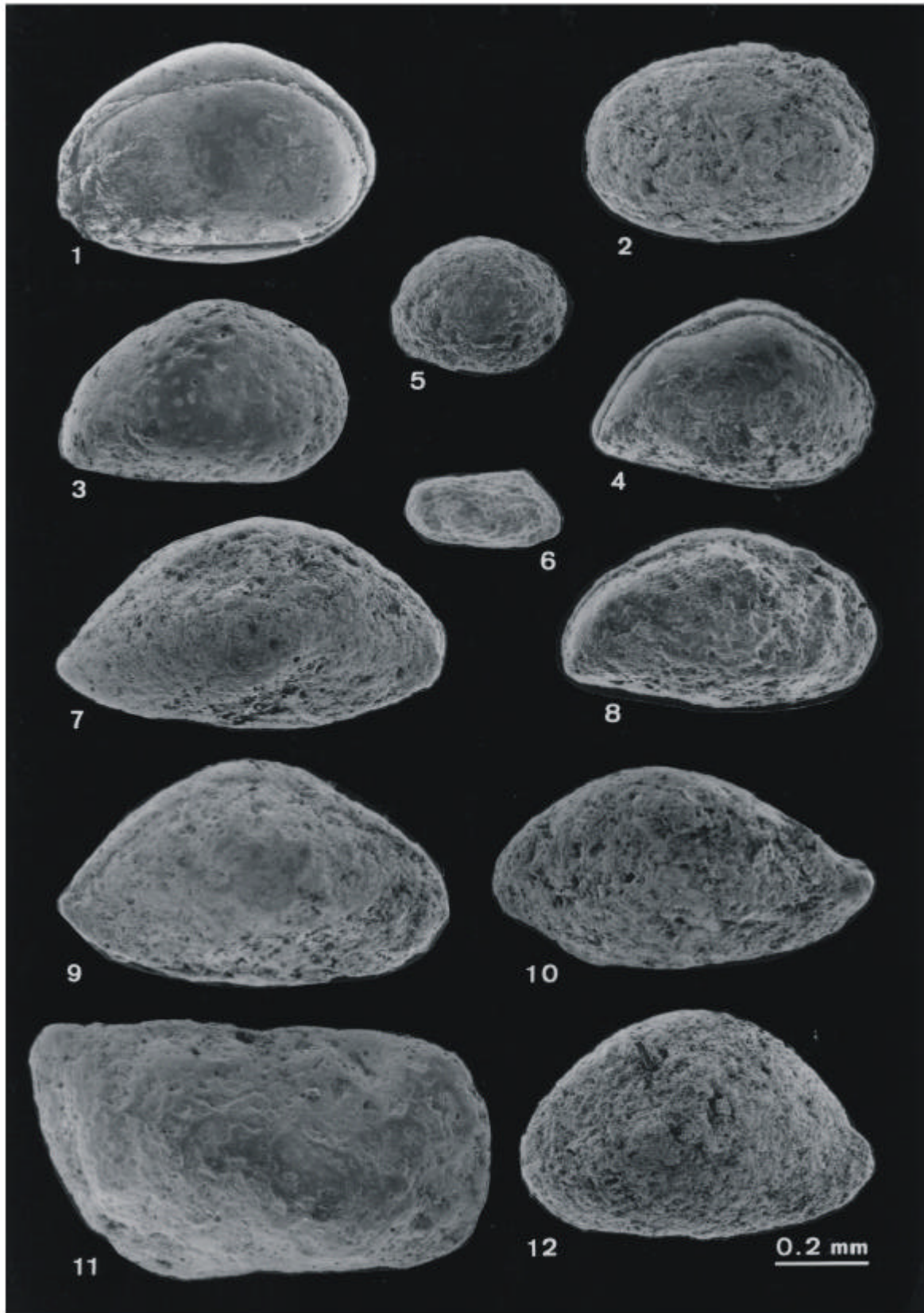


Plate 2. Figure 1: *Cytherella* sp. 1, carapace, left view. Figure 2: *Cytherella* sp. 2, carapace, left view. Figures 3-4: *Haplocytheridea* cf. *dilatipuncta* CRANE; 3. Right valve; 4. Carapace, right view. Figure 5: *Xestoleberis* sp., carapace, left view. Figure 6: *Polylophus asper* CRANE, carapace, right view. Figures 7, 9, 10: *Neonesidea* sp. 1; 7. Carapace, right view; 9. Carapace, right view; 10. Carapace, left view. Figure 8: *Antibythocypris* sp. 1, carapace, right view. Figure 11: *Bythoceratina* sp. 1, right valve. Figure 12: *Bairdoppilata* sp. 1, carapace, left view.

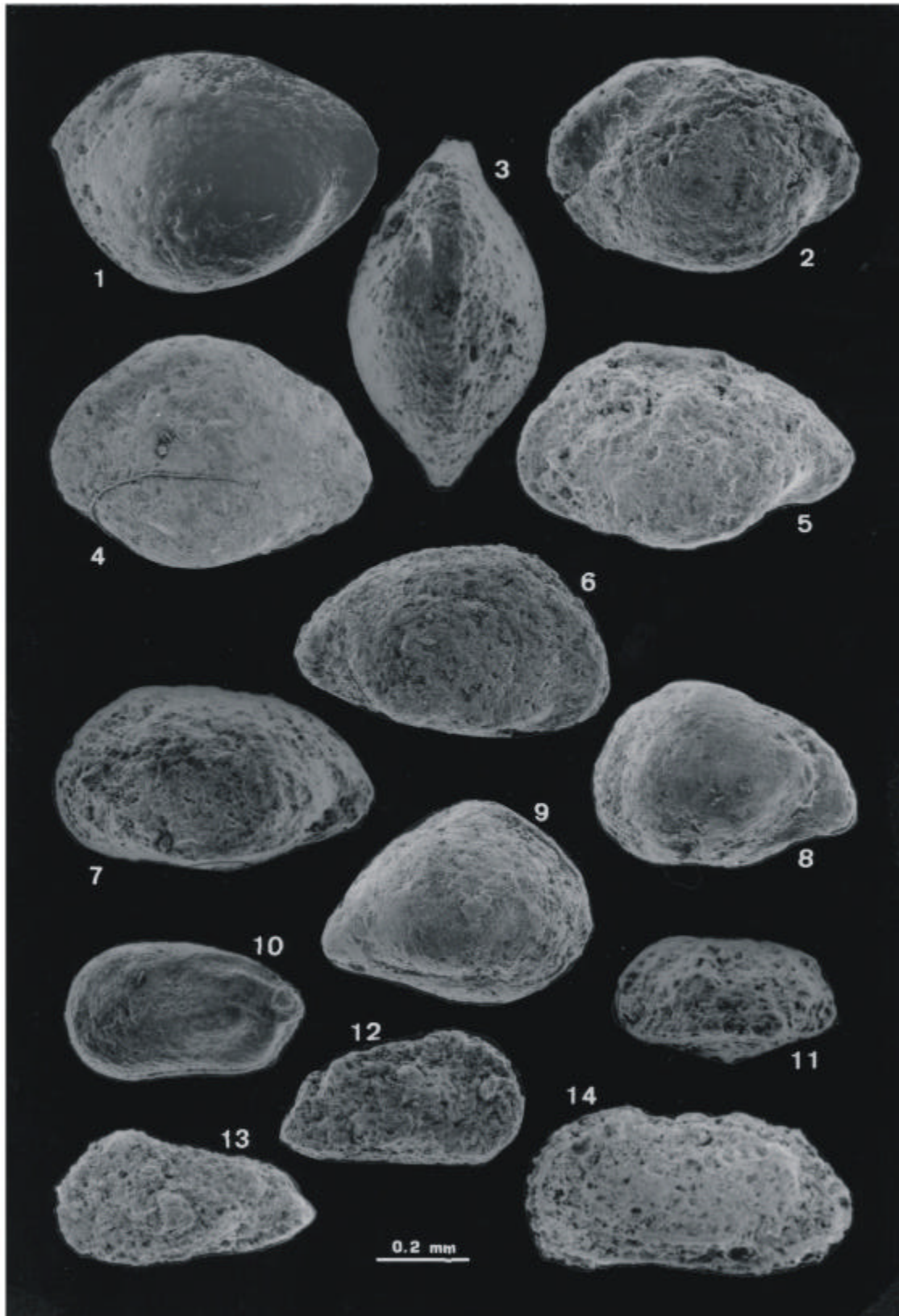


Plate 3. Figures 1-5: *Brachycythere* sp. 1; 1. Carapace, left view; 2. Carapace, left view; 3. Carapace, dorsal view; 4. Carapace, left view; 5. Carapace, left view. Figures 6-7: *Brachycythere* sp. 2; 6. Carapace, right view; 7. Carapace, left view. Figures 8-9: *Brachycythere* sp. 3; 8. Carapace, left view; 9. Carapace, right view. Figure 10: *Cytherelloidea* sp.1, carapace, left view. Figure 11: *Limburgina* sp. 1, carapace, left view. Figure 12: *Trachyleberidea* aff. *geintizi* (Reuss), carapace, right view. Figure 13: *Platycosta* cf. *lixula* (Crane), carapace, left view. Figure 14: *Planileberis* aff. *costatana* (Israesky, 1929), carapace, male, left view.

trichtian) of the U.S. Gulf Coastal Plain;

4) *Platycosta lixula* Crane, 1965, (Plate 3, figure 14), a diagnostic species from the Navarroan (Maastrichtian) of the U.S. Gulf Coastal Plain and also known from the Maastrichtian of Cuba (Ljubimova and Sanchez-Arango, 1974) and of Jamaica (*Platycosta* ? sp. 1 in Hazel and Kamiya, 1993);

5) *Planileberis* aff. *costatana* (Israelsky, 1929) from the upper Taylorian (upper Campanian) of the U.S. Gulf Coastal Plain.

Other Trachyleberididae are represented by very rare specimens of *Limburgina* (Plate 3, figure 11) and *Trachyleberidea* (Plate 3, figure 12). This last genus is represented by a species very similar to *Trachyleberidea geinitzi* (Reuss, 1874), a characteristic species of the European Upper Cretaceous.

Palaeoenvironmental and chronostratigraphical results

Similarly to the foraminifera assemblages, the ostracode faunas characterize the deeper part of a platform as indicated by the mixture of inner to middle neritic genera (*Xestoleberis*, *Haplocytheridea*, *Cytherelloidea*) and of outer neritic ones (*Trachyleberidea*, *Bythoceratina*). The dominance of Bairdiidae together with the genus *Brachycythere* supports this interpretation.

Although at the stage of our knowledge, Mexican Upper Cretaceous ostracode faunas are not suitable for precise age dating, this preliminary study shows some faunal similarities with the Taylorian-Navarroan (Campanian-Maastrichtian) assemblages of the U.S. Gulf Coastal Plain where an ostracode zonation was defined by Hazel and Brouwers, 1982, later emended by Pitatpaivan and Hazel, 1994. The presence of *Platycosta lixula* allows to correlate the Cárdenas Formation with the Maastrichtian *Platycosta lixula* interval-zone of upper Campanian-lower Maastrichtian age (Mancini *et al.*, 1996).

Palaeogeographical comments

The ostracod assemblage of the *Lepidorbitoides minima* type locality strongly differs from the faunas associated with this same larger foraminifera in European outcrops such as in the Campanian type area (Aubeterre SW France), where *Brachycythere*, *Antibithocypris* or *Haplocytheridea* are absent. These two areas belonged during this period to two major distinct provinces separated by the Tethys Ocean, the only tenuous links being the rare occurrence in Mexican assemblages of the Trachyleberidid genera *Limburgina* and *Trachyleberidea*.

The dominance of the genus *Brachycythere* is a common element with the Upper Cretaceous Mexican, Northern American and Caribbean assemblages but also

with the Pan Gondwana faunas *sensu* Dingle (1988) known from the entire Africa and the northern part of South America. It is noticeable that the genus *Brachycythere*, which might have originated as early as in the Aptian in Venezuela (Babinot and Colin, 1988), had during the Upper Cretaceous an extremely widespread distribution in South and North America (Brazil, Surinam, Ecuador, Mexico, the Caribbean, the US Gulf Coastal Plain and the Canadian Atlantic shelf), in the whole Africa, the Middle East and India. Absent in the European Cretaceous, its distribution provides an interesting insight into the development of the Atlantic Ocean and the role of the Tethys as an effective barrier to North-South faunal exchanges.

Affinities with North and West Africa are in fact restricted to the presence of the genus *Brachycythere* but of different species-group. On the contrary, strong affinities are quite obvious with Caribbean Maastrichtian assemblages of Cuba and Jamaica, such as the dominance of clearly related *Brachycythere* species. However, ostracode assemblages from the Cárdenas Formation differs from the Caribbean ones in not missing the South Tethyan genera *Buntonia* and *Ovocytheridea* (Hazel and Kamiya, 1993) also present in South America (Ecuador, Brazil, Surinam and Venezuela) and in Africa. Yet, additional studies concerning Mexican Upper Cretaceous ostracode faunas are necessary to assure that these absences are not only facies-controlled.

The ostracodes from the Cárdenas Formation belong to the clearly individualized Upper Cretaceous Northern American bioprovince (US Gulf Coastal Plain and Canadian Atlantic shelf) because of:

- 1) the dominance of the genus *Brachycythere*, with species clearly related to the Caribbean and Northern American ones;
- 2) the presence of *Polylophus asper* and species closely related to *Platycosta lixula* or *Planileberis costatana*, well known from the Upper Cretaceous of the U.S. Gulf Coastal Plain;
- 3) the presence of the genera *Haplocytheridea* and *Antibithocypris*, well developed in the Upper Cretaceous of the U.S. Gulf Coastal Plain;
- 4) the extreme scarcity of European Trachyleberididae with only a few forms attributed to the genera *Trachyleberidea* and *Limburgina*.

CONCLUSIONS

This new set of microfaunal data relative to the Mexican Upper Cretaceous allows to precise the open marine platform environment of deposition and the middle-upper Campanian age of the lower part of the Cárdenas Formation, assigned to the *Globotruncana ventricosa* and/or *Globotruncana calcarata* planktonic foraminifera Zones and to the *Platycosta lixula* ostracod Zone. These preliminary results might be useful for mapping and deducing the probable geometry of the

Cárdenas Formation. Moreover, the comparison between the studied benthic microfauna with the assemblages recorded in the various Tethysian biogeographical provinces shows that only few significant links exist with European microfaunas, essentially due to the transatlantic occurrence of *Lepidorbitoides*. On the contrary, whereas faunal affinities can be detected with South America despite a very incomplete record, and even slight ones with Africa where *Brachyocythere* is also a dominant element of the ostracod assemblages, the strongest faunal similarities are registered with the Caribbean and Northern American areas.

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