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Salinites grossicostatum (Imlay, 1939) and *S. finicostatum* sp. nov. from the latest Tithonian (Late Jurassic) of northeastern Mexico

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Abstract

Based on our taxonomic revision of the ammonite *Salinites grossicostatum* from the uppermost Tithonian of the La Caja Formation at Puerto Piñones, in the state of Coahuila, northeastern Mexico, we suggest that some specimens described from other Tithonian sites of Cuba and Mexico assigned to *S. grossicostatum* belong to a new species, here presented as *S. finicostatum*. *Salinites grossicostatum* and *S. finicostatum* sp. nov. are endemic to the ancient Gulf of Mexico and are restricted to outer continental shelf environments.

Keywords: *Salinites grossicostatum*, *S. finicostatum*, Tithonian, La Caja Formation, northeastern Mexico.

Resumen

Se describe el amonite Salinites grossicostatum del Tithoniano terminal, basándose en material procedente de la Formación La Caja y coleccionado en Puerto Piñones, estado de Coahuila, en el noreste de México. Nuestra revisión taxonómica indica que algunos especímenes descritos del Tithoniano de Cuba y México asignados a S. grossicostatum, pertenecen a una nueva especie introducida aquí como S. finicostatum. Salinites grossicostatum y S. finicostatum sp. nov., consideradas especies endémicas del antiguo Golfo de México; las cuales se restringen a la plataforma continental exterior.

Palabras clave: Salinites grossicostatum, S. finicostatum, Tithoniano, Formación La Caja, Noreste de México.

1. Introduction

Marine strata of the Upper Jurassic (Kimmeridgian–Tithonian) to lowermost Cretaceous (Berriasian) La Caja Formation is widespread in northeastern and central Mexico and known for their abundant and diverse well-preserved ammonites (*e.g.*, Burckhardt, 1906, 1930; Imlay, 1938; Peña-Muñoz, 1964; Verma and Westermann, 1973; López-Caballero, 2009; Villaseñor *et al.*, 2012, 2015). Here we document ammonites of the genus *Salinites* (Cantú-Chapa, 1968) from these lithostratigraphic units and discuss their stratigraphic and paleoecological importance. *Salinites grossicostatum* (Imlay, 1939) is restricted to the uppermost Tithonian *Crassicollaria* Zone (Adatte *et al.*, 1994) and only occurs in outer shelf environments in the transitional zone between the continental platform and slope, as discussed below.

1.1. Location

The *Salinites*-bearing interval investigated here is located at Puerto Piñones (N25°02.719'/W101°03.396') in southern Coahuila state (Adatte *et al.*, 1994; Zell *et al.*, 2013, 2015; Zell and Stinnesbeck, 2015). A precise description of the locality and the section is provided by Zell and Stinnesbeck (2016, fig. 1). The *Salinites*-bearing layer consists of an approximately 0.3 m thick hemipelagic shaly limestone rich in ammonites. The assemblage is relatively diverse and is

numerically dominated by *Salinites grossicostatum* (Imlay, 1939), but *Himalayites*, *Kossmatia* and *Durangites* are also present. The assemblage characterizes the "*Kossmatia-Durangites-Salinites* beds" (*cf.* Cantú-Chapa, 2006); calpionellids from the layer are indicative of the uppermost *Crassicollaria* Zone (Adatte *et al.*, 1994).

1.2. Material and methods

Our collection of *Salinites grossicostatum* consists of 169 specimens preserved three-dimensionally. They are well preserved, but suture lines are only visible in rare occasions. Specimens analyzed here were collected by WS during the late 1980s and early 1990s over a period of about eight years and are now deposited in the Colección de Paleontología de Coahuila of the Museo del Desierto in Saltillo, Coahuila, Mexico, under the collection numbers CPC-1214–1242, sample box CPC-1243 and CPC-1405–1413. The systematic description follows Arkell *et al.* (1957), Verma and Westermann (1973) and Wright *et al.* (1996). Abbreviations: D, diameter; Wh, whorl height; Ww, whorl width; U, umbilical diameter; U/D, umbilical ratio; Ww/Wh, whorl height to width ratio.

2. Systematic Paleontology

Phylum Mollusca Linnaeus, 1758
Class Cephalopoda Cuvier, 1797
Order Ammonoidea Zittel, 1884
Superfamily Haploceratacea Zittel, 1884
Family Haploceratida Zittel, 1884, *sensu* Ziegler, 1974

Genus *Salinites* Cantú-Chapa, 1968

Type species. *Hildoglochiceras grossicostatum* Imlay, 1939

Salinites grossicostatum (Imlay, 1939)
(Figure 1, Table 1)

Hildoglochiceras grossicostatum sp. nov. Imlay, 1939, p. 27, pl. 2, figs. 5–11, pl. 3, figs. 1–7, 9–11; Imlay, 1942, p. 1444, pl. 2, figs. 3–5; Carreño *et al.*, 1989, p. 219, fig. 77e.

Haploceras cubensis sp. nov. Judoley and Furrazola-Bermúdez, 1968, p. 55, pl. 3, figs. 2–3.

Salinites grossicostatum (Imlay, 1939); Cantú-Chapa, 1976, pl. 1, figs. 1 a–d, f, g, 2 g, 7 a, 8 e, f, pl. 2, fig. 4a; non Cantú-Chapa, 1968, p. 21, pl. 4, figs. 1, 4, 7, 9, pl. 5, figs. 3, 8, 10; ? Imlay and Herman, 1984, p. 160, pl. 1, figs. 9–11; Zell and Stinnesbeck, 2016, p. 4, fig. 3.

Hildoglochiceras (*Salinites*) *grossicostatum* (Imlay, 1939); Myczyński, 1989, p. 86, pl. 2, figs. 10–13, pl. 3, figs. 1–3, 5, 9, 12, pl. 4, figs. 10b, 11a; Myczyński and Pszczółkowski, 1990, pl. 1, fig. 3; non Myczyński, 1989, p. 86, pl. 1, fig. 4, pl. 3, fig. 8, pl. 4, figs. 1, 2, 11b.

2.1. Description

A detailed description of the ontogenetic development and interior shell parameters of *Salinites grossicostatum* is provided by Zell and Stinnesbeck (2016). The authors also document sexual dimorphism in *S. grossicostatum* based on the presence of micro- and macroconchs with diverging trends in septal spacing, especially during the post-embryonic stage. Dimensions of selected specimens are presented in Table 1.

2.2. Remarks

The genus *Hildoglochiceras* is characterized by an evolute compressed shell with a deep median furrow, an apophysis, and strong rursiradiate ventrolateral ribs (see Wright, in Arkell *et al.*, 1957). This diagnosis is only consistent with a single species (*Hildoglochiceras diaboli* Imlay, 1939, p. 25, pl. 6, figs. 8–10) of a total of eight taxa from Mexico originally assigned to *Hildoglochiceras* by Imlay (1939). These Mexican specimens were revised and separated from *Hildoglochiceras* by Cantú-Chapa (1968, p. 19), based on their high degree of involution and the presence of a whorl depression at the dorso- to middle-lateral region of the flank. The author established a new genus, *Salinites*, for these Mexican representatives and included *Hildoglochiceras grossicostatum* Imlay (1939, p. 27, pl. 2, figs. 5–11, pl. 3, figs. 1–7, 9–11) from the "*Durangites* beds" of the La Casita Formation at Sierra de Parras, Coahuila. *Hildoglochiceras propinquum* Waagen (1873–1875, p. 45, pl. 11, figs. 4a, b) and *H. dieneri* Uhlig (1903–1910, p. 18, pl. 7, figs. 8a, b) from the Jurassic of India were considered to be similar to *Salinites grossicostatum* (*e.g.*, Imlay, 1939), but are less involute and their ribs are less pronounced. *Paraglochiceras* Collignon, 1959 has a larger whorl width and no lateral furrow is present, while *Glochiceras* Hyatt, 1900 is more involute and almost smooth.

2.3. Occurrence

Salinites grossicostatum was first described by Imlay (1939) from the upper Tithonian *Durangites* beds in the Sierra de Parras and Sierra de Jimulco, Coahuila, Mexico. The investigated limestone containing *S. grossicostatum* at Puerto Piñones was assigned by Adatte *et al.* (1994) to the uppermost Tithonian "*Durangites* beds" and to the upper *Crassicollaria* Zone, and is stratigraphically located only a few tens of millimeters below the Jurassic–Cretaceous boundary identified on the basis of calpionellid occurrences (Adatte *et al.*, 1994) and the recent identification of the belemnite *Rhaphibelus aciculiformis* Zell *et al.* (2013). At Puerto Piñones, *Salinites grossicostatum* is associated with *Proniceras*, *Himalayites* and *Durangites* (and related forms).

Outside the state of Coahuila, *S.* aff. *grossicostatum* was documented from a bore hole (Paras No. 1) in

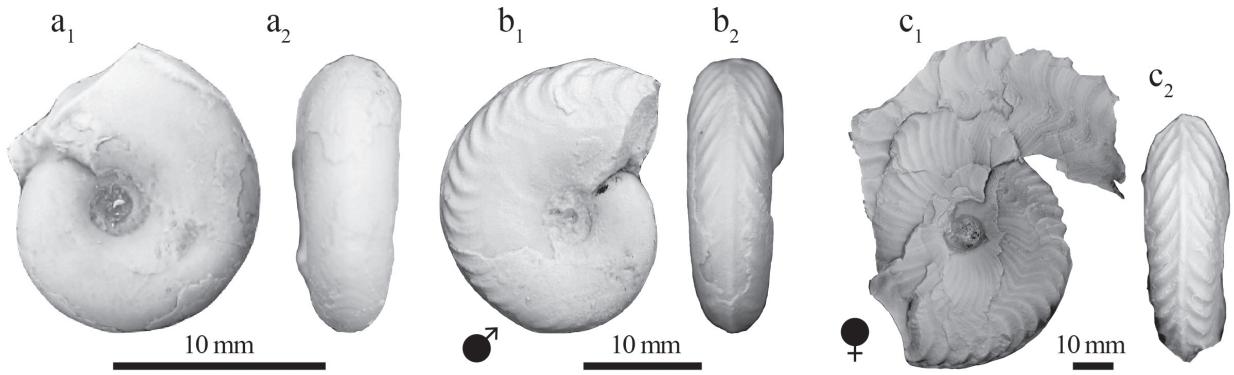

Figure 1. Representative specimens of *Salinites grossicostatum* (Imlay, 1939) from the uppermost Tithonian at Puerto Piñones, Coahuila, Mexico, representing an ontogenetic series from juvenile (a) to mature (c); (a) CPC-1405; (b) CPC-1408, microconch; (c) CPC-1413, macroconch. The specimens were previously illustrated in Zell and Stinnesbeck (2016, fig. 3).

Table 1. Dimensions of selected specimens (in mm).

Sample	D	Wh	Ww	U	U/D	Ww/Wh
CPC-1221	53	25	–	9	0.17	–
CPC-1222	40	19.8	14	7.1	0.18	0.71
CPC-1223	42	21.5	14.2	7.4	0.18	0.66
CPC-1224	38	20.2	12.8	6.5	0.27	0.64
CPC-1225	34.5	17.8	9.8	5	0.15	0.55
CPC-1226	35	19	12.7	5.5	0.16	0.67
CPC-1227	28	14.5	7.6	3.4	0.12	0.52
CPC-1228	24.5	12.6	8	5	0.2	0.54
CPC-1229	34.5	17.4	10.5	5.5	0.16	0.6
CPC-1230	45.6	25	–	6.8	0.15	–
CPC-1231	8.1	4	2.9	1.8	0.22	0.73
CPC-1232	6.9	4.5	3.4	2	0.21	0.76
CPC-1233	10.3	5.2	3.8	2.1	0.2	0.73
CPC-1234	12	6.3	4.3	2.4	0.2	0.68
CPC-1235	12.5	6.8	4.5	2.4	0.19	0.66
CPC-1236	16	8	5	3	0.19	0.63
CPC-1237	17	9	5.5	3	0.18	0.61
CPC-1238	18.5	9	6	3.8	0.21	0.66
CPC-1239	19	10.2	6.5	3	0.16	0.64
CPC-1240	21.2	11.6	6.8	3.2	0.15	0.58
CPC-1241	23.1	12.6	6.5	3.5	0.15	0.52
CPC-1242	24	12.5	7.2	3.7	0.15	0.58
CPC-1405	12	6.1	3.9	2.8	0.23	0.64
CPC-1408	24.1	11	7.9	4.3	0.18	0.69
CPC-1413	–	–	18.9	13.8	–	–

northern Nuevo León (Cantú-Chapa, 1968), associated with *Substeueroceras* ?*imlayi* (Cantú-Chapa, 1963) and *Paradontoceras*. Cantú-Chapa (1976) also identified several specimens of *S. grossicostatum* from the upper Tithonian portion of the La Pimienta Formation in bore hole Bejuco No. 6, 70 km south of Tampico, in Tamaulipas.

In these sections of the Gulf coast of northeastern Mexico (Figure 2), *S. grossicostatum* occurs in outer shelf environments at the transition between the continental shelf and slope (*e.g.*, Adatte *et al.*, 1994). Interestingly, in other correlative sections from the region the taxon is characteristically absent in the Tithonian–Berriasian transition interval; *e.g.*, at Sierra de Chorreras, Chihuahua (Cantú-Chapa, 1976), San Pedro del Gallo, Durango (Burckhardt, 1912; Contreras *et al.*, 1988), Sierra de Catorce, San Luis Potosí (Verma and Westermann, 1973), Tamán, San Luis Potosí (Cantú-Chapa, 1984) and Mazatepec, Puebla (Cantú-Chapa, 1967; Stinnesbeck *et al.*, 1993). These latter sections are either considered to represent environments more shallow than the deposits at the localities with *Salinites grossicostatum* (*e.g.*, Sierra de Chorreras, Chihuahua state, Sierra de Catorce, San Luis Potosí state), or they represent a deeper marine environment on the slope or within the basin (*e.g.*, San Pedro del Gallo, Durango state, Tamán, San Luis Potosí state, and Mazatepec, Puebla state).

Outside Mexico, *Salinites grossicostatum* was reported from the Tithonian Bossier Formation at Sabine Parish, Louisiana, USA (Imlay and Herman, 1984, p. 160, pl. 1, figs. 9–11) and from the upper Tithonian of Sierra de Los Órganos in western Cuba (Imlay, 1942, p. 1444, pl. 2, figs. 3–5; Judoley and Furrazola-Bermúdez, 1968, p. 19; Myczyński, 1989; Myczyński and Pszczółkowski, 1990). The records of the species in Cuba and the southern USA represent depositional environments considered to be similar to the environments containing Mexican occurrences of *S. grossicostatum* (see Fig. 2, localities 6 and 7).

At Puerto Piñones, *S. grossicostatum* is restricted to the latest Tithonian (Adatte *et al.*, 1994; Zell and Stinnesbeck, 2016). This is consistent with the age assigned to the specimens at other sites in Mexico (Imlay, 1939; Cantú-Chapa, 1976). According to Myczyński and Pszczółkowski (1994) and Myczyński (1999), Cuban *Salinites* are also restricted to the latest Tithonian based on the presence of calpionellids preserved in the upper part of the La Zarza Member of the Artemisa Formation, above the "*Vinalesites–Protancyloceras*" assemblage. Myczyński (1989) also identified *Salinites* in the El Americano Member of the Guasasa Formation. Cobiella-Reguera and Olóriz (2009)

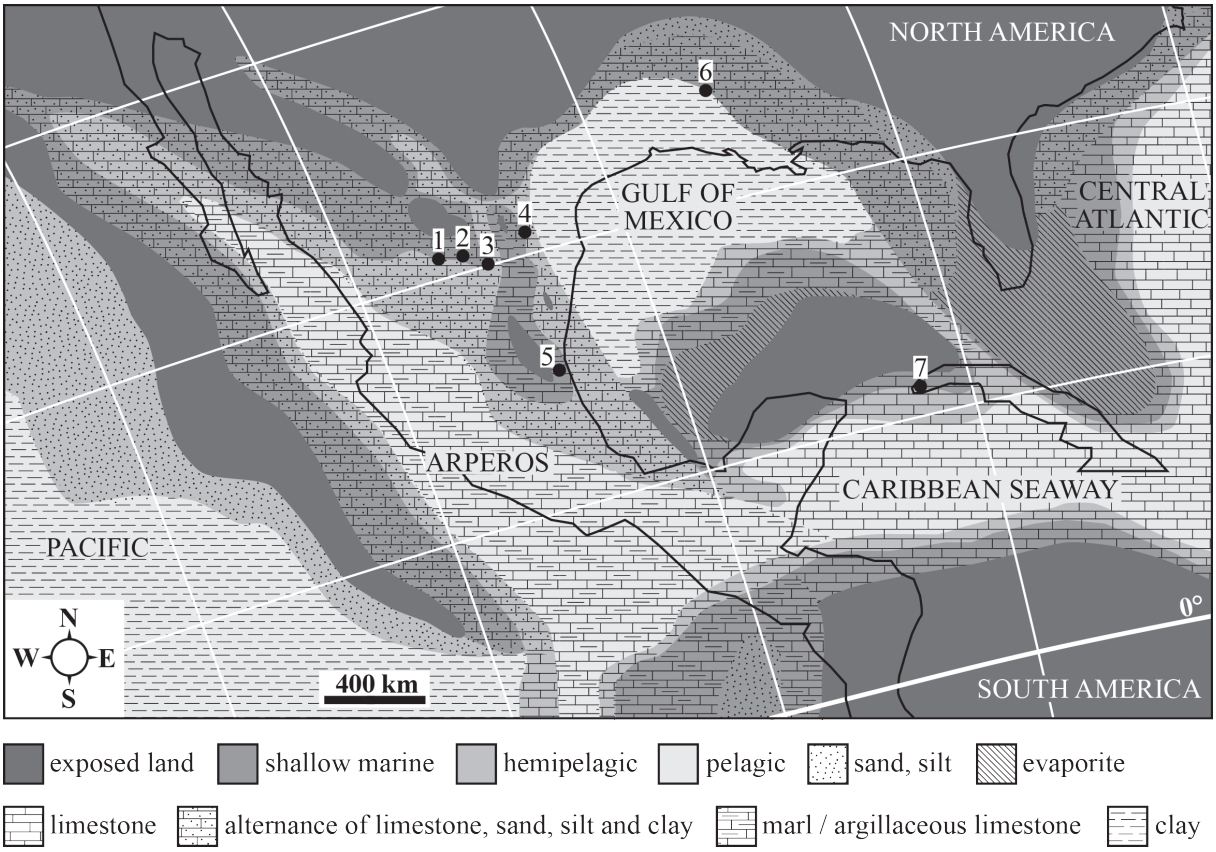

Figure 2. Tithonian paleogeographic map of the Gulf of Mexico and adjacent realms including latest Tithonian occurrences of *Salinites grossicostatum* (see numbers). The distribution of *S. grossicostatum* is restricted to shallow marine, outer shelf environments. (1) Sierra de Jimulco; (2) Sierra de Parras; (3) Puerto Piñones; (4) bore hole Paras No. 1; (5) bore hole Bejuco No. 6; (6) Sabine Parish; (7) Sierra de Los Órganos. Map simplified and redrawn after Wilhem (2014), with additional information from Goldhammer and Johnson (2001); see text for locality information.

assigned Cuban *Salinites*-bearing beds from the El Americano Member to the latest Tithonian–early middle Berriasian (upper *Crassicollaria* and/or *Calpionella* zones). Nevertheless, the precise age of the sediments is debated (see Pszczółkowski, 2013).

Salinites finicostatum sp. nov.
(Figure 3)

Salinites grossicostatum (Imlay, 1939); Cantú-Chapa, 1968, p. 21, pl. 4, figs. 1, 4, 7, 9, pl. 5, figs. 3, 8, 10.

Hildoglochiceras (*Salinites*) *grossicostatum* (Imlay, 1939); Myczyński, 1989, p. 86, pl. 1, fig. 4, pl. 3, fig. 8, pl. 4, figs. 1, 2, 11b.

2.4. Material

One three-dimensionally preserved specimen (CPC-1404) from a Corg.-rich mudstone of the uppermost La Caja Formation at Cañón de Huizachal, Tamaulipas state (for locality see Montellano *et al.*, 2008, p. 1131, fig. 1), associated with an imprint of an ammonite assigned to *Suarites*. Accompanying calpionellids are rare but indicate a latest Tithonian or earliest Berriasian age. Suture-lines are not visible.

2.5. Etymology

The species name "*finicostatum*" is Latin for "fine-ribbed".

2.6. Diagnosis

A *Salinites* with finer and less regular ribs than those of *S. grossicostatum* (Imlay, 1939). The taxon is also distinguished from this latter species by a slightly wider umbilicus, higher whorl widths and a stronger serrated keel.

2.7. Description

Medium sized (D = 29.5 mm), involute (U/D = 0.2), discoidal with largest whorl width closely below the middle of the flank (Wh = 15 mm; Ww = 10.3 mm; Ww/Wh = 0.69). The umbilicus is narrow (U = 6.0 mm) and shallow; the umbilical wall is vertical. The flanks are convex, the venter rounded with a serrated keel. Fine, prorsiradiate ribs of equal strength are present between the umbilical ridge and mid-flank. Fine ventrolateral ribs of irregular strengths and spacing are present; they are simple but some bifurcate closely above mid-flank. Here they are rursiradiate but ventrolaterally become prorsiradiate.

2.8. Remarks

Imlay's type material of *Hildoglochiceras grossicostatum* (Imlay, 1939, pl. 3, figs. 3, 4) consists of juveniles ($D_{max.}$ = 24.5 mm); however, adult material of Cantú-Chapa (1968), as well as specimens described by Myczyński (1989) from the Tithonian of Cuba, differ from Imlay's type material of *Hildoglochiceras grossicostatum* and from our material from Puerto Piñones by finer ribs of irregular expression and spaced at smaller distances. These differences are here considered to be significant and permit definition of a new species of *Salinites*, *S. finicostatum*. *Haploceras cubensis* Judoley and Furrazola-Bermúdez (1968, p. 55, pl. 3, fig. 1) from the upper Kimmeridgian to lower Tithonian Artemisa Formation of western Cuba is similar in ribbing, but differs from *S. finicostatum* by slightly less involute coiling, a pronounced lateral furrow during early ontogenetic stages and by a smaller whorl width.

2.9. Occurrence

Salinites finicostatum is here reported from the upper

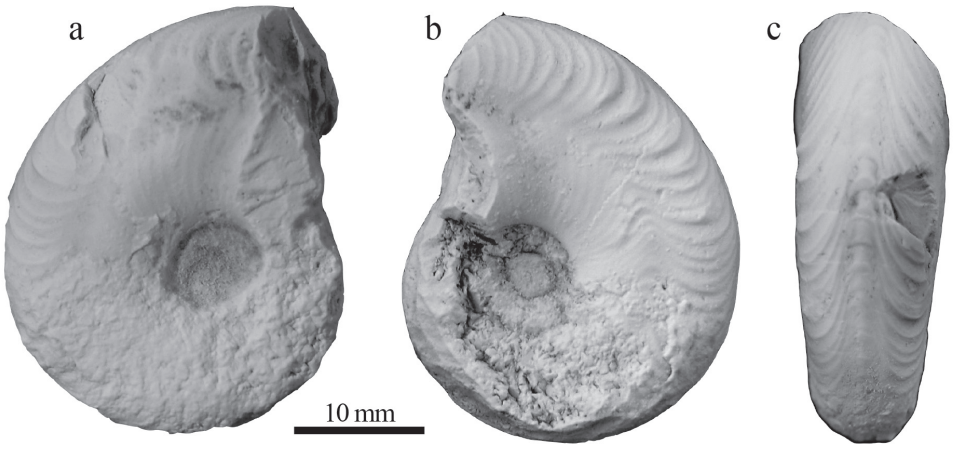

Figure 3. *Salinites finicostatum* sp. nov. (CPC-1404) from the uppermost La Caja Formation at Cañón de Huizachal, Tamaulipas. (a) left side view; (b) right side view; (c) ventral view.

Tithonian–lower Berriasian of Huizachal Canyon in Tamaulipas as described here, and the upper Tithonian at Rancho Las Juanas at Galeana, Nuevo León, associated with *Proniceras* (P.) *subpronum* Burckhardt (1919–1921) and *Durangites* spp. (Cantú-Chapa, 1968). The species is also present in the upper Tithonian of Cuba (Myczyński, 1989, p. 86, pl. 1, fig. 4, pl. 3, fig. 8, pl. 4, figs. 1, 2, 11b) and is there associated with *Salinites grossicostatum* (Myczyński, 1989, p. 86, pl. 2, figs. 10–13, pl. 3, figs. 1–3, 5, 9, 12, pl. 4, figs. 10b, 11a).

3. Conclusions

Salinites grossicostatum (Imlay, 1939) is restricted to the *Crassicollaria* Zone (Adatte *et al.*, 1994) of the uppermost Tithonian "*Kossmatia-Durangites-Salinites* Beds" (*cf.* Cantú-Chapa, 2006). The species, known from Coahuila and Nuevo León in Mexico, western Cuba, and the southern US, only occurs in outer shelf environments in the transitional zone between the inner continental shelf and slope. A second, closely related taxon, *Salinites finicostatum* sp. nov., occurs in coeval strata in the Mexican states of Tamaulipas and Nuevo León (Cantú-Chapa, 1968) and is also present in Cuba (Myczyński, 1989), but its ecological preferences are unclear. *Salinites* is thus endemic to the ancient Gulf of Mexico.

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