ABSTRACT – Plate sections of saccocomid crinoids spotted in the Albian carbonate deposits of the Georgetown Formation from Sierra Azul (Coahuila, NE, Mexico) are reported and described. These microfossil remains consist of discarded proximal plates and partial thecae, i.e. primibrachial plates and radial pieces of a partial cup. These roveacrinioids are associated with calcisphere blooms and an abundant diversified planktic foraminiferal assemblage, mostly consisting of favusellids. All these features are evidence of a high primary productivity within an unstable deepening environment. Such pelagic crinoids have been so far regarded as opportunistic organisms that thrived during transgressive eustatic levels and phyto-planktic blooms, in abundance/accumulation events all indicative of hypoxic conditions. The overall microfossil assemblage assigns to this finding an Albian-Early Cenomanian age. Such an event might be well correlated and/or contemporaneous to the bundle of hypoxic events known as OAE1. Such saccocomid plates in Albian deposits revive the debate on the transition between the late Jurassic genera (Saccocoma Agassiz and Crassicoma Sieverts-Doreck & Hess, in Hess) and the late Cretaceous ones (mainly Applinocrinus Peck).

Keywords: microfacies, Roveacriniida, Albian, Mexico.
RESUMO – Seções de placas de crinoides saccocomídeos oriundas de depósitos carbonáticos albianos da Formação Georgetown, em Sierra Azul (Coahuila, NE, México) são registradas e descritas. Estes restos fósseis consistem de placas proximais descartadas e parte de teca, i.e. placas primibraquiais e peças radiais da taça parcial. Estes roveacrinoides são associados a florações de calcisferas e a uma associação diversificada e abundante de foraminíferos planctônicos, constituída principalmente por favuselídeos. Todos esses aspectos constituem evidência de alta produtividade primária num ambiente instável de batimetria crescente. Tais crinoides pelágicos têm sido considerados como organismos oportunistas que se prosperaram durante fases eustáticas transgressivas e florações fitoplanctônicas, constituindo eventos de acumulação abundante sob condições hipóxicas. O conjunto das associações fósseis leva a atribuir idade albiana a eocenomaniana a este registro. O registro pode ser considerado correlato e/ou coecvo do evento anóxico conhecido como OAE1. Estas placas de saccocomídeos de acumulação abundante sob condições hipóxicas. O conjunto das associações fossilíferas leva a atribuir idade albiana a eocenomaniana a este registro. O registro pode ser considerado correlato e/ou coevo do evento anóxico conhecido como OAE1. Estas placas de saccocomídeos em depósitos albianos vêm reativar a discussão sobre a existência de formas transicionais entre gêneros neojurássicos (Saccocoma Agassiz and Crassicoma Sieverts-Doreck & Hess, in Hess) e os neocretáceos (principalmente Applinocrinus Peck).

Palavras-chave: microfácies, Roveacrinida, Albiano, México.

INTRODUCTION

The north and northeastern parts of Mexico extensively expose Upper Cretaceous marine carbonate deposits that have been long the scope of stratigraphic studies (PEMEX, 1988). There, the Lower Cretaceous (Albian) widely outcropping carbonates record the evolution of a marine shelf environment. Within this tectonic, paleogeographic, and sedimentological framework lies one of the most studied geographic areas in Mexico, the Sabinas Basin, well known for its tremendous geological importance and economic bearings. This basin is restricted by the fold belt and Parras-Popa provinces of the eastern Sierra Madre, and the Coahuila Platform to the south, by the Chihuahua Platform to the west, and by the Burro Platform to the east and north (Eguiluz de Antuñano, 2001).

This basin originated as a rift-type basin bounded by tectonic and paleogeographic blocks: the Coahuila Block in the southeast and the Tamaulipas Block in the northeast (Eguiluz de Antuñano & Aranda-Garcia, 2000). Within this basin were deposited different Mesozoic formations such as the Georgetown Formation, mostly consisting of well stratified, thin to massive, highly fossiliferous limestone beds, with abundant fossil specimens (Hernández, 1977 in Hernández-Noriega et al., 1999, 2000). From the fossil content and its stratigraphic position, the middle carbonates of the Georgetown Formation have been assigned to the Albian (Hill, 1901; Echanove-Echanove, 1986; Humphrey & Díaz, 2003; Housh, 2007). The present study arises from the mapping effort of the Mexican Geological Survey (SGM by its Spanish initials) towards the publication of the Geological-mapping Map Espinazo G14-A73 (scale 1:50,000), covering the adjacent border area between Nuevo León and Coahuila states.

The exploration efforts have been concentrating on a two-fold approach: 1) issuing a detailed paleontological analysis for the Georgetown Formation stratigraphic sequence by means of microfacies (thin sections); 2) proposing a taxonomic identification of spotted roveacrinoidal remains, towards a subsequent biostratigraphic framework and correlation potentials.

Routine micropaleontological analysis recognized a microfossil association characteristic of a late Albian age and consisting of planktic foraminifers, calcispheres and crinoidal remains (order Roveacrinida; Monier Castillo et al., 2017a). This latter find is worth of mention since the occurrence of roveacrinids in these rocks has never been mentioned ever before in this area, except from grey literature (unpublished internal reports). The present study deals with the morphological description and the tentative systematic identification of these roveacrinoids (e.g. Douglas, 1908; Peck, 1943, 1955, 1973; Rasmussen, 1961; Kristan-Tollmann, 1991; Jagt, 1999; Gale, 2016, 2017), sections of which bear interesting stratigraphic promise (e.g. Bonet, 1956; Kristan-Tollmann, 1970; Bengtson & Berthou, 1983; Berthou & Bengtson, 1988; Ferré & Berthou, 1994; Ferré, 1995, 1997; Dias-Brito & Ferré, 1997, 2001; Ferré & Granier, 2001). Accordingly, we report their occurrence and subsequent stratigraphic range within the scope of outlining the correlational potentials of these Albian roveacrinoidal plates for Mexico, the adjacent areas and further abroad.

GEOLOGICAL SETTING AND SAMPLE LOCATION

The studied material comes from a carbonate sequence that outcrops in the locality of Sierra Azul, near Castaños town, Coahuila State (26°24'48.9"N - 101°15'11.6"W; Figure 1). Within the scope of the mapping works of the SGM team for the Espinazo map in the area of Sierra Azul, a lithological sequence, ca. 42 m in thickness, had been logged. During this geological record special attention has been paid to lithological variations, as well as their stratigraphic relationships pending on the specificities of the study area. Hand samples were precisely localized from sound bulk rocks. Thin sections were processed in the facility of the SGM at Centro Experimental Oaxaca, as a couple of large-sized ones, one parallel, the other perpendicular to the bedding plane. While searching for standard/classical microfossil index species in order to record the petrographic description and the paleoenvironmental interpretation of these microfacies, various oriented sections of roveacrinoidal affinity were detected.

The lithological succession (Figure 2) is composed, from base to top, of: 1) dark grey, fine-grained, medium-to-thick limestone beds with common echinoderm remains (16 m); 2) brown to grey, fine-grained, well-bedded medium carbonate beds with hematitic nodules (10 m); and 3) dark brown, fine-grained, thin-to-medium carbonate beds (17.78 m).
According to the lithological succession and associated microfaunal association, these carbonate beds are assigned to the Georgetown Formation of mid–to–upper Albian age (Hill, 1901). Lithological samples displaying roveacrinoidal microfacies are indicated in Figure 2.

**BIOSTRATIGRAPHY AND ASSUMED AGE OF ROVEACRINOIDAL ASSEMBLAGES**

These carbonate deposits were first scrutinized within the scope of the revision of the geological map with the purpose of refining the stratigraphy of this area. To date no macrofaunal evidence has been found during the initial field exploration to provide a precise standard biozonal assignment. Originally Hill (1901) mentioned in this unit the following taxa: *Pachydiscus brazoensis* (Shumard, 1860); *Schloenbachia leonensis* Conrad, 1857; *Epiaster elegans* Adkins, 1920 [now = *Macraster elegans* (Shumard, 1853)]; *Kingena wacoensis* (Roemer, 1852); *Gryphaea washiataensis* Hill, 1884 [now = *Teixigryphaea washiataensis* (Hill, 1884)]; *G. corrugata* Say, 1898; *Exogyra americana* Marcou, 1842; *E. plexa* Cragin, 1893; *Alectryonia carinata* (Lamarck, 1806); and *Lima wacoensis* Roemer, 1852. Likewise, Housh (2007) reported additional species, namely: *Idiohamites fremontii* (Marcou, 1842), *Eopachydiscus marcianus* Cobban, 1987; *Mortoniceras trinodosum* Böse, 1910; *M. maximum* Lasswitz, 1904; *M. wintoni* Adkins, 1920; *Prohysteroceras austinense* (Roemer, 1852); *Mariella brazoensis* Roemer, 1852; *Amphidonte walkerii* (White, 1879); and *Teixigryphaea washiataensis* (Hill, 1898). Ammonites (especially genera *Mortoniceras*, *Mariella*, *Schloenbachia*, and *Eopachydiscus*) and other macrofossil species, both groups of index fossils of the middle–upper Albian then support the middle-to-late Albian age of these fossiliferous layers.

A general microfacial investigation had been performed to look for some standard microfossil index. During routine examination, echinoderm remains were spotted: given their widespread, repeated occurrence, their relative usefulness and meaning in the historical Mexican stratigraphy (e.g. Bonet, 1956), the authors chose to investigate them more thoroughly within the scope of enhanced potentials for stratigraphic precision.

The identified roveacrinoid species from the Albian of the Georgetown Formation display close resemblance to saccoomcid taxa described by Sieverts-Doreck & Hess (in Hess, 2002) from the Upper Jurassic strata of southern Germany. At that time of full description, their extinction before or at the Jurassic–Cretaceous boundary was still a matter of debate. The material at hand is therefore evidence...
Figure 2. Stratigraphic column of the studied section. Keys SA-01 to SA-17 represent sampled levels while stars indicate the samples displaying roveacrinoidal microfacies.
for earlier forms of saccocomids to cross the J/K boundary into Albian deposits. The questions lying ahead now are how long these genuine saccocomids persisted into the Cretaceous and their relationship to the genus Applinocrinus Peck, 1973 and other Cretaceous relatives (Gale, 2016, 2017).

In the Georgetown Formation, these crinoid remains occur in association with planktic foraminifers and calcispheres, indicating a middle–late Albian age (Monier-Castillo et al., 2017b). The microfacies at hand display microfossil evidence such as: planktic foraminifers among which abundant favusellids [Favusella washitensis (Carsey, 1926), F. scitula Michael, 1973, F. pessagnoi Michael, 1973 – all these favusellid species are usually considered conspecific to F. washitensis], some ticinellids [Ticinella roberti (Gandelfi, 1942), T. primula Luterbacher, 1963], bishopellids [Bishopella ornelasae Trejo, 1983; B. alata Trejo, 1983], calcidinoflagellate cysts [Calcisphaerula innominata Bonet, 1956], and some small benthic foraminifers. Such a planktic foraminifer and calcisphere association is characteristic of a middle–late Albian age (Scott, 2009).

**SYSTEMATICS**

The supra-generic systematics follow the scheme proposed by Hess & Messing (2011), amended by Wright et al. (2017). The material herein described (thin sections) is housed in the Paleontological Collection of the SGM, Mexico, under the abbreviation SA (for Sierra Azul) and catalogue numbers from SA-01 to SA-18. Given the lack of complete thecae and/or specific diagnostic thecal plates, we chose to leave these specimens under open nomenclature until further additional material, and compared them to already known species from Upper Jurassic. Worth of mention is that nine roveacrinoidal microfacies levels have been noticed so far, but only four of them (namely samples SA-03, SA-07, SA-08, and SA-09) provided plate sections susceptible to be appropriately identified systematically. The relatively good preservation of sections allowed us to recognize diagnostic features that identify them to family level and compare them to Late Jurassic taxa, on the basis of the seminal works of Lombard (1937, 1945), Brönnimann (1955), Verniory (1954-62), Ferré & Berthou (1993), Ferré & Granier (1997, 2000, 2001), and Hess (2002).

Class CRINOIDEA Miller, 1821
Subclass ARTICULATA Zittel, 1879
Order ROVEACRINIDA Sieverts-Doreck, 1953
Family SACCOCOMIDAE D’Orbigny, 1852

Genus et species indet. 1
(Figures 3A–B)

**Material.** Thin sections labelled SA-08 (SA-08/01 and SA-08/02).

**Description.** Figure 3A (SA-08/01) depicts three plate sections assumed to be conspecific. In the upper left corner is a sub-oblique tangential section of a second primibrachial plate (sub-Obl/TgS-IBr2). The gross outline of this plate section is somewhat blunt and resembles a rice grain; the radial ‘ridge’ is flanked by two large muscular facet areas (the right one is mostly missing on the picture). In the middle lower side lies a tangential longitudinal section of thecal plates (Tg/LgS-Rad/Theca), displaying a deep, elongate ambulacral furrow and suggesting a narrow and long primibrach outline; the articular facet is small. In the lower right corner is a ‘massive’, high-magnesium calcite (HMC) section, with some butterfly-like outline. This is a paraxial transverse section of a theca (Ax/TS-Rad/Theca). The two interradial processes intersected by the section plane are responsible for the two calcitic ‘butterfly wings’ on each side of a small radial articular facet. The theca is small, low but wide due to the oval-rounded interradial lobes flanking the tiny articular facet at the rim of the cup. The lateral outline displays some reticulate, reticulate surface. The minute aboral ligament pit is in the section plane. The basals and/or centra are not visible on the section. Figure 3B (SA-08/02) shows a longitudinal axial section of a first secundibrach (Ax/LgS-IIBr1) of genuine Saccocomidae affinity. The proximal end of this plate is cup-like, suggesting a large slope distal articular facet to the second secundibrach. The main body of the plate is thin and elongate; its outer surface shows neither trace of reticulation, nor ridgelet, nor secondary spine expansion. The axial canal, as a ventral groove, is faint but distinct.

**Discussion.** The overall outline of the presumed thecal section resembles much the theca (basals partly fused with centrale) of Crassicoma feifeli Sieverts-Doreck & Hess (in Hess, 2002; pl. 8, fig. 4). The interradial processes are oval-shaped, instead of sharp and slender, the tiny articular facet is at the rim of the cup, in the central area between the interradial processes. As for the primibrachial plate sections, the first primibrachial plate is slightly elongated, dorso-ventrally flattened, and pin-like; its outline shows a moderate swelling at its end and a relatively ‘wide’ feeding groove. We cannot distinguish any outer ornamentation. It recalls and matches well with the first primibrachial plate of p. 8, fig. 10 (Hess, 2002), the second primibrachial being thin and really elongated (pl. 8, fig. 11; Hess, 2002). Concerning the theca section, the two blunt radial areas are oval and lappet-like, separated by a tiny articular facet at the upper thecal rim. This set of plates is comparable to the brachials from the Upper Jurassic of Germany (Hess, 2002). We suggest that the material at hand from the Albian of Mexico is close to the original lower Kimmeridgian species C. feifeli. However this material is not sufficient to precise their phylogenetic affiliation; they could either be conspecific (with a very large vertical range implying the J/K boundary crossing for genus Crassicoma), or being the Lower Cretaceous descendant of genus Crassicoma.

Class CRINOIDEA Miller, 1821
Subclass ARTICULATA Zittel, 1879
Order ROVEACRINIDA Sieverts-Doreck, 1953
Family SACCOCOMIDAE D’Orbigny, 1852

Genus et species indet. 2
(Figure 3C)

**Material.** Thin section labelled SA-08 (SA-08/03).

**Description.** Figure 3C (SA-08/03) depicts an axial sub-tangential longitudinal section of a first primibrach (Ax/subTg/Lg-IIBr1) of a genuine saccocomid. The section plane...
is slightly deported ‘inwards’ on the interior/proximal side. The plate is higher than broad. The proximal part is thicker than the distal one. The proximal articular fossa is of medium size. The inner side has a V-shaped central part with a broad, flat furrow flanked by two exterior trapezoidal ‘wings’, suggesting a long, broadly ‘blocked’ cryptosynarthrial surface with a rather large central canal (ambulacral furrow between muscle fields).

**Discussion.** The ossicle is identified as a first primibrachial plate IBr1 (Figure 3C): slightly elongated and dorso-ventrally flattened, showing a muscular articulation, a non-muscular and sloping distal articulation, and an external surface devoid of ornamentation. It differs from a second primibrachial plate (IBr2) that is strongly wedge-shaped with a triangular profile, lacking both wings and oral processes. The general silhouette of this section (and subsequent identified plate) recalls that of the first primibrachials illustrated by Hess (2002) for *Crassicoma praeschattenbergi* Sieverts-Doreck & Hess (in Hess, 2002, pl. 6, figs. 7a–b; 8a–b). Indeed the relative proportions of the primibrachial (Hess, 2002, pl. 6, fig. 7) actually matches with the section at hand. Consequently, it raises once more the issue of the stratigraphical range of Upper Jurassic saccochromids: in the present case, either the range of *C. praeschattenbergi* (upper Kimmeridgian) runs through the J/K boundary up to Albian, or the section at hand might represent a brand new saccochromid taxon.

**Genus et species indet.**

(Figures 3D–E)

**Material.** Thin sections labelled SA-08 (SA-08/04 and SA-08/05).

**Description.** Figure 3D (SA-08/04) shows a transverse section of a brachial plate (TS-NBrn) of a genuine saccochromid. Such a microfacial section is typical and recalls the standard brachial sections of the Jurassic saccochroma microfacies (for details, see Lombard, 1937, 1945; Verniory, 1955-1962). Figure 3E (SA-08/05) consists in a partial oblique/tangential longitudinal section of a first/second primibrach (Obl/Tg/LgS-IBr1-2) of a saccochromid. This kind of ‘safety pin’ outline evidences a deep ambulacral furrow, a narrow and long primibrach outline, and a small- to medium-sized articular facet.

**Remarks.** These brachial ossicle sections are distinct from those of any *Saccocoma* brachial plates, they are similar to proximal brachials of *Crassicoma schattenbergi* Sieverts-Doreck & Hess and *Crassicoma subornata* Sieverts-Doreck & Hess (Hess, 2002) but they differ from those ossicles by lacking a reticulate ornament on their surface. This lack of ornamentation could be a mere sign of a new “*Crassicoma*” taxon from Lower Cretaceous.

**Saccocomidae indet.**

(Figures 3F, 4A–E)

**Material.** Four thin sections labelled SA-03 (SA-03/01), SA-07 (SA-07/01) SA-08 (SA-08/06), and SA-09 (SA-09/01, SA-09/2 and SA-09/03) respectively.

**Description.** Assignment to generic and specific positions is difficult; given the lack of specific ornamental features we chose to leave all these morphologically characteristic sections in open nomenclature. Under this family level label are mostly gathered longitudinal paraxial and transverse sections of tertiibrachial (median to distal brachial) plates, morphology of which were extensively studied and illustrated by Lombard (1937, 1945) and Verniory (1956-1962) from the Swiss Upper Jurassic carbonate deposits. Transverse sections display an obvious V-shape while longitudinal paraxial sections resemble some safety pin, sometimes with square-to-rounded ends (that is, traces of articular facets). All these sections are devoid of ornamentation (lack of spines, wings, reticulation and/or corrugations). Figure 3F (SA-03/01) represents a transverse section of a secondibrachial plate (TS-IIBr2). The articular fossa is oval and medium-sized; the inner feeding groove is large, elliptical, and flanked by two alar expansions; the outer rounded side shows some radial ridges (crenulation/slight corrugation). Figure 4A (SA-07/01) both feature most likely a tangential section of a thecal or primibrachial plate (TgS-Theca/IBr1-2) of roveacrinoid affinity (‘saccocomid’). Figure 4B (SA-08/06) shows a tangential longitudinal section of a first/second primibrach (Tg/LgS-IBr1-2) that displays a small articular facet, a deep elongate ambulacral furrow, and suggests a narrow and long primibrach outline. Beside this section (right side) lies a ‘massive’ HMC, butterfly-like section: this is a paraxial transverse section of a theca (Ax/Ts-Rad/Theca); unfortunately the basals and/or centrales are not visible. The two interradial processes intersected by the section plane are responsible for the two ‘butterfly wings’ flanking the small radial articular facet, with a minute aboral ligament (in the section plane). The lateral outline displays some reticulate, crenulate surface. Figure 4C (SA-09/01), slightly below the centre of the picture, is a transverse section of a distal brachial plate (TS-NBrn) of an indeterminate roveacrinoid saccochromid (?), showing a triangular outer shape, a marked inner feeding groove, and a radial ornamental keel. Figure 4D (SA-09/02) illustrates a small and partial section that could be interpreted either as a tangential section of a primibrach, or a partial transverse section of a broken theca. However it is indeed a tangential longitudinal (paraxial) section of a short and blunt primibrachial plate (Tg/LgS-IBr2) of a saccochromid. Figure 4E (SA-09/03) depicts a transverse section of a distal brachial plate (TS-NBrn), showing a triangular outer shape, a marked inner feeding groove, and a radial ornamental keel, all features recalling a true saccochromid.

**Remarks.** The brachial ossicles observable in the thin sections at hand are slightly larger than any *Saccocoma* brachial plate ever reported from Upper Jurassic deposits. Furthermore, they show relatively blunt (compared to true *Saccocoma*) oral projections. They are similar to proximal brachials of *Crassicoma schattenbergi* Sieverts-Doreck & Hess and *C. subornata* Sieverts-Doreck & Hess, figured in Hess (2002).
Figure 3. A–B, Genus et species indet. 1. A, second primibrachial plate, sub-oblique tangential section (sub-Obl/TgS-IBr2); indeterminable primibrachial plate, tangential longitudinal section (Tg/LgS-IBr1-2); and theca/radial plate, paraxial transverse section (Ax/Ts-Rad/Theca) [TS no. SA-08/01]; B, first secundibrachial plate, longitudinal axial section (Ax/LgS-IIBr1) [TS no. SA-08/02]. Both magnification: x 6.3. C, Genus et species indet. 2, first primibrachial plate, axial sub-tangential longitudinal section (Ax/subTg/Lg-IBr1) [TS no. SA-08/03]. Magnification: x 10. D–E, D, Genus et species indet. 3, indeterminable brachial plate, transverse section (TS-NBrn) [TS no. SA-08/04]; E, indeterminable primibrachial plate, partial oblique/tangential longitudinal section (Obl/Tg/LgS-IBr1-2) [TS no. SA-08/05]. Magnification: x 10. F, Saccocomidae indet., secundibrachial plate, transverse section (TS-IIBr2) [TS no. SA-03/01]. Magnification: x 10.
Figure 4. A–E, Saccocomidae indet. A, thecal or primibrachial plate, tangential section (TgS-Theca/IBr1-2) [TS no. SA-07/01]; B, first-second primibrachial plate, tangential longitudinal section (Tg/LgS-IBr1-2), and theca, paraxial transverse section (Ax/TS-Rad/Theca) [TS no. SA-08/06]; C, distal brachial plate, transverse section (TS-NBrn) [TS no. SA-09/01]; D, primibrachial plate, partial tangential section, or broken theca, partial transverse section (TgS-IBr1-2 vel TS-Theca), and primibrachial plate, tangential longitudinal (paraxial) section (Tg/LgS-IBr2) [SA-09/02]; E, distal brachial plate, transverse section (TS-NBrn) [SA-09/03]. All magnification: x 10.
The microfacies and associated roveacrinoidal sections at hand display numerous microfossil evidence such as abundant planktic foraminifers (favusellids, hedbergellids, and ticiellids), bispellids, calcino-dinoflagellate cysts, and some small benthic foraminifers. Such a planktic foraminiferal and calcisphaerulid association is characteristic of the middle–upper Albian (Rosales-Dominguez et al., 2015; Monier-Castillo et al., 2017b). The presence of Bishopella ornelasae in most samples (SA-01 to SA-016) led Rosales-Dominguez et al. (2015) to propose a middle–late Albian age. Likewise, the association of Favusella cf. F. pessagnoi, F. scitula (samples SA-016 to SA-017), and Planomalina sp. (sample SA-018), in the uppermost part of the section is characteristic of a late Albian age (Rosales-Dominguez et al., 2015). Due to the scarcity of stratigraphically based on Lower Cretaceous saccocomids, we cannot infer a direct age inference; therefore, we are keen to retain a middle–late Albian age because of the micropaleontological associations aforementioned.

With the exception of the so-called Microcalamoides used for slanted ancillary dating of Mexican Cretaceous strata [Microcalamoides Bonet, 1956, is the morphological variant thecal sections of Applinocrinus, ranging from Aptian to Maastrichtian, thus invalidating any precise datation (for review, see Ferré, 1997; Ferré & Dias-Brito, 1999; Ferré et al. 1997, 1999, 2018)], no saccocomid remains has ever been reported so far in Mexican Albian deposits and/or elsewhere (only roveacrinids; for review, see: Rasmussen, 1961; Destombes, 1985; Dias-Brito, 1994, 1995; Dias-Brito & Ferré, 1994, 2001; Ferré & Granier, 2001). This relatively restricted occurrence zone of such saccocomid microfossils, very different from the standard Microcalamoides Zone, is consistent with one of the OAE1 hypoxic events. However, in our current state of knowledge, we cannot precisely conclude which one.

When we do not have planktic foraminifers we use calcisphaerulids as fossil markers; the most important is the fossil assemblage. For example, the total stratigraphic range of Bishopella ornelasae is middle–late Albian. The association of B. ornelasae, B. diazi Trejo, 1983 and roveacrinoids is middle Albian. The association of B. salinasi Trejo, 1983, Bonetocardiella conoidea Bonet, 1956 and roveacrinoids is late Albian (Ubilla et al., 2013). We also have roveacrinoids in the lower Albian together with Colomiella mexicana Bonet, 1956, C. recta (Bonet, 1956) and Favusella washitensis. In several wells of the Zona Marina de Campeche, the abundance peak of B. ornelasae coincides with a maximum flooding surface for the middle Albian and it is a regional stratigraphic marker (Aguilera et al., 2008, 2017a, b).
their interest in improving the taxonomic knowledge of this overlooked crinoid group. This new material, though difficult to assign so far more precisely to a generic and/or specific taxonomic assignment, sheds new light on the roveacrinoidal paradigm and provides additional data between the classical Jurassic Saccocoma/Crassicoma (see Hess, 2002), and the Late Cretaceous Applinocrinus and Campanian relatives (Gale, 2017). This emphasizes more vividly the inventory work left to be done. These roveacrinoid taxa from the middle part of the Georgetown Formation are corresponding to paleontological forms that were previously identified by Hess (2002) from the Upper Jurassic strata of southern Germany (see also Hess, 1999). In the particular case of this material at hand, we should tackle first the issue of the J/K boundary crossing/transition of Saccocomaïdes and then the origin of its sister-group Roveacrinidae. This new occurrence zone of such saccocomid microfacies, different from the standard Microcalamoides Zone, is consistent with one of the OAE1 hypoxic events, beyond possibility of precisely concluding which one. Besides these isolated finds in multiple, repeated event-beds lead us to think the importance and value of the “Microcalamoides” paradigm over, and to forecast a thorough taxonomical revision of the “Microcalamoides” mentions their respective datings and correlations.

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