The Cretaceous corals from the Bisbee Group (Sonora; late Barremian - early Albian): Introduction and family Aulastraeoporidae

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ABSTRACT

The present contribution is the first instalment in a systematic revision of the corals from the Sonoran Bisbee Group (late Barremian to early Albian). The article gives a short overview on the lithostratigraphy and outcrops of the study area and reports the corals of the family Aulastraeoporidae (suborder Rhipidogyrina). The family contains 10 genera, three of which were found in Sonora. Since the genera Aulastraeopora and Preverastraea were recently systematically revised including the material from the Bisbee Group, the details are not repeated here. For the genus Paraacanthogyra a new species from the early Albian of the La Ceja mountain range is reported. This species is the first indication of the genus in the Western Hemisphere. It differs from other species of the same genus by its very small calicular diameter.

Key words: corals, Scleractinia, new taxa, Early Cretaceous, Sonora, Mexico.

RESUMEN

Esta contribución es la primera parte de una revisión sistemática de los corales del Grupo Bisbee (Barremiano tardío - Albiano temprano) de Sonora. El artículo da una introducción breve de la litoestratigrafía y las localidades del área de estudio y reporta los corales de la familia Aulastraeoporidae (suborden Rhipidogyrina). La familia cuenta con 10 géneros, tres de ellos se encuentran en Sonora. Los géneros Aulastraeopora y Preverastraea, que recién fueron sistemáticamente revisados, incluyendo el material del Grupo Bisbee, no se reportan con detalle. Dentro del género Paraacanthogyra, se establece una especie nueva del Albiano temprano del área del cerro La Ceja. Esta especie representa la primera evidencia del género en el Hemisferio Occidental. Se distingue de las otras especies del mismo género por sus cálices muy pequeños.

Palabras clave: corales, Scleractinia, taxón nuevo, Cretácico Temprano, Sonora, México.

Löser, H., 2011, The Cretaceous corals from the Bisbee Group (Sonora; late Barremian - early Albian): introduction and family Aulastraeoporidae: Revista Mexicana de Ciencias Geológicas, v. 28, núm. 2, p. 254-261.

INTRODUCTION

In comparison to the central Tethys (*e.g.*, Europe), large coral faunas of the Early Cretaceous are rare in the Western Hemisphere (western Tethys and Caribbean; *e.g.*, the American Continent). Substantial faunas are only known from the Barremian to Aptian of Puebla (Mexico; Felix, 1891, Reyeros-Navarro, 1963, Löser, 2006), the Aptian-Cenomanian faunas of the Texas platform (USA; Wells, 1932, 1933) and the late Barremian to early Albian coral faunas of the Bisbee Basin (Arizona, USA; Sonora, Mexico; Baron-Szabo and González-León, 1999, 2003; Löser and Minor, 2007; Scott, 1981, 1987; Scott and Brenckle, 1977). Corals have been known from the Bisbee Basin for a long time, mainly from Arizona, but taxonomically they were poorly reported because it was difficult to obtain them from the pure carbonates and they were poorly preserved. More recent intensive geological exploration in Sonora yielded a significant quantity of better preserved material and resulted in the first substantial taxonomic contribution to the Early Cretaceous coral fauna of the Bisbee Group (Baron-Szabo and González-León, 1999, 2003). Since then, more material has been obtained from both new and previously sampled outcrops in northern Sonora.

A more detailed taxonomic review of the material is not only necessary because of the large number of new samples, but also because additional type material from collections around the world have been examined in order to apply proper names to the sonoran coral material. Study of type material is critical because the methods to examine Mesozoic corals have changed drastically over the past fifty years. Until the mid-20th century, description and classification were generally based on what was visible at the coral surface, and typically only complete specimens were figured. Following the work of French palaeontologist James Alloiteau, the use of thin sections became more and more common and now is standard. This method resulted in the discovery of numerous, new morphological structures and microstructures and changed the view of the classification of the Mesozoic corals. It also became common to illustrate polished slabs and thin sections in addition to complete, unsectioned specimens. However, these changes have one disadvantage: the published literature before this dramatic change is now in need of profound revision. Unfortunately, much of this revision is still overdue - most of the important fossil coral collections have still not been fully re-examined using modern methods. For the majority of taxa established from the beginning of the study of Cretaceous corals up to the middle of the 20th century, detailed illustrations based on acetate peels or thin sections do not exist. This condition makes taxonomic work difficult since material examined using thin sections is difficult to compare with previously published work using only complete samples. For the present study, substantial type material from important coral collections in America, Asia and Europe was studied, and in many cases it was possible to prepare polished surfaces or obtain thin sections. So, the comparison of the mexican material to other species is not restricted to the literature, but also includes type specimens available for study.

The principal reason for the present study is the large quantity of available samples and the high number of species that were found over the study area. Because of the large number of samples and species, and the resulting time consuming preparation of the material and production of thin sections, the detailed taxonomic revision will be published in instalments.

This first small contribution reports the corals of the Aulastraeoporidae family (suborder Rhipidogyrina) from the Bisbee Group. The family contains ten genera, four of them being synonymous:

Apoplacophyllia Morycowa *in* Morycowa and Marcopoulou-Diacantoni, 2002
Aulastraeopora, Prever, 1909
Blothrocyathus Wells, 1932 (= *Aulastraeopora*)
Bogdanovicoenia Kuzmicheva, 2002 (= *Preverastraea*)
Budiopsis He and Xiao, 1990 (= *Aulastraeopora*)
Oedalmiopsis Roniewicz, 2008
Paraacanthogyra Morycowa and Marcopoulou-Diacantoni, 1997
Preverastraea Beauvais, 1976
Rhipidomeandra Morycowa and Masse, 1998
Saxuligyra Eliášová, 1991 (= *Preverastraea*)

Three of them are known from the Cretaceous of the Bisbee Group: *Aulastraeopora*, *Paraacanthogyra* and *Preverastraea*. *Aulastraeopora* and *Preverastraea* were recently systematically revised (Löser, 2007, 2008) and the material from the Bisbee Group was included in these studies. For the genus *Paraacanthogyra* a new species has been found and is described here.

STUDY AREA

The fossil coral material is derived from the Bisbee Group, Cerro de Oro Formation (late Barremian to early Aptian) and the Mural Formation (late Aptian to early Albian). The geology, lithostratigraphy and chronostratigraphy is reported in Lawton *et al.* (2004) and González-León *et al.* (2008). A description of the study area and data on the occurrence of corals were provided by Löser and Minor (2007). Corals from the Cerro de Oro Formation were collected from only one level close to the top of the section in the Cerro de Oro area. Corals in the Mural Formation occur in various levels: in the clastic Los Coyotes Member, in the marly basal and the carbonatic middle to upper part of the Cerro La Espina Member (all early Albian), and rarely in the Mesa Quemada Member (early or even middle Albian). The limit between the Aptian and Albian in the Mural Formation is for the moment correlated with the base of the Los Coyotes Member based on strontium 86/87 bulk sample

dating (J. Madhavaraju, personal communication, December 2010). Corals are only obtained from the late Barremian to the early Aptian and throughout the whole early Albian (Figure 1). The problems determining the precise age of the coral bearing layers within the Cerro de Oro Formation has been already discussed (Löser and Minor, 2007). Within the study area, the corals come from 43 outcrops or sample points. For most of them, exact sample locations or their position in a measured section are known. Table 1 lists the formations, age, outcrop areas, sample points and positions (WGS84). Sample points are indicated under the occurrence of the species.

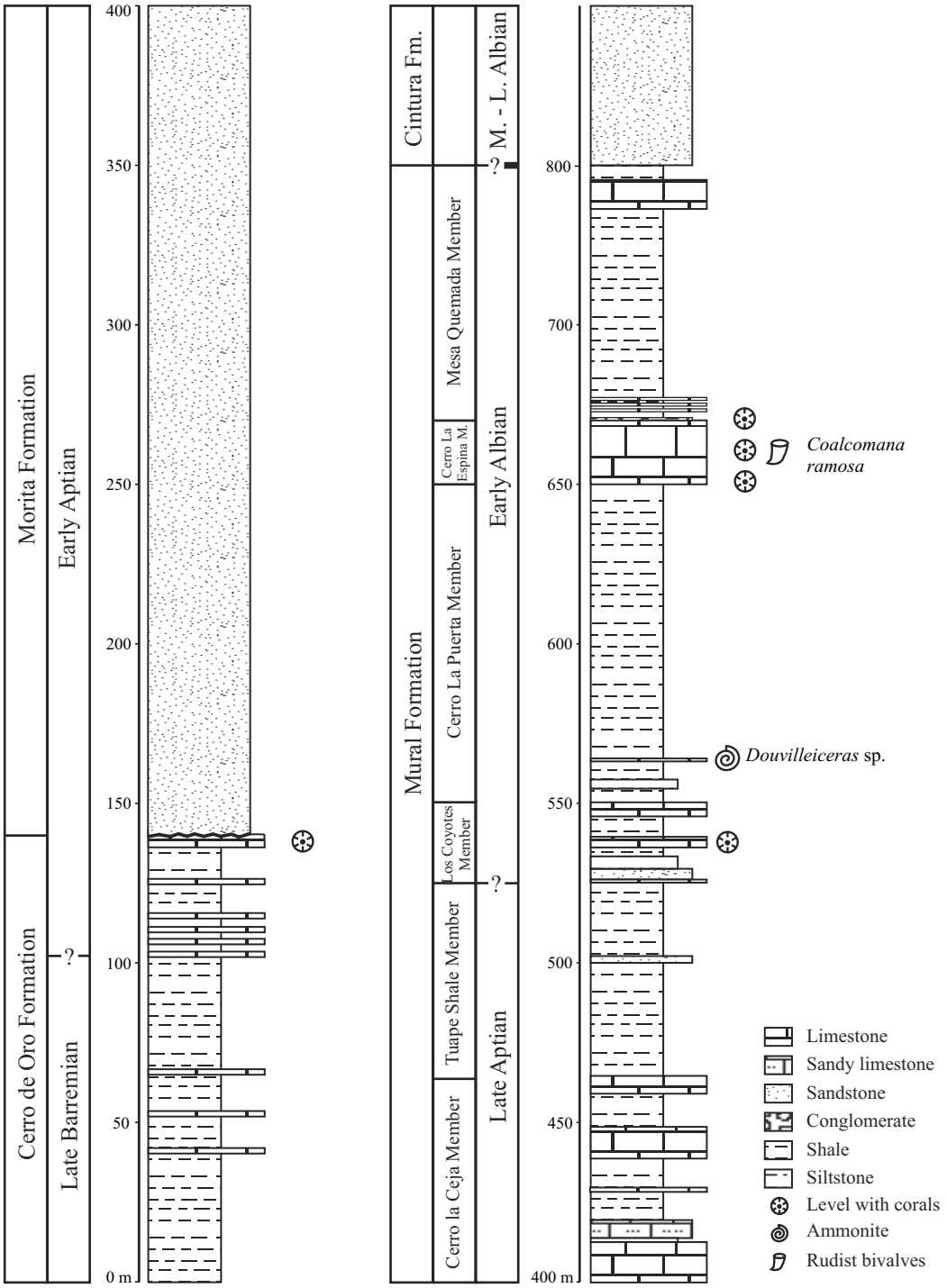

Figure 1. Generalised composite section of the Bisbee Group in the Cerro de Oro area. Part of the Cerro de Oro and Morita Formations after González-León and Jacques-Ayala (1988). The top of the Cintura Formation is not shown. Stage and substage boundaries do not have adequate controls and are only approximate. Modified after Löser and Minor (2007).

Table 1. Formations, age, outcrop areas, sample points and positions (WGS84) of localities with corals in the Bisbee Group.

Formation and age	Outcrop area	Sample pt.	Position
Cerro de Oro Formation Late Barremian to early Aptian	Municipio Ures, Cerro de Oro	CO4	29°36'13" N 110°36'32" W
		COBS1	29°36'14" N 110°36'29" W
		CO	29°35'55" N 110°36'23" W
Mural Formation Los Coyotes Member Early Albian	Municipio Agua Prieta, east San Bernardino valley, cordón Caloso	CC4	31°5'22" N 109°7'36" W
	Municipio Arizpe, El Salmón	SN	30°6'21.4" N 110°12'42.6" W
	Municipio Opodepe, rancho El Pimiento	EPI-1-107	30°6'56.8" N 110°51'58.7" W
	Municipio Opodepe, Tuape, arroyo Coyote	CA.2	30°10'53" N 110°40'33.8" W
	Municipio Santa Ana, El Ocuca section	OC	30°30'11.15" N 111°24'57" W
	Mun. Santa Ana, Santa Ana, Las Pimas	PI1	30°31'41.6" N 111°15'2.1" W
	Municipio Ures, Cerro de Oro	CO6	29°36'0.6" N 110°37'30.6" W
		CO7	29°36'3.8" N 110°37'30.7" W
Mural Formation, Cerro La Espina Member (without differentiation) Early Albian	Municipio Opodepe, Tuape	ESP	30°11'25" N 110°36'15" W
	Cerro de La Espina	CEBS	30°11'22" N 110°36'16" W
	Municipio Ures, Cerro de Oro	COBS2	29°36'4" N 110°37'39" W
		CO1	29°35'45" N 110°37'45" W
Mural Formation Cerro La Espina Member (base) Early Albian	Municipio Agua Prieta, cordón Caloso	AVR-2-53	31°6'59" N 109°7'1" W
	Municipio Arizpe, Arizpe, Cerro La Ceja	CG2	30°28'22.6" N 110°16'15.3" W
	Municipio Cucurpe, Cucurpe, La Mesa	LM2	30°30'42" N 110°27'9" W
		LM3	30°30'47" N 110°27'17" W
		LM4	30°30'54" N 110°27'23" W
	Municipio Opodepe, Tuape,	ES3	30°11'49.4" N 110°36'8.3" W
	Cerro de La Espina	ES4	30°11'22" N 110°36'14" W
		ESC2	30°11'42" N 110°36'11" W
		ESC8	30°11'33" N 110°36'11" W
	Municipio Santa Ana, Santa Ana	SA1	30°31'54.6" N 111°5'41.1" W
	Municipio Ures, Cerro de Oro	CO10	29°35'57" N 110°37'45" W
		CO3	29°35'59.6" N 110°37'43.6" W
		CO5	29°36'2" N 110°37'37" W
		CO9	29°35'48" N 110°37'43" W
Mural Formation Cerro La Espina Member (middle-top) Early Albian	Municipio Agua Prieta, east	CC1A	31°5'29" N 109°7'21" W
	San Bernardino valley, cordón Caloso	CC3A	31°5'21" N 109°7'19" W
	Municipio Arizpe, Arizpe, Cerro La Ceja	CG1	30°28'18.7" N 110°16'13.8" W
	Municipio Cucurpe, Magdalena, La Lámina	LA3	30°25'0.9" N 110°49'12.9" W
	Municipio Naco, Naco, Sierra San José	SJ1	31°14'3.9" N 109°58'50.7" W
		SJ2	31°13'57.4" N 109°58'42.3" W
		SJ4	31°14'1.2" N 109°58'48.7" W
		SJ3	31°14'3" N 109°58'49" W
	Municipio Naco, quarry E Naco	NA	31°19'4" N 109°52'46.2" W
	Municipio Santa Ana, Santa Ana	SA2	30°31'55" N 111°5'43.7" W
	Municipio Trincheras, Sierra Mayo	SMY-2-42	30°4'57.7" N 111°22'20.8" W
	Municipio Ures, Cerro de Oro	CO14	29°35'50" N 110°37'23.5" W
		CO15	29°36'5.2" N 110°37'38.6" W
		CO8	29°36'3" N 110°37'45" W
Mural Formation, Mesa Quemada Member Early Albian	Municipio Opodepe, Tuape, Cerro de La Espina	ES2	30°11'21.9" N 110°36'9.8" W

MATERIAL

The only specimen of the new species derives from a section in the cerro La Ceja area, Municipio Arizpe, Sonora, Mexico (Figure 2). It was found at the base of the Cerro La Espina Member, Mural Formation, Bisbee Group. This layer has an early Albian age (González-León *et al.,* 2008). The specimen is large and well preserved, and even though the surface has been eroded it yielded multiple, well-preserved thin sections. Although extensive fieldwork was carried out over several years and thousands of samples were reviewed or collected, no other specimen could be found, suggesting that this species is extremely rare in the Albian of the Bisbee Basin. The type locality itself was sampled with great care

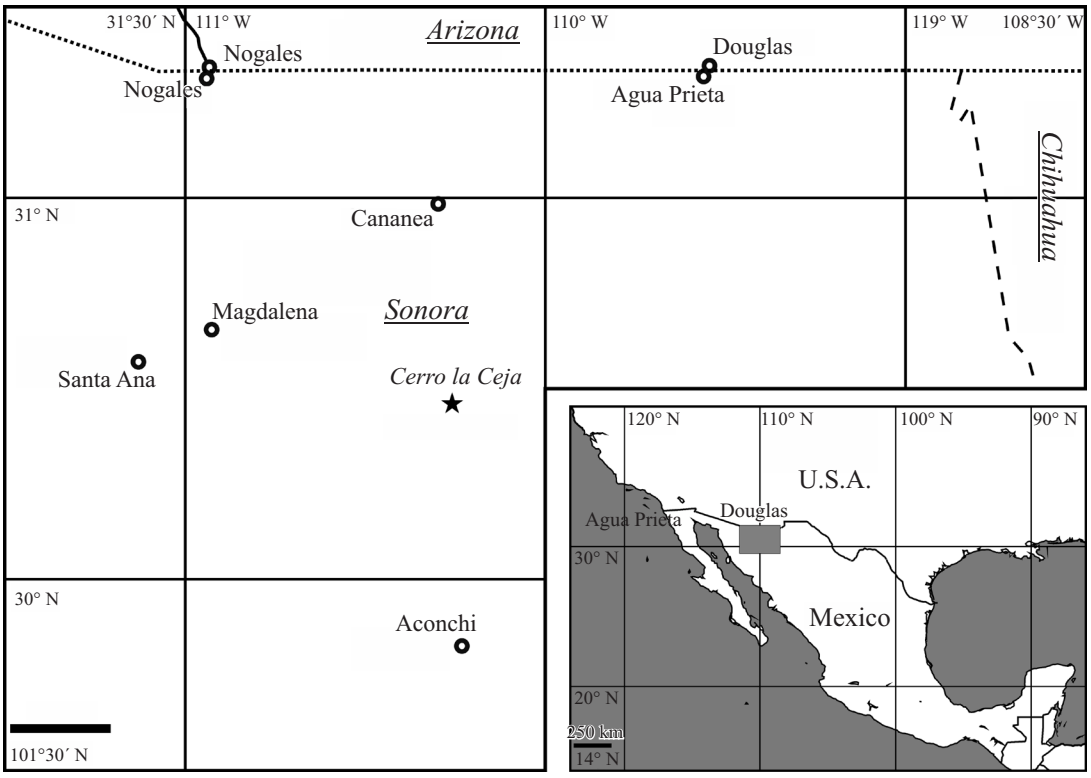

Figure 2. Study area. The star gives the approximate position of the outcrop.

but even there no other sample could be found. The material is kept at the collection of the Universidad Nacional Autónoma de México, Instituto de Geología, Estación Regional del Nororeste, Hermosillo, Sonora, Mexico.

SYSTEMATIC PALEONTOLOGY

Class Anthozoa Ehrenberg, 1834
Order Scleractinia Bourne, 1900
Suborder Rhipidogyrina Roniewicz, 1976
Family Aulastraeoporidae Alloiteau, 1957

Genus *Aulastraeopora* Prever, 1909

Type species. *Aulastraeopora deangelisi* Prever, 1909, designated by Wells (1933).
Discussion. One species, *Aulastraeopora harrisi* (Wells, 1932), has been indicated in the Bisbee Basin. It occurs in the late Barremian to early Aptian of the Cerro de Oro Formation and in early Albian of the Cerro la Espina Member.

Genus *Paraacanthogyra* Morycowa and Marcopoulou-Diacantoni, 1997

Type species. *Paraacanthogyra parnassensis* Morycowa and Marcopoulou-Diacantoni, 1997, originally designated.
Species. *P. aptiana* (Turnšek and Mihajlovic, 1981), *P. parnassensis* Morycowa and Marcopoulou-Diacantoni, 1997, *P. leoni* n. sp.
Occurrence. Central Tethys and Western Hemisphere. Since the stratigraphy of the outcrop of the type species is uncertain (see discussion in Löser, 2005, p. 237), the occurrence cannot be well confined. The first occurrence is Aptian, while the last occurrence is less certain and is early Albian or possibly early Cenomanian.
Discussion. The type species is based on a single, small specimen. All thin sections obtained of the type specimen are oblique and do not clearly show the characteristics ascribed to the genus. Therefore the genus has been considered synonymous with the very closely related *Preverastraea* (Löser, 2007). However, this is not the case. The most striking differentiating feature is the formation of new calices: whereas it is exclusively extracalicinal in *Preverastraea*, it is intracalicinal by septal division in *Paraacanthogyra*. This feature is not clearly observable in the type species, but visible in the new material from Sonora.

Paraacanthogyra leoni new species

Figures 3, 4

Diagnosis. *Paraacanthogyra* with a calicular diameter of 1.7-4.5 mm (small lumen) and 2.7-6.1 mm (large lumen) and 18-27 septa.
Dimensions. See Table 2.

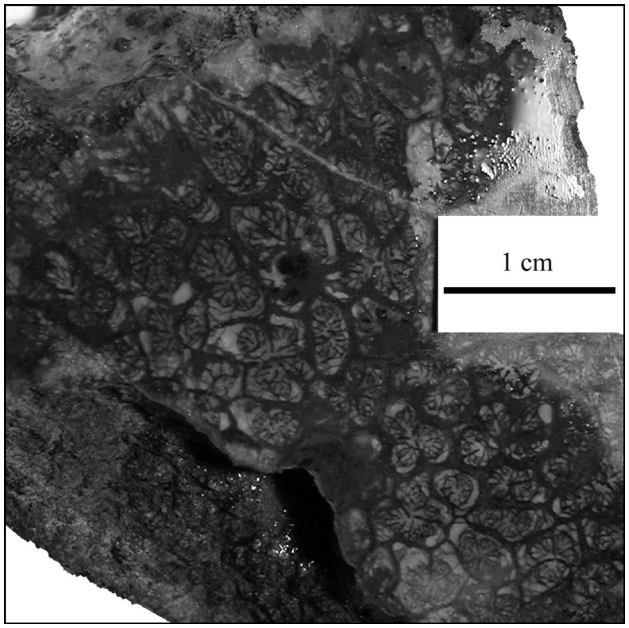

Figure 3. *Paraacanthogyra leoni*, n. sp. Holotype ERNO L-4275. Polished surface of the type before preparing thin sections.

Description. Calicular arrangement is cerioid. Every calice has a wall and the walls are directly connected only rarely leaving a small intercalicular space. Calicular outline is of irregular shape; circular in small calices, elliptical, polygonal or in the form of a four-leaf clover in adult calices. Larger and smaller diameter of the lumen differ remarkably in size. Calicular diameter varies depending on its ontogenetic stage. They are small (2.7-4 mm, larger lumen) when forming and become larger (4-6 mm, larger lumen) until they divide into various small calices. Septal symmetry irregular radial. A hexameral symmetry is most common, but also pentameral or octomeral symmetry can be observed. Typically, only one cycle of septa reach the wall, but rarely there are two. In the latter case, the septa of the second cycle are shorter. Septa of the first cycle(s) reach from the wall into the center of the calice. These septa are generally thicker and may be swollen at their inner tips. All following septa are lonsdaleoid septa that grow from the marginarium. They are shorter and thinner. Endotheca consists of thin transversal tabulae in the center of the calice and thin dissepiments in the marginal zone of the calices. The wall has the same structure as septa. Budding is exclusively intracalicinal, by septal division. An adult calice forms between three and four new calices. The formation of new calices is irregular. Young calices are small and have a round outline. They start with few (four to six) thin lonsdaloid septa and an extensive marginarium. The septa of the first cycle connect to the wall and a second generation of lonsdaleoid septa is subsequently formed. The septa attached to the wall gain length and thickness and develop apophysal septa in places as ornamentation. The septa of the first cycle connect to each other and subsequently form new calices.

Table 2. Dimensions of the holotype of *Paraacanthogyra leoni* based on 15 measurements of each characteristic (all values in mm).

Characteristics	Mininmal value	Maximal value	Arithmetic mean	Standard deviation
Lumen - small diameter	1.71	4.5	2.84	0.74
Lumen - large diameter	2.73	6.1	4.3	0.98
Inner calice (marginarium)	1.47	3.02	2.12	0.47
Distance of calicular centres	3.04	5.07	4.0	0.64

Etymology. Fieldwork in the type locality (and in many other places in Sonora) was only possible through the kind help of Carlos Manuel González-León, undoubtedly the true "Lion" (Spanish: León) of Sonoran geology, to whom the new species is respectfully dedicated.

Type. Holotype ERNO L-4275, five thin sections and four remaining pieces. Mexico, Sonora, Municipio Arizpe, mountain range La Ceja. WGS84 30°28'22.6"N 110°16'15.3"W. Bisbee Group, Mural Formation, basal Cerro La Espina Member. early Albian.

Discussion. The new species is distinguished from the other known species by its much smaller calicular dimensions.

Genus *Preverastraea* Beauvais, 1976

Type species. *Aulastraeopora chelussi* Prever, 1909, by original designation.

Discussion. Several species are known from the Bisbee Basin: *Preverastraea comalensis* (Wells, 1932), *Preverastraea diplothecata* (Hackemesser, 1936), *Preverastraea felixi* (Hackemesser, 1936), *Preverastraea isseli* (Prever, 1909), *Preverastraea maior* (Eliášová, 1991) (= *Stiboriopsis sonoraensis* Baron-Szabo and González-León, 1999), *Preverastraea major* (Hackemesser, 1936), *Preverastraea multistella* (Stoliczka, 1873), *Preverastraea roveretoi* (Prever, 1909). The species created by Filkorn and Pantoja-Alor (2009) are nomina nuda because the publication does not constitute a valid publication (Art. 8.6 of the ICZN, 1999, was not fulfilled). *Preverastraea* species are common in both late Barremian to early Aptian of the Cerro de Oro Formation and early Albian of the Cerro La Espina Formation.

ACKNOWLEDGEMENTS

I am grateful to Carlos Manuel González-León who introduced me to the type locality of the new taxon and reviewed the geological part of the paper. Field work expenses and the preparation of thin sections were covered by project PAPIIT-DGAPA project IN107803. Steve Cairns, Ann Molineux and Elzbieta Morycowa made sample examination in Washington D.C. (USA), Austin (Texas, USA) and Kraków (Poland) possible. Jacob Leloux (Leiden) reviewed

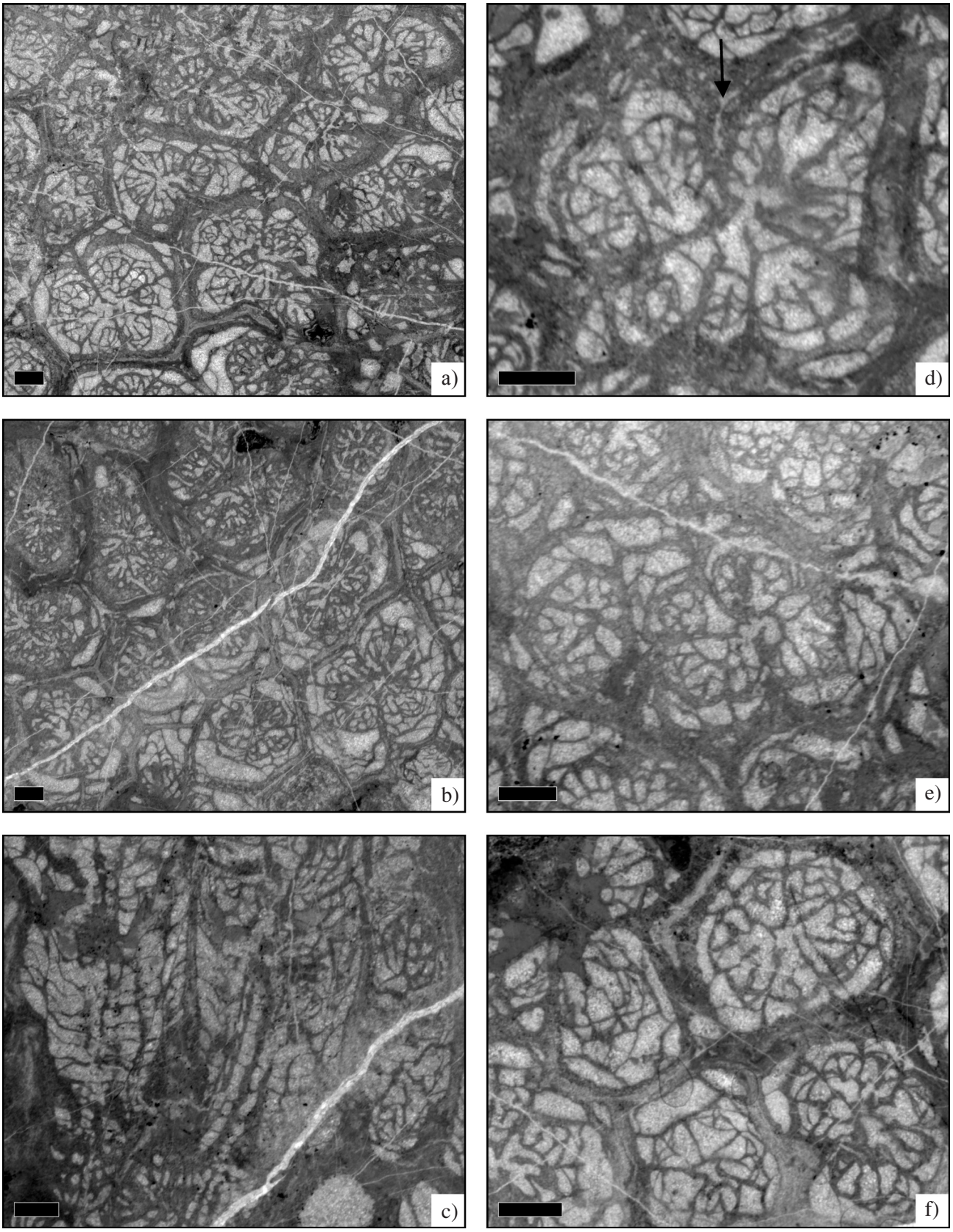

Figure 4. *Paraacanthogyra leoni*, n. sp. Holotype ERNO L-4275. a-b: transversal section; c: longitudinal section; d: adult calice in transversal section showing the beginning separation of the calice along one septum (arrow) which shows temporary apophysal septa; e: adult calice in transversal section with young calices in different ontogenetical stages; f: completely separated young calices in transversal section. Scale 1 mm.

the taxonomic part for what I am grateful. For grammatical correction I would like to thank Brian Hallmark (Tucson, Arizona).

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Manuscript received: September 4, 2010
Corrected manuscript received: December 11, 2010
Manuscript accepted: January 28, 2011