



New mosasaurid teeth (Reptilia: Squamata) from the Maastrichtian of Albaina (Laño quarry, Condado de Treviño)

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ABSTRACT

We report on new mosasaurid remains, namely isolated teeth, from the Upper Maastrichtian shallow marine environment of Albaina in the Laño quarry (Condado de Treviño). The new specimens belong mostly to mosasaurines, i.e., *Mosasaurus hoffmanni*, *Prognathodon solvayi*, *Prognathodon sectorius*, and to the russellosaurine plioplatecarpine *Platecarpus* cf. *ictericus*. *Prognathodon solvayi* and *Platecarpus* cf. *ictericus* were previously known from Albaina. This is the first mention in the site of *Mosasaurus hoffmanni*, widespread in Maastrichtian outcrops located around palaeolatitude 30-40°N, from New Jersey (USA) to Turkey passing through Europe where it is commonly found. *Prognathodon sectorius* has a comparable palaeobiogeographical distribution, though not so expanded, that *M. hoffmanni*, being known in the Maastrichtian of New Jersey (USA) and Europe and, since recently, in the Campanian of Navarre. With six different

RESUMEN

Se describen nuevos restos fósiles de mosasaurios, que consisten en dientes aislados, procedentes de los depósitos marino-litorales del Maastrichtiense superior de Albaina, en la cantera de Laño (Condado de Treviño). El nuevo material pertenece principalmente a mosasaurinos, como *Mosasaurus hoffmanni*, *Prognathodon solvayi*, *Prognathodon sectorius*, y al plioplatecarpino russellosaurino *Platecarpus* cf. *ictericus*. En un trabajo previo se describió la presencia de *Prognathodon solvayi* y *Platecarpus* cf. *ictericus* en Albaina. Esta es la primera cita en el yacimiento de *Mosasaurus hoffmanni*, un taxón ampliamente distribuido en afloramientos maastrichtienses situados en paleolitudes cercanas a los 30-40°N, desde Nueva Jersey (EE. UU.) hasta Turquía, pasando por Europa donde sus restos se han descubierto en numerosas localidades. *Prognathodon sectorius* presenta una distribución paleobiogeográfica comparable, aunque no tan amplia, como

taxa reported here, Albaina is the richest outcrop in specific mosasaurid diversity from the Maastrichtian of southern Europe.

Keywords: Mosasauridae, Iberian Peninsula, latest Cretaceous, palaeobiogeography.

la de *M. hoffmanni*, habiéndose descrito en el Maastrichtiense de Nueva Jersey (EE. UU.) y Europa, y recientemente en el Campaniense de Navarra. Con seis taxones diferentes de mosasáuridos, Albaina es el yacimiento con mayor diversidad específica del Maastrichtiense del sur de Europa.

Palabras claves: Mosasauridae, Península Ibérica, Cretácico final, paleobiogeografía.

1. INTRODUCTION

Mosasaurid fossil remains are very scarce in the latest Cretaceous of the Iberian Peninsula. Though they were first described in Portugal at the end of the XIXth century (Sauvage 1897-1898), other discoveries date from the 1990s and more recently (see Bardet *et al.*, 2008 for an overview). They mainly consist of isolated teeth and vertebrae and were known up to now exclusively from the Campanian-Maastrichtian of the Lusitanian Basin and the Basque-Cantabrian Region (see Bardet *et al.*, 2008 for details), until their recent discoveries in the Maastrichtian of the External Zone of the Betic Cordillera (Bardet *et al.*, 2013).

The Albaina fossiliferous site is located in the Laño quarry, in the Condado de Treviño, an exclave of the Burgos province inside Alava in the Basque Country, in the Northern part of the Iberian Peninsula. In the Laño quarry, two stratigraphic horizons within a continental to shallow marine succession of Late Cretaceous age are known (Baceta *et al.*, 1999): the lower horizon contains the continental sites Laño 1 and 2, the upper horizon contains the Albaina site.

The fluvial beds of Laño, regarded as Late Campanian to Early Maastrichtian in age, have yielded a diverse vertebrate assemblage, which consists of nearly 40 species (at least 11 new taxa), including actinopterygians, amphibians, lizards, snakes, turtles, crocodyliforms, dinosaurs, pterosaurs and mammals (Astibia *et al.*, 1999; Pereda Suberbiola *et al.*, 2000).

The shallow marine vertebrate association of Albaina consists of about 35 species, including shark and rays (among them four new rhinobatoids), actinopterygians, mosasaurids and plesiosaurs, of Late Maastrichtian age (Bardet *et al.*, 1999; Cappetta & Corral, 1999; Poyato-Ariza *et al.*, 1999).

Mosasaurid remains from Albaina were previously reported by Bardet *et al.* (1997, 1999). They are referred to the mosasaurines *Prognathodon solvayi*, *Prognathodon* sp. (= *Leiodon anceps* and *Leidon* sp. of Bardet *et al.*, 1997, 1999), *Mosasaurus* sp., indetermined mosasaurines, and to the russellosaurine plioplatecarpine *Platecarpus* cf. *ictericus* (see Table 1).

Here we describe newly discovered specimens, namely isolated teeth, all found by one of us (G.M.) in the same Albaina horizon of the Laño quarry as the previously described ones. The specimens are kept in Luberrri/Oiartzungo Ikasgune Geologikoa Museoa of Oiartzun.

Institutional abbreviations. IRSNB, Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium; LU, Luberrri, Oiartzungo Ikasgune Geologikoa Museoa, Oiartzun, Gipuzkoa; MCNA, Museo de Ciencias Naturales de Alava/Arabako Natur Zientzien Museoa, Vitoria-Gasteiz, Alava.

2. LOCATION AND GEOLOGICAL SETTING

The Laño-Albaina outcrop is located in a disused quarry, about 30 km south of Vitoria-Gasteiz, in the Basque-Cantabrian Region (Fig. 1). Locally, the outcrop is located on the southern limb of the Miranda-Treviño syncline and R includes both continental and shallow marine successions ranging in age from Late Campanian to Maastrichtian.

The Late Campanian marks a period of overall regression in the southern part of the Basque-Cantabrian Basin (Navarro-Cantabrian Trough), resulting in the emergence of littoral environments in some marginal areas and the deposition of fossil-rich deltaic sandstones in the southern limb of the Miranda-Treviño syncline (Fig. 2: L1A, L1B). But, despite an initially regressive phase in the Laño-Albaina zone (Sobrepeña Formation), the Maastrichtian was overall transgressive in the area, as can be deduced from rock exposures in both limbs of the Miranda-Treviño syncline. Limestones and fossiliferous marls (Puerto de Olazagutía Formation) containing echinoids, ammonites, inoceramids and other bivalves and shark teeth (Corral, 1996) indicate that shallow-marine environments were widespread in the northeastern part of the domain. The collected ammonites *Anapachydiscus fresvillensis* and *Baculites anceps* also indicate a Late Maastrichtian age (Santamaría & López, 1996).

In the southern outcrop of the Laño-Albaina quarry, marine rocks crop out in the upper part of the series. Thus,

Table 1. Mosasaurid remains found in the Late Maastrichtian of Albaina, Laño quarry, Condado de Treviño.

Taxa	Collection number	Material	Reference
Mosasaurinae			
<i>Prognathodon solvayi</i>	MCNA 6449	1 tooth	Bardet <i>et al.</i> 1997, 1999
	LU-GMS-LAÑ001, 005	2 marginal teeth	This work
<i>Prognathodon sectorius</i>	LU-GMS-LAÑ002	1 marginal tooth	This work
<i>Prognathodon</i> sp. (= <i>Leiodon anceps</i>)	MCNA 5487	1 pterygoid tooth	Bardet <i>et al.</i> , 1997, 1999
<i>Prognathodon</i> sp. (= <i>Leiodon</i> sp.)	MCNA 6381	1 tooth	Bardet <i>et al.</i> , 1999
<i>Mosasaurus hoffmanni</i>	LU-GMS-LAÑ004	1 marginal tooth	This work
<i>Mosasaurus</i> sp.	MCNA 5488, 5489, 5490	3 fragmentary teeth	Bardet <i>et al.</i> , 1997, 1999
Mosasaurinae indet.	MCNA 5491	1 caudal centrum	Bardet <i>et al.</i> , 1999
Russellosaurina			
<i>Platecarpus</i> cf. <i>ictericus</i>	MCNA 6380, 6448	2 teeth	Bardet <i>et al.</i> , 1999
	LU-GMS-LAÑ003	1 pterygoid tooth	This work

the friable sandstones and mudstones of the Sobrepeña Formation are connected to yellow calcarenites with fish and mosasaur remains by means of a lag with vertebrate bone fragments and fish remains that will mark an intra-Maastrichtian unconformity (sensu Baceta, 1996). Invertebrate macrofossils in these calcarenites, whose diagenetic history has turned them to decalcified limestones with mouldic porosity, are scarce but layers of accumulated orbitoidids occur. This unnamed formation is considered to be equivalent to the Torme Formation in the Villarcayo area (North-Castilian Platform) (Berreteaga, 2008). This unit lacks good index fossils but selachian biostratigraphy may indicate a Late Maastrichtian age (Cappetta & Corral, 1999).

The Campanian-Maastrichtian interval includes the end of a regressive cycle and the beginning of transgressive period in the domain (Fig. 2). Upwards, carbonate rocks of Danian age indicate that a shallow marine platform lasted for a while in this part of the Basque-Cantabrian Basin.

3. SYSTEMATIC PALAEONTOLOGY

Order SQUAMATA Oppel, 1811
 Family MOSASAURIDAE Gervais, 1853
 Subfamily MOSASAURINAE Gervais, 1853
 Genus *Mosasaurus* Conybeare, 1822
Mosasaurus hoffmanni Mantell, 1829

Material and occurrence. LU-GMS/LAÑ004, a marginal tooth from the anterior part of the jaws; Albaina, Laño quarry, Condado de Treviño; Late Maastrichtian (Baceta *et al.*, 1999; Cappetta & Corral, 1999) (Figs 3a-3b).

Description. The tooth preserved the enameled crown only. It has been found broken in numerous fragments and has been restored and reconstructed by one of us (J.C.C.). Though incomplete, the preserved part of the crown (39 mm high) is high and narrow, its height being more than twice the basalmost preserved length (estimated to about 15 mm). The posterior margin of the crown is almost straight in lateral view, without any pronounced curvature. It bears two marked carinae located anteriorly and posteriorly. Both being eroded it is impossible to see if they bear crenulations. The crown bears a well-marked U-shaped cross-section. The labial surface is slightly convex and bears 3 large prisms. The lingual surface is strongly convex, and bears indistinct prisms that do not reach the apex. The enamel is thick and smooth but longitudinally structured.

Discussion. The U-shaped cross-section of the crown is typical of the genus *Mosasaurus* (Russell, 1967), as well as is the longitudinally structured smooth enamel (N.B., pers. obs.). The respective position of the two carinae, the distinctive size of the labial and lingual surfaces, and the

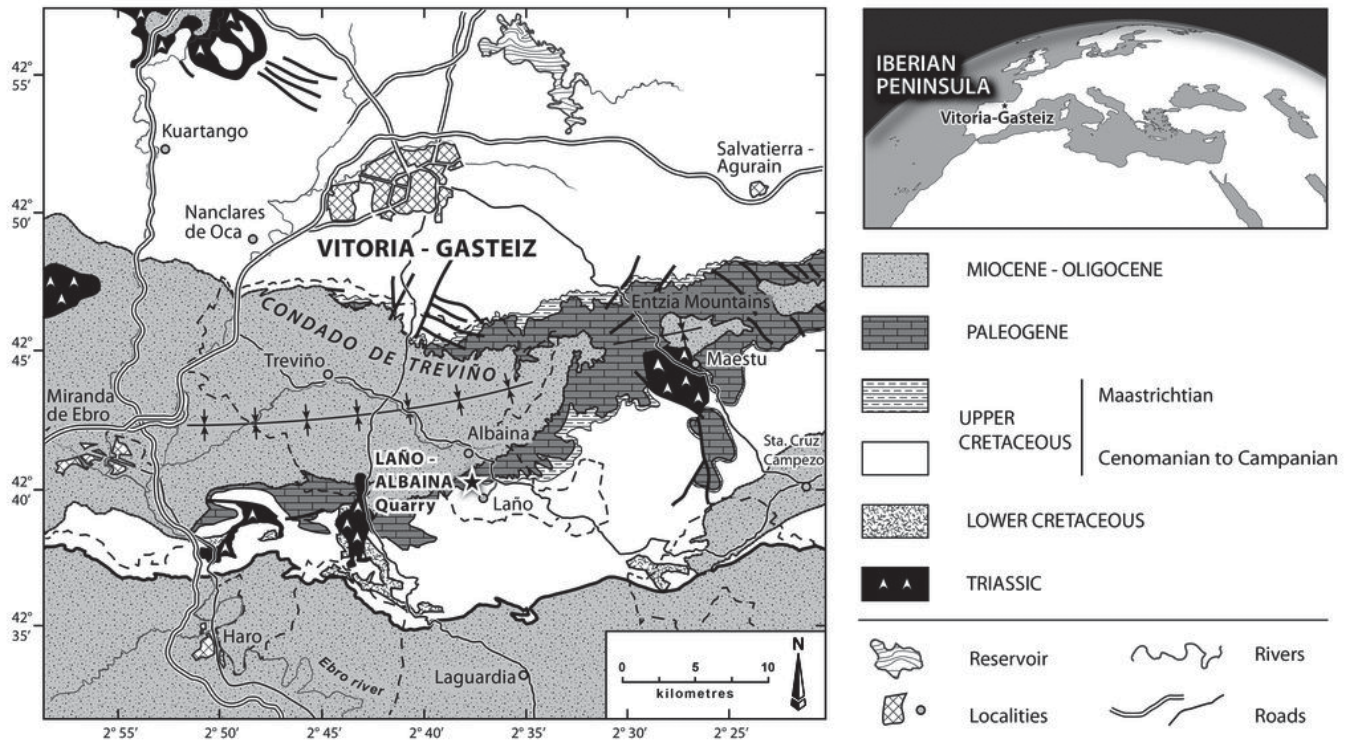


Figure 1. Location of the Laño quarry (Condado de Treviño) and geological sketch map.

reduced number of prisms on the labial surface indicate that this tooth was from the anterior part of the jaws (Lingham-Soliar, 1995). The high and slender shape of the crown, as well as a labial surface bearing 3 prisms and a lingual face with indistinct ones are typical characters of *Mosasaurus hoffmanni* (Lingham-Soliar, 1995).

This species is widespread in the Maastrichtian of Europe up to Turkey and is also known in the Campanian-latest Maastrichtian of North America (see Bardet, 2012 for details). It has a transatlantic palaeobiogeographical distribution around palaeolatitudes 30-40°N (Mulder, 1999; Bardet, 2012).

Genus *Prognathodon* Dollo, 1889

Prognathodon solvayi Dollo, 1889

Material and occurrence. LU-GMS/LAÑ001, a marginal tooth probably from the median part of the jaws; LU-GMS/LAÑ005, a marginal tooth from the median part of the jaws; Albaina, Laño quarry, Condado de Treviño, Late Maastrichtian (Baceta *et al.*, 1999; Cappetta & Corral, 1999) (Figs 3c-f).

Description. LU-GMS/LAÑ001 is a poorly preserved crown with a complete basal portion, but the apex and posterior part are broken. However, it can be deduced

from its shape that its height was probably only one and half its basal length as in LU-GMS/LAÑ005 (see below). LU-GMS/LAÑ001 was probably only slightly posteriorly recurved. The crown is significantly laterally compressed, with subequal and slightly convex labial and lingual surfaces; subsequently, the basal cross-section is a long oval. Both surfaces bear well-marked and defined facets, probably 5 labially and 7 lingually. The anterior carina is eroded. Because the posterior portion of the crown is broken, the occurrence of a posterior carina cannot be confirmed. The enamel is thick, smooth and silky.

LU-GMS/LAÑ005 preserves only the crown, which is complete. It is 14 mm high and 9 mm long basally. This crown is only slightly posteriorly recurved and strongly laterally compressed. It bears two well marked and anteroposteriorly aligned carinae, which bear minute crenulations. The labial and lingual surfaces are comparable in size so that the basal cross-section is an elongated oval. The labial surface is slightly convex and bears 5 well-marked facets, of which only 3 reach the apex. The lingual surface is also slightly convex and bears 6 well-marked facets; one reaches the apex. The enamel is smooth like in LU-GMS/LAÑ001, but because LU-GMS/LAÑ005 is a much smaller crown, it is thin and shiny.

Discussion. With their labial and lingual surfaces of comparable size, anteroposteriorly aligned carinae (in LU-

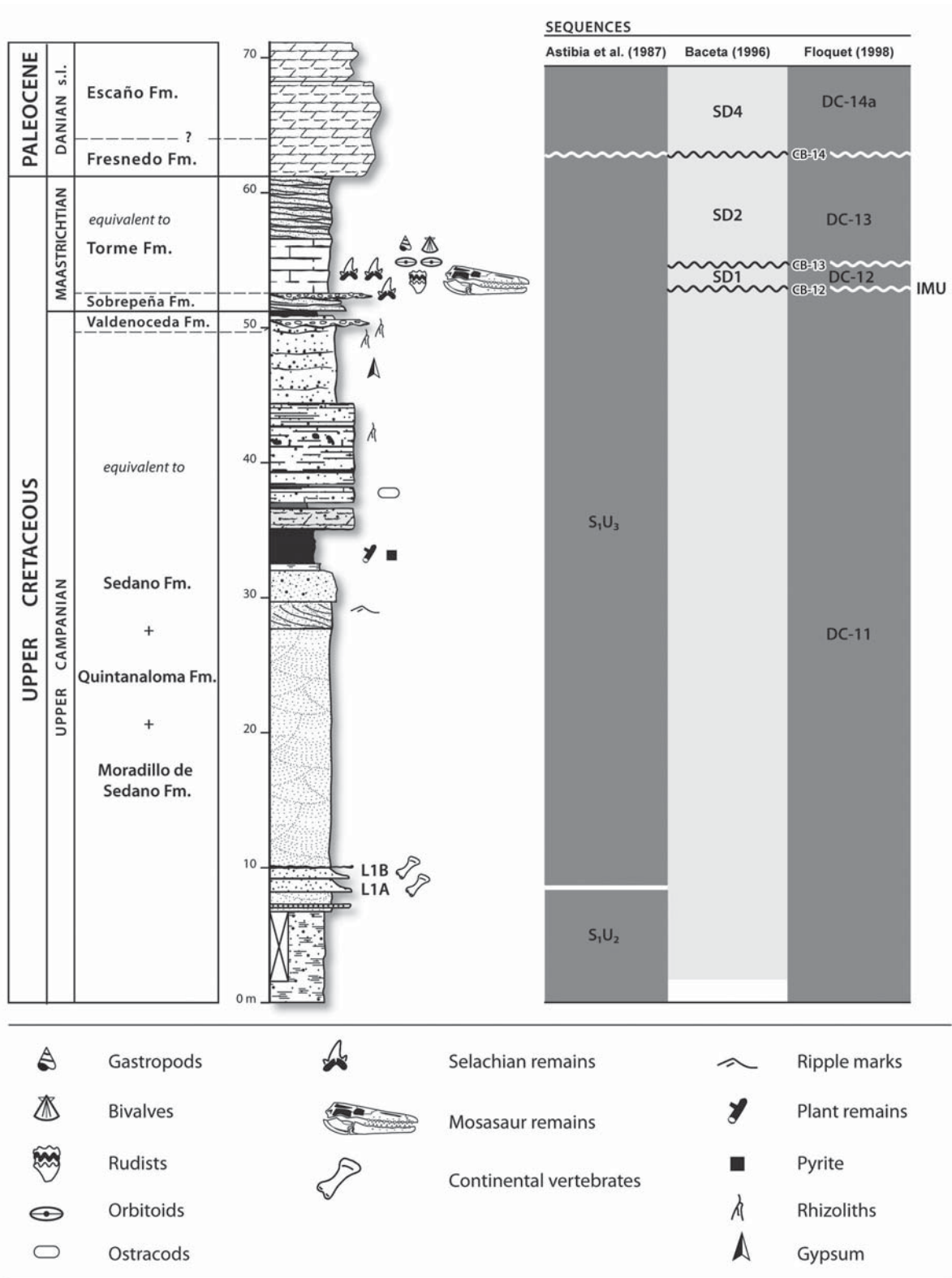


Figure 2. Stratigraphic section of the Laño quarry showing the main lithofacies and the location of the fossiliferous levels (modified from Gómez-Alday *et al.*, 1999). L1A, L1B: continental vertebrate fossil sites; IMU: intra-Maastrichtian unconformity.

GMS/LAÑ005 only), and scarcely posteriorly recurved shape, these teeth probably come from the median part of the jaws. The small size of LU-GMS/LAÑ005 and the fact that its crown is complete without any trace of the root indicate that it is a fully erupted tooth belonging to a small individual. With a comparable number of strong facets on both the labial and lingual surfaces, as well as of a compressed basal cross-section, the above described teeth are very similar to those of *Prognathodon solvayi* (IRSNB R33 and IRSNB R107), type species of the genus and the only one having strongly faceted teeth (Dollo, 1889; Lingham-Soliar & Nolf, 1989). The two studied teeth, especially the larger one (LU-GMS/LAÑ001), are also quite similar to the tooth previously referred to *P. solvayi* from Albaina (Bardet *et al.*, 1997, 1999).

Besides Albaina, *Prognathodon solvayi* is known from the Late Campanian of The Netherlands (Mulder *et al.*,

1998) and the Early Maastrichtian of Belgium (Dollo, 1889; Lingham-Soliar & Nolf, 1989). Its occurrence in the Late Maastrichtian of Albaina is stratigraphically the youngest one and biogeographically the southernmost of this species.

Prognathodon sectorius (Cope, 1871)

Material and occurrence. LU-GMS/LAÑ002, a marginal tooth from the median part of the jaws; Albaina, Laño quarry, Condado de Treviño; Late Maastrichtian (Baceta *et al.*, 1999; Cappetta & Corral, 1999) (Figs 3g-3h).

Description. LU-GMS/LAÑ002 is a complete crown of a fully erupted tooth. It is robust and triangular in lateral view (H = 25 mm, basal L = 18 mm), with a dental

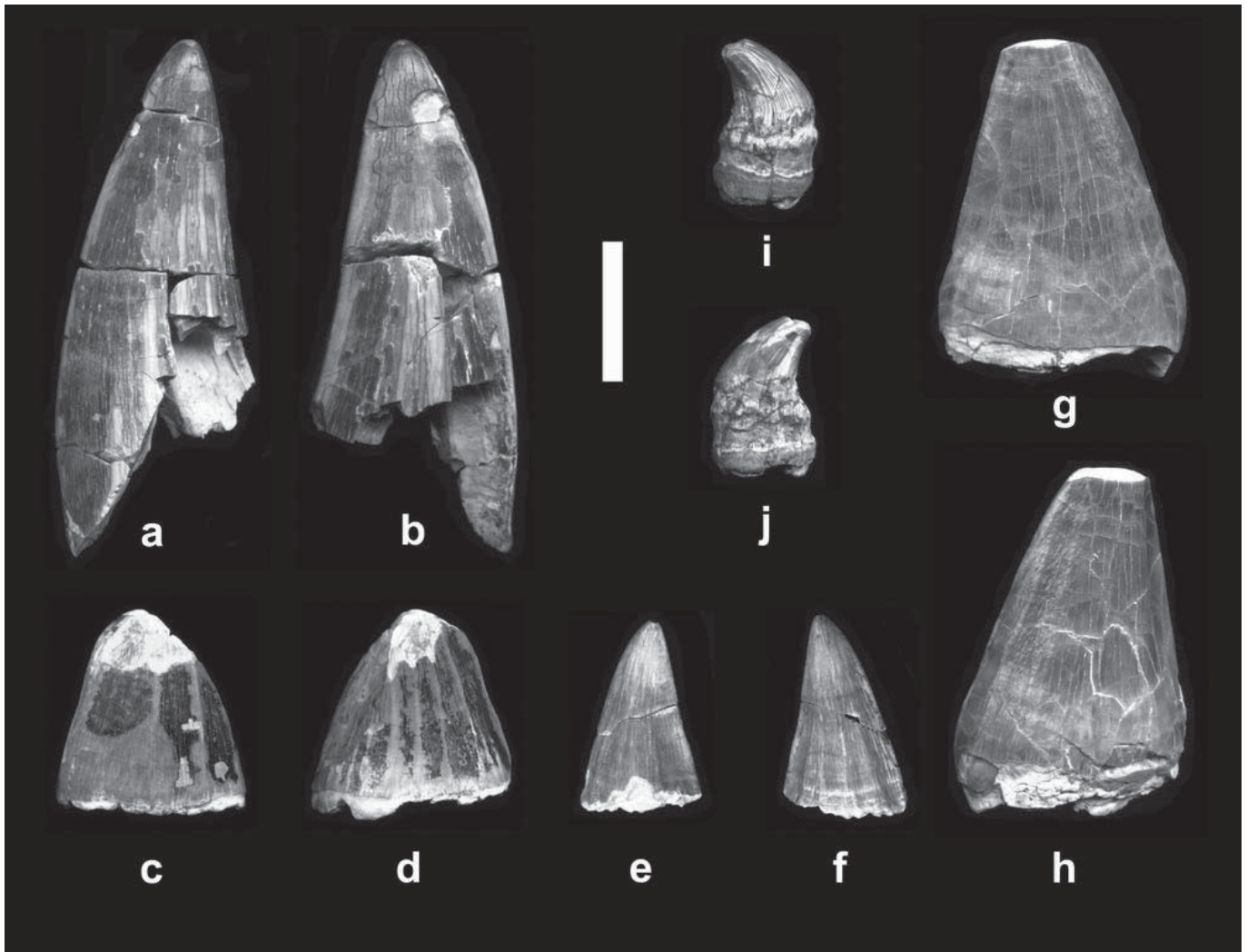


Figure 3. Mosasaurid teeth from Albaina, Laño quarry, Condado de Treviño, Late Maastrichtian. **a-b** *Mosasaurus hoffmanni*, LU – GMS/LAÑ004, marginal tooth in lingual (**a**) and labial (**b**) views. **c-d** *Prognathodon solvayi*, LU – GMS/LAÑ001, marginal tooth in labial (**c**) and lingual (**d**) views. **e-f** *Prognathodon solvayi*, LU – GMS/LAÑ005, marginal tooth in lingual (**e**) and labial (**f**) views. **g-h** *Prognathodon sectorius*, LU – GMS/LAÑ002, marginal tooth in labial (**g**) and lingual (**h**) views. **i-j** *Platecarpus cf. ictericus*, LU – GMS/LAÑ003, pterygoid tooth in labial (**i**) and lingual (**j**) views. Scale = 1 cm.

ratio (H:L, *sensu* Schulp *et al.*, 2008) of about 1.39. The crown is very labiolingually compressed, with a width ($W = 9$ mm) being half the length. Both anterior and posterior surfaces are straight in lateral view. There is a small inflation at the base of the crown both anteriorly and posteriorly. Two anteroposteriorly aligned and well-marked carinae are present. They are smooth and slightly 'pinched' from the main shaft. The apex of the crown shows a large sharply oval wear facet. Both labial and lingual surfaces are slightly convex, the lingual one being slightly larger than the labial one. The enamel is smooth and silky.

Discussion. The anteroposteriorly aligned carinae and the comparable in size lingual and labial surfaces indicate that this tooth belongs to the median part of the jaws. The large size and robustness of the crown, the presence of a smooth and silky enamel devoid of facets, the occurrence of only a small basal inflation, of subequal labial and lingual surfaces and of 'pinched' carinae permit to assign this tooth to *Prognathodon* (i.e., Schulp, 2006). Among the about ten species currently referred to *Prognathodon*, the LU-GMS/LAÑ002 crown is reminiscent of the *Prognathodon* species with slender teeth (see Schulp *et al.*, 2008). The dental ratio of 1.39 is comparable to that of *P. compressidens* (Gaudry, 1892) from the Campanian of France (see Schulp *et al.*, 2008), but the general size and shape of LU-GMS/LAÑ002 are very different. It is particularly reminiscent of the teeth of *P. sectorius* (Cope, 1871), which exhibit median marginal teeth intermediate in lateral compression, lateral shape and posterior curvature between the species *P. kianda* from the Maastrichtian of Angola (Schulp *et al.*, 2008) and *P. mosasauroides* from the Maastrichtian of France (Gaudry, 1892).

Originally described in the Late Maastrichtian of New Jersey (Cope, 1871), *P. sectorius* has been reported from the Early Maastrichtian of Belgium, the Late Maastrichtian of The Netherlands and possibly Bulgaria (see Bardet, 2012). Recently, this species has been described from the Late Campanian of Navarre (Bardet *et al.*, 2012a).

Russellosaurina Polcyn & Bell, 2005

Platecarpus cf. ictericus (Cope, 1871)

Material and occurrence. LU-GMS/LAÑ003, an isolated pterygoid tooth; Albaina, Laño quarry, Condado de Treviño; Late Maastrichtian (Baceta *et al.*, 1999; Cappetta & Corral, 1999) (Figs 3i-3j).

Description. LU-GMS/LAÑ003 is a small pterygoid tooth that preserves the complete crown and a portion of the root. The apex of the crown is broken and its basal part eroded and cracked. It is about 8 mm high and 7 mm long. The basal cross-section is circular. The crown is strongly posteriorly recurved. It bears two very weak

carinae located on the anterior part of the supposed lingual surface and on the posterior part of the supposed labial one. Both carinae are only developed on the upper half of the crown. The entire crown surface exhibit fine striations that reach the apex, more marked basally and on the posterior surface.

Discussion. The above mentioned combination of characters is the same observed in a marginal tooth from Albaina that was previously referred to *Platecarpus cf. ictericus* (Bardet *et al.*, 1997, 1999), with the difference that LU-GNS/LAÑ003 is a pterygoid tooth.

This species is mainly known in the Santonian-Campanian of the Western Interior Seaway of North America (Russell, 1967). Its description in the Santonian-Campanian of France (Bardet *et al.*, 1991) and the Maastrichtian of Albaina (Bardet *et al.*, 1997, 1999) greatly enlarges both its palaeobiogeographical and stratigraphical distributions.

4. CONCLUSIONS

Despite intensive prospecting, the Laño-Albaina quarry is the only known fossil-rich marine outcrop in the southern limb of the Miranda-Treviño syncline. Its richness may be related to a local palaeo-sea depression that allowed the accumulation and preservation of marine deposits.

These new discoveries permit to expand the Laño-Albaina mosasaurid faunal list (see Table 1) by including the first mention here of *Mosasaurus hoffmanni* and *Prognathodon sectorius*. *Prognathodon solvayi* and *Platecarpus cf. ictericus* were previously reported in Albaina (Bardet *et al.*, 1997, 1999). As commonly seen in latest Cretaceous mosasaurid sites, the Albaina fauna predominantly consists of mosasaurine taxa. Moreover, these Maastrichtian mosasaurid faunas are typical of the Northern Tethys margin Palaeoprovince located around palaeolatitudes 30-40°N and differ significantly from those of the Southern Tethys margin around 20°N (Bardet, 2012). With six taxa reported here, Albaina is the richest Maastrichtian outcrop in mosasaurid remains from southern Europe.

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