Facies analysis and stratigraphy of a lower Aptian carbonate platform section (Prebetic, Alicante, Spain)

Estratigrafía y análisis de facies de una sección de una plataforma de carbonatos del Aptiense inferior (Prebético, Alicante, España)

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ABSTRACT

In the Racó Llobet section (Sierra Mariola, Prebetic of Alicante) crops out the Llopis Formation, dated as lower Aptian (lower Bedoulian). Six types of facies have been recognized: 1) orbitolinite facies (packstone and wackestone with orbitolinids); 2) calcarenites with grainstone texture; 3) limestones and marlstones with corals; 4) floatstones and packstones with rudists; 5) wackestone and packstone with foraminifera; and 6) mudstone with scarce fossils. These facies correspond with shallowing upward elementary cycles. In general, this section records the process of installation of a shallow carbonate platform, occurred in two progradational steps, ending with the development of a lagoon.

Key-words: *Prebetic, Aptian, shallowing upward cycles, carbonate platforms.*

RESUMEN

*En la sección de Racó Llobet (Sierra Mariola, Prebético de Alicante) aflora la Fm. Llopis, datada como Aptiense inferior (Bedouliense inferior). Se han reconocido seis tipos de facies: 1) facies de orbitolinas (*packstones *y* wackestones *con orbitolinas); 2) calcarenitas con textura* grainstone*; 3) calizas y margocalizas con corales; 4)* floatstones *y* packstones *con rudistas; 5) wackestones y* packstones *con foraminíferos; y 6)* mudstones *con escaso contenido fósil. Estas facies se corresponden con ciclos elementales de somerización. En general, la sección estudiada registra el proceso de instalación de una plataforma de carbonatos somera, que tuvo lugar en dos fases de progradación, y que finalizaron con el desarrollo de un* lagoon.

Palabras clave: *Prebético, Aptiense, ciclos de somerización, plataformas de carbonatos.*

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Introduction

The Aptian recorded the development of broad carbonate platforms in the Tethys margins (*e.g.*, Skelton and Gili, 2012), including the Southern Iberian Continental Margin (SICM, Fig. 1A).

This study is focused on an Aptian succession located in Sierra Mariola (Alicante Province, SE Spain), which belongs to the Prebetic of the Betic External Zones (BEZ). This area has been studied by Fallot (1943), Busnardo *et al.*, (1968), Company *et al.* (1982), Castro (1998), and Castro *et al.* (2008, 2014), among others.

The BEZ are made up by sedimentary rocks deposited in the SICM, during the Alpine tectonic cycle (Triassic to lower Miocene) (Vera, Cap. 4, 2004). The Prebetic has a parautochthonous character; it is located in the NE of the mountain range and represents the coastal and shallow platform environments of the SICM. During the Early Cretaceous, extensive carbonate platforms were developed in the Prebetic domain under an extensional tectonic regime associated with a rifting phase. The extension resulted in the formation of listric faults, favouring lateral changes in facies and subsidence (Fig. 1B, Vera, Cap. 4, 2004).

The Prebetic of Alicante constitutes the most oriental and distal sector of the Prebetic platform. Here, the Aptian sedimentary record is represented by three units: the Llopis Fm (lower Aptian), the Almadich Fm (lower to upper Aptian) and the Seguilí Fm (upper Aptian-lowermost Albian). The Llopis and Seguilí formations are made of shallow platform carbonates, whereas the Almadich Fm is hemipelagic (Castro *et al.*, 2008).

Here we present a study of the Racó Llobet section in the Sierra Mariola (Alicante), which belongs to the Llopis Fm. The aim of this study is to characterize the stratigraphy and sedimentology of the studied section in order to analyse the processes of installation and development of a shallow carbonate platform.

The fieldwork analysis has been made studying bed-by-bed. Thin sections have been performed from the hard-samples.

Stratigraphy

The Racó Llobet section locates near the village of Cocentaina, and its GPS WGS84 coordinates are: Bottom; Lat. 38.7676670;

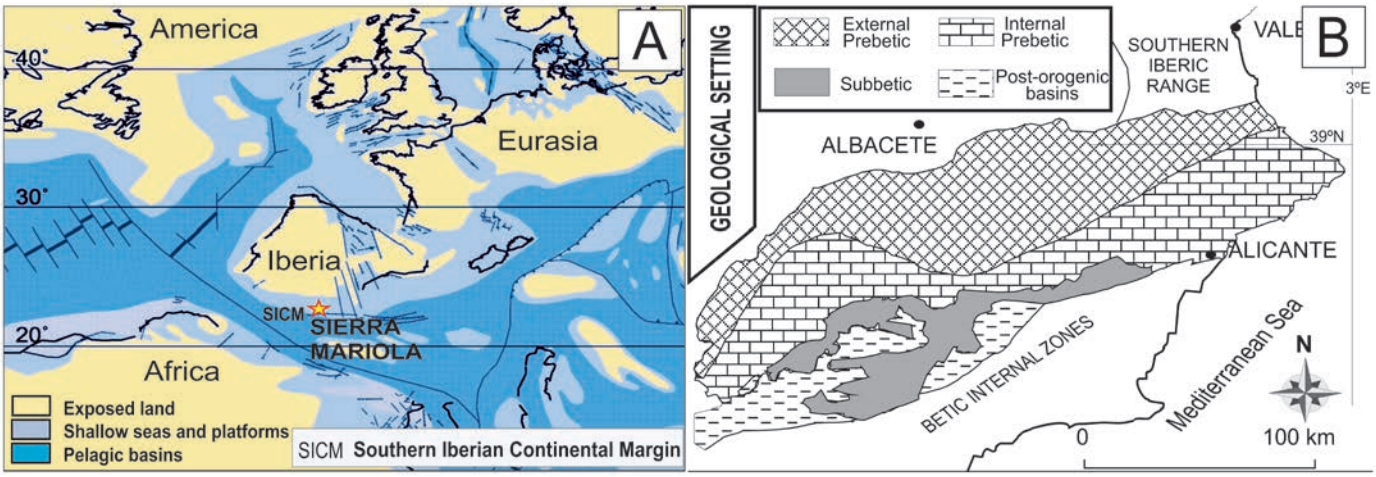

Fig. 1.- A) Palaeogeography of the Iberian Plate during the Aptian (simplified from Masse *et al.*, 1993). B) Regional geological setting of the Betic External Zones in the E of the Iberian Peninsula (modified from Castro *et al.*, 2008). See color figure in the web.

Fig. 1.- A) Paleogeografía de la Placa Ibérica durante el Aptiense (simplificado de Masse* et al.*, 1993). B) Contexto geológico regional de las Zonas Externas Béticas al E de la Península Ibérica (modificado de Castro* et al.*, 2008). Ver figura en color en la web.

Long. -0.4926540; Top; Lat. 38.7643143; Long. -0.4923775.

Lithostratigraphy

The section is 118 m thick and has been subdivided in three main units (1-3 in Fig. 2). Unit 1 (38 m thick) is characterized by the presence of calcarenites. Unit 2 consists of nodular and often bioturbated marly limestones. Its lower part (2.1, from 38 to 50 m) contains abundant brachiopods, whereas the upper part (2.2, from 50 to 60 m) is very rich in orbitolinids. Unit 3 (from 60 to 118 m), is composed mainly of well-bedded limestones with rudists.

Biostratigraphic data

Caprinidae rudists *Offneria interrupta* (Skelton, *pers. comm.*) has been found at the base of the section, and *Caprina douvillei* (Skelton, *pers. comm.*) at the top. Caprinidae rudists *Offneria interrupta* and *Caprina douvillei* (Skelton, *pers. comm.*) have been found at the lowermost part of unit 1 and the uppermost part of unit 3, respectively. Planktic foraminifera *Hedbergella sigali* have been recovered in the unit 2. *Orbitolinopsis sp.*, and *O. buccifer* are also present. Collectively, these data indicate a lower Aptian (lower Bedoulian age), which is consistent with previous data (*e.g.,* Busnardo *et al.*, 1968; Company *et al.,* 1982; Castro, 1998).

Facies analysis

The combined field and microfacies detailed study has led to the differentiation of six main facies types (1-6 in Figs. 2 and 3).

Facies 1 (Fig. 3A) corresponds to packstones and wackestones almost entirely composed of orbitolinids (orbitolinite). The orbitolinids are mostly planar. Less common grains are brachiopods, cortoids, crinoids, scarce rudist fragments, bryozoans and gastropods. The matrix is a peloidal micrite with fine quartz grains.

Facies 2 (Fig. 3B) is represented mainly by coarse brownish grey calcarenites which are arranged in m-thick beds with local, small-scale cross-stratification. The microfacies are bioclastic grainstones with 1 mm mean sized grains and sparry cement. Grains are coated bioclasts, exhibit micrite envelopes or are completely micritized. It is composed of intraclasts, micritized grains, peloids, ooids, cortoids, and some bioclasts such as molluscs, red algae, echinoid spines, crinoids and benthic foraminifera. Some grains present Fe-oxide. The intraclasts are poorly-sorted and sub-angular to sub-rounded in shape.

Facies 3 (Fig. 3C) corresponds to grey limestones and marlstones with scleractinian corals, with usual packstone texture. The corals are small (cm-size) irregular bioclasts often encrusted by red algae, with micrite coatings and borings filled with sediment. The matrix is mudstone to wackestone with bioclasts and benthic foraminifera (mostly miliolids and orbitolinids), along with some lime mudstone intraclasts intensely burrowed.

Facies 4 (Fig. 4D) corresponds to floatstones and packstones with rudists, along with ostreids, other bivalves, coral fragments, and another vagile organisms like echinoderms and gastropods, all rooted in micrite. The matrix is a bioclastic wackestone (locally packstone), with small skeletal debris, including benthic foraminifera (miliolids and orbitolinids with conical morphology), and dasycladalean algae.

Facies 5 (Fig. 3E) is represented by wackestones and packstones with abundant benthic foraminifera. These are miliolids and orbitolinids, among other planispiral, trochospiral and biseriated taxa. The planktic foraminifera distinguished is *Hedbergella sigali.* The matrix is a homogeneous micrite.

Facies 6 (Fig. 3F) is represented by mudstones with scarce small miliolids and undifferentiated bioclasts. The micrite displays small (mm-size) pores.

Facies associations in elementary cycles and sedimentary environments

The described facies are stacked in meter-scale elementary cycles, formed mainly by three different vertical associations of facies. By application of Walther´s law, these vertical associations of facies indicate a 1-2-3-4-5-6 lateral facies relationship during deposition (Fig. 3). The first association (facies 2 and 3) is represented by cycles of calcarenites followed by marlstones with corals, and is mainly found in the lower part of the section (unit 1, Fig. 2). The second facies association (facies 1 and 2) is composed of packstones of orbitolinids and wackestone/packstone with

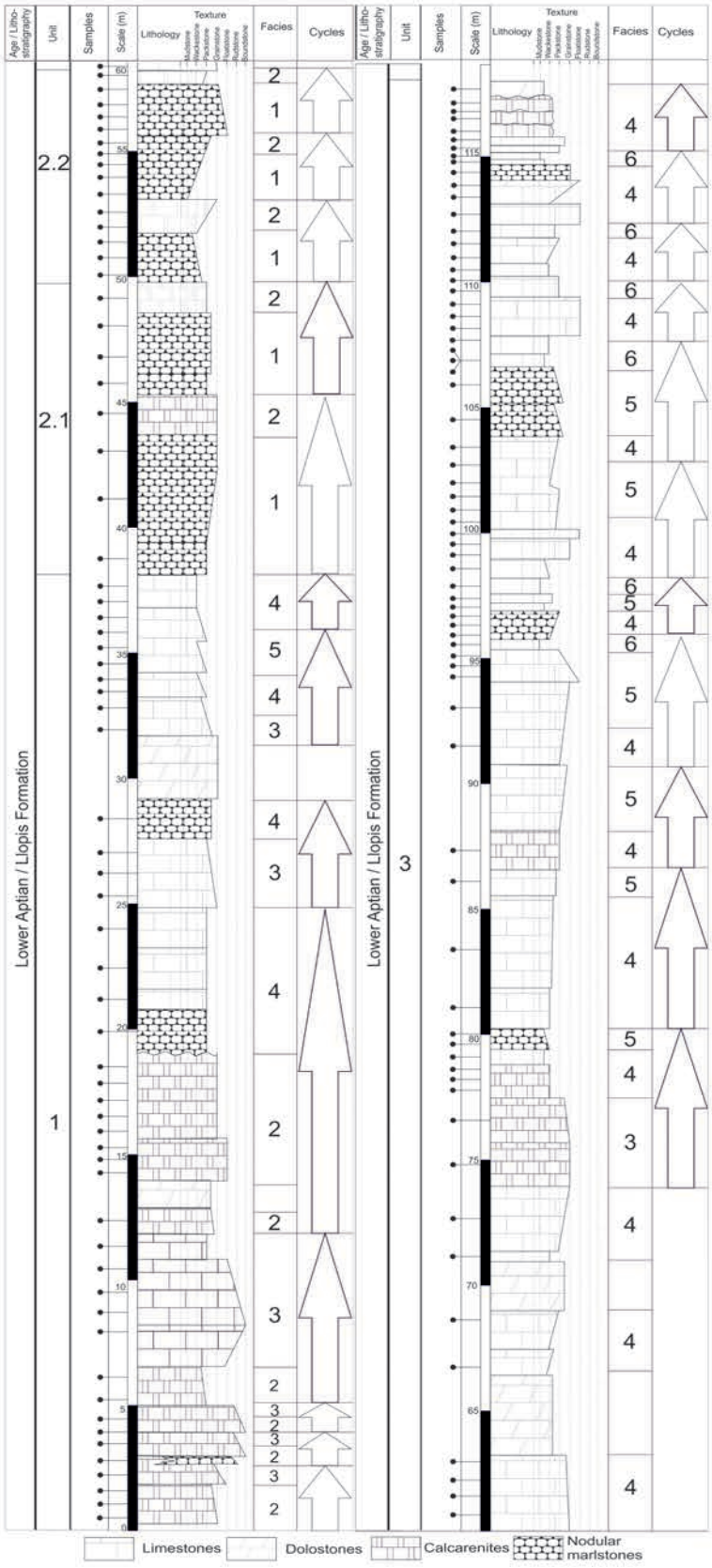

Fig. 2.- Stratigraphic column of the Middle Member of the Llopis Formation at the Racó Llobet section (Sierra Mariola, Alicante). Facies numbers correspond to the facies types described in this paper. The vertical arrows represent sedimentary cycles.

Fig. 2.- Columna estratigráfica del Miembro Medio de la Formación Llopis en la sección de Racó Llobet (Sierra Mariola, Alicante). Los números de la columna de facies corresponden a los tipos de facies descritos en este artículo. Las flechas verticales representan ciclos sedimentarios.

brachiopods, and marlstones with corals, present in the middle part of the section (unit 2, Fig. 2). The third facies association (facies 4, 5, and 6) is composed of calcarenites, rudist floatstones and wackestones or mudstones with a burrowed or bored top, and dominates the upper part of the section (unit 3, Fig. 2).

Facies 1 is characteristic of shallow open marine environments with moderate to high energy. The accumulation of planar orbitolinids has been considered as related to transgressive contexts (Vilas *et al.*, 1995). The laterally related Facies 2 represents shallow marine environments with moderate energy, probably representing sandy (barrier) shoals (Flügel, 2010), as indicated by the grainstone texture and the dominance of cortoids. Facies 3 corresponds to shallow agitated areas with coral growth and bioerosion (James and Dalrymple, 2010), in open platform environments. Facies 4, dominated by rudists and including ostreids, dasycladalean algae and miliolids, was deposited in a low energy, shallow lagoon, with moderate water circulation. Facies 5 indicates a shallow low-energy environment corresponding to a lagoon with moderate water circulation (Flügel, 2010). Facies 6 is interpreted to be deposited in a very shallow low-energy environment with restricted circulation and probable subtidal areas, as indicated by the mudstone texture and presence of fenestral porosity (James and Dalrymple, 2010). Therefore, the elementary cycles are interpreted as shallowing-upwards cycles.

Vertical evolution

The analysis of facies and cycles across the section has led to a discussion of the vertical evolution of the succession.

In unit 1 (Fig. 2), 8 elementary shallowing-upward cycles have been recognized. The cycles have different thickness between 2-3 m to more than 10 m (Fig. 2).

In unit 2 (Fig. 2) 5 elementary cycles involving open platform facies (1 and 2) can be recognized; the first two cycles (unit 2.1) are thicker having an approximate thickness of 5 m, whereas the other three (unit 2.2) are 2-3 m thick.

Eleven cycles have been recognized in unit 3 (Fig. 2). The lower cycles are, in general, thicker (having 5-7 m) than the upper

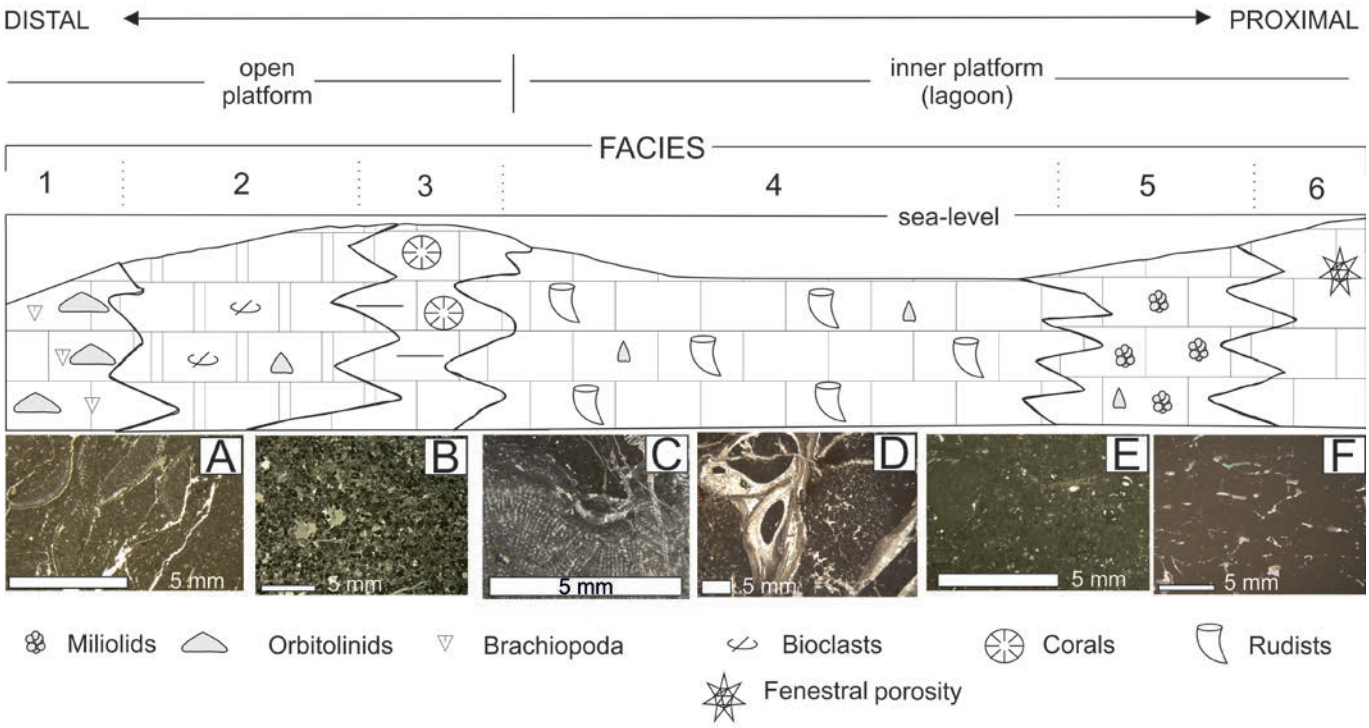

Fig. 3.- Facies model. A) Facies 1. B) Facies 2. C) Facies 3. D) Facies 4. E) Facies 5. F) Facies 6. Not to scale.

Fig. 3.- Modelo de facies. A) Facies 1. B) Facies 2. C) Facies 3. D) Facies 4. E) Facies 5. F) Facies 6. Sin escala.

cycles, which are generally organized in packages of 2-3 m, in a thinning-upward trend.

Discussion and conclusions

The vertical evolution can be explained as related to the development of an open carbonate platform (the first calcarenitic defined unit), that represents a first progradational phase. Unit 2 (mostly nodular limestones) represents a deepening episode with a moderate terrigenous input, due to a rise of the relative sea level. In unit 3, lower energy environments of the inner platform (lagoon facies 4-5-6) are developed, with a pronounced cyclicity, and a general shallowing-upwards trend, related to a progressive decrease in the accommodation space.

This general sedimentary evolution is consistent with the progressive installation, in two progradational pulses, of an Urgonian shallow carbonate platform in the lower Aptian at Sierra Mariola (Castro, 1998), which represents the local expression of the Early Aptian major episode of transgression and development of carbonate platforms occurred in the Prebetic (Vera, 2004).

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