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Review of the early Albian ammonites of the Montmell Formation near Marmellar (Salou-Garraf Basin, Tarragona, Catalonia, Spain)

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Abstract: In this work, we review the ammonites of the Montmell Formation in the Marmellar area housed in the collections of the Museo Geológico del Seminario de Barcelona and the Museu de Geologia de Barcelona. This taxonomic update allows the proper biostratigraphic analysis of the ammonite assemblage and assigns it to the early Albian, *Leymeriella tardefurcata* Zone. The taxonomic analysis of all the studied material allows us to recognize the presence of the following taxa: *Uhligella* sp., *Parengonoceras bassei*, *Hypacanthoplites plesiotypicus*, *Hypacanthoplites milletianus*, *Hypacanthoplites subelegans*, and *Hypacanthoplites* sp. The current work is a step forward in the chronostratigraphic knowledge of the Salou-Garraf Basin in the Catalan Coastal Ranges.

Key-words:

- Marmellar;
- Spain;
- Montmell Formation;
- ammonites;
- early Albian

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Résumé : *Révision des ammonites d'âge albien inférieur de la Formation de Montmell près de Marmellar (Bassin de Salou-Garraf, Tarragone, Catalogne, Espagne).-* Dans cette étude, nous avons réexaminé les ammonites de la Formation de Montmell du secteur de Marmellar déposées dans les collections du Musée géologique du Séminaire de Barcelone et du Musée de Géologie de Barcelone. Cette mise à jour taxinomique a permis une analyse biostratigraphique précise de l'association ammonitique, qui est attribuée à la Zone à *Leymeriella tardefurcata* de l'Albien inférieur. L'analyse taxinomique de l'ensemble du matériel étudié révèle la présence des taxons suivants : *Uhligella* sp., *Parengonoceras bassei*, *Hypacanthoplites plesiotypicus*, *Hypacanthoplites milletianus*, *Hypacanthoplites subelegans* et *Hypacanthoplites* sp. Cette étude représente une étape importante dans la connaissance chronostratigraphique du Bassin de Salou-Garraf dans les Chaînes Côtières Catalanes.

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Mots-clefs :

• Marmellar ;
• Espagne ;
• Formation de Montmell ;
• ammonites ;
• Albien inférieur.

Resumen: ***Revisión de los ammonites del Albiense inferior de la Formación Montmell cerca de Marmellar (Cuenca de Salou-Garraf, Tarragona, Cataluña, España).-*** En este trabajo se revisan los ammonites de la Formación Montmell del área de Marmellar conservados en las colecciones del Museo Geológico del Seminario de Barcelona y del Museu de Geologia de Barcelona. Esta actualización taxonómica permite realizar un preciso análisis bioestratigráfico de la asociación de ammonites asignándola a la Zona *Leymeriella tardefurcata*, del Albiense inferior. El análisis taxonómico del material estudiado permite reconocer la presencia de: *Uhligella* sp., *Parengonoceras bassei*, *Hypacanthoplites plesiotypicus*, *Hypacanthoplites milletianus*, *Hypacanthoplites subelegans* y *Hypacanthoplites* sp. Este trabajo constituye un paso adelante en el conocimiento cronoestratigráfico de la Cuenca de Salou-Garraf de las Cadenas Costeras Catalanas.

Palabras clave:

• Marmellar;
• España;
• Formación Montmell;
• ammonites;
• Albiense inferior.

Resum: ***Revisió dels ammonits de l'Albià inferior de la Formació Montmell a prop de Marmellar (Conca de Salou-Garraf, Tarragona, Catalunya, Espanya).-*** En aquest treball es revisen els ammonits de la Formació Montmell de l'àrea de Marmellar conservats en les col·leccions del Museo Geológico del Seminario de Barcelona i del Museu de Geologia de Barcelona. Aquesta actualització taxonòmica permet la correcta anàlisi biostratigràfica de l'associació d'ammonits assignant-la a la Zona *Leymeriella tardefurcata* de l'Albià inferior. L'anàlisi taxonòmica del material estudiat permet reconèixer la presència d'*Uhligella* sp., *Parengonoceras bassei*, *Hypacanthoplites plesiotypicus*, *Hypacanthoplites milletianus*, *Hypacanthoplites subelegans* i *Hypacanthoplites* sp. Aquest treball constitueix un pas endavant en el coneixement cronoestratigràfic de la Conca de Salou-Garraf de les Cadenes Costaneres Catalanes.

Paraules clau:

• Marmellar;
• Espanya;
• Formació Montmell;
• ammonits;
• Albià inferior.

Introduction

The ammonite record of the Montmell Formation in the Marmellar area, Spain (Fig. 1), was first reported by ALMERA (1895), who concluded that it was Aptian Stage. He collected only one specimen that could be assigned to either the genus *Oppelia* or *Placenticeras*. There is no doubt that the best known and most abundant fossil record of the Marmellar area, and other nearby outcrops of the Montmell Formation, are the corals (*e.g.*, DE ANGELIS D'OSSAT, 1905; BATALLER, 1937), currently under taxonomic review (LÖSER, 2012, 2013, 2014, 2015). The scarce ammonoid record is important in order to calibrate the age of the whole fossil assemblage. BATALLER (1954) described the best known (by the international ammonite-workers community) ammonite of Marmellar, an engonoceratid of the new genus and species *Platiknemiceras bassei*, and assigned it to the Albian. The subsequent work of MARTÍNEZ *et al.* (1994) was the first to provide a more exhaustive list of the ammonite assemblage of the Montmell Formation in the Marmellar area, mentioning the genera *Hypacanthoplites* and *Sonneratia,* as well as *Platiknemiceras*. However, in this latter work only one specimen was illustrated: *Platiknemiceras bassei*. MARTÍNEZ *et al.* (1994) assigned the ammonites of the Montmell Formation to the second zone of the lower Albian, *Douvilleiceras mammillatum*. MORENO-BEDMAR *et al.* (2009) also studied the ammonoids of the Montmell Formation, and reported the genus *Hypacanthoplites,* together with the engonoceratid *Platiknemiceras*, and assigned them to the first Albian ammonite zone, *Leymeriella tardefurcata*. However, no ammonoids of this formation were illustrated by MORENO-BEDMAR *et al.* (2009).

In this work, we review the ammonites of the Montmell Formation, Salou-Garraf Basin, collected in the area surrounding the currently abandoned town of Marmellar (Fig. 1). A fieldwork campaign in the area (2013) focused on ancient croplands where the ammonites were collected in the past, however, no ammonites were found because the croplands were abandoned and quite covered by vegetation. Therefore, in

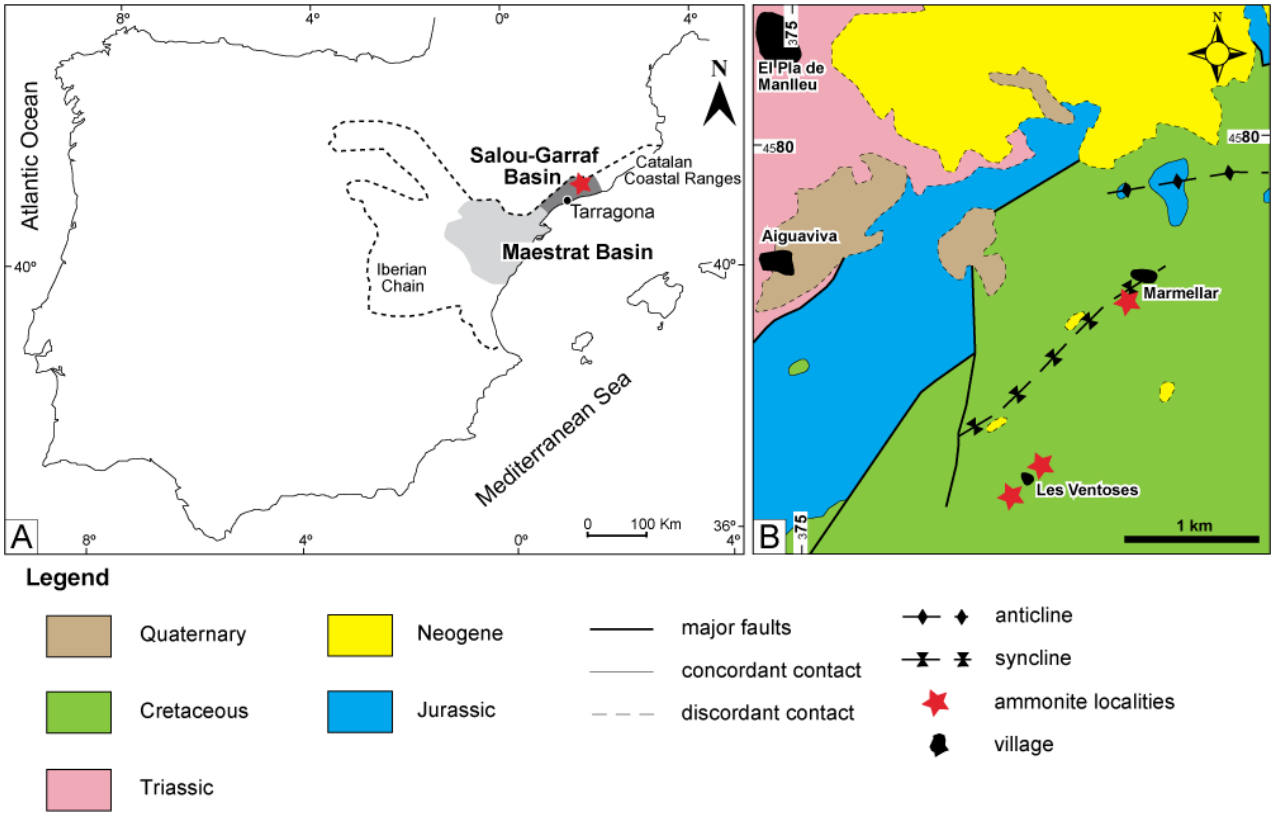
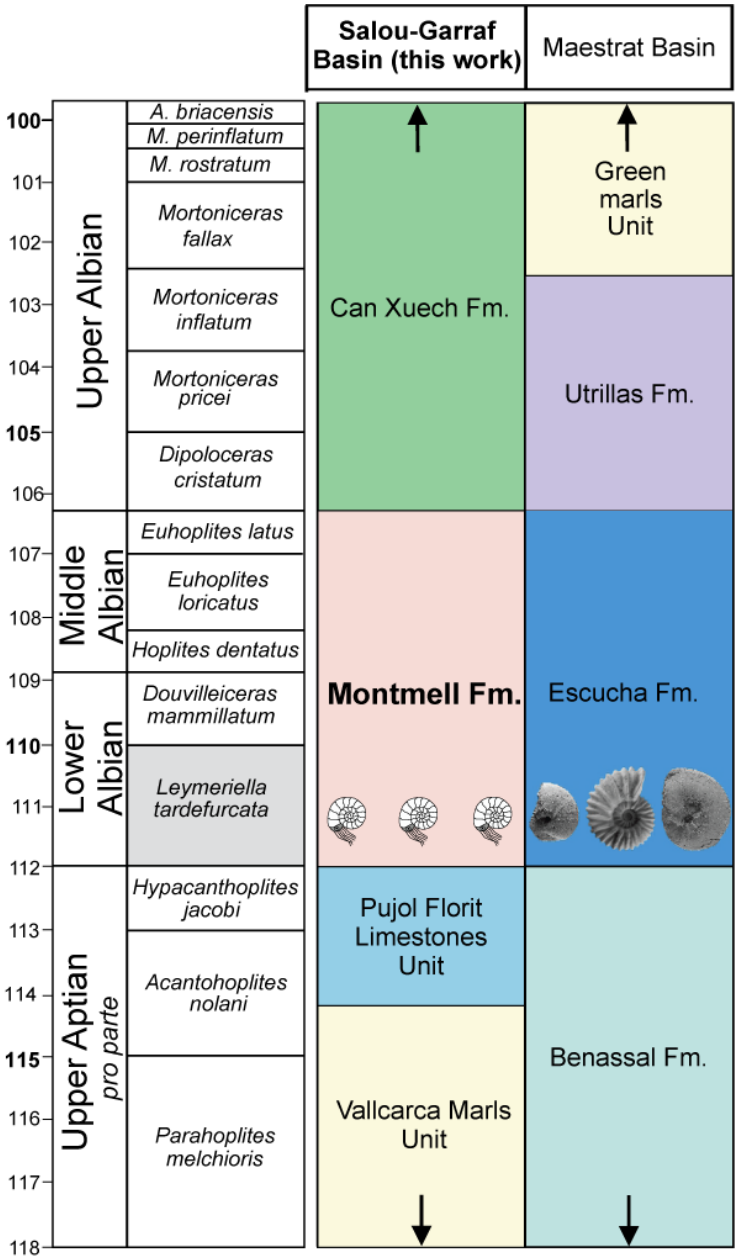


Figure 1: A) Map of the Iberian Peninsula showing the location of the ammonoid sampling site in the Salou-Garraf Basin of the Catalan Coastal Ranges, as well as the nearby Maestrat Basin in the Iberian Chain. Geographic coordinates in degrees. B) Geological map of the area of Marmellar (Comarca of El Baix Penedès) sampled for ammonites (modified from Institut Cartogràfic de Catalunya, 2005). The sampling sites in the surroundings of Marmellar and Les Ventoses villages are indicated with red stars. Geographic coordinates in UTM.

this work we review the ammonites housed in two collections located at the Museo Geológico del Seminario de Barcelona (MGSB) and the Museu de Geologia de Barcelona (MGB). The detailed taxonomic identification of the ammonite assemblage of Marmellar allowed us to make a proper biostratigraphic analysis. In the literature, the only illustrated species of the Montmell Formation is *Platiknemiceras bassei.* In the current work, the complete ammonoid fauna is illustrated. Important improvements in the chronostratigraphic knowledge of the nearby Maestrat Basin were recently carried out (*e.g.*, GARCIA *et al.*, 2014; BOVER-ARNAL *et al.*, 2016). Contrarily, the current state of knowledge of the chronostratigraphy of the Salou-Garraf Basin in the Catalan Coastal Ranges is considerably poorer. Factors that limit suitable data collection in the Salou-Garraf Basin include the very intense faulting caused by the Neogene extension and the opening of the Mediterranean Sea (GUIMERÀ & SANTANACH PRAT, 1978; BARTRINA *et al.*, 1992), which considerably complicates the study of stratigraphy, because the stratigraphic cover is intensely fragmented like a puzzle. The progressive abandonment of the farmlands resulting in the overgrowth of the outcrops and making them less accessible for stratigraphic study or fossil collection. The combination of the aforementioned factors makes this basin less attractive for geologists. The current paper intends to update the chronostratigraphic knowledge of the Salou-Garraf Basin.

Stratigraphy

The ammonoids examined in this study come from the Montmell Formation and are of early Albian age. This lithostratigraphic unit is mainly characterized by an alternation of micaceous red clays, sandstones and calcarenites rich in *Mesorbitolina texana*, up to 90 m-thick (CANÉROT *et al.*, 1982). Other common skeletal components contained in those strata are miliolids, other foraminifera, echinoids, rudists, other molluscs, corals, and dasycladacean algae. Dolomitic levels, as well as ferruginous crusts, are locally found in the upper part of the formation (ESTEBAN, 1973). The lithologies and fossil content indicate a shallow subtidal to coastal depositional environment punctuated by continental conditions (ESTEBAN, 1973). The Montmell Formation is laterally equivalent with the lower part of the Escucha Formation in the Maestrat Basin (SALAS & MORENO, 2008; MORENO-BEDMAR *et al.*, 2009; BOVER-ARNAL *et al.*, 2016). The ammonite assemblage reported in Traiguera, from the basal part of the Escucha



◀ **Figure 2:** Chronostratigraphic chart for the upper Aptian, *pro parte*, to the upper Albian of the Salou-Garraf and Maestrat basins including the stratigraphic position of the ammonoids studied herein in the lower part of Montmell Formation and the equivalent ammonoid record from the lower part of Escucha Formation. Dashed in grey, the early Albian recognized ammonite zone *Leymeriella tardefurcata*.

Formation (Moreno-Bedmar *et al.*, 2008; Garcia *et al.*, 2014: p. 107), is quite similar to the herein studied ammonoids from the Montmell Formation.

The Montmell Formation is overlain and underlain by the Can Xuech Formation (Canérot *et al.*, 1982) and the Pujol Florit lithostratigraphic unit (Salas & Moreno, 2008), respectively (Fig. 2). The Can Xuech Formation is upper Albian-Cenomanian (Canérot *et al.*, 1982), and is represented by a succession of marlstones, marly limestones, limestones and ferroan dolostones, up to 200 m-thick. The fossil content is characteristic of a shallow-water carbonate platform depositional environment and includes orbitolinids, miliolids, other foraminifera, brachiopods, oysters, rudists, other molluscs and corals (Bataller, 1958; Canérot *et al.*, 1982).

The underlying Pujol Florit unit is upper Aptian (Salas & Moreno, 2008; Moreno-Bedmar *et al.*, 2009). This stratigraphic interval is a lateral equivalent of the upper part of the Benassal Formation from the Maestrat Basin (Salas & Moreno, 2008; Moreno-Bedmar *et al.*, 2009; Bover-Arnal *et al.*, 2016). The Pujol Florit unit is composed of a lower 20 m-thick succession of packstone to grainstone decimetric and metric beds of platform carbonates containing abundant orbitolinids and fragments of corals and rudist bivalves. Above, is a 40 m-thick alternation of marlstones with orbitolinids and brachiopods, and decimetric micritic limestone beds. The upper part of the Pujol Florit unit is characterized by a 50 m-thick alternation of marlstones with orbitolinids and micritic limestones with rudists bivalves (Salas & Moreno, 2008).

Ammonite assemblage and biostratigraphic analysis

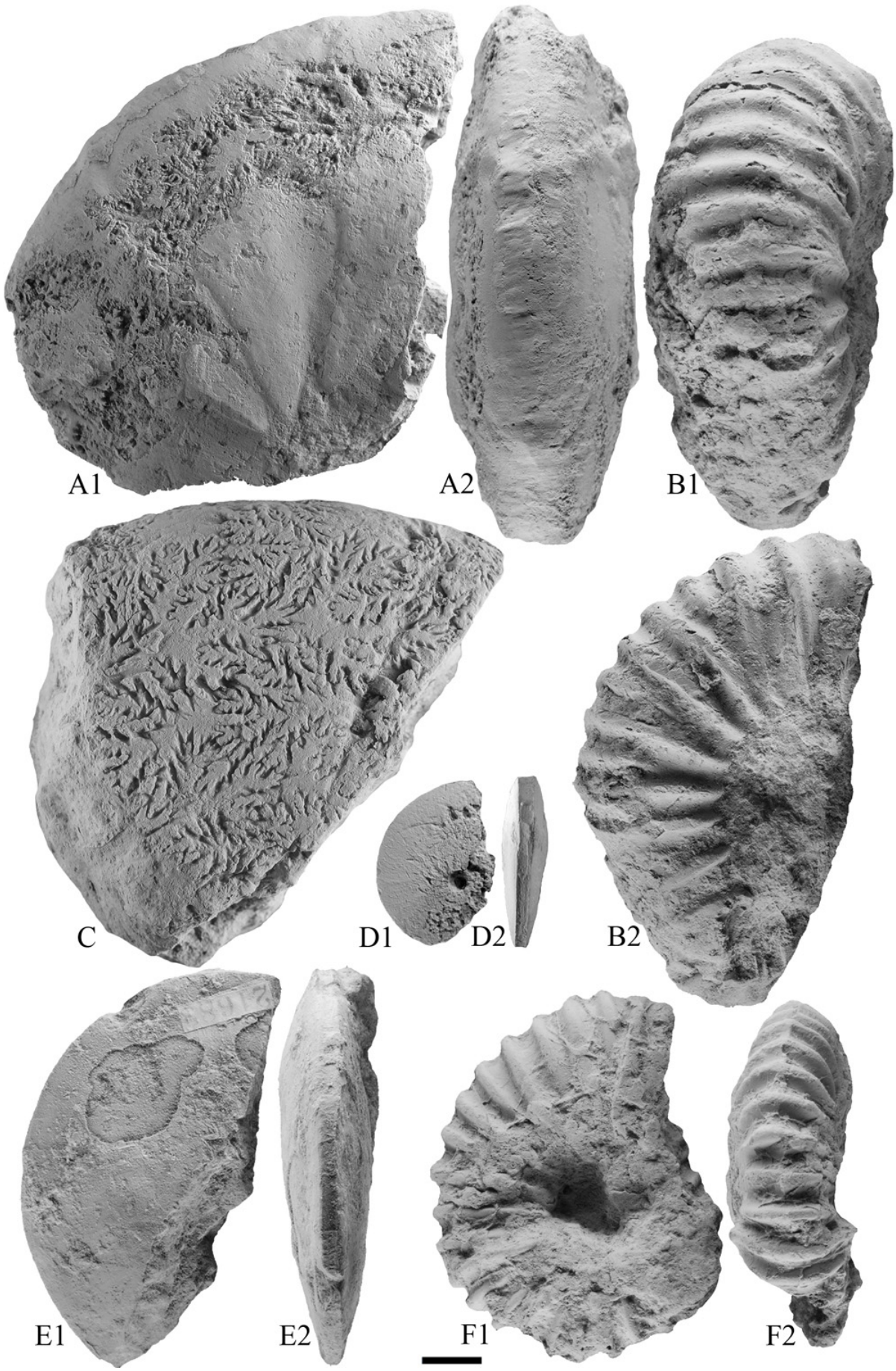
Review of the two museum collections allowed the identification of: *Uhligella* sp. (Fig. 3: A1-2, C), *Parengonoceras bassei* (BATALLER, 1954) (Fig. 3: D1-2, E1-2; Fig. 4: A1-2, B1-2), *Hypacanthoplites plesiotypicus* (FRITEL, 1906) (Fig. 3: B1-2, F1-2), *Hypacanthoplites milletianus* (ORBIGNY, 1841) (Fig. 4: D1-2), *Hypacanthoplites subelegans* (BREISTROFFER, 1936) (Fig. 4: E1-2) and *Hypacanthoplites* sp. (Fig. 4: C).

The taxon *Parengonoceras bassei* is well known to be restricted to the early Albian (MARTÍNEZ *et al.*, 1994; BULOT, 2010; BUTJOR, 2010). In the Traiguera and Marmellar areas of Spain, other recent works tend to assign this species to the *Leymeriella tardefurcata* Zone (MORENO-BEDMAR *et al.*, 2008, 2009; GARCIA *et al.*, 2014). This is the most common age assignment of this species, even thought, at least in Tunisia, it is also present in the *Douvilleiceras mammillatum* Zone (LATIL, 2011). The species of the genus *Hypacanthoplites* range from the late Aptian to the early Albian, disappearing during the later part of the *Leymeriella tardefurcata* Zone. The *Hypacanthoplites* species, displaying flexuous ribs, belong to the late Aptian, whereas the taxa with straight ribs belong to the early Albian (*e.g.*, AMÉDRO, 1992; ROBERT *et al.*, 2001; REY *et al.*, 2013). Most of the *Hypacanthoplites* specimens from the Marmellar area possess rigid costulation. In the particular case of *Hypacanthoplites milletianus*, it is well established that this is an Albian taxon from the *Leymeriella tardefurcata* Zone (*e.g.*, PEYBERNÈS, 1976; LATIL, 1994; MATRION, 2010). The species *Hypacanthoplites subelegans* is present in Normandy, France, also in the *Leymeriella tardefurcata* Zone (DESTOMBES *et al.*, 1974; MARECHAL, 1994). Within the species of the genus *Hypacanthoplites* of the Montmell Formation, *Hypacanthoplites plesiotypicus* is the only one that possesses slightly flexuous costulation (Fig. 3, B2). The range of this species was reviewed in detail by KENNEDY *et al.* (2000: p. 601, Fig. 7), concluding that it belonged to the late Aptian. The aforementioned authors made a particular proposal for the boundary between the Aptian and Albian stages where some species of the genera *Leymeriella*, among which *L. germanica*, and *Preleymeriella* are included in the Aptian. These forms are usually included in the *Leymeriella tardefurcata* Zone and are considered Albian taxa. However, in the present work, we follow the boundary location as was proposed by REBOULET *et al.* (2011, 2014) which corresponds to the classical conception where the whole *Leymeriella tardefurcata* Zone is included in the Albian. When we apply REBOULET's definition, the range of *Hypacanthoplites plesiotypicus* is extended into the lowermost Albian. In summary, we conclude that the ammonite assemblage of the Montmell Formation belongs to the *Leymeriella tardefurcata* Zone of the standard Mediterranean ammonite zonation of REBOULET *et al.* (2014), and must be assigned without a doubt to the early Albian. This age-assignment was previously proposed by MORENO-BEDMAR *et al.* (2009) and it is confirmed in the present work.

Systematic notes

Parengonoceras bassei: CASEY (1961) reviewed the genus *Platiknemiceras* and accepted its validity; however, he also remarked that the new genus was actually similar to *Parengonoceras*. Recent works (MORENO-BEDMAR *et al.*, 2008, 2009; BULOT, 2010) have begun to question the validity of the genus *Platiknemiceras*, considering it a junior synonym of *Parengonoceras*. This question was analyzed in detail by Jean-Louis LATIL, who established that the genus *Platiknemiceras* is indeed a synonym of *Parengonoceras* (LATIL, 2011: p. 348; LATIL & ALY, 2012: p. 161).

Hypacanthoplites subelegans and *Hypacanthoplites plesiotypicus*: these species of *Hypacanthoplites* possess a thick, wide whorl cross-section that differs from the common subrectangular compressed whorl section of the genus. *Hypacanthoplites subelegans*, *Hypacanthoplites plesiotypicus* and others, like *Hypacanthoplites* ? *buloti* LATIL, 2011, have a subrectangular to subquadrate whorl section, some of which are slightly depressed. This difference makes the identification of these species the most difficult taxonomic assignment of the current work. For this reason, in an initial version of the current paper we misidentified *Hypacanthoplites plesiotypicus* as *Arcthoplites*. MARTÍNEZ *et al.* (1994), made a similar mistake for the same reason, which is the unusual wide whorl section of these *Hypacanthoplites*. Among specimens of the Marmellar ammonite assemblage that is housed in the collection of the Museo Geológico del Seminario de Barcelona, MARTÍNEZ *et al.* (1994) also incorrectly identified one specimen as *Sonneratia subglabra*, which probably corresponds to the one here illustrated in Figure 4: E1-2, now determined to be *Hypacanthoplites subelegans*. In the work of MARTÍNEZ *et al.* (1994), the biostratigraphic assignment of the whole assemblage to the *Douvilleiceras mammillatum* Zone was caused by this misidentification, since the majority of the *Sonneratia* species were restricted to this ammonite zone (CASEY, 1965).


A1
A2
B1
C
D1
D2
B2
E1
E2
F1
F2

◄ **Figure 3:** A1-2: *Uhligella* sp. lateral and ventral views of the specimen MGSB 10781-1, Les Ventoses, Marmellar. B1-2: *Hypacanthoplites plesiotypicus* ventral and lateral views of the specimen MGB 21739, Marmellar. C: *Uhligella* sp. lateral view of the specimen MGSB 10781-2, Les Ventoses, Marmellar. D1-2: *Parengonoceras bassei* lateral and ventral views of the specimen MGSB 1044, Marmellar. E1-2: *Parengonoceras bassei* lateral and ventral views of the specimen MGB 66888, Marmellar. F1-2: *Hypacanthoplites plesiotypicus* lateral and ventral views of the specimen MGB 20319, Marmellar. Scale bar = 1 cm.

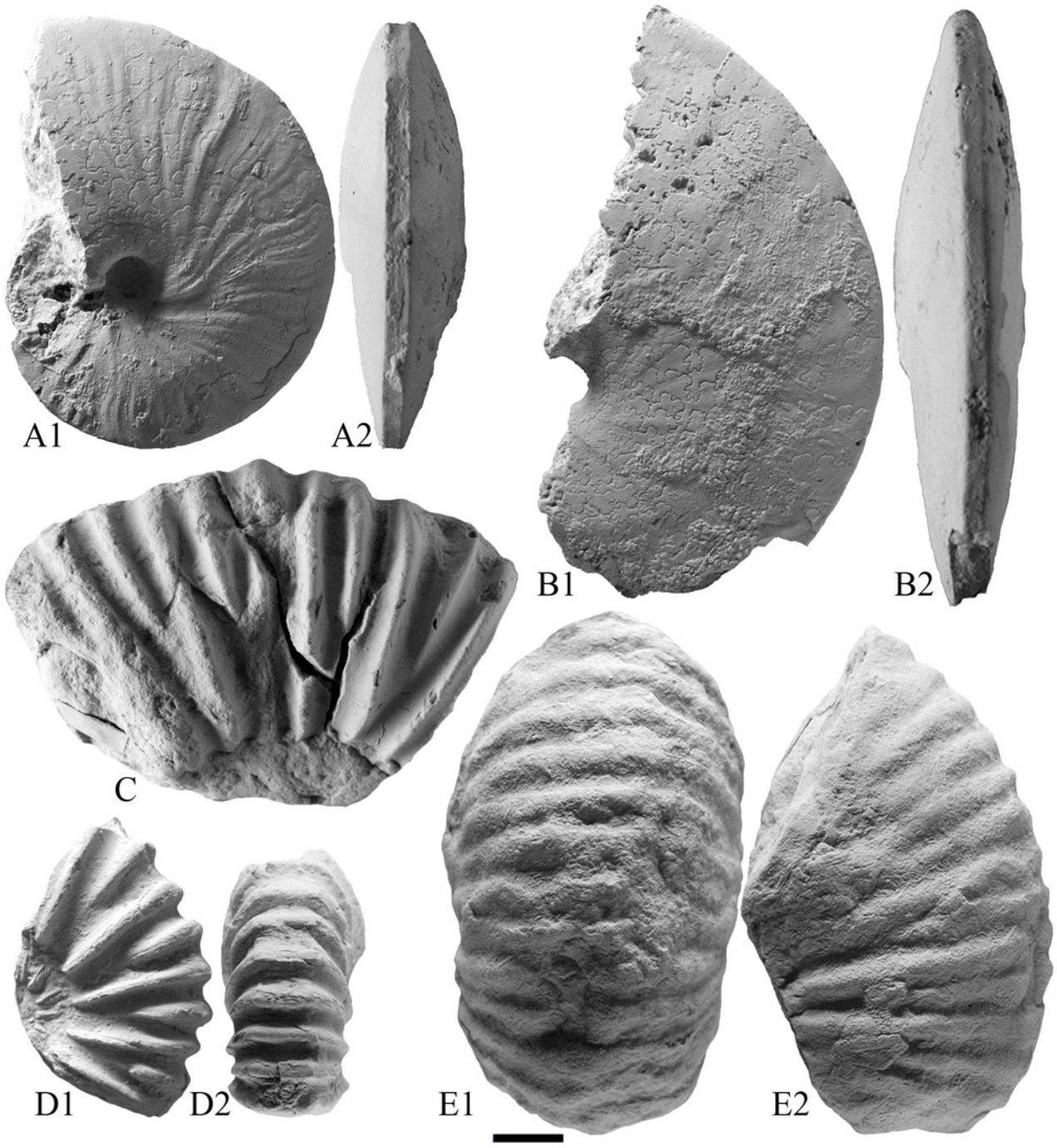
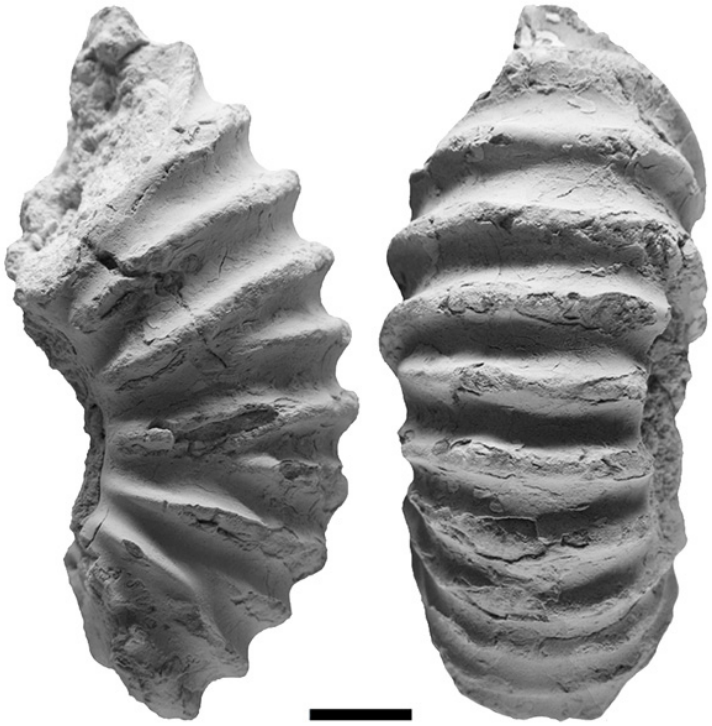


Figure 4: A1-2: *Parengonoceras bassei* lateral and ventral views of the holotype MGSB 11478, Marmellar. B1-2: *Parengonoceras bassei* lateral and ventral views of the specimen MGSB 8689, Les Ventoses, Marmellar. C: *Hypacanthoplites* sp. lateral view of the specimen MGSB 10762, Marmellar. D1-2: *Hypacanthoplites milletianus* lateral and ventral views of the specimen MGSB 11032, Marmellar. E1-2: *Hypacanthoplites subelegans* ventral and lateral views of the specimen MGSB 10571, Marmellar. Scale bar = 1 cm.



◀ **Figure 5:** *Hypacanthoplites plesiotypicus* lateral and ventral views of the specimen AC 5 (Andrés CUMBA collection, La Jana, Province of Castelló, E Spain). Scale bar = 1 cm.

Hypacanthoplites plesiotypicus in Traiguera, Maestrat Basin: in the work of GARCIA *et al.* (2014), one of the depicted ammonites was misidentified as *Douvilleiceras* gr. *leightonense*. We reviewed this specimen in the current work and we reassign it to *Hypacanthoplites plesiotypicus* (Fig. 5) because of the similar whorl section and ornamentation pattern found in the Marmellar specimens. This misidentification also happened because of the unusual wide whorl section of this species of *Hypacanthoplites*.

Conclusions

The ammonite assemblage of the Montmell Formation near Marmellar, Salou-Garraf Basin, must be assigned to an early Albian age, the *Leymeriella tardefurcata* Zone.

The detailed taxonomic analysis of all the studied material allows the identification of the following taxa: *Uhligella* sp., *Parengonoceras bassei*, *Hypacanthoplites plesiotypicus*, *Hypacanthoplites milletianus*, *Hypacanthoplites subelegans*, and *Hypacanthoplites* sp. The complete ammonoid assemblage is illustrated for the first time.

Identification of *Hypacanthoplites plesiotypicus* and *Hypacanthoplites subelegans*, constitutes the most challenging taxonomic issue, because these species possess a characteristic wide whorl section, an unusual trait among the species of the genus *Hypacanthoplites*.

The current work is a step forward in the chronostratigraphic knowledge of the Salou-Garraf Basin by means of age-calibration of the lower part of the Montmell Formation.

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