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Glomospirella cantabrica n. sp., and other benthic foraminifera from Lower Cretaceous Urgonian-type carbonates of Cantabria, Spain: Biostratigraphic implications

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ABSTRACT

A new benthic foraminifer is described as *Glomospirella cantabrica* n. sp. from several sections of the upper Aptian Reocín Formation and one occurrence from the lowermost Albian Las Peñosas Formation of Cantabria (northern Spain). It represents a rather large-sized *Glomospirella*, with up to eight planispiral whorls, observed in lagoonal wackestones and packstones. The upper Aptian (upper Gargasian–Clansayesian) age is indicated by the co-occurrence with other benthic foraminifera, *i.e.* orbitolinids. Further biostratigraphic data of the Aptian-p.p. Albian shallow-water carbonates of the North Cantabrian Basin is provided. The rareness of dasycladalean green algae in these deposits is also highlighted. The resulting stratigraphic and biostratigraphic scheme is integrated in a framework of depositional sequences of the North Cantabrian Basin and compared with the sequential schemes of other areas of the Basque-Cantabrian Basin and the Iberian Chain. Similitudes suggest that these depositional sequences are related to global sea-level changes.

KEYWORDS **Cantabrian Chain. Aptian. Reocín Formation. Systematics. Orbitolinidae. Dasycladales. Stratigraphy.**

INTRODUCTION

Lower Cretaceous Urgonian-type shallow-water limestones are widespread in the North Cantabrian Basin of northern Spain (Najarro, 2015, and references therein). As in other regions, *e.g.* southern France (Arnaud-Vanneau, 1980), these north Iberian platform carbonates contain rich assemblages of benthic foraminifera including taxa that have their type-locality in this basin (Delmas and Deloffre, 1961; Ramírez del Pozo, 1971) or in neighboring basins (Ciry and Rat, 1952; Deloffre, 1961; Schroeder and Poignant, 1964; Moullade and Peybernès, 1978).

Thin-section analysis of Aptian–Albian limestones have yielded a new benthic foraminifer, *Glomospirella cantabrica* n. sp., identified in the upper Aptian Reocín Formation and in one locality of the lower Albian Las Peñosas Formation. The paper furthermore focuses on the implications of other benthic foraminifera, *e.g.* orbitolinids, in the biostratigraphy of the Cantabrian Urgo–Aptian, and Albian *pro parte*. Last but not least, the poorly diversified dasycladalean algal assemblage in these deposits is stressed and documented. The resulting stratigraphic and biostratigraphic scheme allows establishing correlations with coeval carbonate systems of the Basque-Cantabrian Basin and the Iberian Chain, as well as with the global sea-level changes.

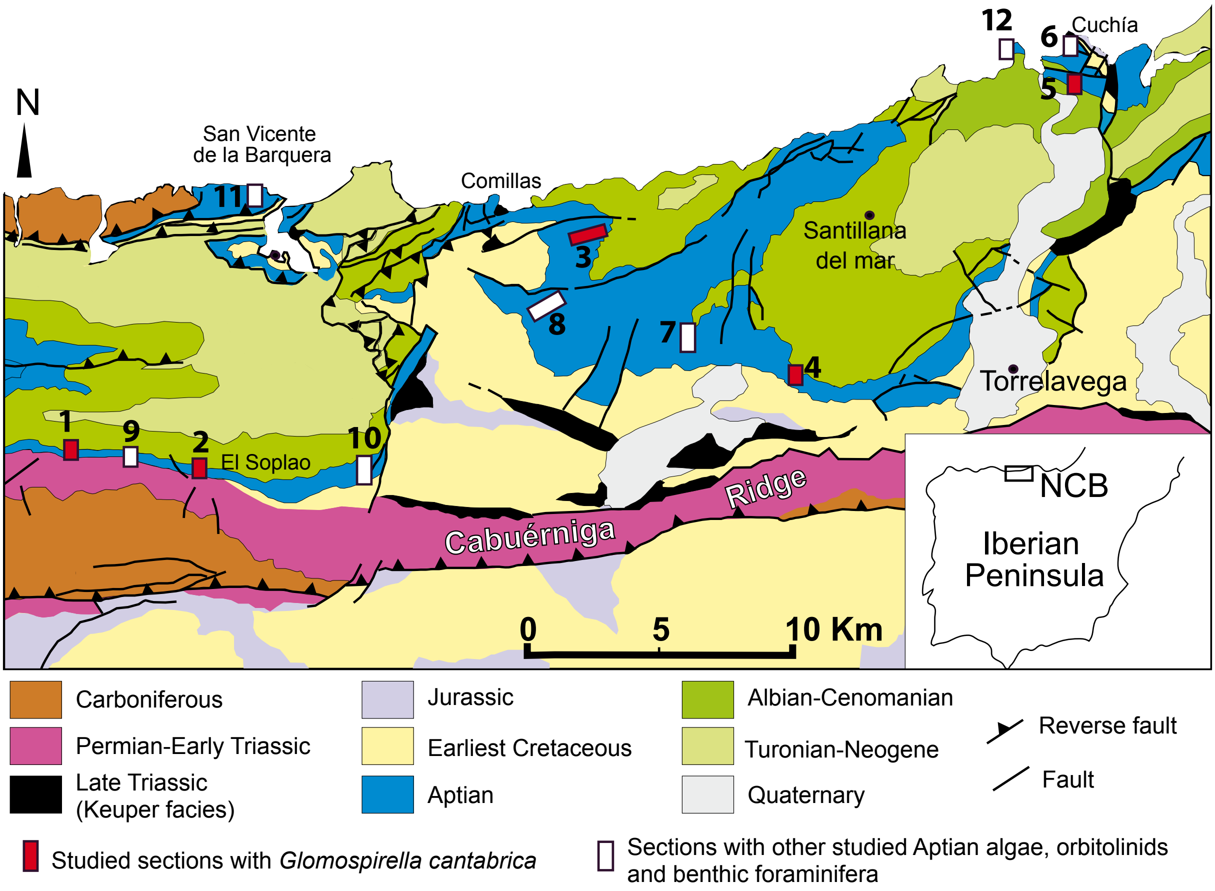

FIGURE 1. Geological map of the North-Cantabrian Basin with location of the studied samples. 1: Río Nansa section (PN samples), 2: El Soplao section (SOP samples), 3: Novales section (No and NO samples), 4: Cantera de Las Lastrías section (CL samples), 5: Cantera de Cuchía section (CCU samples), 6: Cuchía coast section (CU and PH samples), 7: Santa Eulalia section (SE samples), 8: Ruilobuca section (Ru samples), 9: Rábago section (LA samples), 10: Bustriguado section (Bu samples), 11: San Vicente de la Barquera section (SV samples), 12: Suances section (SU samples).

GEOLOGICAL SETTING

The studied Aptian–Albian sections are located in the North Cantabrian Basin (NCB) (Fig. 1), which constitutes the northwestern margin of the Basque-Cantabrian Basin. The NCB was generated by rifting tectonics linked to the opening of the Bay of Biscay and North Atlantic during the Late Jurassic and Early Cretaceous (*e.g.* Le Pichon and Sibuet, 1971; Malod and Mauffret, 1990). During the Early Cretaceous the NCB underwent strong structural segmentation in a series of horsts and tilted blocks, mainly outlined by N017, N060 and E–W oriented faults (Najarro, 2015). These faults controlled differential subsidence and variations in facies, thicknesses and stratigraphy over short distances at least during Hauterivian–Albian times (Figs. 2; 3).

The Aptian–Albian succession of the NCB was initially studied by Mengaud (1920) who established a first stratigraphic and biostratigraphic scheme of the Aptian. Later, Rat (1959), Ramírez del Pozo (1972), Collignon *et al.* (1979), García-Mondéjar (1982), Pascal (1985), Hines (1985) and Wilmsen (2000, 2005) contributed to clarify the general lithostratigraphic framework of the Aptian to Cenomanian. Recently, the depositional sequences of this time interval have been reviewed, new lithostratigraphic units have been established and previous stratigraphic schemes and biostratigraphic data have been updated (Najarro *et al.*, 2011; Najarro, 2015; Rosales and Schlagintweit, 2015).

The Aptian–Albian succession of the NCB is composed of nine formations (Hines, 1985; Najarro *et al.*, 2011; Najarro, 2015). From oldest to youngest, they are (Figs. 2A, 3): i) Rábago Formation (0–36m thick, lowermost lower Aptian), which consists of heterolithic sediments deposited in a mixed shallow platform; ii) Umbrera Formation (0–25m thick, lowermost Aptian), which consists of skeletal-oolitic grainstones deposited in shoal complexes in a high-energy carbonate ramp; iii) Patrocinio Formation (0–80m thick, lower Aptian *Deshayesites forbesi* zone, Najarro *et al.*, 2011), which consists of marls, lutites and minor sandstones deposited in offshore to delta front environments; iv) San Esteban Formation (0–55m thick; upper lower Aptian), which consists of rudist limestones deposited in a shallow inner platform; v) Rodezas Formation (0–105m thick, lowermost upper Aptian), which consists of coral limestones, marly limestones, marls, sandstones and siltstones deposited in environments ranging from open sea to shoreface; vi) Reocín Formation (9–300m thick, upper Aptian), which consists of rudist limestones and skeletal-foraminiferal packstone and grainstones deposited in shallow inner platform to platform margin environments; vii) Las Peñosas Formation (0–200m thick, lower–middle Albian), which consists of coal shales, siltstones and sandstones deposited in deltaic to estuarine environments; viii) Barcenaciones Formation (13–65m thick, middle–upper Albian), which consists mainly of grainstones and *Caprina* limestones deposited in middle to outer platform environments; and finally ix) Bielba Formation p.p. (Somocuevas Member, ca. 128m thick, uppermost Albian, Rosales and Schlagintweit, 2015), which consists of siltstones and sandstones deposited in environments ranging from deltaic-estuarine to shoreface and offshore marine.

The Reocín Formation was formally named by García-Mondéjar (1982), and is equivalent to the "barre urgonienne supérieure" of Collignon *et al.* (1979), the "seconde masse urgonienne" of Rat (1959) and the level C_{15}^{23} of the Magna series of the Spanish Geological Map (Ramírez del Pozo *et al.*, 1974; Portero-García *et al.*, 1976). Recent detailed stratigraphic information on depositional facies and sequences of the Reocín Formation was provided by Najarro *et al.* (2007), Blázquez-Fernández *et al.* (2014), Fernández-Mendiola *et al.* (2015) and Najarro (2015). A summary of the general vertical and lateral facies distribution and lateral changes of sedimentary thicknesses of the Reocín Formation (and other units) is represented in Figure 3. This figure provides a basin-wide cross-section based on the correlation of the sections that yielded *Glomospirella cantabrica* n. sp., selected from 12 measured sections located in Figure 1. Depositional environments of the Reocín Formation range from outer platform, transition between the outer and the inner platform, marginal shoals and tidal bars, inner open platform, and inner restricted platform (Najarro *et al.*, 2007; Blázquez-Fernández *et al.*, 2014). The Reocín Formation can be divided into two main depositional sequences separated by an unconformity with local subaerial exposure, followed by a widespread transgressive marly bed (Najarro *et al.*, 2007; Blázquez-Fernández *et al.*, 2014; Najarro, 2015). This transgressive bed can be correlated over tens of kilometres across the basin (Fig. 3). The first sequence ranges from 8m (Cuchía coast section, Fig. 3) to 100m thick (Novales section, Fig. 3), and it is characterized by the stacking of rudist-bearing lithofacies. It is accompanied by boundstone-floatstone-rudstone of bacinellid fabrics forming thrombolithic masses and oncoids, and by cross-bedded grainstones. These were deposited mainly in inner restricted platform to lagoonal environments with local development of sand shoals and tidal channels/bars. This sequence is commonly dolomitized (López-Cilla *et al.*, 2012). The second sequence ranges from 3m (Cuchía coast section, Fig. 3) to ca. 114m thick (*e.g.* Novales section, Fig. 3) and it is characterized by the development of coral-bearing lithofacies, foraminiferal limestones and bacinellid fabrics with lumps and oncoids. These are interpreted to be deposited in open platform environments with poor development of rudist-bearing lithofacies. A major sea-level fall on top of the Reocín Formation exposed the platform subaerially. The sedimentation continued during the early Albian with a deltaic-estuarine system (Las Peñosas Formation) infilling a kilometric-wide incised valley (Najarro, 2015) (Fig. 3).

MATERIAL AND METHODS

In this study more than 250 thin sections from 12 stratigraphic sections logged along the NCB have been investigated. The geographic location, stratigraphy, thicknesses and previous studies of each section are summarized in Figure 1 and Table I. This study is focussed on the Reocín Formation but limestone samples from the Rábago, San Esteban, Rodezas and Las Peñosas formations were studied in addition.

The thin sections are housed in the Museo Geominero of the Instituto Geológico y Minero de España, Madrid, under the numbers MGM-10847C-1 to -10888C-1. Each figure is assigned an individual number, and the original sample designation is added in brackets after the official museum number. For the sample localities were used the following acronyms (in alphabetical order): BU (Bustriguado section), CCU (Cantera de Cuchía section), CU and PH (Cuchía coast section), CL (Cantera de Las Lastrías section), SOP (El Soplao section), No- and NO (Novales section), LA (Rábago section), PN (Río Nansa section), Ru (Ruilobuca section), SV (San Vicente de la Barquera section), SE2 (Santa Eulalia section), SU (Suances section).

In the present paper, we refer to the Aptian including the Bedoulian as a substage (=lower Aptian, *e.g.* Reboulet *et al.*, 2014). We note that there is also a new concept retaining

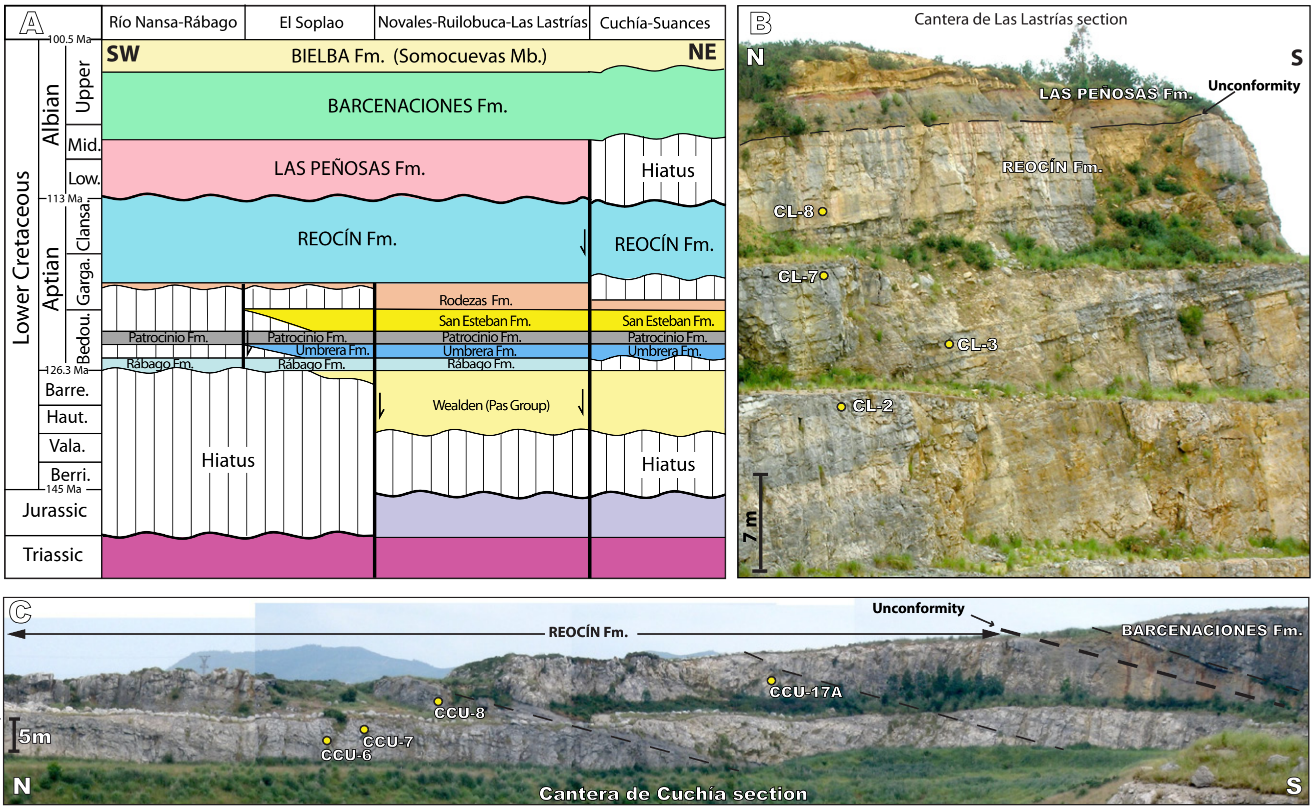

FIGURE 2. A) Lithostratigraphy of the Lower Cretaceous in the North-Cantabrian Basin (modified from Najarro *et al.* 2011). B) Field picture of the upper part of the Reocín Formation and Las Peñosas Formation in the Cantera de Las Lastrías section, with location of some studied samples. C) Field picture of the Reocín and Barcenaciones formations in the Cantera de Cuchía section, with location of some of the studied samples.

the Bedoulian *sensu nuovo* as an individual stage between the Barremian and the Aptian *sensu stricto* (Moullade *et al.*, 2011). In the latter concept, the Aptian *sensu nuovo* is defined at its base (Bedoulian-Aptian boundary) with the First Appearance Datum (FAD) of the ammonoid genus *Dufrenoya* (*D. furcata* zone) and at its top (Aptian-Albian boundary) with the FAD of *Hypacanthoplites* (*H. jacobi* zone).

DESCRIPTION OF THE STRATIGRAPHIC SECTIONS

The samples that have yielded *Glomospirella cantabrica* n. sp., and associated foraminifera, are from six stratigraphic sections (Fig. 3, see location in Table I and Fig. 1):

i) Río Nansa section. It is exposed ca. 0.7km northwest of the Rábago village, at the cut of the road CA-181 from Muñorrodero to Puentenansa, along the Nansa River. Its stratigraphy and micropaleontological content have been investigated by Ramírez del Pozo (1972), Najarro *et al.* (2011) and Rosales *et al.* (2013). In this section the Rábago Formation rests unconformably on Triassic red beds (Buntsandstein facies). The section comprises successively (Fig. 3): the Rábago Formation (ca. 16m), the Patrocinio Formation (ca. 30m), the Reocín Formation (ca. 70m, the first 20m are dolomitized), the Las Peñosas Formation (ca. 60m), the Barcenaciones Formation (ca. 55m) and the base of the Bielba Formation. There are major unconformities on top of the Rábago and Patrocinio formations, with absence of the Umbrera, San Esteban and Rodezas formations (Figs. 2A; 3).

ii) El Soplao section. The section is exposed ca. 4.8km east of the Rábago village. The base is exposed around the entry to the El Soplao cave and the section continues along the road of access to the El Soplao cave from the Rábago village. The ca. 220-m-thick section comprises the Rábago Formation (ca. 8m) resting unconformably on a few meters of lowermost Cretaceous continental red beds (Wealden facies), followed by the Umbrera Formation (ca. 6m), the Patrocinio Formation (ca. 27m), and a limestone-dolostone lithosome ca. 115m thick. The first 15m of this lithosome are constituted by nodular and decimetric-bedded wackestone with requieniids and *Orbitolinopsis*? *simplex* (HENSON) (Rosales *et al.*, 2013), indicating that in this section the basal portion of the lithosome is still lower Aptian (Bedoulian) in age and coeval with the San Esteban Formation (Fig. 3). These basal limestones rapidly pinch-

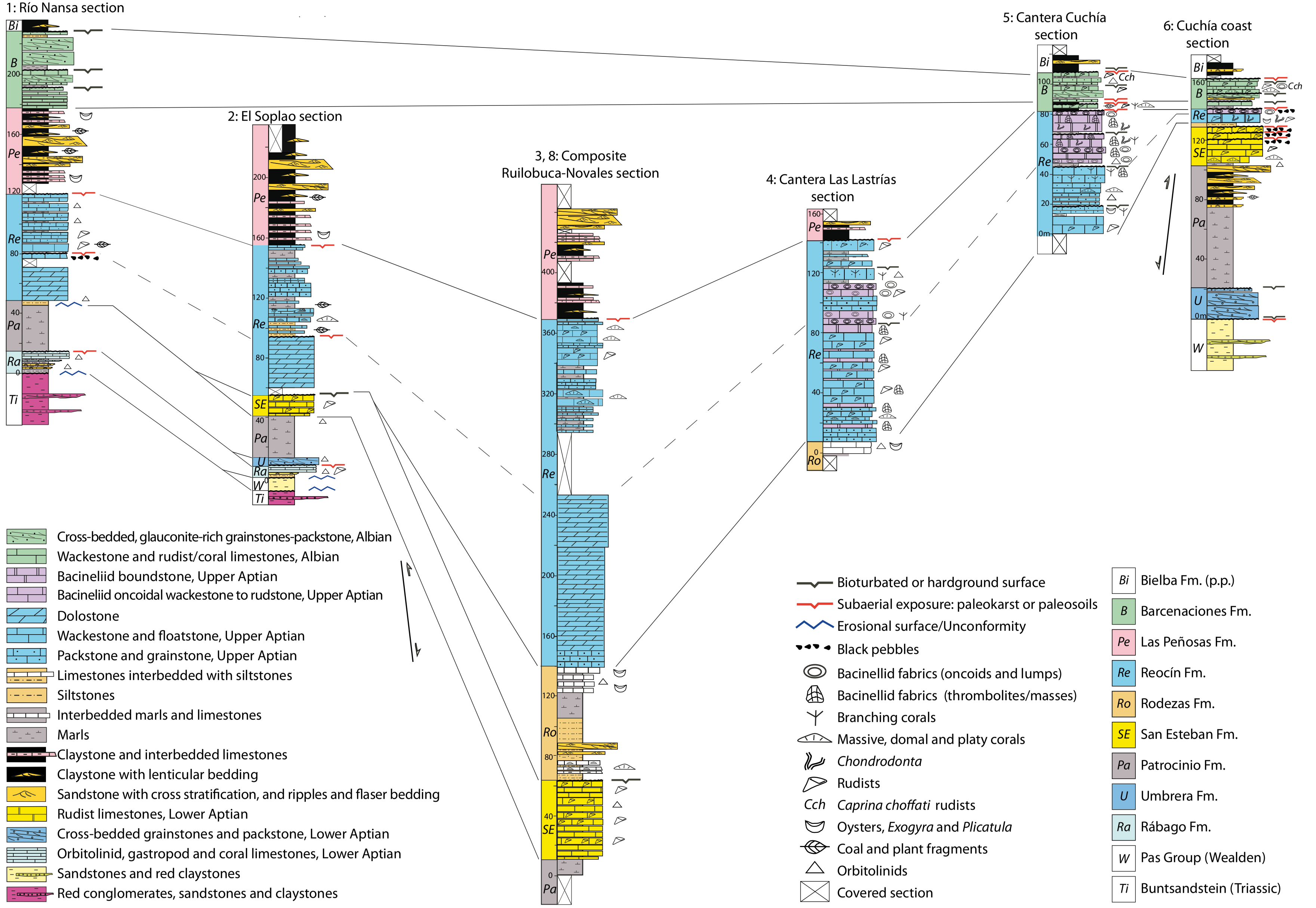

FIGURE 3. Stratigraphic cross-section based on the correlation of several measured sections. Numbers of the sections refer to the numbers of sections in Figure 1. Correlation lines are established on the basis of regional tracing and mapping of the lithostratigraphic units and main unconformities, and on the fossil content with biostratigraphic relevance.

out to the west, being absent in the Rábago section, located 2km to the west. The overlaying ca. 100m correspond to the Reocín Formation, with the first ca. 35m dolomitized and with silty marls, marly limestones, grainstones and coral-rudist limestones in the upper part. Here, the Rodezas Formation is also absent (Figs. 2A; 3). Finally, the section culminates with ca. 60m of marly limestones with oysters, siltstones and sandstones of the lower part of the Las Peñosas Formation.

iii) Novales section. The section is exposed ca. 11 km west of the Comillas town, in the cut of the road CA-353 from Novales to Barrio Cerrazo. The ca. 300-m-thick section comprises the Reocín Formation (ca. 230m thick) and the lower part of the Las Peñosas Formation (ca. 70m thick). The first 160m of the Reocín Formation exhibit pervasive dolomitization hosting Pb-Zn ore mines. The upper 70m of the section has yielded abundant specimens of *Glomospirella cantabrica* n. sp., and the holotype specimen is from sample No-14, located in the midpart of the upper undolomitized interval.

iv) Cantera de Las Lastrías section. The section is exposed ca. 11km west of Torrelavega, in the quarry of Las Lastrías in the San Esteban town (Fig. 2B). The section exhibits in its base (first 7m) the transition between the Rodezas and Reocín formations, followed by 130m of limestones of the Reocín Formation. The upper part of the section shows an unconformity on top of the Reocín Formation, followed by red-green claystones with paleosoils of the Las Peñosas Formation (Fig. 2B).

v) Cantera de Cuchía section. The section is exposed ca. 17km to the North of Torrelavega along the cuts of the Cuchía quarry (Fig. 2C). Limestones cropping out in this section were previously investigated for the foraminiferal content by Collignon *et al.* (1979), who already attributed them to the Upper Aptian. The stratigraphy of the section has been later described by Najarro (2015) and Fernández-Mendiola *et al.* (2015). The ca. 120-m-thick succession exposed in the Cuchía quarry commences with the Reocín Formation (ca. 80m thick) that is directly overlain by the Barcenaciones Formation (ca. 26m thick). In this section, both, the base of the Reocín Formation and the Rodezas Formation (if present) are covered. In addition, the Las Peñosas Formation is absent (Fig. 2A, C), and the contact between the Reocín Formation (upper Aptian) and the Barcenaciones Formation (middle–upper Albian) is represented by an unconformity (Fig. 2C) with features of subaerial exposure and paleokarst development (Najarro, 2015). The overlying Barcenaciones Formation consists of cross-bedded grainstones rich in *Involutina hugarica* (SIDO) and packstone-wackestone with rudist-coral bioherms rich in *Caprina choffati* DOUVILLÉ toward the upper part (Najarro, 2015). In this section, the Barcenaciones Formation shows in its lower part two internal unconformities with features of subaerial exposure, brecciation and/or dissolution, and a final subaerial exposure surface with truncation of strata, paleokarst and bioturbation at the top of the unit, in the contact between the Barcenaciones and the Bielba formations (Fig. 3).

vi) Cuchía coast section. This section is located ca. 17km to the north of Torrelavega and 1km to the north of the Cantera de Cuchía section. It was previously studied by Mengaud (1920) and Collignon *et al.* (1979). Recently, the ammonite fauna of the Patrocinio Formation of this section has been re-studied by Najarro *et al.* (2011) and García-Mondéjar *et al.* (2015), and the stratigraphy has been described in Wilmsen (2005), Najarro (2015) and García-Mondéjar *et al.* (2015). The ca. 160-m-thick section shows an almost continuous exposure of the Hauterivian-Barremian (Wealden) to upper Albian succession (Fig. 3) along the coastal cliffs from Punta del Cuerno to Playa de Cuchía or Playa de Marzán, only interrupted by several normal faults of some few meters of displacement. The base of the section (Punta del Cuerno) shows an erosive unconformity at the contact between the Wealden deposits and the lowermost Aptian Umbrera Formation (ca. 22m thick). In this section the Rábago Formation is missing (Fig. 3). The succession continues with marls, siltstones and sandstones of the Patrocinio Formation (ca. 80m thick) cropping out along the cliff of Playa de los Caballos beach. It is overlain by limestones of the San Esteban Formation, which crop out along the cliff from Playa de los Caballos to Punta de Afuera. The top of the San Esteban Formation at the Punta de Afuera site displays a major unconformity of subaerial exposure with paleokarst depressions filled with limestone breccias containing black pebbles. It is overlain by ca. 1.5m of silty marls and marly limestones with brachiopods and branching corals, which correspond to a reduced equivalent to the Rodezas Formation (Fig. 3). The succession follows with an also very-reduced (ca. 11m thick) Reocín Formation. The contact between the reduced Rodezas Formation and the Reocín Formation is disrupted by a local fault. The Reocín Formation crops out along the cliffs from Punta de Afuera to Playa del Huevo. It consists mainly of rudstone of oncoidal bacinellid fabrics and is capped by a paleokarst surface (Fig. 3) (Najarro, 2015). The succession follows with the Barcenaciones Formation cropping out from Playa del Huevo to Playa de Cuchía or Playa de Marzán. The Barcenaciones Formation (ca. 18m) consists successively of nodular-bioturbated limestones, minor sandstones, cross-bedded grainstones with *Involutina hungarica* (SIDO), and finally rudist-coral limestones with abundant sections of the upper Albian rudist *Caprina choffati* DOUVILLÉ, already reported by Rat (1959). The upper contact of the Barcenaciones Formation with the Bielba Formation, cropping out at Playa de Marzán, is truncated by fault.

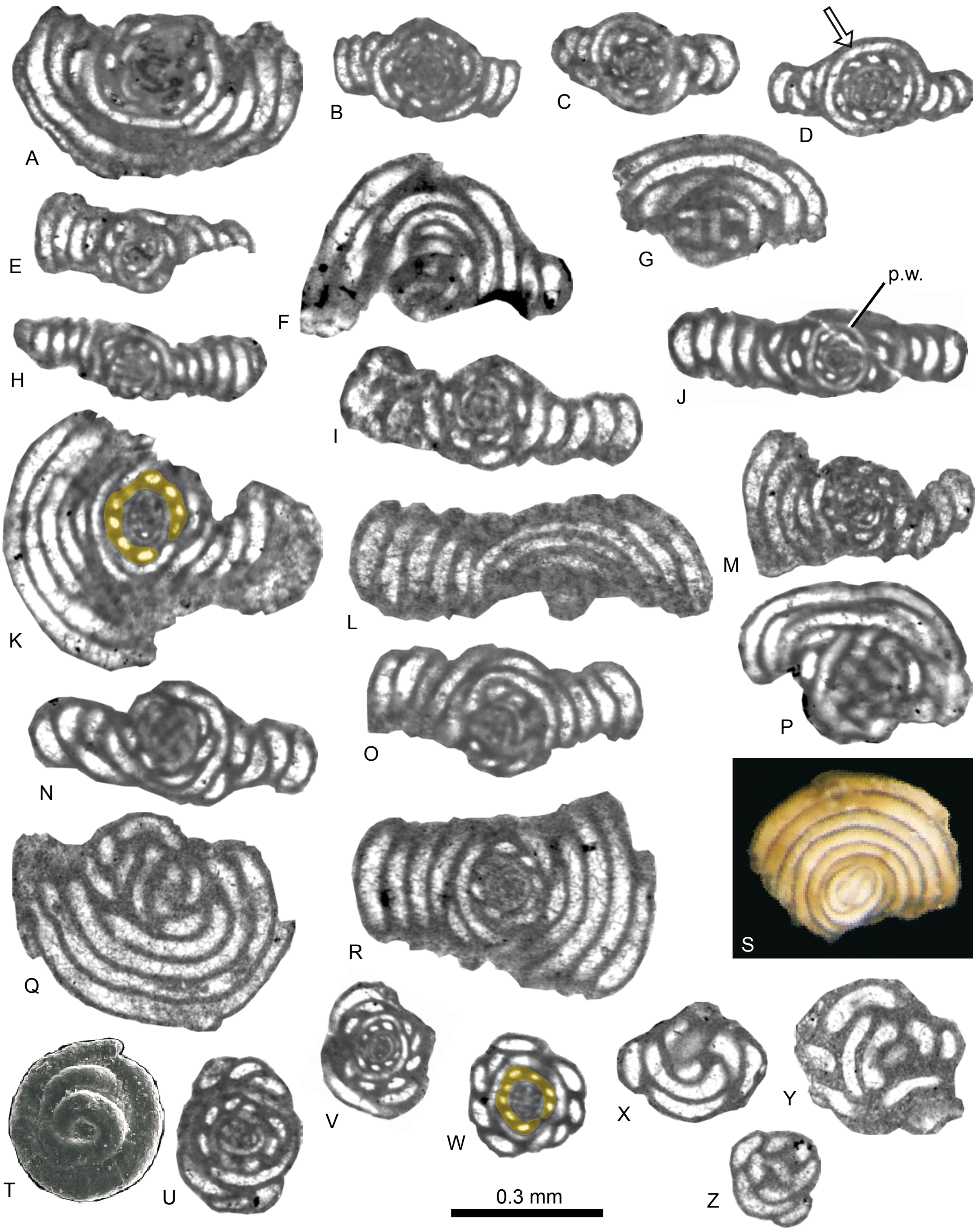

FIGURE 4. A–P) *Glomospirella cantabrica* n. sp., Upper Aptian-lowermost Albian of Cantabria. Oblique equatorial sections (A, F–G, M, O–R), axial sections (B–E, H–J, N), equatorial section (K–L). Holotype in K. Note the single planispiral whorl (p.w.) switched within the early *Glomospira*-type part in J, and the first planispiral whorls differing in their coiling planes in D (arrow). A, E: MGM-10853C-1, -10853C-2 (CCU 6); B: MGM-10863C-1 (Nº 23); C: MGM-10848C-1 (CL 4); D: MGM-10855C-1 (CCU 8); F–H: MGM-10847C-1, -10847C-2, -10847C-3 (CL 3); I–K: MGM-10862C-1, -10862C-2, -10862C-3 (No 14); L: MGM-10880C-1 (SOP 20); M: MGM-10865C-1 (Nº 35); N: MGM-10887C-1 (SOP 78); O: MGM-10881C-1 (SOP 40); P: MGM-10866C-1 (PN 13); Q–R: MGM-10854C-1, -10854C-2 (CCU 7). S) *Glomospirella* sp., (from Setoyama *et al.*, 2011, pl. 2, fig. 18, late Cretaceous of Barents Sea). T) *Glomospirella gaultiana* (Berthelin, 1880) (from Moullade *et al.*, 2008: pl. 1, fig. 3, late Bedoulian of France). U–W) *Glomospira urgoniana* Arnaud-Vanneau, 1980, upper Aptian-lowermost Albian of Cantabria.U: MGM-10861C-1 (Nº 6); V–W: MGM-10879C-1, -10879C-2 (SOP 19). X–Z) *Glomospira*? sp. X–Y: MGM-10859C-1, -10859C-2 (La 23); Z: MGM-10864C-1 (Nº 25).

SYSTEMATIC PALAEONTOLOGY

The high-rank classification follows Pawlowski *et al.* (2013), the low-rank classification Kaminski (2014).

Phylum: Foraminiferida D'ORBIGNY, 1826
Class: Tubothalamea PAWLOWSKI *et al.*, 2013
Order: Ammodiscida MIKHALEVICH, 1980
Family: Ammodiscidae REUSS, 1862
GENUS ***Glomospirella*** PLUMMER, 1945
Type-species: *Glomospirella umbilicata* CUSHMAN AND WATERS, 1927
Glomospirella cantabrica n. sp. (Fig. 4A–R)

?1961 *Glomospirella* sp. – DELOFFRE: p. 107, not figured.
?1982 *Glomospirella* sp. – CHERCHI AND SCHROEDER: p. 155, not figured.
1987 *Glomospirella* sp. – REITNNER: Pl. 2, fig. 6.

Origin of the name. The species is named after the autonomous community of Cantabria in northern Spain.

Type material. The holotype specimen is a partly broken equatorial section with repository number MGM-10847C-1 (No 14) (Fig. 4K), coming from the Novales section (Fig. 3). Seventeen paratypes are designed with the repository numbers: MGM-10853C-1 (Fig. 4A), -10863C-1 (Fig. 4B), -10848C-1 (Fig. 4C), -10855C-1 (Fig. 4D), -10853C-2 (Fig. 4E), -10847C-1 (Fig. 4F), -10847C-2 (Fig. 4G), -10847C-3 (Fig. 4H), -10862C-1 (Fig. 4I), -10862C-2 (Fig. 4J), -10880C-1 (Fig. 4L), -10865C-1 (Fig. 4M), -10887C-1 (Fig. 4N), -10881C-1 (Fig. 4O), -10866C-1 (Fig. 4P), -10854C-1 (Fig. 4Q), -10854C-2 (Fig. 4R).

Diagnosis. Medium-sized discoidal representative of *Glomospirella*. Early part tightly twisted in a glomospiral manner upon a plane with intercalated planispiral whorls. The adult part is irregularly planispiral, composed of up to eight whorls, the first two of them sometimes with coiling planes perpendicular to the next whorls. The diameter of the tubular chamber is increasing slightly in the early part, becoming larger in the planispiral part where its diameter remains more or less constant. Chamber wall dark, homogeneous, finely agglutinated. Aperture simple and terminal.

Description. Test discoidal (diameter up to 0.65mm) with a globular central elevation corresponding to the irregularly coiled early part. The type of coiling of the earliest part (directly following the proloculus) is unknown. Later the undivided tubular second chamber is tightly twisted in a glomospiral manner upon a plane, occasionally with intercalated individual planspiral whorls (Fig. 4J). This early stage may be composed of up to five whorls. In the holotype specimen there are up to ten twisting folds within a glomospirally coiled whorl (Fig. 4K, highlighted in colour). In this part, the diameter of the tubular chamber increases slowly but continuously.

The final part eventually becomes completely planispirally coiled, although slightly oscillating with up to eight whorls. In some specimens, the first two planispiral whorls exhibit a varying coiling plane, perpendicular to the final ones. In the holotype specimen the planispiral final part amounts for more than 2/3 of the total test diameter. The diameter of the tubular chamber is larger than in the early growth part and remains almost constant in width (about 40µm). The wall appears dark, micritic, homogeneous, finely agglutinated. Aperture simple and terminal.

Remarks. *Glomospira* has been a basket for all tubular, irregularly coiled, subglobular, finely agglutinating foraminifera. Refining differences in the coiling mode, some species were taxonomically revised. For example, *Glomospira glomerata* HÖGLUND, which was choosen as the type-species of *Arenomeandrospira* by Jones and Wonders (2000), is characterized by a meandrospiral coiling of the tubular chamber in tight folds displaying subparallel axes. The genus *Glomospira* itself has been emended by Kaminski and Gradstein (2005), defining the coiling initially as a high trochospire about a common axis, later becoming glomospirally coiled. In contrast, *Glomospirella* was defined as a *Glomospira* with a final planispirally coiled part (*e.g.* Loeblich and Tappan, 1987, p. 51). The specimens studied, however, do not allow specifying the coiling mode previous to the glomospiral part.

It is worth mentioning that *Glomospirella* was regarded as a junior synonym of *Glomospira* by Charnock and Jones (1990; p. 156), more precisely as a *Glomospira* species that "tend to become planispiral in later stages". However, this view was not followed by most workers and *Glomospirella* PLUMMER was kept as valid genus in the new classification of agglutinated foraminifera provided by Kaminski (2014) and in the World Foraminifera Database (Hayward and Pignatti, 2015).

Glomospirella cantabrica was most likely observed by Deloffre (1961) and Cherchi and Schroeder (1982) in upper Aptian strata containing *Pseudochoffatella cuvillieri* from the Pyrenean area. Both authors indicate the presence of *Glomospirella* sp. in their material (see synonymy).

Comparisons. The widespread *Glomospirella gaultiana* (BERTHELIN) is a typical outer-shelf to

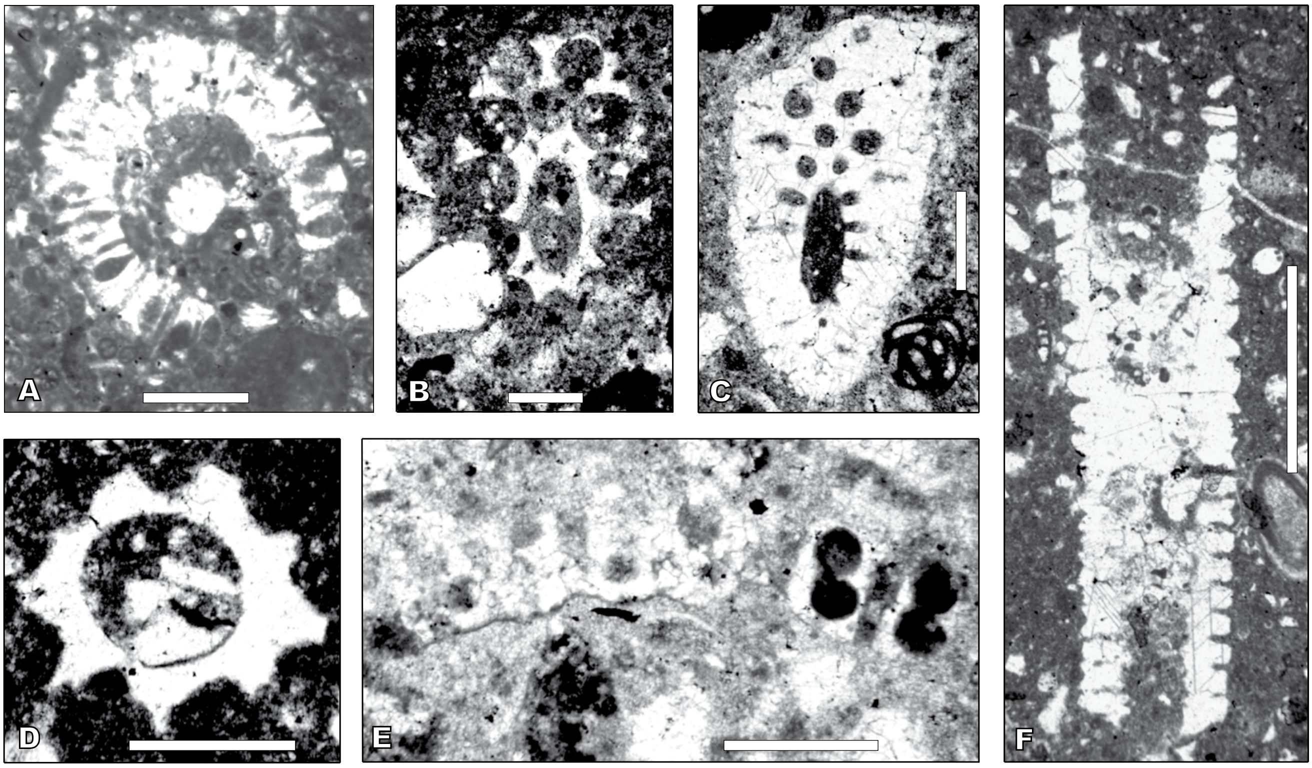

FIGURE 5. Dasycladalean algae from the Aptian of Cantabria. A) *Neomeris* cf. *cretacea* Steinmann. MGM-10874C-1 (Bu 1), lower Aptian Rábago Formation. B) *Montiella elitzae* (Bakalova). MGM-10869C-1 (Ru 3), lower Aptian San Esteban Formation. C) *Cylindroporella*? *pedunculata* (Jaffrezo, Poisson and Akbulut). MGM-10886C-1 (SOP 77), upper Aptian Reocín Formation. D) *Salpingoporella hasi* Conrad, **Radoičić** and Rey. MGM-10885C-1 (SOP 71), upper Aptian Reocín Formation.E) *Genotella pfenderae* (Konishi and Epis). MGM-10884C-1 (SOP 69), upper Aptian Reocín Formation. F) *Salpingoporella melitae* **Radoičić.** MGM-10863C-2 (Nº23), upper Aptian Reocín Formation. Scale bars 0'3mm, except F=1mm.

abyssal plain dwelling "flysch-type" taxon occurring in marly lithologies yielding isolated specimens (*e.g.* Kaminski *et al.*, 1992; Koutsoukos, 2000; Galeotti *et al.*, 2004; Moullade *et al.*, 2008). Accordingly, this species has a long stratigraphic range from the late Aptian to at least the Paleocene-Eocene transition (see Galeotti *et al.*, 2004). Apart from different specific paleoenvironmental requirements, *G. gaultiana* differs from *G. cantabrica* by its smaller size (~0.3mm in the Albian and up to 0.73mm in the lower Maastrichtian according to Koutsoukos, 2000), greater diameter of tubular chamber and its prominent streptospiral stage with only one to two planispiral whorls (see Fig. 4T). Moreover, *G. gaultiana* does not display individual planispiral coiled whorls intercalated in the early glomospiral stage as in *Glomospirella cantabrica*.

General morphological similarities exist also with *Glomospirella* sp. illustrated by Setoyama *et al.* (2011: pl. 2, fig. 18) from the Late Cretaceous Kveite Formation of the Barents Sea (Fig. 4S), are typically deep-water forms like other Cretaceous representatives of *Glomospirella* (*e.g.* Grzybowski, 1898; Setoyama *et al.*, 2011).

Microfacies and associated microfauna and microflora. *Glomospirella cantabrica* occurs generally in foraminifer-rich wackestones to packstones that can be referred to as an internal platform lagoonal facies (Reocín Formation). One ocurrence is found in a packstone bed interbedded with siliciclastic materials referred to as estuarine facies of the Las Peñosas Formation. The foraminifera associated with *G. cantabrica* will be discussed in the next chapter. Additionally, *G. cantabrica* is occasionally associated with dasycladalean green algae in the Reocín Formation such as *Terquemella* sp. (rare spicules), *Cylindroporella*? *pedunculata* (JAFFREZO, POISSON AND AKBULUT) (Fig. 5C), *Salpingoporella hasi* CONRAD, RADOIČIĆ AND REY (Fig. 5D), and *Genotella pfenderae* (KONISHI AND EPIS) (Fig. 5E). The occurrence of *Salpingoporella melitae* RADOIČIĆ in the Novales section is worth mentioning (Fig. 5F), since it was so far reported only from the upper Hauterivian to the lower Aptian (Carras *et al.*, 2006, Table 1). In consequence, the chronostratigraphic range of this species should be extended until the late Gargasian or even the Clansayesian.

Not associated with *G. cantabrica*, we note the occurrence of *Neomeris* cf. *cretacea* STEINMANN in the

TABLE 1. Distribution of taxa from the Aptian–lower Albian formations of Cantabria

Formation Species	Rábago	San Esteban	Rodezas	Reocín	Las Peñosas
Choffatella decipiens	X	X			
Palorbitolina lenticularis	X	X			
Orbitolinopsis? *simplex*		X			
Praeorbitolina cormyi		X			
Nautiloculina cretacea		X	X	X	
Glomospira urgoniana		X	X	X	X
Charentia cuvillieri		X	X	X	X
Akaya minuta		X	X	X	?
Mesorbitolina parva			X		
Mesorbitolina texana			X	X	X
Mesorbitolina birmanica				X	?
Dictyoconus? *pachymarginalis*				X	
Pseudochoffatella cuvillieri				X	
Dobrogelina? *carthusiana*				X	
Coskinolinella daguini				X	
Orbitolinopsis reticulata				X	
Simplorbitolina aquitanica				X	
Simplorbitolina manasi				X	X
Cuneolina cf. *parva*				X	X
Glomospirella cantabrica				X	X
Involutina hungarica					X
Simplorbitolina conulus					X

Rábago Formation (Bustriguado section) (Fig. 5A), and *Montiella elitzae* (BAKALOVA) in the San Esteban Formation (Ruilobuca section) (Fig. 5B).

Chronostratigraphy. The stratigraphic range of *Glomospirella* is indicated by Kaminski *et al.* (2008) as Lower Silurian (Llandovery) to Miocene obviously excluding the Recent *Glomospirella fijiensis* reported from very shallow environments of brackish mangrove-mudflats (Brönnimann *et al.*, 1992; Berkeley *et al.*, 2009). *Glomospirella cantabrica*, of Aptian to lower Albian age, does not show a definite distribution within the Reocín Formation. Details on the biostratigraphy of the Reocín Formation based on benthic foraminifera are discussed in the following chapter.

Biostratigraphic remarks on some other benthic foraminifera

Some of the benthic foraminifera co-occurring with *Glomospirella cantabrica* in the studied sections of the Reocín Formation are of biostratigraphic relevance; some are reported for the first time from the late Aptian, and others for the first time from this region. These taxa and some others are commented in the following subsection, supplemented also with some species observed in the underlying Rodezas and San Esteban and overlying Las Peñosas formations (Figs. 6–8). For the occurrences of individual taxa in the different formations see Table 1. A taxonomical revision of some of the taxa is beyond the scope of the present contribution.

Order: Lituolida LANKESTER, 1885
Family: Nautiloculinidae LOEBLICH AND TAPPAN, 1985
GENUS ***Nautiloculina*** MOHLER, 1938
Nautiloculina cretacea PEYBERNÈS, 1976 (Fig. 6A–B)

N. cretacea was described by Peybernès (1976) from the Hauterivian Organyà section of the Spanish Pyrenees. The genus *Nautiloculina* with its two Lower Cretaceous representatives *N. cretacea* and *N. broennimanni*, was revised by Arnaud-Vanneau and Peybernès (1978). Concerning *N. cretacea* they concluded (op. cit., p. 67) that "it does not seem to exist beyond the upper Bedoulian", referring to its occurrence in southern France. The last occurrence of the genus in the Bedoulian was also included in the monograph of Loeblich and Tappan (1987). However, shallow-water conditions ended in the Urgonian type-region in the upper part of the *Desayesites forbesi*

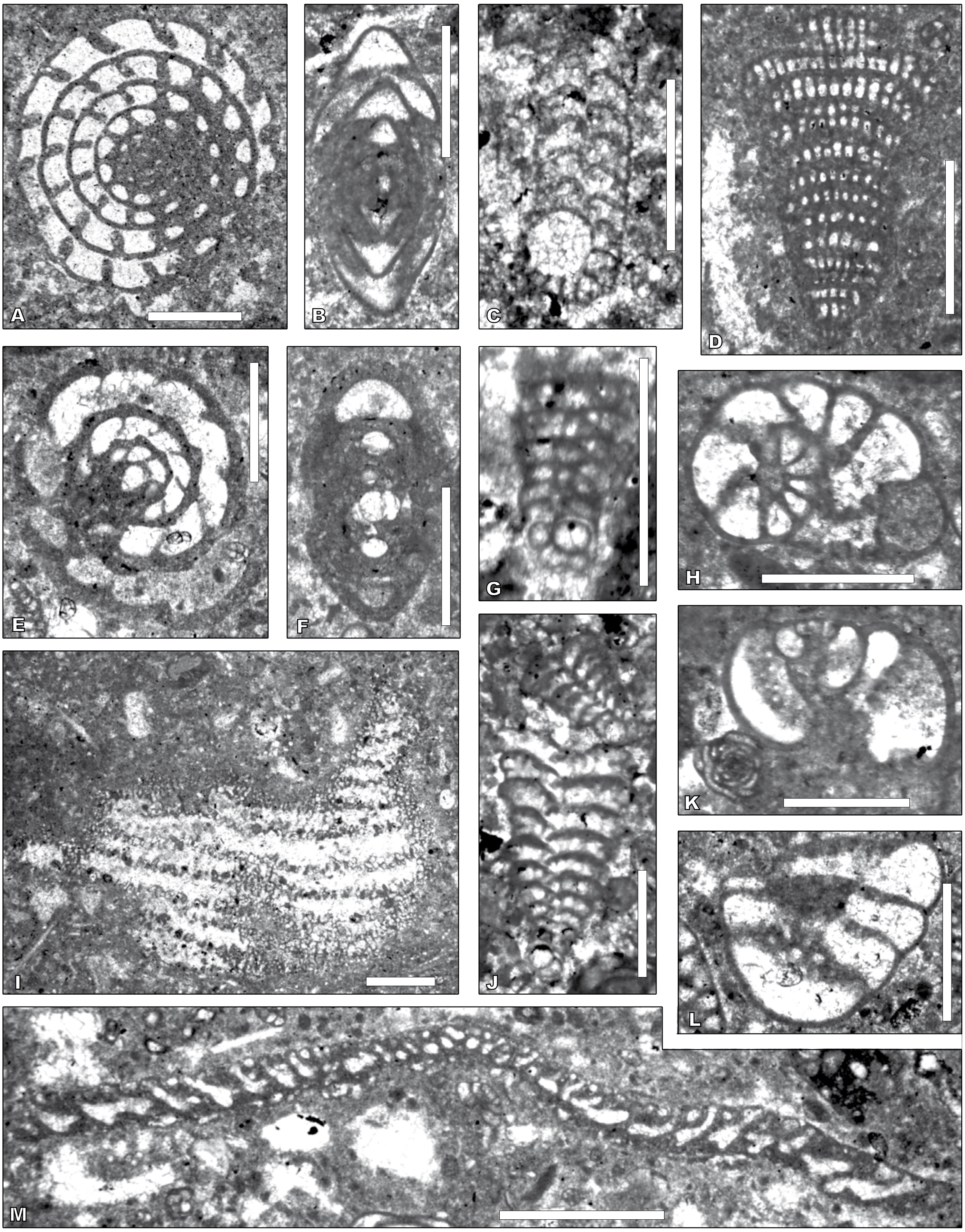

FIGURE 6. Benthic foraminifera from the upper Aptian Reocín Formation. A–B), *Nautiloculina cretacea* Peybernés, slightly oblique equatorial section (A) and axial section (B). C–D), *Cuneolina* cf. *parva* Henson, axial section showing complex embryo (C), longitudinal section parallel to plane of biseriality (D). E–F) *Charentia cuvillieri* Neumann, equatorial section (E), axial section (F). G) *Akcaya minuta* (Hofker). H, K, L) *Dobrogelina*? *carthusiana* Arnaud-Vanneau, transverse section of the dorsal side (H), axial section (K), subaxial sections (L). Note *Glomospira urgoniana* Arnaud-Vanneau in the lower left side of K. I) *Pseudochoffatella cuvillieri* Deloffre, tangential section. J) *Akcaya capitata* (Arnaud-Vanneau) (lower part of the picture) and *Akcaya minuta* (Hofker) (upper part). M) *Coskinolinella daguini* Delmas and Deloffre. A, K: MGM-10856C-1, -10856C-2 (CCU 17A); B: MGM-10850C-1 (CL 8); C: MGM-10860C-1 (PH 14B); D: MGM-10862C-4 (No 14); E, H, M: MGM-10887C-2, -10887C-3, MGM-10887C-4 (SOP 78); F: MGM-10854C-3 (CCU 7); G: MGM-10849C-1 (CL 6); I: MGM-10883C-1 (SOP 68); J: MGM-10866C-2 (PN 13); L: MGM-10882C-2 (SOP 51). Scale bars 0.3mm, except I= 1mm and M= 0.5mm.

ammonite zone (=*D. weissi*, early Bedoulian) (Clavel *et al.*, 2013) so that the last appearance of this species in France is not necessarily coeval with the latest appearances of certain benthic foraminifera such as *N. cretacea*, *Glomospira urgoniana* ARNAUD-VANNEAU or *Dobrogelina*? *carthusiana* ARNAUD-VANNEAU, which were all observed in the upper Aptian Reocín Formation. Accordingly, the ranges of these taxa should be extended to the late Aptian. *N. cretacea* was already reported by Granier (1987) from the upper Aptian to lower Albian of the Prebetic zone.

Order: Loftusiida KAMINSKI ET MIKHALEVICH in Kaminski, 2004
Family: Cuneolinidae SAIDOVA, 1981
GENUS ***Cuneolina*** D'ORBIGNY, 1839
Cuneolina cf. *parva* HENSON, 1948a (Fig. 6C–D)

According to Arnaud-Vanneau and Sliter (1995) the chronostratigraphic range of *C. parva* is Albian to Cenomanian, ?Santonian. Besides its occurrence in the Reocín Formation (and the overlying lower Albian Las Peñosas Formation), there are also other records of *Cuneolina parva* HENSON from upper Aptian strata (*e.g.* Kuss and Schlagintweit, 1988: Egypt; Luperto Sinni and Masse, 1992: Italy).

GENUS ***Akcaya*** ÖZDIKMEN, 2009
Akcaya minuta (HOFKER, 1965) (Fig. 6G, J pars)

The species was originally described by Hofker (1965) as *Textulariella minuta* from the Aptian-Albian transition of the Santander area, northern Spain. It became the type-species of *Sabaudia* as revised later in the same year by Charollais and Brönnimann (1965). The name *Sabaudia* however was already occupied by the ctenophore ("comb jelly") *Sabaudia liguriae* GHIGI, 1909 as compiled by Özdikmen (2009), who established the new combination *Akcaya minuta*, adopted in the recent classification of Kaminski (2014). The specimen illustrated in Figure 6G displays a juvenarium composed of four subglobular chambers. Note that quadrilocular embryos are more seldom than trilocular ones (see Arnaud-Vanneau and Chiocchini, 1985). *A. minuta* is one of the most frequently observed taxa in the Reocín Formation.

Akcaya capitata (ARNAUD-VANNEAU, 1980) (Fig. 6J pars)

S. capitata was described by Arnaud-Vanneau (1980) from the Urgonian of southern France. Its chronostratigraphic range is Barremian to lowermost Albian (Arnaud-Vanneau and Chiocchini, 1985). In the Reocín Formation both *A. minuta* and *A. capitata* are rather common.

Family: Charentiidae LOEBLICH AND TAPPAN, 1985
GENUS ***Charentia*** NEUMANN, 1965
Charentia cuvillieri NEUMANN, 1965 (Fig. 6E–F)

Charentia cuvillieri was described by Neumann (1965) from the Cenomanian of France. It is a geographically widespread taxon reported from the Hauterivian to the Cenomanian (Arnaud-Vanneau, 1985). From the Aptian-Albian transition of the Santander area, northern Spain, it was described by Hofker (1965) as *Haplophragmoides greigi* (HENSON).

Family: Cyclamminidae MARIE, 1941
GENUS ***Pseudochoffatella*** DELOFFRE, 1961
Pseudochoffatella cuvillieri DELOFFRE, 1961 (Fig. 6I)

The species was both poorly illustrated and described by Deloffre (1961) from the upper Aptian of the French-Basque Pyrenees. For a detailed description and illustration of the species see Gušić (1975) and Cherchi and Schroeder (1982).

Later, the chronostratigraphic distribution was refined to the late Gargasian ("biozone à *P. cuvillieri*") for the area of the Pyrenees below the first appearance of *Simplorbitolina manasi* (Fourcade, 1970; Moullade and Peybernès, 1975; Peybernès, 1976). In the studied sections of the Reocín Formation, *P. cuvillieri* appears in the same levels as *Coskinolinella daguini* and coexists with *S. manasi*. Whereas the latter two persist into the lower Albian Las Peñosas Formation, *P. cuvillieri* disappears in the uppermost part of the Reocín Formation concluding its presence also in the uppermost Aptian. In other areas, however, *P. cuvillieri* is recorded also throughout the lower Albian (Granier, 1987; Betic Cordillera, Spain). These varying ranges are due to differences in facies evolution, as *P. cuvillieri* has a preference for internal platform facies and is therefore missing in the estuarine Las Peñosas Formation of Cantabria.

Family: Pfenderinidae SMOUT AND SUDGEN, 1962
GENUS ***Dobrogelina*** NEAGU, 1979
Dobrogelina? *cartusiana* ARNAUD-VANNEAU, 1980 (Fig. 6H, K–L)

The species *D.*? *cartusiana* was described by Arnaud-Vanneau (1980) from the upper Barremian-lower Aptian of SW France. The stratigraphic range can be extended into the upper Aptian. *D.*? *cartusiana* represents a common taxon in the Reocín Formation (*e.g.* Ramírez del Pozo, 1971; Pl. 6, fig. 3, as *Valvulammina*).

Family: unclear (see remarks below)
GENUS ***Coskinolinella*** DELMAS AND DELOFFRE, 1961
Coskinolinella daguini DELMAS AND DELOFFRE, 1961 (Fig. 6M)

C. daguini was described by Delmas and Deloffre (1961) from the upper Aptian to lower early Albian of Aquitaine,

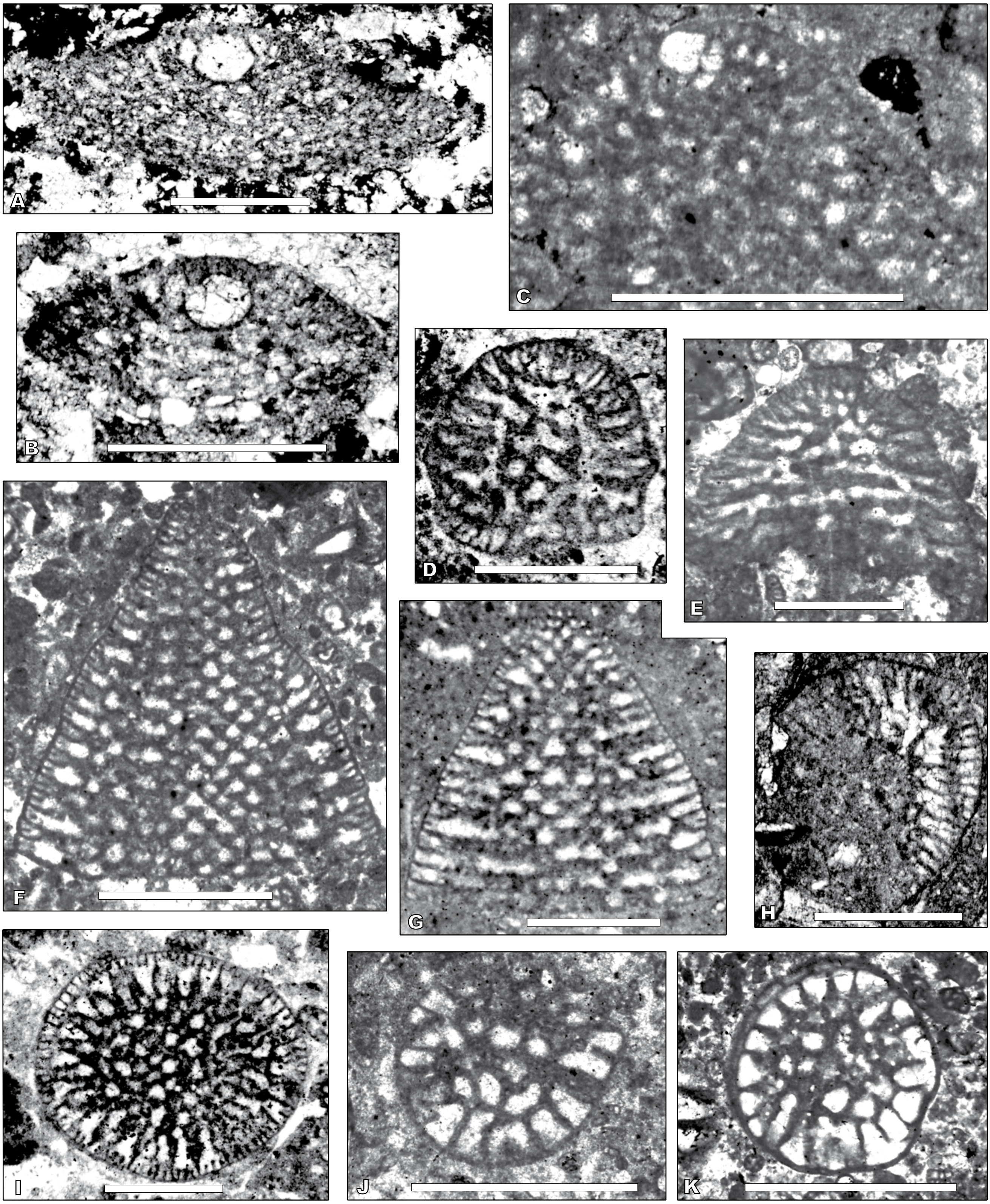

FIGURE 7. Orbitolinids from the lower Aptian Rábago (B) and San Esteban formations (A, C, F–G, I), and the upper Aptian Reocín Formation (D–E, H, J–K). A–B) *Palorbitolina lenticularis* (Blumenbach). MGM-10858C-1 (CU-10), and MGM-10867C-1 (PN-4). C) *Praeorbitolina cormyi* Schroeder. MGM-10871C-1 (RU-12). D–E, H) *Dictyoconus? pachymarginalis* Schroeder. D: MGM-10852C-1 (CCU-1), E: MGM-10851C-1 (CL 14), H: MGM-10868C-1 (PN-14), F–G, I) *Orbitolinopsis? simplex* (Henson). F: MGM-10875C-1 (SU-8), G: MGM-10872C-1 (Ru-29), I: MGM-10870C-1 (Ru-6). J–K) *Orbitolinopsis reticulata* Moullade and Peybernès, oblique transverse sections. J: MGM-10866C-3 (PN-13), K: MGM-10878C-1 (SOP-14). Scale bars 0.5mm.

SW France. Later, it was documented by Hofker (1965) from the Aptian-Albian transition in the Santander area, northern Spain. A detailed description and revision was provided by Cherchi (1985) confirming the given range. Cherchi (1985, p. 53) indicated test diameters from 1.4 to 1.6mm (max. 2.0mm), but up to 1.5mm according to Hofker (1965). The specimen illustrated here from the El Soplao section attains an unusual large size of 3.2mm, and possibly represents a microspheric specimen. It is worth mentioning that in all studied sections, the higher evolved *Coskinolinella santanderensis* RAMÍREZ DEL POZO (with rafters) has not been observed. This species has an upper lower Albian to lower middle Albian chronostratigraphic range (Cherchi, 1985). Both *C. daguini* and *C. santanderensis* were reported by Arnaud-Vanneau and Premoli Silva (1995) from Pacific guyots near Japan. However, in our opinion, the illustrations supplied do not allow confirming these determinations. The presumed paleobiogeographic belonging of *C. daguini* to the northwestern-Tethyan margin is supported by the absence of *Coskinolinella* in the Aptian–Albian of the Prebetic zone, belonging to the former southern Tethyan margin (Masse *et al*., 1992). The genus *Coskinolinella* was treated by Cherchi (1985) as an orbitolinid taxon showing a lineage with increasing test complexity. As a matter of fact, *C. daguini* has no septules at all, *C. santanderensis* displays only rafters (vertical septules), and *C. navarrensis* has both rafters and beams (vertical and horizontal septules). However, Hofker (1965) refuted its attribution to the Orbitolinidae, and assigned it instead to the Lituolidae. Loeblich and Tappan (1987, p. 697) considered *Coskinolinella* as a genus of uncertain status, whereas in the new classification of agglutinated foraminifera provided by Kaminski (2014), it has not been included. Its test architecture (see details in Cherchi, 1985), however, accounts for its attribution to the suborder Orbitolinina as defined by Kaminski (2004, 2014).

Family: Orbitolinidae MARTIN, 1890
GENUS ***Palorbitolina*** SCHROEDER, 1963a
Palorbitolina lenticularis (BLUMENBACH, 1805) (Fig. 7A–B)

Specimens of *P. lenticularis* (BLUMENBACH) were observed in the Rábago Formation (sample PN 4, Río Nansa section; sample SOP 1, El Soplao section) and in the San Esteban Formation (sample CU 10, Cuchía coast section). The sample SOP 1 containing *P. lenticularis* and *Choffatella decipiens* was taken about 1m above the non-marine siliciclastic Wealden facies. It is worth mentioning here that, Neagu and Cîrnaru (2004) consider *Choffatella cruciensis* (PICTET AND RENEVIER) as the type-species of *Choffatella* with *C. decipiens* as a junior synonym of the former. The embryonic apparatus of *P. lenticularis* includes a well-developed peri-embryonic ring (or chamber) surrounding the protoconch in its upper part. The sizes of the protoconchs (inner diameters 0. 145/0.15/0.14/0.21/0.2/0.16mm) and the statistically insufficient number of measured specimens do not allow an assignment to either typical upper Barremian or lower Aptian assemblages (see Gušić, 1981, for details). Note that the first appearance of the species is from the lower Barremian (*pulchella* ammonite zone) as recently evidenced by Granier *et al.* (2013), who showed (plates 1 and 11) that these lower Barremian specimens display a simple embryo, with a subspherical protoconch, only rudimentary septules and no distinct (if ever present) periembryonic ring.

GENUS ***Praeorbitolina*** SCHROEDER, 1964a
Praeorbitolina cormyi SCHROEDER, 1964a (Fig. 7C)

Rare specimens of *Praeorbitolina cormyi* were observed in the lower Aptian (Bedoulian) San Esteban Formation, from where many other specimens of flat to low-conical orbitolinids could not be determined to the specific rank due to the lacking of embryo sections.

GENUS ***Mesorbitolina*** SCHROEDER, 1962
Mesorbitolina texana (ROEMER, 1849) (Fig. 8H, J)

The first occurrence of *M. texana* is at the base of the upper Gargasian (Schroeder *et al*., 2010). In this study, the first specimens of *M. texana* were observed in the upper part of the Rodezas Formation persisting into the Reocín Formation.

Mesorbitolina parva (DOUGLASS, 1960) (Fig. 8K–L)

Rare specimens of *M. parva* were observed in the Rodezas Formation and the lowermost parts of the Reocín Formation. Thin sections that do not cut the megalospheric embryo, such as those found in sandy wackestones below the first definite occurrence of *M. texana*, could either belong to *M. parva* or *M. texana*. *M. parva* has its first appearance in the latest Bedoulian ranging up into the late Gargasian, where it co-occurs with *M. texana* (see Fig.1 in Cherchi and Schroeder, 2013).

Mesorbitolina birmanica (SAHNI, 1937) (Fig. 8I, M–N)

For a recent revision of this poorly known taxon see Schlagintweit and Wilmsen (2014). Ramírez del Pozo (1971) found *M. birmanica*, identified as *Orbitolina (Mesorbitolina) texana melendezi* nov. subsp., exclusively in upper Gargasian carbonates of Escoriaza, which are equivalents of the Reocín Formation. This subspecies was defined by the concave lower side of the subembryonic zone, a feature that can be observed only in some specimens of *M. birmanica*. In the Reocín Formation, *M. birmanica* appears higher up in the sections than *M. texana*, as observed in other areas (*e.g*. Fourcade and Raoult, 1973: reported as *Mesorbitolina* sp. A).

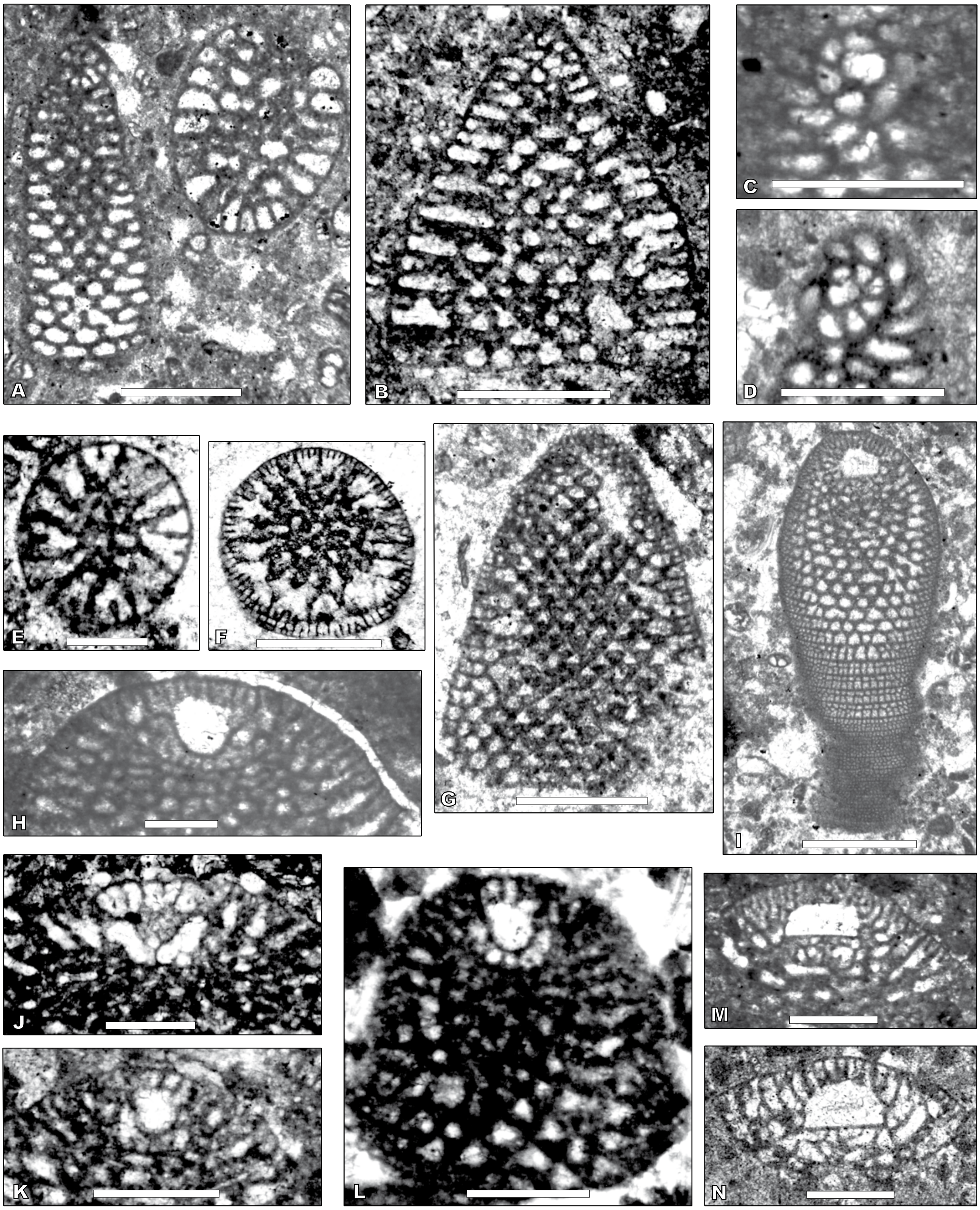

FIGURE 8. Orbitolinids from the upper Aptian Reocín Formation (A–E, H–N) and the lower Albian Las Peñosas Formation (F–G). A) *Simplorbitolina aquitanica* (Schroeder), oblique subaxial section (specimen on the left) and oblique section (specimen on the right). MGM-10878C-2 (SOP-14).B–E) *Simplorbitolina manasi* Ciry and Rat. Subaxial section (B), axial sections showing protoconch and initial trochospire (with up to 12, ?13 chambers; compare with Schroeder, 1985, pl. 20, fig. 15) (C–D), transverse section (E). B: MGM-10888C-1 (SOP-81B); C: MGM-10882C-1 (SOP-51-1); D: MGM-10887C-6 (SOP-51), E: MGM-10887C-5 (SOP-78). F–G) *Simplorbitolina conulus* Schroeder. Oblique transverse section (F), oblique subaxial section (G). MGM-10877C-1, -10877C-2 (SV-31). H, J) *Mesorbitolina texana* (Roemer), axial sections. H: MGM-10876C-1 (SE-2-7); J: MGM-10873C-1 (Ru-69). K–L) *Mesorbitolina parva* (Douglass). Axial section (K), oblique section (L). MGM-10851C-2, -10851C-3 (CL-14). I, M–N) *Mesorbitolina birmanica* (Sahni). Oblique section passing through the marginal zone (lower part) and the central zone (upper part) (I), axial sections of juvenile specimens (M–N). I: MGM-10857C-1 (CCU-17B); M–N: MGM-10856C-3, -10856C-4 (CCU-17A).

GENUS ***Dictyoconus*** BLANCKENHORN, 1900

Dictyoconus? *pachymarginalis* SCHROEDER, 1965a (Fig. 7D, E, H)

Schroeder (1965a) described *Dictyoconus pachymarginalis* from upper Bedoulian-Gargasian strata of the Alborz Mountains, northern Iran. In the Prebetic zone of Spain, Masse *et al.* (1992) considered that it characterizes a comparatively short interval, *i.e.* the middle part of the lower Gargasian (their biozone of *Dictyoconus pachymarginalis*). Recent studies in Central Iran have shown that *D.*? *pachymarginalis* is present throughout the whole *Praeorbitolina cormyi* zone of Schroeder *et al.* 2010, (fig. 10: *Deshayesites deshayesi* and *D. furcata* ammonite zones) and co-occurs with *M. texana* in its upper range (Schlagintweit *et al.*, 2013). Rare specimens of *D.*? *pachymarginalis*, previously not reported from the North Cantabrian Basin, have been observed in the lower part of the Reocín Formation, in beds directly overlying the dolomitic unit (Río Nansa section, samples PN-13, -14) and in samples CCU 1 of the Cantera de Cuchía section, LA 17 of the Rábago section, and CL 14 of the Cantera de Las Lastrías section, where it occurs along with *Mesorbitolina parva*. The whole vertical range might be masked by the dolomitic portion of the sections, where identification of taxa was not possible.

GENUS ***Orbitolinopsis*** HENSON, 1948b

Orbitolinopsis? *simplex* (HENSON, 1948b) (Fig. 7F, G, I)

Originally described as *Iraqia simplex* by Henson (1948b) from the Lower Cretaceous of Iraq, the species has been reported repeatedly from different regions in Spain (*e.g.* Schroeder, 1964b; Ramírez del Pozo, 1971; Masse *et al.*, 1992; Ullastre *et al.*, 2002). According to Ramírez del Pozo (1971) it characterizes the upper Bedoulian (see also Moullade *et al.*, 1985; Masse, 2003). While most authors consider *Iraqia* as a valid genus (Douglass, 1960; Billiard and Moullade, 1964; Loeblich and Tappan, 1987; Masse, 2003; Kaminski, 2004, 2014), it is regarded a junior synonym of *Orbitolinopsis* by others (Schroeder *et al.*, 1968; Schroeder, 1972; Ramírez del Pozo, 1971; Ullastre *et al.*, 2002). In the studied sections, *O.*? *simplex* is restricted to the San Esteban Formation, where it is a common taxon, reaching the top of the formation (see also Najarro *et al.*, 2011; García-Mondejar *et al.*, 2015). In conclusion, the occurrence of *O.*? *simplex* is restricted to the first "système biosédimentaire Urgonien" (=Bedoulian) *sensu* Pascal (1985).

Orbitolinopsis reticulata MOULLADE AND PEYBERNÈS, 1978 (Fig. 7J–K)

O. reticulata was described by Moullade and Peybernès (1978) from the Pyrenean upper Aptian (middle-upper Gargasian). In the French type-locality, it occurs in the "calcaires à *Pseudochoffatella cuvillieri*", a taxon also reported from the Reocín Formation. *O. reticulata* was mentioned by Collignon *et al.* (1979) from the Gargasian of the Reocín Formation of the Cuchía section. In the Prebetic zone *O. reticulata* and *Simplorbitolina aquitanica* occur in a small range in the lower upper Gargasian (Masse *et al.*, 1992). In contradiction to all existing data in the literature, Millán *et al.* (2014; p. 170) reported the occurrence of *O. reticulata* and *Simplorbitolina aquitanica* (without illustrations) in their Unit 4 of the Artxueta Formation (southeastern part of the Basque-Cantabrian Basin), ascribed to the lower Albian (op. cit., fig. 3). An early Albian age was recently erroneously assigned to the Reocín Formation based on the occurrence of *O. reticulata* and *Mesorbitolina* gr. *texana-minuta* (Fernández-Mendiola *et al.*, 2015).

In the Reocín Formation *O. reticulata* was observed in the strata overlying the dolomitic complex (*e.g.* Río Nansa section, sample PN 13; El Soplao section, sample SOP 14). The whole range might be masked by the dolomitic portion of the sections, where identification of taxa was not possible.

GENUS ***Simplorbitolina*** CIRY AND RAT, 1952

Simplorbitolina aquitanica (SCHROEDER in Schroeder and Poignant, 1964) (Fig. 8A)

The species *Orbitolinopsis aquitanica* was described by Schroeder in Schroeder and Poignant (1964) from the upper Aptian (Gargasian) of Aquitaine (Basque Pyrenees, SW France). Later the new combination *Simplorbitolina aquitanica* was introduced by Moullade and Peybernès (1979) based on material from the upper Gargasian of the Pyrenees. Both *S. aquitanica* and *O. reticulata* were assigned to the lower Gargasian interval by Moullade *et al.* (1985, fig. 1).

In the Prebetic zone of the Murcia area, Masse *et al.* (1992) indicated the co-occurrence of *O. reticulata* and *S. aquitanica*, defined as a biozone of short duration within the early upper Gargasian. Later Fenerci-Masse *et al.* (2006; p. 770), confirmed that both species "identify the upper Gargasian". *S. aquitanica* is reported here for the first time from the Reocín Formation.

Simplorbitolina manasi CIRY AND RAT, 1952 (Fig. 8B–E)

The species *Simplorbitolina manasi* was described by Ciry and Rat (1952) from the area near Pamplona, autonomous community of Navarra, northern Spain. The cartographically isolated outcrop was tentatively assigned to the Aptian-Albian transition. *S. manasi* appears in the upper part of the Reocín Formation after the first occurrences of *P. cuvillieri* and *C. daguini*. Youngest specimens were observed in the lower part of the Las Peñosas Formation. For a detailed description and compilation on occurrences and chronostratigraphy of this species see Schroeder (1985). The specimen from the Reocín Formation shown in Figure 8C is directly comparable to the specimen of Schroeder (1985: pl. 20, fig. 15), who showed that the initial spire (following the embryo) is composed of 4-6 chambers. In addition we observed specimens with a more pronounced initial spire consisting of up to 12 (?13) chambers (Fig. 8D).

Simplorbitolina conulus SCHROEDER, 1965b (Fig. 8F–G)

Simplorbitolina conulus was described by Schroeder (1965b) from Navarra, northern Spain. Its chronostratigraphic range is upper lower to middle Albian (Berthou and Schroeder, 1979; Schroeder and Neumann, 1985; Table 1). *S. conulus* was observed in the upper part of the Las Peñosas Formation of the San Vicente de la Barquera section (sample SV 31). The species was recently illustrated by Bodego *et al.* (2015; Fig. 8G) from the Buruntza Formation of the eastern Basque-Cantabrian Basin.

DISCUSSION

Biochronostratigraphic attribution of the Reocín Formation: a historical overview

Different biostratigraphic subdivisions of the upper Aptian shallow-water carbonates in Spain were proposed mainly based on orbitolinids (see Schroeder, 1963b, 1964b; Ramírez del Pozo, 1971, 1972; García-Hernández, 1981; Masse *et al.*, 1992; Castro *et al.*, 2001). Differences in the datation of the Reocín Formation are due to varying ranges and taxonomic attributions of taxa, different understanding of lithostratigraphic units in the study area, variable lithostratigraphic evolution leading to differing ranges of units, and last but not least the problematic subdivision of the upper Aptian (Gargasian, Clansayesian) in the Tethyan domain. This resulted in a lack of consensus for the chronostratigraphy of the Reocín Formation. Based on the orbitolinids *Simplorbitolina manasi* and *Mesorbitolina texana*, Ramírez del Pozo (1972) indicated an upper Aptian age for this formation (see also Najarro *et al.*, 2011). However, as both of the mentioned orbitolinids range into the middle Albian (see Schroeder and Neumann, 1985), their occurrence is not necessarily a proof for a late Aptian age. An upper Gargasian – lower Albian or lowermost Albian age was indicated for the Reocín Formation by García-Mondéjar (1982) and García-Mondéjar *et al.* (1985). Recently, a lower-middle Albian range (upper Aptian not excluded for the lowermost part) was assigned to the Reocín Formation of the Cuchía section (García-Mondéjar *et al.*, 2015). Finally, a lower Albian age was attributed to the Reocín Formation based on orbitolinids that are typically upper Aptian such as *Orbitolinopsis reticulata* (Férnandez-Mendiola *et al.*, 2015).

The only data based on ammonites to establish the minimum age of the Reocín Formation are available from the upper part of the Rodezas Formation, which is referred to the *Epicheloniceras gracile* subzone of the *Epicheloniceras martini* zone (Mengaud, 1920; Moreno-Bedmar *et al.*, 2011), belonging to the middle part of the lower Gargasian (see Reboulet *et al.*, 2014) (Fig. 9).

New biochronostratigraphic data of the Reocín Formation and discussion

The biochronostratigraphic data for the Reocín Formation presented herein were obtained from the analysis of several stratigraphic sections with varying thicknesses including also under- and overlying formations. In the San Esteban Formation of the Cuchía and Ruilobuca sections we observed *Palorbitolina lenticularis* (BLUMENBACH), rare *Praeorbitolina cormyi* SCHROEDER, and the most common *Orbitolinopsis*? *simplex* (HENSON). These taxa were also reported by Pascal (1985) and García-Mondéjar *et al.* (2015) from the San Esteban Formation. In marly limestones of the lower part of the San Esteban Formation, *O.*? *simplex* is typically associated with *Choffatella decipiens* SCHLUMBERGER, also referred to as *Choffatella cruciensis* (PICTET AND RENEVIER) by Neagu and Cîrnaru (2004). In the Rodezas Formation we observed *Mesorbitolina parva* and, in its upper part, the first specimens of *Mesorbitolina texana* (ROEMER).

Based on orbitolinids, an upper Gargasian-Clansayesian age is assigned to the Reocín Formation (Fig. 9). Its extension into the lower Albian can neither be proven nor excluded. In continuous sections (*i.e.* without a stratigraphic gap), the Reocín Formation is followed by the lower Albian Las Peñosas Formation (García-Mondéjar, 1982; Hines, 1985) that in turn is overlain by the middle-late Albian Barcenaciones Formation. In several sections the latter directly follows the Reocín Formation with a gap, *e.g.* Suances, Cantera de Cuchía, and Cuchía coast sections (Figs. 2; 3). In the Reocín Formation of the Cuchía section, García-Mondéjar *et al.* (2015, p. 13) did not mention any orbitolinid but only *Hensonina lenticularis* (HENSON). These specimens, referred to as *Involutina hungarica* (SIDO) (see Schlagintweit and Piller, 1990; Rigaud *et al.*, 2015), were not observed in the Reocín Formation but in the middle-upper parts of the Las Peñosas Formation (*e.g.* Fonfría section) and in all the studied sections of the Barcenaciones Formation (Rosales *et al.*, 2013; Najarro,

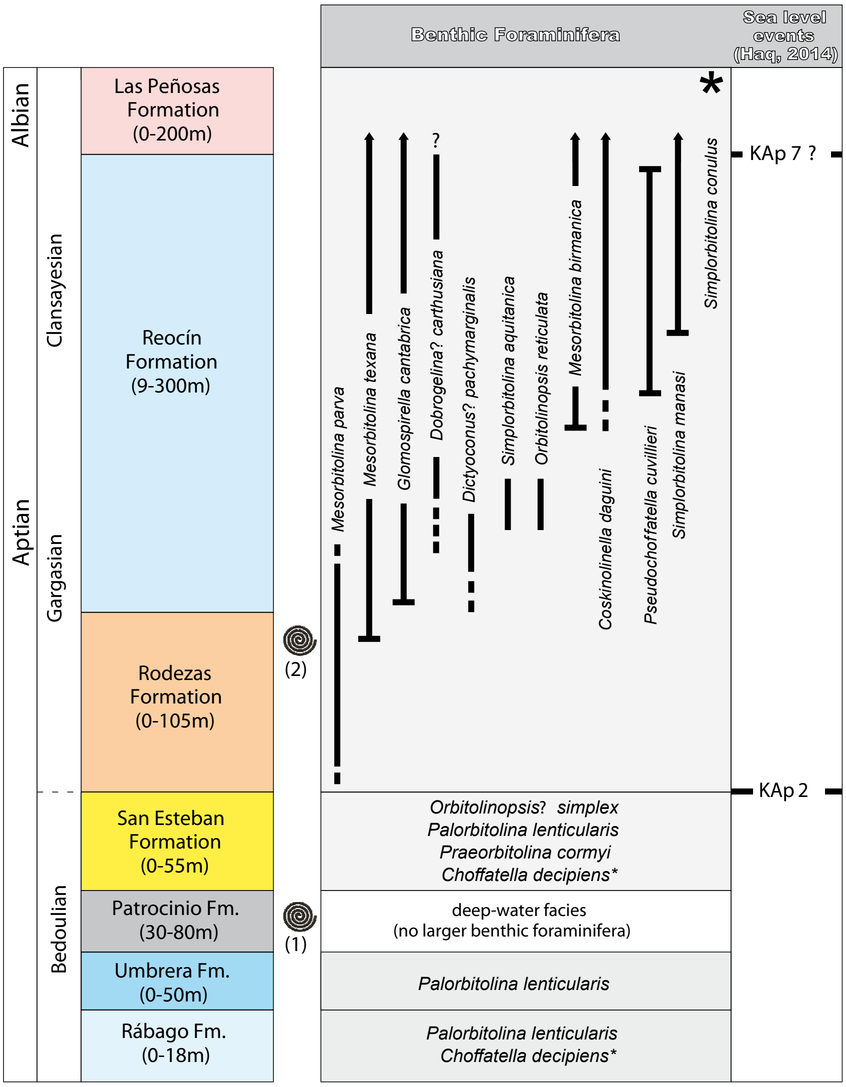

FIGURE 9. Biostratigraphy of the Cantabrian Urgonian (Aptian) and distribution of selected benthic foraminifera (orbitolinids and others). The boundary Bedoulian-Gargasian is tentatively placed based on the biostratigraphy of orbitolinids and other benthic foraminifera. The Gargasian-Clansayesian and Aptian-Albian boundaries are intentionally left open. Ammonite data: 1) *Deshayesites forbesi* and *D. deshayesi* zones (Collignon *et al*., 1979; Najarro *et al*., 2011; García-Mondejar *et al*., 2015). 2) *Epicheloniceras martini* Zone, *Epicheloniceras gracile* subzone (Collignon *et al*., 1979; Moreno-Bedmar *et al*., 2011).

2015). Together with debris of the udoteacean alga *Boueina camenitzae* (DRAGASTAN AND BUCUR), *Involutina hungarica* typically occurs in high-energy open marine carbonates in the middle-late Albian Barcenaciones Formation (*e.g.* Río Nansa, Cantera de Cuchía, Cuchía coast, Bustriguado sections) (see *e.g.* fig. 3F in Rosales *et al*., 2013). The lower part of the Las Peñosas Formation includes instead sandy, marly limestones with oysters. Therefore it can be concluded that the report of *Hensonina lenticularis* HENSON [=*Involutina hungarica* (SIDO)] from the Reocín Formation by García-Mondéjar *et al.* (2015) in fact refers to samples from the Barcenaciones Formation that unconformably overlies the Reocín Formation, *e.g.* Cantera de Cuchía section (Figs. 2C; 3) and Cuchía coast section (Fig. 3).

Due to differences in facies evolution, the vertical distribution of taxa presented here for the North-Cantabrian Basin cannot be applied directly to other regions. The vertical distribution of orbitolinids and other foraminifera and the resulting biozonation established by Masse *et al.* (1992) for the Prebetic zone of southern Spain is different from the Cantabrian distribution in details, since in the former area, *Orbitolinopsis*? *simplex-Praeorbitolina cormyi*, and *Pseudochoffatella cuvillieri-Simplorbitolina manasi* are distinctly separated from each other. *Coskinolinella daguini* is missing presumably due to its palaeobiogeographic restriction to the northern Tethyan domain.

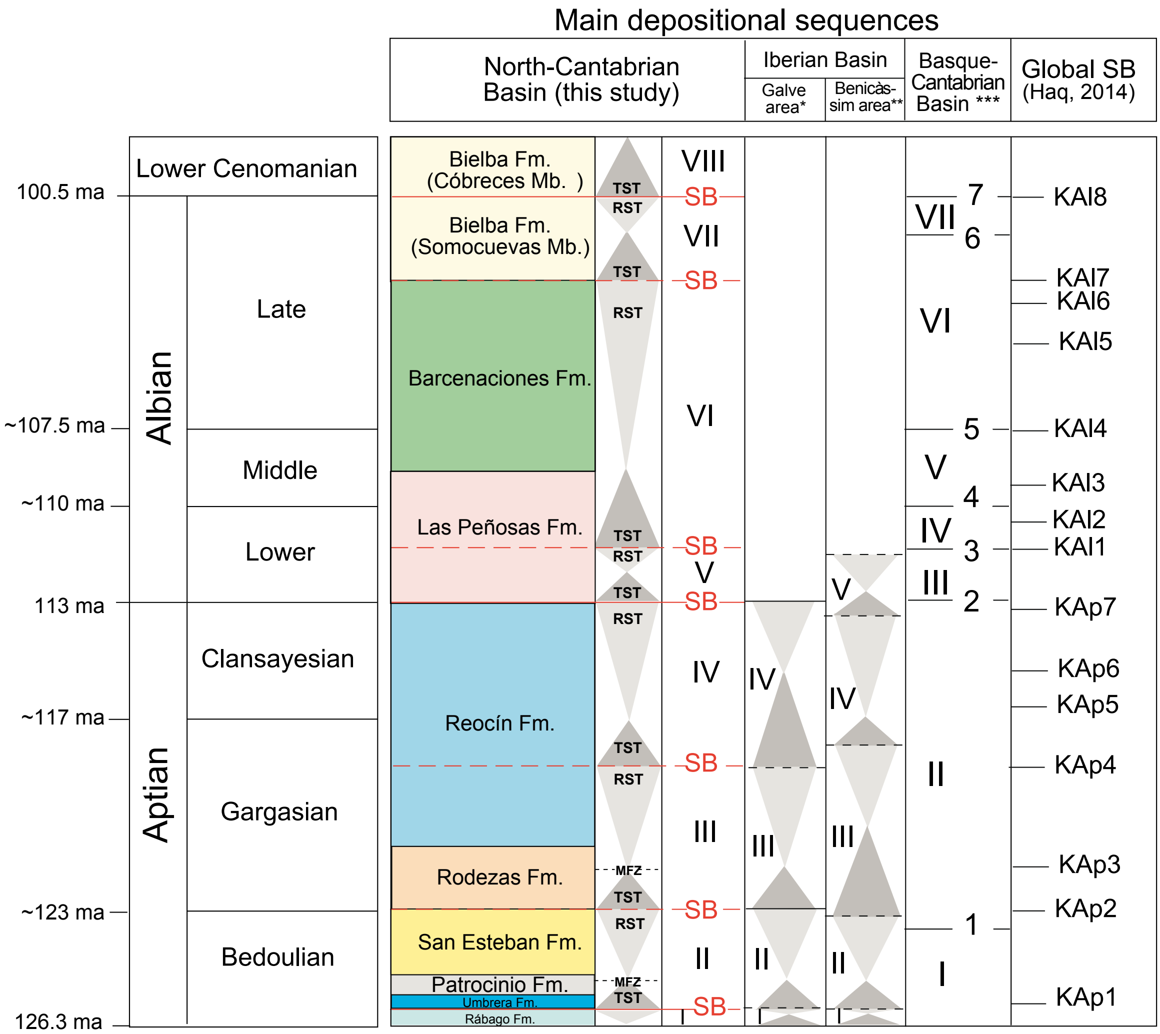

FIGURE 10. Chrono-, lithostratigraphic and depositional sequences chart showing comparison of the depositional sequences of the North-Cantabrian Basin (this study) with the global cycle boundaries (after Haq, 2014) and the main depositional sequences of the Basque-Cantabrian Basin (BCB) after García-Mondéjar *et al.*, 2004 (***), and the Iberian Chain (Benicàssim and Galve areas) after Martín-Martín *et al.*, 2013 (**) and after Bover-Arnal *et al.*, 2009 (*). I to VIII: depositional sequences. SB: Sequence Boundaries. The dashed lines of the SB indicate uncertainty in the chronostratigraphic dating. TST: Transgressive System Tract, RST: Regressive System Tract, MFZ: Maximum Flooding Zone. Absolute ages are taken from Haq (2014).

Implications in sequence stratigraphy

The biostratigraphic results obtained in this paper provide new data to help in the datation and correlation of the sequence stratigraphy scheme of the basin (Fig. 9). The unconformity at the transition Reocín to Las Peñosas formations possibly relates to the sea level event KAp7 (~ 113.3Ma) *sensu* Haq (2014) that occurred around the Aptian-Albian boundary. On the other hand, the transition between the San Esteban and Rodezas formations possibly is coincident with the KAp2 event (~123Ma) at the top of the *Dufrenoyia furcata* ammonite zone, the base of the Gargasian (*sensu* Reboulet *et al.*, 2014). This boundary might then be coeval to the Gargasian tectonic event of Pascal (1985) (see also Wilmsen, 2005).

Based on the identification of regional unconformities and facies stacking patterns, eight depositional sequences (transgressive-regressive sequences compiled from Najarro, 2015, and Rosales and Schlagintweit, 2015) can be recognized in the Aptian–lower Cenomanian succession of the NCB (Fig. 10). The biostratigraphic results of this study based on benthic foraminifers improve the chronostratigraphy of the depositional sequences and allow their comparison with the main depositional sequences recognized in other areas of the Basque-Cantabrian Basin and the Iberian Chain (García-Mondéjar *et al.*, 2004; Bover-Arnal *et al.*, 2009; Martín-Martín *et al.*, 2013) and the recently revised global sea level falls of Haq (2014).

The first depositional sequence of the North-Cantabrian Basin is a short cycle that occurred at the lowermost

Aptian (sequence I, Fig. 10). The base of the sequence corresponds to the widespread marine transgression at the base of the Aptian. The upper sequence boundary is marked by a subaerial exposure surface between the Rábago and Umbrera formations. In the Iberian Chain, this cycle correlates with a coeval initial short cycle identified in both the Galve and Benicàssim areas of the Maestrat Basin (Bover-Arnal *et al*., 2009; Martín-Martín *et al*., 2013), whereas in other areas of the Basque-Cantabrian Basin it has not yet been distinguished (García-Mondéjar *et al*., 2004). This depositional sequence may be correlated to the global sea-level fall KAp1 (~125.6Ma).

The sequence II (Fig. 10) is lower to upper Bedoulian and comprises the Umbrera, Patrocinio and San Esteban formations. The Maximum Flooding Zone (MFZ, Fig. 10) of this sequence, represented by the Patrocino Formation, is coeval with the oceanic anoxic event 1a (Najarro *et al*., 2011; García-Mondéjar *et al*., 2015). The top of the sequence is a subaerial exposure surface with paleokarst development and brecciation on top of the San Esteban Formation. In the Maestrat Basin, this sequence correlates well with the sequence II of the Galve and Benicàssim areas (Fig. 10) identified respectively by Bover-Arnal *et al*. (2009) and Martín-Martín *et al*. (2013). In other areas of the Basque-Cantabrian Basin, the sequences I and II of this study correspond to the main depositional sequence I of García-Mondéjar *et al*. (2004). There are some discrepancies regarding the age of the upper boundary of sequence II between the different areas (Fig. 10). In the Galve area, Bover-Arnal *et al*. (2009) located the boundary on top of the last ammonite biozone of the Bedoulian (*D. furcata* ammonite zone). Later the same authors (Moreno-Bedmar *et al*., 2012; Bover-Arnal *et al*., 2014) relocated the boundary within the *D. furcata* ammonite zone on the basis of the occurrence of *Dufrenoyia* ammonites in the transgressive deposits just above the sequence boundary, adopting the same stratigraphic position for this boundary as in the Benicàssim area (Martín-Martín *et al*., 2013). In other areas of the Basque-Cantabrian Basin, García-Mondéjar *et al*. (2004) located the sequence boundary in a lower position (Fig. 10), below the *Tropaeum bowerbanki* ammonite zone, which is equivalent to the *D. furcata* ammonite zone of the Mediterranean region. In the present study, the boundary has been located at the Bedoulian-Gargasian transition (*sensu* Reboulet *et al*., 2014) in agreement with the global sea-level fall KAp2 (~123Ma), although a lower position below the Bedoulian-Gargasian transition cannot be excluded.

The transgressive deposits of the sequence III correspond to the Rodezas Formation (Fig. 10). The MFZ (Fig. 10) is recognized in the argillaceous-marly interval with ammonites of the *E. gracile* ammonites sub-zone (Mengaud, 1920; Moreno-Bedmar *et al*., 2011) of the middle part of the lower Gargasian (Fig. 10), approximately in the same stratigraphic position than in the Maestrat Basin (Moreno-Bedmar *et al*., 2012). The upper sequence boundary of sequence III is related to facies regression and local subaerial exposure that occurred within the Reocín Formation (Najarro *et al*., 2007). In the North-Cantabrian Basin, the age of this sequence boundary falls in an uncertain position within the Gargasian (dashed red lines in Fig. 10). In the Maestrat Basin a likely equivalent sequence boundary has been recognized on top of the *E. martini* ammonite zone (Bover-Arnal *et al*., 2009; Moreno-Bedmar *et al*., 2012), which can be approximately equivalent to the global event KAp4 (~118.2Ma) of Haq (2014) (Fig. 10).

Sequence IV, late Gargasian to Clansayesian in age, corresponds with the upper part of the Reocín Formation. The upper sequence boundary is placed around the Aptian to Albian transition (Fig. 10). A nearly equivalent sequence boundary has been recognized in the Galve and Benicàssim areas of the Maestrat Basin (Bover-Arnal *et al*., 2009; Martín-Martín *et al*., 2013). In other areas of the Basque-Cantabrian Basin, the sequences III and IV documented in the North-Cantabrian Basin and the Iberian Chain correspond to the main depositional sequence II of García-Mondéjar *et al*. (2004), with its upper boundary located as well around the Aptian to Albian transition (Fig. 10). This sequence boundary, which is nearly coeval in the different areas, most likely corresponds with the global event KAp7 (~113.3Ma) *sensu* Haq (2014).

Sequences V and VI, lower to late Albian in age, corresponds with the Las Peñosas and Barcenaciones formations (Fig. 10). The precise age of their upper sequence boundaries is still uncertain but they fall within the early Albian and late Albian, respectively (Fig. 10). Depositional sequences roughly equivalent to sequence V have been recognized in other areas of the Basque-Cantabrian Basin (sequence III of García-Mondéjar *et al*., 2004) and in the Benicàssim area of the southern Maestrat Basin, with their upper boundary at the top of the *Leymeriella tardefurcata* ammonite zone of the early Albian (García-Mondéjar *et al*., 2004; Martín-Martín *et al*., 2013). This boundary could be coincident with the global event KAl1 (~111.4Ma) of Haq (2014). The sequence VI of the North-Cantabrian Basin (upper Las Peñosas and Barcenaciones formations, Fig. 10), comprises the sequences IV to VI of García-Mondéjar *et al*. (2004) for other areas of the Basque-Cantabrian Basin. Their correspondence with the global sequences of Haq (2014) is unsure. Finally, the depositional sequences VII and VIII correspond respectively to the Somocuevas and Cóbreces members of the Bielba Formation (Fig. 10). The boundary between these two sequences is located around the Albian–

Cenomanian transition (Rosales and Schlagintweit, 2015), and is coincident with the major global cycle boundary KAl8 (~100.6Ma) *sensu* Haq (2014).

Therefore, it could be concluded that despite the evidence of syn-rift tectonic activity in all these basins, the main depositional sequences can be correlated between the different basins of Iberia and with some of the global sequences of Haq (2014), suggesting a strong eustatic control in their origin. A more precise dating of the sequences and their boundaries is needed to improve the intra- and inter-regional correlation and their precise correspondence with global events.

CONCLUSIONS

i) Despite recent studies focused on lithofacies and depositional sequences of the Aptian platform carbonates of the North-Cantabrian Basin, there is still a lack of knowledge on the composition of their benthic assemblages. The biostratigraphic results provided here allows filling this gap and provide relevant information for regional stratigraphical and sequential correlations. In addition, the new benthic foraminifer *Glomospirella cantabrica* n. sp. is described from the upper Aptian Reocín and Lower Albian Las Peñosas formations.

ii) Microfacies analysis of the Aptian platform limestones of Cantabria reveals a scarceness of dasycladalean green algae and a proliferation of benthic foraminifera. Based on the assemblage of benthic foraminifera of the Reocín Formation, an upper Aptian age is proposed for this unit.

iii) Owing to their presence in the upper Aptian Reocín Formation, the chronostratigraphic ranges of *Salpingoporella melitae* RADOIČIĆ, *Nautiloculina cretacea* PEYBERNÈS, *Glomospira urgoniana* ARNAUD-VANNEAU and *Dobrogelina? carthusiana* ARNAUD-VANNEAU have to be extended to the upper Aptian.

iv) Major unconformities related to sea-level falls with subaerial platform exposure occurred on top of the Rábago (lowermost Aptian), San Esteban (lower Aptian), Reocín (upper Aptian) and Barcenaciones (middle-late Albian) formations. They could be related respectively to the sea level global events KAp1 (~125.6Ma), KAp2 (~123Ma), KAp 7 (~113.3Ma) and KAl7 (~103Ma) *sensu* Haq (2014). Other two sequence boundaries related to facies regression and local subaerial exposure occurred within the Reocín and Las Peñosas formations. The precise age of these two sequence boundaries is still uncertain but falls within the Gargasian and lower Albian, respectively. They could be related tentatively to the sea-level global events KAp4 (~118.2Ma) and KAl1 (~111.4Ma), respectively. The correlation of the identified sequences with the global events of Haq (2014), and with other areas of the Basque-Cantabrian Basin and of the Iberian Chain, indicates a strong eustatic control in the origin of the sequences.

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REFERENCES

Arnaud-Vanneau, A., 1980. L'Urgonien du Vercors septentrional et de la Chartreuse. Géologie Alpine, 11(3, Mémoire), 1-874.

Arnaud-Vanneau, A., 1985. Genre *Charentia* Neumann, 1965. In: Schroeder, R., Neumann, M., (coords.). Les Grands Foraminifères du Crétacé Moyen de la région Méditerranénne. Géobios, mémoire special 7, 17-18.

Arnaud-Vanneau, A., Peybernès, B., 1978. Les représentants éocrétacés du genre *Nautiloculina* Mohler, 1938 (Foraminifera, Fam. Lituolidae?) dans les Chaînes Subalpines Septentrionales (Vercors) et les Pyrénées Franco-Espagnoles. Géobios, 11(1), 67-81.

Arnaud-Vanneau, A., Chiocchini, M., 1985. Le genre *Sabaudia* Charollais et Brönimman, 1965 (Foraminifère benthique Crétacé) et ses différentes especès. Revue de Micropaléontologie, 28(1), 3-22.

Arnaud-Vanneau, A., Premoli Silva, I., 1995. Biostratigraphy and systematic description of benthic foraminifers from Mid-Cretaceous shallow-water carbonate platform sediments at Sites 878 and 879 (MIT and Takuyo-Daisan Guyots). In: Haggerty, J.A.A. Premoli Silva, I., Rack, F.R., McNutt, M.K.. (eds.). Procceddings of the Ocean Drilling Program, Scientific Results, 144, 199-219.

Arnaud-Vanneau, A., Sliter, W.V., 1995. Early Cretaceous shallow-water benthic foraminifers and fecal pellets from Leg 143 compared with coeval faunas from the Pacific Basin, Central America, and the Tethys. Proceedings Ocean Drilling Program, Scientific Results, 143, 537-564.

Berkeley, A., Perry, C.T., Smithers, S.G., Horton, B.P., Cundy, A.B., 2009. Foraminiferal biofacies across mangrove-mudflat environments at Cocoa Creek, north Queensland, Australia. Marine Geology, 263, 64-86.

Berthelin, G., 1880. Mémoire sur les foraminifères fossils de l'étage Albien de Moncley (Doubs). Mémoires de la Société Géologique de France, série 3, 1(5), 1-84.

Berthou, P.Y., Schroeder, R., 1979. Découverte d'un niveau à *Simplorbitolina* Ciry et Rat dans l'Albien de Guincho (région de Lisbonne, Portugal). Comptes Rendus de l'Académie des Sciences Paris, 288, Série D, 591-594.

Billiard, J., Moullade, M., 1964. Étude de quelques représentants du genre *Iraqia* (Orbitolinidae) dans l'Aptien des contreforts Pyrénéens Français et Espagnols. Revue de Micropaléontologie, 6(4), 237-242.

Blanckenhorn, M., 1900. Neues zur Geologie und Paläontologie Ägyptens. Zeitschrift der Deutschen Geologischen Gesellschaft, 52, 403-479.

Blázquez-Fernández, S., López-Cilla, I., Gasparrini, M., Rosales, I., Lerat, O., Doligez, B., Martín-Chivelet, J., 2014. Geostatistical workflows for modeling the facies-texture-porosity interdependence in a partially dolomitized platform (Lower Cretaceous, Basque-Cantabrian basin, Spain). IFP Énergies Nouvelles, Report 63256, 115pp.

Blumenbach, J.F., 1805. Abbildungen naturhistorischer Gegenstände. Göttingen, Heft 8 (80), H. Dieterich, 1-2.

Bodego, A., Iriarte, E., Agirrezabala, L.M., García-Mondéjar, J., 2015. Synextensional mid-Cretaceous stratigraphic architecture of the eastern Basque-Cantabrian basin margin (western Pyrenees). Cretaceous Research, 55, 229-261.

Bover-Arnal, T., Salas, R., Moreno-Bedmar, J.A., Bitzer, K., 2009. Sequence stratigraphy and architecture of a late Early-Middle Aptian carbonate platform succession from the western Maestrat Basin (Iberian Chain, Spain). Sedimentary Geology, 219, 280-301.

Bover-Arnal, T., Salas, R., Guimerà, J., Moreno-Bedmar, J.A., 2014. Deep incision in an Aptian carbonate sucession indicates major sea-level fall in the Cretaceous. Sedimentology, 61, 1558-1593.

Brönnimann, P., Whittaker, J.F., Zaninetti, L., 1992. Brackish water foraminifera from mangrove sediments of southwestern Viti Levu, Fiji Island, southwest Pacific. Revue de Paléobiologie, 11, 13-65.

Carras, N., Conrad, M.A., Radoičić, R., 2006. *Salpingoporella*, a common genus of Mesozoic Dasycladales (calcareous green algae). Revue de Paléobiologie, 25(2), 457-517.

Castro, J.M., Company, M., De Gea, G.A., Aguado, R., 2001. Biostratigraphy of the Aptian-Middle Cenomanian platform to basin domain in the Prebetic Zone of Alicante, SE Spain: calibration between shallow water benthonic and pelagic scales. Cretaceous Research, 22, 145-156.

Charnock, M.A., Jones, R.W., 1990. Agglutinated foraminifera from the Palaeogene of the North Sea. In: Hemleben, C., Kaminski, M.A., Kuhnt, W., Scott, D.B. (eds.). Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera. NATO ASI Series, Dordrecht, Kluwer Academic Publishers, 139-244.

Charollais, J., Brönnimann, P., 1965. Premiére note sur les foraminifères du Crétacé inférieur de la région genevoise. *Sabaudia* CHAROLLAIS ET BRÖNNIMANN, n. gen. Archives des Sciences, 18(3), 615-624.

Cherchi, A., 1985. Genre *Coskinolinella* DELMAS & DELOFFRE, 1961. In: Schroeder, R., Neumann, M., (coords.). Les Grands Foraminifères du Crétacé Moyen de la région Méditerranénne. Géobios, mémoire special 7, 52-56.

Cherchi, A., Schroeder, R., 1982. Précisions sur *Pseudochoffatella* DELOFFRE et remarques sur *Balkhania balkhanica* MAMONTOVA (Foraminifères). Revue de Micropaléontologie, 25(3), 154-162.

Cherchi, A., Schroeder, R., 2013. The *Praeorbitolina*/*Palorbitolinoides* association: an Aptian biostratigraphic key-interval at the southern margin of the Neo-Tethys. Cretaceous Research, 39, 70-77.

Ciry, R., Rat, P., 1952. Déscription d'un nouveau genre de Foraminifère: *Simplorbitolina manasi* nov. gen., nov. sp. Bulletin Scientifique de Bourgogne, 14, 85-100.

Clavel, B., Conrad, M.A., Busnardo, R., Charollais, J., Granier, B., 2013. Mapping the rise and demise of Urgonian platforms (Late Hauterivian – Early Aptian) in southeastern France and the Swiss Jura. Cretaceous Research, 39, 29-46.

Collignon, M., Pascal, A., Peybernès, B., Rey, J., 1979. Faunes d'Ammonites de l'Aptien de la région de Santander (Espagne). Annales de Paléontologie (Invertébrés), 65(2), 139-156.

Cushman, J.A., Waters, 1927. Arenaceous Paleozoic foraminifera from Texas. Contributions from the Cushman Laboratory for Foraminiferal Research, 3, 146-153.

Delmas, M., Deloffre, R., 1961. Découverte d'un nouveau genre d'Orbitolinidae dans la base de l'Albien en Aquitaine. Revue de Micropaléontologie, 4(3), 167-172.

Deloffre, R., 1961. Sur la découverte d'un nouveau lituolidé du Crétacé inférieur des Basses-Pyrénées: *Pseudochoffatella cuvillieri* n. gen., n. sp. Revue de Micropaléontologie, 4, 105-107.

Douglass, R.C., 1960. The foraminiferal genus *Orbitolina* in North America. Geological Survey Professional Papers, 333, 1-52.

Fernández-Mendiola, P.A., Pérez-Malo, J., García-Mondéjar, J., 2015. Facies analysis and correlation in an Albian carbonate platform (Cuchía quarry, Cantabria, Spain). Geogaceta, 57, 99-102.

Fenerci-Masse, M., Masse, J.-P., Arias, C., Vilas, L., 2006. *Archaeoradiolites*, a new genus from the Upper Aptian of the Mediterranean region and the origin of the rudist family Radiolitidae. Palaeontology, 49(4), 769-794.

Fourcade, E., 1970. Le Jurassique et le Crétacé aux confins des chaînes bétiques et ibériques (Sud-Est de l´Espagne). PhD Thesis. University Pierre and Marie Curie, Paris, 427pp.

Fourcade, E., Raoult, J.F., 1973. Crétacé du Kef Hahouner et position stratigraphique de "*Ovalveolina*" *reicheli* P. De Castro (série septentrionale du mole néritique du Constantinois, Algérie). Revue de Micropaléontologie, 15(4), 227-246.

Galeotti, S., Kaminski, M.A., Coccioni, R., Speijer, R.P., 2004. High-resolution deep-water agglutinated foraminiferal record across the Paleocene/Eocene transition in the Contessa Road Section (Central Italy). In: Bubík, M., Kaminski, M.A. (eds.). Proceedings of the Sixth International Workshop on Agglutinated Foraminifera. Grzybowski Foundation Special Publication, 8, 83-103.

García-Hernández, M., 1981. Biozonation du Crétacé inférieur à l'aide des foraminifères benthiques et des algues Dasycladacées dans le Prébetique occidental (Cordillères Bétiques, Esp.). Géobios, 14, 261-267.

García-Mondéjar, J., 1982. Aptiense y Albiense. El Cretácico de España. Universidad Complutense Madrid, 63-84.

García-Mondéjar, J., Hines, F.M., Pujalte, V., Reading, H.G., 1985. Sedimentation and tectonics in the western Basque-Cantabrian area (northern Spain) during Cretaceous and Tertiary times. In: Milá, M.D., Rosell, J. (eds.). Excursion Guidebook. 6th European Regional Meeting, International Association of Sedimentologists, 308-392.

García-Mondéjar, J., Fernández-Mendiola, P.A., Agirrezabala, L.M., Aranburu, A., López-Horgue, M.A., Iriarte, E., Martínez-Rituerto, S., 2004. El Aptiense-Albiense de la Cuenca Vasco-Cantábrica. In: Vera, J.A. (ed.). Geología de España. Madrid, Sociedad Geológica de España-Instituto Geológico y Minero de España, 291-296.

García-Mondéjar, J., Owen, H.G., Fernández-Mendiola, P.A., 2015. Early Aptian sedimentary record and OAE1a in Cuchía (northern Spain): new data on facies and ammonite dating. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 276(1), 1-26.

Ghigi, A., 1909. New Zealand Ctenophores. Raccolte planctoniche, fatte dalla R. nave Liguria. Ctenofori, 2 (19).

Granier, B., 1987. Le Crétacé inférieur de la Costa Blanca entre Busot et Altea, Alicante (Espagne). Biostratigraphie, Sédimentologie, Evolution tectono-sédimentaire. Thèse, Docteur de l'Université Paris VI (nouveau régime), 23 Novembre 1987; Mémoires des Sciences de la Terre, Université Pierre et Marie Curie, Paris, 87-49, vol. I (texte): 281 pp., 63 fig. ; vol. II-(planches): 54 pl.

Granier, B., Clavel, B., Moullade, M., Busnardo, R., Charollais, J., Tronchetti, G., Desjacques, P., 2013. L'Estellon (Baronnies, France), a "Rosetta Stone" for the Urgonian biostratigraphy. Carnets de Géologie (Notebooks on Geology), Article 2013/04 (CG2013_A04).

Grzybowski, J., 1898. The Foraminifera of the oil-bearing deposits of the Krosno region. Rozprawy Wydziału Matematyczno-Przyrodniczego, Akademia Umiejętności w Krakowie, serya 2, 41, 219-286.

Gušić, I., 1975. Lower Cretaceous imperforate Foraminiferida of Mt. Medvednica, northern Croatia. Palaeontologia Jugoslavica, 14, 1-51.

Gušić, I., 1981. Variation range, evolution, and biostratigraphy of *Palorbitolina lenticularis* (BLUMENBACH) (Foraminiferida, Lituolacea) in the Lower Cretaceous of the Dinaric Mountains in Yugoslavia. Paläontologische Zeitschrift, 55(3-4), 191-208.

Haq, B.U., 2014. Cretaceous eustasy revisited. Global and Planetary Change, 113, 44-58.

Hayward, B., Pignatti, J., 2015. *Glomospirella* PLUMMER, 1945. In: Hayward, B.W., Cedhagen, T., Kaminski, M., Gross, O. (eds.). World Foraminifera Database. Last accessed: January 2016. Website: www.marinespecies.org/foraminifera

Henson, F.R.S., 1948a. New Trochamminidae and Verneuilinidae from the Middle East. Annals and Magazine of Natural History, Series 11, 14 (117), 605-630.

Henson, F.R.S., 1948b. Larger imperforate Foraminifera of south-western Asia. Families Lituolidae, Orbitolinidae and Meandropsinidae. London, Monograph British Museum (Natural History), 127pp.

Hines, F.M., 1985. Sedimentation and tectonics in north-west Santander. In: Milá, M.D., Rosell, J. (eds.). Excursion Guidebook. 6th European Regional Meeting, International Association of Sedimentologists, 371-398.

Hofker, J., 1965. Some foraminifera from the Aptian-Albian passage of northern Spain. Leidse Geologische Mendelingen, 33, 183-189.

Jones, R.W., Wonders, A.A.H., 2000. On *Arenomeandrospira* gen. nov. (Foraminiferida, Ammodiscidae), and its association with Natural Gas Seepage. In: Hart, M.B., Kaminski, M.A., Smart, C.W. (eds.). Proceedings of the Fifth International Workshop on Agglutinated Foraminifera. Gryzbowski Foundation Special Publication, 7, 179-184.

Kaminski, M.A., 2004. The year 2000 classification of the agglutinated foraminifera. In: Bubík, M., Kaminski, M.A. (eds). Proceedings of the Sixth International Workshop on Agglutinated Foraminifera. Grzybowski Foundation Special Publication, 8, 237-255.

Kaminski, M.A., 2014. The year 2010 classification of the agglutinated foraminifera. Micropaleontology, 60 (1), 89-108.

Kaminski, M.A., Gradstein, F.M., 2005. Atlas of Palaeogene cosmopolitan deep-water agglutinated foraminifera. Grzybowski Foundation Special Publication, 10, 1-548.

Kaminski, M.A., Gradstein, F.M., Geroch, S., 1992. Uppermost Jurassic to Lower Cretaceous deep-water benthic foraminiferal assemblages from Site 765 on the Argo abyssal plain. In: Gradstein, F.M., Adamson, A.C., Ludden, J.N., Poag, W (eds.). Proceedings of the Ocean Drilling Program, Scientific Results, 123, 239-269.

Kaminski, M.A., Setoyama, E., Cetean, C.G., 2008. Revised stratigraphic ranges and the Phanerozoic diversity of agglutinated foraminiferal genera. In: Kaminski, M.A., Coccioni, R., (eds). Proceedings of the Seventh International Workshop on Agglutinated Foraminifera. Grzybowski Foundation Special Publication, 13, 79-106.

Koutsoukos, E., 2000. "Flysch-type" foraminiferal assemblages in the Cretaceous of northeastern Brazil. In: Hart, M.B., Kaminski, M.A., Smart, C.W. (eds.). Proccedings of the Fifth International Workshop on Agglutinated Foraminifera. Grzybowski Foundation Special Publication, 7, 243-260.

Kuss, J., Schlagintweit, F., 1988. Facies and stratigraphy of Early to Middle Cretaceous (Late Aptian-Early Cenomanian) strata from the northern rim of the African craton (Gebel Maghara-Sinai, Egypt). Facies, 19, 77-96.

Lankester, E.R., 1885. Protozoa. Encyclopedia Brittanica, 19 (9th Edition), 830-866.

Le Pichon, X., Sibuet, J.C., 1971. Western extension of the boundary between European and Iberian plates during the

Pyrenean orogeny. Earth and Planetary Science Letters, 12, 83-88.

Loeblich, A.R.Jr., Tappan, H., 1985. Some new and redefined genera and families of agglutinated foraminifera I. Journal of Foraminiferal Research, 15, 91-104.

Loeblich, A.R.Jr., Tappan, H., 1987. Foraminiferal genera and their classification, Van Nostrand Reinhold. New York, 2, 970pp, 847pls.

López-Cilla, I., Rosales, I., Najarro, M., 2012. Diagenesis in lower Cretaceous platform carbonates of northern Spain (NW Cantabria): an example of multistage dolomitization and calcite cementation. Geofluids VII International conference, IFP Énergies Nouvelles, Proceedings, 205-208.

Luperto Sinni, E., Masse, J.P., 1992. Biostratigrafia dell'Aptiano in facies di piattaforma carbonatica delle Murge baresi (Puglia – Italia medridionale). Rivista Italiana di Paleontologia e Stratigrafia, 98(4), 403-424.

Malod, J.A., Mauffret, A., 1990. Iberian plate motions during the Mesozoic. Tectonophysics, 184, 261-278.

Marie, P., 1941. Les foraminifères de la Craie à *Belemnitella mucronata* du Bassin de Paris. Mémoires du Museum Nationale d'Histoire Naturelle, 12(1), 1-296.

Martin, K., 1890. Untersuchungen über den Bau von Orbitolina (*Patellina* auct.) von Borneo. Sammlungen des Geologischen Reichs-Museums in Leiden, 1(4), 209-231.

Martín-Martín, J.D., Gomez-Rivas, E., Bover-Arnal, T., Travé, A., Salas, R., Moreno-Bedmar, J.A., Tomás, S., Corbella, M., Teixell, A., Vergés, J., Stafford, S.L., 2013. The Upper Aptian to Lower Albian syn-rift carbonate succession of the southern Maestrat Basin (Spain): Facies architecture and fault-controlled stratabound dolostones. Cretaceous Research, 41, 217-236.

Masse, J.P., 2003. Integrated stratigraphy of the Lower Aptian and applications to carbonate platforms: a state of the art. In: Gili, E., Negra, M.E.H., Skelton. P.W. (eds.). North African Cretaceous Carbonate Platform Systems, Nato Science Series 203-214.

Masse, J.P., Arias, C., Vilas, L., 1992. Stratigraphy and biozonation of a reference Aptian–Albian, p.p. Tethyan carbonate platform succession: The Sierra del Carche series (oriental Prebetic zone – Murcia, Spain). In: Kollmann, H.A., Zapfe, H. (eds.). New aspects on Tethyan Cretaceous fossil assemblages. Schriftenreihe der Erdwissenschaftlichen Kommissionen der Österreichischen Akademie der Wissenschaften, 9, 201-221.

Mengaud, L., 1920. Recherches géologiques dans la région Cantabrique. Bulletin de la Société d'Histoire naturelle de Toulouse, 48, 73-272.

Mikhalevich, V., 1980. Systematics and evolution of foraminifera in the light of new data on their cytology and ultrastructure. Trudy Zoologicheskogo Instituta, Akademiya Nauk SSSR., 94, 42-61.

Millán, M.I., Weissert, H.J., López-Horgue, M.A., 2014. Expression of the late Aptian cold snaps and the OAE1b in a highly subsiding carbonate platform (Aralar, northern Spain). Palaeogeography, Palaeoclimatology, Palaeoecology, 411, 167-179.

Mohler, W., 1938. Mikropaläontologische Untersuchungen in der nordschweizerischen Juraformation. Abhandlungen der Schweizerischen Paläontologischen Gesellschaft, 60, 1-53.

Moreno-Bedmar, J.A., Grauges, A., Matínez, R., Barragán-Manzo, R., 2011. Revisión sistemática de las amonitas del Aptiano Tardío de Reocín (Cuenca Vasco-Cantábrica; Norte de España) de la colección Mengaud (Univ. Paul Sabatier, Toulouse). Mexico, XII Congreso Nacional de Paleontología, Puebla de los Ángeles, Abstract, 99.

Moreno-Bedmar, J.A., Bover-Arnal, T., Barragán, R., Salas, R., 2012. Uppermost Lower Aptian transgressive records in Mexico and Spain: chronostratigraphic implications for the Tethyan sequences. Terra Nova, 24, 333-338.

Moullade, M., Peybernès, B., 1975. Biozonation par Orbitolinidés du Clansayesien et de l´Albien calcaires des Pyrénées franco-espagnoles. Comptes Rendus de l'Académie des Sciences, D, 280, 2529-2532.

Moullade, M., Peybernès, B., 1978. Un nouvel Orbitolinidé du Gargasien Supérieur (Aptien Supérieur) des Pyrénées, *Orbitolinopsis reticulata* n. sp. Géobios, 11(4), 493-503.

Moullade, M., Peybernès, B., 1979. Révision d'"*Orbitolinopsis*" *aquitanica* SCHROEDER, 1964, Orbitolinidé du Gargasien (= Aptien Supérieur) Pyrénéen. Archives des Sciences, 32(3), 261-166.

Moullade, M., Peybernès, B., Rey, J., Saint-Marc, P., 1985. Biostratigraphic interest and paleobiogeographic distribution of early and mid-Cretaceous Mesogean orbitolinids (Foraminiferida). Journal of Foraminiferal Research, 15(3), 149-158.

Moullade, M., Tronchetti, G., Bellier, J.B., 2008. Associations et biostratigraphie des Foraminifères benthiques et planctoniques du Bédoulien sommitale et du Gargasien inférieur de La Tuilière – St-Saturnin-lès-Apt (aire stratotypique de l'Aptien, Vaucluse, SE France). Carnets de Géologie-Notebooks on Geology, Article 2008/01, CG2008_A01.

Moullade, M., Granier, B., Tronchetti, G., 2011. The Aptian stage: back to fundamentals. Episodes, 34(3), 148-156.

Najarro, M., 2015. Las plataformas carbonatadas y sistemas deltaicos del Aptiense-Albiense inferior del noroeste de Cantabria: registro de cambios paleoambientales y eventos anóxicos. PhD Thesis. Madrid, Universidad Complutense de Madrid, 450pp.

Najarro, M., Rosales, I., Martín-Chivelet, J., 2007. Evolución de la plataforma carbonatada de la Florida durante el rifting del Cretácico Inferior (Aptiense, NO de Cantabria). In: Bermúdez, D.D., Najarro, M., Quesada, C. (eds.). Volumen Monográfico de la II Semana de Jóvenes Investigadores del Instituto Geológico y Minero de España. Publicaciones del Instituto Geológico y Minero de España, 123-128.

Najarro, M., Rosales, I., Moreno-Bedmar, J.A., de Gea, G.A., Barrón, E., Company, E., Delanoy, G., 2011. High-resolution chemo- and biostratigraphic records of the Early Aptian oceanic anoxic event in Cantabria (N Spain): Palaeoceanographic and palaeoclimatic implications.

Palaeogeography, Palaeoclimatology, Palaeoecology, 299, 137-158.

Neagu, T., 1979. Données nouvelles concernant les répresentants de la famille des Pfenderinidae de l'Eocrétacé de la Dobrogea Méridionale (Roumanie). Revista Española de Micropaleontología, 11, 479-504.

Neagu, T., Cîrnaru, P., 2004. Genus *Choffatella* (SCHLUMBERGER), 1904 (Foraminifera) in the lower Aptian (Bedoulian) from Southern Dobrogea and SE part of the Romanian plain. Acta Palaeontologica Romaniae, 4, 269-275.

Neumann, M., 1965. Contribution á l'étude de quelques Lituolidés du Cénomanien de l'île Madame (Charente-Maritime). Revue de Micropaléontologie, 8(2), 90-95.

Orbigny, A., d', 1826. Tableau méthodique de la classe des Céphalopodes. Annales des Sciences Naturelles, 7, 245-314.

Orbigny, A., d', 1839. Foraminifères. In: de la Sagra, R. (ed.). Histoire physique, politique et naturelle de l'île de Cuba. Paris, Arthus Bertrand, 1-224.

Özdikmen, H., 2009. Substitute names for some unicellular animal taxa (Protozoa). Munis Entomology & Zoology, 4(1), 233-256.

Pascal, A., 1985. Les Systems biosédimentaires urgoniens (Aptien–Albien) sur la marge Nord Ibérique. Mémoires Géologiques de l'Université de Dijon, 10, 1-569.

Pawlowski, J., Holzmann, M., Tyszka, J., 2013. New supraordinal classification of Foraminifera: Molecules meet morphology. Marine Micropaleontology, 100, 1-10.

Peybernès, B., 1976. Le Jurassique et le Crétacé inférieur des Pyrénées franco-espagnoles entre la Garonne et la Méditerranée. PhD Thesis. University Paul Sabatier, Toulouse, 459pp.

Plummer, H.L., 1945. Smaller foraminifera in the Marble Falls, Smithwick, and lower Strawn strata around the Llano uplift in Texas. Bulletin University of Texas, Bureau of Economic Geology and Technology, 4401, 209-271.

Portero-García, J.M., Ramírez del Pozo, J., Olivé-Davó, A., Martín-Alafont, J.M., 1976. Mapa Geológico de España a escala 1:50.000, Hoja nº 33, Comillas, Serie Magna. Instituto Geológico y Minero de España.

Ramírez del Pozo, J., 1971. Bioestratigrafía y microfacies del Jurásico y Cretácico del Norte de España (región cantábrica). Memoria del Instituto Geológico y Minero de España, 78, 1-357.

Ramírez del Pozo, J., 1972. Algunos datos sobre la Estratigrafía y Micropaleontología del Aptense y Albense al oeste de Santander. Revista Española de Micropaleontología, num. Extraord, 30, 59-97.

Ramírez del Pozo, J., Portero-García, J.M., Olivé-Davó, A., Martín-Alafont, J.M., Aguilar-Tomás, M.J, 1974. Mapa Geológico de España a escala 1:50.000, Hoja nº 35, Santander. Serie Magna. Instituto Geológico y Minero de España.

Rat, P., 1959. Les pays crétacés basco-cantabriques (Espagne). Publications de l'Université de Dijon, 18, 1-525.

Reboulet, S., Szives, O., Aguirre-Urreta, B., Barragán, R., Company, M., Idakieva, V., Ivanov, M., Kakabadze, M.V., Moreno-Bedmar, J.A., Sandoval, J., Baraboshkin, E.J., Çaglar, M.K., Főzy, .I, González-Arreola, C., Kenjo, S., Lukeneder, A., Raisossadat, S.N., Rawson, P.F., Tavera, J.M., 2014. Report on the 5th International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the Kilian Group (Ankara, Turkey, 31st August 2013). Cretaceous Research, 50, 126-137.

Reitner, J., 1987. Mikrofazielle, palökologische und paläogeographische Analyse ausgewählter Vorkommen flachmariner Karbonate im Basko-Kantabrischen Strike Slip Fault-Becken-System (Nordspanien) an der Wende von der Unterkreide zur Oberkreide. Documenta naturae, 40, 1-239.

Reuss, A.E., 1862. Entwurf einer systematischen Zusammenstellung der Foraminiferen. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Classe (1861), 44(1), 355-396.

Rigaud, S., Blau, J., Martini, R., Rettori, R., 2015. Taxonomy, phylogeny, and functional morphology of the foraminiferal genus *Involutina*. Acta Palaeontologica Polonica, 60(1), 235-244.

Roemer, F., 1849. Texas: mit besonderer Rücksicht auf deutsche Auswanderung. Adolph Marcus: Bonn. 379pp.

Rosales, I., Schlagintweit, F., 2015. The uppermost Albian–lower Cenomanian Bielba Formation of the type-area (Cantabria, northern Spain): facies, biostratigraphy, and benthic Foraminifera. Facies, 61(3), 16, 30pp. DOI: 10.1007/s10347-015-0441-9

Rosales, I., Barrón, E., de Gea, G.A., Najarro, M., Castro, J.M., 2013. Nuevas aportaciones al conocimiento bioestratigráfico del Aptiense–Albiense del entorno de El Soplao. In: Rosales, I. (ed.). Avances en la investigación geológica de la Cueva El Soplao y su entorno. Publicaciones del Instituto Geológico y Minero de España, Serie Informes Técnicos, 7, 53-66.

Sahni, M.R., 1937. Discovery of Orbitolina-bearing rocks in Burma, with a description of *Orbitolina birmanica* sp. nov. Records of the Geological Survey of India, 71(4), 360-375.

Saidova, Kh.M, 1981. On an up-to-date system of supraspecific taxonomy of Cenozoic benthonic foraminifera (in Russian). Institut Okeanoligi P.P. Shirshova, Moscow, Akademija Nauk SSSR, 73pp.

Schlagintweit, F., Piller, W., 1990. *Involutina hungarica* (SIDO) from allochtonous Urgonian limestones of the Northern Calcareous Alps and remarks on the genus *Hensonina* Moullade and Peybernès, 1974. Beiträge zur Paläontologie, 16, 145-153.

Schlagintweit, F., Wilmsen, M., 2014. Orbitolinid biostratigraphy of the top Taft Formation (Lower Cretaceous of the Yazd Block, Central Iran). Cretaceous Research. 49, 125-133.

Schlagintweit, F., Bucur, I.I., Rashidi, K., Saberzadeh, B., 2013. *Praeorbitolina claveli* n. sp. (benthic foraminifera) from the Lower Aptian (Bedoulian) of Central Iran. Carnets de Géologie-Notebooks on Geology, Letter 2013/04, 255-272.

Schroeder, R., 1962. Orbitolinen des Cenomans Südwesteuropas. Paläontologische Zeitschrift, 36(3-4), 171-202.

Schroeder, R., 1963a. *Palorbitolina*, ein neues Subgenus der Gattung Orbitolina (FORAM.). Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 117, 346-359.

Schroeder, R., 1963b. Grundlagen einer Orbitoliniden-Biostratigraphie des tieferen Urgons im pyrenäisch-kantabrischen Grenzgebiet (Nordspanien). Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 3, 320-326.

Schroeder, R., 1964a. Communication préalable sur l'origine des Orbitolines. Compte Rendu sommaire des séances de la Société géologique de France, 10, 411-413.

Schroeder, R., 1964b. Orbitoliniden-Biostratigraphie des Urgons nordöstlich von Teruel (Spanien). Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 1964, 462-472.

Schroeder, R., 1965a. *Dictyoconus pachymarginalis* n. sp. aus dem Apt des Elburz-Gebirges (Nord-Iran) (Studien über primitive Orbitolinidae III). Eclogae Geologicae Helvetiae, 58(2), 976-979.

Schroeder, R., 1965b. *Neorbitolinopsis* n. gen. und ihre systematische Position innerhalb der Orbitoliniden. Eclogae Geologicae Helvetiae, 58(1), 579-589.

Schroeder, R., 1972. Zwei neue Orbitolinidae (Foram.) der spanischen Kreide. Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 2, 108-119.

Schroeder, R., 1985. Genre *Simplorbitolina* Ciry & Rat, 1953. In: Schroeder, R., Neumann, M., (coords.). Les Grands Foraminifères du Crétacé Moyen de la région Méditerranénne. Géobios mémoire special, 7, 46-50.

Schroeder, R., Poignant, A.F., 1964. *Orbitolinopsis aquitanica*, eine neue Foraminifere der Unterkreide der Aquitaine (SW-Frankreich) (Studien über primitive Orbitolinidae I). Eclogae Geologicae Helvetiae, 57(2), 553-558.

Schroeder, R., Neumann, M. (coords.), 1985. Les grands Foraminifères du Crétacé Moyen de la région Méditerranénne. Geobios, Mémoire Spécial, 7, 1-160.

Schroeder, R., Conrad, M.A., Charollais, J., 1968. Sixième note sur les Foraminifères du Crétacé inférieur de la region genevoise. Contribution à l'etude des Orbitolinidae: *Valserina brönnimanni* SCHOEDER & CONRAD, n. gen., n. sp.; *Paleodictyoconus barremianus* (MOULLADE) et *Paleodictyoconus cuvillieri* (FOURY). Archives des Sciences, 20(2), 199-222.

Schroeder, R., Van Buchem, F.S.P., Cherchi, A., Baghbani, D., Vincent, B., Immenhauser, A., Granier, B., 2010. Revised orbitolinid biostratigraphic zonation for the Barremian–Aptian of the eastern Arabian Plate and implications for regional stratigraphic correlations. GeoArabia Special Publication, 4, 49-96.

Setoyama, E., Kaminski, M.A., Tyszka, J., 2011. Late Cretaceous agglutinated foraminifera and implications for the biostratigraphy and palaeobiogeography of the southwestern Barents Sea. In: Kaminski, M.A., Filipescu, S. (eds). Proceedings of the Eight International Workshop on Agglutinated Foraminifera. Grzybowski Foundation Special Publication, 16, 251-309.

Smout, A.H., Sudgen, W., 1962. New information on the foraminiferal genus *Pfenderina*. Palaeontology, 4, 581-591.

Ullastre, J., Schroeder, R., Masriera, A., 2002. Sobre la estratigrafía del singular corte de la Roca de Narieda (parte S de la serie del Cretácico inferior de Organyà). Pirineo catalán. España. Treballs del Museu de Geologia de Barcelona, 11, 67-95.

Wilmsen, M., 2000. Evolution and demise of a Mid-Cretaceous carbonate shelf: the Altamira Limestones (Cenomanian) of northern Cantabria (Spain). Sedimentary Geology, 133, 195-226.

Wilmsen, M., 2005. Stratigraphy and biofacies of the Lower Aptian of Cuchía (Cantabria, northern Spain). Journal of Iberian Geology, 31(2), 253-275.

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ELECTRONIC APPENDIX I

TABLE I. Geographic coordinates and stratigraphy of the studied sections

Name of the stratigraphic section	Geographic coordinates	Previous studies/ descriptions	Stratigraphic succession	Sample ID	Remarks
1: Río Nansa section	Top: 43º 18' 35.89" N; 4º 28' 11.76" W Base: 43º 18' 09.94" N, 4º 27' 46.01" W	Ramírez del Pozo, 1972. Najarro *et al.*, 2011a Rosales, 2013.	Rábago Fm.: ca. 16m Patrocinio Fm.: ca. 30m Reocín Fm.: ca. 70m Las Peñosas Fm.: ca. 60m Barcenaciones Fm.: ca. 55m	PN	The Rábago Fm. overlays unconformably Triassic (Bunt) siliciclastics. Absence of the Umbrera, San Esteban and Rodezas fms.
2: El Soplao section	Top: 43º 18' 05.54" N; 4º 25' 10.57" W Base: 43º 17' 44.31" N; 4º 24' 31.28" W	Najarro, 2015. Rosales *et al.*, 2013	Rábago Fm.: ca. 8m Umbrera Fm.: ca. 6m Patrocinio Fm.: ca. 27m San Esteban Fm.: ca. 15m Reocín Fm.: ca. 100m Las Peñosas Fm.: ca. 60m (top covered)	SOP	Absence of the Rodezas Fm. The first 35m of the Reocín Fm. are pervasively dolomitized.
3: Novales section	Top: 43º 22' 33.74" N; 4º 09' 46.94" W Base: 43º 22' 58.25" N; 4º 10' 13.14" W	Najarro, 2015.	Reocín Fm.: ca. 230m Las Peñosas Fm.: ca. 70m (lower part, top covered)	No and NO	The first 160m of the Reocín Fm. are dolomitized.
4: Cantera de Las Lastrías section	Top: 43º 20' 16.02" N; 4º 09' 05.23" W Base: 43º 20' 11.41" N; 4º 09' 15.35" W	Najarro, 2015.	Reocín Fm.: ca. 130m Las Peñosas Fm.: ca. 5m (lower part)	CL	
5: Cantera de Cuchía section	Top: 43º 25' 42.23" N; 4º 01' 03.74" W Base: 43º 25' 55.94" N; 4º 00' 55.68" W	Collignon *et al.*, 1979. Najarro, 2015. Fernández-Mendiola *et al.*, 2015.	Reocín Fm.: ca. 80m (base covered). Barcenaciones Fm.: 26m	CCU	Absence of the Las Peñosas Fm.

TABLE I. Continued.

Name of the stratigraphic section	Geographic Coordinates	Previous studies/ descriptions	Stratigraphic succession	Sample ID	Remarks
6: Cuchía coast section	Top: 43º 26' 10.52" N; 4º 01' 47.38" W Base: 43º 26' 42.00" N; 4º 01' 19.20" W	Mengaud, 1920. Collignon *et al.,* 1979. Wilmsen, 2005. Najarro, 2015. García-Mondéjar *et al.*, 2015.	Umbrera Fm.: ca. 22m Patrocinio Fm.: ca. 80m San Esteban Fm.:. ca. 26m Rodezas Fm.: ca. 1.5m (top disrupted by fault) Reocín Fm.: ca. 11m Barcenaciones Fm.: ca. 18m	CU and PH	Very reduced Rodezas and Reocín fms., and absence of the Rábago and Las Peñosas fms.
7: Santa Eulalia section	Top: 43º 20' 52.94" N; 4º 11' 47.03" W Base: 43º 20' 14.70" N; 4º 12' 03.69" W	Najarro, 2015. Blázque-Fernández, 2013.	Rodezas Fm.: ca. 76m Reocín Fm.: ca. 211m	SE2	The middle part of the Reocín Fm. exhibits pervasive dolomitization.
8: Ruilobuca section	Top: 43º 22' 37.49" N; 4º 15' 12.75" W Base: 43º 22' 08.63" N; 4º 15' 47.16" W	Najarro, 2015.	San Esteban Fm.: ca. 55m Rodezas Fm.: ca. 105m Reocín Fm.: ca. 20m (base only).	Ru	The top of this section correlates with the base of the Novales section.
9: Rábago section	Top: 43º 18' 21.22" N; 4º 26' 02.95" W Base: 43º 18' 03.32" N; 4º 26' 12.30" W	Najarro *et al.,* 2011b. Najarro, 2015.	Rábago Fm.: ca. 16m Patrocinio Fm.: ca. 33m Reocín Fm.: ca. 78m Las Peñosas Fm.: ca. 70m Barcenaciones Fm.: ca. 40m	LA	Absence of the Umbrera, San Esteban and Rodezas formations.
10: Bustriguado section	Top: 43º 18' 19.83" N; 4º 21' 18.80" W Base: 43º 17' 55.34" N; 4º 21' 01.42" W	Najarro, 2015.	Rábago Fm.: ca. 36m Umbrera Fm.: ca. 16m Patrocinio Fm.: ca. 30m San Esteban Fm.: ca. 38m Reocín Fm.: ca. 267m Las Peñosas Fm.: ca. 125m Barcenaciones Fm.: ca. 70m	Bu	Absence of the Rodezas Fm. The first 150 m of the Reocín Fm. exhibits pervasive dolomitization.

TABLE I. Continued.

Name of the stratigraphic section	Geographic Coordinates	Previous studies/ descriptions	Stratigraphic succession	Sample ID	Remarks
11: San Vicente de la Barquera section	Top: 43º 23' 42.03" N; 4º 23' 47.35" W Base: 43º 23' 42.05" N; 4º 25' 50.42" W	Najarro, 2015.	Reocín Fm.: ca. 152m Las Peñosas Fm.: ca. 80m (top covered)	SV	The Reocín Fm. overlays unconformably Carboniferous limestones, with absence of the Rábago, Umbrera, San Esteban and Rodezas formations.
12: Suances section	Top: 43º 26' 35.33" N; 4º 02' 43.76" W Base: 43º 26' 39.72" N; 4º 02' 45.17" W	Rat, 1959. Najarro, 2015.	San Esteban Fm.: ca. 17m (base covered) Rodezas Fm.: ca. 4–6m Reocín Fm.: 8m Barcenaciones Fm.: ca. 12m.	SU	Stratigraphy similar to the Cuchía coast section. Absence of the Las Peñosas Fm.