CALCAREOUS ALGAE (DASYCLADALES, UDOTEACEAE) FROM THE CENOMANIAN ALTAMIRA FORMATION OF NORTHERN CANTABRIA, SPAIN

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Abstract An assemblage of calcareous algae (Dasycladales, Udoteaceae) is described from the upper Lower to Middle Cenomanian Altamira Formation of the North Cantabrian Basin, northern Spain. The algae occur in bioclastic for-algal grain-/packstones and near-reefal rudstones of an external carbonate platform facies. An equivalent assemblage is known from the late Albian of the Pyrenees and the Basco-Cantabrian Chains. One new species is introduced as Boueina iberica n. sp.

Keywords: Calcareous Algae, Dasycladales, Udoteaceae, Boueina, Systematics, Cenomanian

INTRODUCTION

Mid-Cretaceous (Albian–Cenomanian) sediments are widespread and superbly exposed in coastal sections of the North Cantabrian Basin in northern Spain (Wiedmann et al., 1983; Reitner, 1987; Wilmsen, 1996, 1997, 2000). Shallow water carbonates with larger benthic foraminifera (orbitolinids) and calcareous algae are well represented by the Lower–Middle Cenomanian Altamira Formation of Cantabria, representing the deposits of the shelf-attached Altamira Platform. In the present contribution, the inventory of calcareous green algae coming from three coastal sections of the Altamira Formation is presented.

GEOLOGICAL SETTING

The study area is located in the northern part of the Spanish province of Cantabria, along the coast of the Bay of Biscay (Fig. 1). Due to opening of the Biscay Ocean in Cretaceous times (e.g., Olivet, 1996), numerous sedimentary (intra-shelf) basins developed in the North Iberian passive margin, often in halfgraben settings due to the tilting of fault blocks. The North Cantabrian Basin (NCB, Wiese & Wilmsen, 1999) represents one of these extensional basins, which developed as an independent tectono-sedimentary unit in the mid–Valanginian (Wilmsen, 1997, 2000, 2005). During the mid-Cretaceous (Aptian–Cenomanian), the NCB was an E–W elongated, gulf-like embayment opening to the strongly subsiding Basque Basin/Navarro-Cantabrian Ramp in the east, and the basin progressively shallowed to the west. Wet (sub-)tropical climatic conditions in a palaeo-latitude of about 30°N prevailed (Rat, 1989; Philip & Floquet, 2000), and the mid-Cretaceous (Aptian–Turonian) depositional history of the NCB has been discussed in considerable detail by Wilmsen et al. (1996), Wiese (1995, 1997), Wilmsen (1997, 2000, 2005), Wiese and Wilmsen (1999) and Najarro et al. (2011).

The studied thin-sections have been prepared from rock specimens sampled from the Cenomanian Altamira Formation (Fig. 2). Previous studies of this unit concentrated on isolated sections or on special features such as hardgrounds or patch reefs (Reitner, 1987, 1989; Reitner, et al., 1995; Wilmsen, 1996). The first detailed study based on numerous measured sections resulted in a regional integrated stratigraphic framework of the

Fig. 1 Locality map of the study area with indication of the Liencres (Playa de Somocuevas), Cobreces–Toñanes and La Rabia sections (modified from Wiese, 1997).

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complete Cenomanian succession (Wilmsen, 1997).

The well-known Cenomanian transgression was subdivided by Wilmsen (2000) into an earlier constructive phase and a later destructive phase, separated by a significant low sea-level stand in the Early to Middle Cenomanian boundary interval. In a first step, the Cenomanian sea inundated a deltaic system of latest Albian to earliest Cenomanian age (Bielba Formation, lower member; see Fig. 2).

This flooding of the north Iberian continental margin in the earliest Early Cenomanian promoted the establishment of a carbonate ramp (Bielba Formation, upper member), evolving into a shelf-attached platform (lower Altamira Formation) during the remaining part of the Early Cenomanian. A major sea-level fall at the Early/Mid-Cenomanian boundary exposed the Altamira Platform and ended the constructive phase. During the Middle to early Late Cenomanian destructive phase, the platform drowned, first in the eastern part of the NCB, later in the west (Wilmsen, 2000). An associated Fe-rich, diachronous (Middle to early Late Cenomanian), condensed discontinuity surface known as “Nivel ferruginizado” or “Hardground 99” caps the Altamira Formation, forming the drowning unconformity of a stepwise platform drowning event (Wilmsen, 2000: fig. 3).

The algae-bearing samples studied are from the following sections (Fig. 1):

a) The Liencres section, ca. 10 km west of Santander (standard succession).
Base of the section: 43° 28' 11.58'' N, 3° 56' 39.79'' W
Top of the section: 43° 28' 10.68'' N, 3° 56' 11.85'' W
The Liencres section represents the standard for the Cenomanian in the North Cantabrian Basin (Wilmsen et al., 1996). The ca. 205-m-thick succession is exposed at the coast of the Bay of Biscay, north of Liencres, in the eastern part of Playa de Somocuevas. It comprises the uppermost Albian to lowermost Cenomanian Bielba Formation (ca. 130 m) and the ca. 75 m thick Altamira Formation (Lower to lower Middle Cenomanian; see also Wilmsen, 1997: pp. 37–51, figs 18, 20). The algal-bearing samples (samples S 133, S 135, S 176, S 178 and S 180) are from the upper part of the formation. One additional sample (AM 2), likewise from the upper part of the formation, is from a nearby section east of Playa de Las Dunas, ca. 1 km to the southwest of Playa de Somocuevas (43° 27' 46.69'' N, 3° 57' 0.07'' W).

b) The Cobreces-Toñanes section.
Base of the section: 43° 23' 54.69'' N, 4° 11' 53.98'' W
Top of the section: 43° 23' 26.34'' N, 4° 19' 03.46'' W
This 330-m-thick section is exposed along the coast between the villages of Cobreces and Toñanes. At this location, the Bielba Formation has a thickness of 195 m and the Altamira Formation of 135 m. The succession that has been described in detail by Wilmsen (1997, pp. 88–97, detailed log in fig. 46) includes a patch reef complex (Wilmsen 1996). Samples Co 33, 35, 37 and 41 and the Altamira Formation of 135 m thick, followed by the Altamira Formation (ca. 140 m). A comprehensive description and detailed log has been published by Wilmsen (1997: pp. 97–105, fig. 49). Samples LR 110, LR 149, LR 170, LR 198, LR 202, LR -5 and LR 2 have been taken from the interval between 185 m (LR 110, lowermost sample) and 297 m (sample LR 2), corresponding to the Lower (LR 110, 149) and Middle Cenomanian, respectively.

c) The La Rabia section, ca. 2 km west of Comillas.
Base of the section: 43° 23' 30.51'' N, 4° 18' 41.15'' W
Top of the section: 43° 23' 26.34'' N, 4° 19' 03.46'' W
The ca. 300-m-thick La Rabia section is exposed along the coast east of the mouth of the small river Rio Turbio. The section commences above the Upper Albian Carapina Limestones with the Bielba Formation (ca. 160 m thick), followed by the Altamira Formation (ca. 140 m). A comprehensive description and detailed log has been published by Wilmsen (1997: pp. 97–105, fig. 49).

Samples LR 110, LR 149, LR 170, LR 198, LR 202, LR -5 and LR 2 have been taken from the interval between 185 m (LR 110, lowermost sample) and 297 m (sample LR 2), corresponding to the Lower (LR 110, 149) and Middle Cenomanian, respectively.

**Fig. 2** Lithostratigraphy of the uppermost Albian and Cenomanian in the study area (after Wilmsen, 1997).

**MICROFACIES, MICROPALAEONTOLOGY, STRATIGRAPHY**

The samples mostly comprise bioclastic grain- to packstones with foraminifers, echinoderm fragments and fine-grained debris of corals and sponges (Fig. 3a). Apart from a diverse assemblage of trocholids, benthic foraminifers include subordinate miliolids (e.g. *Meandrospira* *washitensis*, *Loeblichia* & Tappan, *Epistomina* *sp.*, *Gavelinella* *sp.*, *Lenticulina* *sp.*, *Dictyopsella* *cf.* *libanica* Saint-Marc), small neozooxanthellates, *Phenanophragma* cf. *assurgen* *Applin*, *Loeblichia* & Tappan, *Altamirella* *biscayana* Schlagintweit, Rigaud & Wilmsen and orbitolinds such as *Orbitolina* *concava* (Lamarck), *Conicorbitolina* *corbarica* (Schroeder), and *Conicorbitolina* *conica* (d’Archiac). Planktonic foraminifera are represented by the finely pustulose tests of *Favusella* *washitensis* (Carsey) and more rarely specimens of *Rotalipora*. The observed calcareous algae are clearly dominated by dasycladaleans (*Dissocladella*, *Trinocladius*, *Neomeris*) and halimedeaceans, and very rare
Calcareous algae (Dasycladales, Udoteaceae) from the Cenomanian Altamira Formation of northern Cantabria, Spain.

Rhodophycean algae only include some fragments of solenoporaceans and Marinella lugeoni Pfender. Another microfacies type is represented by wacke- to packstones, with reddish matrix and iron-stained oncoidal crusts enveloping the bioclasts (Fig. 3b-c). The microfauna is dominated by an assemblage of orbitolinids and large-sized trocholinids, the microflora by Trinocladus tripolitanus Raineri and debris of Halimeda. It cooresponds to the middle Cenomanian “arenite-oncoid facies” described by Reitner (1987, e.g., pl. 44, fig. 8) from the Basco–Cantrabrian Basin, comprising also the area of Tonanes (locality b, see above) (Figs. 3b–c). This microfacies is furthermore characterized by excellent preservation of microstructural details of primary aragonitic foraminifera (trocholinids, epistominids) and some algae (Fig. 4). Some of the algae-bearing samples can be classified as near-reefal rudstones with large metazoan bioclasts [corals, sponges, e.g., Spirastrella (Acanthochaetetes) sp.] (Fig. 3d). A characteristic floral element of these rudstones (that is lacking in the grainstones) is Frederica aff. conicoconvexa Dieni, Massari & Radoičić. We also observed the encrusting arcurvulinid Menaella.

Fig. 3 Microfacies of the Cenomanian algal-bearing carbonates (Altamira Formation) of Cantabria, Spain. a Packstone with benthic foraminifera, e.g., Lenticulina sp. (L), trocholinids (t), and calcareous algae Dissocladella? n. sp. 1 Conrad & Peybernès (D). b-c Wackestone with trocholinids, orbitolinids [Conicorbitolina (C) in c], Trinocladus tripolitanus Raineri (T), Neomeris cf. mokragorensis Radoičić & Schlagintweit (N). Note the oblique section of Coscinococcus indet. showing the complex canal system (arrow). d Reefal rudstone with Spirastrella (Acanthochaetetes) sp. and some trocholinids (circles). Thin-sections: S 180 (a), Co 35 (b), Co 41 (c), AM 2 (d). Scale bars 1.0 mm.

Fig. 4 Examples of preservation of primary aragonitic microfossils (benthic foraminifera and algae). a-b Coscinococcus sp. and Epistomina sp. showing lamellar microstructure. c Halimeda sp. 1. Thin-sections: Co 41 (a-b), LR 110 (e). Scale bars 0.2 mm.
bustamantei described by Cherchi and Schroeder (2005) from the uppermost Albian of the Caniego Limestone of northern Spain. The bioclastic grain-packstones and the rudstones are laterally associated as evidenced by the more or less equivalent micropaleontological associations of algae and foraminifera and interfingering in the field. The orbitolinids indicate early and mid-Cenomanian ages (e.g., Schroeder & Neumann, 1985). It is worth to mention that the above listed foraminifera do not occur all together but represent the observed spectrum in this interval.

SYSTEMATICS

The thin-sections studied are housed in the Palaeozoological collection of the Senckenberg Naturhistorische Sammlungen Dresden (repository SpK). The samples from Liencres (Playa des Somocuevas) are abbreviated with S, from La Rabia with LR, from Cobreces with Co, from Cabo Toñanes with CT, and those from Las Dunas with AM. The calcareous algae listed below are described and the semi-quantitative abundances in the studied thin-sections (X = rare, XX = common, XXX = abundant) are indicated just for general orientation.

Dasycladales

Dissocladella? n. sp. Conrad & Peybernès, 1982 (XXX)
Dissocladella bonardii Radoičić, Conrad & Carras, 2005 (XX)
Dissocladella? sp. (X)
Neomeris cf. mokragorensis Radoičić & Schlagintweit, 2007 (X)
Trinocladas tripolitanus Raineri, 1922 (XXX)
Frederica aff. coniconvexa Dieni, Massari & Radoičić, 1985 (X)
Terquemella sp. (X)

Udoteaceae

Boeinea hochstetteri Toula (X)
Boeinea iberica n. sp. (XX)
Halimeda sp. 1 (X)
Halimeda sp. 2 (X)

Order Dasycladales Pascher, 1931

Family Dasycladaceae Kützing, 1843

Genus Dissocladella Pia, 1936

Dissocladella? n. sp. 1 Conrad & Pybernès, 1982

Figs. 3a (pars), 5
1982 ?Dissocladella nov. sp. 1 - Conrad & Pybernès, p. 778, pl. 1, figs. 5-10.
1987 Dissocladella n. sp. - Reitner, pl. 21, fig. 4, pl. 27, figs. 1–3, pl. 36, fig. 5 (Dissocladella sp.).

Description: Rather frequent, discoidal to elliptical sections (most values between 0.4 and 0.65 mm) can be observed displaying a large and mostly round, central pore with diameters from 0.07 to 0.15 mm (Fig. 5b-h). Rather commonly, the median plane is crossed by a central canal (diameter ~0.02 to ~0.04 mm). From both, the central pore and the canal, regularly spaced branching pores arise (e.g., Fig. 5c). Another type of sections, interpreted as longitudinal sections, is represented by cylindrical, bended morphologies of various lengths depending on state of fragmentation (e.g., Fig. 5i versus 5j). The greatest observed length is about 4.4 mm provided by a specimen illustrated by Reitner (1987, pl. 27, fig. 1), re-illustrated here in Fig. 5a. This specimen shows a swollen part which roughly doubles the thickness of the non-swollen portion. Oblique sections through such swollen parts may result in the elliptical forms described above (Figs. 5b-h). In some parts of the non-swollen portion (diameter: 0.15-0.3 mm), a central canal occurs discontinuously from which regularly arranged (vertical spacing h: 0.065-0.08 mm) branching pores arise from both sides. In tangential sections, a row of pores arranged in line each with four thin diverging pores, can be observed (Figs. 5i-1).

Remarks: Already Conrad & Peybernès (1982) remarked that the thickened parts represent a uncommon feature in dasycladalean algae that in consequence prevented them from formally introducing a new species. In fact, these unusual sections are so frequent that they cannot be considered as “aberrant” specimens but represent the “normal” thallus morphology that cannot be accommodated in the spectrum of standard morphotypes (e.g., Bassoulet et al., 1975, fig. 1; De Castro, 1997). From the longitudinal section of Reitner (1987) it can be deduced that the thallus of Dissocladella? n. sp. 1 was not straight cylindrical but irregularly bended. In sections, this obviously leads to a shift from parts cutting the central canal and parts transecting only the calcareous skeleton. The swollen, thickened parts might belong to parts where the thallus displays both a more pronounced bending and swelling. The swelling obviously went along with a widening of the main axis in this part. Conrad & Peybernès (1982) interpreted the large central pore of the ellipsoidal sections (Figs. 5b-h) as representing fertile organs. It is here interpreted as thickened part of the main axis.

Dissocladella bonardii Radoičić, Conrad & Carras, 2005

Figs. 6a-i

*2005 Dissocladella bonardii n. sp. - Radoičić et al., p. 313–316, pl. 1, figs. 4-17 (with synonymy).
2010 Dissocladella sp. - Bucur et al., p. 32, pl. 2, fig. 4.

Description: Thallus small, cylindrical with a rather smooth main axis. The length of the primary (set perpendicular to the axis) and the secondary laterals is almost equal. The secondaries widen distally thus reaching almost the same diameter as the primaries. In the studied material, D. bonardii often occurs as core of oncocids or in lumps displaying oncolithic coatings (Fig. 6d-f, i).

Dimensions (data of Radoičić et al., 2005 in brackets):

D: 0.15-0.2 mm (0.14-0.35 mm)
d: 0.06-0.08 mm (0.05-0.13 mm)
d/D: 0.33-0.47 (0.24-0.44)
h: 0.05-0.06 mm (0.037-0.049 mm)
p: 0.015-0.025 mm
p′: ~0.02 mm
w: 6-8 (7; 8 according to Pia, 1936)

Remarks: The species in question was previously established and subsequently reported (see synonymy in Radoičić et al., 2005) as Dissocladella undulata (Raineri, 1922). According to the revision of Radoičić et al. (2005), the species was based on heterogeneous specimens.
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Therefore, the species *D. bonardii* was “introduced for the genuine specimens of *Dissocladella*, in replacement of *D. undulata*” by Radoičić et al. (2005, p. 311). In the Spanish specimens, an undulation of the main axis (with widening at the vertical planes) that represents the original name-giving character (see also Pia, 1936, p. 4, “constricted between the whorls”) is not detectable. This diagenetic feature is not necessarily present (e.g., Radoičić et al., 2005, pl. 1, fig. 17).

Genus *Neomeris* Lamouroux, 1816


Figs. 3c (pars), 6j-l

1987 *Neomeris cretacea* - Reitner: pl. 44, fig. 6.

*2007 Neomeris mokragorensis* n. sp. - Radoičić & Schlagintweit, p. 43-44, fig. 7, pls. 1-2, pl. 3, figs. 1-6 (with synonymy).

**Remarks:** Some thallus fragments displaying subspherical fertile ampullae and light-brown preservation are referred to *Neomeris mokragorensis*, described from the Alban and Turonian of Serbia (Radoičić & Schlagintweit, 2007). It co-occurs with *Trinocladus tripolitanus* Raineri, *Halimeda* sp. 1, and a trocholinid-orbitolinid foraminiferan assemblage preferentially in the oncolithic wacke-packstones with iron-impregnated bioclasts.

Genus *Trinocladus* Raineri, 1922

*Trinocladus tripolitanus* Raineri, 1922

Figs. 3b-c (pars), 6m-u

*1922 Trinocladus tripolitanus* n. gen., n. sp. - Raineri: 79, pl. 3, figs 15-16, Upper Cretaceous of Lybia.


1983 *Trinocladus tripolitanus* Raineri - Schroeder & Willems, figs. 4.11 and 4.12.

1987 *Trinocladus tripolitanus* Raineri - Reitner, pl. 33, fig. 4, pl. 44, fig. 2.

**Remarks:** *T. tripolitanus* is one of the most common algae observed in the Altamira Formation. Relying on the detailed description of Raineri (1922) and Pia (1936), just a few remarks are given here. First of all, we note the common occurrence of slightly club-shaped thallus fragments (Figs. 6r, s), and an occasional occurrence of a secondary widening of the main axis at the levels of the laterals (Fig. 6r). In rare cases, the calcareous skeleton around the primaries is more or less completely dissolved given the outline of rounded embayments (Fig. 6u). The main axis may be outlined just by a thin calcareous envelope.

According to Reitner (1987, fig. 110, and p. 210), *T. tripolitanus* is restricted to the reef flat areas, platform sands (shoals) and the open lagoon of the Alban-Cenomanian carbonate platforms of northern Spain. It ranges up to the Santonian–Campanian boundary (Barattolo, 2002, tab. 2).

*Trinocladus* sp.

Fig. 6v

**Remarks:** One transverse section, slightly larger than most specimens of *T. tripolitanus* and with a secondarily widened, undulating axial cavity is here treated as *Trinocladus* sp. Concerning the conspicuous dissolution features, we note similarities to both *Trinocladus undulatus* (Raineri, 1922) (see Radoičić, Conrad &
Carras, 2005) from the Upper Cretaceous of Lybia and to specimens of Trinocladus divnae Radoičić illustrated by Bucur et al. (2010, e.g., pl. 1, fig. 7) from the Cenomanian of Egypt. T. divnae was described from the Cenomanian of Serbia (Radoičić, 2006). On the other hand, comparable diagenetic alterations may also occur in T. tripolitanus (Fig. 6u).

Remarks: The subconical to roughly triangular-rounded bodies (diameter: ~0.25-0.4 mm) exhibiting 11 to ~16 densely set peripheral pores (diameter: 0.03-0.05 mm) were observed in the near-reefal rudstones (Fig. 3d). Total number of pores cannot be evaluated due to the poor preservation. The triangular shape is often transformed into rounded shapes due to marginal erosion. The Cenomanian forms can be compared with those described by Dieni et al. (1985) from the Palaeocene of Sardinia. The genus Frederica Barta-Calbus was so far only known from Danian–Priabonian strata (Barattolo, 2002, tab. 1). As for Acicularia and Terquemella, also Frederica represents a form genus as representing pluricystate fertile ampullae (see diagnosis of Dieni et al., 1985).
filaments arranged subparallel to the longitudinal axis. The medullary filaments are rather thick compared to the segment diameter (see Remarks, i.e., differences to other Boueina species). The cortical filaments are bended towards the axis. Shape and order of branching are masked by their poor state of preservation.

**Dimensions (mm):** external diameter (D) = 0.15-0.35 (mean 0.23), diameter of the medullary filaments = 0.015-0.04 mm (mean ~0.025 mm).

**Comparisons:** B. iberica represents the smallest representative of the genus. The only species that comes near in dimensions is Boueina minima Bucur, Rashidi & Senowbari-Daryan, 2012 from the Barremian - ?lower Aptian of Iran with diameters from 0.23-0.48 mm (mean: 0.34 mm). Boueina pygmaea from the Upper Cretaceous of Libya has segment diameters from 0.5 - 0.9 mm (Pia, 1936). For data on dimensions of different Boueina species, see Bassoullet et al. (1983: Tab. 5) and Bucur et al. (2012: Tab. 3).

The size ratio of the diameters of the medullary filaments and the thallus segments represents a further characteristic of B. iberica. For example the ratio of diameter segment/diameter medullary filaments (using mean values) is 0.05 in B. montcharmonti (De Castro et al., 2008: tab. 1) or ~0.08 in B. minima (see Bucur et al., 2012) compared to ~0.1 in B. iberica. Whether the thallus of B. iberica was tree-like branching (see fig. 1 in De Castro et al., 2008) or simple cylindrical is unknown.

Boueina hochstetteri Toula, 1884
Figs. 8a-w

*1884 Boueina hochstetteri n. gen., n. sp. - Toula: p. 41-46, pl. 5, figs. 10a-b, pls. 7-9.
1994 Boueina hochstetteri Toula - Bucur: p. 160, pl. 16, figs. 1-2, 4, 6-14, pl. 7, figs. 1-4, 7-16.

**Remarks:** Segment fragments of B. hochstetteri are not as common as B. iberica in the studied thin-sections. They occur in external platform for-algal packstones. The diameter of the Cenomanian segments is 0.8 to ~1.0 mm (Toula, 1884: up to 3.5 mm) and can therefore (without taking into consideration other features) easily be differentiated from Boueina iberica.

Genus Halimeda Lamouroux, 1812
Halimeda sp. 1
Figs. 9a-c
Halimeda sp. 2
Fig. 9d

**Remarks:** Halimeda sp. 1 and sp. 2 are separated mainly on the base of their utricle structure. In Halimeda sp. 1, the cortex consists of large subconical primary utricles bearing short bulbous higher order utricles. The utricles are arranged more or less perpendicular to the well calcified medulla. In Halimeda sp. 2, the utricles of the cortex are slender and bended towards the medulla. The preservation of the material is insufficient for specific assignment and biometric measurements. The medullary zone is generally well calcified in Halimeda sp. 1 and poorly calcified in the specimen of Halimeda sp. 2. Whether this is just an accidental observation is unknown.

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**Forma genus Terquemella Munier-Chalmas ex. Morellet & Morellet, 1913
Terquemella div. sp.

**Remarks:** Different morphotypes of Terquemella were rarely observed in the near-reefal rudstones (Fig. 3d). For a recent taxonomic summary, see Bucur et al. (2012).

Order Bryopsidales Schaffner, 1922
Family Udoteaceae (Endlicher) Agardh, 1887-1888
Genus Boueina Toula, 1884
Boueina iberica n. sp.
Figs. 8a-t

**Holotype:** Specimen in longitudinal section in Fig. 8a, thin-section LR 202.

**Origin of the name:** Refers to the occurrence in Spain.

**Type locality:** La Rabia section, ca. 2 km west of Comillas (Fig. 1).

**Type level:** Altamira Formation, middle Cenomanian.

**Diagnosis:** Small and well calcified representative of Boueina. Medullary zone broad, with rather thick filaments (compared to the thallus diameter), subparallelly arranged to the thallus axis. Cortical zone narrow, with branching filaments smaller in diameter than those of the medullary zone. Thallus uncompressed, circular in transverse section.

**Description:** Thallus fragments (termed segments here) cylindrical in shape (greatest observed length: 1.8 mm, holotype specimen in Fig. 8a) and well calcified comprising both medullary and cortical zones. Transverse sections of the segments are circular in outline. The outer part of the segments is often micritized and displays signs of erosion. The medullary zone comprises about 60 to 70% of the total diameter and consists of interwoven
CONCLUDING REMARKS

The microfacies inventory of the Lower–Middle Cenomanian Altamira Formation of northern Cantabria (Spain) has been studied based on numerous thin-sections from three sections that have been measured in great detail. Stratigraphic and micro-/biofacies analyses indicate that the sediments have been deposited on a shelf-attached platform (Altamira Platform). The external platform facies is characterized by a moderately diverse dasycladalean–udoteacean assemblage. Amongst the dasycladales, representatives of *Trinocladus* and *Dissocladella* predominate, associated with udoteaceans (*Boueina, Halimeda*). One new species of *Boueina* is described as *B. iberica*, characterized (among other features) by the smallest segment diameters observed in the genus. Although the Late Albian Caniego Limestone of southern Cantabria lacks a detailed investigation of its algal assemblages, the published results available in the literature suggest a similar microflora as reported from the Lower–Middle Cenomanian Altamira Formation of north Cantabria.

Fig. 8 Udoteacean algae from the Cenomanian of Cantabria, Spain. a-t *Boueina iberica* n. sp. u-w *Boueina hochstetteri* Toula. Thin-sections: LR 202 (a), LR HG-5 (b, d-e, g-k, m-t), LR 110 (c), LR 2 (f, l), LR 170 (u, w), LR 202 (v).
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