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Two new Cretaceous calcareous nannofossils from SE Spain and Tunisia

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Abstract Recent calcareous nannofossil research of three late Hauterivian to earliest Barremian sections from SE Spain and two latest Cenomanian to earliest Turonian sections (S Spain and Tunisia) has revealed two new calcareous nannofossil taxa *Discorhabdus hannibalis* and *Micrantholithus spinulentus*. *D. hannibalis* was found throughout the latest Cenomanian to earliest Turonian, whilst *M. spinulentus* was observed from the late Hauterivian to the earliest Barremian. Both species are described and illustrated here.

Keywords Calcareous nannofossils, taxonomy, Hauterivian–Barremian, Cenomanian–Turonian, SE Spain, Tunisia.

1. Introduction

Subbetic (SE Spain) late Hauterivian to early Barremian sediments have been investigated for ammonite and calcareous nannofossil content. Special attention has been paid to the direct correlation between nannofossil and ammonite biostratigraphy (Aguado *et al*., 2001, 2008; Company *et al*., 2003, 2005a), the biotic and isotopic characterization of the latest Hauterivian Faraoni Level equivalent (FLE) (Aguado *et al*., 2003, 2008; Company *et al*., 2005a, 2007) and the proposal of a section in the Río Argos area ($X.Ag_1$ section, Figure 1A) as a global boundary stratotype section and point (GSSP) for the base of the Barremian (Company *et al*., 2005b, 2011). We have also investigated the Cenomanian/Turonian boundary sediments in the Penibetic (El Chorro section, SE Spain; Sánchez-Quiñonez *et al*., 2010) and Oued Bahloul (central Tunisia) for planktonic foraminifer and nannofossil content in order to gain a better knowledge about the biostratigraphy and paleoceanography of this interval.

These works have uncovered a new pentalith nannofossil, assigned to the genus *Micrantholithus*, and a new placolith, assigned here to the genus *Discorhabdus*. The aim of this short note is to formally describe and illustrate these two new nannofossil species.

2. Material

Detailed bed-by-bed sampling was performed throughout the upper Hauterivian to lower Barremian sediments

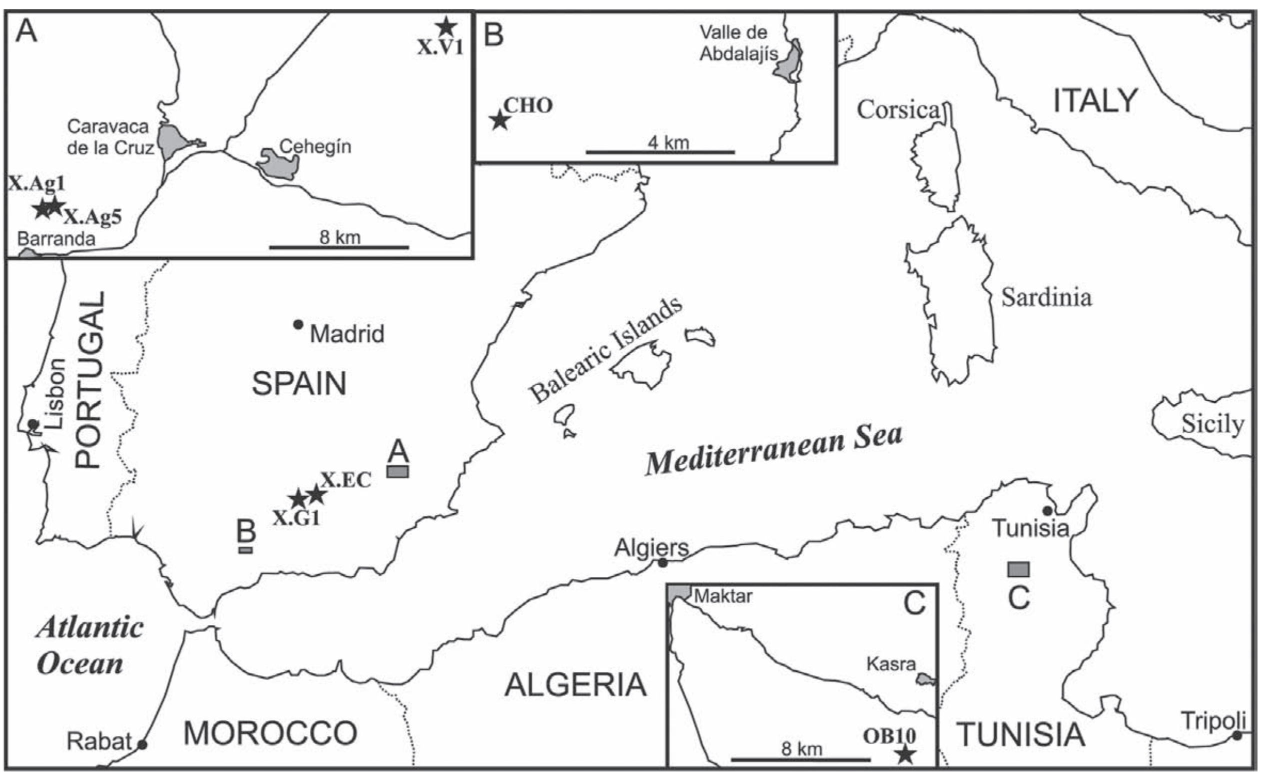


Figure 1: General location of the study sections. A, Río Argos (X.Ag1 and X.Ag5) and Arroyo de Gilico (X.V1) sections. B, El Chorro (CHO) section. C, Oued Bahloul (OB10) section. X.EC = Ermita de Cuadros section. X.G1 = La Guardia section.

of the Subbetic (SE Spain). In two sections from the Río Argos area ($X.Ag_1$: 38º 4' 13" N, 1º 56' 55" W; $X.Ag_5$: 38º 4' 19" N, 1º 56' 31" W; 2.7 km NNE of the village of Barranda, Figure 1A) and in the Arroyo de Gilico section ($X.V_1$: 38º 9' 36" N, 1º 40' 42.5" W; 12.7 km NE of the village of Cehegín, Figure 1A), more than 116 samples were collected from marly lithologies and examined for nannofossil content. The sampled interval corresponds to part of the Carretero Formation and is equivalent to nannofossil Subzones NC5B and NC5C ($X.Ag_1$ and $X.Ag_5$ sections), and NC5B to lowest part of NC5D ($X.V_1$ section) using the zonation of Bralower *et al*. (1995). The three sections studied encompass the Hauterivian/Barremian boundary and, in addition, the Río Argos sections contain a discrete interval of latest Hauterivian age black shales, identified as the FLE (Aguado *et al*., 2003, 2008; Company *et al*., 2005a, 2007). For details about the lithostratigraphy and the ammonite and nannofossil biostratigraphy of these sections, see Aguado *et al*. (2001, 2003, 2008) and Company *et al*. (2003, 2005a, 2005b, 2011).

The Oued Bahloul (OB10) section (35º 46' 18" N, 9º 21' 4" E) is located in central Tunisia, about 5 km SSW of the village of Kasra (Figure 1C), and contains sediments of latest Cenomanian – earliest Turonian age (see Maamouri *et al*., 1994; Amédro *et al*., 2005; Robaszynski *et al*., 2010 for descriptions of lithology, ammonite and carbon-isotope stratigraphy). A total of 25 samples were collected, covering the uppermost part of the Fahdène Formation, the complete Bahloul Formation, and the lowest part of the Aleg Formation, and subsequently examined for calcareous nannofossil and planktonic foraminiferal content. Moderately to well-preserved calcareous nannofossil assemblages allowed the identification of the UC3c–UC3d, UC3e, UC4, UC5a, UC5c, UC6a, and UC6b Zones/Subzones of Burnett (1998).

The El Chorro (CHO) section (36°54'54" N, 4°46'16" W) is located in southern Spain, about 8.4 km WSW of the village of Valle de Abdalajís (Figure 1B). A complete lithological description, and details of fossil content, can be found in Martín-Algarra (1987) and Rodríguez-Tovar *et al*. (2009). Calcareous nannofossils were investigated in 38 samples taken from the Capas Blancas Formation throughout the latest Cenomanian to earliest Turonian interval. Calcareous nannofossil assemblages are moderately to poorly preserved and allowed identification of the Zones/Subzones UC3a–UC3d, UC6 and UC7. Full calcareous nannofossil biostratigraphical and palaeoecological data on the OB10 and CHO sections will be provided in separate publications.

3. Methods

For the samples from the Río Argos and Arroyo de Gilico sections, simple smear slides (Bown and Young, 1998) were mounted with coverslips using Canada balsam, while for the samples from the Oued Bahloul section, the smear slides were prepared following the decantation method described in Geisen *et al*. (1999) for quantitative analysis of the nannofossil assemblages. In addition, temporary mobile mounts, to allow rotation of nannofossil specimens, were also made using immersion oil, and finally some samples were selected for analysis under the scanning electron microscope (SEM).

Smear slides were examined for nannofossil content using a polarizing light microscope Olympus BHSP at 1200x magnification, and SEM samples were examined with a FESEM Carl Zeiss SMT Auriga at the Centro de Instrumentación Científica, University of Granada. Digital images were captured with an Olympus Camedia C5050 camera at 1024x768 pixels (light micrographs) and with a CrossBeam FIB workstation at 3072x2304 pixels (SEM micrographs). The plate images were taken under cross-polarized light (XPL), inserting gypsum plate (GP), or using SEM (SEM). In the GP images, the fast ray in the gypsum plate was orientated NW–SE.

4. Systematic palaeontology

The taxonomic descriptions below follow the terminology guidelines of Young *et al*. (1997). Only taxonomic references that do not appear in Bown (1998) are provided in the reference list. In the following descriptions, D = diameter, H = height. The reference biozonations are from Bralower *et al*. (1995) for the Hauterivian – Barremian and Burnett (1998) for the Cenomanian – Turonian.

4.1. Heterococcoliths

Order **PODORHABDALES** Rood, 1971, emend. Bown, 1987
Family BISCUTACEAE Black, 1971

Discorhabdus hannibalis sp. nov.
Pl. 1, Figures 1–20, 25

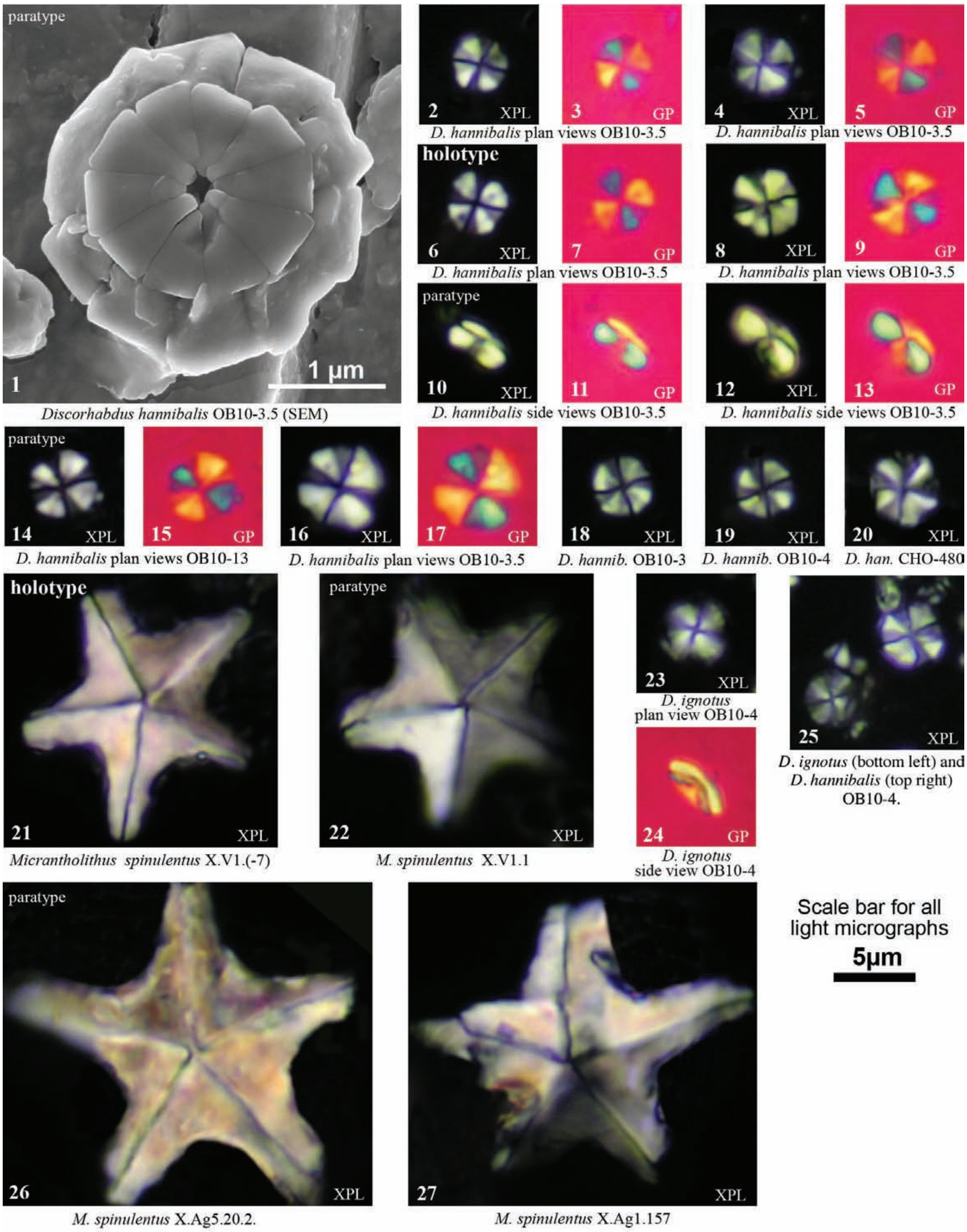
Derivation of name: As this species was originally observed in samples from Tunisia (ancient Carthage), it is named after Hannibal, the famous Carthaginian general, who married the Iberian princess Himilce in the ancient city of Castulo (now Linares, SE Spain).

Diagnosis: Small to very small species of *Discorhabdus* with two closely appressed shields. Unlike other species in this genus, the proximal shield of *D. hannibalis* is wider than the distal shield, protruding beyond it (Pl. 1, Figures 1, 10–13). Typically, the proximal shield is at least twice as thick as the distal shield in side view (Pl.1, Figures 10–13). It usually comprises 10 wedge-shaped, radially-arranged and subtly dextrally-imbricated elements, showing high birefringence and radial c-axis (R-crystal units), when observed under cross-polarized light in plan view. The smaller distal shield consists of an equal number of elements with faint birefringence (vertical c-axis, V-crystal units) under cross-polarized light, and is usually not visible when observed in plan view.

Differentiation: In plan view and cross-polarized light, this species can be differentiated from top views of *Nannoconus* and plan views of *Eprolithus* using the gypsum plate. *D. hannibalis* shows radial orientation of the c-axis (Pl. 1, Figures 3, 5, 7, 9, 15, 17), whereas *Nannoconus* and *Eprolithus* display tangential orientation of the c-axis. In plan view, this species is distinct from other species of *Discorhabdus* (e.g., *D. ignotus*: Pl. 1, Figures 23,

Plate 1

SEM and light micrographs of *D. hannibalis* and *M. spinulentus*. (SEM) = SEM image; (XPL) cross-polarized light; (GP) gypsum plate inserted. Each GP micrograph corresponds to the same specimen in the XPL micrograph placed to its left side.



25) in having higher birefringence under cross-polarized light (Pl. 1, Figures 2, 4, 6, 8, 14, 16, 18–20, 25). Unlike other species in this genus (e.g., *D. ignotus*, Pl. 1, Figure 24), the side views of *D. hannibalis* (Pl. 1, Figures 10–13) are characterized by having a proximal shield wider and thicker than the distal shield.

Remarks: Although this species has a typical placolith structure, it has a peculiar shield construction (proximal shield wider and thicker than the distal one) that is not seen in any other species of the genus *Discorhabdus*.

Holotype: Pl. 1, Figures 6, 7 (are the same specimen).

Holotype dimensions: D = 3.7 µm.

Paratypes: Pl. 1, Figures 1 (D = 3.16 µm). Pl. 1, Figures 10, 11 (are the same specimen, D = 4 µm, H = 2 µm). Pl 1, Figures 14, 15 (are the same specimen, D = 4.4 µm).

Type locality: Oued Bahloul section, about 5 km SSW of the village of Kasra, central Tunisia (35º 46' 18" N, 9º 21' 4" E).

Type level: Sample OB-3.5, upper Fahdène Formation, upper Cenomanian (Subzone UC3c–UC3d).

Occurrence: Oued Bahloul (Tunisia), upper Cenomanian to lower Turonian (Subzone UC3c–UC6c); El Chorro section (Betic Cordillera, Spain), lower Cenomanian (Zone UC3).

4.2. Nannoliths

Family BRAARUDOSPHAERACEAE Deflandre, 1947

Micrantholithus spinulentus sp. nov.
Pl.1, Figures 21, 22, 26, 27

1988 *Micrantholithus* sp. Applegate and Bergen, pl. 29, figure 13.
1993 *Micrantholithus* sp. 1 Aguado, pl. 21, figures 13, 14.
2005 *Micrantholithus* sp. 1 Company *et al*., figures 7.37–7.39.

Derivation of name: From the Latin, '*spinulentus*', meaning 'spinous, prickly', alluding to its outline.

Diagnosis: A *Micrantholithus* species characterized by its very large size (14–25 µm) and deeply indented sides, which usually results in medium to long free rays. Typically, the free-ray length is nearly equal to, or slightly greater than, the radius of the central body in each pentalith.

Differentiation: This species can be differentiated from other Lower Cretaceous species of the genus *Micrantholithus* by its greater size (typically >14 µm in diameter), deeply indented sides, and long rays. *M. spinulentus* broadly resembles some Paleogene forms, such as *M. attenuatus* Bramlette and Sullivan, 1961, *M. excelsus* Bown, 2005 and *M. hebecuspis* Bown, 2005. However, *M. attenuatus* and *M. excelsus* differ from *M. spinulentus* in having more gracile, longer rays, and *M. hebecuspis* has blunt, flat-ended apices. *M. spinulentus* appears to be restricted to the upper Hauterivian and lower Barremian interval (Company *et al*., 2005, 2011).

Remarks: The *Micrantholithus* segments illustrated by Bown (2005), in pl. P11, figure 28, and found at Site 1214 from Leg 198 (Shatsky Rise, northwestern Pacific Ocean), probably correspond to *M. spinulentus*.

Holotype: Pl. 1, Figure 21.

Holotype dimensions: D = 16.7 µm.

Paratypes: Pl. 1, Figure 22 (D = 15.6 µm) and Pl. 1. Figure 26 (D = 20.7 µm).

Type locality: Arroyo de Gilico section ($X.V_1$), about 12.7 km NE of the village of Cehegín, Murcia province, SE Spain (38º 9' 36" N, 1º 40' 42.5" W).

Type level: Sample $X.V_1$-7, upper Hauterivian (NC5B Subzone, *C. krenkeli* ammonite Subzone).

Occurrence: This species was found throughout the upper Hauterivian to lowermost Barremian sediments of the Galicia Margin (Applegate & Bergen, 1988) and the Subbetic (Aguado, 1993; Company *et al*., 2005, 2011). In the Subbetic, *M. spinulentus* was found in various sections of the Río Argos area ($X.Ag_1$, $X.Ag_5$) and in the Arroyo de Gilico ($X.V_1$) section (Company *et al*., 2005; 2011) throughout Subzones NC5B and most of NC5C (*C. krenkeli* to *P. colombiana* ammonite Subzones). It has also been found in the upper Hauterivian to lowermost Barremian in the Ermita de Cuadros (X.EC) and La Guardia (X.G1) sections (Figure 1), located in the Intermediate Domain of the Subbetic (pers. observ.). Its last occurrence is observed in the beds equivalent to the upper part of the earliest Barremian Subzone NC5C (upper part of the *P. colombiana* ammonite Subzone).

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