LOWER CRETACEOUS CALCAREOUS ALGAE AND FORAMINIFERA FROM TRBUŠNICA (VARDAR ZONE, SERBIA)

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Abstract The basal part of the Miocene sedimentary deposits from Trbušnica region (south-west of Belgrade, Serbia, Vardar zone) consists of conglomerates containing pebbles of Mesozoic limestones. The study of two of these pebbles led to the identification of an interesting assemblage of dasycladalean calcareous algae with Andreiella rajkai, Montiella elitzae, Neomeris sp., Salpingoporella muehlbergii, Salpingoporella gr. pygmaea, Salpingoporella sp., Suppiluliumaella gr. polyreme, ?Suppiluliumaella sp., Suppiluliumaella sp., Triploporella sp. and Zittelina hispanica. Foraminifera accompany this algal association: in one of the samples Montseciella arabica is dominant, while the other one contains orbitolinid fragments (possibly Palorbitolina lenticularis). The two orbitolinids point to a Late Barremian – earliest Aptian (early Bedoulian) age for the studied limestone pebbles.

Keywords: orbitolinids, dasycladaleans, Lower Cretaceous, Serbia

INTRODUCTION AND GEOLOGICAL SETTING

The study area is located southwest of Belgrade, between Rudovci and Trbušnica localities where Neogene deposits (Middle Miocene and Pliocene) crop out (Fig. 1, based on Filipović et al., 1976, geological map 1: 100000, sheet Obradovac). In the area located between the Bistrička River and Trbušnica Upper Cretaceous (“Senonian”) rocks are topped by basal Miocene conglomerates.

These conglomerates contain numerous calcareous pebbles assigned to the Jurassic or Cretaceous, besides Paleozoic metamorphic ones. Locally, the composition of the pebbles is dominated by gabbro, diabase, pyroxenite and serpentine, imprinting a characteristic feature of these deposits. The conglomerates are overlain by coarse or fine sandstones, and rarely by marls with coal interbeds (Fig. 2). The conglomerates cropping out in the Trbušnica area...
contain numerous limestone pebbles of Early Cretaceous age, some with microfossil content that can be identified. We have studied 10 thin sections obtained from two samples (sample RR013234, thin sections RR4523, RR4524, RR4525, RR4527, and sample RR013205, thin sections RR4516, RR4517, RR4518, RR4519, RR 4520 and RR4521). The present paper briefly describes the calcareous algae and the foraminifera identified in this material, in order to more closely understand the age relationships of the pebbles. The samples are part of Rajka Radoičić’s private collection.

**FORAMINIFERA**

The studied Lower Cretaceous pebble samples contain numerous sections of the orbitolinid *Montseciella arabica* (sample RR013235). Additionally, rare specimens of *Charentia cuvilieri*, *Everticyclammina* sp., *Palorbitolina lenticularis* (sample RR013234), miliolids, nodosariids and other non-identified foraminifers were found.

**Genus Montseciella** Cherchi & Schroeder, 1999

*Montseciella arabica* (Henson, 1948) Schroeder et al., 2002

Fig. 4 a-l.

Description. Conical test (Fig. 4 a-e), 1.0-2.3 mm in diameter and 1.0-1.8 mm in height, displaying about 14 chamber layers per millimeter in the axial-sub-axial plane. We did not observe embryos, with the possible exception of the specimen illustrated in Fig. 4 l where the presence of an eccentric one might be assumed. An eccentric embryo location is also suggested by the overall configuration of the apical area of the specimen in Fig. 4 e.

One of the typical features for this species is represented by the rudimentary radial partitions in the external part of the central area, as extensions of the marginal chambers’ separating walls (Fig. 4 g, h, k) (Schroeder & Cherchi, 1979; Baud et al., 1994; Cherchi & Schroeder, 1999; Maksoud et al., 2014). Especially based on this feature, Schroeder et al. (1968) have assigned this species originally ascribed to *Dictyoconus* by Henson (1948) to the genus *Paleodictyoconus*. Subsequently, Schroeder et al. (2002) have transferred it to the genus *Montseciella*. The inner part of the central area is separated by pillars displaying vermicular or pillar-like structures (Fig. 4 g, k). The pillars alternate from one chamber layer to another (Fig. 4 a-f). The chamberlets from the marginal area are subdivided by one rather short horizontal plate (Fig. 4 a-f) and one or two vertical ones (Fig. 4 g-i, k), the result being the formation of sub-epidermal chamberlets (Fig. 4 j). The apertural pores with diagonal display are visible in the subaxial (Fig. 4 a-f), as well as in the oblique (Fig. 4 h) or the transversal-oblique sections (Fig. 4 g, k).

Remarks. In a recent publication, Schroeder et al. (2010) have summarized the existing data and revised the biostratigraphical zonation based on orbitolinids, as well as on the phyletic lineages of Barremian-Aptian orbitolinids. Accordingly, the Barremian-Aptian interval was divided into six zones and three subzones. *Montseciella arabica* is present in deposits covering...
Lower Cretaceous calcareous algae and foraminifera from Trbušnica (Vardar zone, Serbia)

Fig. 3 Microfacies of the Lower Cretaceous limestone pebbles from Trbušnica. **a-c** Coarse grainstone to rudstone containing bivalve, gastropod and echinoderm fragments, rare coral fragments, cortoids and bacinellid oncoids as well as rare metamorphic, siliceous and sandy lithoclasts. Neoformation quartz is preferentially located in the micritic cortex of some oncoids. Large dasycladaleans (*Andreiella, Suppilliumaella*) and orbitolinid foraminifera (*Montseciella*) are present; **a**, thin section RR4516; **b, c**, thin section RR4518. **d** Bioclastic rudstone with bivalve, gastropod, echinoderm, sponge and rare coral fragments. Reworked orbitolinids agglutinating terrigenous quartz (*?*Palorbitolina), as well as large dasycladaleans (*Zittelina*) are present. Thin section RR4524. **e, f** Rudstone/floatstone with coral, bivalve, sponge and echinoderm fragments, large dasycladaleans (*Trioploporella*) and foraminifera. The large bioclasts are encrusted by foraminifera and red algae (*Polystrata and Sporolithon*); **e**, thin section RR4525; **f**, thin section RR4527. Scale bar = 1 mm.
almost the whole Late Barremian to earliest Aptian interval. This species is extremely abundant in the Late Barremian, where it represents the index species for the *M. arabica* subzone.

**DASYCLADALEAN ALGAE**

The dasycladalean algae assemblage identified in the studied samples includes: *Andreiella rajkae*, *Montiella elitae*, *Neomeris* sp., *Salpingoporella muehbergii*, *Salpingoporella* gr. *pygmaea*, *Salpingoporella* sp., *Suppiluliumaella* gr. *polyreme*, *Suppiluliumaella* sp., *Triploporella* sp. and *Zittelina hispanica*. A brief description of these species in alphabetical order follows.

We used the following symbols for the measured size parameters: \( D \) = external diameter of the thallus; \( d \) = diameter of the axial cavity; \( l \) = length of the primary laterals; \( p \) = width of the primary laterals; \( l' \) = length of

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**Fig. 4** Foraminifera from the limestone pebbles of Trbušnica. a-l *Montseciella arabica* (Henson); a-f, l, subaxial sections; g, k, transverse-oblique sections; h, i, obliques sections; j, tangential-oblique section. a, c, f, g-j, thin section RR4518; b, e, k, l, thin section RR4521; d, thin section RR4516. Scale bar = 0.25 mm.
the secondary laterals; \( p' \) = width of the secondary laterals; \( h \) = distance between two successive verticils; \( w \) = number of primary laterals in a verticil; \( w' \) = number of secondary laterals per primary one.

**Genus Andreiella** Bucur, 2014

Andreiella rajkae Bucur, 2014

(Fig. 5 e)

Andreiella rajkae was recently described by Bucur (2014) from Upper Barremian – lowermost Aptian (lower Bedoulian) limestones in the Hăghimaş Mountains (Eastern Carpathians, Romania). It is characterized by a cylindrical thallus with a narrow main stem and two orders of laterals. The first order laterals, large and club-shaped, gradually broaden from the proximal to the distal part where they slightly narrow towards the exterior. The secondary laterals are short and vesiculiform to ovoid in shape. Calcification forms an irregular sleeve around the distal end of the primary laterals, embedding the secondary ones.

A single specimen was identified in the studied samples from Trbušnica (Fig. 5 e), however it is very representative for the species. Until this study, A. rajkae has been identified in only three sites: Mount Rujen (Vardar zone, Macedonia) (Radoičić, 2002), Bicaz Gorges (Hăghimaş Mountains, Eastern Carpathians, Romania) (Bucur & Şasăran, 2011; Bucur, 2014), and Munella Platform (Albania) (Schlagintweit, unpublished; Bucur, 2014). Thus, Trbušnica represents the fourth location for this species.

Dimensions (mm): \( D = 2.60; d = 0.60; p \) (distal) = 0.30; \( p' = 0.07. \)

**Genus Montiella** L. Morellet & J. Morellet, 1922

Montiella elizae (Bakalova, 1971) Radoičić, 1980

(Fig. 5 d)

Only one specimen, cut in tangential-oblique-longitudinal section revealing only partly the axial cavity, was identified. Nevertheless, it displays the typical arrangement of the fertile and sterile secondary laterals.

Dimensions (mm): \( D = 1.0; d = 0.11; \) Diameter of the fertile ampoules = 0.26.

**Genus Neomeris** Lamouroux, 1916

Neomeris sp.

(Fig. 5 g, h)

We have identified two specimens in sub-transversal section, both showing secondary laterals and ovoidal fertile ampoules similar to those of Neomeris cretacea Steinmann. However, while oblique or longitudinal sections are missing, a species assignment cannot be without doubt.

Dimensions (mm): \( D = 1.30-1.50; d = 0.65; l' = 0.20-0.32; \) length of fertile ampoules = 0.15-0.20; width of fertile ampoules = 0.07.

**Genus Salpingoporella** Pia in Trauth 1918, emend. Carras et al., 2006

Salpingoporella muelhbergii (Lorenz, 1902) Pia in Trauth, 1918

(Fig. 6 a, b)

Only a few specimens were identified in thin section RR4518 that display the typical shape and size features for the species Salpingoporella muelhbergii. This is one of the most frequent dasycladaleans found in Barremian – Aptian deposits in the Tethys area.

Dimensions (mm): \( D = 0.37-0.50; d = 0.15-0.20; \) (distal) = 0.08-0.10; \( h = 0.10. \)

**Salpingoporella** gr. *pygmaea* (Gümbel, 1891) emend Carras et al., 2006

(Fig. 6 d)

Also in the case of this species, only a few specimens were identified – mainly cut in oblique sections.

Dimensions (mm): \( D = 0.78; d = 0.35; l = 0.25-0.30. \)

**Salpingoporella** sp.

(Fig. 6 c, e)

We have identified a few larger specimens in a poorer preservation state than that of S. muelhbergii, showing about eight phloiophorous laterals per verticil and a thick calcareous wall; however, a distinct species assignment is difficult.

Dimensions (mm): \( D = 0.62-0.77; d = 0.15-0.32; l = 0.22; p \) (distal) = 0.10-0.15.

**Genus Suppiluliumaella** Elliott, 1968

Suppiluliumaella gr. *polyreme* Elliott, 1968

(Fig. 6 f, h)

The specimens identified in the Trbušnica samples are present in transversal-slightly oblique sections. The primary laterals are originally tubular but then they broaden distally, giving rise to 4-6 secondary laterals directly connected to the distal part of the primary laterals, without constrictions (like the fingers of a glove).

Dimensions (mm): \( D = 1.20-2.10; d = 0.80-0.95; l = 0.30-0.65; p' \) (distal) = 0.15-0.20; \( l' = 0.15-0.20. \)

Remarks. Bakalova (1971) has described two new species of Suppiluliumaella: *S. praebalcanica* and *S. elliotti*. The difference between the first and *S. polyreme* is represented by the presence of third order laterals, a feature that still needs to be documented. *S. elliotti* differs from *S. polyreme* … "par l'absence de parois autour de la cellule axiale" [while it shows no wall around the axial cell] (Bakalova, 1971: 125). Table A (in Bakalova, 1971) summarizing the size differences recorded for the three species (*S. polyreme*, *S. praebalcanica* and *S. elliotti*) shows little discrimination, being mainly a proof for some dimensional overlaps. Some of the apparent differences may be the result of different sectioning angles: most of the specimens described by Bakalova (1971) are present in oblique and transverse sections, in which the inclination of the primary laterals, their length, the length of the secondary laterals etc. are more difficult to evaluate. One cannot exclude that the two species identified by Bakalova (1971) are recent synonyms for the species *S. polyreme*. More samples, including toptype material, need to be studied in order to confirm this assumption.

Dimensions (mm): \( D = 2.10-2.10; d = 0.80-0.95; l = 0.35-0.65; l' = 0.15-0.20; p \) (distal) = 0.15-0.20; \( p' = 0.05-0.07; w = 18-20. \)

?Suppiluliumaella (Fig. 6 g, j, k)
Fig. 5 Dasycladalean algae from the limestone pebbles of Trbušnica. a-c, f *Zittelina hispanica* Masse, Arias & Vilas. Transverse-slightly oblique (a, b) and oblique (c) sections; f, enlargement of the lower part of the specimen in b. a, c, thin section RR4524; b, thin section RR4523. d *Montiella elitzae* (Bakalova) in longitudinal-subaxial section; thin section RR4521. e *Andreiella rajkae* Bucur in oblique section; thin section RR4516. g, h *Neomeris* sp. in transverse sections; thin section RR4518. Scale bar = 0.25 mm.
Fig. 6 Dasycladalean algae from the limestone pebbles of Trbušnica. a, b Salpingoporella muehlbergii (Lorenz); longitudinal-oblique (a) and transverse-oblique (b) sections; thin section RR4518. c, e Salpingoporella sp. in transverse section (c) and oblique section (e); thin section RR4518. d Salpingoporella gr. pygmaea (Gümbel) in oblique section; thin section RR4518. f, h Suppiluliumaella gr. polyreme Elliott; transverse-slightly oblique sections; e, thin section RR4516; h, thin section RR4517. i ?Triploporella sp.; longitudinal-oblique section, thin section RR4518. g, j, k ?Suppiluliumaella sp. in oblique sections (g, j) and longitudinal-oblique (k) sections; g, thin section RR4519; j, k, thin section RR4521. Scale bar = 0.25 mm.
Present as fragments of relatively large thallus with ovoidal to ovoidal-elongated-cylindrical primary laterals that are approximately perpendicular to the axial cavity to which they are connected through a short peduncle, and with Suppilliumaella-type secondary laterals. Dimensions (mm): D = 1.80-2.50; d = 0.60-0.80; p (maximum) = 0.30; l = 0.55; p′ = 0.08-0.10; l′ = 0.20; h = 0.10-0.12. Remarks. Similar specimens were identified in Upper Barremian – basal Aptian limestones from Bicaz Gorge (Eastern Carpathians, Romania) (Bucur & Săsăran, 2011: 60-61, Plates 10-11). In spite of the similitude of the laterals’ morphology between this form and genus Dissocladelia, the authors (Bucur & Săsăran, 2011) have considered that they represent sections through the lower part of the Suppilliumaella elliotti thallus (see also Barattolo, 1983, with a reconstruction of Suppillaritum showing different morphologies and different inclination of laterals along the axis). Unfortunately, no section illustrating the continuity between the two parts of the same algae was identified: thus, this assignment is still questionable.

Genus Triploporella Steinmann, 1880
?Triploporella sp. (Fig. 6 i)
We have identified a longitudinal-oblique section through a specimen that shows well-preserved primary laterals. They are slightly inclined in respect to the axial cavity. The distal, probably broadened part of these laterals, as well as the secondary laterals, are not clearly visible. Dimensions (mm): D = 1.94; d = 0.64; l = 0.60; p (distal) = 0.22; h = 0.20.

Triploporella sp. (Fig. 7 a-g)
In three of the studied sections obtained from sample RR013234 we have identified the rests of a large Triploporella species present in transversal-oblique sections (Fig. 7 a-d); one fragment is present in a longitudinal-oblique section (Fig. 7 b).
The two transversal sections differ in the size of the axial cavity and in the display of the laterals. The specimen in Fig. 7 a shows a broad axial cavity, while that in Fig. 7 d shows a narrower one. Also, the laterals seem to be less inclined in the first specimen (Fig. 7 a) and more inclined in the second one (Fig. 7 d). These features point to the fact that the alga may display a claviform thallus with a narrower external diameter and axial cavity in the lower part (Fig. 7 d) broadening towards the upper part (Fig. 7 a). Secondary laterals are not visible (possibly they are primarily not-calcified). Typical for the specimens from Trbušnica are the very small cyst-containers (Fig. 7 b, c, e-g) as compared to those in other Triploporella species (e.g. Bucur et al., 2013). At a first glance, they seem to be simple cysts; when investigated in detail, some show inner round, micritic corpuscles, and can be considered intracellular receptacles-type reproducing organs – cyst-containers that are typical for the genus Triploporella and are present in most species of this genus (Barattolo, 1980, 1981; Barattolo et al., 2013). Such small cyst-containers were recently noticed also in other Triploporella specimens identified in Upper Aptian limestones from the Apuseni Mountains (Romania) (Bucur et al., 2013).
Dimensions (mm): D = 5.60-6.60; d = 2.00-4.20; l = 1.40-1.50; p = 0.25-0.30; w = 45-70; diameter of cyst-containers = 0.050-0.090/0.040-0.070; cyst diameter = 0.020-0.030.

Genus Zittelina L. Morellet & J. Morellet, 1913
Zittelina hispanica Masse, Arias & Vilas, 1993 (Fig. 5 a-c, f)
Three specimens of a large dasycladalean alga were identified in transverse-slightly oblique (Fig. 5 a, b) and oblique (Fig. 5 f) sections. The thallus is calcified only around the central stem and at the distal end of the laterals. The area between the two calcified zones is filled with calcified and partly cement-bound cyst-containers, around the original area of the primary laterals (Fig. 5 f).
Two Zittelina species are known in Lower Cretaceous deposits: Z. hispanica and Z. massei (Bucur et al., 2010). Based on their overall appearance, mainly on the width of the axial cavity and the d/D ratio, we consider that the Trbušnica specimens correspond to species Zittelina hispanica.
Dimensions (mm): D = 5.10-5.90; d = 2.90-3.50; l = 1.10-1.30; cyst-container diameter: 0.10-0.12/0.18; cyst diameter: 0.06-0.08.
Remarks. The dimensions of our specimens are slightly larger than those indicated by Masse et al. (1993) for the type-specimens. However, a specimen that one of the authors (I.I.B.) has collected from the type-locality and that was illustrated in Bucur (2002) shows an external diameter of 6.8 mm – thus, the Trbušnica specimens fall in the dimensional range of Z. hispanica.

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REFERENCES
Fig. 7 Dasycladalean algae from the limestone pebbles of Trbušnica. a-g. *Triploporella* sp. Transverse (a) and transverse-oblique (d) sections; b, section of a fragment, cutting some laterals; c, enlargement of the specimen in b showing the cyst containers (arrows); e-g, enlargement of different parts of the specimen in d; a, thin section RR4525; b, thin section RR4524; d, thin section RR4527. Scale bar = 1mm (a, d); 0.25 mm (b, c, e-g).


