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ON THE PRESENCE OF GREEN ALGAE (DASYCLADALES, BRYOPSIDALES) IN THE MIDDLE MIOCENE DEPOSITS FROM PODENI (WESTERN BORDER OF THE TRANSYLVANIAN BASIN, ROMANIA)

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Abstract. The Lower Badenian deposits from the western border of the Transylvanian Basin developed on a littoral carbonate platform, and consist of red algae-dominated sediments. Green algae (halimedacean Bryopsydales and Dasycladales) are reported from the upper part of the succession of Gârbova de Sus Formation, at Podeni. *Halimeda* segments occur together with red algae and benthic foraminifera, and are sometimes associated with *Neomeris* specimens. This is the second report of *Neomeris* in Miocene deposits

Keywords: green algae (dasycladales, bryopsidales), microfacies, Transylvanian Basin, (Romania).

INTRODUCTION

The Miocene formations of the Transylvanian Basin reveal a wide range of depositional settings due to the peculiar evolution of the basin as part of the Paratethys (Laskarev, 1924; Rögl, 1998). Full marine deposits are characteristic to the Badenian (equivalent of the Langhian and, partly, Serravallian). Carbonate platform facies with dominant red algae locally developed during the early Badenian (Rasser et al., 2008). The green algae represent a peculiar feature of these deposits. Our purpose is to point out their presence in the Lower Badenian limestones from Podeni (Filipescu, 1996; Saint-Martin et al., 2007) at the western border of the Transylvanian Basin (Fig. 1).

GEOLOGICAL FRAMEWORK

A littoral carbonate platform, where red algae played an important role in the formation of carbonate sediments, developed during the Early Badenian (Gârbova de Sus Formation) at the western border of the Transylvanian Basin. The formation was deposited on a Mesozoic substrate; around Podeni it rests over the Jurassic volcanic arc and it is covered by the Middle Badenian evaporites of Cheia Formation (Filipescu, 1996, 2001).

The lower part of Gârbova de Sus Formation consists of algal limestones with bioclastic intercalations, while the upper part contains coral bioconstructions, algal and biocastic limestones with green algae (Saint Martin et al., 2007).

The lower part of the succession is well displayed in Podeni Quarry (Pl. I, fig. 4). The lower and middle parts of the quarry consist of bioclastic limestones, with a 2-3 m thick interval containing rare rhodoids, and a distinct biohorizon with bivalves (Pl. I, fig. 6). The upper 5-6 m of the quarry are dominantly made up of large (10-20 cm in diameter) rhodoids. This rhodolitic level has a very good correlation potential along the western border of the basin (Bucur & Filipescu, 1994).

The covering sedimentary succession (400 m north-northwest of the quarry) - Pl. I, figs 1, 2) contains retrograding coral patch reefs and algal to bioclastic limestones with green (halimedacean and dasycladacean) calcareous algae to the top.

MATERIAL AND METHODS

The fossil algae have been studied from sixty five thin sections prepared from the limestones occurring in two locations. The specimens were observed using the Zeiss Stemi 2000C and Zeiss Axioscop microscopes and afterwards photographed with a Canon power shot A 640 model digital camera.

MAIN MICROFACIES TYPES

The carbonate deposits displayed in Podeni quarry consist basically of three types of microfacies revealing particular paleoenvironmental settings: a) bioclastic packstone-wackestone; b) bioclastic-intraclastic grainstone, and c) rhodoid-bearing mudstone-wackestone. The bioclastic packstone-wackestone is dominant in the lower part of the succession, associated with marly or shaly mudstones. The bioclastic-intraclastic grainstones have centimetre-scale thickness and are intercalated in the lower and middle part of the succession. The rhodoids represent a distinct feature and form meter-thick beds in the upper part of the quarry (Pl. I, figs 5,7,8,10,11). Rhodoids consist of successive crusts of red algae, bryozoans and encrusting foraminifera (e.g. Pl. II, fig. 1). The main red algae which contribute to the rhodoid formation are (Bucur & Filipecu, 1994): *Sporolithon lvovicum* MASLOV, *Lithothamnion moretti* LEMOINE, *Mesophyllum roveretoi* CONTI, "*Lithophyllum*" *ramoississimum* (REUSS) and *Spongites albanense* (LEMOINE). The rhodoid morphology suggests paleodepths of 30-50 m (Bucur & Filipescu, 1994, 2001). The mudstone-wackestone matrix of the red algae accumulations, together with the presence of intact bivalves and frequent perforations indicate a low- to middle-energy environment having low sedimentation rates.

The upper part of the succession continues in the outcrop situated 400 m north - northwest of the quarry with the following facies types: a) coral or coralgal boundstone to bafflestone; b) rhodoidic wackestone/packstone to algal-foraminiferal boundstone, and c) bioclastic packstone to packstone/grainstone.

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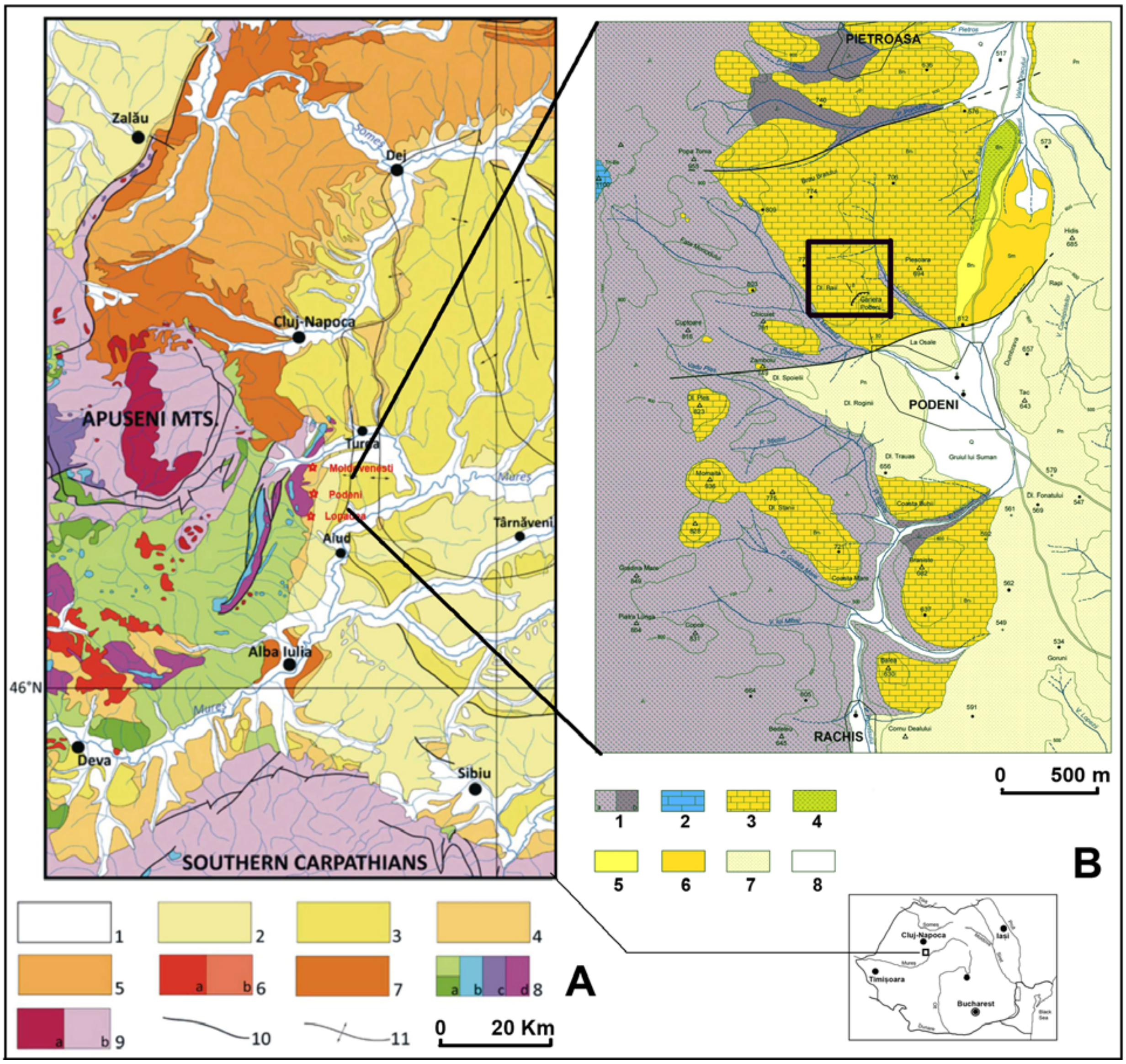

Fig. 1 – Location of the studied area on: A - geological map of the western part of the Transylvanian Basin (modified after Săndulescu et al, 1978), and B - geological map of the Podeni area.
Legend for A: 1-Quaternary; 2-Pannonian; 3-Sarmatian; 4-Badenian; 5-Lower Miocene; 6-Neogene volcanic arc (a, volcanic rocks; b, volcano-sedimentary deposits); 7-Paleogene; 8-Mesozoic (a, Cretaceous; b, Jurassic; c, Triassic; d, Triassic-Jurassic volcanic arc); 9-Pre-Mesozoic units (a. magmatites; b, metamorphites).
Legend for B: 1, 2-Bedeleu Nappe units of the Apuseni Mountains (1a, andesite; 1b, basalt; 2, massive limestone); 3-8. Transylvanian Basin lithostratigraphic units: 3, Gârbova de Sus Formation; 4, Cheia Formation; 5, Pietroasa Formation; 6, Măhăceni Formation; 7, Lopadea Formation; 8-Quaternary deposits.

The coral (Pl. I, fig. 3) and coralgal facies were described by Saint Martin et al. (2007). The main corals forming the patch reefs are *Tarbellastraea* sp., *Heliastraea* sp., *Favites* sp. and *Porites* sp.

The algal limestones developing along the entire eastern border of the Trascău Mountains were studied by Bucur & Filipecu (1994, 2001). *Spongites albanense* (Pl. II, fig. 7) is one of the most important species contributing to the formation of red algal wackestones/packstones as well as to that of the distinct levels with rhodoids. *Sporolithon* sp. (Pl. II, fig. 8) occur frequently together *Spongites* within the limestones situated under the limestone-level with green algae or inside this level.

THE GREEN ALGAE

Bioclastic packstones and grainstones with fragments of bivalves, gastropods, annelids, bryozoans, echinoderms, foraminifera (frequently large calcareous benthics) and calcareous green algae (*Halimeda* sp. and *Neomeris* sp.) occur above the reef facies (Pl. II, figs. 2-6) Sometimes halimedaceans are present in the matrix of the rhodolitic facies (Pl. II, fig. 2). Alveolinids (*Borelis* sp.) are also frequent in the *Halimeda*-bearing intervals (Pl. II, figs. 3, 5). Non-geniculate and geniculate corallinaceans (including *Titanoderma* sp. and *Corallina* sp.) have been occasionally identified (Pl. II, fig. 4). Dasycladaceans were rarely identified and are represented only by *Neomeris* specimens (Pl. III, figs 5-12).

Miocene halimedaceans and dasycladaceans seem to be more related to Recent than to fossil taxa. The different sections through *Halimeda* segments (Pl. III, figs. 1-4) are comparable to sections of Recent *Halimeda tuna* (ELLIS & SOLANDER). Halimedaceans are also known as very important sediment producers in modern shallow-water carbonate environments. Moreover, since Miocene, *Halimeda* has built sometimes bioclastic mounds, as documented from Spain (Braga et al., 1996).

As regarding dasycladaceans, it is important to point out that very few species of *Neomeris* were described from Neogene deposits: *Neomeris ambigua* MORELLET, *Neomeris ignota* MORELLET (both species from the Badenian of Coştei and Lăpugiu in Romania), *Neomeris bowdenensis* RACZ and *Neomeris venezuelensis* WEISBORD (the last two from the Pliocene of Jamaica and Venezuela, respectively) (Deloffre & Genot, 1982). Additionally, seven Recent species of *Neomeris* are known (Genot, 1987; Berger & Kaever, 1992). The specimens we found at Podeni represent the second report of Middle Miocene (Lower Badenian) *Neomeris*.

CONCLUSIONS

The Middle Miocene carbonate deposits in Podeni area preserve green algae assemblages consisting of Bryopsidales (Halimedaceae) and Dasycladales. The green algae, especially the dasycladaceans identified above the coral patch-reefs, document a shallowing trend in the depositional environment. This trend is also supported by the foraminifera assemblages and the presence of beach-rock intercalations in the upper part of the sequence (e.g., Pl. II, fig. 6).

The co-occurence of corals, *Sporolithon* red algae and dasycladaceans points to a tropical to subtropical, shallow water environment.

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PLATES

PLATE I

Fig. 1 – Photo of the outcrop situated N-NW from Podeni quarry showing the limestones with green algae. R1 and R2 indicate the position of two of the patch reef levels.
Fig. 2 – Sedimentary log with the succession of the limestones from Fig. 1.
Fig. 3 - Detail of a coral patch reef (R2).
Fig. 4 – Limestones in Podeni quarry.
Fig. 5 – Weathered surface of a rhodoidic bed in the upper part of Podeni quarry.
Fig. 6 – Sedimentary log with the limestone succession in Podeni quarry showing the location of the identified facies.
Figs 7, 8, 11 – Rhodoids from Podeni quarry.
Fig. 9 – Bioclastic limestones made up predominantly of red algae, situated in the basal part of the outcrop from Fig. 1B.
Fig. 10 – Rhodoids situated under the patch-reef levels in outcrop from Fig. 1B.

PLATE II

Fig. 1 – Successive crusts of red algae and encrusting foraminifera from the rhodolitic facies. Sample 10229.
Halimedacean segments (left) in the internal sediment between red algae. Sample 10231.
Figs. 3-5 – Bioclastic packstone with halimedacean segments, alveolinid foraminifera (3, 5) and geniculate corallinaceans (4). Sample 10241 (3) and 10242 (4, 5).
Fig. 6 – Bioclastic packstone with halimedacean segments, fragments of red algae and microgastropods. The clasts are surrounded by beach-rock type cement. Sample 10240.
Fig. 7 – *Spongites albanense* (LEMOINE). Sample 10221.
Fig. 8 – *Sporolithon* sp. Sample 10233.

PLATE III

Figs 1-4 – Segments of *Halimeda* sp. Samples 10247 (1), 10242 (2), 10244 (3) and 10250 (4).
Figs 5-12 – Several sections through *Neomeris* sp. Samples CP 27 (5, 8), 10241 (7), 10249 (9), 10254 (10), 10234 (11) and 10250 (12).

PLATE I

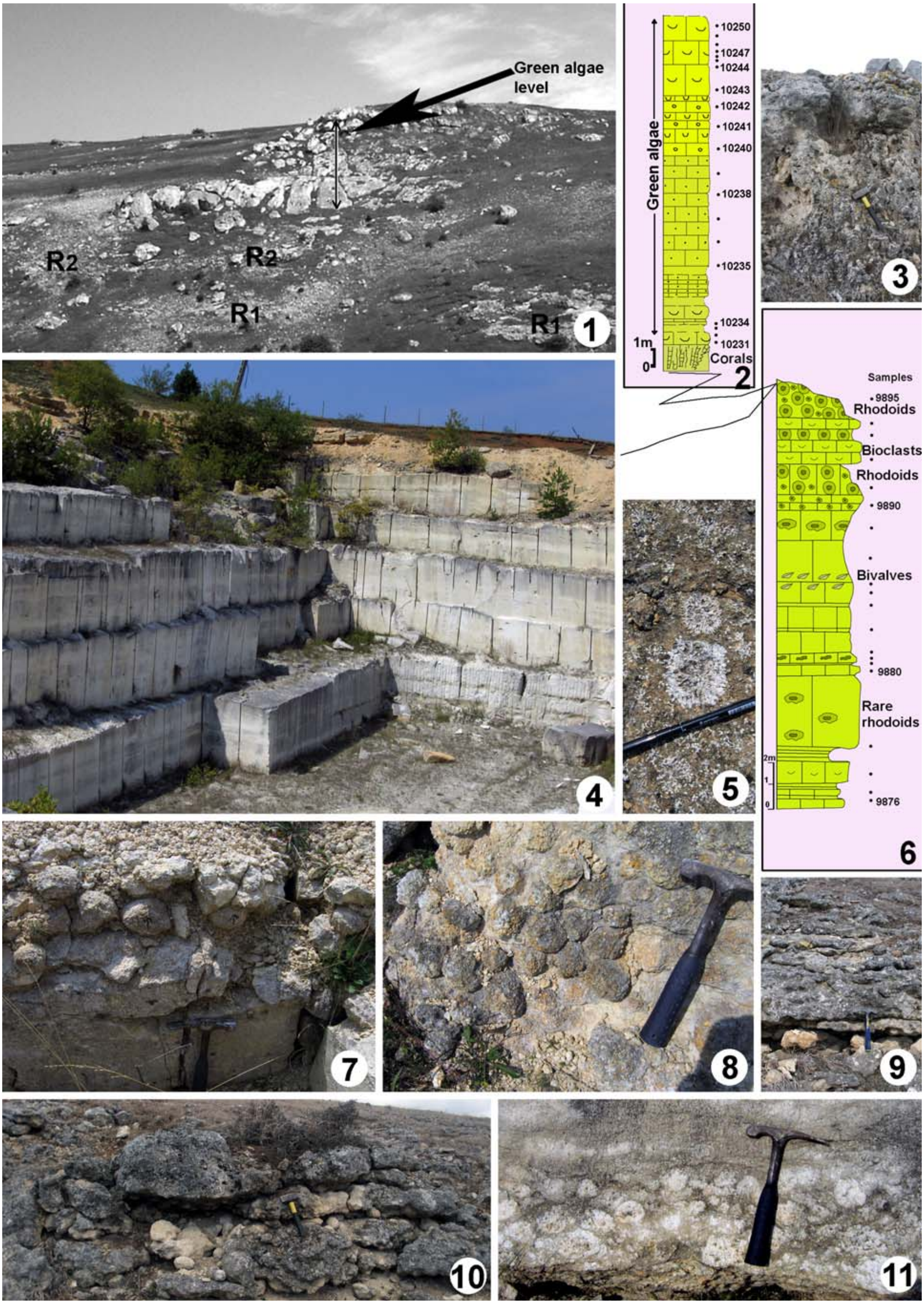
Green algae level
R2
R2
R1
R1
1
Green algae
10250
10247
10244
10243
10242
10241
10240
10238
10235
10234
10231
1m
0
Corals
2
3
Samples
9895
Rhodoids
Bioclasts
Rhodoids
9890
Bivalves
9880
Rare rhodoids
2m
1
0
9876
6
4
5
7
8
9
10
11

PLATE II

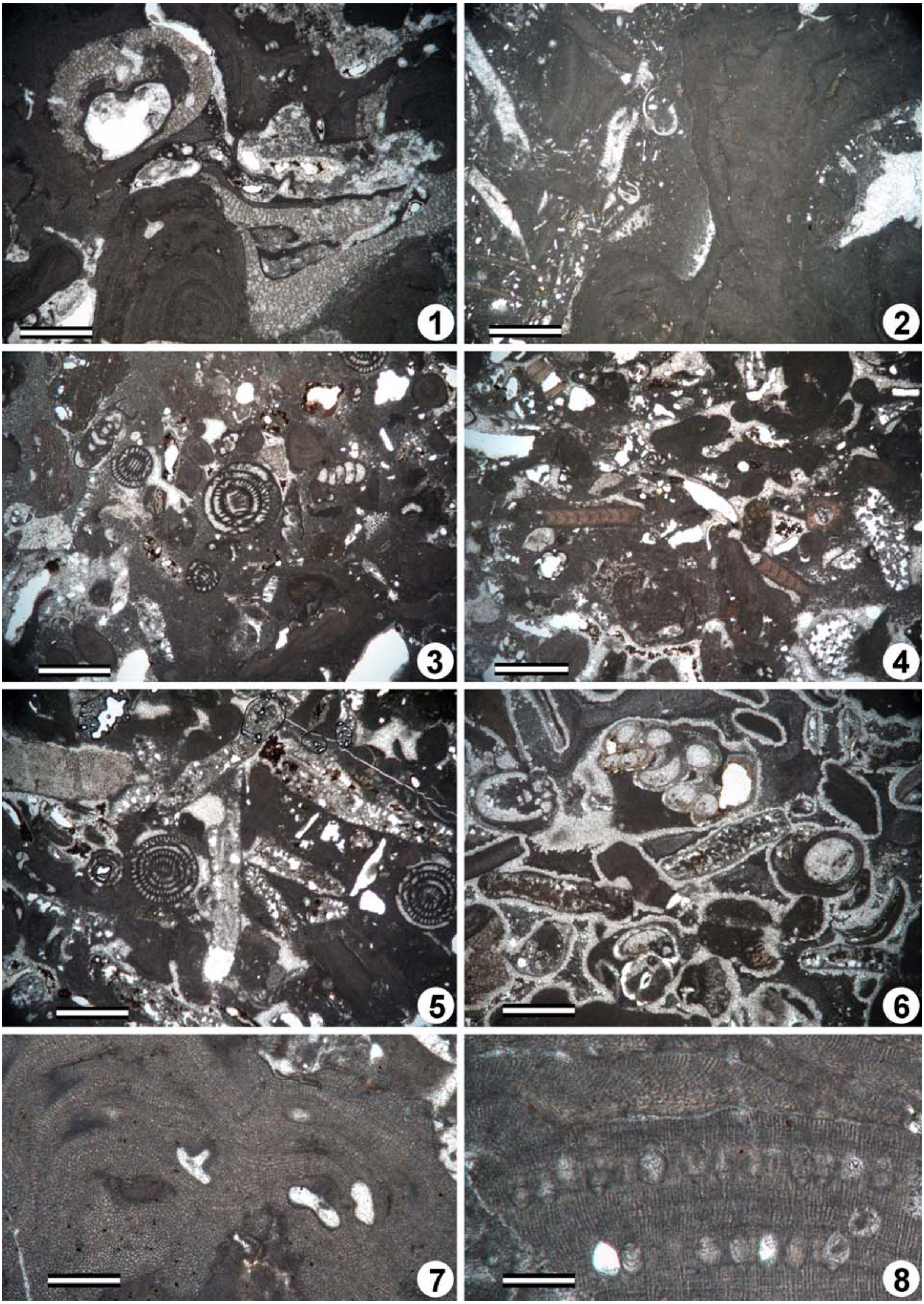

PLATE III