MICROFACIES AND MICROFOSSILS OF THE UPPER TITHONIAN–LOWER BERRIASIAN CALCAREOUS KLIPPES FROM AMPOIȚA (WEST OF ALBA IULIA, ROMANIA)

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Abstract. The carbonate breccias that build-up the isolated limestone klippes from Ampoița (Metaliferi Mountains, Romania) represent gravitational flow sediments deposited at the base of the slope. Microfacies, biotic composition, a high contribution of binding and baffling organisms (algae, sponges and microproblematica) indicate a source area characterized by bioconstructions situated, probably, on the uppermost slope. The biogenic components of the carbonatic clasts that form the breccia are dominated by corals, sponges, microbial crusts and microproblematic organisms. Bryozoans, echinoderms, serpulids, bivalves, foraminifera and green algae are subordinate. Four types of carbonate microfacies were distinguished: coral-microbial boundstone, bindstone (algal microbial crusts), lithoclastic-bioclastic rudstone and intraclastic-bioclastic grainstone. Based on the micropaleontological assemblage, the calcareous blocks from Ampoița can be assigned to the Late Tithonian–Early Berriasian.

Keywords: microfacies, microfossils, calcareous klippes, wildflysch, Metaliferi Mountains (Romania).

INTRODUCTION

The wildflysch sequences within the Mesozoic deposits from South Apuseni Mountains contain frequent calcareous klippes (olistoliths) which represented essential structural elements in the formation of these deposits. Pietrele Ampoiței (=Ampoița Stones), described below, are good examples of such elements. In the geological literature Pietrele Ampoiței are known as calcareous klippes (Bleahu & Dimian, 1967). These klippes exhibit limestone breccias whose microfacies, micropaleontological composition and depositional features are the subject of our study.

LOCATION AND STRATIGRAPHIC FRAMEWORK

Pietrele Ampoiței are situated on the southern border of Trascău Mountains, on the left flank of Ampoi Valley, eight kilometers away from Alba Iulia town (Fig. 1).

The calcareous klippes from Ampoița belong to Meteş Formation (Bleahu & Dimian, 1967) included in the Feneş Nappe (Lupu M., 1975) of the Transylvanides (Săndulescu, 1984; Balintoni, 1997). The Transylvanides represent antithetical nappes, consisting of magmatic rocks and associated sedimentary series (Balintoni, 2001). The Transylvanides were emplaced during the Austrian tectonic phase and they were reworked during the Laramian phase (Balintoni, 1997; 2001).

The Upper Aptian-Middle Albian Meteş Formation has a typical wildflysch character. It implies two members (Lupu D. & Sornay, 1978): a "lower member" characterized by an olistostrome with some interbedded turbiditic and thick-layered sandstones, and an "upper member" consisting of breccias with a marly-silty matrix and olistoliths represented by ofiolitic rocks, Upper Jurassic massive limestones, granodioritic rocks and Lower Cretaceous sandstones (Bleahu et al., 1981).

GEOLOGY OF STUDY AREA

This study focuses on three isolated white limestone blocks, generically known as Pietrele Ampoiței (=Ampoița Stones) (two on the western side of the valley, and the largest one on the eastern side) with heights between 15 and 44 meters (Pl. I, Figs 1-2). A closer look at the limestone blocks reveals their breccious nature. This calcareous breccia is made up of angular to subrounded poorly sorted clasts, with sizes varying from gravel to boulder size; they are embedded in scarce, very fine-grained matrix (Pl. I, Figs 3-4).

On the surface of the eastern block, beside carbonate clasts, angular to subrounded volcanic clasts of varying dimensions are also present (Pl. I, Fig. 7).

No visible volcanic clasts could be observed on the surface of the two western blocks; in turn we observed large corals and algae fragments (Pl. I, Figs 5-6).

In-between the two large blocks, in a lower position, we found mixed siliciclastic-carbonate rocks representing the wildflysch deposits that embedded the limestone blocks (Fig. 2, A-in base). These deposits are represented by sandy limestones with sparitic matrix and angular, fine sand-sized quartz grains, glauconite grains, ooids (Fig. 2, B, E). Bioclasts are represented by echinoderm plates, bivalve fragments, green algae, foraminifera [miliolids, textularids, *Andersenolina odukpaniensis* (DESAUVAGIE) (Fig. 2, D), cf. *Palorbitolina lenticularis* (BLUMENBACH) (Fig. 2, C)], as well as the microproblematica *Crescentiella morronensis* (CRESCENTI) and *Koskinobulina socialis* CHERCHI & SCHROEDER. These bioclasts were probably reworked and redeposited within the siliciclastic sand.

The presence of cf. *Palorbitolina lenticularis* and *Andersenolina odukpaniensis* within the sandy limestone hosting the olistoliths indicates an Late Barremian-Early Aptian age (Masse, 1976; Arnaud-Vanneau, 1980; Bucur, 1997a) for the formation of the wildflysch deposits.

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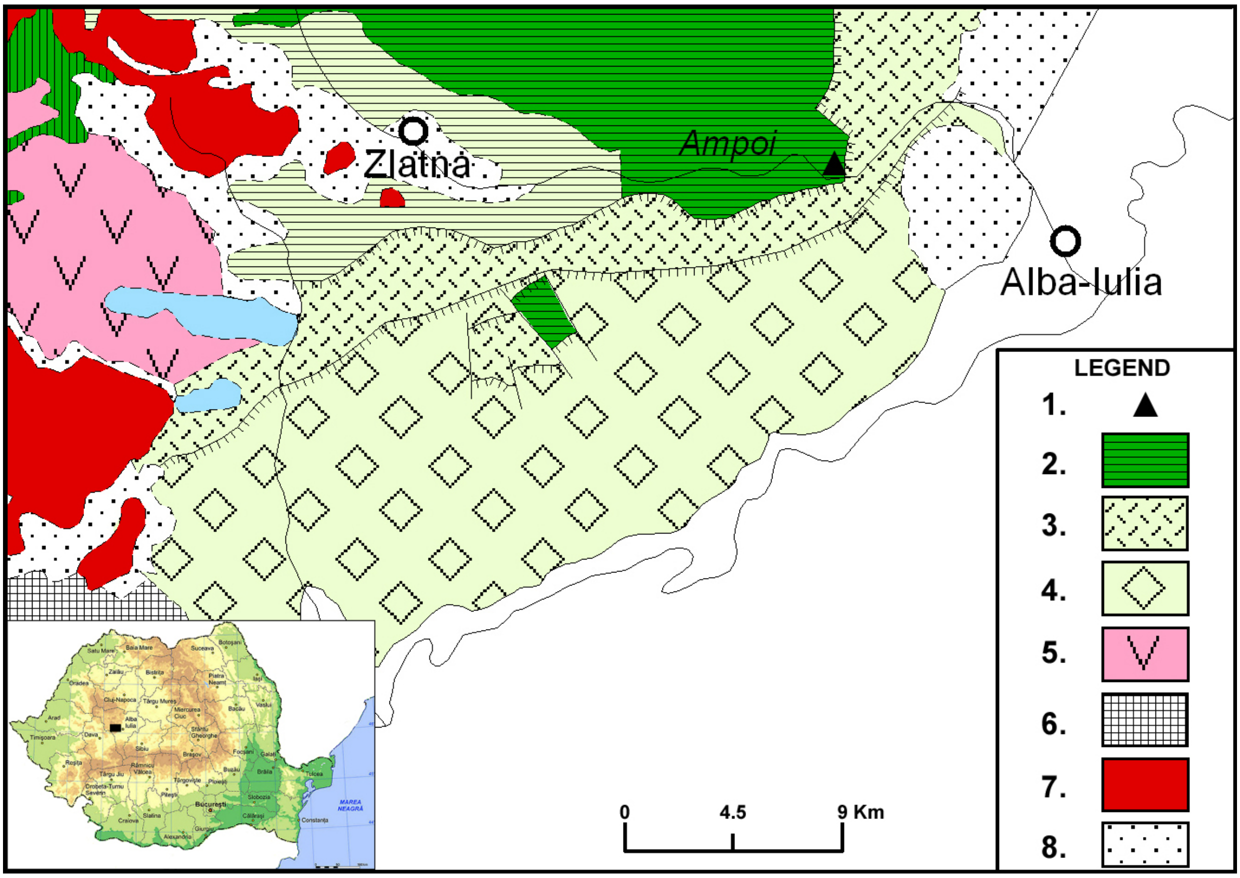

Figure 1.– Location of the studied area. 1. Location of the studied section (Pietrele Ampoiţei); 2. Feneş Nappe; 3. Valea Mică-Galda Nappe; 4. Bozeş Nappe; 5. Căpâlnaş-Techereu Nappe; 6. Metamorphic rocks; 7. Magmatic rocks; 8. Cenozoic sedimentary formations.

MICROFACIES AND MICROPALEONTOLOGICAL ASSEMBLAGE

The calcareous breccia of the limestone blocks from Pietrele Ampoiţei consists of four microfacies types: (1) coral-microbial boundstone; (2) bindstone (microbial algal crusts); (3) lithoclastic-bioclastice rudstone and (4) intraclastic-bioclastic grainstone. The most common microfacies types are rudstones (occurring in about half of the total samples) and boundstones (in about 38 % of the samples), followed by bindstone and grainstone (rare).

(1) Coral-microbial boundstone

Bioconstructions are generated by high-growing communities represented here only by corals who appear free or encrusted by various organisms such as red algae, bryozoans, foraminifera and some microproblematic organisms (Pl. II, Fig. 1). The most frequently identifiable encrusting microfossils are *Thaumatoporella parvovesiculifera* (RAINERI), *Lithocodium aggregatum* ELLIOTT, *Koskinobulina socialis* CHERCHI & SCHROEDER, *Bacinella irregularis* RADOIČIĆ and endolithic borers (*Troglotella incrustans* WERNLI & FOOKES). Low-growing communities such as sponges, bryozoans and microproblematic organisms (e.g., *Crescentiella morronensis*) also contribute to trapping of the sediment. Sponges (*e.g.*, sclerosponge-type *Ellipsactinia*) are quite common in thin-sections; they occur isolated, but locally also as concentrations (Pl. II, Fig. 2). Bryozoans occur together with sponges, microproblematic organism and algal microbial mats.

The most common and significant biogenic structure within the Pietrele Ampoiţei limestone blocks is the microproblematic microfossil *Crescentiella morronensis* (CRESCENTI) (Pl. III, Fig. 10). *Crescentiella* is an important binding organism within the shallow part of the reef front. It dominates in high-energy zones (Pomoni-Papaioannou et al., 1989; Senowbari-Daryan et al., 2008).

Dasycladacean algae are also important constituents of bioconstructions. One good example is *Neoteutloporella socialis* (PRATURLON), species that formed algal meadows and small biostromes in outer carbonate platform environments in the Oxfordian–Tithonian interval (Dragastan et al., 1987). Small peloids and cavities filled with sparry cement have been observed between the algae thalli (Pl. III, Fig. 1). Solenoporacean red algae (*"Solenopora"* sp.) are also present in some of the boundstones (Pl. III, Fig. 2).

The matrix between and around the bioconstructions is often represented by microbial crusts which bound the intrareefal sediment, and by fine-grained microbial-peloidal packstone (probably also of microbial origin) with foraminifera, algae, echinoderm plates, worm tubes, fragments of brachiopods, microproblematica [*Labes atramentosa* ELIAŠOVA (Pl. III, Fig. 9),

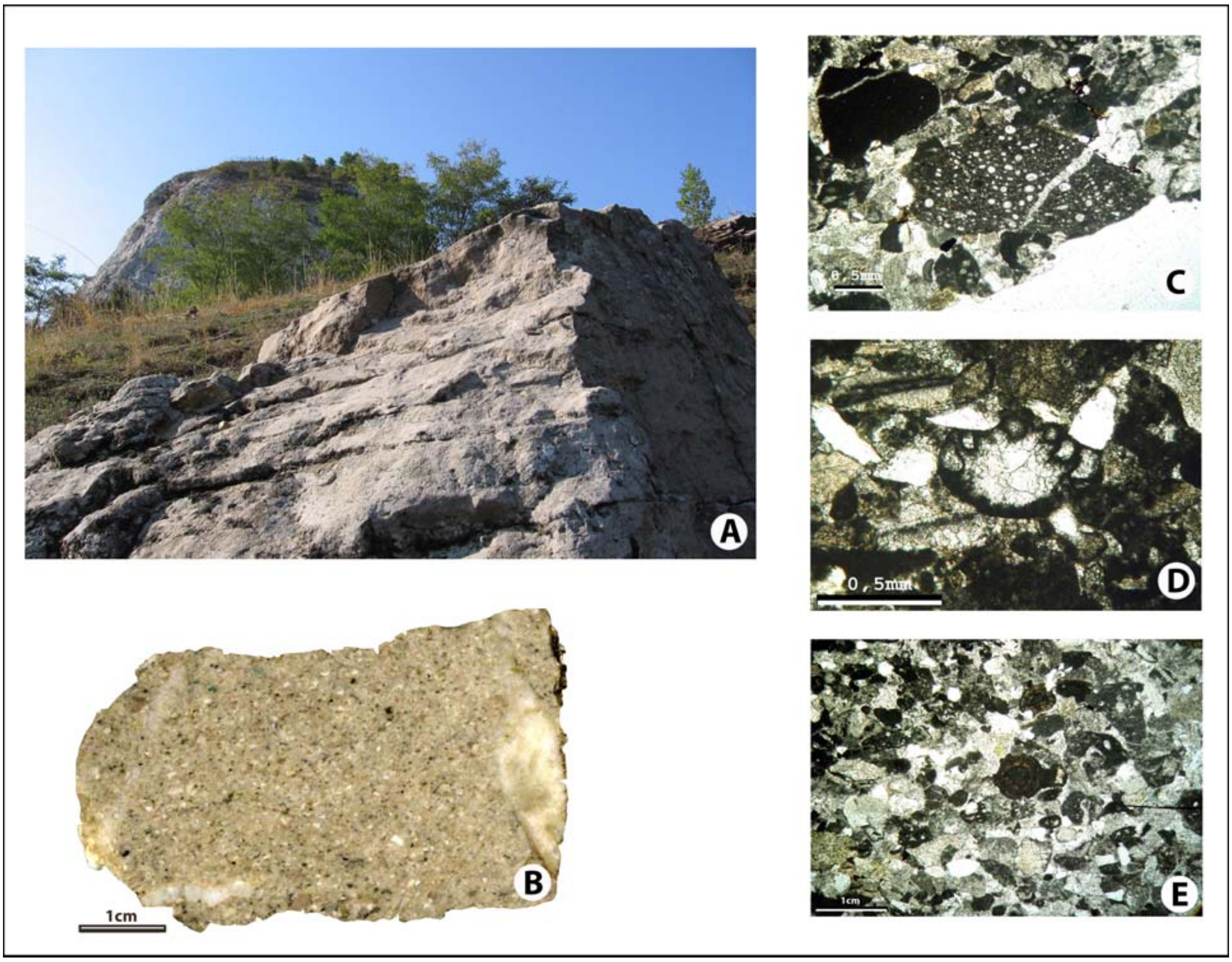

Figure 2 – Wildflysch deposits containing the studied olistoliths. **A** - mixed siliciclastic carbonate rocks (base of the photo); **B** - polished slab of the sandy allochemic limestone; **C**-**E** - thin section of the same sample as in B; **E** - sandy allochemic limestone consisting of fine sand-sized calcareous (ooids, peloids, lithoclasts) clasts, volcanic lithoclasts and quartz grains; **C** - cf. *Palorbitolina lenticularis* (note the agglutination of sponge rhaxes); **D** - *Andersenolina odukpaniensis*.

Radiomura cautica SENOWBARI-DARYAN & SCHÄFER (Pl. III, Fig. 8), *Iberopora bodeuri* GRANIER & BERTHOU (Pl. III, Fig. 11), *Koskinobulina socialis* CHERCHI & SCHROEDER (Pl. III, Fig. 7)] and cyanobacteria [*Diversocallis* sp. (Pl. III, Fig. 12), and *Rivularia* sp.]. Very small filaments occurring within the packstone matrix may represent relicts of cyanobacteria which were rapidly destroyed (Brandner et al., 1991). Frequently the matrix between the bioconstructions contains small micritic peloids originating from the vital activity of bacterial colonies (Kazmierczak et al., 1996; Brandner et al., 1991, Chafez, 1986). This facies presents solution voids filled with vadose silt, indicating subaerian exposure.

(2) Bindstone (microbial algal crusts)

This microfacies type is commonly associated with the rudstone facies. Biogenic crusts play an important role in the stabilization of the substrate and are the most common elements contributing to the formation of bindstones.

Bindstones consist of two biogenic crust types showing different compositions: (a) Micritic crusts and (b) “Festooned” crusts (Bradner et al., 1991).

(a) Micrite crusts are important constituents of the reef rocks and are characterized by irregular thin micrite laminae separating packstone areas consisting of very small peloids, sometimes accompanied by ooids and small intraclasts (Pl. II, Fig. 3). These micrite crusts may show irregular or domal shapes, but they may also form nodules (oncoids). Oncoids are built-up of thin micrite crusts separating a densely fine peloidal packstone with *Crescentiella morronensis* and echinoderm plates (Pl. II, Fig. 4).

Micritic crusts are generally attributed to algal or bacterial activity (*e.g.* Pomoni-Papaioannou et al., 1989).

(b) “Festooned” crust bindstones were interpreted as partially induced by bacteria and fungi (Bradner et al., 1991). They are defined by a festoon-shape and they generate large biogenic structures consisting of irregular, interrupted thin micrite laminae and thicker sparite areas. This is the most common crust type identified during this study (Pl. II, Fig. 5).

Beside biogenic crusts, some encrusting organisms such as bryozoans, foraminifera and microproblematica (*Radiomura cautica* Senowbari-Daryan & SCHÄFER and *Baccinella-Lithocodium-Thaumatoporella* association-type) take part to the stabilization of the sediment and the rapid lithification of the reef slopes. Serpulid tubes (*Mercierella dacica* DRAGASTAN) (Pl. III, Fig. 13) are also common in this microfacies type.

(3) Lithoclastic-bioclastic rudstone

Rudstone microfacies type is the most common one; it consists of carbonate lithoclasts, isolated bioclasts and sometimes extraclasts (Pl. II, Figs. 6-7).

Lithoclasts are generally poorly sorted, angular, subrounded or rounded, showing varying sizes and chaotic sedimentation. They are represented by fragmented boundstone clasts with corals, sponges, green algae or microbial crusts with serpulids, peloidal-bioclastic grainstone/packstone, peloidal microbial packstone with small foraminifera or by packstone/wackstone with sponge spicules, ooids and calpionellids [*Calpionella alpina* LORENZ (Pl. IV, Fig. 15) and *Tintinopsella* sp. (Pl. IV, Fig. 16)]. Extraclasts are represented by angular to subrounded volcanic clasts and quartz grains, while the isolated and often broken fossils are represented by corals (frequently encrusted), sponges, bryozoans, echinoderm plates with syntaxial cement, crab fragments (*Carpathocancer* sp.) (Pl. III, Fig. 14), bivalves, brachiopods, gastropods; microproblematica [*Crescentiella morronensis* (CRESCENTI) is very common, accompanied by *Koskinobulina socialis* CHERCHI & SCHROEDER, *Iberopora bodeuri* GRANIER & BERTHOU], rivulariacean-type cyanobacteria (*Rivularia* sp., *Diversocallis* sp.), solenoporaceae (*"Solenopora"* sp.), foraminifera and green algae. Bioclasts are more common than lithoclasts.

The bioclasts and lithoclasts may be surrounded by rims of fibrous and radiaxial calcite cement, the remaining pore space being filled by drusy cement. Sometimes lithoclasts and bioclasts appear dissolved. The enlarged intra- and interparticle voids were lined by dog-tooth cement and filled with vadose crystal silt.

The clasts that build-up the rudstone microfacies reflect their source area. They derived from the reef and from the peri-reefal deposits, as individual bioclasts or other carbonate grains with varying shapes, sizes and random orientation. The composition and fabric of these deposits are characteristic for gravity flow deposits.

(4) Intraclastic bioclastic grainstone

Limestones exhibiting only fine-grained grainstone microfacies are rare. Grains are represented by well-sorted micritic small peloids, subrounded intraclasts and micritised or recrystallised bioclasts (Pl. II, Fig. 8). The intraclasts consist of broken boundstone, peloidal packstone with sponge spicules and peloidal packstone/wackstone with small foraminifera. Fossils occurring together with smaller intraclasts are represented by echinoderm plates (sometimes with syntaxial cement), bivalve fragments, small gastropods, *Crescentiella morronensis*, isolated corals, small ooids with a very thin radial structure, serpulids, algae and small benthic foraminifera.

AGE OF THE CALCAREOUS KLIPPES

The following micropaleontological association has been identified in the limestone pebbles forming the breccia: foraminifera [*Andersenolina alpina* (LEUPOLD) (Pl. IV, Fig. 1), *Andersenolina* cf. *perconigi* NEAGU (Pl. IV, Fig. 4), *Andersenolina* cf. *molesta* (GORBACHIK) (Pl. IV, Fig. 2), *Trocholina* sp. (Pl. IV, Fig. 5), *Neotrocholina* sp. (Pl. IV, Fig. 14), *Charentia evoluta* (GORBATCHIK) (Pl. IV, Fig. 11), *Protopeneroplis ultragranulata* (GORBACHIK) (Pl. IV, Fig. 6), *Nautiloculina bronnimanni* ARNAUD-VANNEAU & PEYBERNÈS (Pl. IV, Fig. 9), *Everticyclammina* sp. (Pl. IV, Fig. 7), *Kurnubia* sp. (Pl. IV, Fig. 8), *Mohlerina basiliensis* (MOHLER) (Pl. IV, Fig. 3), *Troglotella incrustans* WERNLI & FOOKES (Pl. IV, Fig. 13), *Spirillina* sp. (Pl. IV, Fig. 12), *Coscinophragma* sp. (Pl. IV, Fig. 10)], and algae [*Neoteutloporella socialis* (PRATURLON) (Pl. III, Fig. 1), *Salpingoporella pygmaea* (GUEMBEL) (Pl. III, Fig. 3), *Salpingoporella annulata* CAROZZI (Pl. III, Fig. 5), *Salpingoporella* sp.(Pl.III, Fig. 4), and *Clypeina sulcata* (ALTH) (Pl. III, Fig. 6)].

Among the foraminifera, the *Andersenolina* assemblage is typical for the basal Lower Cretaceous (Berriasian-Valanginian) (Arnaud-Vanneau et al., 1988; Neagu, 1994; Bucur et al., 1995; Bucur & Săsăran, 2005), although *Andersenolina alpina* has been reported also from Upper Jurassic deposits (Altiner, 1991; Ivanova, 2000; Schlagintweit et al., 2005). *Protopeneroplis ultragranulata* is known from the Middle Tithonian to the Lower Barremian (Bucur, 1993, 1997b), but the most frequent occurrence of this species has been recorded from the Berriasian-Valanginian interval (Boisseau 1987; Granier 1987; Chiocchini et al. 1988, 1994; Bucur et al. 1995, Schlagintweit et al., 2005). Other foraminiferal species have a broader stratigraphical distribution.

The same is valid for the calcareous algae association, except for *Clypeina sulcata* that is typical for the Kimmeridgian–Berriasian interval (Granier & Deloffre, 1993; Bassoullet, 1997; Bucur, 1999). *Neoteutloporella socialis* is also regarded as an Upper Jurassic marker (Dragastan et al., 1987; Granier & Deloffre, 1993; Bassoulet, 1997; Bucur, 1999).

Thus, the whole micropaleontological assemblage consisting of foraminifera and algae is typical for the Late Tithonian-Berriasian of the tethyan realm.

CONCLUSIONS

The limestone klippes from Ampoița exhibit clast-supported, poorly-sorted limestone breccia consisting of angular and rounded clasts of different sizes. The microscopic study of the clasts revealed the polymictic character of the breccia, the limestone pebbles displaying four facies association types (in decreasing frequency order): coral-microbial boundstone, microbial algal crusts, lithoclastic-bioclastic rudstone and intraclastic bioclastic grainstone.

The interpretation of microfacies types shows that the pebbles were eroded from a bioconstructed platform margin (coral-microbial boundstones) and from its upper and middle slope (rudstones and bindstones). The less common peloidal grainstone facies containing small foraminifera and green algae might have derived from the platform itself. This eroded and reworked material was then subject of downslope transportation by gravity flow processes and finally deposited in a base-of-slope position (possibly as channel infillings).

The age of the limestone pebbles that form the klippes is Late Tithonian-Berriasian. The presence of cf. *Palorbitolina lenticularis* and *Andersenolina odukpaniensis* in the sandy allochemic limestones situated at the base of the olistoliths indicates an Late Barremian–Early Aptian age for the wildflysch deposits themselves.

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PLATES

Plate I

Fig. 1-2 – View on the limestone klippes from Ampoița: the western blocks (fig. 1) and the eastern block (fig. 2).
Fig. 3-4 – The calcareous blocks consist of poorly sorted, subangular to subrounded carbonate clasts with gravel- to block-size dimensions, embedded in a scarce fine-grained matrix.
Fig. 5-6 – Large coral colonies occurring on the surface of the blocks. They are more frequent on the surface of the two western blocks.
Fig. 7 – Angular to subrounded volcanic clasts with varying sizes visible on the surface of the largest block.

Plate II

Fig. 1 – Coral-microbial boundstone. Corals are encrusted by microbialites. The internal sediment is represented by peloidal packstone (probably of microbial origin), the remaining pores were filled by drusy cement; sample X1.
Fig. 2 – Bioconstruction with sclerospongea-type *Ellipsactinia*; sample 147.
Fig. 3 - Micrite crusts with irregular thin micrite laminae separating packstone areas with small peloids; sample 164.
Fig. 4 – Micrite crusts with nodular structure (oncoids) consisting of thin micrite crusts separating fine peloidal packstone with *Crescentiella morronensis* and echinoderm plates; sample 151.
Fig. 5 - Microsolenid coral surrounded by festoon-shaped crusts (upper part); sample 169.
Fig. 6 – Lithoclastic-bioclastic rudstone with *Crescentiella morronensis*; sample 150.
Fig. 7 – Rudstone containing lithoclasts represented by microbial peloidal crusts and bioclasts such as foraminifera, bryozoans, *Crescentiella morronensis* and *Diversocalis* sp.; sample 174.
Fig. 8 – Bioclastic-peloidal grainstone to packstone with numerous small benthic foraminifera; sample 160.

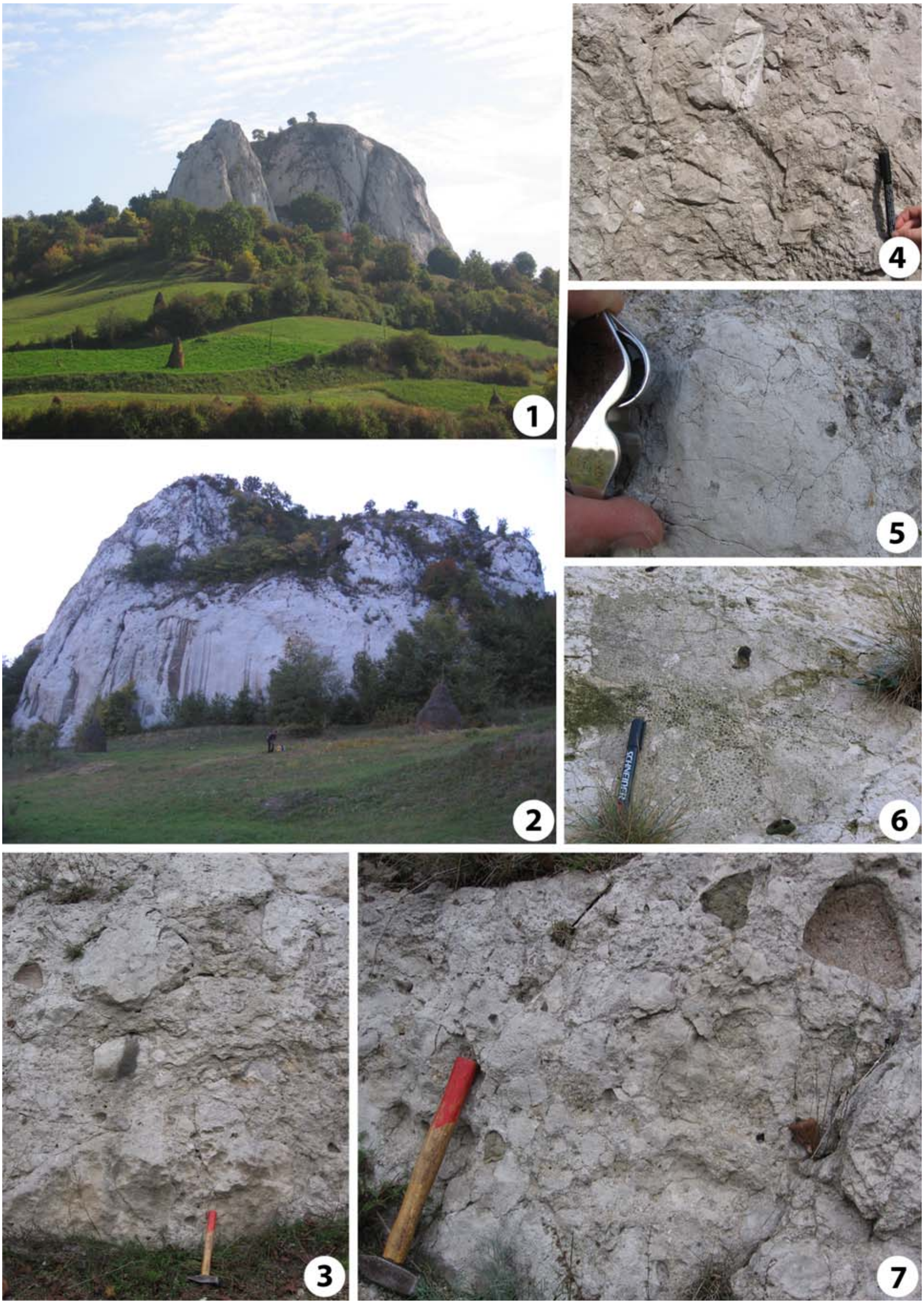
Plate III

Fig. 1 - *Neoteutloporella socialis* (PRATURLON); sample 155.
Fig. 2 - *“Solenopora”* sp.; sample 186.
Fig. 3 – *Salpingoporella pygmaea* (GÜMBEL); sample 143.
Fig. 4 – *Salpingoporella* sp.; sample 174.
Fig. 5 – *Salpingoporella annulata* CAROZZI; sample 146.
Fig. 6 – *Clypeina sulcata* (ALTH); sample 175.
Fig. 7 – *Koskinobulina socialis* CHERCHI & SCHROEDER; sample 158.
Fig. 8 – *Radiomura cautica* SENOWBARI-DARYAN & SCHÄFER; sample 169.
Fig. 9 – *Labes atramentosa* ELIAŠOVA; sample 169.
Fig.10 – *Crescentiella morronensis* (CRESCENTI); sample 185.
Fig. 11 – *Iberopora bodeuri* GRANIER & BERTHOU; sample 143.
Fig. 12 – Rivulariacean-type cyanobacteria - *Diversocallis* sp.; sample 176.
Fig. 13 – *Mercierella dacica* DRAGASTAN; sample 151.
Fig. 14 – *Carpathocancer* sp.; sample 148.

Plate IV

Fig. 1 - *Andersenolina alpina* (LEUPOLD); sample 158.
Fig. 2 – *Andersenolina* cf. *molesta* (GORBACHIK); sample 154.
Fig. 3 – *Mohlerina basiliensis* (MOHLER); sample 166.
Fig. 4 – *Andersenolina* cf. *perconigi* NEAGU; sample 157.
Fig. 5 – *Trocholina* sp.; sample 157.
Fig. 6 – *Protopeneroplis ultragranulata* (GORBACHIK); sample 163.
Fig. 7 – *Everticyclammina* sp.;sample 160.
Fig. 8 – *Kurnubia* sp.; sample 148A.
Fig. 9 – *Nautiloculina bronnimanni* ARNAUD-VANNEAU & PEYBERNÈS; sample 149.
Fig. 10 – *Coscinophragma* sp.; sample 158.
Fig. 11 – *Charentia evoluta* (GORBATCHIK); sample 151.
Fig. 12 – *Spirillina* sp., sample 158.
Fig. 13 – *Troglotella incrustans* WERNLI & FOOKES; sample 150.
Fig. 14 – *Neotrocholina* sp.; sample 142.
Fig. 15 – *Calpionella alpina* LORENZ; sample 150.
Fig. 16 – *Tintinopsella* sp.; sample 143.

PLATE I



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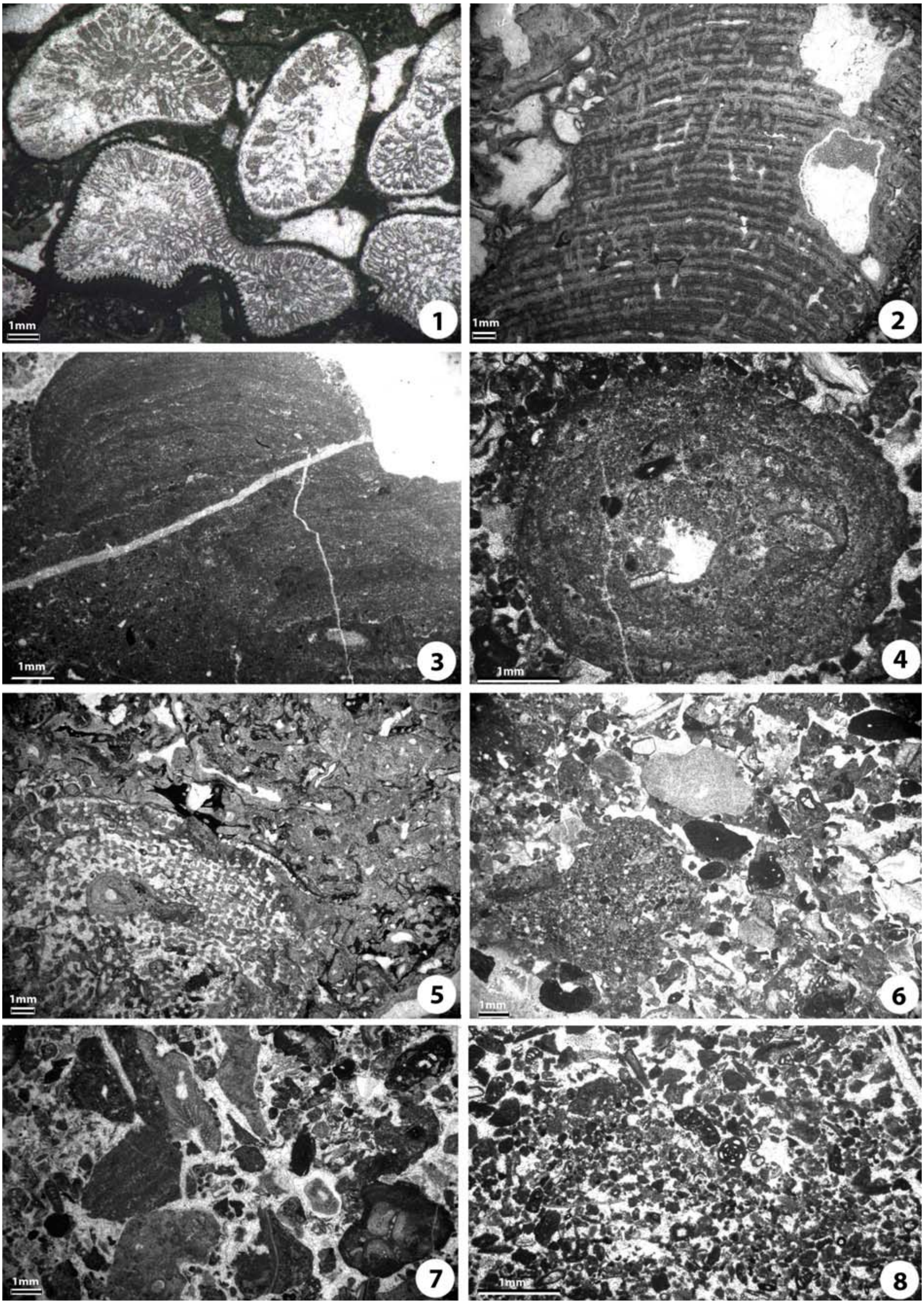

PLATE III

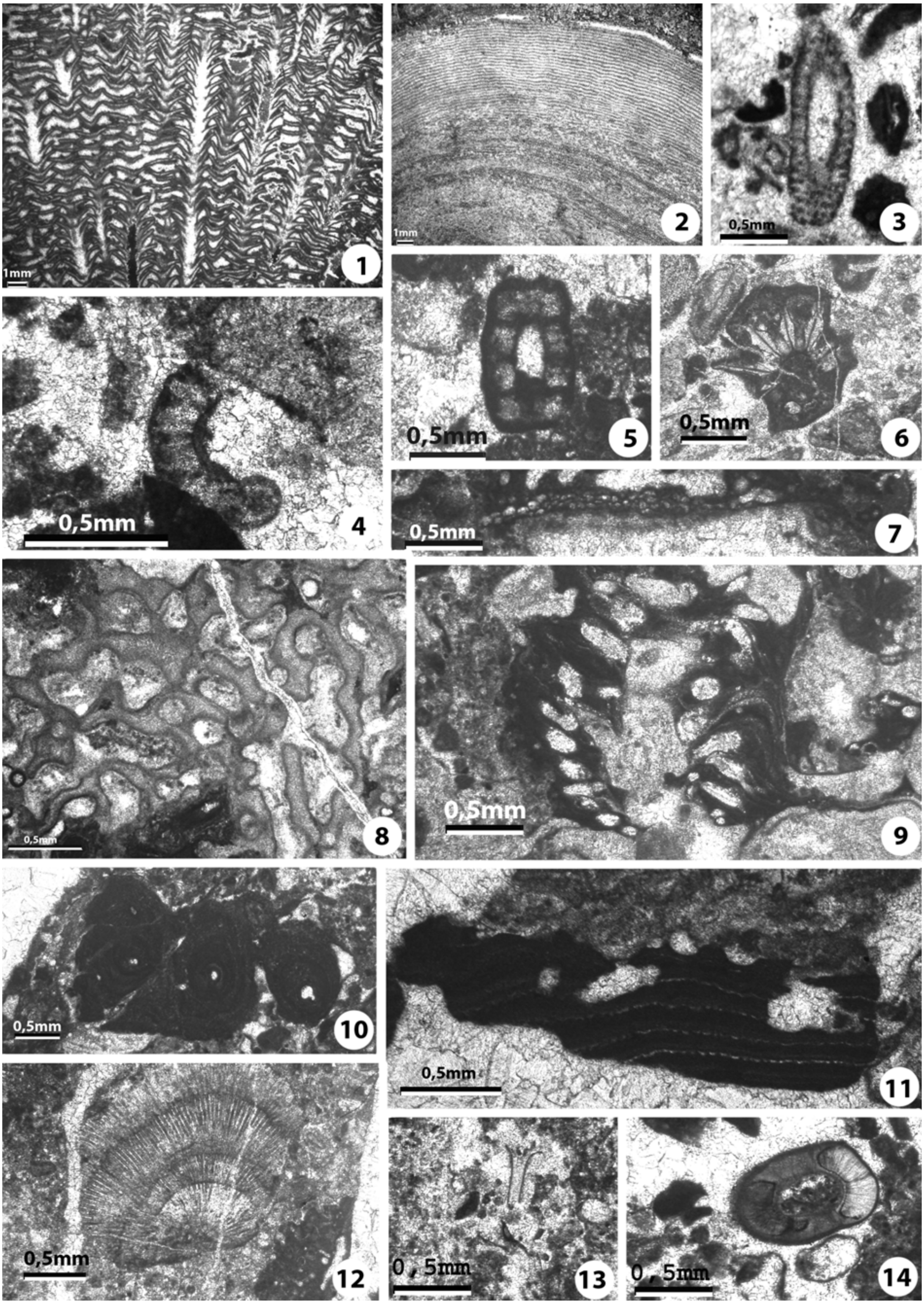
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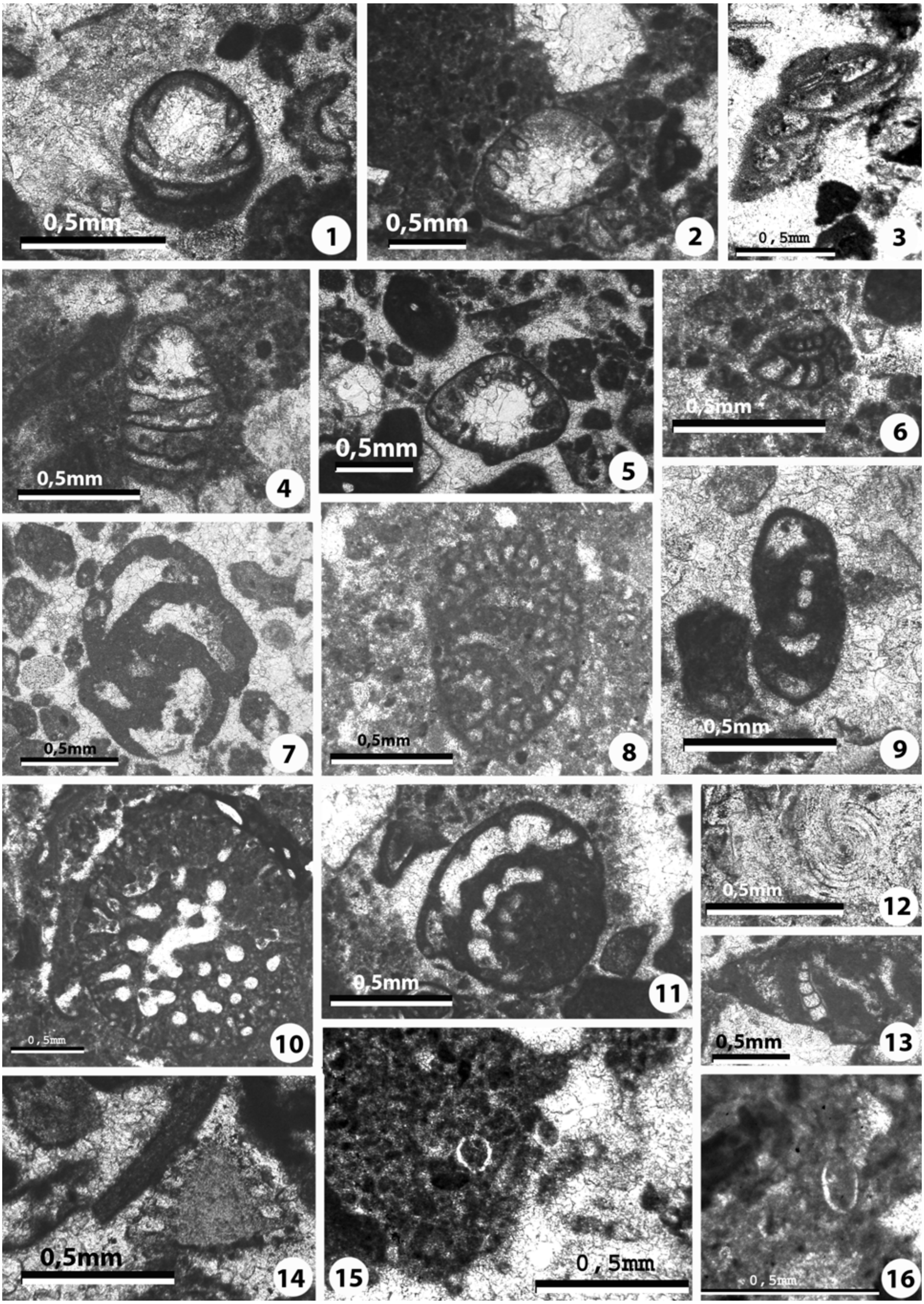
PLATE IV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