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UPPER CRETACEOUS RUDIST-BEARING MIXED SILICICLASTIC-CARBONATE AND - VOLCANOCLASTIC DEPOSITS FROM STRÂMTURII VALLEY, BOROD BASIN, NORTHERN APUSENI MOUNTAINS: DESCRIPTION, MICROFACIES AND DEPOSITIONAL ENVIRONMENTS

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Abstract The Upper Cretaceous deposits exposed in the eastern part of Borod Basin (Corniţel village area, at the confluence of Strâmturii Valley and Cioroi-Negru Brook) unconformably overlie rhyolitic lavas. The most common lithologies are represented by alternance of marls, sandstones and conglomerates with intercalated two carbonate lithosomes rich in rudists. Rhyolitic tuffs cap the examined section. The rudist fauna comprises the next genera: *Bournonia*, *Gorjanovicia*, *Praeradiolites*, *Radiolites*, *Sphaerulites*, *Hippuritella* and *Vaccinites*. A number of species belonging to the fore-mentioned genera have been recognized and taxonomically described. Rudist communities thrived in open shelf environments strongly influenced by high energy regimes and siliciclastic sedimentation during the Upper Cretaceous. Gravity flows were responsible for the processes of reworking and transport of rudists towards the slope or to the shelf slope toe.

Keywords: rudists, bivalvia, microfacies, depositional environments, Upper Cretaceous, Borod Basin, Romania.

INTRODUCTION

The Upper Cretaceous sedimentary deposits widely exposed in Borod Basin have been separated in three distinct sedimentary areas (Givulescu, 1954): (i) the deposits from northern zone of the Borod Basin cropping out within the Cetea-Borod localities; (ii) the outcrops from Corniţel village in the eastern part of the basin; and (iii) the rudists bearing deposits from Valea Neagră de Criș, in the southeastern part of Borod basin, close to the Valea Crișului village (Fig. 1). Since the 19th century these areas have been investigated by numerous researchers owing to economic interests related to the coal accumulations, common in the lower part of the succession. Especially in the last decades, the Upper Cretaceous deposits from Borod Basin were investigated by many authors (Givulescu, 1954; Lupu & Lupu, 1960; Șuraru, 1962, 1972; Istocescu et al. 1965, 1968; Mureșan et al., 1974; Șuraru & Șuraru, 1975; Lupu, 1976; Meszaros et al., 1976; Popa, 1981; Mogoș, 1992; Schuller, 2004; Săsăran et al., 2010), all of them contributing to a better understanding of the stratigraphy, biostratigraphy or tectonic context of the studied areas.

The present study focuses on investigations of two rudist-bearing carbonates from the Cornițel village area, especially on the taxonomy of relatively well preserved rudist fauna but also in description and interpretation of the facies and microfacies characteristics and interpretation of the depositional paleoenvironment.

MATERIAL AND METHODS

The studied section is located in the north-eastern part of Cornițel village (Fig. 1), the outcrop being in the forest, at confluence of Strâmturii Valley and Cioroi-Negru Brook (co-ordinates: 46°59'15.18"N; 22°39'46.59"E). Representative rock samples were collected at every change in lithology and chosen for thin sections (Fig. 2b) in order to obtain microfacies characteristics. The rudist specimens collected from two carbonate levels are represented by entire valves, fragments or embedded shells in limestone. The best preserved rudist shells (nos 24078 to 24090) were prepared in laboratory and high-resolution scan photos were taken on the transverse sections of rudists.

Depository. All specimens of rudists described and/or figured in this study have been registered and kept in the Museum of Paleontology-Stratigraphy (nos 24078 to 24090 BBU-MPS), Department of Geology, Babeș-Bolyai University, Cluj-Napoca, Romania.

GEOLOGICAL SETTING AND STRATIGRAPHY

The Cornițel area is located between Borod Valley to the north, and Măgurii Valley to the south (Fig. 1), where the Upper Cretaceous deposits unconformably overlie the middle Triassic carbonates (Ferchii Brook, Măgurii Valley) or rhyolites (Cioroi-Negru Brook) (Șuraru, 1972). The most comprehensive Upper Cretaceous succession occurs at the confluence of Strâmturii Valley and Cioroi-Negru Brook and is characterized by mixed volcanoclastic and siliciclastic-carbonate deposits that have been previously separated into four units (Șuraru, 1972; Mureșan et al., 1974; Șuraru and Șuraru, 1975), from bottom to top, as follows (Fig. 2a):

Unit I: consists of marls and sandstones with intercalations of conglomerates and two levels of bituminous limestone with *Charophytes* (Șuraru, 1972)**.** From marls levels, besides bivalves and gastropods fragments, Șuraru (1962, 1972) identified a poor coral fauna consisting in a few, solitar coral species: *Trochosmilia* cf. *humilis*, *Trochocyanthus* sp., *Cunnolites pseudonummulus*, *Aulosmilia inconstans*, and *Diploctenium* cf. *mixtum*.;

Unit II: prevailing sandstones-conglomerates follow upwards, with tuffs and marls and two intercalations of

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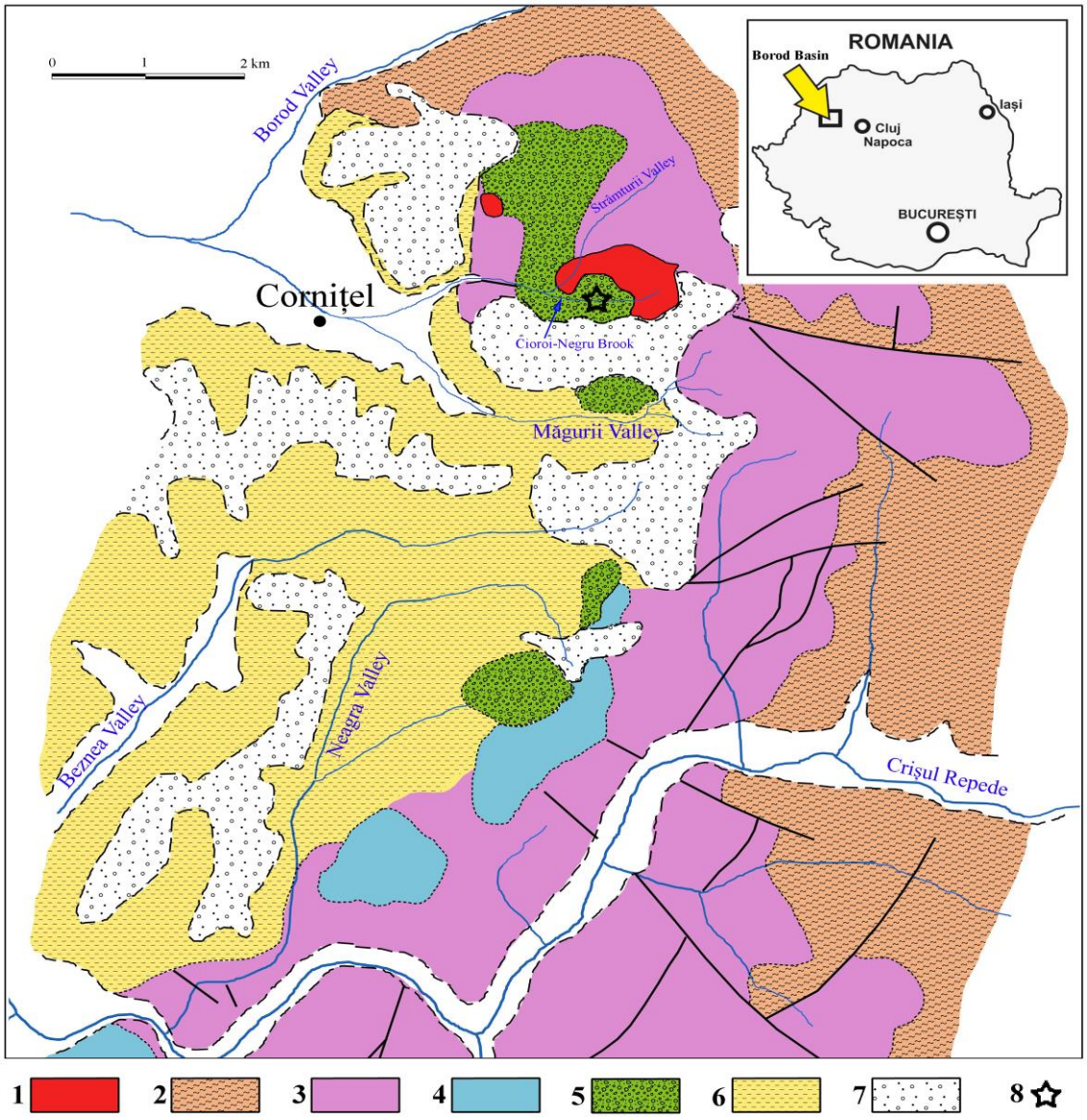

Fig. 1 Geological map of Borod Basin (redrawn after Popa, 1981). Legend: **1** Magmatic rocks; **2** Metamorphic rocks; **3** Triassic; **4** Jurassic; **5** Upper Cretaceous; **6** Miocene; **7** Quaternary; **8** Location of studied area.

rudist-rich carbonate lithosomes previously interpreted as "rudist reefs"(Șuraru, 1972; Popa, 1981; Mogoș, 1992). From these two carbonate intercalations, the rudist species mentioned in literature by Șuraru (1972) and Lupu (1976) consists of four hippuritids and two radiolitids species as follows: *Hippurites nabresinensis, Vaccinites gosaviensis, V. oppeli, V. gaudryi, Sauvagesia* sp. (from the first intercalation) and *Bournonia bournoni* (from the second carbonate intercalation). Unfortunately, only two species (*Sauvagesia* sp. and *Bournonia bournoni*) has been illustrated by Lupu (1976) thus new investigations on this rudist fauna was required. The palynomorph assemblages (Fig. 2a) founded in marls levels of unit II by Mogoș (1992) supports a general Santonian-early Campanian age for these deposits. Unit III: prevailing marls and silty-marls with intercalations of rhyolitic tuffs. Unit IV: a marly unit in which foraminifera and rare fragments of *Inoceramus (Endocostea) balticus* and *Inoceramus (Platyceramus) cycloides*) have been found (Șuraru, 1972). List of planktonic foraminifera identified in the matrix of marls from the unit IV contains *Globotruncana* species (*G. lapparenti, G. thalmani, G. elevata elevata*) and rare lenticulinids, suggesting an early Campanian age for unit IV (Șuraru, 1972; Șuraru and Șuraru, 1975).

Thus, biostratigraphic data based both on macrofossils like rudists (Șuraru, 1972; Lupu, 1976), inoceramids and corals (Șuraru, 1972) and microfossils assemblages especially foraminifera (Șuraru, 1972; Șuraru and Șuraru, 1975) and palynomorph (Mogoș, 1992) indicates a late Santonian-early Campanian age for these deposits.

Unfortunately, at present, many outcrops well known from literature (Givulescu, 1954; Șuraru, 1972; Lupu, 1976) are covered by vegetation. Thus, it is not possible to restore the whole stratigraphic succession described by the fore-mentioned authors from Strâmturii Valley and Cioroi-Negru Brook (Fig. 2a). Considering this situation, our investigations have been focused on the rudist carbonate lithosomes of unit II (Fig. 2b) more precisely

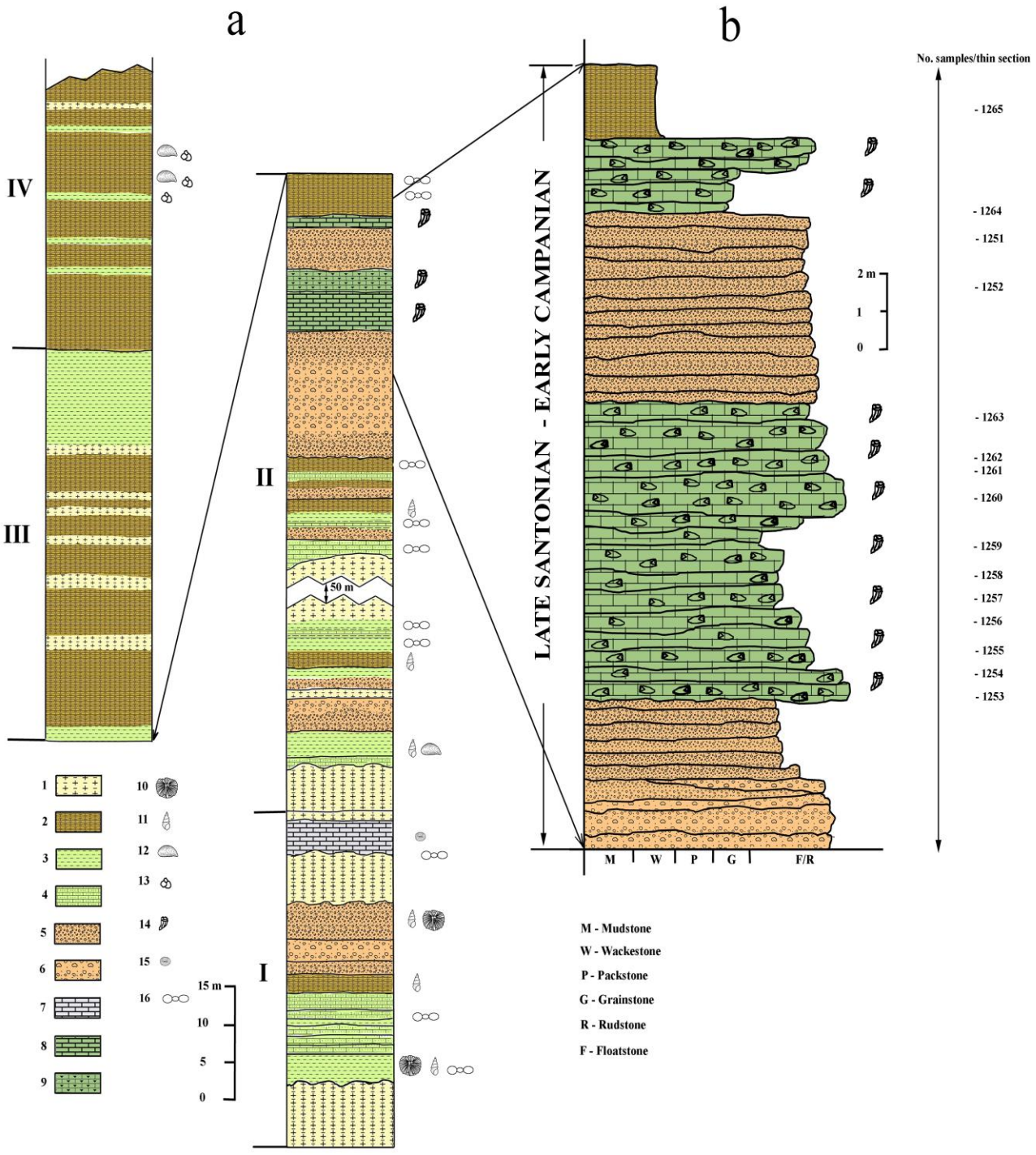

Fig. 2 a Lithostratigraphic succession from Strâmturii Valley and Cioroi-Negru Brook, Cornițel village, Borod Basin (redrawn after Mureșan et al., 1974) showing the units (I, II, III, and IV) defined by Șuraru (1972) and Mureșan et al. (1974). **b** Detailed studied section near the top of the unit II. Legend: **1** tuffs and tuffites; **2** marls; **3** siltic marls; **4** sandy marls; **5** sandstones; **6** conglomerates; **7** limestones with charophytes; **8** hippuritid-bearing limestones; **9** "hippurites reefs"; **10** corals; **11** gastropods; **12** bivalves; **13** foraminifera; **14** rudists; **15** charophytes; **16** palynomorphs.

on the identifications of the rudist fauna and the interpretation of the depositional paleoenvironment.

DESCRIPTION AND INTERPRETATION OF THE FACIES AND MICROFACIES OF RUDIST-BEARING LITHOSOMES

The mixed siliciclastic-carbonate Upper Cretaceous sequence with rudists (middle and upper parts of unit II) from Strâmturii Valley and Cioroi-Negru Brook overlies a volcanoclastic rocks package (of unit I) consisting of rhyolitic lavas approximately 55 to 60 meters thick (Șuraru, 1972) (Fig. 2a). The examined succession begins with 12-50 meters of alternating sandstones, silty marls with a low percentage of quartz sand-sized grains and fossiliferous marlstones. This part of the succession is largely covered by vegetation is some places and cannot be examined. A 4 meters thick package of sandstones with quartz pebbles follows up capped by 10 meters thick package of conglomerates characterized by clayey and limonite-rich cement. Two bodies of grey compacted limestones with rudists, respectively 8 and 2 meters thick, are intercalated within a succession of sandstone and conglomerate beds (Fig. 2a, b). Sandstone and conglomerate beds show sheet-like and lens geometry.

Well rounded to sub-rounded quartz and metamorphic rock fragments form the main clasts of the conglomerate and pebbles-bearing sandstone. Poorly sorted conglomerates contain pebbles, chaotically dispersed within quartz rich silty-sandy matrix.

The first rudist-bearing lithosome, **8** meters thick, is well exposed (Fig. 3a, b). Centimeter to decimeter thick limestone-beds present sheet-like and lens geometry. Some beds show basal erosional structures. Coarse sand to pebble sized, poorly sorted carbonate clasts show angular to subangular shapes. Many limestone beds present a characteristic breccia texture.

Rudist shells are visible within these limestones as isolated specimens randomly dispersed in a coarse, intraclastic-bioclastic sediment (Fig. 3c-d). The rudists are predominantly represented by small elevator radiolitids shells and moreover rare hippuritid shells.

The entire spectrum is dominated by bioclastic-intraclastic floatstone/rudstone microfacies (Fig. 4a-e, g). Generally, the carbonate clasts are poorly sorted with angular to subangular shapes.

The fore-mentioned dominating facies are intercalated with layers of bioclastic-extraclastic packstone / wackestone and grainstone (Fig. 4f, h). Well sorted grainstones contain rudist fragments, echinoderm fragments, rare red algae fragments, bryozoans and benthic foraminifera. Very small foraminifera not well preserved and difficult to establish their benthic or planktonic origin are present in the micritic matrix of the packstone and floatstone. Silty to sandy extraclasts are also present in all the carbonate facies.

Interpretation:

Continental terrigenous input is proved by the presence of sandstones both underlying and overlying the carbonate lithosomes. Pebble origin, size and shapes suggest a possible delivery from an alluvial-fluvial depositional system Sediments were sourced from these areas and they were hypothetically routed through a network of fan deltas towards margin of the shelf and successively down along the slope. Gravity flows were responsible for the deposition of these carbonate rocks. Associated facies types include bioclastic extraclastic packstone/wackestone with small foraminifera that were accumulated from suspension.

The second rudist-bearing lithosome forms two-meter thick outcrop (Fig. 2b). Texture, structures and composition of the limestone beds are similar to the ones described above for the first lithosome. The body comprises various erosionally overlain beds with distinct granulometry (Fig. 3e). The last bed contains abundant rudists, mostly small radiolitids (*Bournonia*, *Gorjanovicia*, *Praeradiolites* and *Radiolites* genera) (Fig. 3f). The rudists specimens collected from this level show the outer layer of the shells strongly abraded and also bioeroded (bioperforated).

Bioclastic-extraclastic floatstone breccias are common (Fig. 5a, c-e). Associated lithofacies include bioclastic-extraclastic rudstone/grainstones (Fig. 5b). Frequent bioclasts are represented by rudist and echinoderm fragments, together with red algae fragments, bivalves, bryozoans and benthic foraminifera. Some rudists are encrusted by foraminifera, cyanobacteria and *Lithocodium aggregatum*. Extraclasts are represented by metamorphic lithoclasts (quartzite, crystalline schists) (Fig. 6a, b), monomineral quartz, muscovite and biotite.

The upwards transition from the carbonate to the siliciclastic units is gradational. The later deposits of the unit II (Fig. 2b) contain alternating silty marls and volcanoclastic sediments (Fig. 6c, d) made by tuffites with altered volcanic glass and various crystalloclasts (angular quartz, biotite and calcite) (Fig. 6c, d).

Interpretation:

Gravity flow deposition is indicated by the presence of reworked rudists and fragments of angular bioclasts which are chaotically embedded in extraclastic micritic matrix. The ”bulk” of the data comprising also the siliciclastic and volcanoclastic sediments suggests that these carbonate deposits were accumulated at the base of the shelf slope through a series of gravity flows. The rudist shells are frequently eroded, indicating a high energy setting, probably in open, marginal sectors of the shelf. High-energy processes and submarine erosion presumably operated migrations of the materials along different sectors of the shelf margin. All these reworking processes were triggered by the collapse of the shelf margin due to seismic, eustatic or tectonic events (uplift-subsidence).

SYSTEMATIC PALAEONTOLOGY

The classification scheme and terminology for higher taxa of rudists used here follows Skelton (2013). Synonymy lists of rudist species described here are not exhaustive, only relevant references to the scope of this paper are included. For more detailed synonymy lists existing until 2002, the free database created by Steuber (2002) can be consulted. Abbreviations used in text and figures: BBU-MPS - Babeș-Bolyai University, Museum of

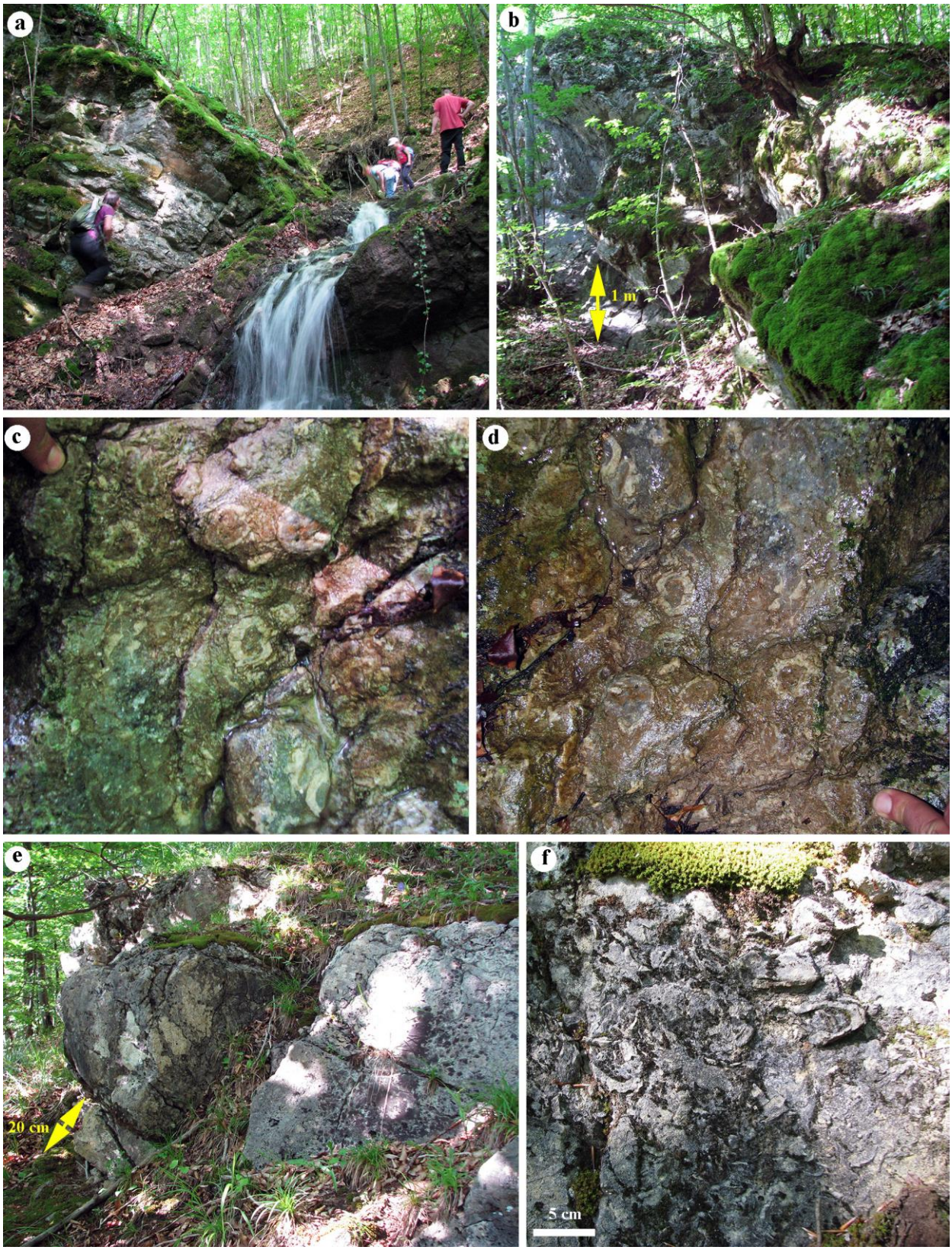

Fig. 3 a, b The first rudist bearing lithosome from Cioroi-Negru Brook; **c, d** Rudists and rudist fragments visible in this outcrop; **e** The second rudist-bearing lithosome; **f** Rudists of the second lithesome. Yellow arrows represent scale bars.

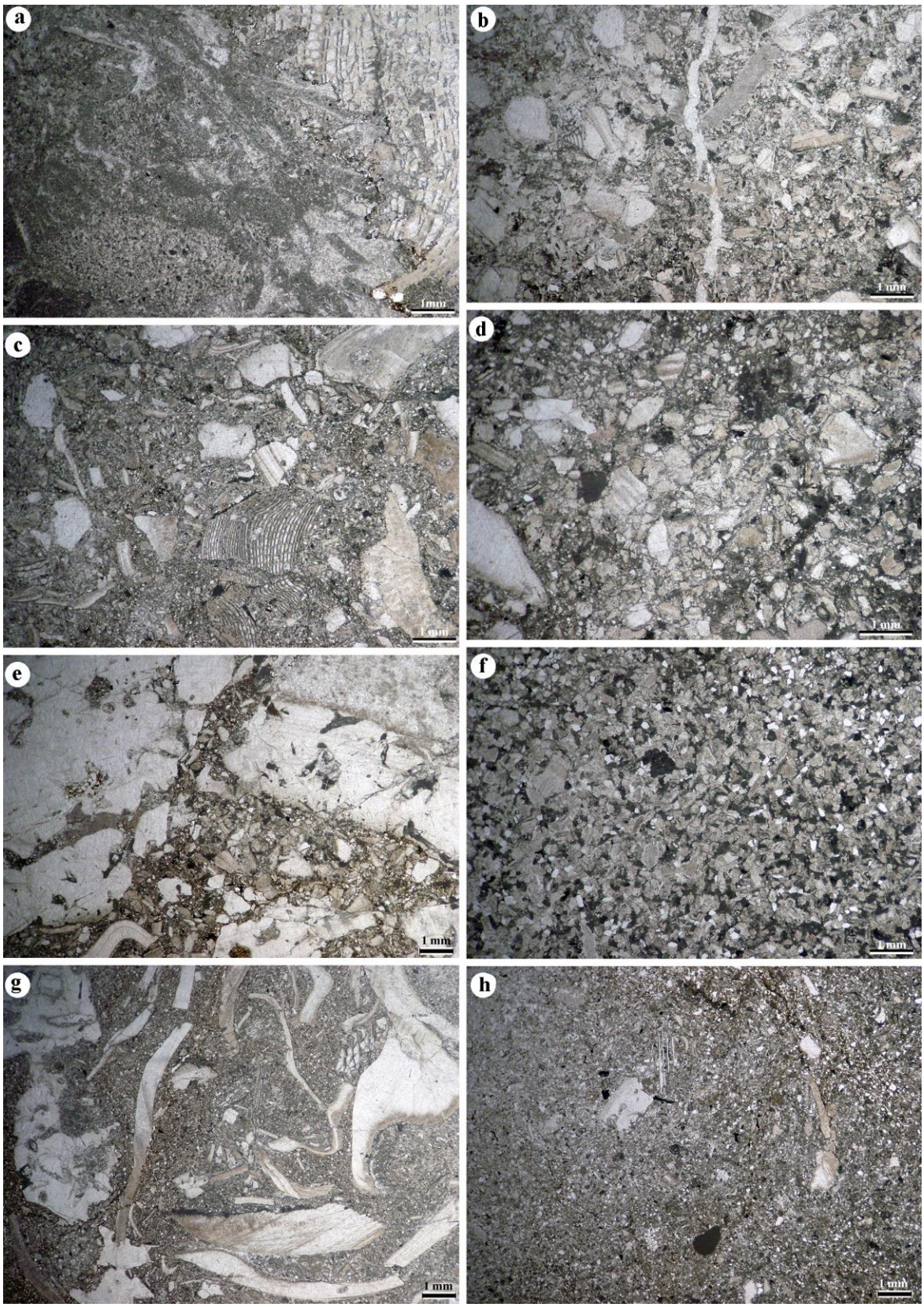

Fig. 4 a, b Microfacies from the first rudist-bearing lithosome. **a-e, g** bioclastic-intraclastic floatstone/rudstone; bioclasts are poorly sorted with angular to subangular shapes. **f** bioclastic-extraclastic grainstone. **h** bioclastic-extraclastic packstone/wackestone.

Palaeontology-Stratigraphy; LV = left valve; RV = right valve; at = anterior tooth; am = anterior myophore; pt = posterior tooth; pm = posterior myophore; ct = central tooth; L = ligament ridge (internal); P1 = first pillar; P2 = second pillar; Vb = ventral radial band; Pb = posterior radial band; Ib = interband; ac = accesory cavity; All scale bars represent 10 mm.

Order Hippuritida Newell, 1965
Superfamily Radiolitoidea! d'Orbigny, 1847
Family Radiolitidae d'Orbigny, 1847
Genus *Bournonia* Fisher, 1887
Type species: *Sphaerulites bournoni* Des Moulins, 1826
***Bournonia excavata* d'Orbigny, 1842**
Fig. 7a-b
1842 *Radiolites excavata*- d'Orbigny, p. 156, 185.
1850 *Radiolites excavata* d'Orbigny- p. 215, pl. 556.
1907 *Bournonia excavata* (d'Orbigny)- Toucas, p. 27, pl. 2, figs. 11-13a.
1912 *Bournonia excavata* (d'Orbigny)- Parona, p. 285, fig. 4.
1968 *Bournonia excavata* (d'Orbigny)- Pejović, pl. 5, fig. 2.
1989 *Bournonia excavata* (d'Orbigny)- Cestari and Sirna, p.145, fig.3.
1992 *Bournonia excavata* (d'Orbigny)- Vicens, p. 185, pl. 74, fig. 1.
1995 *Bournonia excavata* (d'Orbigny)- Caffau and Pleničar, p. 230; pl. 7, figs. 2, 2a; pl. 12, fig.3.
1995 *Bournonia excavata* (d'Orbigny) - Cestari and Sartorio, p.136.
1995 *Bournonia excavata* (d'Orbigny)- Scott, p. 303, pl.2, figs. 3-4; text-fig. 6-D.
1999 Bournonia excavata (d'Orbigny)- Sirna & Paris, p.51, pl. X, fig. 3.
2002 *Bournonia excavata* (d'Orbigny)- Caffau, p. 92-94, figs.2-3.
2005 *Bournonia excavata* (d'Orbigny)- Pleničar, p. 80, pl.28 figs. 1-2.
2007 *Bournonia excavata* (d'Orbigny)- Macé-Bordy, p. 99-100, fig. 9D-E.
2008 *Bournonia excavata* (d'Orbigny)- Pons and Vicens, p. 230, fig. 14C.
Material: one RV (24078-BBU-MPS).
Description: Lower attached RV is conical, height up to 55 mm (incomplete) (Fig. 7a-b). The ornamentation of the shell as well as the outer shell layer from the anterior side of RV is entirely removed probably due to erosion. In ventral side only Pb is visible as a prominent costa that corresponds to downfolds of the laminae of the outer shell layer. Vb is broken but its location can be easily recognized. Vb and Pb are separated by a narrow furrow, 9 mm wide, concav (Ib). In the transverse section, the contour of the RV is oval to quadrangular, with a flat posteroventral side, having a diameter of about 30 mm antero-posterior and 40 mm dorsal-ventral (Fig. 7a). The elements of the myocardinal apparatus are visible (pm) and (am) and the (at) and (pt) (Fig. 7a); the ligamental ridge is absent. Transverse sections of the RV indicate two well defined layers. The inner layer is less 1 mm thick and is represented by calcite spar. The thickness of the outer shell layer varies from 3-4 mm in dorsal and posterior side to 10 mm in area of Pb. The outer shell layer has a prismatic structure, typical for the *Bournonia* genus.
Remarks: Specimens very similar with *Bournonia excavata* d'Orbigny have been reported by Douvillé (1910, 1913, 1915) and recently by Abdel-Gawad et al. (2011) from Turonian deposits in Egypt. This fact has a great implication extending to Turonian stratigraphical ranges of species *B. excavata* Also, detailed taxonomical studies on small shelled species of *B. fourtaui* and *B. africana* are required, because of their morphological similarities with *B. excavata* (Steuber, 1999). If these three species formed a single species (Steuber, 1999) thus *Bournonia excavata* (d'Orbigny, 1850) has priority according to the rules of International Commission on Zoological Nomenclature (ICZN, Ride et al., 1999).
Age: middle Santonian in Spain (Vicens et al, 1998; Pons and Vicens, 2008) and France (Toucas, 1907); late Santonian–early Campanian in Croatia (Polšac and Mamuzic, 1969), Italy (Sirna and Paris, 1999), Romania (Lupu, 1976), Slovenia (Pleničar, 2005); late Campanian-Maastrichtian in southern Italy (Cestari and Sirna, 1989) and Guatemala - Carribean Province (Scott, 1995); Maastrichtian in Montenegro (Pejović, 1968)

Genus *Gorjanovicia* Polšak, 1967
Type species: *Radiolites endrissi* Böhm, 1927 (new designation by Fenerci-Masse et al., 2011)
***Gorjanovicia endrissi* Böhm, 1927**
Fig. 7c
1927 *Radiolites endrissi* n. sp. Böhm, p. 210, pl. 14, figs 1-7.
1967 *Gorjanovicia lipparinii*- Polšak, p. 107, pl. 67, fig. 31.
2011 *Gorjanovicia endrissi* (Böhm, 1927)- Fenerci-Masse et al., p. 2, text-fig. 1; p.8, text-fig. 5; p.17-18, text-figs. 12-13.
Material: one fragment of lower valve. (sample no. 24079 BBU-MPS)
Description: The shape of right valve is cylindro-conical, 30-60 mm in length, characterized by a compact shell structure. The transverse section is circular to oval in shape and the diameter ranges from 18x25 mm to 36x40 mm. The ornamentation consists of well-developed longitudinal costae, which are acute ribs in small specimen and blunt or roundish costae in larger specimen.
The outer shell layer is 3-4 mm thick and composed of compact prismatic calcite. The ligamental ridge is well developed, having 3 mm length in small specimen and 7 mm in the other and generally 1 mm wide (Fig. 7c). The extremity of the ligamental ridge is triangular and truncated. The ventral band (Vb) is 5-10 mm wide and concave located between two rounded costae. The posterior band of the two specimens is flat, 10 and 15 mm wide respectively and has three fine rounded costae (Fig. 7c). The interband is narrower than the bands, forming a shallow groove, 9-10 mm wide between two pronounced ribs (Fig. 7c).
Discussion. A revision of all described *Gorjanovicia* species and of their diagnostic taxonomic criteria has been made by Fenerci-Masse et al. (2011) so that three taxonomic groups, each defined by a key species are currently recognized based on quantitave analisys of morphological characters: *Gorjanovicia endrissi* (Boehm), *G. ugarensis*

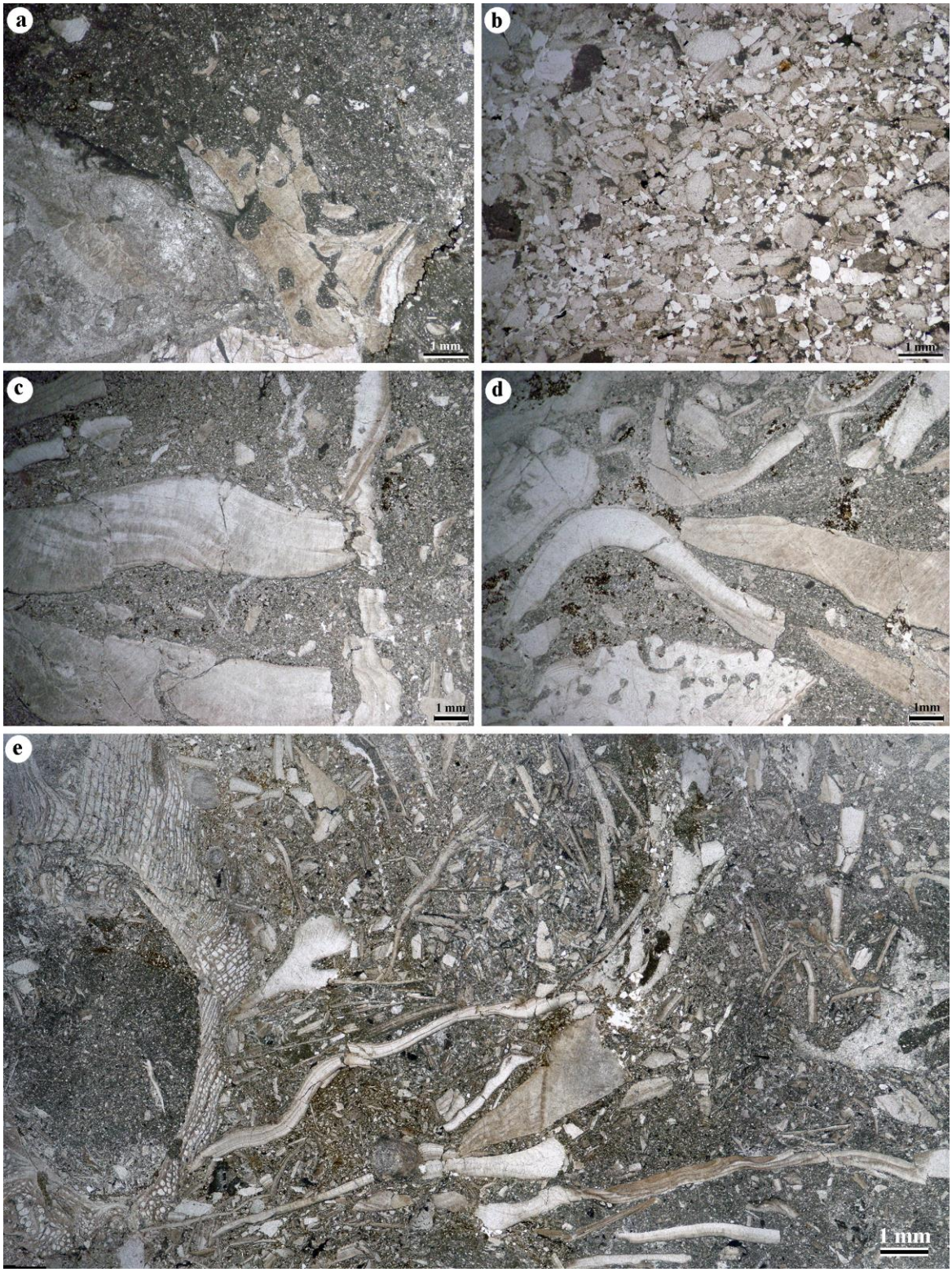

Fig. 5 a, b Microfacies from the second rudist-bearing lithosome. **a, c-e** Bioclastic-extraclastic floatstone; frequent bioclasts are represented by rudist fragments, echinoderm fragments and bivalves fragments; the rudist shells are fragmented and perforated (a, d). **b** Bioclastic-extraclastic rudstone/grainstones with rudist, echinoderm fragments and red algae fragments.

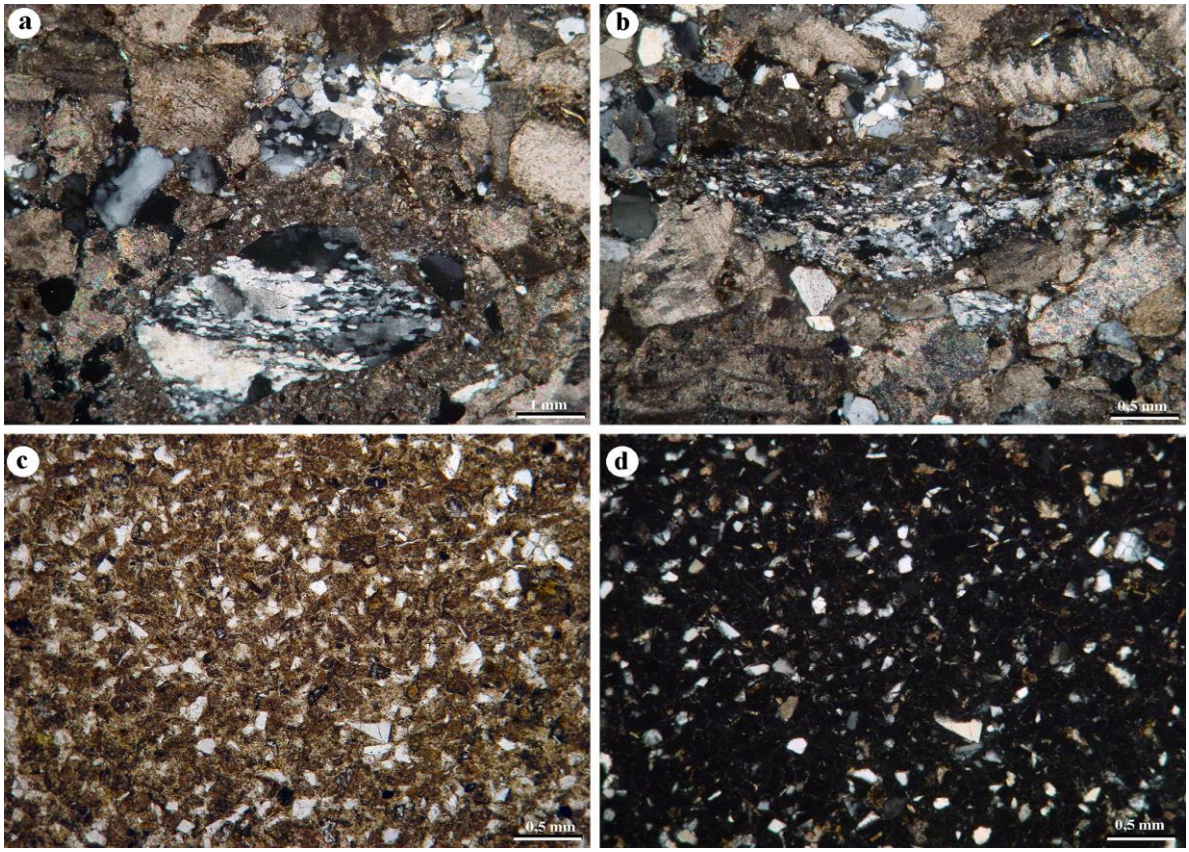

Fig. 6 a, b Extraclastic sediments from the rudist-bearing lithosomes; they are represented by metamorphic lithoclasts (quartzite, crystalline schists), monomineral quartz, muscovite and biotite (crossed polars). **c, d** Tuffites with altered volcanic glass and various crystalloclasts, angular quartz, biotite and calcite (c- plane-polarized light; d - crossed polars).

Sliskovic´ and *G. kvarneri* Polšak. Our specimens are similar with *Gorjanovicia lipparinii* described by Polšak (1967) from Istria in Santonian-lower Campanian deposits. Actually, this species is considered as junior synonym of *Gorjanovicia endrissi* Böhm (*sensu* Fenerci-Masse et al., 2011) being assimilated into this taxonomic group. Group of *Gorjanovicia endrissi* is characterized by flat anterior band (AB), generally concave interband (I) and flat or concave posterior band (PB), numerous costae and ornamented PB. The broad variations of morphological characters within this group are regarded as echophenotypic variations (Fenerci-Masse et al., 2011).

Age and distribution: Coniacian in Greece (Steuber, 1999); late Santonian in Slovenia (Pleničar and Jurkovsek, 1998), Santonian-early Campanian in Croatia (Polšak and Mamuzic, 1969; Polšak, 1967; Polšak et al, 1982), Italy (Caffau and Pleničar, 1995), Romania (this study) and early Maastrichtian in Turkey (Fenerci, 1999).

Genus *Praeradiolites* Douvillé, 1902

Type species: *Sphaerulites ponsiana* d'Archiac, 1835 (subsequent designation by Pons and Vicens, 2011).

***Praeradiolites subtoucasi* Toucas, 1907**

Fig. 7 d-e.

1907 *Praeradiolites subtoucasi* n.sp.- Toucas, p. 31, pl. 3, figs. 8, 9.

1954 *Praeradiolites subtoucasi* Toucas- Astre, p. 61, 76-77, 83, pl. 6, figs. 1, 2.

1962 *Praeradiolites* cf. *subtoucasi* Toucas- Astre, p. 306, 308.

1965 *Praeradiolites subtoucasi* Toucas- Pamouktchiev, p. 37, pl. 4, fig. 1, text-fig. 6.

1976 *Praeradiolites subtoucasi* Toucas- Lupu, p. 126, pl. 17, figs. 4,5a-b, pl. 39, fig. 6.

1977 *Praeradiolites subtoucasi* Toucas- Pons, p. 69, pl. 50, figs. 1a-d.

1992 *Praeradiolites subtoucasi* Toucas- Vicens, p. 201, pl. 75, figs. 1-15, pl. 76, figs. 3-4, pl. 79, figs. 1-5.

1995 *Praeradiolites* cf. *subtoucasi* Toucas- Morris & Skelton, p. 292, pl.6, figs.3,4.

1999 *Praeradiolites subtoucasi* Toucas- Fenerci, p. 90-94, text-figs. 3.28, 3.29, pl. VII, figs. 1-7.

2004 *Praeradiolites subtoucasi* Toucas- Fenerci, p. 93, pl. 1, figs. 1-6.

2006 *Praeradiolites subtoucasi* Toucas- Pons and Vicens, p. 15-16, fig. 13F, fig. 14G.

2012 *Praeradiolites subtoucasi* Toucas- Pons et al., p. 690, fig. 11B.

2013 *Praeradiolites subtoucasi* Toucas- Özer et al., p. 35-36, pl. II, figs. A-F; pl. III, figs. A-H.

Material: two lower valves (samples nos.24080, 24081 BBU-MPS).

Description: The shape of RV is conical to cylindrical in both specimens, having 38 and 42 mm in length and its surface is ornamented with horizontal growth lines. Diameter of RV near to the commissure is 30 mm (24081 BBU-MPS) and 35 mm (24080 BBU-MPS) with an oval contour in transverse sections (Fig. 7d, e). The outer shell layer is generally thin, ranging from 3 to 8 mm thickness on the dorsal side, were cellular structures alternate with

thin calcitic compact layers. In ventral side of both RVs the outer shell layer is very eroded and the radial bands (Vb and Pb) are represented by two longitudinal grooves that show approximately the same width (Fig. 7d, e). The Ib is represented by longitudinal costae and has a width ranges from 4 to 7 mm. The ligamental ridge (L) is long (5 respectively 7 mm) has a thin stem and is rounded at its extremity (Fig. 7d, e). The cardinal apparatus is preserved showing the teeth (at and pt) and the posterior (pm) and anterior myophores (am) (Fig. 7e).

Discussion and remarks: Vicens (1992) designated *Praeradiolites aristidis (*Munier-Chalmas, 1888) and *Praeradiolites echennensis (*Astre, 1954) as synonyms of *Praeradiolites subtoucasi* (Toucas, 1907). Instead, Steuber (1999) described from Greece species of *Praeradiolites echennensis (*Astre, 1954) that can be distinguished from the other two species (*P. aristidis* and *P. subtoucasi*) therefore considered *P. echennensis* as valid species.

Age and distribution: late Santonian-early Campanian in France (Astre, 1962), Spain (Vicens, 1992), Romania (Lupu, 1976; Săsăran et al., 2010); Maastrichtian in Croatia (Gušić and Jelaska, 1990; Steuber et al., 2005), Oman (Morris and Skelton, 1995), Turkey (Fenerci, 1999, 2004), Iraq (Özer et al., 2013).

Genus *Radiolites* Lamarck, 1801

Type species: *Ostracites angeiodes* Picot de Lapeirouse, 1781

***Radiolites squamosus* d'Orbigny, 1842**

Fig. 7, f-g.

1842 *Radiolites squamosa* - d'Orbigny, pp. 185-186

1850 *Radiolites squamosus* d'Orbigny- d'Orbigny, p. 219, pl.561

1908 *Radiolites squamosus* d'Orbigny- Toucas, p. 71, pl.13, figs.9-11

1976 *Radiolites squamosus* d'Orbigny- Lupu, p. 124, pl.13, fig.5

1993 *Radiolites squamosus* d'Orbigny- Swinburne and Noacco, text-fig.2

Material: 1 specimen, both valves (no. 24082 BBU-MPS).

Description: Small size shell, with right valve (RV) long conical, 40 mm long and 20 mm in diameter at the commissural plane (Fig. 7f-g). The ornamentation consists of dense growth lamellae (Fig. 7f). The radial bands are folds curved towards the commissure separated by a narrow interband with one fold (Fig. 7g). Left valve (LV) is highly convex, with central apex but much eroded (Fig. 7f).

Discussion and remarks: Because we found only one specimen, the shell of *Radiolites squamosus* was not been cut for study in cross-section. This species is also mentioned by Lupu (1976) from Roșia Basin (Northen Apuseni Mountains).

Age and distribution: early - middle Santonian in France (Toucas, 1907); late Santonian- early Campanian in Croatia (Polšak and Mamuzic, 1969), Romania (Lupu, 1976), Slovenia (Pleničar and Jurkovsek, 1999), middle-late Campanian in Spain (Floquet, 1991) and early Maastricthian in east Serbia (Milovanovic, 1935).

***Radiolites nouleti* Bayle, 1857**

Fig. 7h-i.

1908 *Radiolites nouleti* Bayle- Toucas, p. 72, pl.13, figs.18-19.

1967 *Radiolites nouleti* Bayle- Polšak, pp. 69, 180, pl.44, fig.4,4a, pl.45, figs.2-5

1967 *Radiolites nouleti* Bayle- Lupu and Lupu, p. 308.

1982 *Radiolites nouleti* Bayle- Czabalay, p. 50, 85; pl.39, fig.11, pl.40, figs.3-4,7.

Material: One RV specimen (BBU-MPS-24083).

Description. Right valve conical, thick-shelled, having more than 50 mm length and 78 mm diameter antero-posterior and 55 mm dorsoventral (Fig. 7h). The ornamentation consists in fine and rounded longitudinal ribs, 2 mm in thickness in the dorsal side. On the ventral side, dense, regularly folded growth lamellae can be seen, slightly ondulated in interband. The interband (Ib) is very wide, centrally depressed separating the radial bands Vb and Pb which are simple folds with almost the same amplitude (Fig. 7h). In transversal section, the ligamental ridge (L) is triangular at base, with 11 mm in length and its inner margin truncated. Anterior and posterior of the ligamental ridge are two small, oval cavities (Fig. 7i). The outer shell layer varies between 13 to 15 mm in thickness, having only 5 mm in ventral side in interband area. Cells of the outer shell layer are irregular polygonal, predominantly penta- and hexagonal (Fig. 7i).

Remarks: *Radiolites nouleti* is a large radiolitid easy identifiable by its thick-shelled, large interband and dense folded growth lamellae.

Age and distribution: Santonian-early Campanian in Croatia (Polšak et al., 1982), Romania (Lupu, 1976); early Campanian in France (Bilotte, 1985), Hungary (Czabalay, 1982), Serbia (Milovanovic, 1935) and Spain (Vicens, 1992); late Maastrichtian in Spain (Bilotte, 1985).

Genus *Sphaerulites* Lamarck, 1819

Type species: *Sphaerulites foliacea* Lamarck, 1819

***Sphaerulites boreaui* Toucas, 1908**

Fig. 7j-k.

1908 *Sphaerulites boreaui* nov. sp.- Toucas, p. 56, pl.9, fig.6, text-figs. 28-29.

1976 *Sphaerulites boreaui* Toucas- Lupu, p. 129, pl.20, fig.1a-b.

2000 *Sphaerulites* cf. *boreaui* Toucas- Pleničar and Jurkovsek, p. 59, pl.3, fig.1.

Material: 1 specimen, both valves (BBU-MPS-24084).

Description: The shape of right valve is conical, rapidly expanding, having 40 mm height and 110 mm diameter antero-posterior. Growth lamellae of RV are subhorizontal, markedly expanded. In postero-ventral area, radial structures are not visible because the valves are broken. Left valve is slightly convex, thin and smaller than RV, measuring 15 mm heigh and 60 mm the antero-posterior diameter (Fig. 7j). In transverse section through the valves near the commissure, the ligament ridge is visible having a long pedicle, 16 mm length, and expanded distal end (Fig. 7k); two dorsal cavities developed between the ligament ridge and the myocardinal apparatus (Fig. 7k). The cellular outer shell layer of RV has variable thickness; largest toward the anterior side, with cells extremely radially elongated giving the appearance of radial ridges (Fig. 7k).

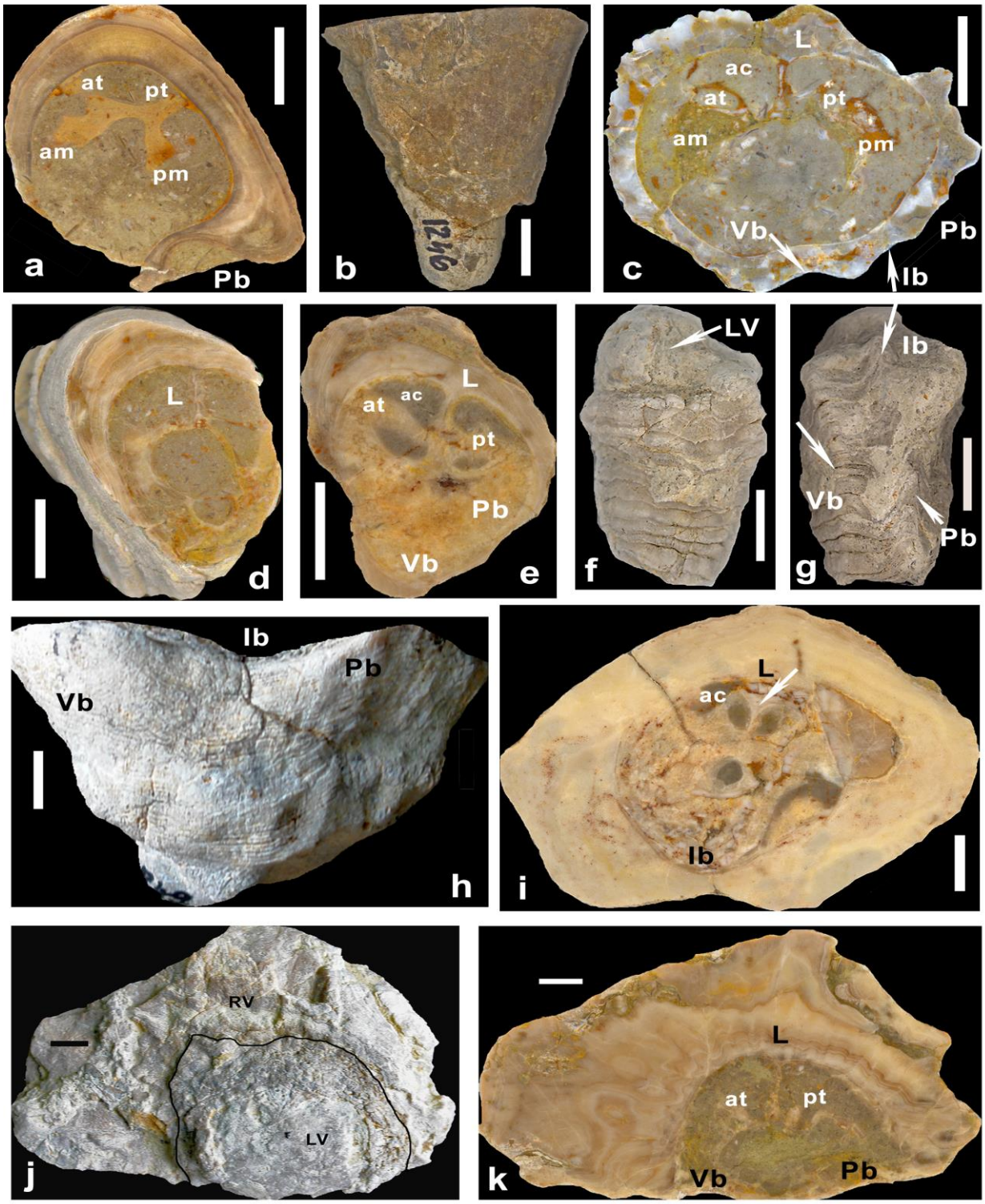

Fig. 7 a, b *Bournonia excavata* d'Orbigny, 1847, (inventory no. 24078 BBU-MPS =no.1246 sample field); **a** transverse section through RV close to the commissure, showing the myocardinal elements: anterior and posterior tooth and myophores (am, pm) of the opposite valve; **b** view of flat posteroventral side of RV; **c** *Gorjanovicia endrissi* (Böhm)(24079 BBU-MPS) – transverse section of RV showing compact layer, concave ventral band (Vb); Ib- narrow and wide Pb with 3 fine rounded costae; **d, e** *Praeradiolites subtoucasi* (Toucas): **d** transverse section through RV (24080-BBU-MPS), unknown commissure. The outer shell layer from ventral side is eroded thus the radial bands are missing. **e** transverse section on other specimen (24081-BBU-MPS) having outer shell layer partially broken but preserve the myocardinal apparatus. **f, g** *Radiolites squamosus* (d'Orbigny): **f** specimen with both valves showing convex LV, very eroded and the ornamentations of RV consist in dense growth lamellae (sample no. 24082 BBU-MPS); **g** ventral side of RV of the same specimen showing radial bands (Vb and Pb) with folds upward to commissure and the narrow interband (Ib). **h-i** *Radiolites nouleti* (Bayle)(sample no. 24083 BBU-MPS): **h** large conical RV, thick-shelled, with dense folded growth lamellae, slightly ondulated in large interband (Ib); **i** transverse section in RVof the same specimen, showing thick cellular outer shell layer, ligamental ridge and accessory cavities. **j, k** *Sphaerulites boreaui* (Toucas)(sample no. 24084 BBU-MPS), **j** specimen with both valves, top view, showing LV, thin and smaller than lower valve and large RV with expanded, sub-horizontal growth lamellae; **k** transverse section through RV, showing thickness of cellular outer shell layer, positions of radial bands (Vb and Pb), the length of ligamental ridge and myocardinal apparatus.

Remarks: Our specimen is similar with species of *Sphaerulites boreaui* previously described by Lupu (1976) from Late Santonian deposits from Roșia Basin.
Age and distribution: early-middle Santonian in France (Toucas, 1907), late Santonian-early Campanian in Bosnia-Herzegovina (Sliskovic, 1971), Slovenia (Pleničar and Jurkovsek, 2000), Romania (Lupu, 1976) and Spain (Vicens, 1992).

Family Hippuritidae Gray, 1848
Genus *Hippuritella* Douvillé, 1908
Type species: *Hippurites maestrei* Vidal, 1878
***Hippuritella lapeirousei* Goldfuss, 1840**
Fig. 8 a-g
1895 *Hippurites (Orbignya) lapeirousei* Goldfuss- Douvillé, p. 164, pl.24, figs.7-10.
1903 *Orbignya lapeirousei* Goldfuss- Toucas, p. 53, pl.6, figs.10-11.
1976 *Hippurites lapeirousei* Goldfuss- Lupu, p. 122, pl.12, fig.5.
1995 *Hippuritella lapeirousei* (Goldfuss)- Caffau and Pleničar, p. 135, pl. 1, figs. 1-14.
1999 *Hippuritella lapeirousei* (Goldfuss)- Steuber, p. 116, text-fig.46h, J-M.
2000 *Hippuritella lapeirousei* (Goldfuss)- Steuber and Löser, p. 96.
2001 *Hippuritella lapeirousei* (Goldfuss)- Götz, p. 64, pl.1, fig.4, pl.3, fig.2, pl.4, fig.6, pl.7, fig.16
2005 *Hippuritella lapeirousei* (Goldfuss)- Pleničar, p. 172, pl. 74, fig. 1.
2010 *Hippuritella lapeirousei* (Goldfuss)- Moro et al., p. 626, 630, figs. 6, 9.
2014 *Hippuritella lapeirousei* (Goldfuss)- Pons et al., p. 64, fig. 16.1-6.
Material: 1 specimen with both valves (24085 BBU-MPS) and 3 fragments of lower valves (24086, 24087, 24088 - BBU-MPS).
Description: The specimen with both valves shows a very thin, flat left valve (LV) with a sub-central apex. The almost all surface of the LV is eroded and only on the edge the radial canals are visible (Fig. 8c). All specimens have small, elongated-conical right valves (RV), without prominent longitudinal ribs, the surface of the shell is very eroded (Fig. 8b,d). The length of right valves (RV) varies between 20 to 42 mm and diameter measures 18 mm to 25 mm maximal. The position of the pillars (P1 and P2) is indicated externally on the outer shell layer by two shallow longitudinal furrow (Fig. 8b,d). The internal characters observed in the transversal sections of right valves shows lack of ligament ridge and small pillars (Figs. 8a, e,f,g). The pillars P1 and P2 are short and rounded and have same size (Figs. 8a,e,f). Only in one specimen (BBU-MPS-24088) the first pillar P1 is slightly smaller than the second pillar (P2) and both pillars are broad and less prominent (Fig. 8-g). The myocardinal apparatus is not visible in none of specimens. The outer shell layer shows variably thickness and seems to present radial ribbing (Fig. 8a, c, e-g).
Discussion: Long time some authors placed *Hipuritella nabresinensis* in synonymies with *Hipuritella lapeirousei* (Douville, 1895; Parona, 1900; 1926; Toucas, 1903-1904). Others rudistologists (Sladić - Trifunović, 1972, 1978; Lupu, 1976; Accordi et al., 1982; Laviano, 1985; Caffau and Pleničar, 1995) considered that the two species have distinctive characteristics as follows: in *H. nabresinensis* the right valve is cylindrical (Sladić - Trifunović, 1978; Laviano, 1985), have more pronounced rounded costae (Futterer, 1893; Lupu, 1976; Accordi et al., 1982) and their pillars are not of the same size (Laviano, 1985; Caffau and Pleničar, 1995). In *H. lapeirousei* the right valve is small conical (Sladić - Trifunović, 1978) without prominent longitudinal ribs (Steuber, 1999) and the pillars P1 and P2 are similar in size (Sladić - Trifunović, 1972; Lupu, 1976; Caffau and Pleničar, 1995; Moro et al., 2010) or P1 slightly smaller than P2 (Douville, 1895; Moro et al., 2010). The ligamental ridge (L) is absent or reduced to a small inflexion in outer layer (Douville, 1895; Vicens, 1992) in both species. Steuber (1999) considered as the thin outer shell layer and faintly projecting pillars as safe elements to recognition of *H. lapeirousei*. Our specimens resembles more with those described from Serbia (Sladić-Trifunović, 1972), Italy (Laviano, 1985) and Spain (Vicens et al., 2004) which have thick-shelled valves and same size pillars.
Age and distribution: late Santonian-early Campanian in Croatia (Polšak and Mamuzic, 1969); middle Campanian in Spain (Floquet, 1991); middle Campanian –early Maastrichtian in Croatia (Polšak and Mamuzic, 1969), Italy (Swinburne and Noacco, 1993), Spain (Vicens, 1992); Maastrichtian in Greece (Steuber, 1999), France (Toucas, 1903; Bilotte, 1985), Italy (Pons and Sirna, 1994), Spain (Astre, 1962), Turkey (Özer, 1994; Fenerci, 1999).

Genus *Vaccinites* Ficher, 1887
Type species *Hippurites cornuvaccinum* Bronn, 1831
***Vaccinites gosaviensis* Douvillé, 1890**
Fig. 8h, i.
1891 *Hippurites gosaviensis* n. sp.- Douvillé, p. 24, text-figs.9, 12-14
1904 *Vaccinites gosaviensis* Douvillé- Toucas, p. 92, pl.13, fig.3, text-fig.146
1966 *Hippurites (Vaccinites) gosaviensis* Douvillé - Todiriță-Mihăilescu, p. 72, pl.17, fig.2, pls.18-20.
1960 *Hippurites (Vaccinites) gosaviensis* Douvillé- Lupu and Lupu, pp. 635-636, pl. 1, figs. 28-29, text-figs.3-4.
1969 *Hippurites (Vaccinites) gosaviensis* Douvillé- Polšak & Mamuzic, pp. 235, 239.
1976 *Vaccinites gosaviensis* Douvillé- Lupu, p. 110, pl.2, figs.1a-c,2, pl.35, figs.5,6.
2001 *Vaccinites gosaviensis* (Douvillé)- Steuber, pp. 438, 441, tab.1.
Material: 1 specimen with both valves (no. 24089-BBU-MPS), one right valve (no. 23503-BBU-MPS).
Description: The upper valve (LV) is very thin, slight convex but do not preserve any significant morphological characters due to erosion. The right valve (RV) has a conical shape, gently curved, 100 mm in length and a diameter of 47/60 mm at 5 mm below to the commissural plane. The outer shell layer of the right valve is thin, 2 to 4 mm in thickness, partly eroded (Fig. 8 h-i). In the transversal section trough the RV, the ligamental ridge (L) appears straight, 8 mm in length, with its inner termination truncated (Fig. 8i). The first pillar (P1) is very pinched at the base and have a rounded-elliptic head, 9 mm total length; the second pillar (P2) is more pedunculated having 12

mm in length and an oval head which is curved towards to ligamental ridge (Fig. 8i). The elements of the myocardinal apparatus are also visible: anterior tooth (at) in prolongation of L, posterior tooth (pt) located parallel and not surpassing the tip of ligamental ridge; posterior myophore (pm) rectangular outline, aligned sub-parallel to the first pillar (P1) and projecting interiorly 5 mm over the tip of P1 (Fig. 8i).

Discussion and remarks: From the area of Valea Neagră de Criș, southeastern part of Borod Basin, Lupu & Lupu (1960), Lupu,(1976) described sub-species *Vaccinites gosaviensis acicularis* (Lupu & Lupu, 1960) that differs from *Vaccinites gosaviensis* by its ligamental ridges with sharp inner termination curved anteriorly and more wide and rounded furrows on the shell ornamentations.

Age and distribution: Santonian-early Campanian in Austria (Steuber, 2001), Croatia (Polšak and Mamuzic, 1969), Greece (Kollman et al., 1985), Italy (Sirna, 1990), and Romania (Todiriță-Mihăilescu, 1966; Lupu, 1976); early Maastrichtian in Turkey (Fenerci, 1999).

***Vaccinites archiaci* Douvillé, 1892**

Fig. 8j

1892 *Hippurites archiaci* Munier Chalmas- Douvillé, p. 45, pl.5, figs.1-3, text-figs.30-33

1904 *Vaccinites archiaci* Munier-Chalmas- Toucas, p. 103, pl.15, figs.4-5, text-figs.164, 165.

1966 *Hippurites (Vaccinites) archiaci* Munier- Chalmas-Todiriță-Mihăilescu, p. 72, pl. 21,22.

1968 *Hippurites (Vaccinites) archiaci* Munier- Chalmas-Lupu, p. 77, pl.1, fig.8, text-fig.5.

1969 *Hippurites (Vaccinites) archiaci* Munier- Chalmas-Polšak and Mamuzic, pp. 235, 239.

1976 *Vaccinites archiaci* Munier-Chalmas-Lupu, p. 114, pl.3, figs.12,12a-b,13, pl.36, fig.1.

1992 *Vaccinites archiaci* (Douvillé)- Vicens, p. 120, pls.32-34, pl.45, figs.1-2.

1999 *Vaccinites archiaci* (Douvillé)- Steuber, p. 125, pl.23, fig.1, text-fig.48a-c.

2016 *Vaccinites archiaci* (Douvillé)- Moro et al., p.16,18, figs. 11d, 12c.

Material: fragment of RV, embedded in rock (no. 24090-BBU-MPS).

Description: Right valve is conical with umbo curved ventrally, having 70 mm in length and 45/50 mm in diameter. The thickness of the outer shell layer varies between 3 to 4 mm. The ligamental ridge (L) is shorter, 7 mm in length, wider and clearly truncated (Fig. 8j). The first pillar (P1) is square and shorter than the second pillar (P2) which is slightly pedunculated at the base. In the specimen with right valve embedded in limestone the diameter in transverse section measure 35/45 mm, showing a ligamental ridge (L) strongly developed, triangular at the base and lamelliform, 13 mm in length, with inner termination truncated with V-shaped incision (Fig. 8j). The first pillar (P1) is thick, rectangular in shape, with sub-parallel flanks; shorter than L and P2, having 10 mm in length. The second pillar (P2) is slightly pinched at the base, 15 mm in length with a head oval-elongated and curved anteriorly. The compact outer shell layer is thin, 2-3 mm in thickness. No preserved myocardinal apparatus.

Observations: For many years species *Vaccinites archiaci* was assigned to Munier-Chalmas in the synonymy lists used by various authors. But, Vicens (1992) and Steuber (1999) draw attention that Douvillé (1892) described and illustrated this species for the first time based on the material from Munier-Chalmas which only mentioned "*Hippurites archiaci*" in his work, without description. So, correct attribution is *Vaccinites archiaci* Douvillé, 1892.

Age and distribution: Santonian-early Campanian in Croatia (Polšak and Mamuzic, 1969), Greece (Steuber, 1999), Romania (Lupu, 1976), early Campanian in France (Astre, 1954; Bilotte, 1985), middle Campanian in southern Pyrenees (Vicens, 1992); Campanian-Maastricthian in Afghanistan (Vogel, 1971), Bosnia-Herzegovina (Sliskovic, 1984); Slovenia (Pleničar and Sribar, 1992).

***Vaccinites sulcatus* Defrance, 1821**

Fig. 8k.

1821 *Hippurites (Vaccinites) sulcatus*-Defrance, p. 195, pl. LXXXIII, fig. 3.

1904 *Vaccinites sulcatus* Defrance-Toucas, p. 102, pl.15, figs.1-3, text-figs.161-163.

1966 *Hippurites (Vaccinites) sulcatus* Defrance- Todiriță-Mihăilescu, p. 73, pl.26, figs.1,2.

1967 *Hippurites (Vaccinites) sulcatus* Defrance- Polšak, p. 124, 212, pl.79, fig.2.

1969 *Hippurites (Vaccinites) sulcatus* Defrance- Lupu, p. 208, pl.1, fig.20, text-fig.4.

1976 *Vaccinites sulcatus* Defrance- Lupu, p. 109, pl.1, figs.1a-b,2, pl.35, figs.1,2.

1992 *Vaccinites sulcatus (*Defrance*)*- Vicens, p. 117, pl.31, figs.1-14.

1998 *Vaccinites sulcatus (*Defrance*)*- Peza, p. 264, text-fig.14; fig. 4:5; figs.8:3-5; fig.10:2.

2004 *Vaccinites sulcatus (*Defrance*)*- Caffau et al., p.160, pl. 2, fig.3.

Material: 1 specimen, only right valve (no. 23504-BBU-MPS).

Description: Lower valve is conical, 50 mm in length and with a diameter equal to 35 mm. The triangular ligamental ridge (L) is wide and short, having its end clearly truncated (Fig. 8k). The first pillar (P1) is wide and short, with the same length as ligamental ridge. The second pillar (P2) is longer than the first pillar (P1), and is slightly pinched at the base with a head oval-elongated, curved anteriorly (Fig. 8k).

Remarks: *Vaccinites sulcatus* is very similar to *Vaccinites archiaci* but differs from the latter species by its wide and shorter ligamental ridge. In *Vaccinites archiaci* the ligamental ridge is thin and longer than first pillar (P1).

Age and distribution: Santonian-early Campanian in Albania (Peza, 1992, 1998), Austria (Steuber, 2001), Croatia (Polšak and Mamuzic, 1969), Italy (Caffau et al., 2004), France (Astre, 1962) Romania (Todiriță-Mihăilescu, 1966; Lupu, 1969, 1976), Slovenia (Pleničar, 1961), and Turkey (Özer, 1998); Campanian-Maastrichtian in Croatia (Polšak and Mamuzic, 1969).

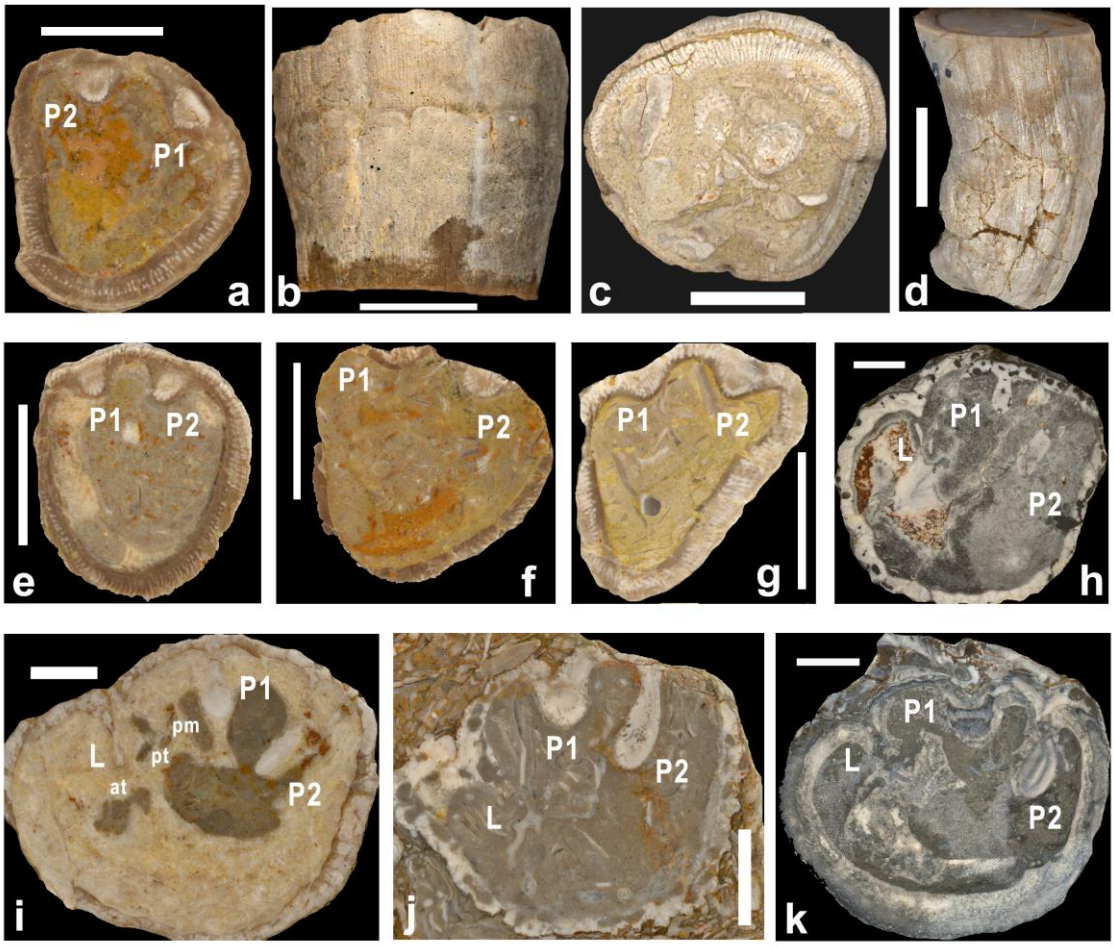

Fig. 8 a-g *Hippuritella lapeirousei* (Goldfuss)(nos. 24085, 24086, 24087, 24088-BBU-MPS). **a** Transverse section made close to the beak of right valve (RV), the outer shell layer is thick, reaching 3 mm. **b** RV showing the position of the pillars (P1 and P2) as shallow longitudinal furrows (24085 BBU-MPS). **c** thin and nearly flat LV very eroded showing remains of radial canals (24085 BBU-MPS). **d** ventral area of conical, slightly curved RV (24086 BBU-MPS) showing the position of the pillars as two shallow longitudinal furrows; **e** transverse section of RV showing short and rounded pillars (P1 and P2) with the same size (24086 BBU-MPS). **f, g** transverse sections through specimens (nos. 24087, 24088 BBU-MPS) that have the first pillar (P1) slightly smaller than the second pillar (P2). Note the erosion of the outer shell layer in f) (24087 BBU-MPS**)**. **h-i** *Vaccinites gosaviensis* (Douvillé)- transverse section made on two RVs (nos. 23503, 24089 BBU-MPS) showing truncated ligamental ridge (L) and characteristic shape of the pillars. **j** *Vaccinites archiaci* (Douvillé), transverse section on RV (no. 24090 BBU-MPS) showing triangular in base and lamelliform ligamental ridge (L), first pillar (P1) thick and shorter and slightly pinched P2. **k** *Vaccinites sulcatus* (Defrance) – transverse section on lower valve (no. 23504 BBU-MPS) in which ligamental ridge (L) is wide and short having the same length with first pillar (P1) and second pillar is slightly pinched at its base and curved anteriorly.

DISCUSSION AND CONCLUSIONS

The present study focused on the revision of the rudists fauna belonging to the families Radiolitidae and Hippuritidae collected from the two limestone lithosomes. The identified species are as follows: *Bournonia excavata, Gorjanovicia endrissi, Praeradiolites subtoucasi, Radiolites nouleti, Radiolites squamosus, Sphaerulites boreaui, Hippuritella lapeirousei, Vaccinites gosaviensis, Vaccinites archiaci, Vaccinites sulcatus.* The identified rudist species are characteristic for central-eastern Mediteranean province (sensu Steuber and Schlüter, 2012) and they confirm a late Santonian-early Campanian age of these deposits.

Previous studies considered the rudist-bearing carbonate lithosomes from the Strâmturii Valley and Cioroi-Negru Brook as ”rudist reefs” and ”hippuritid reefs” (e.g. Șuraru, 1972) or ”reef debris” (e.g. Mogoș, 1992). However, the present study shows that these carbonate rocks were accumulated by gravity flows at the base of the shelf slope.

Specimens of rudists characterized both by entire and fragmented shells collected from the carbonate lithosomes show evidence of abrasion and bioerosion processes recording high energy environments. In open marginal sector of the shelf settled by rudists the waves and currents reworked these bioclasts before they were transported towards the margin of the shelf and/or to the shelf slope toe. All these reworking processes were triggered by the collapse of the shelf margin due to seismic, eustatic or tectonic events (uplift-subsidence).

Siliciclastics deposits from the unit III and IV covered the carbonate rocks of the unit II and accumulated as the entire basin was gradually flooded. Volcanic eruptions and basin extension provoked by tectonic phases were re-

sponsible for destroying of the environments in which the rudists were once thriving.

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