Cretaceous Research 43 (2013) 59–69

Contents lists available at SciVerse ScienceDirect

Cretaceous Research

journal homepage: www.elsevier.com/locate/CretRes

Description of *Pseudosabinia klinghardti* and some species of *Pseudopolyconites* (rudist bivalves) from the Late Cretaceous shallow-marine deposits from the Roşia Basin, Apuseni Mountains, Romania: Systematic palaeontology, biostratigraphy, and palaeobiogeography

Liana Săsăran [a,*], Sacit Özer [b], Emanoil Săsăran [a]

[a] Babeş-Bolyai University, Department of Geology, 1 Mihail Kogălniceanu Street, 400084 Cluj-Napoca, Romania
[b] Dokuz Eylül University, Engineering Faculty, Department of Geological Engineering, Tınaztepe Campus, Buca, TR-35160 İzmir, Turkey

ARTICLE INFO

Article history:
Received 18 September 2012
Accepted in revised form 22 February 2013
Available online 6 April 2013

Keywords:
Pseudosabinia
Pseudopolyconites
Taxonomy
Biostratigraphy
Palaeobiogeography
Late Cretaceous
Apuseni Mountains
Romania

ABSTRACT

The shallow-marine, mixed siliciclastic-calcareous Late Cretaceous deposits from the Apuseni Mountains have been extensively studied and compared to coeval deposits from the Alpine Gosau. The former are mainly represented by conglomerates, sandstones, marls, and limestones with rudists that unconformably overlie the crystalline basement and its Permo-Mesozoic cover. Our new, detailed investigations on the rudist fauna from Măgura Hill, the type locality of *Pseudopolyconites hirsutus* (Patrulius) and *Miseia costulata* Patrulius, indicate a Late Santonian–Early Campanian age for these deposits instead of an Early Santonian one as previously suggested (Patrulius, 1974). This study also mentions for the first time the occurrences of *Pseudosabinia klinghardti* (Böhm) and *Pseudopolyconites parvus* Milovanović in the rudist-bearing deposits from the Apuseni Mountains. We include their palaeontological features, as well as the ones for *Pseudopolyconites hirsutus*. Based on new biostratigraphic data, our study expand the stratigraphic range of *Pseudosabinia klinghardti* and *Pseudopolyconites parvus* – previously considered characteristic for the Early Campanian–Maastrichtian interval. Also we add new information on their palaeobiogeographic distribution within the central-eastern Mediterranean area during the Late Cretaceous.

1. Introduction

Rudists are shallow-marine, heterodont, aberrant bivalves (order Hippuritida Newell, see classification by Carter et al., 2011). They were among the most important colonizers of various substrates on the Late Cretaceous shelves (Sanders, 1998; Sanders and Pons, 1999; Steuber, 2002a). In the Apuseni Mountains, the Late Cretaceous shallow-marine sequence comprises mixed siliciclastic-carbonate deposits ranging in age from the Late Turonian to the Early Maastrichtian. The deposits consist of conglomerates, sandstones, marls, and rudist-bearing limestones discordantly overlying the crystalline basement and/or its Permo-Mesozoic cover (Lupu, 1976; Patrulius, 1974; Schuller, 2004). Late Turonian–Early Maastrichtian rudist assemblages from the Apuseni Mountains have been previously investigated by numerous authors, with the rudist faunas being generally described as Gosau-type associations (Givulescu, 1954; Ianovici et al., 1976; Lupu, 1960, 1969, 1970, 1974, 1976, 2002; Patrulius, 1974; Săsăran and Săsăran, 2007; Todiriţă-Mihăilescu and Preda, 1972). Late Turonian–Early Santonian rudist assemblages are poorly represented; they were found only in small areas in the northern (Borod Basin), north-western (Roşia Basin), and south-western (Drocea occurrences) parts of the Apuseni Mountains. The furthest landward extent of the shallow-marine sediments in the Apuseni Mountains occurred during the Late Santonian–Early Campanian interval (Lupu, 1976; Schuller, 2004). Then, rudist associations commonly developed together with corals and gastropods in shallow-marine environments with a prominent influx of siliciclastics. The resulting deposits consist of alternating conglomerates, bioclastic sandstones, and rudist-bearing limestones (Lupu, 1976; Patrulius, 1974; Săsăran and Săsăran, 2007; Săsăran et al., 2004, 2006, 2010). Starting in the Early Campanian, diachronous deep-water sedimentation occurred due to rapid subsidence (Schuller, 2004). Accordingly, the Late Campanian–Early Maastrichtian rudist fauna was impoverished;

* Corresponding author. Tel.: +40 741792255.
E-mail addresses: liana.sasaran@ubbcluj.ro (L. Săsăran), sacit.ozer@deu.edu.tr (S. Özer), emanoil.sasaran@ubbcluj.ro (E. Săsăran).

0195-6671/$ – see front matter
http://dx.doi.org/10.1016/j.cretres.2013.02.005

rudists were found only in small outcrops from the Borod and Roşia basins.

The present study focuses on palaeontological aspects concerning small *Pseudopolyconites* and *Pseudosabinia* specimens that have been identified from the shallow-marine deposits from Măgura Hill, Roşia Basin, Apuseni Mountains (Fig. 1). The rudists were registered in the collection of the Museum of Palaeontology, Department of Geology, Babeş-Bolyai University. The numbers of the studied and figured specimens are given with the abbreviation BBUMP (Babeş-Bolyai University, Museum of Palaeontology).

2. Geological setting and biostratigraphy

The sedimentation of Late Cretaceous shallow-marine deposits from the Roşia Basin (Fig. 1), was initiated during the Coniacian in the eastern areas (Lupu, 1974, 1976; Schuller, 2004; Schuller et al., 2009) and during the Early Maastrichtian extended to the northern areas (Şuraru, 1961; Patrulius, 1974; Lupu, 1976). The presently investigated deposits are located along the south-western border of the Roşia Basin, in outcrops from the western slope of Măgura Hill (Fig. 1). Here, the mixed siliciclastic-carbonate Upper Cretaceous stratigraphic succession transgressively overlies Mesozoic tectonic units (the Vălani Unit and Finiş-Gârda Nappe from the Codru Nappe complex) (Balintoni, 1997, 2001; Patrulius, 1974; Săndulescu, 1984).

The stratigraphic succession is ~40 m-thick (Fig. 2) and commences with a basal conglomerate which is succeeded by sandstones/marls intercalations with plant remains and mollusc fragments. These are followed by gastropod-rich limestones dominated by actaeonellids and nerineids, with rare rudists. These limestones are overlain by marls and marly limestones rich in solitary and meandroid colonial corals. The succession continues with interlayers of marls/sandstones/conglomerates containing three calcareous levels (Fig. 2). From the first calcareous level, Patrulius (1974) has identified a rudist assemblage containing *Radiolites sauvagesi* d'Hombres-Firmas, *Hippurites socialis* Douvillé, *Vaccinites gaudryi* Munier-Chalmas which he assigned to the Early Santonian. The same author also mentioned *Radiolites subquamosus* Toucas, *Praeradiolites toucasianus* d'Orbigny, *Lapeirouseia zitteli* Douvillé, *Prelapeirouseia* sp., *Sphaerulites* sp., *Durania* sp. as well as two new radiolitids species, *Miseia costulata* Patrulius and *Pseudopolyconites hirsutus* (Patrulius) (=*Duranddelgaia hirsuta* Patrulius), and very rare hippuritid species, *H. matheroni* Douvillé, *H. nabresinensis* Futterer, and *Vaccinites gosaviensis* Douvillé from the last calcareous levels at the top of the succession. Based on the presence of *H. matheroni*, Patrulius (1974) assigned these limestones to the Early Santonian. However, during our field investigations we did not identify this species in the analysed stratigraphic succession.

The rudist taxa identified in the present study are characteristic of the Late Santonian–Early Campanian; their distribution within the sequence is illustrated in Fig. 2. Only two species, *H. socialis* and *R. angeiodes* are restricted to the lower part of the succession whereas the other species, *V. gosaviensis*, *V. alpinus*, *Miseia pajaudi*, *Praeradiolites*

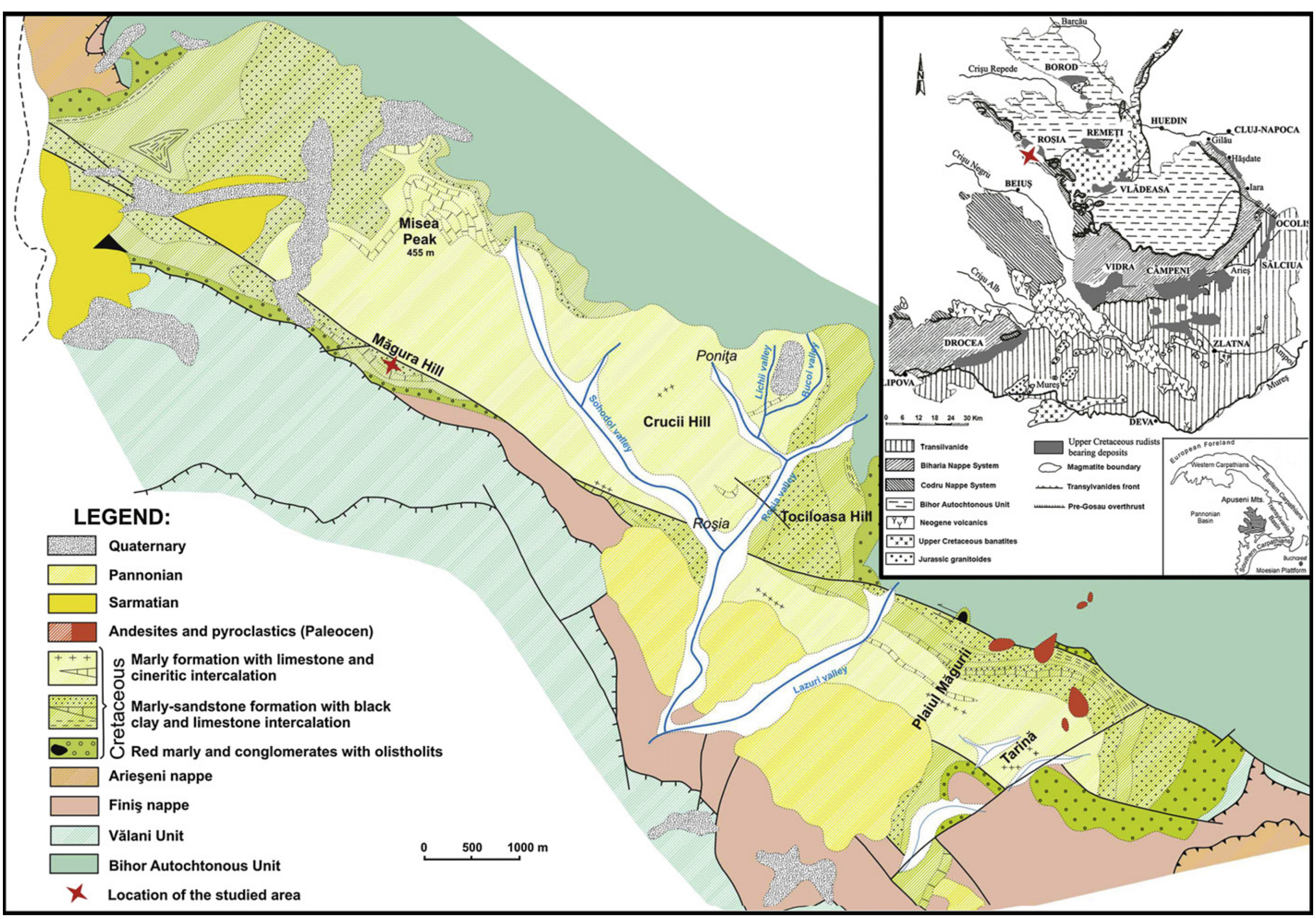

Fig. 1. Regional geological setting of the Apuseni Mountains with the locations of the Late Cretaceous rudist-bearing deposits (upper right side) (modified after Schuller et al., 2009) and geological setting of Roşia Basin, Northern Apuseni Mountains (modified after Patrulius, 1974).

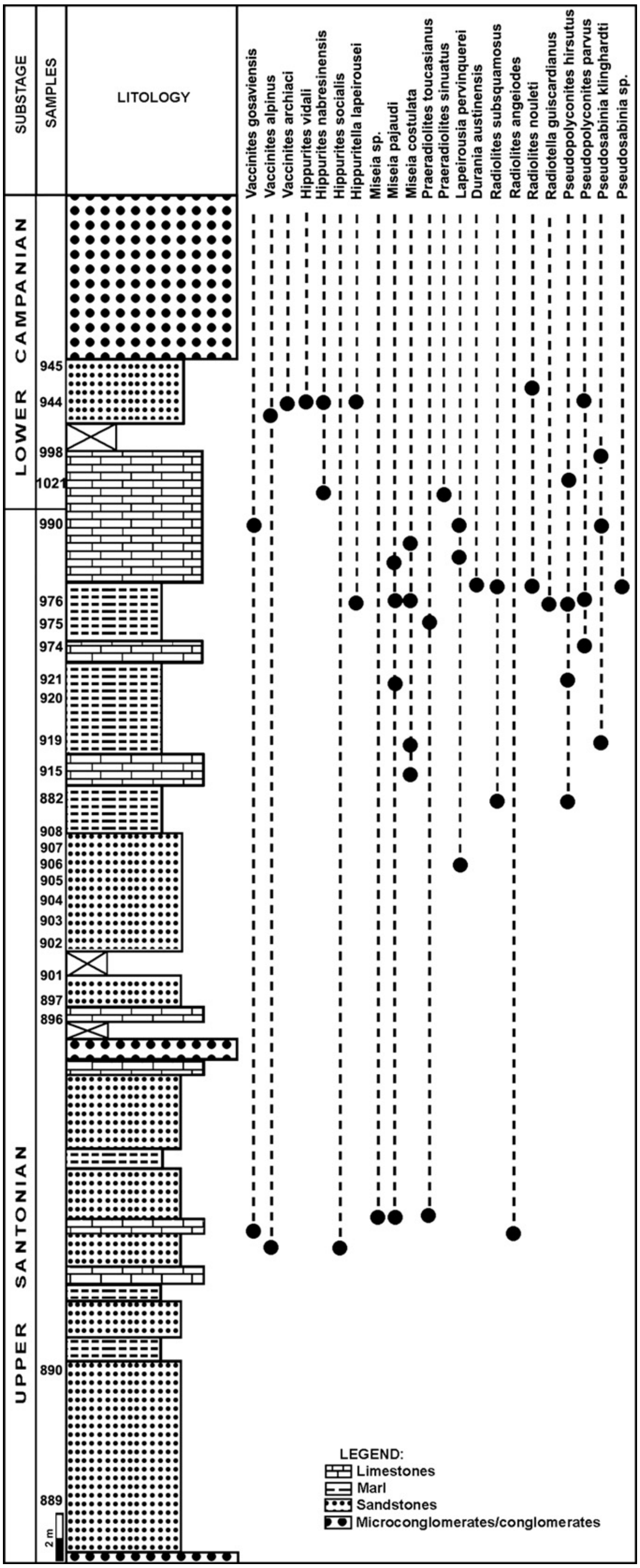

Fig. 2. Lithology of the Late Cretaceous deposits from Măgura Hill (Roşia Basin) and the distribution of the identified rudist assemblages within the stratigraphic succession.

toucasianus, appear throughout the sequence. Besides these, in the upper part we have identified *V. archiaci*, *H. vidali*, *H. nabresinensis*, *Hippuritella lapeirousei*, *M. costulata*, *Praeradiolites sinuatus*, *Lapeirousia pervinquierei*, *Durania austinensis*, *Radiolites subsquamosus*, *Radiolites nouleti*, *Radiotella guiscardianus*, *Pseudopolyconites hirsutus*, *Pseudopolyconites parvus* and *Pseudosabinia klinghardti*.

The stratigraphic distribution of some of the identified rudist taxa, *e.g.*, *V. gosaviensis*, *V. archiaci*, *V. alpinus*, *H. nabresinensis*, *Radiolites angeiodes* suggests a Late Santonian–Early Campanian age for these deposits. They were also found in coeval deposits from Austria (Steuber, 2001), Croatia (Polsak et al., 1978), Greece (Steuber, 1999), Serbia (Milovanović, 1935). It is worth mentioning that *Vaccinites alpinus* and *Hippurites nabresinensis* frequently co-occur as characteristic taxa denoting the Upper Santonian to basal Upper Campanian in the Alpine Gosau, Spain, Tunisia, Italy, Croatia, Slovenia, Serbia and Turkey (Steuber and Löser, 2000; Steuber, 2001, 2003; Steuber and Schlüter, 2012). Other biostratigraphic data support this designation, *e.g.*, calcareous nannoplankton zones CC17/UC13 identified after the standard zonation schemes of Perch-Nielsen (1985: CC zones) and Burnett (1998: UC zones) sets the Santonian–Campanian boundary (Melinte-Dobrinescu and Bojar, 2010; Bălc et al., 2012); thus, a Late Santonian–Early Campanian age can be assigned to *Pseudopolyconites parvus* and *Pseudosabinia klinghardti* but also to *Pseudopolyconites hirsutus* (Patrulius) and *Miseia costulata* Patrulius. The identification of this rudist fauna, as well as facies association's description and results on nannofossils will constitute the subject of further study.

The recent interest in the phylogeny and biogeographic distribution of *Pseudopolyconites* (Tarlao et al., 2010; Tunis et al., 2011) led us to reconsider the rudist fauna from the Măgura Hill, the type locality were *Pseudopolyconites hirsutus* (Patrulius) and *Miseia costulata* Patrulius have been described. For this purpose, we have performed field investigations in the Măgura Hill sections, and palaeontological analyses on selected valves.

3. Systematic palaeontology

Abbreviations: LV, left valve; RV, right valve; Vb, ventral radial band; Pb, posterior radial band; Ib, interband; L, ligament ridge; am, anterior myophore; pm, posterior myophore; at, anterior tooth; pt, posterior tooth; BC, body cavity; cl, canals (inner) shell layer of the LV; cp, celluloprismatic outer shell layer of the right valve; co, inner canals of the right valve; cy, cystose inner shell layers of the right valve.

Class BIVALVIA
Order Hippuritoida Newell, 1965
Superfamily: Hippuritoidea Gray, 1848
Family: Radiolitidae d'Orbigny, 1847b
Genus: *Pseudopolyconites* Milovanović, 1935
Type species: *Pseudopolyconites parvus* Milovanović, 1935

Pseudopolyconites hirsutus (Patrulius, 1974)
Fig. 3A–N

1974 *Durrandelgaia hirsuta* n. sp.: Patrulius, p.175, pl. I, figs. 1–7, pl. II, figs. 1–6.
1977 *Pseudopolyconites hirsutus* (Patrulius): Pejović and Sladić-Trifunović, p. 177, 179, pl. I, figs. 1–3, figs. 4–6 [copy Patrulius 1974]; pl. II, figs. 1–2; pl. III figs. 1–2; pl. IV, figs. 2–3; pl. V, figs. 2–3; pl. VI, figs. 1–3; pl. VII, fig. 1.
1983 *Pseudopolyconites hirsutus* (Patrulius): Sladić-Trifunović, p. 299, text-fig. 12, pl. XLIII, figs. 1–2.

Material: Two articulated specimens (BBUMP 23839 and 23840) and many right valve fragments.

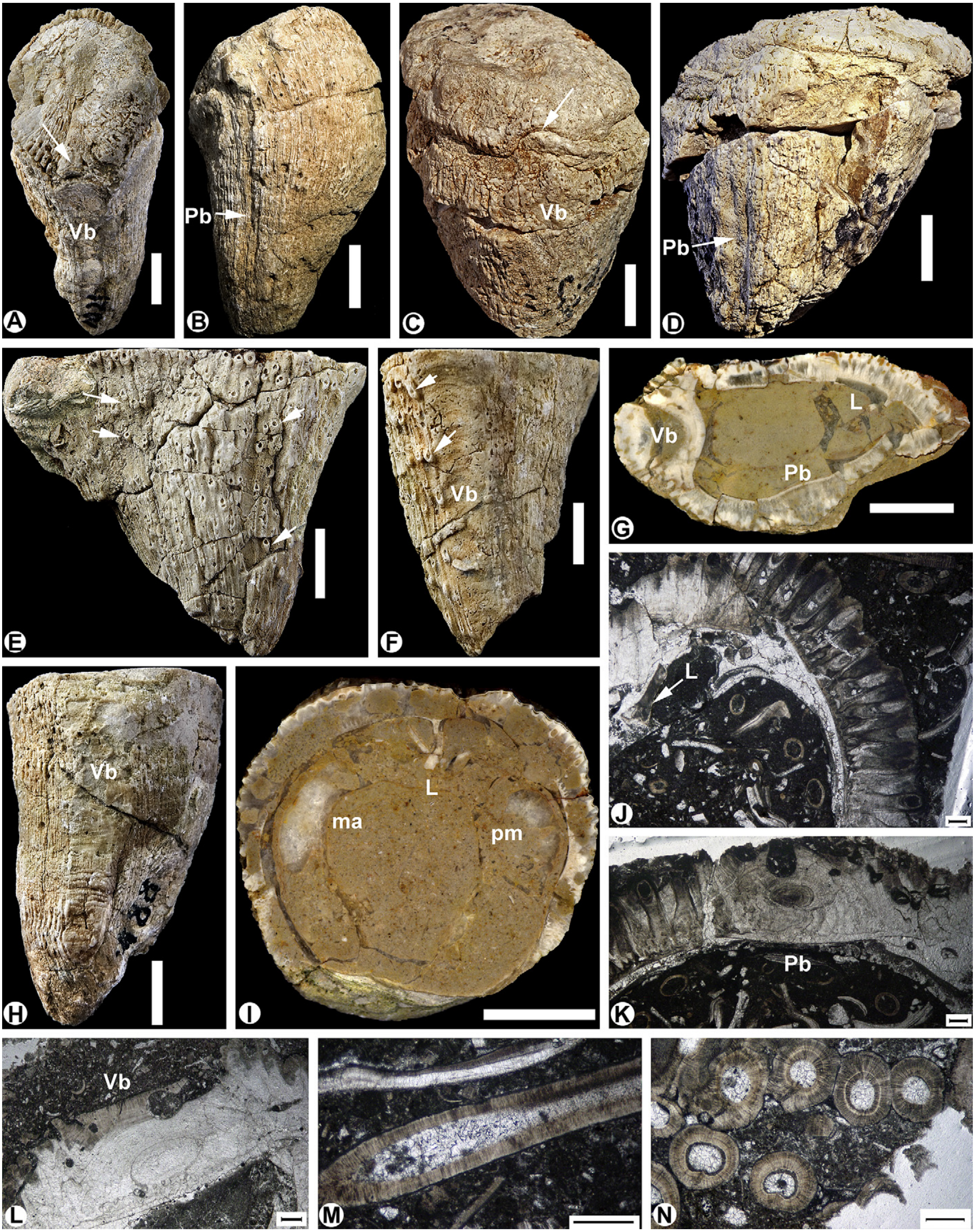

Fig. 3. A–N *Pseudopolyconites hirsutus* (Patrulius) – Măgura Hill, Apuseni Mountains, Romania. A. Complete valves, showing the flat and thin LV with radial rib (white arrow) above Vb of RV (specimen BBUMP 23840). Flat Vb, without tubular excrescences, can be observed in the RV of the same specimen. B. Conical and slightly curved RV showing the Pb with

Description: The LV is flat and very thin (1–2 mm) leaving the limb of the RV uncovered; on its surface, a large radial rib can be observed (Fig. 3A). Some differences in shape of LV can also appear; in BBUMP 23839, the LV is slightly convex and thicker (Fig. 3C and D). The tubular excrescences are not visible on the LV probably as a result of corrosion of the valve. The Vb of the RV is covered by a bulging radial rib in the LV. This bulge is composed of slightly arched concentric layers having a semi-circular opening on the edge of the LV (Fig. 3A and C). There is no radial rib on the LV above the posterior band of the RV. The RV is conical or cylindrical-conical, slightly curved in some specimens (Fig. 3B), 34–60 mm in height. The surface of the valve is covered by tubular excrescences (Fig. 3B, E and F) usually broken with a length of 2–3 mm and curved upwards (Fig. 3E and F). The Vb is flat, about 5–8 mm wide, without tubular excrescences (Fig. 3A, C, F and H). The Pb appears as a narrow furrow with one fine, longitudinal costae in some specimens (Fig. 3B and D), but usually the Pb is not discernable on the surface of the RV (*e.g.*, specimens Nos. 23838 and 23841). The area between Vb and Pb is flat and 20 mm wide below the commissural plane. In some specimens, the L is marked on the outer shell of the RV as a shallow groove, 2–3 mm wide.

In transverse section, the tubular excrescences form an envelope on the surface of the RV (Fig. 3G, I and J), its thickness varies from 3 mm dorsally, to ~5 mm in the posterior sector of the shell. These tubular excrescences have about 1.5 mm in diameter and a rounded or oval contour. Internally, they are filled with sediment and/or calcite and the tube walls have reticulate lamellar structure (Fig. 3M and N). In thin section the Vb displays an elliptical shape and a lamellar structure in the outer shell layer (Fig. 3L). In the cross-section the Pb is oval with ambiguous structure (Fig. 3G) while the thin section through the Pb shows an oval outline and the presence of the lamellar layers of the outer shell (Fig. 3K). The L is short, about 3–4 mm length, truncated at the top and widening distally (Fig. 3G, I, and J). The cardinal apparatus can be observed in some specimens: small accessory cavities located symmetrically to the dorso-ventral axis (Fig. 3I); sockets of cardinal teeth are rectangular, and myophores are elongated.

Discussions and remarks: *P. hirsutus* was assigned to *Duranddelgaia* by Patrulius (1974). Later, it was transferred to *Pseudopolyconites* due to the presence of the typical features found in both valves. Thus, they have been considered early Santonian ancestor of *Pseudopolyconites* by Pejović and Sladić-Trifunović (1977).

Our specimens show close similarities to those described by Pejović and Sladić-Trifunović (1977) from eastern Serbia. However, in some specimens they present some differences such as slightly convex LVs and the presence of weak longitudinal costae in the narrow furrow of Pb. The same variability of external morphological features of both valves in small species of *Pseudopolyconites* has been also observed by Sladić-Trifunović (2004) within the rudist fauna from Lesak (Serbia). The modifications concern the thickening of the longitudinal costae in Pb of RV in addition to the formation of a rounded opening in the LV above the Pb of the RV. We can speculate that this modification in *P. hirsutus* could be an evolutionary change in lineage towards *Pseudopolyconites parvus*. This hypothesis still demands more detailed investigation on the other species of *P. hirsutus* and *P. parvus* described from coeval deposits (*e.g.*, from Serbia).

Occurrence: The type locality of *P. hirsutus* is the Late Santonian–Early Campanian Măgura Hill sequence, Roşia Basin, Romania. Species of *P. hirsutus* have also been found in a Santonian–Early Campanian large olistolith from eastern Serbia (Lesak) (Pejović and Sladić-Trifunović, 1977; Sladić-Trifunović, 1998; Tarlao et al., 2010; Tunis et al., 2011).

Pseudopolyconites parvus (Milovanović, 1935)
Fig. 4A–I

1935 *Pseudopolyconites parvus* nov. gen, nov. sp.: Milovanović, p. 54, figs. 1b, 2–8.
1937 *Pseudopolyconites parvus* n. gen, n. sp.: Milovanović, p. 4, figs. 2–9 [copy Milovanović 1935].
1958 *Pseudopolyconites parvus* Milovanović: Milovanović and Sladić, p. 196, figs. 1, 2.
1977 *Pseudopolyconites parvus* Milovanović: Pejović and Sladić-Trifunović, pl. 4, fig. 1; pl. 5 fig. 1 [copy Milovanović 1935].
1983 *Pseudopolyconites parvus* Milovanović: Sladić-Trifunović, p. 269, text-fig. 8b; text-figs.17 a, c_1–c_2; text-fig. 18a; text-fig. 19; pl. I, fig. 2; pl. X, figs. 1–3; pl. XI, figs. 1–2; pl. XII, figs. 1-2; pl. XLIV, figs. 1–2.

Material: A single articulated specimen (BBUMP 23842), and thin sections through the lower valve of the other specimen (BBUMP 23843).

Description: The LV is very thin and slightly convex with the edges bent over the radial bands of the RV (Fig. 4A). Towards the Vb of the RV, the edge of the LV bends, forming slightly arched concentric layers and leaving an ovate opening of ~9 mm in length by 3 mm in height. A rounded opening ~3 mm in diameter is also observed above the posterior radial band of the lower valve (Fig. 4A).

The RV is conical and ~40 mm in height (Fig. 4B and C). On the surface of the valve, the eroded bases or the longitudinal tracks of the tubular excrescences are visible (Fig. 4B). The Pb is demarcated by a prominent longitudinal rib, 3–4 mm wide (Fig. 4B). The Vb is slightly concave, ~8 mm wide, without tubular excrescences (Fig. 4C). The area between Vb and Pb is 20 mm wide and flat with visible eroded bases of the tubular excrescences on the surface.

In transverse section, ~5 mm below the commissural plane, the RV has a circular contour with a minimum and maximum diameter of 30 and 35 mm, respectively (Fig. 4D). The outer shell layer is formed by lamellar and prismatic layers usually with a thickness of 3–4 mm but reaching maximum thickness of 5 mm at Pb (Fig. 4D, G and H). The cross-sections through the RV made in two ontogenetic stages reveals in the thin sections, the internal structure of the Vb and Pb (Fig. 4E–H). In the thin section of the lower cross-section, the Vb has an elliptical shape and only the lamellar wall of the outer shell layer is visible. This lamellar structure also covered the tubular excrescences situated on both sides of Vb (Fig. 4E). The

finely longitudinal costae in a narrow furrow (same specimen). C. Complete valves (specimen BBUMP 23839), showing the convex and thicker LV and the semi-circular opening (white arrow) on the edge of the LV above Vb of RV. Note the wide Vb of RV. D. Pb of RV like a narrow furrow with finely longitudinal costae of the same specimen. E. Conical RV (specimen BBUMP 23838) showing the tubular excrescences curved upwards in the cardinal area of RV. F. Flat Vb of RV without tubular excrescences. Note the eroded bases of the tubules in the antero-ventral side of the RV (same specimen). G. Adapical view of deformed RV showing the elliptical shape of the Vb, the circular shape of the Pb and the short L (BBUMP 23838). H. Cylindrical-conical specimen with flat Vb of RV (BBUMP 23841). I. Transversal section of the same specimen through the RV (adapical view), showing the elements of the cardinal apparatus symmetrically distributed in relation to L. J. Thin section showing the short L, truncated at the top and widening distally (specimen BBUMP 23844). K. Thin section through the Pb in RV showing the oval shape and thin external lamellar layers (same specimen). L. Elliptical shape and fine reticulate outer shell layer in Vb in RV (same specimen in thin section). M. Longitudinal section showing the closed end of the tubular excrescence. N. Transversal sections of the tubular excrescences showing internal structure. Scale bar is 10 mm in Figs. A–I and 1 mm in Figs. J–N.

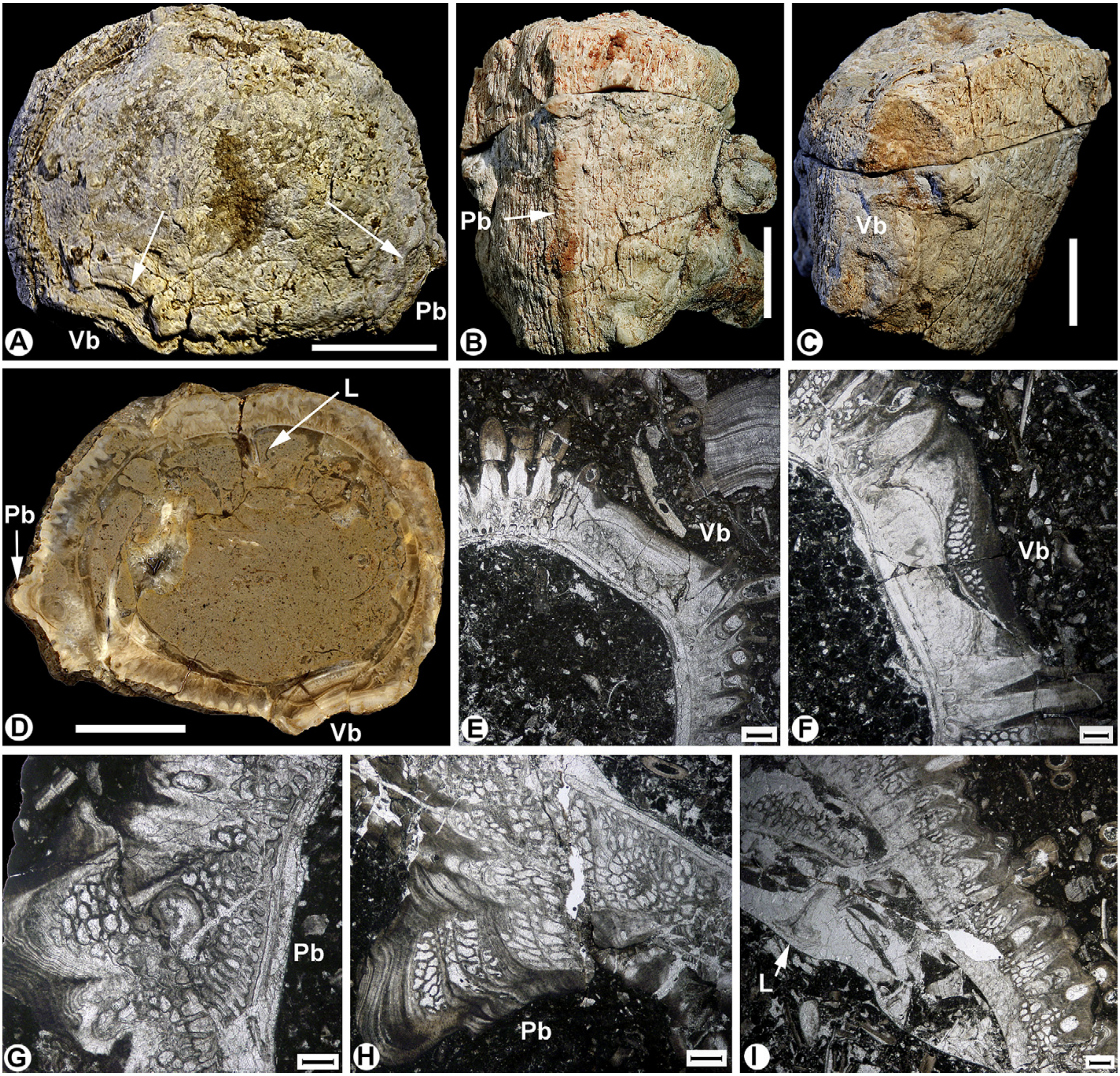

Fig. 4. A–I *Pseudopolyconites parvus* (Milovanović) – Măgura Hill, Apuseni Mountains, Romania. A. LV, top view showing the semi-circular and rounded openings (white arrows) above the Vb and Pb of the RV (BBUMP 23842). B and C. RV of the same specimen, showing the Pb forming a longitudinal rib (B) and wide, concave shape of Vb (C). Note the eroded bases of the tubular excrescences on the surface of RV. D. Transverse section through RV, 5 mm below commissure, adapical view, same specimen. E and F. Two successive cross-sections of RV (in thin sections, specimen BBUMP 23843) showing the structure of Vb. E. Thin section of the lower cross-section showing elliptical Vb, the lamellar outer shell layer and the tubular excrescences growing on both sides of Vb. F. Higher cross-section in the thin section through the Vb of RV now showing the mixed structure that consists of three rows of prismatic structure and concave external lamellar layers. G. The rounded shape of Pb in the lower cross-section with internal prismatic structure covered by convex external lamellar layers. H. Higher cross-section of Pb showing the internal structure that consists of alternating prismatic and lamellar structures. I. The double-hooked shape of L in higher cross-section. Scale bar is 10 mm in Figs. A–D and 1 mm in Figs. E–I.

higher cross-section through the Vb of RV reveals the mixed structure of the outer shell layer that consists of three rows of prismatic structure and the concave external lamellar wall (Fig. 4F). The Pb of RV has a round shape in the lower cross-section (Fig. 4G) and internal prismatic structure that is covered by convex external lamellar layers (Fig. 4D, G). Higher cross-section of Pb shows a more complex internal structure that consists of four alternating prismatic and lamellar layers (Fig. 4H). In the thin section of higher cross-section of the same specimen, the L is short, ~3 mm in length and thick, with the distal part double-hooked having an anchor shape (Fig. 4I). The triangular accessory cavities are symmetrically situated on both sides of the L (Fig. 4D). The sockets of cardinal teeth are close to L and have a rectangular shape; the posterior is longer than the anterior tooth socket. The myophores are well developed, the am with an indistinguishable shape and the pm ventrally elongated running parallel to the inner shell wall (Fig. 4D).

Discussion and remarks: The specimens of *P. hirsutus* and *P. parvus* identified at Măgura Hill show almost identical valve dimensions. Nevertheless, differences concerning external and internal morphologic characters can be observed: in *P. parvus*, the radial rib of the LV above the Vb of the RV is less prominent, but a semi-circular opening above the Vb and a rounded opening above Pb are preserved. Also, in RVs of *P. parvus*, the Vb is slightly concave and Pb is more prominent, developed as a longitudinal rib. The internal structure of the Pb is more complex in *P. parvus* than in *P. hirsutus*, being characterized by the presence of 3–4 alternating levels of prismatic and lamellar layers. The shape of the ligamental ridge is also different in *P. parvus* having the distal part double-hooked as opposed to *P. hirsutus* were the L is truncated at the top and widening distally. Thus, the differences concerning external and internal morphologic characters between *P. hirsutus* and *P. parvus* are large and we cannot speak about the intraspecific variability these two species being distinct. The specimens of *P. parvus* identified at Măgura Hill have smaller dimensions as compared to specimens describes by Sladić-Trifunović (1983) from Bacevica (Eastern Serbia) whose diameters vary between 5 and 11 cm. However, they show all the characteristic features of *P. parvus.*

Pseudopolyconites parvus was previously known only from Eastern Serbia and is here reported for the first time in Romania, in association with the rudist taxa illustrated in Fig. 2.

Occurrence: Late Campanian in Eastern Serbia (Bacevica, Vrbovac); Late Santonian–Early Campanian in Romania (Roşia Basin, Apuseni Mountains).

Genus: *Pseudosabinia* Morris and Skelton, 1995
Type species: *Sabinia klinghardti* Böhm, 1927
Pseudosabinia klinghardti (Böhm, 1927)
Fig. 5A–L

1927 *Sabinia Klinghardti* n. sp.: Böhm, p. 205, pl. 15, figs. 1a, 2a–c, pl. 16, fig.1a-b.
1986 *Sabinia klinghardti* Böhm: Özer, p. 101, pl. 1, fig. 5.
1988 *Sabinia klinghardti* Böhm: in Özer (2002), p. 177, pl. IV, fig. 1.
1995 *Pseudosabinia* aff. *klinghardti* (Böhm, 1927): Morris and Skelton, p. 303, pl. 10, fig. 1, pl. 11, figs. 1, 3–5.
1996 *Sabinia klinghardti* Böhm: Laviano, p. 7, text-fig. 8.
1999 *Pseudosabinia klinghardti* (Boehm): Fenerci, p. 135–140, text-figs. 3.42–3.43, pl. XV, figs. 1–5, pl. XVI, figs. 1–8, pl. XVII, figs. 1, 2.
2000 *Pseudosabinia klinghardti* (Boehm): Skelton and Smith, p. 103, 107–109, 123, text-fig. 10b.
2008 *Pseudosabinia klinghardti* (Boehm): Schlüter et al., p. 105, 111.
2009 *Pseudosabinia klinghardti* (Boehm): Steuber et al., p. 43, 44.
2010 *Pseudosabinia klinghardti* (Böhm): Özer, p. 647, pl. 1, figs. 1–5; pl. 2, figs. 1–4; pl. 4, figs. 1–3.
2010 *Pseudosabinia klinghardti* (Böhm): Korbar et al., p. 724, fig. 3A–E.

Material: Two articulated specimens (BBUMP 23845 and 23846), as well as one right valve and a partially preserved left valve (BBUMP 23847).

Description: The LV is capuloid in shape and strongly incurved postero-dorsally (Fig. 5B and J). On the surface of the valve, two narrow grooves corresponding to the radial bands of the RV are observed. The outer shell layer of LV is thinner and smooth; it is preserved only on small areas of the beak. The outer shell layer is broadly eroded showing the canals of the inner shell layer (Fig. 5A, I and J). Transverse section of the valve (Fig. 5H) shows that the inner shell layer consists of one row of pyriform and three rows of polygonal and oval canal sections (Fig. 5H and K).

The RV is conical (Fig. 5A, B, E and I–J) ranging from 44 to 100 mm in height, with circular (Fig. 5F and G) or oval contour in transverse section. The radial bands of the valve are clearly observed (Fig. 5A and E): the Vb is flat (Fig. 5E) or slightly concave (Fig. 5A), 15–20 mm-wide, while the Pb as a longitudinal groove (Fig. 5A and E), 4 mm-wide, better observed close to the commissure. The Ib is flat, 7–10 mm-wide, narrower than the ventral band (Fig. 5A and E). The outer shell layer (cp) is only partially preserved in the upper part of the RV, close to the commissure (Fig. 5E, I and J).

In transverse section through RV, the diagnostic combination of finely celluloprismatic outer shell layer and inner shell layer with canals of the *P. klinghardti* species can be observed. The outer shell layer is finely celluloprismatic, 4 mm-thick (Fig. 5D, F, G and L) and the inner shell layer is thicker, *i.e.*, 7–8 mm wide, consisting of three rows of irregular, polygonal and oval canal sections in specimen BBUMP 23845 (Fig. 5D). The other two specimens (BBUMP 23847, 23846) have cystose tabulae in the inner shell layers (Fig. 5F and L). The L is well developed and bifurcated at its extremity (Fig. 5C, F and H). Radiolitiform myocardinal apparatus can be clearly observed: two asymmetrical sockets for the teeth and large myophores running parallel to the inner shell layer (Fig. 5G). No accessory cavities.

Discussion and Remarks: The specimens show diagnostic internal and external features of *Pseudosabinia.* As a rule, the combination of finely celluloprismatic outer shell layer and inner shell layer with canals of the RV of the *P. klinghardti* was not emphasized by previous studies (Böhm, 1927; Fenerci, 1999; Korbar et al., 2010; Morris and Skelton, 1995; Özer, 2002; Skelton and Smith, 2000). However, this diagnostic feature of the genus was first pointed out from its type locality (Hereke-Kocaeli Peninsula, NW Turkey) and also from SE Anatolia, Turkey by Özer (2010). This feature has been observed again in one of our specimens (Fig. 5D and G, specimen BBUMP 23845). The width of the Ib in our specimens is smaller than that noticed in the Turkish specimens.

Pseudosabinia klinghardti is for the first time mentioned in rudist-bearing deposits from Romania.

Occurrence: Late Campanian–Maastrichtian deposits in Turkey (Özer, 1986, 2002, 2010; Özer and Fenerci, 1993; Özer et al., 2008, 2009; Steuber et al., 2009), Croatia (Korbar et al., 2010), Middle Campanian–Maastrichtian deposits in Italy (Laviano, 1996; Schlüter et al., 2008), Arabia (Morris and Skelton, 1995), and Late Santonian–Early Campanian deposits in Romania (present study).

4. Palaeobiogeography

Previous work on the Late Cretaceous palaeogeographic distribution of rudists (Philip, 1982, 1985, 1998; Pons and Sirna, 1992; Sladić-Trifunović, 1998; Steuber and Löser, 2000; Fenerci, 2004; Steuber et al., 2005; Steuber and Schlüter, 2012) reveals that the genera *Pseudopolyconites* and *Pseudosabinia* show almost identical palaeobiogeographic distribution within the central-eastern Mediterranean area. *Pseudopolyconites* genus was defined by Milovanović (1934, 1935) based on specimens collected from Late Cretaceous mixed siliciclastic-carbonate-volcanoclastic deposits in eastern Serbia (Bačevica). The numerous species in this genus cover a stratigraphic range from Late Santonian to Late Maastrichtian. They also show wide biogeographical distribution within the eastern Mediterranean and Arabian plate: E Serbia (Milovanović, 1934, 1935; Milovanović and Sladić-Trifunović, 1958; Sladić-Trifunović, 1986; Tarlao et al., 2010), W Slovenia (Pleničar, 1977), Croatia (Sladić-Trifunović, 1980; Pejović and Radoićic, 1987), S and NE Italy (Sladić-Trifunović and Campobasso, 1980; Sladić-Trifunović and Nereo, 1990; Swinburne and Noacco, 1993), Bulgaria (Pamouktchiev, 1982), Greece (Sladić-Trifunović and Campobasso, 1980; Steuber, 1999), Romania (Lupu, 1974; Patrulius, 1974), NW,

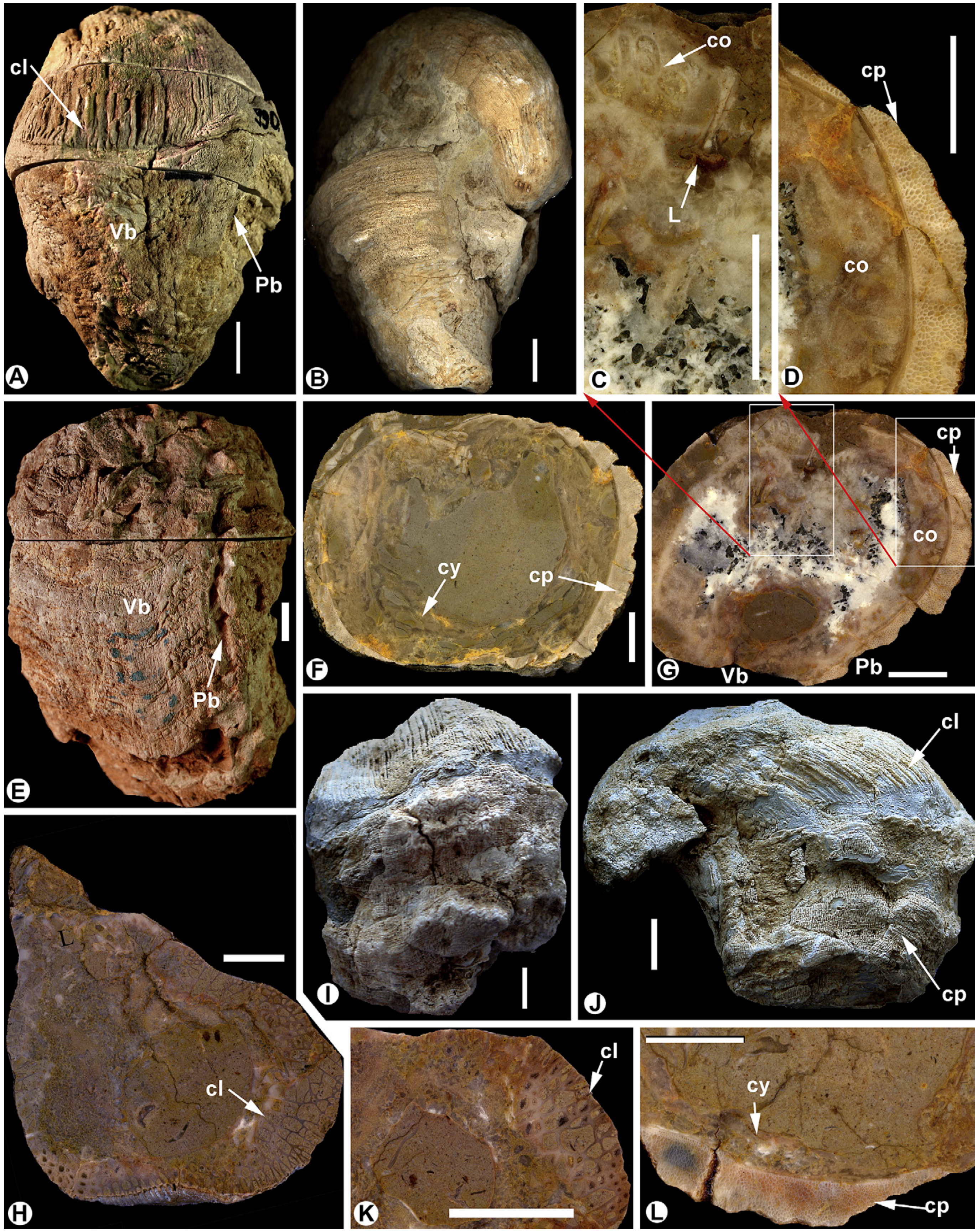

Fig. 5. A–L *Pseudosabinia klinghardti* (Böhm) – Măgura Hill, Apuseni Mountains, Romania. A. Ventral side of both valves of *P. klinghardti* (BBUMP 23845) showing the Vb slightly concave, and Pb forming a longitudinal groove. B. Dorsal view of the same specimen, showing the postero-dorsally incurved LV. C. Detail of Fig. 5G, showing the ligamental ridge

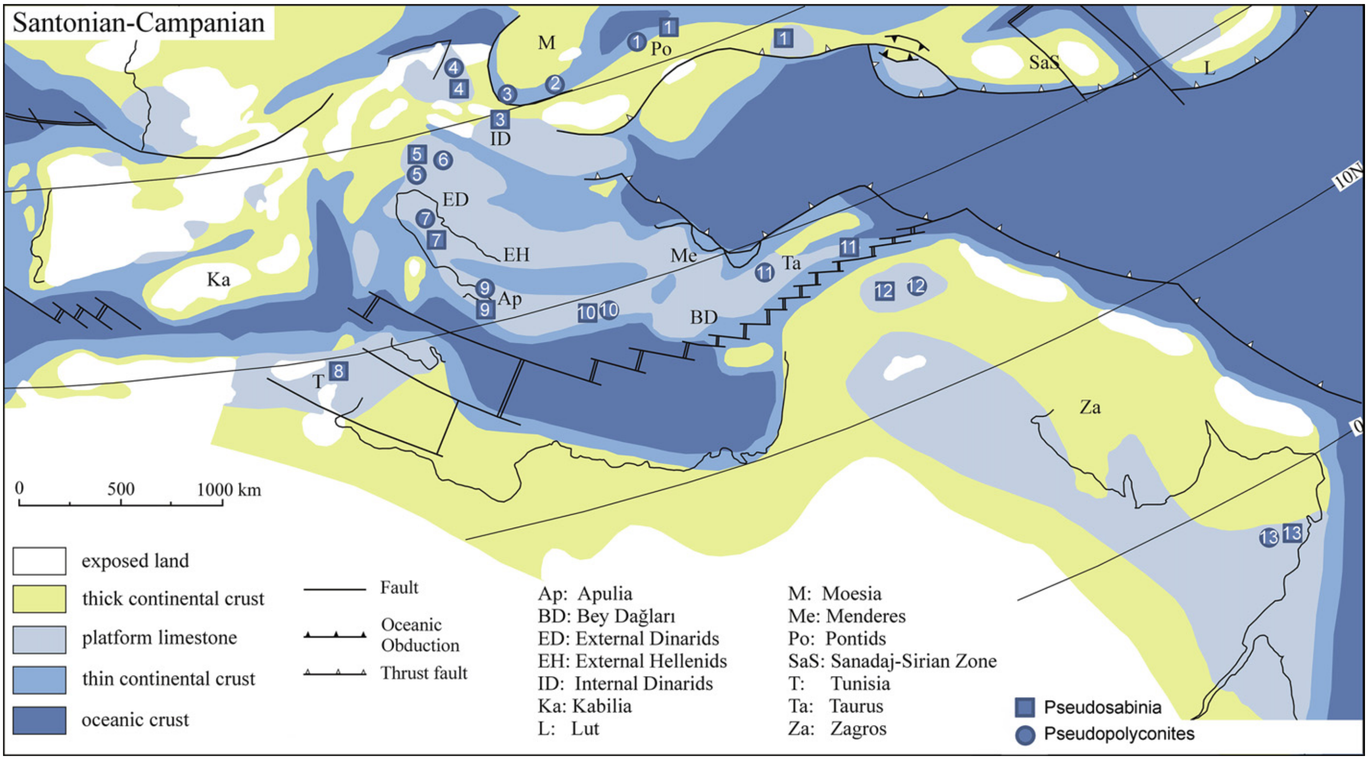

Fig. 6. Santonian–Campanian palaeobiogeographic distribution of *Pseudosabinia* and *Pseudopolyconites* genera in central-eastern Mediterranean Tethys and Arabia (modified after Dercourt et al., 1986). Legend: 1 – north-western **(left two indications) and north-eastern (right one indication)** Turkey (Pontide); 2 – Bulgaria; 3 – Serbia; 4 – Romania (Apuseni Mountains); 5 – north-eastern Italy (Carnian Alps); 6 – west Slovenia; 7 – Croatia (Island of Hvar-Adriatic platform); 8 – Tunisia; 9 – south Italy (Apulian platform); 10 – Greece (preapulian zone); 11 – central Turkey (Anatolide–Tauride); 12 – south-eastern Turkey (north Arabian platform); 13 – Arabia (locating of the occurrences of these genera in Oman during Maastrichtian).

central and SE Turkey (Özer, 1983, 1986, 1988, 1992a, b, 2010; Özer et al., 2009), and Arabia-Oman (Philip and Platel, 1996). *Pseudopolyconites* has also been mentioned from the Gosau Group of Krappfeld in Central Alps (Sanders, 1998) in the rudist limestones redeposited into deep-water facies (Faupl and Wagreich, 2000).

Pseudosabinia (Morris and Skelton, 1995) is generally abundant in Early Campanian–Maastrichtian deposits from central-eastern Mediterranean area and from Arabia (Morris and Skelton, 1995; Skelton and Smith, 2000; Steuber, 2002b; Özer, 2010; Korbar et al., 2010; Steuber and Schlüter, 2012). Different species of this genus have been reported in shallow-marine siliciclastic-carbonatic deposits in Turkey (Böhm, 1927; Karacabey, 1972; Özer, 1986, 2002, 2010; Özer and Fenerci, 1993; Steuber et al., 2009), Serbia (Kühn and Pejovic, 1959; Pejović, 1967), in limestones from a relatively deeper subtidal environment in Croatia (Korbar et al., 2010), or in shallow marine carbonates in south Italy (Laviano, 1996; Schlüter et al., 2008), Tunisia (Philip, 1986) and Arabia (Morris and Skelton, 1995; Skelton and Smith, 2000).

The occurrence of *Pseudopolyconites parvus* and *Pseudosabinia klinghardti* in the Late Santonian–Early Campanian succession from Măgura Hill provides new data about their biogeographical distribution. They invaded the Upper Cretaceous basins of the Roşia Basin from central and northeast Serbia through the southern part of the Apuseni Mountains (Lupu, 1976), thus delineating the north-western palaeobiogeographical boundaries within the central-eastern Mediterranean area (Fig. 6).

5. Discussion and conclusions

The similarities between the stratigraphic evolution and sedimentary records of Late Cretaceous shallow-marine deposits from the Apuseni Mountains and those recorded in the Lower Gosau Subgroup of the Eastern Alps (sensu Wagreich and Faupl, 1994) are indisputable and well documented (Ianovici et al., 1976; Lupu and Lupu, 1983; Lupu and Zacher, 1996; Schuller, 2004; Schuller et al., 2009; Willingshofer et al., 1999). Previously, the rudist fauna from the Apuseni Mountains has been considered as a Gosau-type association. Species of *V. gosaviensis, V. alpinus, V. archiaci, Hippurites nabresinensis, Radiolites angeiodes* identified in Măgura Hill are typical for the Gosau-type deposits showing a wide palaeogeographic distribution in the central-eastern Mediterranean area (Steuber, 2001; Steuber and Löser, 2000). The presence of some endemic genera (*e.g.*, *Miseia*, *Pseudopolyconites* and *Pseudosabinia)* supports the idea that Roşia Basin was connected with the central

very long and it bifurcates at the extremity. D. Detail of the transverse section through RV (G) showing the combination of the outer shell layer finely celluloprismatic and the inner shell layer consisting of three rows of irregular, polygonal and oval canal sections. E. Ventral view of RV and partially preserved LV (BBUMP 23847) with flat Vb and Pb forming narrow longitudinal groove. F. Abapical view of RV (same specimen) with cystose inner shell layers and celluloprismatic outer shell layer. G. Adapical view of lower valve (specimen BBUMP 23845) with the celluloprismatic outer shell layer and inner shell layer with canals. H. Adapical view of LV (BBUMP 23846) showing the inner shell layer. I. Ventral view of both valves (BBUMP 23846): the radial bands are not clearly defined maybe because of deformation of the shell. J. Anterodorsal side of both valves (BBUMP 23846) showing the posterodorsally incurved LV and fragment of RV. K. The inner shell layer of LV consists of one row of pyriform and three rows of polygonal and oval canal sections (detail of Fig. 5H). L. Detail of the outer shell layer finely celluloprismatic (cp) partly preserved in ventral side of the RV and the cystose inner shell layers. Scale bar is 10 mm in Figs. A–B, E and I and J and 1 mm in Figs. F–H.

(Gosau basins) but also with the eastern Mediterranean during the Upper Cretaceous.

Also, the rudist taxa of Măgura Hill succession and other independent biostratigraphic data (*e.g.*, nannoplankton) denote a Late Santonian–Early Campanian age, in contrast to the Early Santonian age suggested by Patrulius (1974). Additionally, this is the first mention on a Late Santonian age for *Pseudopolyconites parvus* and *Pseudosabinia klinghardti*. This supports the hypothesis based on SIS that many species previously considered characteristic for Campanian–Maastrichtian are in fact of Campanian age, or even older (Steuber, 2001, 2003; Steuber et al., 2005; Schlüter, 2008; Schlüter et al., 2008; Swinburne et al., 1992). Implicitly, the same age reassignment has to be considered for the specimens of *Pseudopolyconites hirsutus* and *Miseia costulata* previously described by Patrulius (1974) from Măgura Hill. The occurrences of *Pseudopolyconites parvus* and *Pseudosabinia klinghardti* in the rudist-bearing deposits of the Apuseni Mountains delineate the species' northwestern palaeobiogeographic boundary within the central-eastern Mediterranean area during the Late Cretaceous.

Acknowledgements

The authors would like to thank the two anonymous reviewers for their valuable comments and constructive criticism that helped to improve the quality of the manuscript. Special thanks are addressed to colleagues Dana Pop for improving the English spelling and Forray Ferenc for the rudists photos. This work was made possible by the financial support of the Sectorial Operational Programme for Human Resources Development 2007–2013, co-financed by the European Social Fund, under the project number POSDRU 89/1.5/S/60189 entitled "Postdoctoral Programs for Sustainable Development in a Knowledge Based Society".

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