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Campanian–Maastrichtian *Pseudosabinia* from Turkey: Descriptions and Taxonomic Problems

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Abstract: Specimens of taxa assigned to *Pseudosabinia* Morris & Skelton, collected from the Campanian–Maastrichtian sequences of different regions of Turkey such as the Kocaeli Peninsula, Amasya, Bayburt (Pontides), Sivas, Malatya, Elazığ (eastern Anatolian platform) and Kahta-Adıyaman and Yaylaçiftliği-Antakya (northernmost part of the Arabian platform), are determined and the taxonomic statuses of the species are discussed. *Pseudosabinia klinghardti* (Böhm) uniquely presents all the characteristic features of the genus. Other species and subspecies assigned to the genus '*Pseudosabinia*' *rtanjica* (Pejović), '*Pseudosabinia*' *serbica* (Kühn & Pejović), '*Pseudosabinia*' *rtanjica triangularis* (Karacabey) and '*Pseudosabinia*' *rtanjica tunisiensis* (Philip) lack the cellular prismatic structure of the outer shell layer in the right valve – a characteristic feature of the type species – despite sharing with the latter a radiolitiform myocardinal apparatus, indicating some taxonomic problems about the definition of *Pseudosabinia*. Meanwhile, the right valve of '*Pseudosabinia*' *rtanjica triangularis* (Karacabey) is unknown. These problematical species may belong to another genus of, most probably, Radiolitidae; but more detailed study is needed before a new taxon is created. *Sabinia ornata* Özer & Fenerci is here transferred to *Pseudosabinia* because it presents all of the generic characteristics.

Key Words: Rudists, *Pseudosabinia*, description, taxonomy, Campanian–Maastrictian

Türkiye'de bulunan Kampaniyen–Mastrihtiyen *Pseudosabinia*'ları: Tanımlama ve Taksonomik Sorunlar

Özet: Kocaeli Yarımadası, Amasya, Bayburt (Pontidler), Sivas, Malatya, Elazığ (Doğu Anadolu), Kahta–Adıyaman ve Yaylaçiftliği–Antakya (Arap platformu) gibi Türkiye'nin değişik bölgelerindeki Kampaniyen–Mastrihtiyen istiflerinden derlenen *Pseudosabinia* Morris & Skelton örnekleri tanımlanmış ve türlerin taksonomik konumları tartışılmıştır. *Pseudosabinia klinghardti* (Böhm) türü cinsin tipik özelliklerinin tümünü içerir. Cinse dahil edilen '*Pseudosabinia*' *rtanjica* (Pejović), '*Pseudosabinia*' *serbica* (Kühn & Pejović), '*Pseudosabinia*' *rtanjica triangularis* (Karacabey) ve '*Pseudosabinia*' *rtanjica tunisiensis* (Philip) gibi diğer türler ve alttürlerin, radolitid tip miyokardinal içermelerine karşın, tip türün tanımsal özelliği olan prizmatik yapılı sağ kavkı dış kavkı tabakasının eksikliği, *Pseudosabinia* 'nın tanımlamasındaki bazı taksonomik sorunları işaret eder. Ayrıca, '*Pseudosabinia*' *rtanjica triangularis* (Karacabey) alt türünün sağ kavkısı da bilinmemektedir. Sorunlu bu türler ve alt türlerin büyük bir olasılıkla Radiolitidae'nin diğer bir cinsine ait olabilirler; ancak yeni bir takson oluşturulurken ayrıntılı çalışmaya gereksinim vardır. *Sabinia ornata* Özer & Fenerci türü, cinsin tüm özelliklerini içermesi nedeniyle bu çalışmada *Pseudosabinia* cinsine dahil edilmiştir.

Anahtar Sözcükler: Rudistler, *Pseudosabinia*, tanımlama, taksonomi, Kampaniyen–Mastrihtiyen

Introduction

The genus *Pseudosabinia* Morris & Skelton (1995) is characterized by typically radiolitiform myocardinal elements and also a finely cellular outer shell layer of the right valve (MacGillavry 1937). Because of these distinct features some of the species previously referred to *Sabinia* Parona such as *S. klinghardti* Böhm, *S. serbica* Kühn & Pejović and *S. rtanjica* Pejović and two sub-species of *S. rtanjica*- *S. rtanjica triangularis* Karacabey and *S. rtanjica tunisiensis* Philip were transferred to *Pseudosabinia* (Morris & Skelton 1995; Steuber 2002).

Pseudosabinia klinghardti (Böhm) is the type species of the genus and it was described from NW Turkey, around Tavşanlı village-Hereke (Kocaeli Peninsula) by Böhm (1927). The holotype and paratypes of the species are actually housed in the Natural History Museum in London and the majority of these specimens were recently re-photographed and the current taxonomic status of the specimens were discussed by Skelton & Fenerci-Masse (2008).

Many new specimens of the type species from the type locality and numerous additional specimens of *Pseudosabinia* were found in the Campanian-Maastrichtian transgressive sequences of Amasya, Maden-Bayburt, Sivas, Malatya, Elazığ, Kahta-Adıyaman and Yaylaçiftliği-Antakya showing its a wide geographic distribution in Turkey (Figure 1).

The aim of this study is to determine the specimens of *Pseudosabinia* and to discuss the taxonomic statuses of the species of the genus.

Geological Setting and Stratigraphy

Turkey consists tectonically of four main plate (lithospheric) fragments, which, from north to south, are as follows: (1) the Pontides (PP), (2) the Anatolide-Tauride platform or block (ATP), (3) the Kırşehir Massif (KM) and (4) the Arabian platform (AP) (Figure 1) (Ketin 1966; Şengör & Yılmaz 1981; Okay & Tüysüz 1999; Görür & Tüysüz 2001). Campanian-Maastrichtian transgressive sequences were deposited on the flanks of the PP, ATP and AP and are characterized, from bottom to top, by clastic-dominated sediments and consist of the following units: (i) reddish-conglomerates, sandstones and mudstones, (ii) greenish-grey bioclastic and biostromal sandy limestones rich in benthic fauna and (iii) grey pelagic mudstones including volcanic intercalations. The three units show lateral and vertical changes and varying thicknesses indicating diachronism. They unconformably overlie Triassic, Jurassic and Lower Cretaceous carbonates, metamorphic and ophiolitic rocks (Özer 2002; Özer *et al.* 2009a).

The specimens of *Pseudosabinia* Morris & Skelton come from the Campanian–Maastrichtian transgressive mixed siliciclastic-carbonate successions (typical of unit 2, above) on the PP in the Hereke area on the Kocaeli Peninsula and at Kışlacık village-Amasya and Maden-Bayburt, on the eastern Anatolia ATP block at the Hekimhan-Yazıhan-Darende-Yeşilyurt areas (Malatya), Divriği (Sivas) and Elazığ, and also on the AP in the southeastern Anatolian areas of Kahta (Adıyaman) and Yaylaçiftliği (Antakya) (Figure 1).

Pontides

In the Hereke (Kocaeli) area, the basal Akveren Formation consists of reddish coarse clastics and rudist-bearing limestones passing upward into marly pelagic limestones and mudstones (Figure 2). It contains rudists (Böhm 1927; Özer 1982, 1992a; Kaya *et al.* 1986a, b; Özer *et al.* 1990, 2009a; Fenerci 1999, 2004) and benthic foraminifera (Özer *et al.* 1990, 2009a, b; Fenerci 1999) indicating a late Campanian–Maastrichtian age. Planktonic foraminifera in the overlying section give an early-late Maastrichtian–Danian to Montian age (Özer *et al.* 1990; Fenerci 1999).

Fore-arc sequences unconformably overlie the North Anatolian Ophiolitic Complex (Figure 2) in the Amasya region and begin with fluvial reddish clastics, which grade upwards into sandstones and rudist-bearing biostromal limestones (Alp 1972; Rojay 1995; Tüysüz 1996; Steuber *et al.* 1998; Özer & Sarı 2008; Özer *et al.* 2008b). The rudist fauna consists essentially of hippuritids including species of *Yvaniella* Milovanovic (Karacabey 1968; Steuber *et al.* 1998; Özer 2008a). Karacabey (1968) and Özer & Sarı (2008) proposed a Campanian age for the rudist fauna. Steuber *et al.* (1998) also suggested an early Campanian age based on Sr-isotope analysis of rudist shells. The rudist limestones pass upward into volcanogenic flysch-type rocks consisting of blocks of limestones with rudists. The planktonic foraminifers indicate a late Campanian–Maastrichtian age for the volcanogenic flysch type rocks (Özer & Sarı 2008). The upper part of the sequence is characterized by volcanic rocks, which are widely distributed in the region and also by the alternation of *Pseudosabinia*-bearing rudist limestones and volcanics and yellowish-reddish volcanogenic sandstones (Özer & Sarı 2008) (Figure 2).

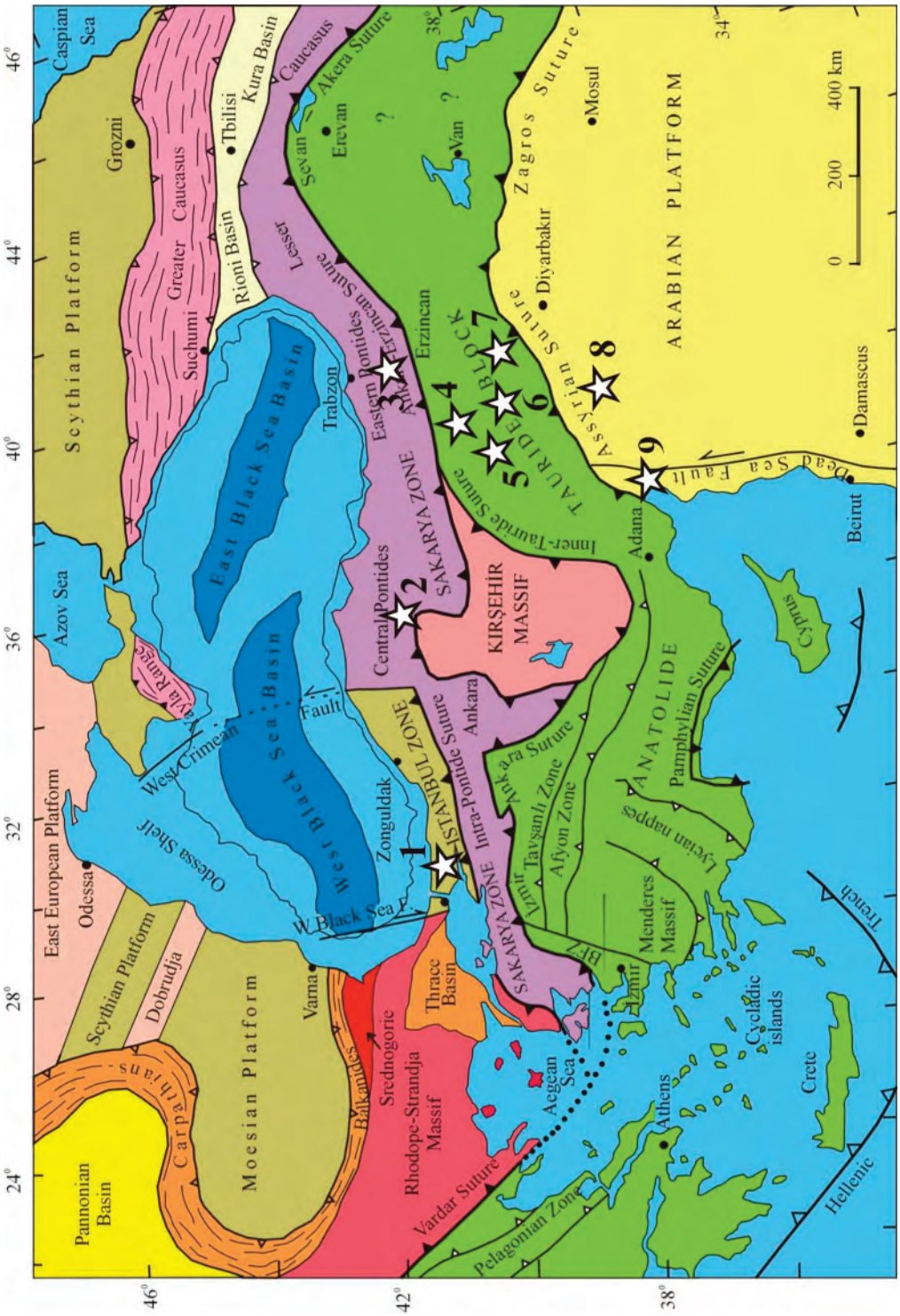

Figure 1. Tectonic maps of Turkey (after Okay & Tüysüz 1999) showing the distribution of *Pseudosabinia* localities (asterisks) in the tectonic belts: 1– Tavşanlı village-Hereke-Kocaeli; 2– Kışlacık village-Amasya, 3– Maden-Bayburt, 4– Güneş village-Divriği-Sivas, 5– Darende-Malatya, 6– Hekimhan-Yazılhan-Yeşilyurt-Malatya, 7– Elazığ, 8– Alidamı village-Kahta-Adıyaman, 9– Yaylaçiftliği- Antakya.

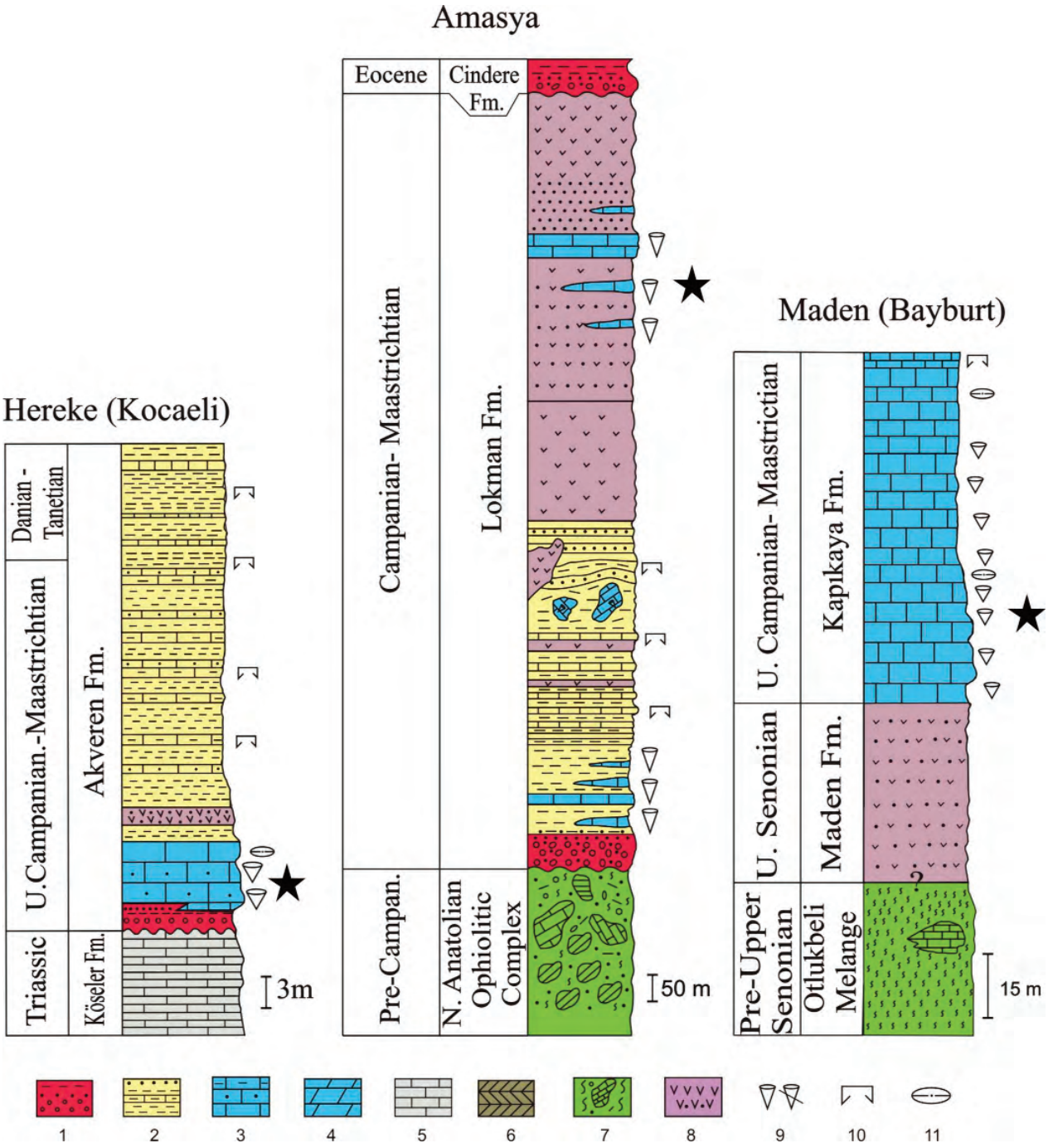

Figure 2. Stratigraphic sections of Hereke (Özer *et al.* 1990; Özer 1994; Fenerci 1999), Amasya (Özer & Sarı 2008; Özer *et al.* 2008 b) and Maden-Bayburt (Özer & Fenerci 1993; Fenerci 1994; Özer *et al.* 2008 b) areas showing the *Pseudosabinia* levels (asterisks). See Figure 1 for location of the sections. 1– conglomerates, sandstones and mudstones, 2– mudstones, clayey limestones and sandstones, 3– limestones, sandy limestones and clayey limestones, 4– dolomitic limestones, 5– limestones, 6– anhydrites, 7– ophiolitic complex, 8– volcanics and volcaniclastics, 9– rudists and fragments, 10– planktic foraminifera, 11– benthic foraminifera.

Rudist-rich limestones were also observed overlying the volcaniclastics in the Maden-Bayburt area (Figure 2) (Ağar 1977; Özsayar *et al.* 1981; Bergougnan 1987; Yılmaz *et al.* 2003). Specimens of *Joufia, Mitrocaprina, Lapeirousia, Pseudosabinia* and *Vaccinites* are very abundant in the rudist fauna, mainly forming biostromes. The rudists and scarse benthic foraminifers indicate a late Campanian–Maastrictian age for these rudist-bearing limestones (Özer & Fenerci 1993; Fenerci 1994; Özer *et al.* 2008b, 2009 a, b).

Anatolide-Tauride Platform

In eastern Anatolia, the Campanian–Maastrichtian transgressive sequence is well-exposed around Malatya, Sivas and Elazığ, and starts with reddish-clastics and continues into rudist-rich limestones including *Pseudosabinia* and larger benthic foraminifers (Akkuş 1971; Görmüş 1990, 1999; İnceöz 1996; Meriç & Görmüş 1997, 1999; Aksoy *et al.* 1999; Görmüş *et al.* 2001; Önal & Kaya 2007; Özer *et al.* 2007, 2008a, 2009 a; Özer 2008b). In the Malatya area, the pelagic mudstones conformably overlie the rudist-bearing limestones and pass upward into submarine volcaniclastics and volcanics, clayey limestone to limestone and *Loftusia*- and rudist-bearing limestone and dolomites indicating regression (Figure 3). The rudist fauna of eastern Anatolia, especially around Hekimhan, Darende, Balaban, Yazıhan and Yeşilyurt in the Malatya Basin, is remarkably well developed and contains many well preserved new genera and species (Karacabey 1970, 1974; Karacabey-Öztemür 1976, 1979a, 1980; Özer 1988, 1992a, 2002, 2006; Özer *et al.* 2009a). Sr-isotope analysis of rudist shells indicating a late Campanian age for the rudist-bearing limestones of the transgressive sequence in the Malatya Basin have been recently demonstrated by Özer *et al.* (2008 a) and Schlüter *et al.* (2008a).

Arabian Platform

The upper Campanian–Maastrichtian–lower Paleocene transgressive sequences of southeastern Anatolia were deposited on top the ophiolitic nappes and consist of, from bottom to top, reddish clastics with rudist limestone lenses (Terbüzek Formation), rudist-bearing shallow-water carbonates (Besni Formation), and pelagic mudstones (Germav Formation) (Figure 3). These units show lateral facies changes indicating diachronous transgressive sedimentation and are overlain by clastics of the Gercüş Formation and the carbonates of the Eocene Midyat Formation (Yalçın 1976; Perinçek 1979; Şengör & Yılmaz 1981; Altıner 1989; Yılmaz & Yiğitbaş 1991; Yılmaz 1993; Elmas & Yılmaz 2003). *Pseudosabinia* specimens are found in the rudist limestone lenses in reddish clastics around Alidamı village-Kahta-Adıyaman and Yayladağı-Antakya (Özer 1986, 2008b). The Maastrichtian age for the rudist-bearing limestones lenses was accepted by Karacabey-Öztemür (1979b) and Özer (1986, 1992b, c, d, 2006) based on the presence of typical benthic foraminifers in the rudist limestones (Meriç *et al.* 1985, 1987, 2001; Meriç & Görmüş 2001). However, Özcan (1993, 2007) identified some benthic foraminifera in the lowest limestone lense with rudists and concluded a late Campanian age. Recently, Steuber & Özer (2008), Schlüter *et al.* (2008a) and Steuber *et al.* (2009) likewise concluded a late Campanian age, based on Sr-isotope values from the rudist shells.

Taxonomy and Description

Class BIVALVIA Linné 1758

Subclass HETERODONTA Neumayr 1884

Order HIPPURITOIDA Newell 1965

Superfamily HIPPURITOIDEA Gray 1848

Family RADIOLITIDAE d'Orbigny 1847

Genus *Pseudosabinia* Morris & Skelton 1995

Type species *Sabinia klinghardti* (Böhm 1927)

Pseudosabinia klinghardti (Böhm 1927)

Plate 1, Figures 1–5; Plate 2, Figures 1–4;

Plate 4, Figures 1–3

1927 *Sabinia Klinghardti* n. sp. Böhm, p. 205, plate15, figures 1a, 2a–c, plate 16, figure 1a, b.

1986 *Sabinia klinghardti* Böhm, Özer, p. 101, plate 1, figure 5.

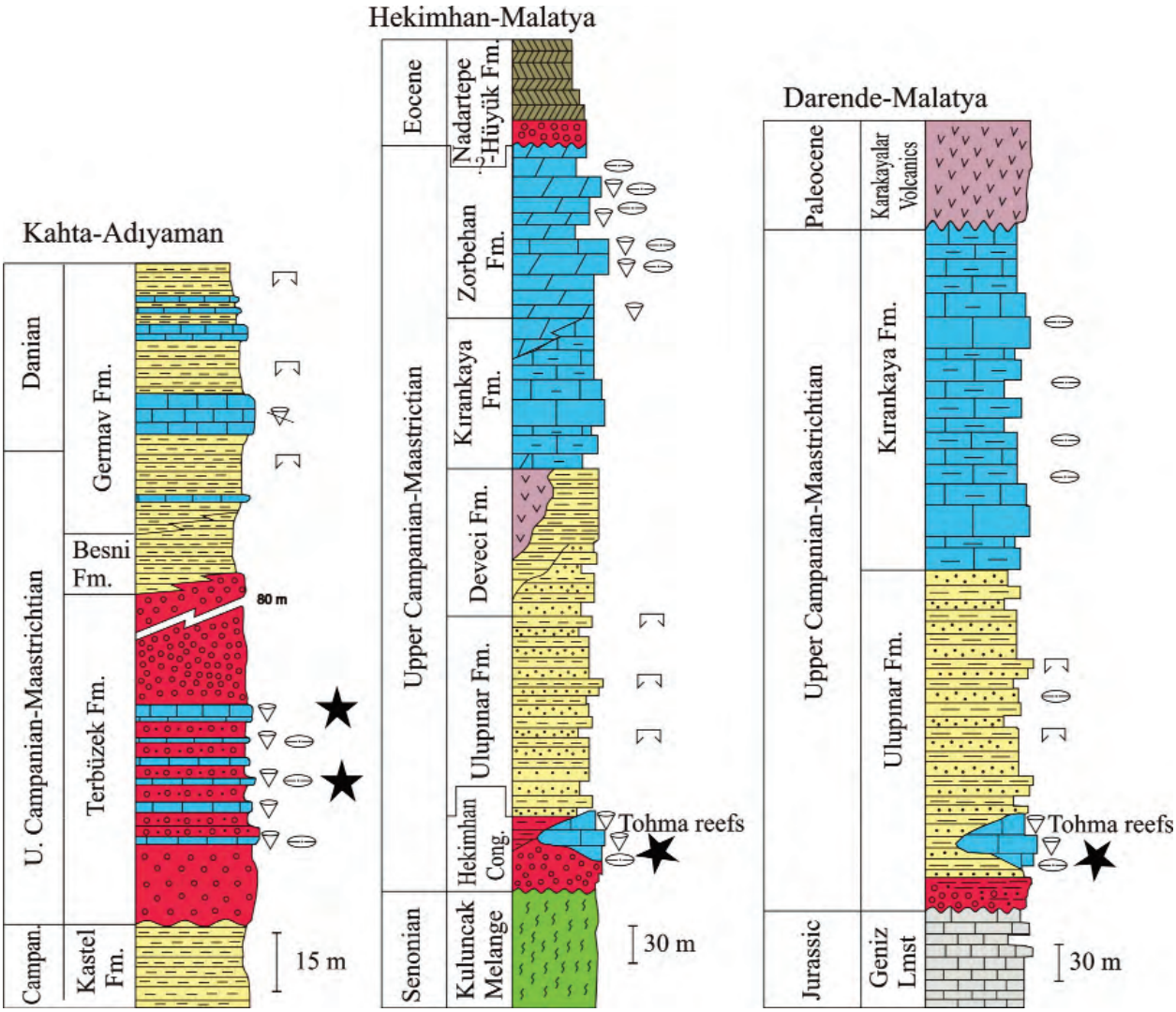

Figure 3. Stratigraphic sections of Alidamı-Kahta-Adıyaman (Meriç *et al.* 1985; Özer 1986, 1992d; Özer *et al.* 2008 a; Steuber *et al.* 2009), Hekimhan and Darende-Malatya areas (Akkuş 1971; Görmüş 1990; Özer *et al.* 2008 a) showing the *Pseudosabinia* levels (asterisks). See Figure 1 for location of the sections and Figure 2 for explanations of lithologies.

1988 *Sabinia klinghardti* Böhm, *in* Özer 2002, p. 177, Plate 4, figure 1.

1995 *Pseudosabinia* aff. *klinghardti* (Boehm, 1927), Morris & Skelton, p. 303, plate 10, figure 1, plate 11, figures 1, 3–5.

1996 *Sabinia klinghardti* Böhm, Laviano, p. 7, text-figure 8.

1999 *Pseudosabinia klinghardti* (Boehm), Fenerci, p. 135–140, text-figures 3.42–3.43, plate 15, figures 1–5, plate 16, figures 1–8, plate 17, figures 1, 2.

2000 *Pseudosabinia klinghardti* (Boehm), Skelton & Smith, p. 103, 107–109, 123, text-figure 10b.

2008 b *Pseudosabinia klinghardti* (Boehm), Schlüter *et al.*, p. 105, 111.

2008 *Pseudosabinia klinghardti* (Boehm), Skelton & Fenerci-Masse, plate 2, figures a–e, plate 3, figures a–d.

2009 *Pseudosabinia klinghardti* (Boehm), Steuber *et al.*, p.43, 44.

Material and Localities. Numerous well-preserved specimens with both valves of *Pseudosabinia klinghardti* (Böhm) were collected from the type locality of the species, Tavşanlı village, around Hereke. Three specimens of the left valve and two specimens with both valves of the species were also found in the Alidamı village, Kahta-Adıyaman area.

Description. The right valve (RV) is conical, ornamented by very rare longitudinal costae and well-marked, gently undulating growth lines. The radial bands region is clearly observed and well-preserved. The anterior radial band is shallowly indented, but the posterior radial band is marked by a longitudinal groove. The anterior radial band is approximately two times broader than the posterior radial band. The interband is flat and always much larger than the other bands. The outer shell layer is finely celluloprismatic. The ligamental ridge is long and bifurcates at the extremity; the teeth and myophores are well-developed. Rectangular, circular and oval canal sections can be observed in the inner shell layer. The left valve (LV) is inclined postero-dorsally and two grooves corresponding to the radial bands of the right valve are clearly observed. A single row of pyriform, and two, three or four rows of suboval, polygonal and quadrangular canal sections are observed from the periphery to the internal part of the left valve. These canals are also present between the ligamental ridge, teeth and myophores.

Remarks. The specimens show the characteristic internal and external features of the species. New material collected from the type locality of the species and Alidamı village-Kahta area shows for the first time the combination of a finely celluloprismatic outer layer and an inner layer with canals in the RV, which was not clearly presented in the previous studies (Böhm 1927; Morris & Skelton 1995; Fenerci 1999; Skelton & Smith 2000; Özer 2002; Skelton & Fenerci-Masse 2008).

Pseudosabinia rtanjica (Pejović 1967)

Plate 5, Figures 1–7

1967 *Sabinia rtanjica* n.sp., Pejović, p. 295, 298, plates 1, 2.

1972 *Sabinia rtanjica* Pejović, Karacabey, p. 47, text-figure 2, plates 1–5, plate 9, figures 2, 3, plate 12, figures 2, 3.

1986 *Sabinia rtanjica tunisiensis* nov.subsp., Philip, p. 248, 249, plate 1, figures 1–6.

1992 a *Sabinia rtanjica* Pejović, Özer, p. 134.

Material and Localities. The specimens of this species were found in the Güneşli village-Sivas (Karacabey 1972). New material comes from Güneşli village (three well-preserved specimens with both valves), Darende-Malatya (four specimens with both valves and some left valves partly preserved) and Elazığ (one specimen with both valves and one specimen with both valves partly preserved).

Description. The valves have very different dimensions, though in all specimens the RV is conical and is much smaller than LV. The outer layer of the LV is very thin (1 to 2 mm) and has a compact structure, but the inner layer contains radially extended canals in the exterior and small polygonal canals towards the interior of the layer. The LV is remarkably developed and strongly inclined and coiled towards the dorsal side, generally passing across the commissural plane. The transverse section of the LV presents small radial canals in the periphery of the valve, irregular polygonal canals in all parts of the valve and one row of hexagonal or pentagonal canals separating the myophores from the central cavity. The radiolitiform myocardinal apparatus is very well preserved and the teeth show a tightly folded structure.

Remarks. P. rtanjica is considered to be characterized by one row of canals separating the myophores from the central cavity. This specific feature is regularly observed in specimens from Serbia (Pejović 1967) and eastern Anatolia-Sivas (Karacabey 1972). Our present material from the different localities in eastern Anatolia also shows the same specific character and Philip (1986) likewise reported it in the Tunisian specimens. However a few, large polygonal canals are also situated between the central cavity and myophores in the holotype of *P. klinghardti* (Böhm 1926, plate 16, figure 1a). So the

two species cannot be differentiated from this character alone. Nevertheless, the structure and thickness of the outer shell layer of the RV is clearly different in the two species. The outer shell layer of the RV of *P. rtanjica* is very thin (approximately 1–2 mm) and compact which was clearly determined by Karacabey (1972), and also observed in our specimens (Plate 5, Figures 4–7). In contrast, the outer shell layer of the RV of *P. klinghardti* is very thick (approximately 10 mm) and cellulоprismatic which is well defined by many studies (Böhm 1926; Morris & Skelton 1995; Fenerci 1999; Skelton & Smith 2000; Schlüter *et al.* 2008b). Our recent material confirm this as a specific character of *P. klinghardti*. However, Morris & Skelton (1995, p. 303) noted that the presence a localized 'a thin zone of cells on the innermost zone of outer shell layer grading into dense structure in the outer part' in the right valve of one specimen with both valves partly preserved of *P. rtanjica*, from Serbia, suggesting that the cells may have been secondarly suppressed in *P. rtanjica.* This may be suggest the possiblity of affinity and intergradation between two species as indicated by Morris & Skelton (1995). But, it seems to demonstrate this character in the additional specimens and detailed further investigations for reveal the evolutionary relationships between these species, due to the absence of cellular structure in our numerous specimens, and also those of Karacabey (1972) just explained above. Philip (1986) also demonstrated that the outer shell layer of *P. rtanjica tunisiensis* has a very thin compact outer shell layer in the RV instead of characteristic cellular structure of *Pseudosabinia*, suggesting the presence the same character in the specimens from different localities of Mediterranean province.

Pseudosabinia rtanjica triangularis

(Karacabey 1972)

Plate 6, Figures 1–4

1972 *Sabinia rtanjica triangularis* nov. subsp., Karacabey, p. 50, text-figure 3, plates 7, 8.

Material and Localities. Two LV from the type locality (Güneşli village, around the Divriği area-Sivas), and five LV from the Hekimhan-Yazıhan-Yeşilyurt areas in the Malatya basin.

Description. The LV is inclined towards the dorsal part and its surface is very smooth. The anterior and posterior radial bands are well-marked with grooves. The outer shell layer is very thin and inner shell layer is partly preserved because of the recrystallization, but the triangular canal sections can be observed as well as fusiform and polygonal canal sections (Plate 6, Figures 2–4).

Remarks. Karacabey (1972) described a subspecies of '*Pseudosabinia*' *rtanjica* based on the presence of triangular canal sections in the LV and also the well-marked radial bands, which are also observed in our specimens. However, these characters were based only on the LV, the RV of the subspecies being still unknown. On the other hand, Böhm's (1926) holotype and paratypes of *P. klinghardti* show similar well-marked radial bands in the LV like this subspecies. Moreover, the triangular canal sections of '*Pseudosabinia*' *rtanjica triangularis* may be considered to be within the variability of *P. klinghardti*. Because of these features '*Pseudosabinia*' *rtanjica triangularis* seems to be a synonym of *P. klinghardti*. However the precise taxonomic position of this subspecies must remain problematic until its RV is described.

Pseudosabinia ornata (Özer & Fenerci 1993)

Plate 3, Figures 1, 1A, 1B, 2, 3

1993 *Sabinia ornata* nov. sp., Özer & Fenerci, p. 18–20, text-figure 4–6, plate 3, figures 1–5; plate 4, figures 1–4; plate 5, figures 1, 2.

This species is characterized by both valves with canals, the structure of radial bands and cellulоprismatic outer shell layer of the RV as described in detail by Özer & Fenerci (1993). The myocardinal apparatus is typically radiolitiform corresponding exactly with that determined by Skelton (1979, p. 91, figures 2, 3). These indicate the generic characters of *Pseudosabinia.* It shows some resemblance to *Pseudosabinia klinghardti* by the shape of the LV, however the structure of the radial bands is completely different from *P. klinghardti.* The posterior radial band of *P. ornata* is characterized by

a longitudinal costa instead of the longitudinal groove seen in *P. klinghardti*. The inter band of *P. ornata* is very large and well-ornamented with longitudinal costae like that of *P. klinghardti*. The RV of *P. ornata* is also densely-ornamented by longitudinal costae and grooves which are not observed in the specimens of *P. klinghardti*.

Pseudosabinia sp.

Plate 6, Figures 5, 6

Material and Localities. Five LV and many LV sections mostly embedded in limestones from the Alidamı-Kahta (Adıyaman) area and three specimens from the Yaylaçiftliği (Antakya) area in southeastern Anatolia, and also five specimens of LV from the northern Anatolia (Pontides belt), around Amasya.

Description. The LV specimens are remarkably large and openly coiled towards the posterior-dorsal part. The pallial canals of the inner shell layer can be clearly observed in the eroded parts of the valve. The diameter is approximately 20 cm in the transverse section showing a thin, elongate ligamentary infolding and radiolitiform myocardinal apparatus and also a canaliculate structure (polygonal and quadrangular canal sections) of the inner shell layer.

Remarks. These large specimens closely resemble *Schisoia bilinguis*, which was described as a new species by Böhm (1927). It is very probable that Böhm's specimens represent large indivuduals of *P. klinghardti* as noted by Skelton & Fenerci-Masse (2008). These large and openly coiled specimens from Turkey may also be likened to the *P. klinghardti* specimens recorded from Arabia by Morris & Skelton (1995). However, these Turkish specimens are doubtfully accepted as *Pseudosabinia* because of the absence of the RV.

Discussion

Sabinia Parona and *Pseudosabinia* Morris & Skelton are characterized by canals in both valves. However, *Pseudosabinia* was created based on the finely cellular outer shell layer of the RV and its typically radiolitiform myocardinal elements (Morris & Skelton 1995) separating this new taxon from *Sabinia* Parona. Because of these characters some species of *Sabinia* such as *S. klinghardti* Böhm, *S. serbica* Kühn & Pejović and *S. rtanjica* Pejović and two sub-species of *S. rtanjica- S. rtanjica triangularis* Karacabey and *S. rtanjica tunisiensis* Philip, were transferred to *Pseudosabinia* (Morris & Skelton 1995; Steuber 2002). Although Philip (1986) assigned all the Mediterranean species of *Sabinia* to the Radolitidae, Morris & Skelton (1995) and Schlüter *et al.* (2008 b) indicate that *Sabinia* has a myocardinal apparatus very similar to that of *Plagioptychus*. The myocardinal arrangement is diagnostic for rudists on the family level while the structure of outer shell layer may vary from compact to cellular in some Radiolitidae.

Based on the published descriptions and also on new studies of Turkish specimens some taxonomic problems with the definition of *Pseudosabinia* appear as follows:

The type species of *Pseudosabinia, P. klinghardti* (Böhm) is characterized by the structure of the radial bands and canal organisation of the LV. The outer shell layer of the RV of the species consists of finely celluloprismatic cells. The structure of the inner shell layers of the RV was incompletely described and figured because it is recrystallised or badly preserved in previously described specimens (Böhm 1927; Morris & Skelton 1995; Fenerci 1999; Skelton & Smith 2000; Skelton & Fenerci-Masse 2008). The additional specimens were recently collected from the type locality of *P. klinghardti,* around Tavşanlı village-Hereke and also another locality, Alidamı village-Kahta (SE Anatolia), and they allow us for the first time to determine the generic characters of the RV in full, including both celluloprismatic outer and canaliculate inner shell layer. The transversal sections of the valves are strinkingly oval or suboval in outline with the maximum diameter antero-posterior in all the specimens, as is also the case in Böhm's (1926) specimens.

Pejović (1967) defined *Sabinia rtanjica*, based only on LV specimens, as characterised by one row of canals between the myophores and the central cavity. The RV of the species was described in detail by

Karacabey (1972). According to the latter author, the outer shell layer of the RV has a very simple structure and is very thin (approximately 2 mm), which also is observed in our specimens. Although *S. rtanjica* has a radiolitiform myocardinal apparatus and canals in both valves, the outer shell layer of the RV contains no celluloprismatic cells like those in *P. klinghardti*, which is one of the main generic characters. But, Morris & Skelton (1995, p. 303), noted the presence of localised residual cells in a part of the outer shell layer of a RV probably from this species, donated by Mme Pejović. So it is possible that the difference between this species and *P. klinghardti* is only that the cells have been secondarily suppressed in *P. rtanjica*. This is a very interesting question that needs further investigation. The transversal sections of the valves are oval in shape but, in contrast to *P. klinghardti*, with the maximum diameter oriented dorsa-ventrally, which can be observed in all our specimens and in also Pejović's (1967) and Karacabey's (1972) specimens.

'Pseudosabinia' rtanjica tunisiensis also has the same thin compact outer shell layer of the RV (Philip 1986). In detail, the shell of this subspecies consists of three layers (1) a calcitic, thin, compact external layer, (2) a recrystallised calcite sparite middle layer with canals and (3) a recrystallised calcite sparite inner layer, which were clearly described by Philip (1986). The recrystallized inner shell layers of this subspecies were originally composed of aragonite. Some specimens of '*Pseudosabinia*' *rtanjica* identifed by Karacabey (1972, p. 42, plate 12, figure 3) also show the same shell layer features of the RV and they may be compared with '*Pseudosabinia*' *rtanjica tunisiensis* (Philip 1986, p. 248, plate 1, figure 6).

The structure of the outer and inner shell layer of '*Pseudosabinia*' *rtanjica triangularis* (Karacabey) is still unknown because of the RV has not yet been recovered. However, the well-marked radial bands of this subspecies show close ressemblances to those of *P. klinghardti*.

'Pseudosabinia' serbica (Kühn & Pejović) has canal structures only in the LV, but it contains a radiolitiform myocardinal apparatus. The structure of the outer layer of the RV was not clearly determined. It seems to be both lamellar and prismatic (Kühn & Pejovic 1959; Plenicar 1977). However, Philip (1986) was accepted it as having a prismatic outer layer.

Özer & Fenerci (1993) described a new species of S*abinia, S. ornata,* based on numerous specimens from the eastern Pontides, around Maden-Bayburt, containing the typical characteristics of *Pseudosabinia* such as radiolitiform myocardinal apparatus, RV with finely cellular outer shell layer and both valves with canals. So, this species is here proposed to belong to the genus *Pseudosabinia. P. ornata* (Özer & Fenerci) resembles *P. klinghardti* (Böhm), but clearly differs from it in the structure of radial bands.

These data indicate that the compact structure of the outer shell layer of the RV of '*Pseudosabinia*' *rtanjica* (Pejović) differs from the generic character of *Pseudosabinia* though the species is otherwise radiolitiform in character. So the taxonomic position of this species seems to be controversial. It is probably belongs to another genus of Radiolitidae or to a new genus.

The RV of *'Pseudosabinia' rtanjica tunisiensis* (Philip) has a compact calcitic structure in the thin outer shell layer, but contains radial, oval to round canal sections in the inner shell. The same features are also observed in some specimens of '*Pseudosabinia*' *rtanjica* from Turkey as explained above. Because of the thin and non-celluloprismatic outer shell layer of the RV, this subspecies differs from *Pseudosabinia klinghardti*, and may be a new radiolitid genus.

The taxonomic status of '*Pseudosabinia*' *rtanjica triangularis* (Karacabey) is unsettled because the RV is still unkown. So, the transfer of this subspecies to the genus *Pseudosabinia* (Steuber 2002) remains open to question.

'Pseudosabinia' serbica (Kühn & Pejović) has no canal structure in the inner shell layer of the RV and because of this character is differentiated from *Pseudosabinia* and also from *Sabinia*.

Hence, from the characters reviewed here, only *Pseudosabinia ornata* (Özer & Fenerci) can be assigned to the genus besides the type species, *P. klinghardti* (Böhm). Other species and subspecies that appear to fall outside it need more detailed study before a new taxon can be created for them.

Conclusions

The Campanian–Maastrichtian transgressive mixed siliciclastic-carbonate sequences of the Pontides in northern Turkey, of central and eastern part of the Anatolian-Tauride platform, and on the northernmost part of the Arabian platform (southeastern Turkey) consist of, in ascending order, reddish clastics, greenish-gray sandy limestones with benthic fauna (especially rudists and abundant large benthic foraminifera) and pelagic mudstones showing lateral and vertical changes.

Many specimens hitherto referable to *Pseudosabinia* Morris & Skelton were collected from the transgressive sequences of Tavşanlı-Hereke, Kocaeli Peninsula (the type locality of the type species *Pseudosabinia klinghardti*), Amasya and Bayburt in the Pontides, Malatya, Sivas and Elazığ in the eastern of Anatolide-Tauride platform and Adıyaman and Antakya in the Arabian platform. The following taxa were determined: *Pseudosabinia klinghardti* (Böhm), *P. rtanjica* (Pejović), and *P. rtanjica triangularis* (Karacabey), and their taxonomic statuses discussed.

- *Pseudosabinia klinghardti* (Böhm) illustrates the generic characters of a radiolitiform myocardinal apparatus, finely cellular outer shell layer of the right valve and the presence of canals in the inner shell layer of both valves. The specimens collected from the type locality (Tavşanlı-Hereke) and from Kahta-Adıyaman show the structure of both the outer and inner shell layers of the right valve, which is figured here for the first time.
- '*Pseudosabinia*' *rtanjica* (Pejović) and '*Pseudosabinia*' *rtanjica tunisiensis* (Philip) have a radiolitiform myocardinal apparatus and canals in the inner shell layer of both valves. Morever, a single row of canals separating the myophores from the central cavity seen in these taxa was also figured in specimens of *P. klinghardti* by Böhm (1927). So, *P. rtanjica* and *P. rtanjica tunisiensis* are clearly related to *P. klinghardti*, but they differ from it by the very thin compact outer shell layer in the right valve instead of cellular structure of the layer that is characteristic of *Pseudosabinia*. These indicate that the '*Pseudosabinia*' *rtanjica* (Pejović) and '*Pseudosabinia*' *rtanjica tunisiensis* (Philip) present a controversial taxonomic status and they may consitute another genus of (most probably) Radiolitidae. The presence of thin cellular zone in a single specimen partly preserved of '*Pseudosabinia*' *rtanjica* as explained by Morris & Skelton (1995) indicate to need detailed further investigations for better understand the evolutionary relationships between these species.
- '*Pseudosabinia*' *rtanjica triangularis* (Karacabey) has well-marked radial bands and triangular canal sections in the left valve. But its holotype and paratypes and our specimens of *Pseudosabinia klinghardti* (Böhm) also show similar radial bands indicating that this subspecies may be close to *P. klinghardti*. However, its right valve is as yet unknown so it is problematic at present to include this taxon in *Pseudosabinia*.
- '*Pseudosabinia*' *serbica* (Kühn & Pejović) lacks canals in the inner shell layer of the right valve and the structure of the outer layer of the right valve seems to change from lamellar to prismatic. These characters also pose a taxonomic problem for placement of this species in *Pseudosabinia* Morris & Skelton.
- These determinations and discussions reveal that the taxonomic statuses of *Pseudosabinia klinghardti* (Böhm) is very clear and unproblematic, but other species and subspecies assigned to *Pseudosabinia* need new material and detailed study.
- *Sabinia ornata* Özer & Fenerci has identical generic characteristics of *Pseudosabinia* such as radiolitiform myocardinal apparatus, finely cellular outer shell layer of the right valve and canaliculate inner shell layer in both valves. So, this species is here proposed to be included in the genus *Pseudosabinia*.

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References

Ağar, Ü. 1977. *Demirözü (Bayburt) ve Köse (Kelkit) Bölgesinin Jeolojisi [Geology of Demirözü (Bayburt) and Köse (Kelkit) Region]*. PhD Thesis, İstanbul University, İstanbul, Turkey [in Turkish, unpublished].

Akkuş, M.F. 1971. Geologic and stratigraphic investigation of the Darende-Balaban Basin (Malatya, ESE Turkey). *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **76**, 1–64.

Aksoy, E., Türkmen, İ., Turan, M. & Meriç, E. 1999. Harami Formasyonu'nun (Üst Kampaniyen–Maastrihtiyen) stratigrafik konumu ve çökelme ortamıyla ilgili yeni bulgular, Elazığ güneyi [New findings on the stratigraphic position and depositional environment of the Harami Formation (Upper Campanian–Maastrichtian), south of Elazığ]. *Türkiye Petrol Jeologları Derneği Bülteni* **11**, 1–15 [in Turkish with English abstract].

Alp, D. 1972. *Amasya Yöresinin Jeolojisi (Geology of Amasya Region)*. İstanbul Üniversitesi Fen Fakültesi Monografileri (Tabii İlimler Kısmı) **22** [in Turkish].

Altiner, D. 1989. An example for the tectonic evolution of the Arabian platform margin (SE Anatolia) during Mesozoic and some criticism of the previously suggested models. *In:* Şengör, A.M.C. (ed), *Tectonic Evolution of the Tethyan Region*. Academic Publishers, Dordrecht, 117–129.

Bergougnan, H. 1987. *Etudes géologiques dans l'est Anatolien*. Mémoires des Sciences de la Terre, Academie de Paris Université Pierre et Marie Curie.

Böhm, J. 1927. Beitrag zur Kenntnis der Senonfauna der bithynischen Halbinsel. *Palaeontographica* **69**, 187–222.

Elmas, A. & Yilmaz, Y. 2003. Development of an Oblique Subduction Zone–Tectonic Evolution of the Tethys Suture Zone in Southeast Turkey. *International Geology Review* **45**, 827–840.

Fenerci, M. 1994. Rudists from Maden (Bayburt) area, NW Turkey. *Turkish Journal of Earth Scieces* **3**, 1–11.

Fenerci, M. 1999. *Cretaceous Rudist Fauna of Kocaeli Peninsula and Western Pontides*. PhD Thesis, Dokuz Eylül Üniversitesi, İzmir, Turkey.

Fenerci, M. 2004. Campanian–Maastrichtian rudists from the western Pontides (NW Turkey): new findings and their paleogeographic significance. *In:* Hofling, R. (ed), *Contributions to the 5th International Congress on Rudists, Erlangen, Germany 1999,* Courier Forschungsinstitut Senckenberg **247**, 89–112.

Görmüş, M. 1990. *Stratigraphy and Foraminiferal Micropaleontology of Upper Cretaceous in Hekimhan, NW Malatya, Turkey*. PhD. Thesis, University of Hull, England.

Görmüş, M. 1999. *Pseudedomia hekimhanensis* n.sp from the Late Campanian? to Maastrichtian of Hekimhan, NW Malatya, Turkey. *Journal of Foraminiferal Research* **29**, 64–70.

Görmüş, M., Meriç, E. & Önal, M. 2001. Quantitative data on the genus *Loftusia* from the Sarıkız and Zorbehan areas (Hekimhan, NW Malatya). *4th International Symposium on Eastern Mediterranean Geology, Isparta, Turkey, 21–25 May 2001*, *Proceedings*, 105–122.

Görür, N. & Tüysüz, O. 2001. Cretaceous to Miocene Palaeogeographic evolution of Turkey: implications for hydrocarbon potential. *Journal of Petroleum Geology* **24**, 1–28.

İnceöz, M. 1996. Elazığ yakın kuzeyinde Harami formasyonunun (Üst Maastrihtiyen) stratigrafisi ve çökelme ortamları. *Türkiye Petrol Jeologları Derneği Bülteni* **8**, 130–136.

Karacabey, N. 1968. Sur les nouvelles espèces de *Vaccinites* Fisher et *Yvaniella* Milovanovic trouvées dans la région d'Amasya. *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **71,** 29-41.

Karacabey, N. 1970. Quelques espèces de *Vaccinites* et de *Pironaea* de l'Anatolie orientale. *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **74**, 84–90.

Karacabey, N. 1972. Quelques rudistes provenant de la région de Divrigi (Turquie orientale). *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **78**, 46–54.

Karacabey, N. 1974. Sur une nouvelle espèce de *Colveraia* Klinghardt et une novelle sous-espèce de *Joufia* Boehm en Turquie. *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **82**, 78–85.

Karacabey-Öztemür, N. 1976. Un nouveau genre de Radiolitidae: *Darendeella* n. gen. *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **86**, 69–76.

Karacabey-Öztemür, N. 1979a. Three new species of the genus *Misea* and proposal of a new subfamily of Radiolitidae. *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **92**, 40–46.

Karacabey-Öztemür, N. 1979b. Two new species of the genus *Dictyoptychus* in Turkey. *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **92**, 64–67.

Karacabey-Öztemür, N. 1980. Two new genera of *Radiolitidae* from Turkey. Geological Society of Turkey Bulletin **23**, 79–86.

Kaya, O., Dizer, A., Tansel, İ. & Özer, S. 1986b. Upper Cretaceous–Paleogene stratigraphy of the Yığılca (Bolu) area. *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **107**, 13–32.

Kaya, O., Wiedmann, J., Kozur, H., Özdemir, U., Özer, S. & Beauvais, L. 1986a. A new discovery of the Lower Cretaceous in İstanbul, Turkey. *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **107**, 106–111.

Ketin, İ. 1966. Anadolu'nun tektonik birlikleri [Tectonic units of Anatolia]. *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **66**, 20–34.

Kühn, O. & Pejović, D. 1959. Zwei neue Rudisten aus Westserbien. *Österreichische Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Klasse, Sitzungsberichte* **168**, 979–989.

Laviano, A. 1996. Late Cretaceous rudist assemblages from the Salento Peninsula (southern Italy). *Geologica Romana* **32**, 1–14.

MacGillavry, H.J. 1937. *Geology of the Province of Camaguey, Cuba, with Revisional Studies in Rudist Paleontology*. Geographische en geologische Mededeelingen **14**. Utrecht.

Meriç, E., Ersoy, Ş. & Görmüş, M. 2001. Paleogeographical distribution of the species of *Loftusia* (Foraminiferida) in the Tethyan Ocean during the Maastrichtian (Late Cretaceous). *Cretaceous Research* **22**, 353–364.

Meriç, E. & Görmüş, M. 1997. *Pseudosiderolites vidali* (Douvillé, 1906)'nin Doğu Anadolu (Darende-B Malatya) Erken Maastrihtiyen'indeki varlığı [The presence of *Pseudosiderolites vidali* (Douvillé, 1906) in the Early Maastrichtian sediments of Eastern Anatolia (Darende-W Malatya)]. *Yerbilimleri (Geosound)* **29**, 83–98 [in Turkish with English abstract].

Meriç, E. & Görmüş, M. 1999. *Orbitoides gruenbachensis* Papp'ın Maastrihtiyen (Geç Kretase) Tetis Okyanusu'ndaki paleocoğrafik yayılımı [Palaeogeographic distribution of *Orbitoides gruenbachensis* Papp in the Maastrichtian (Late Cretaceous) Tethys ocean]. *Türkiye Jeoloji Bülteni* **42**, 1–11 [in Turkish with English abstract].

Meriç, E. & Görmüş, M. 2001. The genus *Loftusia*. *Micropaleontology* **47**, supplement 1.

Meriç, E., Oktay, F.Y. & Özer, S. 1985. Besni Formasyonu'nun Alidamı (Kahta-Adıyaman) kuzeybatısındaki stratigrafik gelişimi ile ilgili yeni gözlemler [New observations on the stratigraphy of Besni Formation in the northwest of Alidamı (Kahta-Adıyaman)]. *Jeoloji Mühendisliği* **25**, 51–54 [in Turkish with English abstract].

Meriç, E., Oktay, F.Y., Toker, V., Tansel, İ. & Duru, M. 1987. Adıyaman yöresi Üst Kratese–Eosen istifinin sedimenter jeolojisi ve biyostratigrafisi [Sedimentary geology and biostratigraphy of Upper Cretaceous–Eocene sequence in Adıyaman region]. *Türkiye Jeoloji Kurumu Bülteni* **30**, 19–32 [in Turkish with English abstract].

Morris, N.J. & Skelton, P.W. 1995. Late Campanian–Maastrichtian rudists from the United Arab Emirates - Oman border region. *Bulletin of the British Museum (Natural History), Geology Series* **51**, 277–305.

Okay, A.İ & Tüysüz, O. 1999. Tethyan sutures of northern Turkey. *In:* Durand. B., Jolivet, L., Horvath, E & Seranne, M. (eds), *The Mediterranean Basins: Tertiary Extension within the Alpine Orogen*. Geological Society, London, Special Publications **156**, 475–515.

Önal, M. & Kaya, M. 2007. Stratigraphy and tectono-sedinentary evolution of the Upper Cretaceous-Tertiary sequence in the southern part of the Malatya Basin, East Anatolia, Turkey. *Journal of Asian Earth Sciences* **29,** 878-890.

Önal, M. & Kaya, M. 2007. Stratigraphy and tectono-sedinentary evolution of the Upper Cretaceous–Tertiary sequence in the southern part of the Malatya Basin, East Anatolia, Turkey. *Journal of Asian Earth Sciences* **29**, 878–890.

Özcan, E. 1993. Late Cretaceous benthonic foraminiferal proliferation on the Arabian platform: taxonomic remarks on the genus *Orbitoides* d' Orbigny 1848. *Geological Journal* **28**, 309–317.

Özcan, E. 2007. Morphometric analysis of the genus *Omphalocyclus* from the Late Cretaceous of Turkey: new data on its stratigraphic distribution in Mediterranean Tethys and description of two new taxa. *Cretaceous Research* **28**, 621–641.

Özer, S. 1982. Three new species of the genus *Gorjanovicia* Polsak (Rudistacea) from Kocaeli region (Northwestern Anatolia). *Geologija* **25**, 229–236.

Özer, S. 1986. Faune de Rudistes maestrichtienne de l' environ de Kahta-Adıyaman (Anatolie Sud-Est). *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **107**, 101–105.

Özer, S. 1988. Orta-Doğu-Güneydoğu Anadolu ve Kocaeli Yarımadasında bulunan Pironaea (Rudist) türlerinin paleontolojisi ve biyocoğrafyası [Palaeontology and biogeography of the pironaean species (Rudist) from the central-east-southeast Anatolia and Kocaeli Peninsula]. *Geological Bulletin of Turkey* **31**, 47–58 [in Turkish with English abstract].

Özer, S. 1992a. Deux nouvelles espèces du genre *Miseia* (Rudistes) en Turquie. Remarques systématiques et phylogénétiques. *Palaeontographica Abt, A* **220**, 131–140.

Özer, S. 1992b. Relationships between the Anatolian and Arabian plates during the Maastrichtion related to the rudist fauna. *9th Petroleum Congress of Türkiye, Proceedings,* 255–262.

Özer, S. 1992c. Stratigraphic setting and biogeographic characteristics of rudists in SE Anatolia. *Turkish Association of Petroleum Geologists Bulletin* **4**, 47–58.

Özer, S. 1992d. Rudist carbonate ramp in southeastern Anatolia, Turkey. *In:* Simo, J.A.T, Scott, R.W. & Masse, J.-P. (eds), *Atlas of Cretaceous Carbonate Platforms.* American Association of Petroleum Geologist Bulletin Memoir **56**, 163–171.

Özer, S. 2002. Distributions stratigraphiques et géographiques des rudistes du Crétacé supérieur en Turquie. *In:* Sladić-Trifunović, M. & Grubić, A. (eds), *Proceedings-First International Conference on Rudists (Beograd, 1988),* USGY, Memorial publication, 173–187.

Özer, S. 2006. Upper Cretaceous carbonate platforms with rudists of Turkey. Biostratigraphic and paleobiogeographic significance. *Réunion Spécialisée de le Société Géologique de France: Histoire et dynamique des plates-formes carbonatées et de leurs biotas durant le Phanéruzoique.* Livret des Résumés 32, Marseille.

Özer, S. 2008a. *Yvaniella* of Turkey: description a new species, morphologic and biogeographic remarks, *Eighth International Congress on Rudists June 23–25, 2008 İzmir-Turkey, Abstracts,* p. 58.

Özer, S. 2008b. Campanian–Maastrictian *Pseudosabinia* from different regions of Turkey. *Eighth International Congress on Rudists, June 23–25, 2008, İzmir-Turkey, Abstracts,* p. 33.

Özer, S. & Fenercİ, M. 1993. Two new species of Caprinidae from the Bayburt area (eastern Black Sea, Turkey). *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin* **115**, 15–21.

Özer, S., Meriç, E., Görmüş, M. & Kanbur, S. 2009a. Biogeographic distributions of the rudists and benthic foraminifers: an approach to Campanian–Maastrichtian paleobiogeography of Turkey. *Geobios* **42,** 623-638.

Özer, S., Önal, M. & Sari, B. 2007. Geometry and biofacies characteristics of the rudist biostromes and carbonate mounds of the late Campanian–Maastrichtian transgressive-regressive sequences of the Malatya Basin. *60th Geological Congress of Türkiye, Ankara, International participation, Abstracts Book*, 450–452.

Özer, S. & Sari, B. 2008. Rudist-bearing Campanian–Maastrichtian fore-arc sequences of the Amasya region (Central Pontides, Turkey). *Eighth International Congress on Rudists, June 23–25, 2008, İzmir-Turkey, Abstracts,* p. 7.

Özer, S., Sari, B., Kandemİr, R., Görmüş, M. & Yilmaz, C., 2009b. Campanian–Maastrichtian carbonate platform (Southern Zone of Pontides): model of depositional environments, palaeogeography and palaeotectonic significance. *2nd International Syposium on the Geology of the Black Sea Region. 5-9.October.2009, Congress Center of MTA, Ankara-Turkey, Abstract Book,* p. 148-150.

Özer, S., Sari, B. & Önal, M. 2008a. *Campanian–Maastrichtian Rudist-bearing Mixed Silisiclastic-carbonate Transgressive-regressive System Tracts of the Eastern and Southeastern Anatolia: Faunal Correlation, Depositional Facies and Palaeobiogeographic Significance*. Eighth International Congress on Rudists June 23–25, 2008, İzmir-Turkey, Pre-meeting Field Trip (1) Excursion Guide.

Özer, S., Sari, B., Yilmaz, C., Görmüş, M. Kandemİr, R. & Akdenİz, N. 2008b. *Biostratigraphy, Facies Analysis and Palaeobiogeographic Characteristics of the Rudist and Foraminifera-bearing Campanian–Maastrichtian Sequences of the Pontides (N Turkey)*. Report, TÜBİTAK Project No. **106Y144** [in Turkish with English abstract, unpublished].

Özer, S., Tansel, İ. & Meriç, E. 1990. Hereke-Kocaeli dolayında Üst Kretase-Paleosen istifinin biyostratigrafisi (rudist, foraminifer) [Biostratigraphy (rudist, foraminifera) of the Upper Cretaceous-Paleocene sequences in the Hereke-Kocaeli area (NW Anatolia)]. Selçuk Üniversitesi Mühendislik-Mimarlık Fakülyesi Dergisi, *Konya* **5**, 29–40 [in Turkish with English abstract].

Özsayar, T., Pelİn, S. & Gedİkoğlu, A. 1981. Doğu Pontidler'de Kretase [Cretaceous in Eastern Pontides]. *Karadeniz Teknik Üniversitesi Yer Bilimleri Dergisi, Jeoloji* **1**, 65–114 [in Turkish with English abstract].

Pejović, D. 1967. *Sabinia rtanjica* n. sp. du Maestrichtien de la Serbe orientale. *Zavod za geoloska i geofizicka Istrazivanja, Vesnik Geologija, (A)* **24–25**, 295–299.

Perİnçek, D. 1979. Geological investigation of the Çelikhan-Sincik-Koçali area (Adıyaman province). *Revue de la Faculté des Sciences de l'Université d'İstanbul B* **44**, 127–147.

Philip, J. 1986. Etude paléontologique du genre *Sabinia* (rudiste à canaux) des récifs du Campanien de Tunisie. *Geobios* **19**, 247–251.

Plenicar, M. 1977. Rudists from the Cretaceous beds of Slovenia. *Geologija* **20**, 5–31.

Rojay, B. 1995. Post-Triassic evolution of Central Pontides: Evidence from Amasya region, northern Anatolia. *Geologica Romana* **31**, 329–350.

Schlüter, M., Steuber, T., Özer, S. & Sari, B. 2008a. Numerical ages of Late Cretaceous (Campanian-Maastrichtian) rudist formations of southeastern Anatolia. *Eighth International Congress on Rudists, June 23–25, 2008, İzmir-Turkey, Abstracts,* p. 17.

Schlüter, M., Steuber, T. & Parente, M. 2008b. Chronostratigraphy of Campanian-Maastrichtian platform carbonates and rudist associations of Salento (Apulia, Italy). *Cretaceous Research* **29**, 100–114.

Şengör, A.M.C. & Yilmaz, Y. 1981. Tethyan evolution of Turkey: a plate tectonic approach. *Tectonophysics* **75**, 181–241.

Skelton, P.W. 1979. preserved ligament in a radiolitid rudist bivalve and its implication of mantle marginal feding in the group. *Paleobiology* **5**, 90–106.

Skelton, P.W. & Fenercİ-Masse, M. 2008. Turkish rudists described and figured by Boehm (1927) and Woodward (1855). *Prepared within the Coverage of the Eighth International Congress on Rudists – Cretaceous Rudists and Carbonate Platforms, 23–25, June, 2008, İzmir-Turkey, Abstracts,* 2 p, 9 plates.

Steuber, T. & Özer, S. 2008. Re-description of *Paracaprinula syriaca* Piveteau (Plagioptychidae) from southeastern Turkey. *Eighth International Congress on Rudists, June 23–25, 2008, İzmir-Turkey, Abstracts,* p. 44.

Skelton, P.W. & Smith, A.B. 2000. A preliminary phylogeny of rudist bivalves: sifting clades from grades. *In:* Harper, E.M., Taylor, J.D. & Crame, J.A. (eds), *The Evolutionary Biology of the Bivalvia.* Geological Society, London, Special Publications **177**, 97–127.

Steuber, T. 2002. A palaeontological database of Rudist Bivalves (Mollusca: Hippuritoidea, Gray1848). http://www.ruhr-uni-bochum.de/sediment/rudinet/intro.htm.

Steuber, T., Özer, S., Schlüter, M. & Sari, B. 2009. Description of *Paracaprinula syriaca* Piveteau (Hippuritoidea, Plagioptychidae) and a revised age of ophiolite obduction on the African-Arabian Plate in southeastern Turkey. *Cretaceous Research* **30**, 41–48.

Steuber, T., Yilmaz, C. & Loser, H. 1998. Growth rates of early Campanian rudists in a siliciclastic-calcareous setting (Pontid Mts., North-Central Turkey). *In:* Masse, J.-P. & Skelton, P. W. (eds), *Quatrième Congrès International sur les Rudistes, Marseille-1996*, Geobios Mémoire Special **22**, 385–401.

Tüysüz, O. 1996. Geology of Amasya and surroundings. *11th Petroleum Congress of Turkey, Proceedings*, 32–48.

Yalçın, N. 1976. Geology of the Narince-Gerger area (Adıyaman province) and its petroleum possibilities. *Revue de la Faculté des Sciences de l'Université d'İstanbul* **B 41**, 57–82.

Yilmaz, Y. 1993. New evidence and model on the evolution of the southeast Anatolian orogen. *Geological Society of America Bulletin* **105**, 251–271.

Yilmaz, C., Kandemir, R. & Kiliç, N. 2003. Kapıkaya Formasyonu: Doğu Pontid-Doğu Torid etkileşiminin Geç Kretase'deki çökel kayıtları [Kapıkaya Formation: Late Cretaceous sedimentary record of Eastern Pontide-Eastern Torides collision]. *Jeoloji Mühendisliği Bölümü 20. Yıl Sempozyumu Özel Sayısı,* Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi **7**, 73–82 [in Turkish with English abstract].

Yilmaz, Y. & Yiğitbaş, E. 1991. The different ophiolitic-metamorphic assemblages of S.E. Anatolia and their significance in the geological evolution of the region. *8th Petroleum Congress of Turkey, Ankara, Geology Proceedings*. Turkish Association of Petroleum Geologist Bulletin **3**, 128–140.

PLATE 1

Figures 1–5. *Pseudosabinia klinghardti* (Böhm).

Figure 1. Antero-ventral side showing the LV and RV. Note gently undulating growth lines and shallowly indented Ab and flat Ib. No. K 43-8. Tavşanlı village-Gebze, Hereke, Kocaeli Peninsula, NW of Anatolia. Scale indicate 30 mm.

Figure 2. Whole valves, antero-ventral view. Note traces of pallial canals of the inner shell at the eroded parts of the LV. No. AK 26. Alidamı village-Kahta, Adıyaman, SE Anatolia. Scale bar is 20 mm.

Figure 3. RV, ventral view showing shallowly indented Ab, flat Ib and Pb marked by a longitudinal groove. No. Ç 28. Tavşanlı village-Gebze, Hereke, Kocaeli Peninsula, NW of Anatolia. Scale indicate 30 mm.

Figure 4. Transverse section of RV, probably just below of the commissure showing the L and together with the radiolitiform myocardinal apparatus (at, pt, am, pm) of the LV. The typical structures of the radial bands (Ab, Ib, Pb) are clearly observed in the section. Note relatively thick (nearly 7–8 mm) outer shell layer. No. Ç 20. Tavşanlı village-Gebze, Hereke, Kocaeli Peninsula, NW of Anatolia. Scale bar is 20 mm.

Figure 5. Detail from a transverse section of the anterior side of the RV showing finely celluloprismatic structure in the outer shell layer. The canals are not preserved because of the recrystallization. No. K 42-3. Tavşanlı village-Gebze, Hereke, Kocaeli Peninsula, NW of Anatolia. Scale bar is 10 mm.

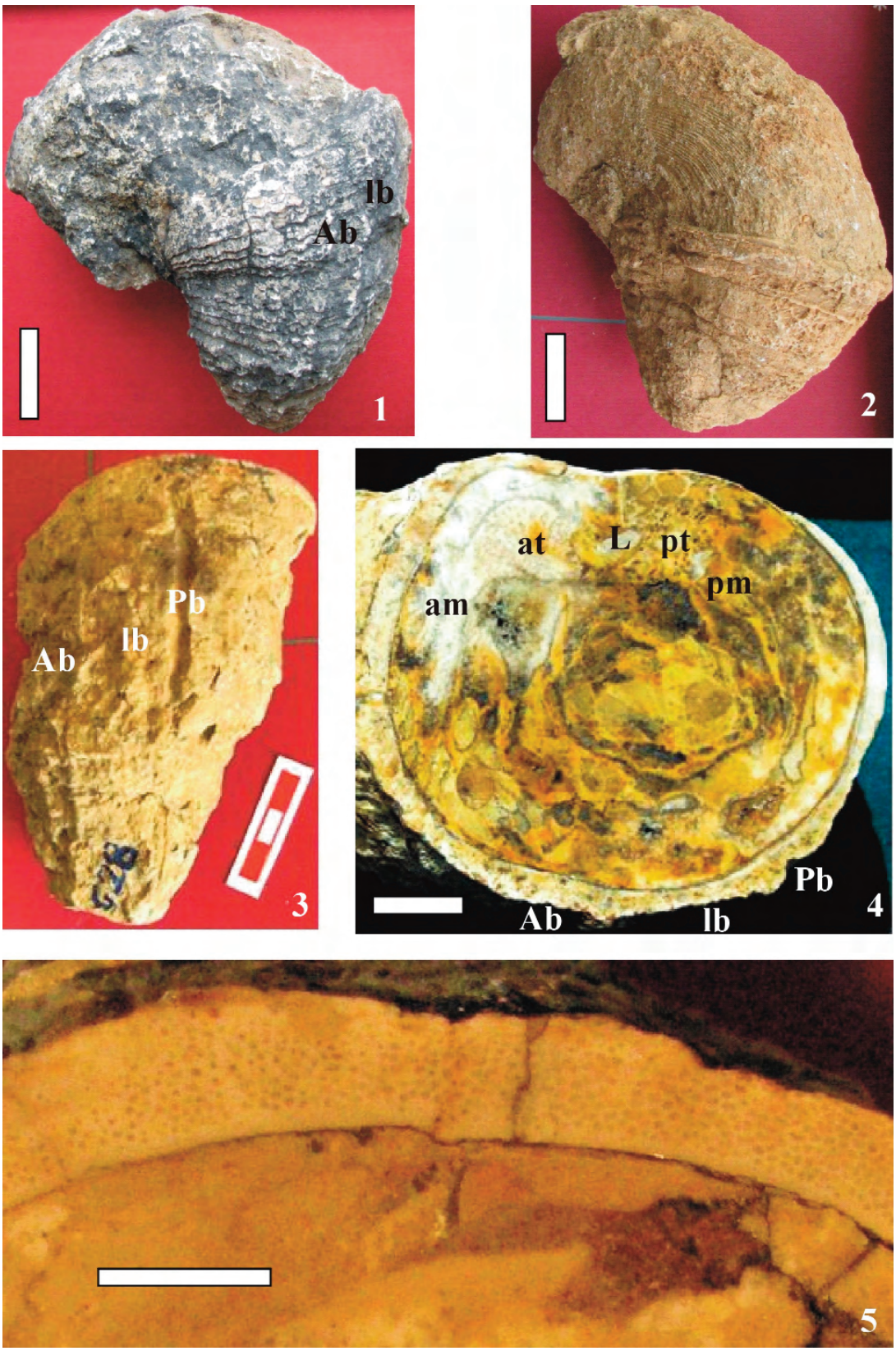
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PLATE 2

Figures 1–3. *Pseudosabinia klinghardti* (Böhm).

Figure 1. Detail from a transverse section part of the antero-ventral side of the RV revealing finely cellulоprismatic structure in the outer shell layer (black arrow) and rectangular and oval canal sections in the inner shell layer (white arrow). No. K 41-6. Tavşanlı village-Gebze, Hereke, Kocaeli Peninsula, NW of Anatolia. Scale bar is 10 mm.

Figure 2. Transverse section of RV showing partly preserved cellular outer layer (white arrows) and canal sections. No. AK 26. Kahta-Alidamı village, Adıyaman, SE Anatolia. Scale bar is 10 mm.

Figure 3. Partial enlargment of Figure 2 showing the well-preserved canal sections in the inner shell layer and finely cellulоprismatic cells of the outer shell layer. Broken ligamentary ridge (L) can also be observed. Scale bar is 5 mm.

Figure 4. RV, dorsal view showing the heavy ondulated the growth lines (white arrow). Note the thin longitudinal groove correspond L (black arrow). No. Ç 20. Tavşanlı village-Gebze, Hereke, Kocaeli Peninsula, NW of Anatolia. Scale indicate 20 mm.

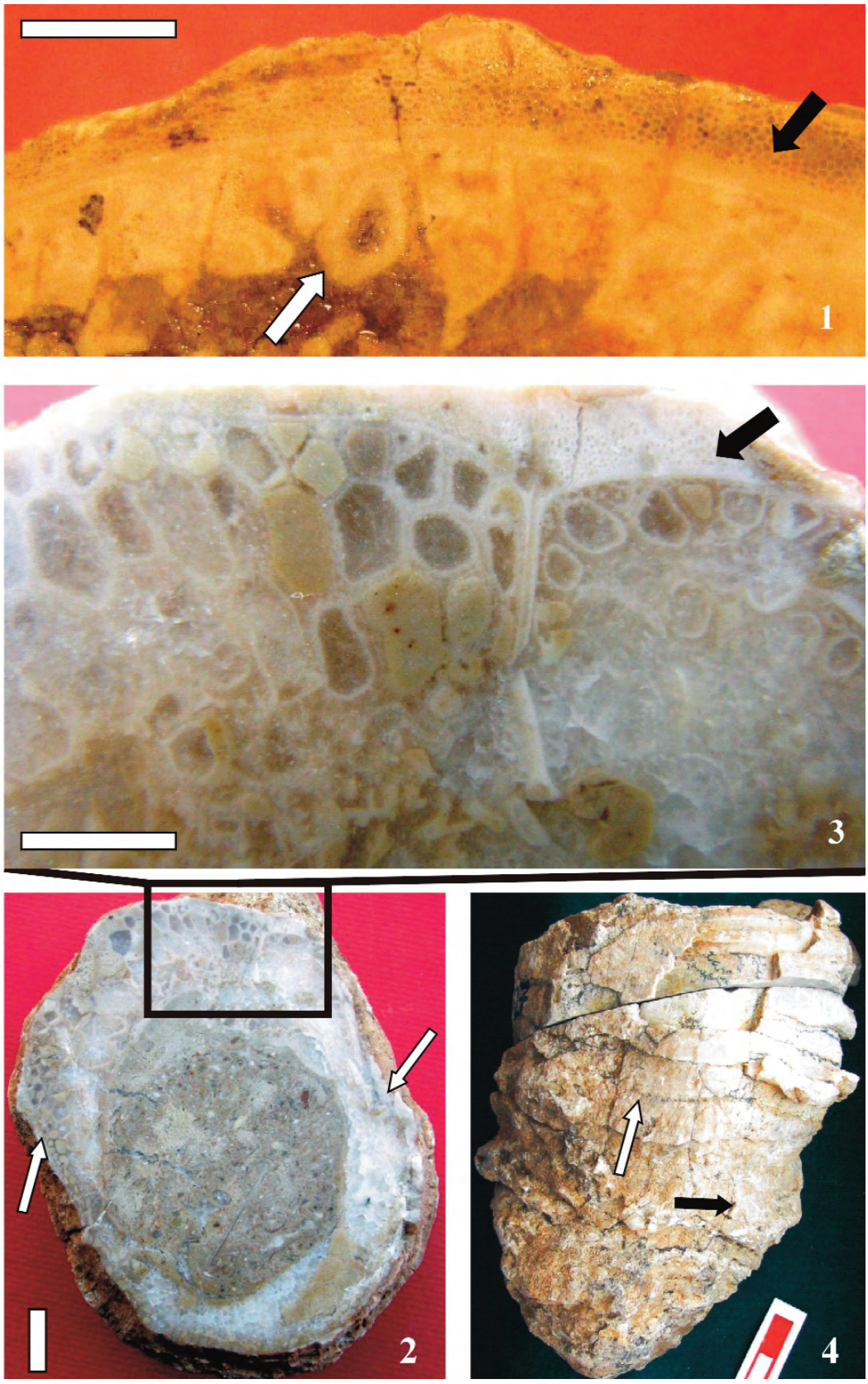
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PLATE 3

Figures 1–3. *Pseudosabinia ornata* (Özer & Fenerci)

Figure 1. Transverse section of RV, 10 mm below of the commissure showing the canaliculate inner shell layer and cellular outer shell layer. No Pm 25. Maden-Bayburt. Scale bar is 20 mm.

Figure 1A. Partial enlargement of the Figure 1 showing well-preserved canal sections in the inner shell layer and finely cellulоprismatic outer shell layer of the RV. at and pt are partly preserved but L is clearly observed. Scale bar is 10 mm.

Figure 1B. Partial enlargement of the anterior part of the same specimen (Figure 1) showing finely cellulоprismatic outer shell layer and fusiform canal sections of the inner shell layer of the RV. Scale bar is 5 mm.

Figure 2. Transverse section of LV passing 10 mm above of the commissure showing well-preserved radiolitiform myocardinal apparatus and fusiform and polygonal canal sections around the antero-dorsal part of the valve. No Pm 25. Maden-Bayburt. Scale bar is 20 mm.

Figure 3. Partial enlargement of the same specimen (Figure 2) showing the well-preserved myocardinal apparatus. Scale bar is 10 mm.

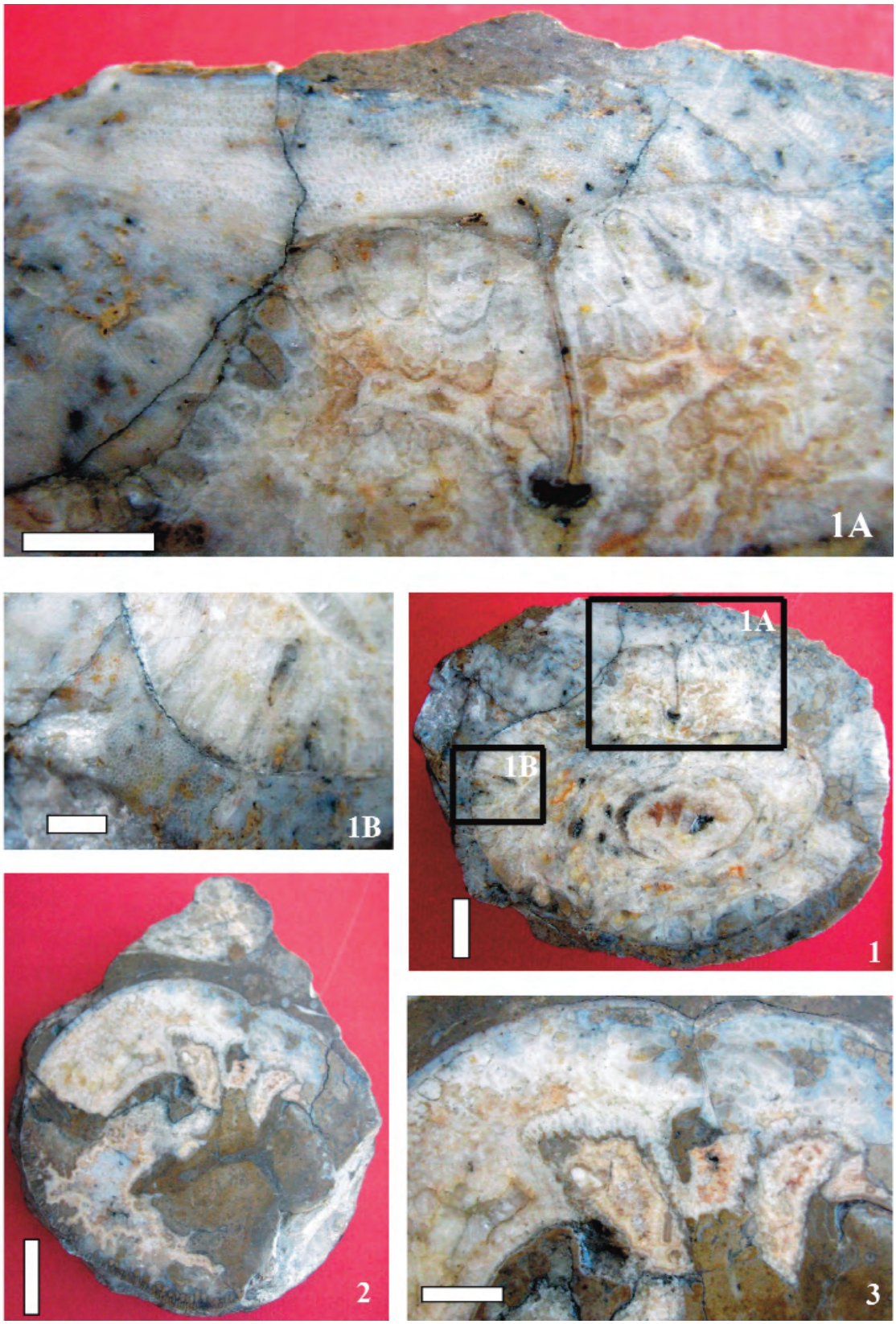
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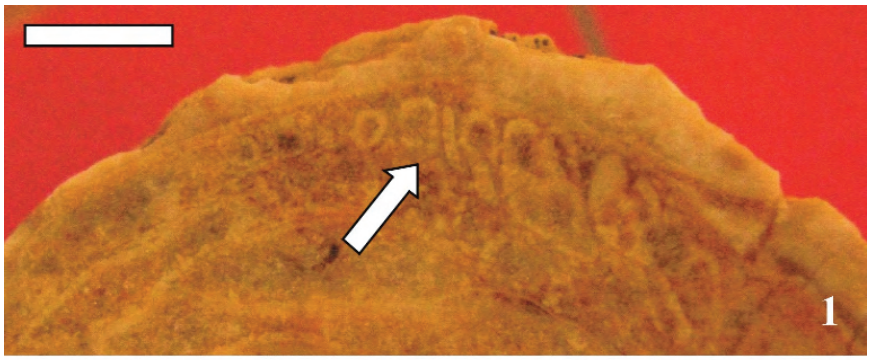
PLATE 4

Figures1–3. *Pseudosabinia klinghardti* (Böhm).

Figure 1. Transverse section of RV showing circular, oval and rectangular canal sections in the inner shell layer (white arrows). The outer shell layer is also finely cellulоprismatic structure. No. AK 18. Tavşanlı village-Gebze, Hereke, Kocaeli Peninsula, NW of Anatolia. Scale bar is 10 mm.

Figure 2. Transverse section of LV showing ligamentary infolding, radiolitiform myocardinal apparatus and well-preserved pallial canals throughout the inner shell. Note well-developed canal structure characterized by a single row of pyriform canals around the whole periphery of the valve and two, three or four rows of suboval, polygonal and quadrangular canals in the internal part of the valve. Some quadrangular canal sectons (black arrow) are also observed between the posterior tooth and myophore. No. Ç-21. Tavşanlı village-Gebze, Hereke, Kocaeli Peninsula, NW of Anatolia. Scale bar is 10 mm.

Figure 3. Transverse section of LV showing pallial canals throughout the inner shell. Compare the canal structure with previous Figure 3. No. AD 5. Kahta-Alidamı village, Adıyaman, SE Anatolia. Scale bar is 10 mm.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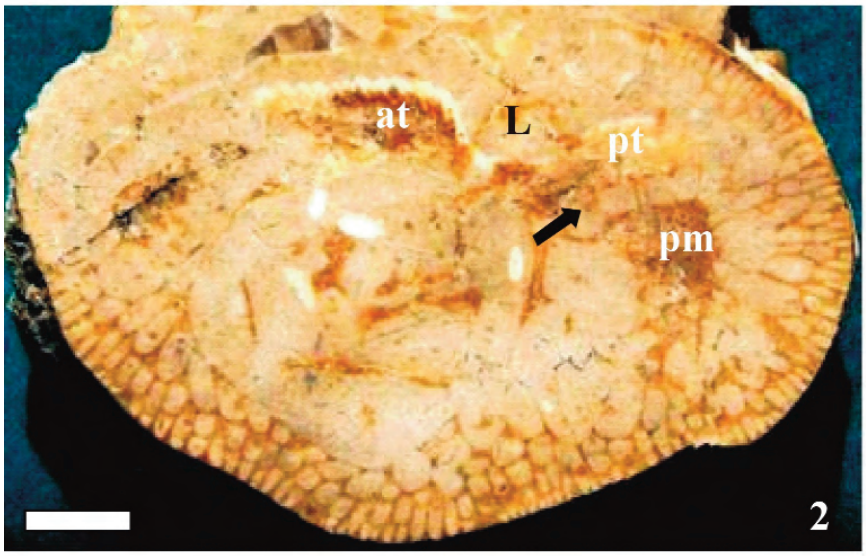
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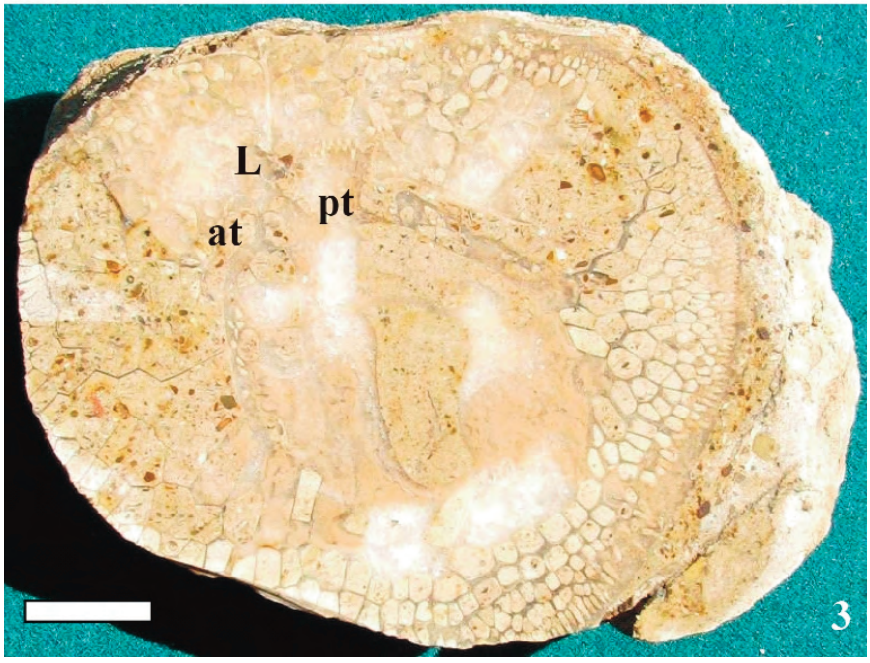
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PLATE 5

Figures 1–3. *Pseudosabinia rtanjica* (Pejović)

Figure 1. Transverse section of LV passing approximately 10 mm above of the commissure. Radiolitiform myocardinal apparatus is well-preserved and teeth show tightly folded structure. Pallial canals are clearly observed. Central cavity is oval in form. No. DM 3. Darende-Malatya, E Anatolia. Scale bar is 10 mm.

Figure 2. Transverse section of LV passing approximately 10 mm above of the commissure. Note well-developed pallial canals filling all of the inner shell including myophores and also radiolitiform myocardinal apparatus. No. EH 6. Elazığ, E Anatolia. Scale bar is 10 mm.

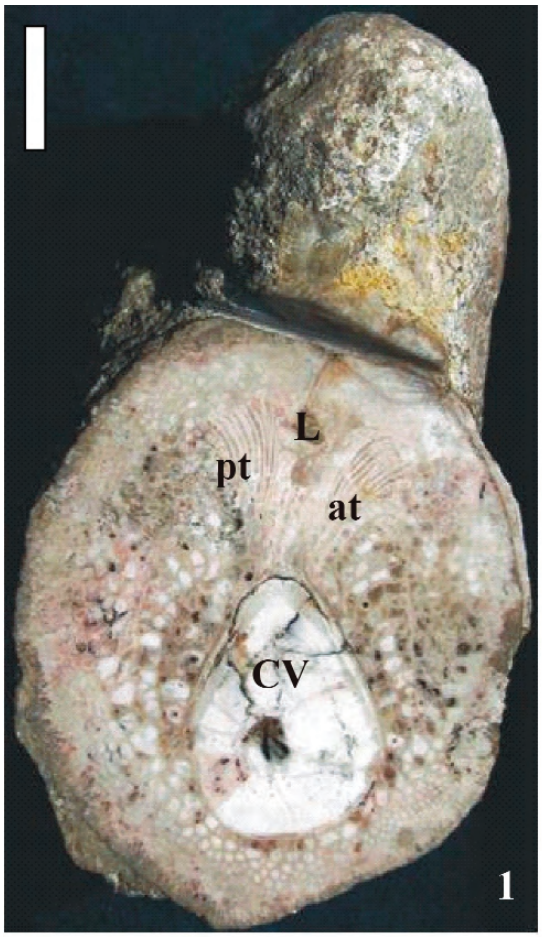
Figure 3. Whole valves, posterior view. Note strong inclination of the LV. The traces of the pallial canals of the inner shell layer can be seen in the eroded part of the LV. RV is conical and is much smaller than LV. The white arrow indicates commisural plane. The green arrow shows the place of the transversal section presented in the Figure 4. No. GD 17. Güneşli village-Divriği-Sıvas, E of Anatolia. Scale bar is 20 mm.

Figure 4. Transverse section of RV of the same specimen (Figure 3) passing approximately 10 mm above of the commissure. The outer layer is very thin and can be seen only in some places (whitre arrow). Scale bar is 20 mm.

Figure 5. Partial enlargement of the anterior part of transversal section of RV. The compact outer shell layer is very thin (white arrow). No. DM 6. Darende-Malatya, E of Anatolia. Scale bar is 10 mm.

Figure 6. Transverse section of RV passing approximately 5 mm above of the commissure. Cardinal apparatus is very well-observed. Note some canal sections around CV (white arrow) and in the inner shell layer (black arrow). No. EH 8. Elazığ, E Anatolia. Scale bar is 10 mm.

Figure 7. Partial enlargement of the same specimen (Figure 6) showing thin compact outer shell layer. Scale bar is 10 mm.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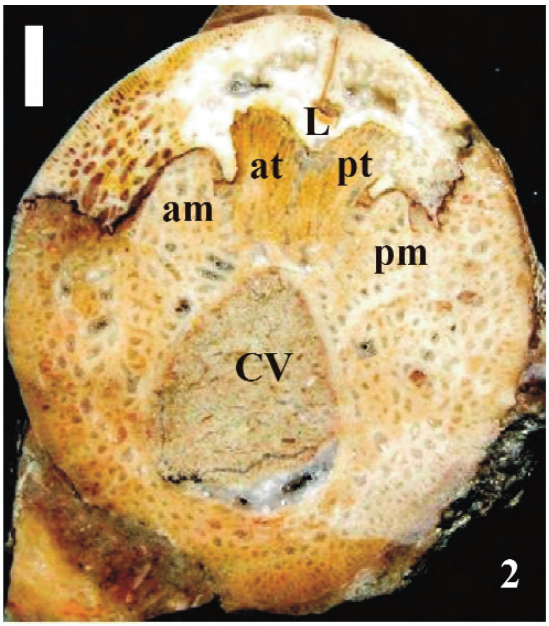
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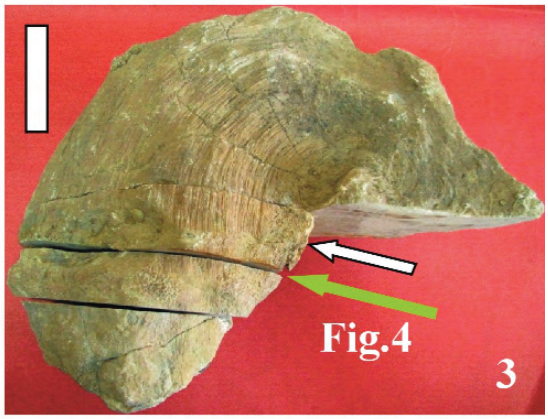
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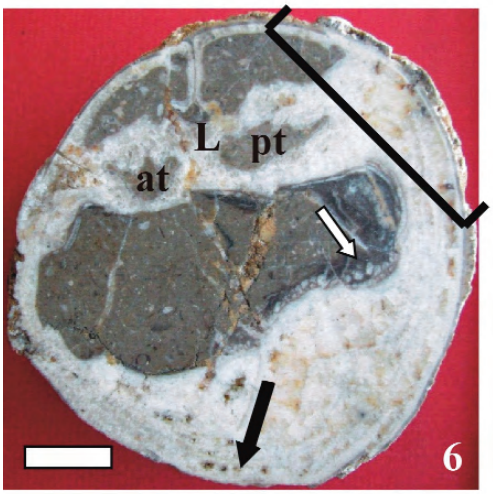
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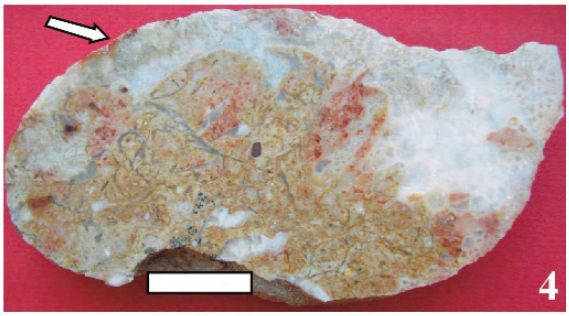
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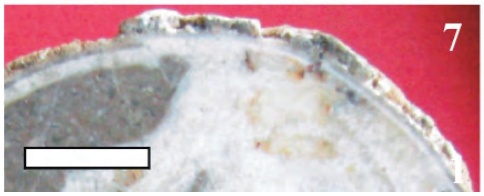
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5

PLATE 6

Figures 1–4. *Pseudosabinia rtanjica triangularis* (Karacabey).

Figure 1. Upper view of LV presenting the characteristic features of radial bands. No I 3-6 A. İnekpınarı-Yeşilyurt-Malatya, E of Anatolia. Scale bar is 20 mm.

Figure 2. Transverse section of LV, commissure unknown. The anterior and posterior teeth are very well-preserved. The polygonal and some triangular canal sections can be observed in the ventral part of the section. No. GD 11. Güneşli village-Divriği-Sıvas, E of Anatolia. Scale bar is 20 mm.

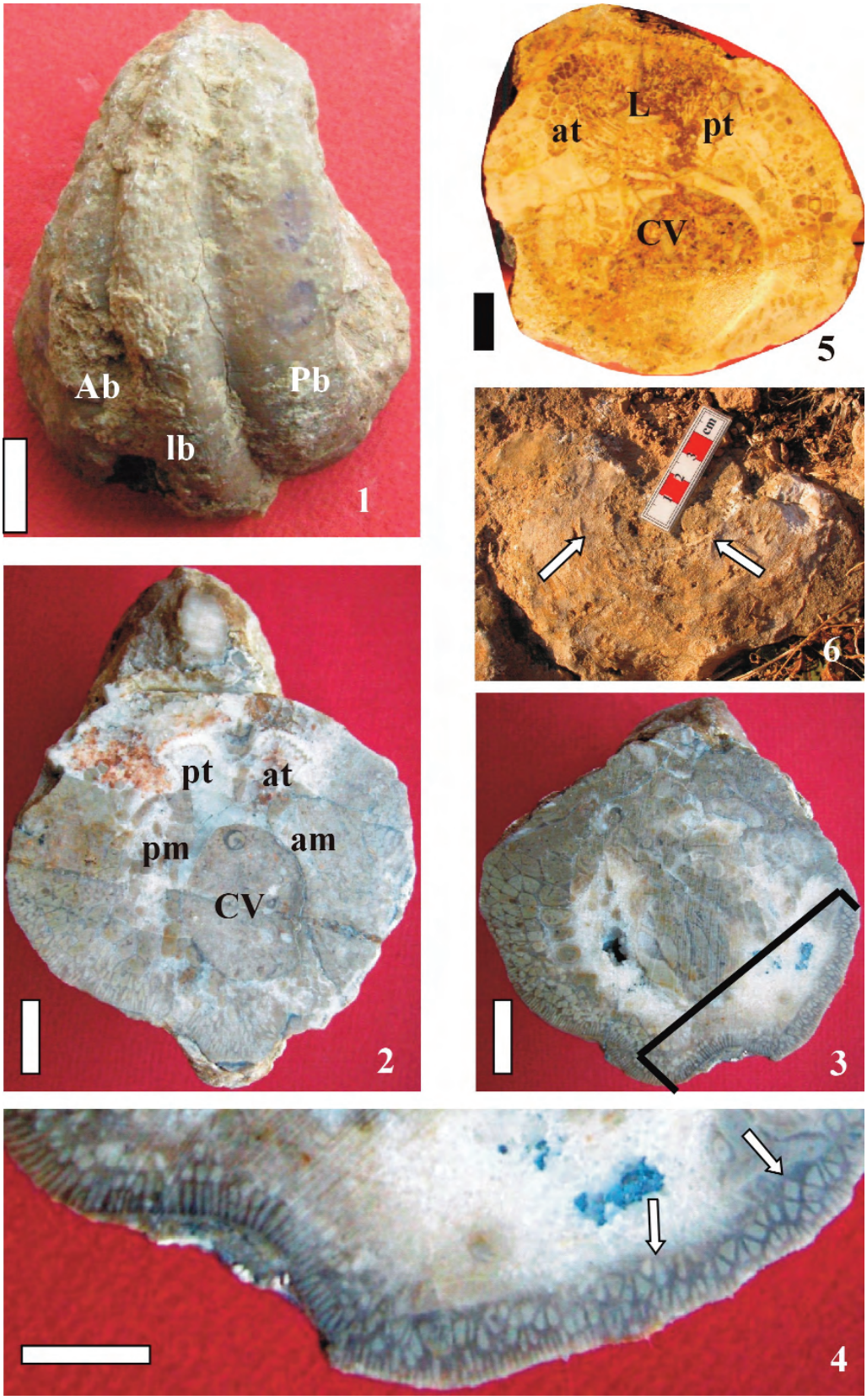
Figure 3. Transverse section of LV, commissure unknown. The fusiform, polygonal and triangular canal sections can be observed in the inner shell layer (for detail see Figure 4). No. HM 19. Hekimhan-Malatya, E Anatolia. Scale bar is 10 mm.

Figure 4. Partial enlargement of the same specimen (Figure 3) showing the well-preserved fusiform, polygonal and triangular (white arrows) canal sections. Scale bar is 5 mm.

Figures 5–6. *Pseudosabinia* sp.

Figure 5. Transverse section of LV, commissure unknown. L and radiolitiform myocardinal apparatus are observed. In the posterior part of the inner layer and the upper part of the myocardinal apparatus the pallial canals are preserved. No. 07-04/8. Kışlacık village-Amasya, central Pontides. Scale bar is 10 mm.

Figure 6. Anterior view of large-sized recumbent LV. The pallial canals (arrows) of the inner shell layer can be observed. Field photo, scale is 40 mm. Kışlacık village-Amasya, central Pontides.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