



Maastrichtian Rudist Fauna from Tarbur Formation (Zagros Region, SW Iran): Preliminary Observations

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Received 23 June 2009; revised typescript received 24 November 2009; accepted 07 December 2009

Abstract: The uppermost Cretaceous Tarbur Formation of the Zagros region (SW Iran) is mainly siliciclastic in composition, though it also incorporates some carbonate units including several rudist lithosomes. Two sections through this formation, in the Semirom and Gerdbisheh areas, have been chosen for study of the lithosomes and their rudist fauna. These lithosomes vary in faunal content, geometry and internal organization (density and diversity). Preliminary investigation of the specimens collected from the studied sections reveals a diverse rudist fauna. Eleven genera and 23 species have been determined, belonging to the rudist families Hippuritidae, Radiolitidae and Dictyoptychidae. These rudist assemblages indicate a Maastrichtian age for the Tarbur Formation in these areas.

With regard to their growth geometries, most of the specimens are of elevator rudist morphotype, forming many different associations (e.g., bouquets and clusters). Comparison between the present rudist fauna, particularly taxa considered endemic to this part of the Mediterranean province, with the Late Cretaceous fauna recorded from other parts of the Zagros, Turkey and South of the Persian Gulf (Oman and UAE) show similarities that confirm the faunal connection between them.

Key Words: Rudists, Tarbur Formation, Iran, Semirom, Gerdbisheh, Maastrichtian

Tarbur Formasyonu Maastrichtiyen Rudist Faunası (Zagros Bölgesi, GB İran): Ön Gözlemler

Özet: Zagros Bölgesi (GB İran) en üst Kretase Tarbur Formasyonu başlıca silisiklastik bileşimde olmasına karşın çok sayıda rudist litosomları içeren karbonat birimlerini de kapsar. Bu formasyonda Semirom ve Gerdbisheh alanlarında olmak üzere iki kesit, litosomlar ve onların rudist faunasını incelemek üzere seçilmiştir. Bu litosomlar faunal içerik, geometri ve iç düzeninde (yoğunluk ve çeşitlilik) değişiklikler gösterir. Kesitlerden derlenen örneklerin ön incelemeleri, farklı bir rudist faunasının varlığını ortaya koyar. Hippuritidae, Radiolitidae ve Dictyoptychidae'ye ait 11 cins ve 23 tür tanımlanmıştır. Rudist toplulukları Tarbur Formasyonu için Maastrichtiyen yaşını işaret eder.

Büyüme geometrileri, örneklerin büyük bir çoğunluğunun farklı topluluklar (örneğin, buketler ve kümeler gibi) içeren dikey rudist morfotiplerinden oluştuğunu gösterir. Bu çalışmada tanımlanan, özellikle Akdeniz Bölgesi'nin bu alanı için endemik kabul edilen bu çalışmadaki rudist faunasının Zagros, Türkiye ve İran Körfezi'nin güneyindeki (Umman ve Birleşik Arab Emirlikleri) Geç Kretase faunasıyla karşılaştırılması birbirleriyle faunal ilişkilerin olduğunu kanıtlayan benzerlikler olduğunu gösterir.

Anahtar Sözcükler: Rudistler, Tarbur Formasyonu, İran, Semirom, Gerdbisheh, Maastrichtiyen

Introduction

During the Maastrichtian, thrust faulting along the main Zagros range (SW Iran) led to NE–SW-oriented expansion of carbonate platform development with incorporated rudist formations (Motiei 1993).

The succession in the Zagros region was first described by James & Wynd (1965) who proposed the name Tarbur Formation for these deposits. This formation extends across the internal Fars and Lurestan structural provinces of the Zagros (Motiei 1993).

On the basis of Foraminifera from the type section of the Tarbur Formation, James & Wynd (1965) proposed a Campanian–Maastrichtian age for this succession, and correlated it with the Tayarat Formation of Kuwait and the Aruma Formation of Saudi Arabia.

Some earlier works reported on Zagros rudists from different (sometimes unknown) stratigraphic levels in the Cretaceous. Monographs by Douvillé (1904, 1910) focusing on rudists of the Zagros and other Mediterranean areas in Iran, Italy, Algeria, Egypt and Lebanon were the first and most important among these reports.

Cox (1934) described some new rudist genera and species from this region, while rudists of Turonian–Maastrichtian age from parts of the Zagros Mountains (Zard kuh) were also studied by Parona (1934–35). Finally, some further taxa were reviewed by Kühn (1937), Chubb (1956) and Vogel (1970).

Although these classic investigations are still largely reliable, revision is necessary in the light of more recent findings on rudist taxonomy and palaeoecology as well as new stratigraphic data and divisions in the Zagros region.

This paper accordingly presents preliminary findings on the rudist fauna and lithosomes studied in two sections of the Tarbur Formation, followed by a brief description of the rudists' growth forms and fabrics as a prelude to palaeoecological analysis. The final section discusses the palaeobiogeography of the known taxa in and around Zagros region with particular emphasis on endemic taxa of the eastern side of the Mediterranean Tethyan Realm (Arabian platform), from Oman-UAE in the South to SE Turkey in the North.

Stratigraphy of the Tarbur Formation

The Tarbur Formation in the Central Zagros consists mainly of siliciclastic rocks comprising shales, sandstones and polygenic conglomerates, but also includes some carbonate units consisting of rudist lithosomes. In some cases the latter are accompanied by ahermatypic corals, non-rudist bivalves, gastropods and algae.

Two sections of the Tarbur Formation in the central part of the Zagros mountains have been chosen for this study: the first section is located 5 km southwest of Semirom town (Isfahan province) and the second one, 1 km east of Gerdbisheh village (Chaharmahal and Bakhtyari province), beside the Isfahan-Yasouj road (Figure 1).

In these sections, the Tarbur Formation conformably overlies the dark shale of the Amiran Formation, with a sharp contact. In the Gerdbisheh section, the Upper boundary of the Tarbur Formation with the Shahbazan Formation is covered by Recent deposits and is unexposed. In the Semirom section, the Tarbur Formation is conformably overlain by medium- to coarse-grained terrigenous deposits of the Kashkan Formation (Paleocene) with a transitional contact.

Rudist Fauna and Lithosomes

Semirom Section

As shown in the stratigraphic columns (Figure 2), the Semirom section has a total thickness of more than 500 m and contains carbonate units A1 to A4-2 from the base to the top of the section: (1) A1 consists of 9.5 m of thick-bedded bioclastic limestones (packstone/grainstone) with abundant rudists and skeletal fragments. Two laterally equivalent rudist lithosomes are exposed in separate A1 outcrops: a densely packed assemblage of elevator *Vautrinia* that forms a tabular lithosome up to 1.5 m thick, and a semi-compact aggregation of *Dictyoptychus*, which forms a restricted lithosome with finite lateral dimensions (Figure 3). The rudist taxa determined within this layer are listed in Table 1. (2) A1-2 includes a 1-m-thick bioclastic limestone that contains scleractinian corals and rudist fragments. (3) A2 consists of 1–1.5 m of fine-grained limestones. Small and scattered radiolitids are the main rudist components in this layer. A2 pinches out bilaterally in a few tens of metres. (4) A3 contains approximately 10 m of thick-bedded bioclastic limestones. This is the most important layer because of its diverse fauna of rudists, colonial and individual forms of ahermatypic scleractinian corals, echinoids, non-rudist bivalves and brachiopods. In the lower part of A3, a community of a different large-sized

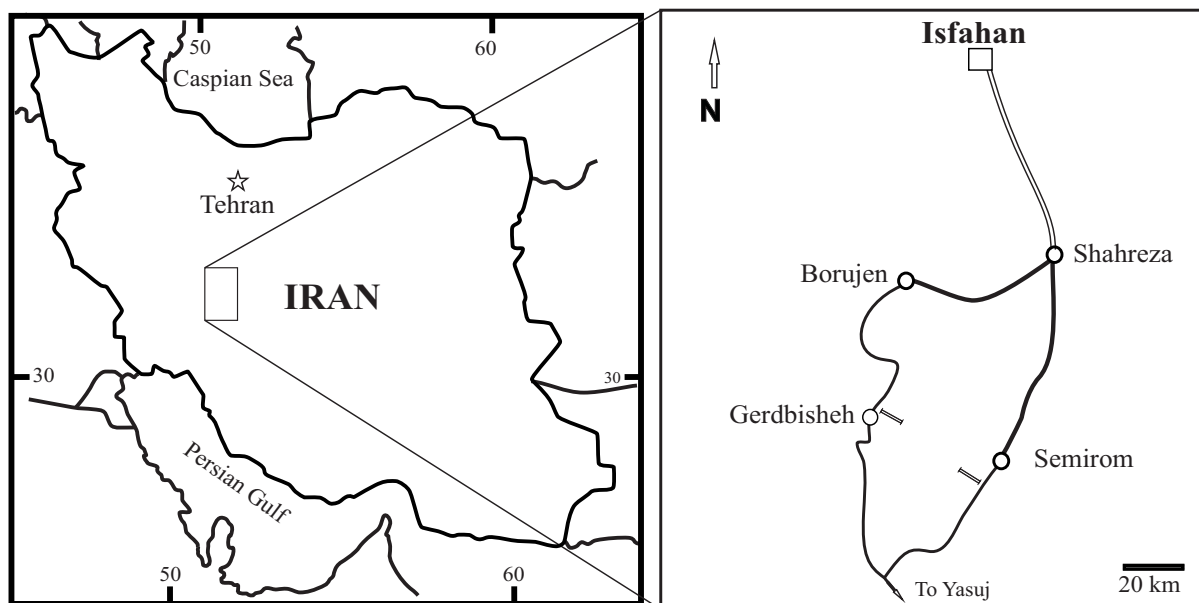


Figure 1. Location map of the studied sections of the Tarbur Formation (double line symbols) near Semirom and Gerdbisheh in central part of Zagros Mountains, SW Iran.

species of *Dictyoptychus* and some Radiolitidae forms a moderately packed lithosome (Figure 4). This lithosome shows a sheet-like geometry with a gradational lower contact. It is locally covered by another densely compact elevator hippuritid lithosome. Slender cylindrical *Hippurites cornucopiae* DeFrance, more than 30–40 cm in length, constitute the main species of this paucispecific lithosome, which crops out with varying thickness in different locations (Figure 5). (5) A3-2 is lithologically similar to A3, but differs in having less thickness (7.5 m) and being characterized by a limited and dispersed fauna of Radiolitidae and Hippuritidae. Table 1 shows the diverse assemblage of rudists determined among the specimens collected from A3 and A3-2. (6) A4 consists of 20 m of medium-bedded bioclastic limestones with a rich fauna of individual and aggregated rudists accompanied by foraminifera (mainly *Loftusia*), individual and colonial forms of scleractinian corals (specially Cunnolitidae) and gastropods. A diverse and low to moderate density radiolitid lithosome has also been found in this layer. (7) A4-2 at the top of the section is composed of 24 m of limestones with

the same characters and fauna described for A4, but with less compaction. Systematic study of rudist samples of A4 and A4-2 layers has yielded the taxa shown in Table 1.

Gerdbisheh Section

The total thickness of the Tarbur Formation measured at the Gerdbisheh section (Figure 2) is more than 450 m. Three carbonate units have been found in this section. As in the Semirom section, these units generally show lateral changes in thickness, faunal composition, density and facies: (1) B1 at the base of the section contains 5 m of bioclastic rudist-bearing limestone. Inside this layer, there is a thick rudist lithosome characterized by a low density (open fabric) and diversity of rudists. The lithosome is dominated by *Dictyoptychus* and *Vaccinites* and has clear lower and upper boundaries. Also there are some sparse Radiolitidae (individuals and few clusters) in company with colonial corals and rudist fragments. Table 2 lists the rudist taxa that were determined from this section. (2) B2 consists of 4 m of grey nodular limestone including a thin and

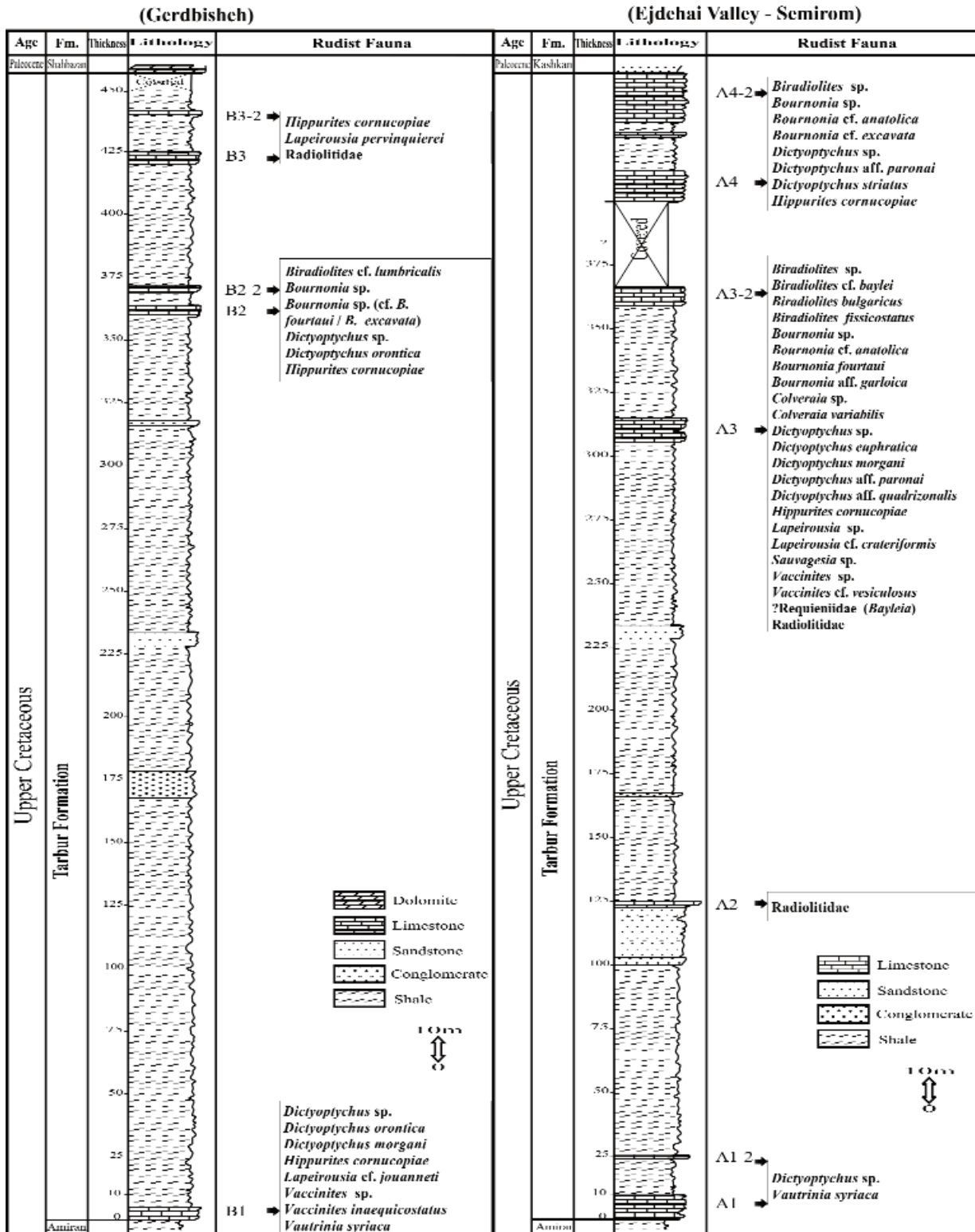


Figure 2. Stratigraphic columns of Gerdbisheh (left) and Semirom (right) sections showing lithostratigraphic units, main lithologies and rudist fauna.



Figure 3. Natural cross section (parallel to bedding) of medium to densely-packed assemblage of elevator *Dictyoptychus* forming a lithosome in the A1 layer of the Semirom section.



Figure 4. Vertical section of a dictyoptychid lithosome in lower part of the A3 layer of the Semirom section, made up of large specimens of *Dictyoptychus*. Individuals in this assemblage have no close contact (low density).



Figure 5. Densely-packed paucispecific hippuritid lithosome. Elongated elevator hippuritid rudists (mainly *Hippurites cornucopiae*) formed these large conical assemblages preserved in life position, A3 Semirom section.

restricted radiolitid lithosome with low density and medium diversity. Large amounts of isolated forms, bouquets and clusters are interspersed. (2) B2-2 (above B2, though merging with it laterally) comprises 2.5 m of limestones with the same lithology of B2, containing rudists, corals and foraminifera but without any specified rudist lithosome. The results of identification of rudist taxa of these two layers are as shown in Table 2. (3) B3 includes 5 m of thick-bedded limestone containing abundant rudists, as individuals and bouquets, as well as colonial and solitary corals, skeletal fragments and foraminifera. (4) B3-2 is comprised of grey limestones 1.5–2 m thick with rudists and some non-rudist bivalves. There is no specified rudist lithosome in B3 and B3-2 layers due to the scarcity of rudist components. Table 2 shows rudist taxa determined from these layers (B3 and B3-2).

Age

Stratigraphically significant taxa determined from the two studied sections constrain the age for the Tarbur Formation. *Hippurites cornucopiae* Defrance is a well-recognized taxon recorded from Maastrichtian carbonate platforms across the Mediterranean province from Spain to Iran

Table 1. List of rudist taxa found in different carbonate units of the Semirom section and where they are figured in the plates.

Unit	Rudist species	
A1	<i>Vautrinia syriaca</i> (Vautrin 1933)	plate 3, figure 7
	<i>Dictyoptychus</i> sp.	
A3 & A3-2	<i>Hippurites cornucopiae</i> DeFrance 1821	plate 2, figure 3
	<i>Vaccinites</i> sp.	
	<i>Vaccinites</i> cf. <i>vesiculosus</i> (Woodward 1855)	plate 2, figure 1a, b
	<i>Biradiolites</i> sp.	
	<i>Biradiolites</i> cf. <i>baylei</i> Toucas 1909	plate 2, figures 8, 9
	<i>Biradiolites bulgaricus</i> Pamouktchiev 1967	
	<i>Bournonia</i> sp.;	
	<i>Bournonia</i> cf. <i>anatolica</i> Özer 1988	
	<i>Bournonia fourtaui</i> Douvillé 1910	plate 2, figure 7a, b
	<i>Bournonia</i> cf. <i>garloica</i> Pamouktchiev 1979	plate 3, figure 9
	<i>Colveraia</i> sp.	
	<i>Colveraia variabilis</i> Klinghardt 1921	plate 2, figure 10a, b
<i>Lapeirousia</i> sp.	plate 2, figure 5a, b	
<i>Lapeirousia</i> cf. <i>crateriformis</i> (des Moulins 1826)	plate 3, figure 4a, b	
<i>Praeradiolites</i> sp.	plate 3, figure 5a, b	
<i>Sauvagesia</i> sp.	plate 2, figure 6	
A4 & A4-2	<i>Dictyoptychus</i> sp.	
	<i>Dictyoptychus euphratica</i> Karacabey-Öztemür 1979	plate 3, figure 3
	<i>Dictyoptychus morgani</i> (Douvillé 1904)	
	<i>Dictyoptychus</i> aff. <i>paronai</i> (Kühn 1929)	
	<i>Dictyoptychus</i> aff. <i>quadrizonalis</i> Özer 2005	plate 3, figure 2a, b
	<i>Bayleia</i> sp.	plate 2, figure 4a, b
A4 & A4-2	<i>Hippurites cornucopiae</i> DeFrance 1821	plate 2, figure 2
	<i>Biradiolites</i> sp.	
	<i>Bournonia</i> sp.	
	<i>Bournonia</i> cf. <i>anatolica</i> Özer 1988	
	<i>Bournonia</i> cf. <i>excavata</i> (d'Orbigny 1842)	plate 3, figure 8
	<i>Dictyoptychus</i> sp.	
<i>Dictyoptychus</i> aff. <i>paronai</i> (Kühn 1929)		
<i>Dictyoptychus striatus</i> Douvillé 1910	plate 3, figure 1a, b	

(Douvillé 1910; Kühn 1932; Morris & Skelton 1995). The fauna described here is also characterized by the presence of some endemic taxa (e.g., species of *Dictyoptychus* and *Vautrinia syriaca* (Vautrin)), which are restricted to the Arabian platform. These taxa have been reported within assemblages from Turkey, Iran, Syria, Oman, UAE and Somalia that have likewise been assigned a Maastrichtian age (Kühn 1932; Karacabey-Öztemür 1979; Özer 1986, 1992, 2002; Nolan *et al.* 1990; Pons *et al.* 1992; Morris & Skelton 1995; Özer *et al.* 2008).

Though *Vaccinites vesiculosus* (Woodward) has been reported mainly from Campanian–Maastrichtian deposits of Turkey, Oman and UAE (Karacabey 1968; Morris & Skelton 1995; Philip & Platel 1995; Özer 1986, 1988), the *Vaccinites* cf. *vesiculosus* recorded here is the first likely record of its presence among the Maastrichtian fauna of the Zagros region.

Some other taxa (e.g., *Bournonia* cf. *anatolica* Özer and *Biradiolites bulgaricus* Pamouktchiev) belong to Late Cretaceous associations that have also

Table 2. List of rudist taxa found in different carbonate units of the Gerdbisheh section and where they are figured in the plates.

Unit	Rudist species	
B1	<i>Hippurites cornucopiae</i> Defrance 1821 <i>Vaccinites</i> sp. <i>Vaccinites inaequicostatus</i> (Münster in Goldfuß 1840)	plate 1, figure 8
	<i>Lapeirousia</i> cf. <i>pervinquieri</i> (Toucas 1908) <i>Vautrinia syriaca</i> (Vautrin 1933)	plate 1, figure 1a, b
	<i>Dictyoptychus</i> sp. <i>Dictyoptychus orontica</i> Karacabey-Öztemür 1979 <i>Dictyoptychus morgani</i> (Douvillé 1904)	plate 1, figure 7 plate 1, figure 10
	<i>Hippurites cornucopiae</i> Defrance 1821	plate 1, figures 3, 5
	<i>Biradiolites</i> cf. <i>lumbricalis</i> (d' Orbigny 1842) <i>Bournonia</i> sp.	plate 1, figure 2 plate 1, figure 6
	<i>Dictyoptychus</i> sp. <i>Dictyoptychus orontica</i> Karacabey-Öztemür 1981	
B3 & B3-2	<i>Hippurites cornucopiae</i> Defrance 1821	
	<i>Lapeirousia pervinquieri</i> (Toucas 1908) Radiolitidae	plate 1, figure 4a, b plate 1, figure 9

been reported from the Eastern Mediterranean province of the Tethys, but again particularly assigned to the Maastrichtian in Turkey (Özer 1988).

The comparison of the studied rudist specimens with other documented assemblages thus confirms a Maastrichtian age for the Tarbur Formation.

Growth Forms and Congregation Fabrics

There are close relationships between the shell growth forms of rudists and the nature of the substrate. Based on this fact, rudists have been classified into three major morphotypes, each representing a suitable growth form for a specific regime of sedimentation (Skelton & Gili 1991; Ross & Skelton 1993). This classification was primarily established by Skelton (1978) and later revised and redefined by Skelton & Gili (1991) in terms of measurable parameters. According to quantitative indices related to the stability and growth forms of rudists, 'elevator', 'clinger' and 'recumbent' morphotypes have been defined (Skelton & Gili 1991).

Rudist specimens of the two studied sections of the Tarbur Formation are classified as elevators, except for some radiolitid forms (e.g., *Biradiolites*) in A3 and A4 layers of the Semirom section, which belong to the lateral clinger morphotype (Plate 3, figures 8 & 9). The abilities of elevators to form rudist aggregations according to their particular shapes (cylindrical to elongate conical) and packing potential (Gili *et al.* 1995), locally allowed for the development of bouquets, clusters and large thickets within the carbonate units.

Elevator radiolitid bouquets and clusters are the most abundant assemblages among the rudist aggregations. The fabrics of these associations differ from a sparsely packed or an open fabric (e.g., in A2 layer of the Gerdbisheh section) to medium-packed (e.g., in A4 layer of the Semirom section) and most examples are relatively diverse in taxonomic composition (Plate 1, Figure 9; Plate 3, Figure 6). These types of rudist structures usually formed in a low energy, shallow marine setting with positive net sedimentation (Gili *et al.* 1995).

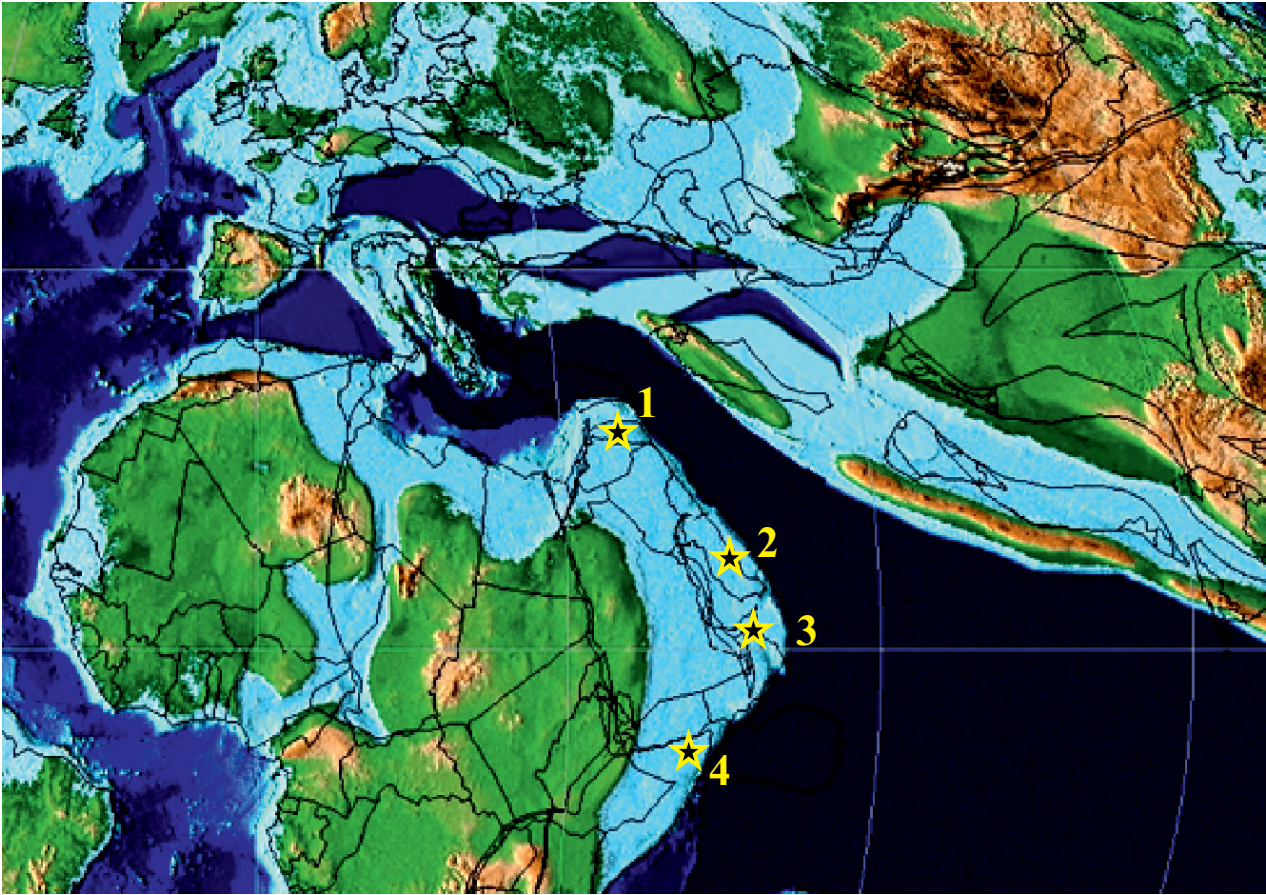


Figure 6. Palaeogeographic map of the Late Cretaceous showing the biogeographic distribution of endemic rudist taxa in the Arabian Plate. Stars indicate the approximate locations of the rudist faunas mentioned in the text: 1– Southeastern Turkey, 2– Zagros region, Southwestern Iran, 3– UAE-Oman region and 4– Northern Somalia. (modified from the Campanian palaeogeographical map. Base map from Chris Scotese, PALEOMAP Project, University of Texas at Arlington, USA).

Elevator dictyoptychid assemblages can be observed in two of the lithosomes described above from the A1 and A3 layers of the Semirom section: in A1, a community of small-sized (less than 10 cm in diameter) dictyoptychids with moderate to dense packing is preserved in life position (Figure 3), while in the lower part of A3, large-sized dictyoptychids form a loose-packed assemblage. The abundance of these large elevators may reflect amelioration of conditions in an otherwise restricted low energy environment.

The elevator hippuritid congregations are exposed as small bouquets and clusters (sometimes largely attached) (Plate 1, figure 3; Plate 2, figure 3). A typical form of this type of aggregation is a

paucispecific lithosome in the A3 layer of the Semirom section. Densely-packed clusters of parallel (and sub-parallel) *Hippurites cornucopiae* Defrance with more than 30–40 cm in length grew upwards together to create large conical-shaped aggregations (Figure 5). Dense compaction, presence of a fine-grained matrix and preservation in life position constitute the main evidence for constrictal growth of the rudists, in a low energy and calm environment (Skelton *et al.* 1995).

Palaeobiogeography

The Tarbur Formation, except in the central Zagros region, is known mainly as a carbonate-dominated

formation containing rich microfauna associated with abundant rudists and other macrofossils (James & Wynd 1965). The rudist fauna of this formation and its geographic distribution in some parts of the Zagros, has already been described by a number of authors.

In a part of Bakhtyari province (located near Gerdbisheh), Douvillé (1904) reported a fauna containing *Dictyoptychus morgani* and large foraminifers such as *Loftusia persica* Brady, indicating a Maastrichtian age (Chubb 1956), which is comparable with the fauna described herein. From the NW Zagros mountains (Lurestan province, western Iran), Douvillé (1910) described an assemblage containing *Hippurites cornucopiae*, *Lapeirousia jouanneti*, *Dictyoptychus striatus* and *Bournonia* sp., again showing similarities with the present fauna. Near Neyriz (southern Iran), a fauna including *Dictyoptychus morgani*, *Hippurites cornucopiae*, *Lapeirousia pervinquieri* and some other taxa with the same resemblances was recorded by Kühn (1932).

Correlation between the present fauna and those reported from the Upper Cretaceous of adjacent areas in the southern Persian Gulf and SE Turkey is required for clarifying the relationships among depositional environments and carbonate platforms of the Zagros region and other parts of the Eastern Mediterranean province of the Tethyan Realm during the Late Cretaceous (Figure 6).

One assemblage described by Kühn (1929) from Oman includes two index species, *Dictyoptychus paronai* and *Dictyoptychus leesi* Kühn 1929, accompanied by a rich fauna of corals, gastropods, echinoids and foraminifera of Maastrichtian age. Another diverse rudist fauna from the Simsima and Qahlah formations of Oman (and Oman-UAE border), consisting of some species of *Dictyoptychus*, *Vaccinites* and *Hippurites* together with *Vautrinia*, *Durania* and *Bournonia* species and different types of Radiolitidae, was discussed by Skelton *et al.* (1990) and described in detail by Morris & Skelton (1995). This diverse rudist fauna and assemblages of micro- and macrofossils indicate a Maastrichtian age for these formations (Nolan *et al.* 1990). Comparison of the Tarbur Formation rudists and those mentioned

above reveal affinities between them, with East Mediterranean endemic taxa present in both regions.

In the northernmost Arabian platform margin, now situated in SE Turkey, Upper Cretaceous rudist limestones crop out along a fold bed. The sedimentary succession encompassing the rudist limestones was deposited in a transgressive sequence on an uplifted platform. This succession has been divided into three formations (Terbüzek, Besni and Germav formations) (Özer 1992a). A Maastrichtian age has been suggested for these formations from their rudist and foraminiferal fauna (Özer 1992a; Özer *et al.* 2008; Steuber *et al.* 2009).

The rudist fauna obtained from this part of the Mediterranean province (Arabian platform) has a low diversity, but is characterized by a few endemic taxa with limited distribution in Turkey, Syria, Iran and Oman (Özer 1992a, b). Abundant species of *Dictyoptychus* consisting of a variety of old and new species described by Karacabey-Öztemür (1979) and Özer (1986), together with species of *Vautrinia* and some special types of *Hippurites* are included in this fauna (Özer 1992a, b) and show close similarities with the Tarbur Formation rudist assemblages.

The faunal contents and relationships between the Anatolian and Arabian platforms in SE Turkey are discussed in detail by Özer (1992a, b) based on plentiful data concerning rudist distribution in this region. A sharp break between the two platforms is demonstrated by some endemic taxa which are localized in the Arabian platform, indicating a major barrier to faunal exchange during the Late Cretaceous. This could reflect the existence of a deep basin between them, such as a branch of Neotethys (Özer *et al.* 2008). The fauna reported herein is consistent with this interpretation (Figure 6).

Conclusions

The Tarbur Formation in Semirom and Gerdbisheh sections contain rudist-bearing limestones in which rudists, corals, foraminifera, echinoids, and some other invertebrates are the main faunal components. In more than 500 m of measured section in the Semirom area, there are seven planar to lenticular limestone units which total 73 m in thickness, and in

the Gerdbisheh section, five carbonate units, expanded laterally as sheet-like (lenticular in some cases) bodies, amount to 18 m in approximately 450 m of formation thickness. The rudist lithosomes in these units show various shapes, faunal contents, diversities and densities, as well as different preservational aspects.

Among the rudist specimens collected from the two sections, 11 genera and 23 species belong to the following families: Hippuritidae, Radiolitidae, Dictyoptychidae [and Requiiniidae?].

This fauna confirms a Maastrichtian age for the Tarbur Formation as already inferred from its microfossil content by previous authors.

The rudists studied herein, with the exception of some clinger biradiolitinids, are classified as of elevator rudist morphotype, showing a variety of bioconstructional forms (bouquet and clusters), densities (open to densely compact) and diversities (paucispecific to diverse).

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The comparison of the present fauna with those reported from the Upper Cretaceous of the southern Persian Gulf (Oman-UAE) and SE Turkey show major resemblances, confirming the connection between these parts of Neotethys during the Late Cretaceous.

Acknowledgements

We would like to thank Dietrich Schumann and an anonymous referee for reviewing the paper and giving valuable advice, and especially Sacit Özer for many helpful suggestions and editorial notations that greatly improved the final paper. This paper has benefited from the careful review of G. Mirab Shabestari and S.Naser Raisossadat who helped to improve the early manuscript. This study was financially supported by the office of graduate studies at the University of Isfahan (Iran). The authors are grateful to the office for their support.

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PLATE 1

(Specimens from Gerdbisheh Section)

- Figure 1.** *Lapeirousia cf. pervinquieri* (Toucas): (a) side view of right valve (RV); (b) transverse section (adumbonal view) of lower valve showing posterior (pp) and anterior (ap) pseudopillars and microstructure of shell, B1 layer.
- Figure 2.** *Biradiolites cf. lumbricalis* (d'Orbigny): natural cross section of a compact bouquet, B2 layer.
- Figure 3, 5.** *Hippurites cornucopiae* DeFrance: (3) right valve transversal section of a pair of specimens; P₁ and P₂ pillars indicated; (5a) transverse section of right valve showing P₁ and P₂ pillars; (5b) side view of right valve (RV), B2 layer.
- Figure 4.** *Lapeirousia pervinquieri* (Toucas): (a) upper view of right valve, posterior (pp) and anterior (ap) pseudopillars; (b) Side view of right valve (RV), B3 layer.
- Figure 6.** *Bournonia* sp., transversal section of right valve (in adumbonal view): upper valve teeth (at & pt), posterior myophore (pm), anterior myophore (am), radial bands (ab, pb), B2 layer.
- Figure 7.** *Dictyoptychus* sp. (cf. *D. orontica* Karacabey-Öztemür), transverse section of attached valve (RV) showing body cavity (BC), lower valve central tooth (ct) and canals (C), B1 layer.
- Figure 8.** *Vaccinites cf. inaequicostatus* (Münster), Transverse section of right valve showing pillars (P₁, P₂) and ligament support (L), B1 layer.
- Figure 9.** Radiolitid cluster, A3 layer.
- Figure 10.** *Dictyoptychus morgani* (Douvillé), Side view of attached valve (RV), B1 layer.

(Scale bars are equal to 1 cm except in figure 10.)

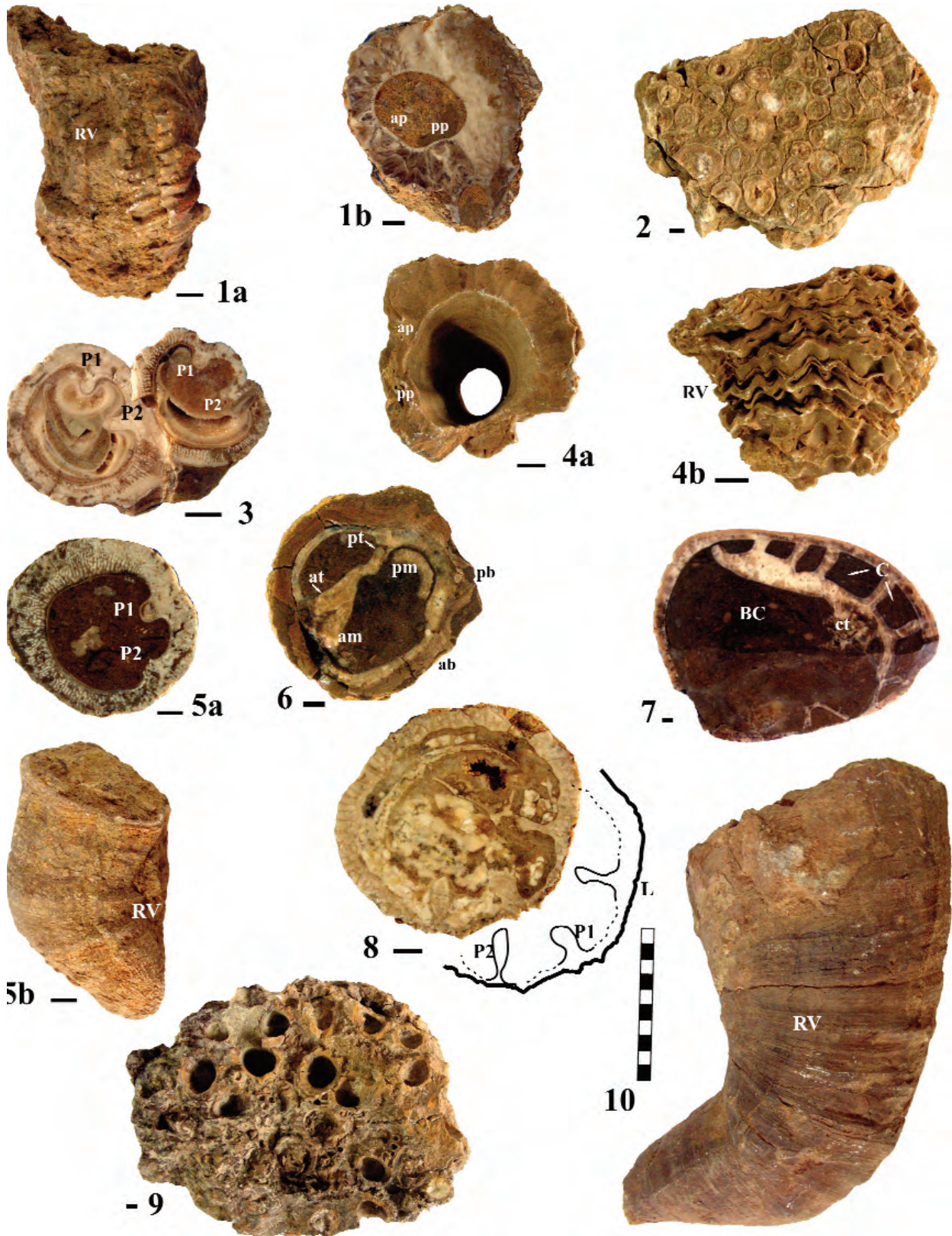


PLATE 2

(Specimens from Semirom Section)

- Figure 1.** *Vaccinites vesiculosus* (Woodward): (a) transverse section of right valve showing cardinal apparatus, pillars (**P₁**, **P₂**) and ligamental ridge (**L**); (b) side view of right valve (**RV**) and a conjoined young specimen, A3 layer.
- Figure 2.** *Hippurites cornucopiae* Defrance, transverse section of right valve showing pillars (**P₁**, **P₂**) and internal layer (**i**), A4 layer.
- Figure 3.** *Hippurites cornucopiae* Defrance, Section through a cluster (in abumbonal view) with young (left) and adult (right) specimens, pillars (**P₁**, **P₂**), A3 layer.
- Figure 4.** ? Requiieniidae (*Bayleia* sp.): (a & b) ventral and dorsal views, A3 layer.
- Figure 5.** *Lapeirousia* sp., (a) transverse section of right valve, notice the radial bands (**ab** & **pb**), (b) side view of right valve (**RV**) and outer layer undulations, A3 layer.
- Figure 6.** *Sauvagesia* sp., Transverse section of right valve, fragmented ligament ridge (**L**), A3 layer.
- Figure 7.** *Bournonia fourtaui* Douvillé: (a) transverse section of right valve, posterior tooth (**pt**), anterior tooth (**at**), posterior myophore (**pm**), anterior myophore (**am**) and radial bands (**ab**, **pb**), (b) side view of right valve (**RV**) and left valve (**LV**), A3 layer.
- Figure 8, 9.** *Biradiolites cf. baylei* Toucas: adumbonal transverse sections of right valve, posterior myophore (**pm**), anterior myophore (**am**), A3 layer.
- Figure 10.** *Colveraia variabilis* Klinghardt: (a) abumbonal transverse section of right valve, posterior tooth (**pt**), anterior tooth (**at**), ligament ridge (**L**) and pallial canals of upper valve (**pc**), (b) side view of right valve (**RV**) and left valve (**LV**), A3 layer.

(Scale bars are equal to 1 cm)

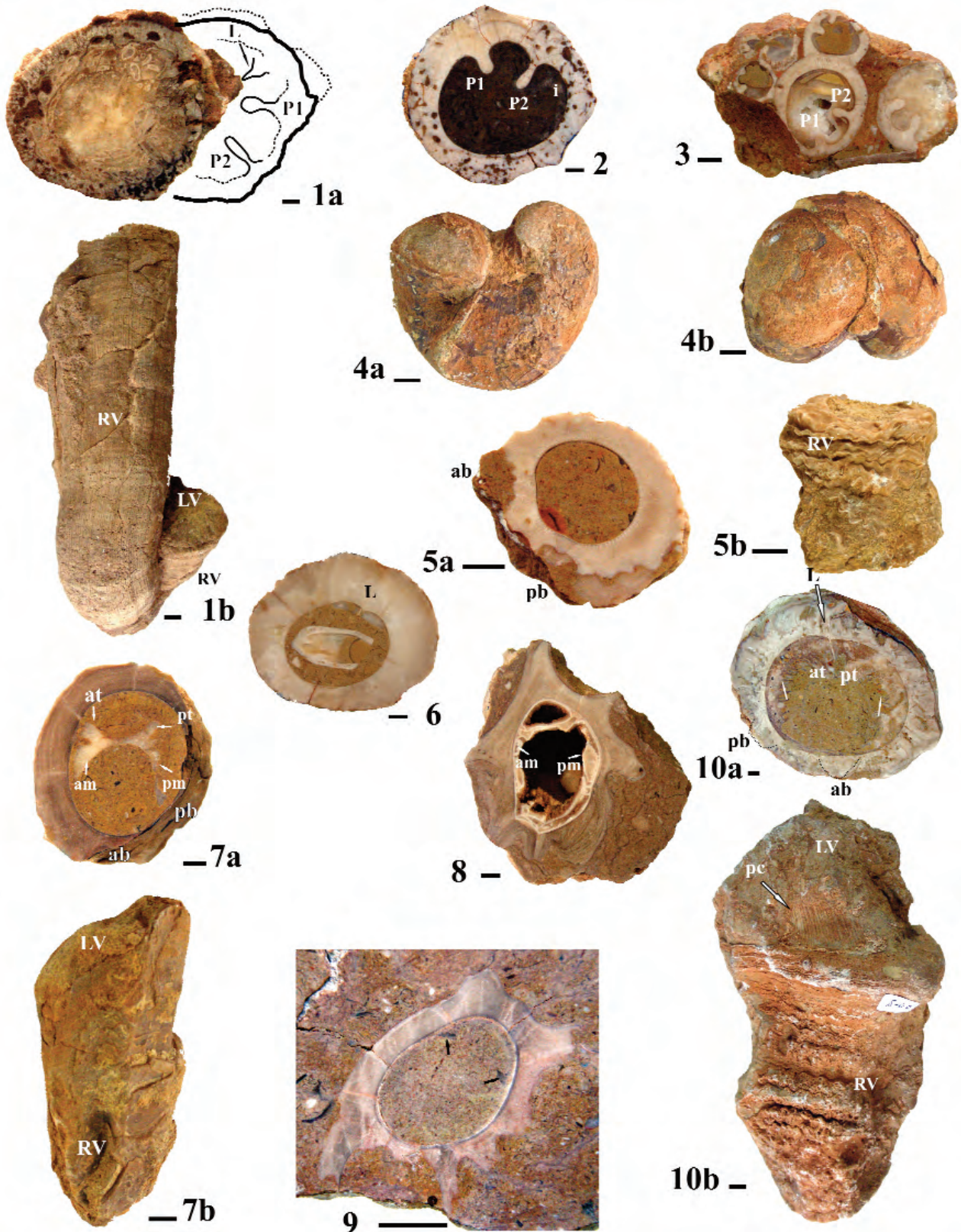


PLATE 3

(Specimens from Semirom Section)

- Figure 1.** *Dictyoptychus striatus* Douvillé, (a) side view of right valve (RV) and left valve (LV), (b) transverse section of right valve, body cavity (BC), lower valve canals (C) and tooth (ct), A4 layer.
- Figure 2.** *Dictyoptychus* aff. *paronai* (Kühn), (a) side view of right valve (RV), (b) transverse section of right valve, body cavity (BC), lower valve canals (C), A3 layer.
- Figure 3.** *Dictyoptychus* cf. *morgani* (Douvillé), Transverse section of right valve, body cavity (BC), lower valve canals (C) and tooth (ct), accessory cavity (x) and outer shell layer (ol), A3 layer.
- Figure 4.** *Lapeirousia* cf. *crateriformis* (des Moulins) (a) side view of right valve (RV) and remaining parts of left valve (LV), (b) transverse section of right valve (in adumbonal view), showing posterior (pp) and anterior (ap) pseudopillars and myophores, A3 layer.
- Figure 5.** *Praeradiolites* sp., (a) side view of right (RV) and left valve (LV) and radial bands (ab & pb), (b) transverse section of right valve (in abumbonal view) showing ligament ridge (L), posterior (pm) and anterior (am) myophores and inner shell layer (il), A3 layer.
- Figure 6.** A bouquet of Radiolitidae, A3 layer.
- Figure 7.** *Vautrinia syriaca* (Vautrin), Natural cross section of right valve showing Pseudopillars (ap & pp) and tuberculate undulation of outer layer (tu), A1 layer.
- Figure 8.** *Bournonia* cf. *excavata* (d'Orbigny): adumbonal transverse section of right valve, showing anterior myophore (am), posterior tooth (pt) and myophore (pm), radial bands (ab & pb), A4 layer
- Figure 9.** *Bournonia* cf. *garloica* Pamouktchiev: transverse section of right valve, showing anterior tooth (at) and myophore (am), posterior tooth (pt) and myophore (pm), A3 layer.

(Scale bars are equal to 1 cm except in figure 7)

