NEW EARLY TUVALIAN (CARNIAN, TRIASSIC) RADIOLARIANS FROM THE HUĞLU-PINDOS SUCCESSION IN THE SORGUN OPHIOLITIC MÉLANGE, SOUTHERN TURKEY

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ABSTRACT

Three new radiolarian genera (*Paramonocapnuchosphaera*, *Monocoronella* and *Minicrampus*) and eight new species are described herein from one of the most diverse and best preserved Carnian (Late Triassic) radiolarian faunas of the world, from the early Tuvalian sequence of the Sorgun Ophiolitic Mélange, southern Turkey. The radiolarian fauna belongs to the *Spongotortilispinus moixi* Zone (equivalent to *Paragondolella postinclinata - Paragondolella noah* conodont Zone). The very similar late Julian-early Tuvalian radiolarian faunas from the Northern Calcareous, Alps through the Lagonegro Basin, Sicily, Rhodes Island, Greece and farther east in the Antalya nappes, in the Mersin Mélange and in Elbistan, Turkey may confirm that the Pindos-type succession found in different units of early Mesozoic oceanic basins formed in a single oceanic basin.

INTRODUCTION

The Mersin Ophiolitic Complex in southern Turkey is a special area to study a very complicated tectonic mixture of an infra-ophiolitic mélange associated to South-Taurides ophiolitic belt (Fig. 1). According to a detailed study of Moix et al. (2011) on the geology of this area, the Mersin Mélange was subdivided into two bigger independent units: the Late Cretaceous Sorgun Ophiolitic Mélange (SOM) and the Middle to Late Triassic Hacialanı Mélange (Moix et al., 2011). Both mélanges consist of a chaotic accumulation of blocks and rocks in a sedimentary mixture (olistostrome) of clastics, ophiolitic material, and oceanic and exotic blocks of various ages. Slide blocks in the mélanges typically range in size from a few meters to hundreds of meters. Broken formations are represented by elongated bodies ranging in size from hundreds of meters to kilometers. Many coherent successions with kilometric lateral extent were identified within the SOM. In addition to these kilometer-sized blocks, there is a multitude of smaller blocks: carbonates ranging in age from the Early Carboniferous to the Late Triassic, radiolarites ranging from the Ladinian to the late Turonian-early Coniacian, rare blocks of amphibolites, blocks of partially serpentinized peridotites, gabbros and pillow-lavas, and blocks of debris-flows (including ophiolitic debris).

One of the most important and well developed tectonic blocks of the SOM is the Tavusçayırı block (Masset and Moix, 2004; Moix et al., 2011). This block contains several typical deep-sea sedimentary units (e.g., the Huğlu-Pindos succession), which are well-known from the Hellenides-Taurides belt. Part of the investigated sequence contains a very well-preserved and particularly diverse early Tuvalian (late Carnian, Late Triassic) radiolarian fauna, which has been already described in a series of papers by Moix et al. (2007), Kozur et al. (2007a; 2007b; 2007c; 2009), Ozsvárt et al. (2015; 2016). In this paper, we continue this taxonomic work with the description of several new Spumellaria, Entactinaria and spicular Nassellaria and discuss some implications for the geodynamic reconstruction of the Eastern Mediterranean region. The illustrated type material has been deposited in the Hungarian Natural History Museum, Budapest.

GENERAL GEOLOGY OF THE HELLENIDES-TAURIDES BELT

The deep-sea sedimentary units in the Hellenides-Taurides belt provide important clues to the geodynamic evolution of the Paleotethyan and Neotethyan domains in the Eastern Mediterranean region (Fig. 1). The most external parts of the Hellenides-Taurides system present striking similarities: in particular, the platform development of the Beydağları parautochthonous sequence in Turkey correlates well with the pre-Apulian units of the Paxos-Zanthe-Kastellórizo zone in Greece (Moix et al., 2013). In addition, the classical Pindos-type succession in Greece and the Huğlu-Pindos-type sequences in Turkey (the Köycegiz and Haticeana Dağ succession in the Lycian Nappes, part of the Antalya Nappes, the Beyşehir-Hoyran Nappes, broken formations in the Mersin Mélange, and the Köseyahya Nappe in Elbistan) show striking similarities. Both types of succession are related to the latest extensional events leading to opening of back-arc basins in the Variscan cordillera during the Late Triassic. These events are marked by widespread Middle and Late Triassic volcanism (e.g., Huğlu tuffitic succession in Turkey) and by deposition of condensed Ammonitico Rosso horizons during the Liassic, leading to the onset of passive margin development that lasted until the Late Cretaceous obduction of supra-subduction-type ophiolites (Moix et al., 2011). All above mentioned nappes represent segments of the northern Mesozoic passive margin of the Anatolian and Sitia-Pindos terranes (e.g., Huğlu-Pindos back-arc basin margins), including its flexure during the Late Cretaceous (from Cenomanian to Senonian). Similar Pindos-type units are also found in Crete and in several islands of the Dodecanese.

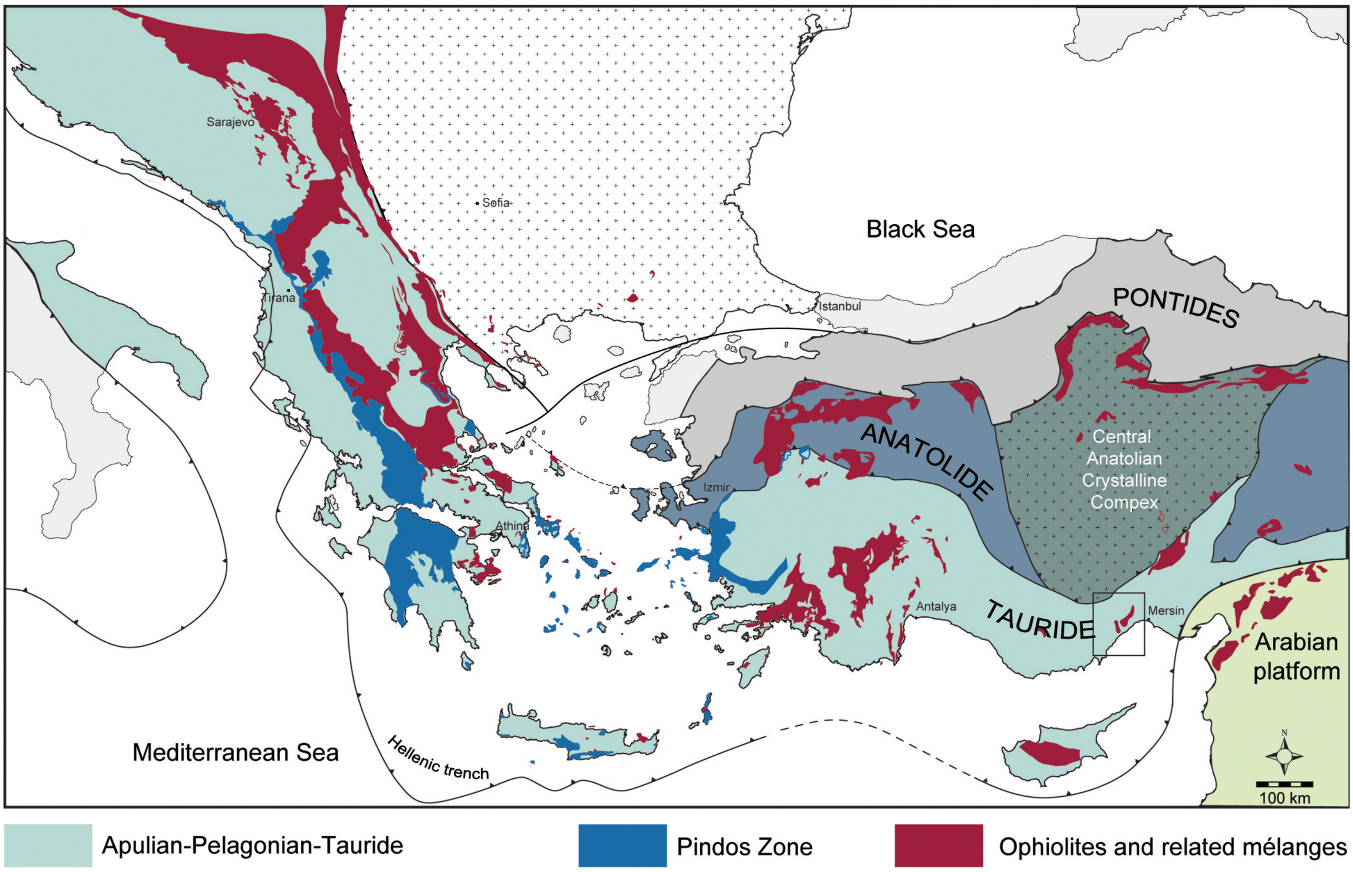

Fig. 1 - Schematic tectonic map of the Eastern Mediterranean region (after Ozsvárt et al., 2016). Rectangle shows studied area.

GEOLOGICAL SETTING OF TAVUSÇAYIRI BLOCK

The geological setting and the derivation of the Tavusçayırı block (Fig. 2a, b) in the SOM has already been described and discussed in Masset and Moix, (2004), Moix et al. (2007), Kozur et al. (2009), Moix et al. (2013) and in Ozsvárt et al. (2015). The isolated 600 meters thick Tavusçayırı block represents a typical transgressive sequence marking the break-up of a platform and the opening of a rift basin from the Late Triassic (Carnian) to Middle Jurassic (late Bajocian). Tectonically, the Late Triassic to Early Jurassic Tavusçayırı block set in a sheared Late Cretaceous clastic sedimentary matrix (Fig. 3a, d). The matrix of the SOM is composed partly by the Cenomanian to Santonian-Campanian Başpınar Formation (Pampal, 1987), which contains deep-sea radiolarites, pelagic limestones and ophiolite-derived rocks. Elsewhere, the matrix is composed of mass- and debris-flows rich in ophiolitic material, lavas and radiolarites (Moix et al., 2011). The succession starts with polymict breccias and cross-bedded conglomerates (Fig. 2a) and continues with brownish shallow-water limestones. It is unconformably overlain by pink, neritic nodular Hallstatt Limestone (Figs. 2a and 3b) yielding ammonoids (late Julian *Austrotrachyceras austriacum* Zone), foraminifera, echinoderms, crinoids, fish remains, brachiopods and conodonts of Carnian age. In the reference section (Fig. 2a), the Hallstatt Limestone is conformably overlain by 130 m of thin-bedded Huğlu-type redeposited green tuffites (Pietra Verde-like tuffs) showing flute-casts, load-casts and also Bouma sequences. The tuffitic succession is interspersed with alternating micritic limestones and calciturbidites. One micritic limestone level (Fig. 3c) contains conodonts, sponge spicules, ostracods and a well-preserved radiolarian fauna of the early Tuvalian *Spongotortilispinus moixi* Zone (Kozur et al., 2007a; 2007b; 2007c; 2009; Moix et al., 2007, Ozsvárt et al., 2015; 2016). The Late Triassic (middle to late Norian) limestones are overlain by Bathonian brownish radiolarian cherts (Fig. 2a) which correspond to the Early-Middle Jurassic radiolarites reported by Kozur (1997) in the Huğlu type area. The succession of the Tavusçayırı block corresponds to the Huğlu-type sequences described by Özgul (1976) in the Bozkır Units and by Monod (1977) in the Beyşehir-Hoyran Nappes.

RADIOLARIAN FAUNA

The age of the radiolarian fauna (sample G11) is based on the occurrence of *Paragondolella noah* (Hayashi) in sample G11 and several other conodonts recovered from the underlying Hallstatt Limestone of the section. Sample G4 (Fig. 2a) indicates Anisian age, determined by the presence of the foraminiferal species *Pilammina densa* Pantić (Moix et al., 2011). Sample G7 contains a relatively rich conodont association with *Carnepigondolella nodosa* (Hayashi) s.s. (= *Epigondolella carnica* Krystyn), *Gladigondolella tethydis* (Huckriede) and *Paragondolella noah* (Hayashi), indicating a late Julian age. Unpublished am-

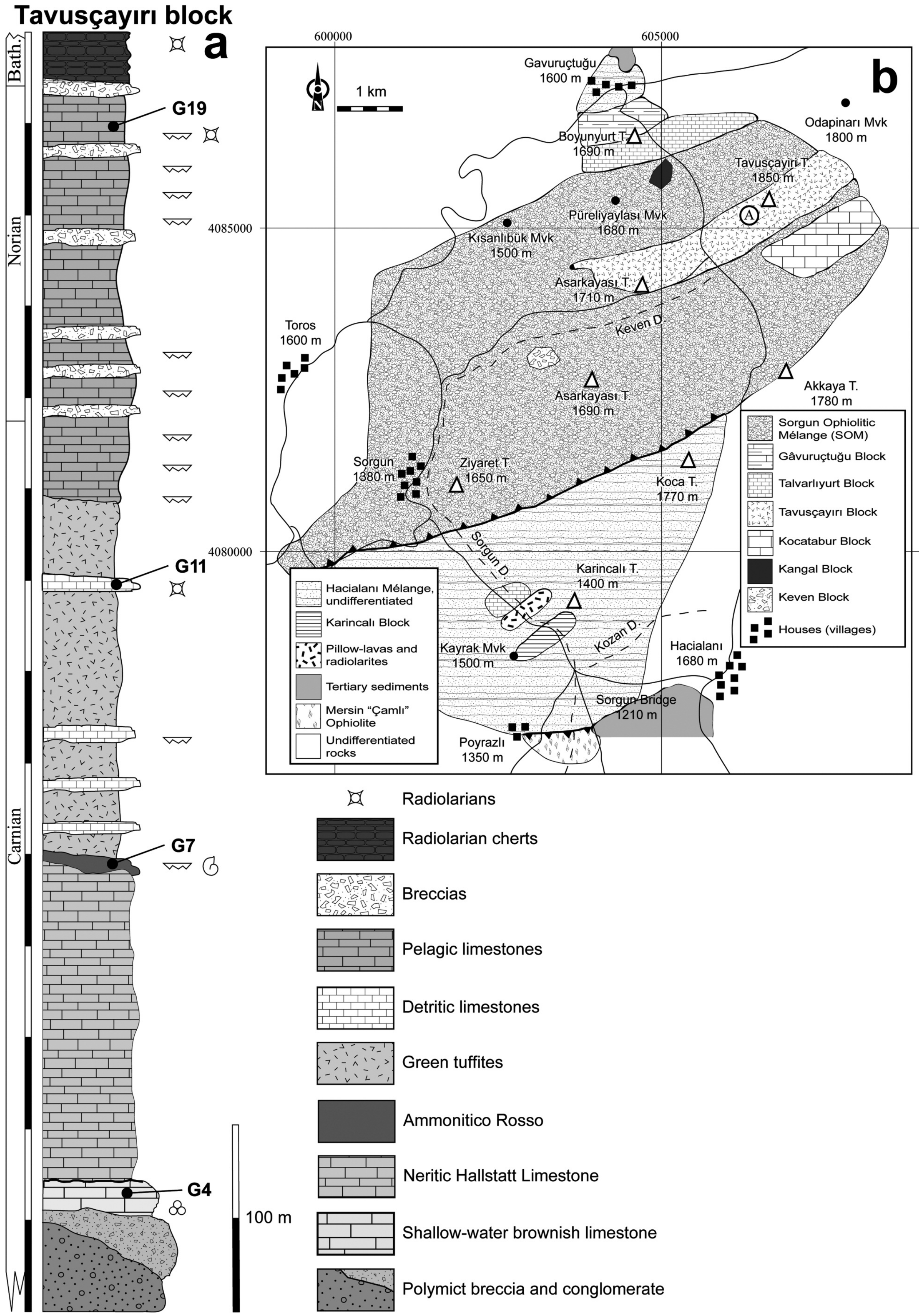

Fig. 2 - a. Lithostratigraphic log of the Tavusçayırı block. b. Schematic geological map (modified from Moix et al., 2011) of the studied area, showing the location of the Sorgun Ophiolitic Mélange. The investigated section is located at the spot A (see geological map). All the taxa described herein are from a single radiolarian-rich sample (G11) belonging to the early Tuvalian *Spongotortilispinus moixi* Radiolarian Zone (Moix et al. 2007).

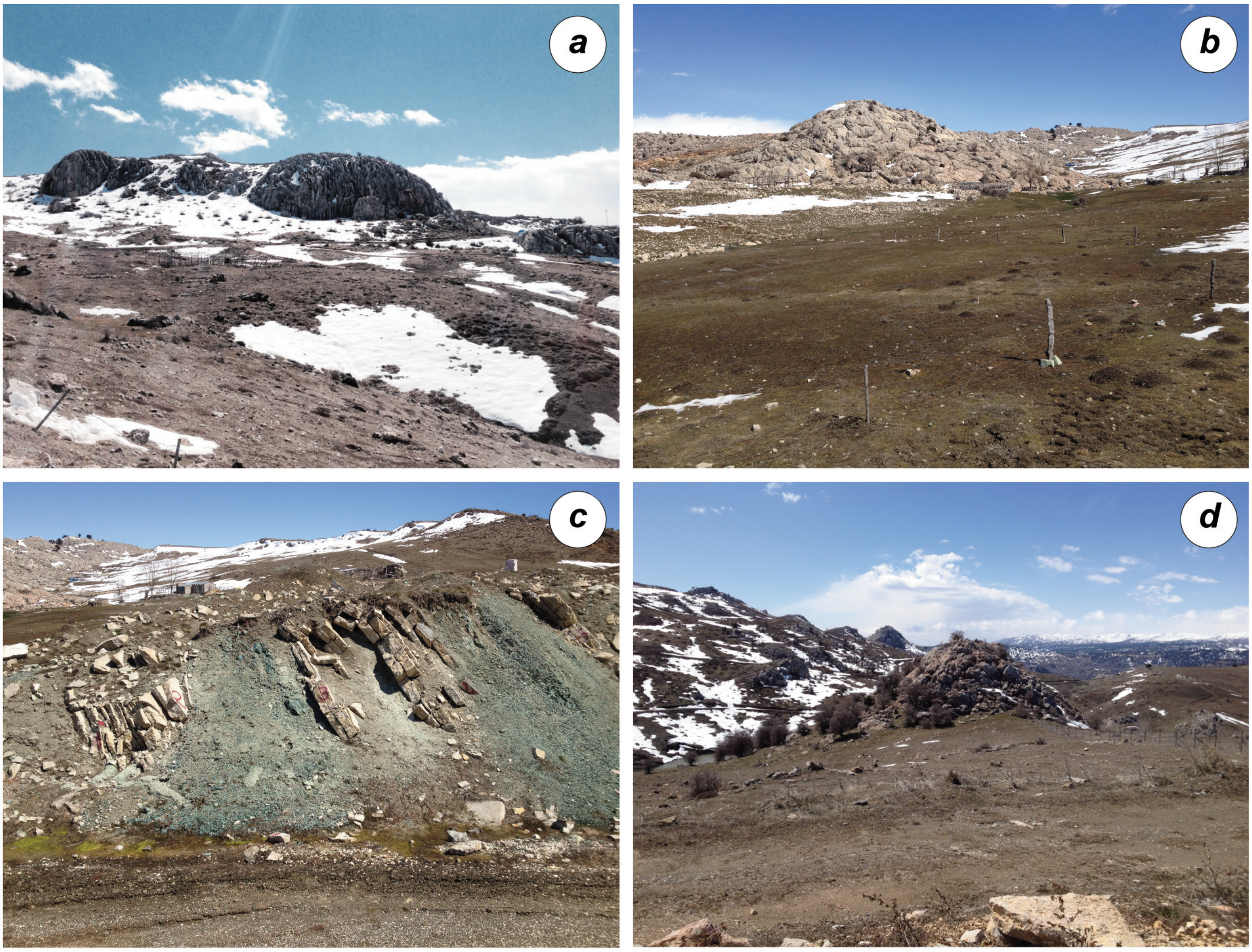

Fig. 3 - a. The detached Late Triassic to Early Jurassic Tavusçayırı block set in a Late Cretaceous sheared clastic sedimentary matrix. b. Typical, red pelagic Hallstatt Limestone, which yielded a relatively rich ammonoid fauna of the late Julian *Austrotrachyceras austriacum* Zone. c. Huğlu-type, green tuffites (Pietra Verde-like tuffs) intebedded with calciturbidites and micritic limestones. d. Typical mélange outcrops in the SOM area, near Tavusçayırı.

monite data from the underlying Hallstatt Limestone succession confirms this age (*Austrotrachyceras austriacum* ammonoid Zone, L. Krystyn, pers. comm.). Sample G 11 contains the best-preserved and most diverse radiolarian fauna of the basal Tuvalian (*Spongotortilispinus moixi* Zone) anywhere in the world (Fig. 4). An equivalent radiolarian fauna was partly described by Dumitrica et al., (2010, 2013a; 2013b) from the Zulla Formation, Hawasina Complex, Oman. Sample G19 yielded a few specimens of *Annulotriassocampe* spp. and ?*Livarella densiporata* Kozur and Mostler. According to this assemblage and to the general succession, the age is most probably middle to late Norian (Moix et al., 2011).

Similarly rich and very well-preserved but older radiolarian faunas, belonging to the Julian *Tetraporobrachia haeckeli* Zone were published from Göstling and Großreifling (Northern Calcareous Alps, Austria) by Kozur and Mostler (1972; 1978; 1979; 1981; 1994) and Lahm (1984). However, the best preserved and richest fauna of this age, from the Köseyahya Nappe in Elbistan, Turkey, has been only partly published thus far (Tekin and Bedi, 2007a; 2007b; Dumitrica et al., 2010; 2013a; 2013b; Dumitrica and Tekin, 2014). The composition of this fauna from Turkey is rather similar to that of the faunas from Göstling and Großreifling, but the radiolarians are more abundant and better preserved. These faunas represent the temporal range of the species *Tetraporobrachia haeckeli* and the family Spongosaturnaloididae Kozur and Mostler, as well as that of the genus *Heliosaturnalis* Kozur and Mostler, and the acme of the families Veghicycliidae Kozur and Mostler, (Dumitrica et al., 2010) and Multiarcusellidae Kozur and Mostler. At present it is difficult to compare in detail these faunas of the *T. haeckeli* Zone with the early Tuvalian faunas of the *Spongotortilispinus moixi* Zone, because a major part of the faunas from Elbistan and from the SOM remains still unpublished. Since in the present state of knowledge a detailed discussion on the resemblance and difference between the two faunas is premature. Therefore the focus of the present article is to continue to describe some new species and genera from the SOM (Fig. 6 and 7). For the same reason, it was probably premature to establish a special zone, the *Elbistanium gracile* Zone, by Kozur et al. (2009), for the Elbistan fauna, which had already been considered as belonging to the *T. haeckeli* Zone. A more detailed and critical discussion of this *Elbistanium gracile* Zone is found in Dumitrica et al. (2013b).

Stage	Substage	Tethyan Ammonoids (Kozur, 2003 and Balini et al., 2010)		Conodont Zones (Kozur, 2003)	Tethyan Radiolarian Zones (Kozur, 2003, Moix et al., 2007 Kozur et al., 2009)
Carnian	Tuvalian	*Anatropites spinosus*	*Gonionotites italicus*	*Carnepigondolella pseudodiebeli*	*Nakasekoellus inkensis*
			Discotropites plinii	*Carnepigondolella zoae*	
		Tropites subbullatus	*Tropites subbullatus*	*Metapolygnathus carpathicus*	
			Prohungarites crasseplicatus		
		Tropites dilleri		*Paragondolella postinclinata - Paragondolella noah*	*Spongotortilispinus moixi*
	Julian	*Austrotrachyceras austriacum*	*Neoprotrachyceras*	*Gladigondolella tethydis - Paragondolella postinclinata*	*Elbistanium gracile*
			Austrotrachyceras triadicum		
		Trachyceras aonoides			*Tetraporobrachia haeckeli*
		Trachyceras aon		*Budurovignahus diebeli - Paragondolella polygnathiformis*	*[un-named]*
					Tritortis kretaensis
		Daxatina canadensis			

Fig. 4 - Integrated ammonite after Balini et al. (2010), conodont and radiolarian zonation for the Carnian after Kozur (2003), Moix et al. (2007) and Kozur et al., (2009).

GEODYNAMIC IMPLICATIONS

Currently, two main types of models exist to describe the general geodynamic evolution of the Mesozoic Neotethys. The so-called "one-ocean thesis" or the single ocean model was first formulated by Bernoulli and Laubscher (1972) and later elaborated, by Neubauer and von Raumer (1993); Schmid et al. (2008) and Bortolotti et al. (2013). The other model proposes multiple oceanic basins and microcontinents (Şengör, 1984; Robertson and Dixon, 1984; Stampfli and Borel, 2004; Stampfli and Kozur, 2006; Moix et al, 2008; Robertson et al., 2009; 2013). Many authors suggest a relatively simple one-ocean-type model for the Alpine-Dinaric-Hellenic belt, whereas comparisons with areas farther east (i.e., Eastern Mediterranean, Middle East) suggest more complicated scenarios (e.g., Robertson et al., 2009). In fact, the Paleotethys existed between Eurasia and Gondwana in Late Paleozoic time and it was subducted northwards during Middle and Late Triassic time (Robertson and Dixon, 1984, Dercourt et al., 1986; 1993; 2000; Moix et al, 2008). The closure of the Paleotethys triggered the opening of the Neotethys by the rifting of continental fragments (Taurides, Cimmerian blocks) from the northern margin of the Gondwana. On the other hand, the northward subduction of Paleotethys beneath Eurasia opened up a series of back-arc basins (e.g., Küre) along the southern part of Eurasia (Fig. 5). The closure of the Paleotethys was completed by the collision of the Taurides to Eurasia by latest Triassic times, during the Cimmerian orogenic event, whereas a wide ocean (Neotethys) was opening in the south. The pelagic sedimentation in the back-arc subbasins began only in middle-late Anisian time, followed by sporadic basaltic volcanism later in the Ladinian. Pelagic sedimentation (Pindos-type succession, Hallstatt-type limestones, and radiolarites) associated with basaltic volcanism commenced in Oman already in the Middle-Late Permian (e.g., Maury et al. 2003). However, this volcanism is clearly linked to the Neotethyan, rather than to the Paleotethyan domain. The classical Pindos Zone (Brunn, 1956) is commonly characterized by a continuous sequence of siliceous deposits, pelagic limestones, volcaniclastics and abundant radiolarites, which accumulated from the Late Triassic through Cretaceous time. This succession ends with Paleocene-Eocene flysch sediments (e.g., Degnan and Robertson, 1998; 2006). The NW-SE trending Pindos Zone (Fig. 1) is equivalent to the Budva Zone in Montenegro, the Krasta-Cukali Zone in Albania, and stretches through continental Greece and the Peloponnese but wedges out south-eastward, although it reappears in the Aegean islands, Crete and Rhodes, as well (Fig. 1). In addition, sequences comparable to the classical ones in the Pindos domain are exposed in the Lycian nappes in south-western Turkey (Moix et al., 2013), in the Antalya domain (Brunn et al., 1976) and in the ophiolite-related Mersin Mélange of the Taurides (Moix et al., 2007; 2011). Although many authors assume the presence of oceanic lithosphere beneath the Pindos Zone (e.g., Stampfli and Borel, 2004), up to now there is no known evidence for ophiolitic basement (Schmid et al., 2008). Moreover, the so-called Pindos Ophiolite Group (Dramala Complex) of the Pindos Mountains (Jones and Robertson, 1991) in Greece, including its metamorphic sole and underlying, presumably Jurassic-age mélange formation appears to be a southern continuation of the Dinarides Ophiolite Belt-Mirdita Zone (e.g., Schmidt et al., 2008). Consequently, the "Pindos Ocean" might not be a separate small oceanic basin (Channel and Kozur, 1997), but rather part of the early Mesozoic Neotethys (Schmid et al., 2008; Ozsvárt et al., 2012; Bortolotti et al., 2013). The identification of Pindos-type succession in different units of Early Mesozoic oceanic basins, from the Budva Zone and Krasta-Cukali Zone through the external Hellenides and in Dodecanese in the Aegean Sea, and continuing eastward in the Lycian nappes and farther east in the Antalya nappes, as well as in Mersin and in Elbistan, confirms the "one-ocean thesis" for the Late Triassic (Fig. 5). This is also confirmed by the similar late Julian-early Tuvalian radiolarian faunas which appear from the Northern Calcareous Alps (Göstling, Großreifling) through the Lagonegro Basin, Sicily (Sosio Valley) and Rhodes (Aegean Sea) and farther east in the Antalya nappes, in the Mersin Mélange and in Elbistan, Turkey (Fig. 5).

SYSTEMATIC PALEONTOLOGY

Class Radiolaria Müller, 1858
Subclass Polycystina Ehrenberg 1838 emend. Riedel, 1967
Order Spumellaria Ehrenberg, 1875
Family Capnuchosphaeridae De Wever, 1979

Genus *Monocapnuchosphaera* Tekin, 1999
Type species: *Monocapnuchosphaera longispina* Tekin, 1999

Monocapnuchosphaera subtornata Tekin, 1999
Fig. 6. 1

1999 *Monocapnuchosphaera subtornata* n. sp. - Tekin, 1999. p. 78. Pl. 6. figs.1 - 5.
1999 *Monocapnuchosphaera subtornata dextra* n. ssp. - Tekin, 1999. p. 78. Pl. 6. figs.1 - 3.
1999 *Monocapnuchosphaera subtornata sinistra* n. ssp. - Tekin, 1999. p. 79. Pl. 6. figs.4 - 5.

Material: More than 5 specimens.
Remarks: The illustrated specimen differs from this early Norian species by having a little shorter tumidaspina and more additional spines. Due to these differences we did not use for this specimen the subspecies as described by Tekin (1999), because the two subspecies he described come from younger stratigraphic levels (latest Carnian/earliest Norian to early Norian). Moreover, the subspecies *Monocapnuchosphaera subtornata dextra*, as the first subspecies, should be called *M. subtornata subtornata* Tekin, because, according to ICZN, when a taxon is divided into two or more subtaxa,

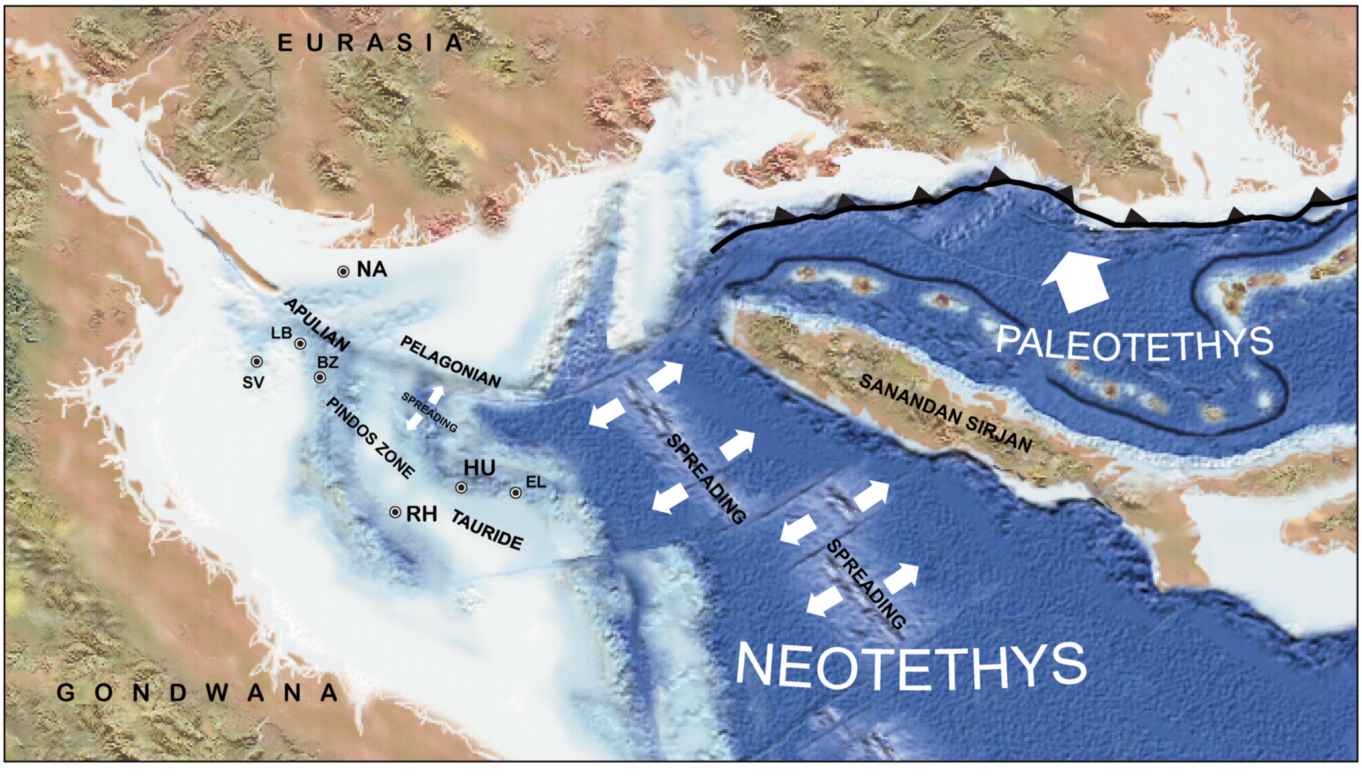

Fig. 5 - Paleogeographic reconstruction of the Western Neotethyan area for the Late Triassic, based on paleogeographic map of Blakey (https://www2.nau.edu/rcb7/paleogeographic_alps.html). NA- Northern Calcareous Alps, LB- Lagonegro Basin, SV- Sosio valley, Sicily, BZ- Budva Zone, RH- Rhodes Island, Greece, HU- Huğlu Unit including Mersin, EL Elbistan, Turkey.

one of the subtaxa receives the name of the taxon.
Range and occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey and early Norian from the Yaylakuzdere Measured section, Alakircay Nappe, Antalya Nappes, Kemer, Antalya, Turkey.

Genus *Paramonocapnuchosphaera* n. gen.
Type species: *Paramonocapnuchosphaera fusiformis* n. sp.

Diagnosis: Test latticed, ovoidal or ellipsoidal with two opposite and completely dissimilar spines. One spine, longer and robust is of tumidaspine type, with a conical tunnel and a distal tumor. The other spine is small and simple.
Remarks: This genus differs from *Monocapnuchosphaera* Tekin by having a spine opposite to the tumidaspina, which changes the shape of the cortical shell from spherical to ellipsoidal. Inner structure is unknown. At present, when it is known that tumidaspina could appear during the Late Triassic in various radiolarian groups phylogenetically unrelated, we could suppose that the presence of this opposite spine suggests that the genus does not belong to the family Capnuchosphaeridae.
Etymology: From the Latin *para* - beside, beyond, and *Monocapnuchosphaera*, allusion to the similarities of this genus with the genus *Monocapnuchosphaera* Tekin. Feminine gender.
Range and occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

Paramonocapnuchosphaera fusiformis n. gen., n. sp.
Fig. 6. 2-3.

Description: Test composed of an ellipsoidal cortical shell and two spines of significantly different size and structure. Cortical shell relatively thick with polygonal to irregular pore frames. The tumidaspina, equal with or longer than shell, is smooth and has a few pores or none at the proximal part, and becomes triradiate distally, the smaller spine is triradiate as well. Triradiate distal part of the tumidaspina slightly twisted dextrally.
Material: More than 10 specimens.
Holotype: The specimen in Fig. 6.2.
Dimensions (in µm based on 2 specimens): Diameter of test: 85-100; Length of tumidaspina: 100-110.
Etymology: In allusion to its spindle-shaped outline.
Occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

Family Gomberellidae Kozur and Mostler, 1981
Genus *Monocoronella* n. gen.
Type species: *Monocoronella spinifera* n. sp.

Diagnosis: Test completely spongy, ellipsoidal or spindle-shaped, with a bladed spine at one end and a crown of spines at the other end.
Remarks: This genus seems to be the last evolutionary member of a series of species with spongy shell that started with the late Anisian-early Ladinian *Monospongella* sp. of Lahm (described as *Monostylus* n. sp. on page 67, 1984), continued with late Ladinian (Longobardian) *Monospongella* Kozur and Mostler (2006) species and another undescribed species of the same genus in the late Julian of Turkey. Possibly there is a close relationship with the genus *Bitubopyle* Kozur and Mostler that has also a spongy ellipsoidal test but crown-like structures at both ends of shell.
Etymology: From the Latin *mono* - single and the diminutive of *corona* - crown, allusion to the crown-like structure at one end.
Occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

Monocoronella spinifera n. gen., n. sp.
Fig. 6. 4-8

Description: Test spindle-shaped in lateral view with a massive, grooved spine at one end and a crown-like structure at the other end. Shell is completely spongy, meshwork composed of irregular pore frames. Spine is robust, probably initially three-bladed but with blades divided into two or more secondary blades by secondary grooves and finally most of blades interconnected externally by transversal bars leaving between them small pores. Opposite end of shell terminates in a fringe-like or crown-like structure composed of 5-6 or possibly more blunts and multi-bladed spines interconnected to make a funnel-shaped structure. This structure is smooth or perforated by relatively large, circular pores.
Remarks: As the illustrations show, there is a variability of the thickness and shape of the spine and of the crown, depending probably on the ontogenetic stages.
Material: More than 20 specimens.
Holotype: The specimen in Fig. 6.6.
Dimensions (in µm based on 6 specimens): Diameter of test: 90-100; Length of test: 130-140; Length of spine: 50-60.
Etymology: In Latin *spiniferus, -a, -um* - bearing spines, allusion to the massive, spiny crown.
Range and occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

Genus *Tamonella* Dumitrica, Kozur and Mostler, 1980
Type species: *Tamonella multispinosa* Dumitrica, Kozur and Mostler, 1980

Tamonella multispinosa Dumitrica, Kozur and Mostler, 1980
Fig. 6. 9

1980 *Tamonella multispinosa* n. sp. - Dumitrica, Kozur and Mostler, p. 7, Pl. 10, figs. 1, 3, 8.
2007 *Tamonella multispinosa* Dumitrica, Kozur and Mostler. - Feng et al., figs. 7.8-10.

Material: More than 10 specimens.
Range and occurrence: Late Permian of South China; Illyrian of Southern Alps to early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

Tamonella aspinosa n. sp.
Fig. 6. 10, 11

Description: Shell spongy ellipsoidal with 5-7 concentrically arranged inner shells beneath the outer layer. Outermost layer consist of pentagonal to hexagonal pore frames with tiny elevated vertices. Inner layers have smooth surface with dense polygonal to circular pores and are interconnected by numerous short beams.
Material: More than 5 specimens.
Holotype: The specimen in Fig. 6.10.
Dimensions (in µm based on 4 specimens): Diameter of test: 90-100; Length of test: 160-170.
Remarks: *Tamonella aspinosa* n. sp. differs from *Tamonella multispinosa* Dumitrica, Kozur and Mostler, 1980 and *T.*

rarispinosa Kozur and Mostler, 1994 by the absence of the spines.
Etymology: In allusion to the absence of spines.
Occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

Order Entactinaria Kozur and Mostler, 1982
Family Eptingiidae Dumitrica 1978 emend. Dumitrica et al., 2010
Genus *Coronatubopyle* Kozur and Mostler, 2006
Type species: *Coronatubopyle coronata* Kozur and Mostler, 2006

Coronatubopyle denticulata Dumitrica and Tekin, 2010
in Dumitrica et al., 2010
Fig. 6. 12 - 14

2010 *Coronatubopyle denticulata* n. sp. - Dumitrica and Tekin in Dumitrica et al., 2010, p. 272, figs. 11g-i.

Material: More than 10 specimens.
Remarks: Lateral spines of several specimens from the Sorgun Ophiolitic Mélange terminate in a pointed spindle-shaped spine.
Range and occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey, Zulla Formation, Wadi Bani Khalid, and Haliw Formation, Hamadiyin, Oman.

Coronatubopyle omanensis Dumitrica and Tekin, 2010
in Dumitrica et al., 2010
Fig. 6. 15 - 17

2010 *Coronatubopyle omanensis* n. sp. - Dumitrica and Tekin in Dumitrica et al., 2010, p. 272, Figs. 11j-l.

Material: More than 5 specimens.
Remarks: Some specimens from the SOM differ from those from Oman in only having the lateral spines terminated in a relatively short needle like spine (Fig. 6.15).
Occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey; Zulla Formation, Wadi Bani Khalid, and Haliw Formation, Hamadiyin, Oman.

Genus *Minicrampus* n. gen.
Type species: *Minicrampus longispinosus* n. sp.

Diagnosis: Test globular to subtriangular in lateral view, asymmetric, with 3 massive conical spines at corners and one perforated tube adjacent to one spine. Cortical shell latticed with small nodes interconnected by bars in all directions. Inner shell or structure is unknown.
Remarks: Although we do not know yet the internal skeletal structure, the external morphology suggests that this genus should be an eptingiid. The presence of the perforated tube allows us to compare it with the genera *Pylostephanidium* Dumitrica and *Coronatubopyle* Kozur and Mostler. *Pylostephanidium* Dumitrica has also a massive and long apical spine, but its lateral spines are always three-bladed with nodes on blades (Dumitrica et al., 2010). By contrast, the species of the genus *Coronatubopyle* Kozur and Mostler, which represents, in fact, a group of species very close to *Pylostephanidium,* have similar smooth or tubular lateral spines, but their apical spine never breaks through the cortical shell.
Etymology: In allusion to its similarity to a head of a devil (*crampus* in Latin) and *mini* = small, very small.
Range and occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey, so far as known.

Minicrampus longispinosus n. gen., n. sp.
Fig. 7. 1, 2

Description: Test is composed of a subglobular and very asymmetric shell, with conical or spindle shaped spines at corners. Apical spine very long, rod-shaped, distally pointed inserted in the wall of the apical tube. Apical tube wide, relatively short, with ragged distal end and bordered by spines. Its wall has approximately the same type of structure as the cortical shell, but less regular. Lateral spines long, spindle-shaped and quite asymmetrically disposed; one is practically coaxial with the apical spine and the other one makes different angles with the apical and the other lateral spine. Cortical shell single-layered, with nodular surface, nodes interconnected by crests forming a completely irregular network. Pores are relatively small and irregularly disposed.
Material: More than 5 specimens.
Holotype: The specimen in Fig. 7. 1.
Dimensions (in µm based on 2 specimens): Diameter of test: 90-100; Length of apical spine: 130-150; Length of lateral spines: 100-150.
Etymology: In allusion to its long apical spine
Range and occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

Order ?Entactinaria Kozur and Mostler, 1982
Remarks: The uncertain classification of the following genera is due to the hidden internal structure.

Family ?Hindeosphaeridae Kozur and Mostler, 1981
Genus Spinostylosphaera Ozsvárt, Moix and Kozur, 2015
Type species: *Spinostylosphaera andrasi* Ozsvárt, Moix and Kozur, 2015
Emended diagnosis: Spherical to ellipsoidal test with single-layered and latticed cortical shell. An external spongy layer may be present. Inner structure is hidden, unknown. Test bears two short and broad tricarinate polar spines. The blades extend laterally into a verticil of large and flat triangular spinules. Between shell and distal ends of these triangular spinules, the blades are longitudinally divided into two secondary blades by a longitudinal groove. In older species, portion of spines between central test and triangular spinules forms a latticed cylindrical neck and these extensions are part of tumidaspinae. In younger species the neck of tumidaspinae is reduced, its remains forming 3 large pores at the base of spines. In some species the tricarinate polar spines are straight or slightly twisted and they might bear straight or slightly curved secondary spines (verticil of spinules). 2-6 shorter spines are also around the equatorial plane.
Remarks: Morphologically these specimens seem to belong to the genus *Spinostylosphaera* Ozsvárt, Moix and Kozur, 2015, but because the inner structure is unknown, we uncertainly assign them to the family Hindeospaeridae Kozur and Mostler, 1981.
Occurrence: Middle Triassic (?) of the Southern Alps to Late Triassic (Julian to lower Tuvalian) of Northern Calcareous Alps and the Sorgun Ophiolitic Mélange, Turkey (*Spongotortilispinus moixi* Zone).

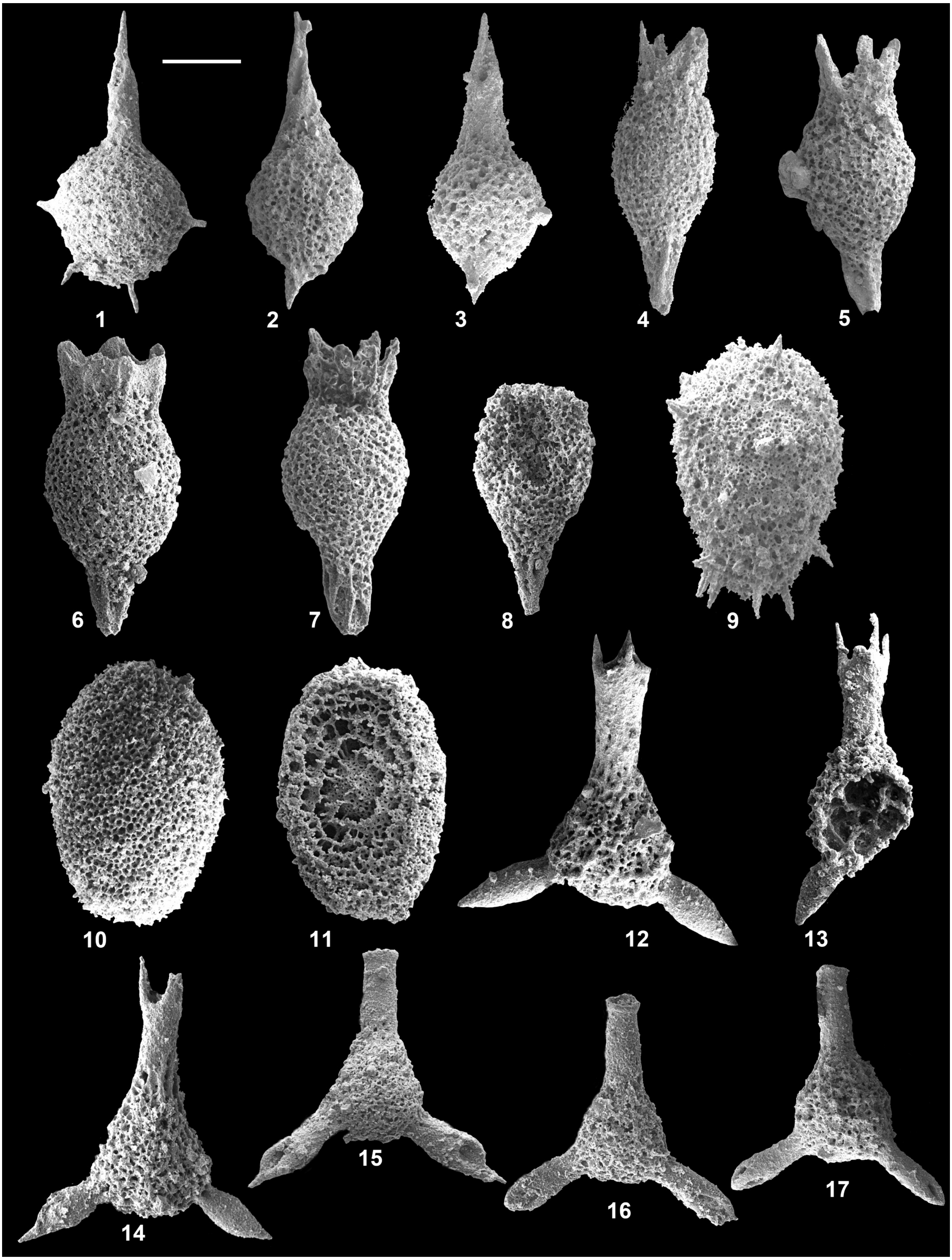

Fig. 6 - 1 - *Monocapnuchosphaera subtornata* Tekin. 2-3 - *Paramonocapnuchosphaera fusiformis* n. gen., n. sp.; 2- holotype. 3- paratype. 4-8 - *Monocoronella spinifera* n. gen., n. sp.; 6- holotype, 4-5 and 7-8- paratypes. 9 - *Tamonella multispinosa* Dumitrica, Kozur and Mostler. 10-11 - *Tamonella aspinosa* n. sp.; 10- holotype, 11- paratype. 12-14 - *Coronatubopyle denticulata* Dumitrica and Tekin. 15-17 - *Coronatubopyle omanensis* Dumitrica and Tekin. Scale bar = 100 µm.

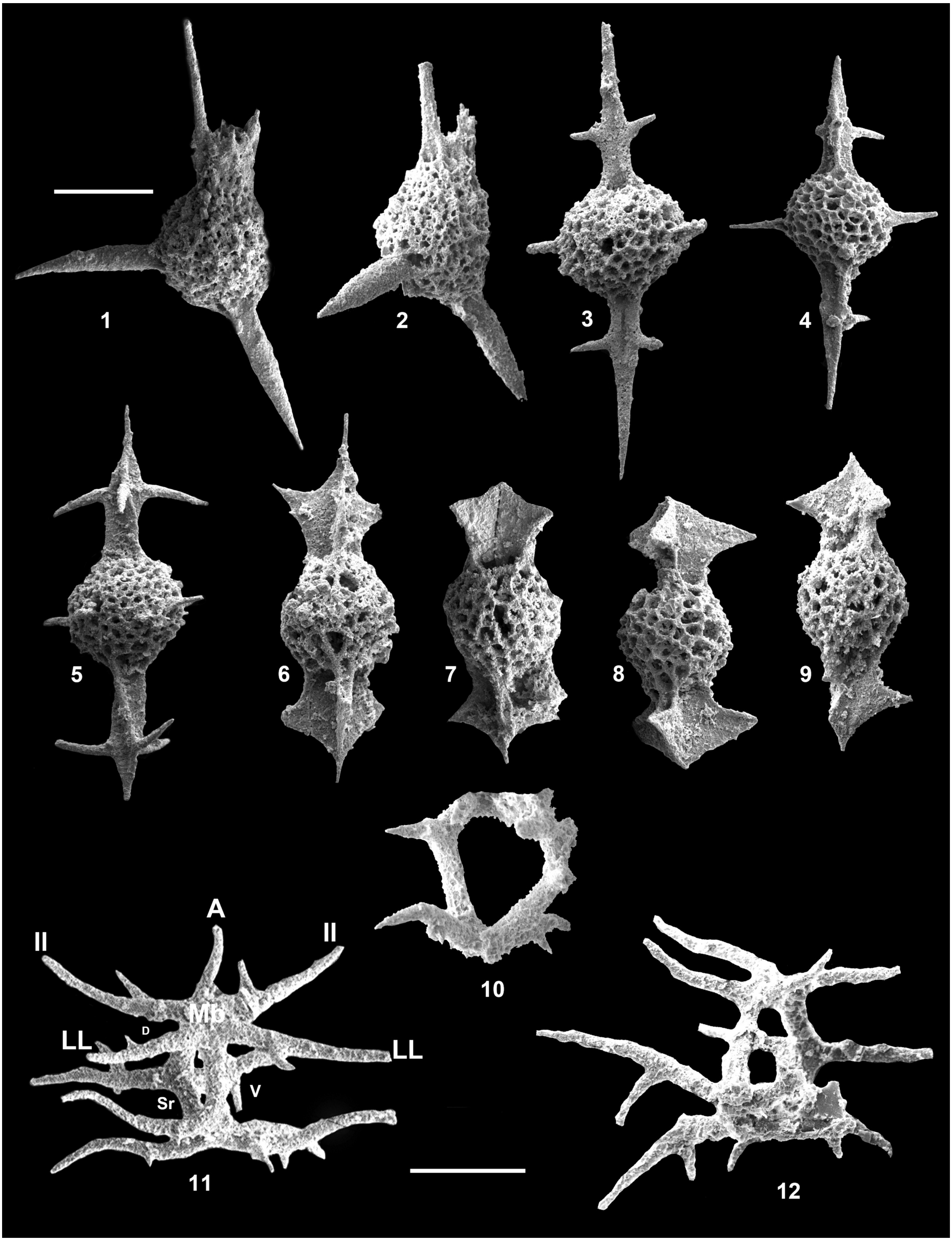

Fig. 7 - 1-2 - *Minicrampus longispinosus* n. gen., n. sp.; 1- holotype, 2- paratype. 3-4 - *Spinostylosphaera masseti* n. gen., n. sp.; 3- paratype, 4- holotype. 5 - *Spinostylosphaera sengoeri* n. gen., n. sp., holotype. 6-9 - *Spinostylosphaera michelae* n. gen., n. sp. 6- holotype, 7-9- paratypes. 10-12 - *Archaeosemantis multispinosa* n. sp.; 10, 12- paratypes, 11- holotype. Mb- median bar, A- apical spine, D- dorsal spine, V- ventral spine, LL- primary lateral spine, II- secondary lateral spine, Sr- sagittal ring. Scale bar 100 µm - figs. 1-9. Scale bar (lower) 50 µm - figs. 10-12.

Spinostylosphaera masseti n. sp.
Fig. 7. 3, 4

Description: Cortical shell spherical with usually pentagonally to hexagonally framed pores of different size and arrangement; pores with very small pointed by-spines at the vertices. Polar spines equal, tricarinate, massive, straight or slightly twisted bearing a verticil of three spinules; spinules pointed, straight or weakly curved; they are located at a distance from cortical shell practically equal with the radius of shell. Polar spines long to very long, proximally tricarinate, distally pointed. Equatorial area with two pointed, tricarinate and smaller spines (length = 50-60 μm). At base of polar spines there are three large circular pores on the shell.
Material: More than 10 specimens.
Holotype: The specimen in Fig. 7. 4.
Dimensions (in μm based on 2 specimens): Diameter of test: 100-110; Length of polar spines: 150-160.
Remarks: Although the length of the polar spines is variable, the distance of the verticils from the cortical shell remains the same.
Etymology: In honor of Dr. Olivier Masset, for his outstanding work on the Mersin Mélanges.
Range and occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

Spinostylosphaera sengoeri n. sp.
Fig. 7. 5

Description: Cortical shell spherical with small pentagonal to mostly polygonal pores. Equatorial spines very short (length 20-30 μm), pointed. Polar spines equal, tricarinate, massive, slightly twisted sinistrally and bearing a verticil of three pointed spinules (length 50-70 μm). Spinules slightly curved inwardly and located at a distance from cortical shell slightly longer than the radius of shell. Distal portion of polar spines pyramidal, three-bladed, short, with a relatively long axial needle-shaped spine.
Material: More than 5 specimens.
Holotype: The specimen in Fig. 7. 5.
Dimensions (in μm based on 2 specimens): Diameter of test: 100-110; Length of polar spines: 100-120.
Remarks: *Spinostylosphaera sengoeri* n. sp. differs essentially from *S. masseti* n. sp. by having twisted polar spines and spinules of verticils inwardly directed and situated at a longer distance from the cortical shell.
Etymology: In honor of Dr. A. M. C. Şengör, Istanbul, for his outstanding work on the geology of Turkey.
Range and occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

Spinostylosphaera michelae n. sp.
Fig. 7. 6-9

Description: Cortical shell ellipsoidal and latticed with large pentagonal, hexagonal and dominantly polygonal; elevated pore frames. Polar spines short tricarinate, with a large pore on each interval between blades at the contact with the cortical shell. Triangular extensions of blades of spines directed laterally or slightly upwards, sometimes prolonged in a spine. Distal end of the axis of spines may also be prolonged into a spine. Blades of spines always divided into 2 secondary blades by a longitudinal groove on the portion between cortical shell and vertex of triangular extensions.
Material: More than 10 specimens.
Holotype: The specimen in Fig. 7. 6.
Dimensions (in μm based on 4 specimens): Diameter of test: 50-70; Length of polar spines: 60-80.
Remarks: *Spinostylosphaera michelae* n. sp. differs all other species of the genus *Spinostylosphaera* by large, triangular blades of spines and a large pore on each interval between blades at the contact with the cortical shell.
Etymology: In honor of Dr. Michela Canevascini, Lausanne, for her outstanding work on suicide prevention and mental health.
Occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

Order Nassellaria Ehrenberg, 1875
Family Archaeosemantidae Kozur and Mostler, 1981 emend. Dumitrica in De Wever et al., 2001

Genus *Archaeosemantis* Dumitrica, 1978
Type species: *Archaeosemantis pterostephanus* Dumitrica 1978

Archaeosemantis multispinosa n. sp.
Fig. 7. 10-12

Description: Skeleton consisting of a D-shaped or rounded triangular sagittal ring (Sr) from which radiate in lateral direction secondary lateral curved or undulating spines. Spines simple or with short spinules. Median bar (Mb) short and straight, hardly visible, with two pairs of long, same sized (100-120 μm) and pointed primary (LL) and secondary lateral (ll) spines. Bars of sagittal ring corresponding to apical (A) and ventral (V) spines dissimilar and straight, the only part of ring that is curved corresponding to the arch between them. A dorsal (D) spine may be also present, which is the only spine in sagittal plane. Spines free, not interconnected or branched.
Material: More than 10 specimens.
Holotype: The specimen in Fig. 7. 11.
Dimensions (in μm based on 2 specimens): Length of apical spine: 40-50; Length of lateral spines: 100-120.
Remarks: *Archaeosemantis multispinosa* n. sp. differs from all the other *Archaeosemantis* species by having long, needle-like lateral spines arising from the sagittal ring.
Etymology: In allusion to its numerous spines and spinules.
Range and occurrence: Early Tuvalian (*Spongotortilispinus moixi* Zone) of the Sorgun Ophiolitic Mélange, Turkey.

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