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Article

New Carnian (Upper Triassic) radiolarians from the Sorgun Ophiolitic Mélange, southern Turkey

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With 6 figures

Abstract: The lower Tuvalian sequence of the Sorgun Ophiolitic Mélange (S Turkey) harbors one of the most diverse and best preserved Late Triassic (Carnian) radiolarian faunas of the world. Here we describe a new genus (*Spinostylosphaera* n. gen.) and 7 new species from the Tavusçayırı block north of Erdemili. The fauna belongs to the *Spongotortilispinus moixi* radiolarian Zone (*Paragondolella postinclinata – Paragondolella noah* conodont zone).

Key words: Radiolaria, Spumellaria, Entactinaria, Carnian, Early Tuvalian, Sorgun Ophiolitic Mélange, Southern Turkey.

1. Introduction

The Tavusçayırı Block sensu Masset & Moix (2004) is one of the most important and well developed tectonic blocks belonging to the Sorgun Ophiolitic Mélange, southern Turkey (Moix et al. 2011). This tectonic block is comparable to the Huğlu unit described elsewhere in the Taurides. Part of the investigated sequence contains a very well-preserved and particularly diverse lower Tuvalian (Carnian, Triassic) radiolarian fauna, which was already discovered in 2002 by Masset & Moix. Several lower Tuvalian radiolarians were reported in the MSc thesis of Masset & Moix (2004), and more than 2000 SEM pictures were taken by Kozur in 2003 and 2004. In 2007, Heinz W. Kozur, in collaboration with Péter Ozsvárt and Patrice Moix began to study this assemblage in more detail. Consequently, Moix et al. (2007) established the lower Tuvalian *Spongotortilispinus moixi* radiolarian zone and described a few of the radiolarian species from this zone. Numerous additional radiolarian taxa were subsequently described from the type locality of the *S. moixi* zone by Kozur et al. (2007a, b, c, 2009). Thus far, 3 new families, 10 new genera, and 106 new species and subspecies were described. Unfortunately, on the 20th of December 2014, Heinz W. Kozur passed away. Shortly before, he managed to handover the complete lower Tuvalian radiolaria material to Péter Ozsvárt including digital and printed SEM pictures. In this paper, we intend to continue his work and we would like to dedicate this paper to the memory of Heinz W. Kozur. The illustrated type material has been deposited in the Hungarian Natural History Museum, Budapest.

2. Geological setting

The Mersin Mélanges are situated in southern Turkey and belong to the South-Taurides Exotic Units defined by Moix et al. (2008). Moix et al. (2011) introduced the concept of Mersin Mélanges to describe two major independent units identified in the Mersin Ophiolitic Complex, i.e. the Late Cretaceous Sorgun Ophiolitic Mélange (SOM) and the Middle to Upper Triassic Hacialanı Mélange (Figs. 1-2). Both mélanges consist

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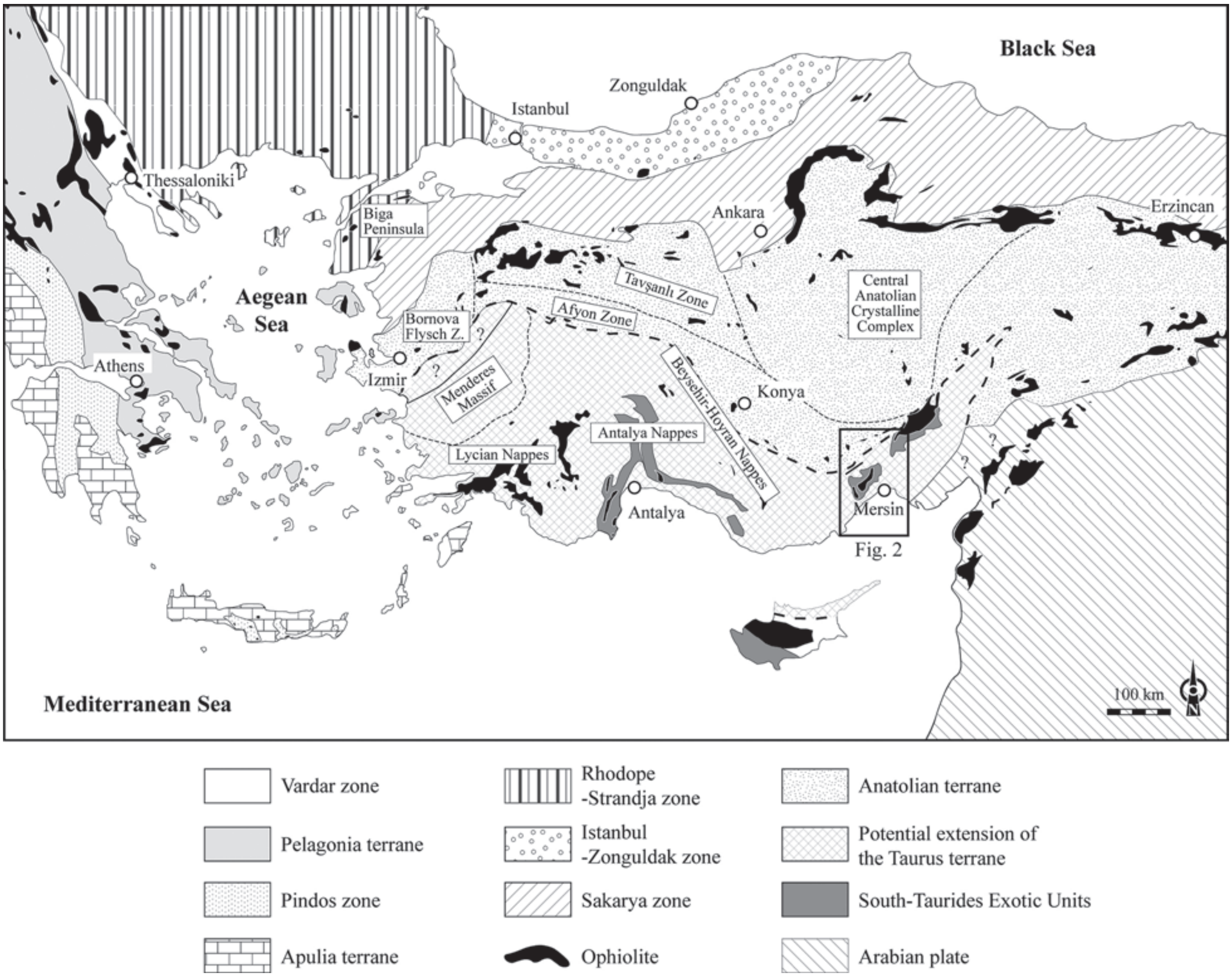

Fig. 1. Tectonic map of Turkey and surrounding region. Modified from Moix et al. (2008). Location of Fig. 2.

of a chaotic accumulation of blocks and rocks in a tectonic and sedimentary mixture (olistostrome) of clastics, ophiolitic material, and oceanic and exotic blocks of various ages. Blocks in the mélanges typically range in size from meters to hundreds of meters. Individual formations are represented by elongated bodies ranging in size from hundreds of meters to kilometers.

The Sorgun Ophiolitic Mélange is part of the infra-ophiolitic mélanges associated to the Mersin Ophiolitic Complex (Parlak 1996) and was emplaced on the Bolkardağ during the Late Cretaceous (Campanian-Maastrichtian). The Mersin ophiolite formed in a supra-subduction zone tectonic setting during the Late Cretaceous (Parlak & Delaloye 1996). Many coherent series were identified within the Sorgun Ophiolitic Mélange. One of them is represented by the Tavusçayırı block which is presented in detail below. In addition to these km-sized blocks, there is a multitude of smaller blocks: carbonates ranging from Early Carboniferous to Late Triassic; radiolarites ranging from Ladinian to late Turonian–early Coniacian; rare blocks of amphibolites; blocks of partially serpentinous peridotites, gabbros and pillow-lavas, and blocks of debris-flows (including ophiolitic debris).

3. Stratigraphy

The section investigated (Tavusçayırı block) is situated north of Erdemli (Mersin, southern Turkey) and is bounded by the villages of Gâvuruçtuĝu to the north and Sorgun to the south (Fig. 3). The Tavusçayırı block

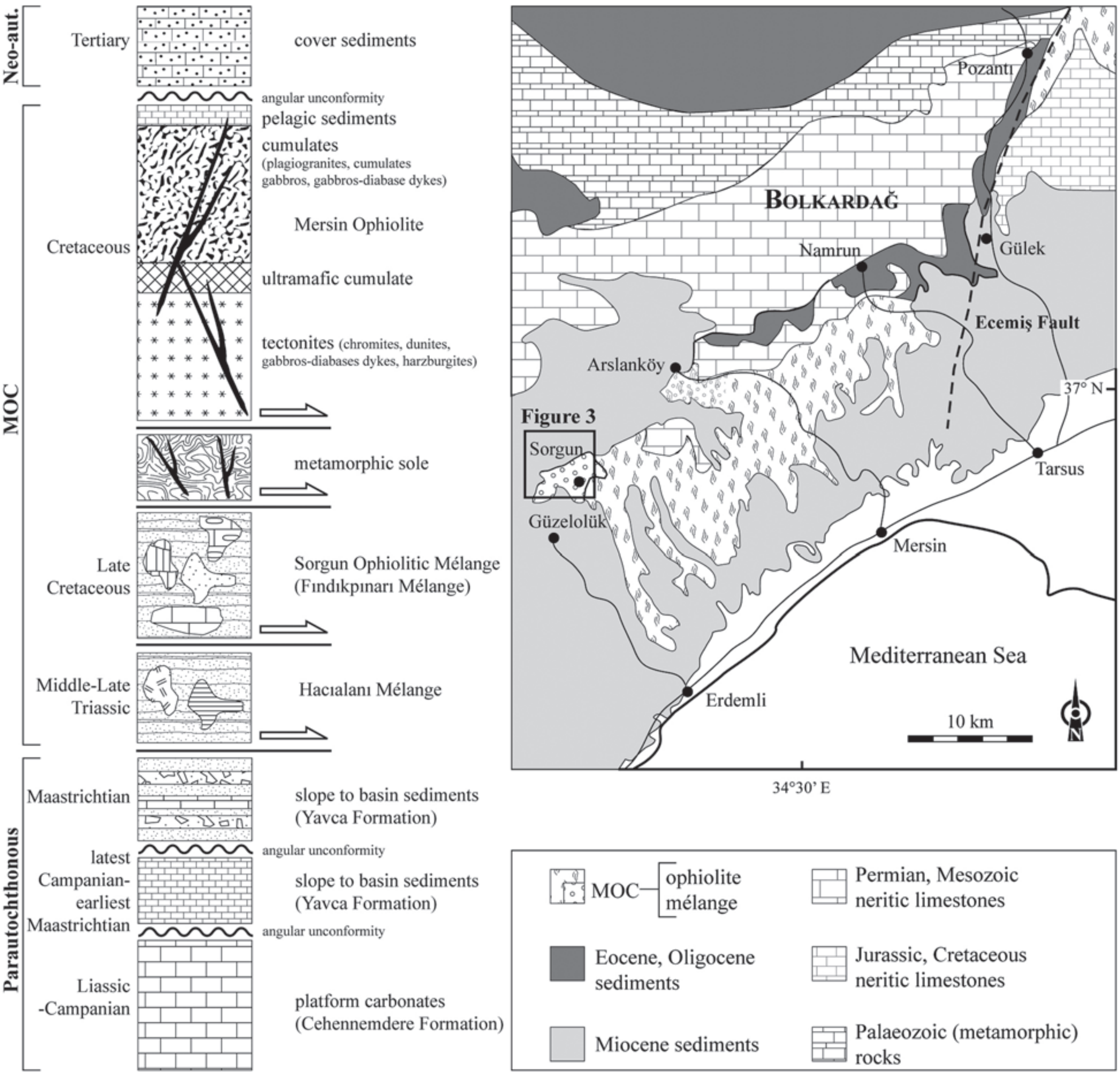

Fig. 2. Composite section and simplified geological map of the Mersin Ophiolitic Complex (MOC). Modified from Moix et al. (2011). Location of Fig. 3.

(Fig. 4) is an isolated 600-m-thick formation. Its lateral extent is large (km-scale), and its lithological components are sometimes reproduced on a smaller scale elsewhere in the SOM. This succession represents a typical transgressive sequence marking the break-up of a platform and the opening of a rift basin during the Late Triassic. The sequence starts with 15 to 20 m polymictic breccia in a red micritic matrix. The elements are heterogeneous in size, varying from mm- to m-size, and are mostly composed of white neritic limestones, pink micritic limestones and red calcarenites. Some elements yielded Middle Triassic pelagic faunas. Above an erosional contact, the breccia is followed by a 60 m polygenic clast-supported conglomerate with a red silty matrix. The conglomerate shows cross-bedding and is composed of cm- to dm-size elements, such as black and white, partly reefal limestone, beige and red micritic limestones, and sandstones.

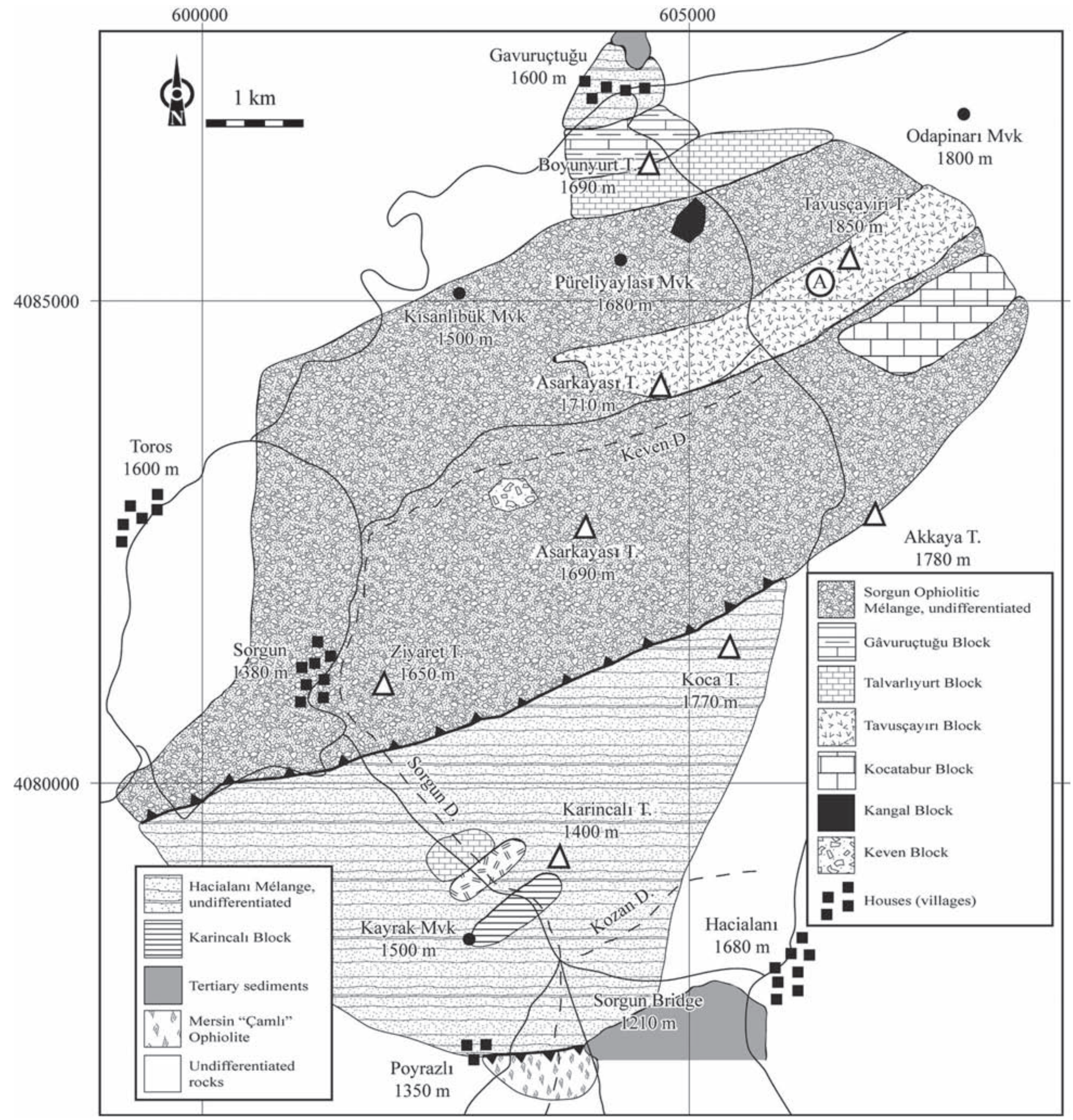

Fig. 3. Schematic geological map of the studied area, showing the location of the Sorgun and Hacialanı mélanges, and the main blocks. Modified from Moix et al. (2011).

This conglomerate is interpreted to be the product of the dismantling of a platform. It is followed by 15 m of black Middle Triassic (Anisian?) calciturbidites, reworked foraminifers, corals (Permian?), algae and megalodontid-type bivalves. The series continues with a brownish medium-bedded Upper Triassic (Carnian?) wackestone containing echinoderms, ostracods and foraminifera typical for reef environments which could be compared to assemblages described from Cyprus by Martini et al. (2009). The platform ends with an irregular surface made of reef limestone showing synsedimentary faulting.

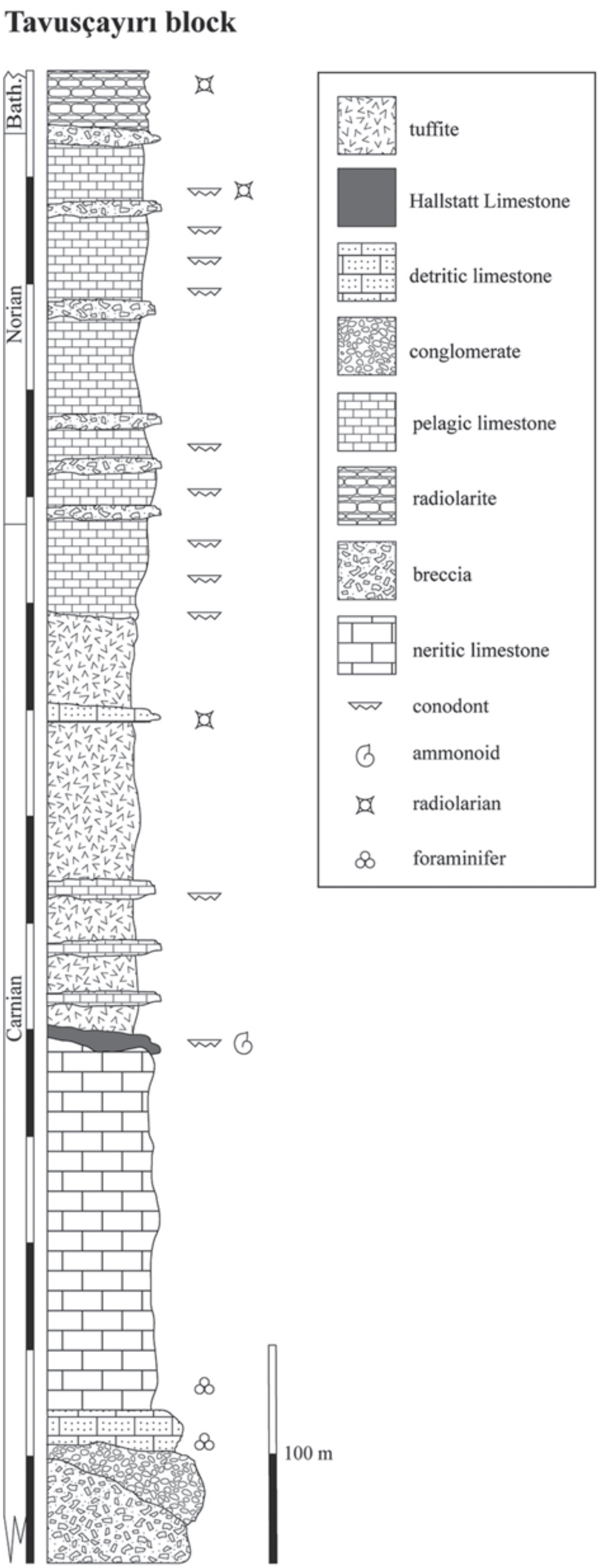

Fig. 4. Synthetic lithostratigraphic section of the Tavusçayırı block in the Sorgun Ophiolitic Mélange. Adapted from Moix et al. (2011).

The palaeo-surface is covered by discontinuous pink micritic nodular limestones in Hallstatt Limestone facies which yielded ammonoids (*Austrotrachyceras austriacum* Zone), foraminifera, echinoderms, crinoids, fish remains, brachiopods and conodonts of middle Carnian age. Near Tavusçayırı Tepe in the SOM, these levels were erroneously assigned to the Early Jurassic by Parlak & Robertson (2004).

On the reference section, the Hallstatt Limestone is conformably overlain by 130 m of thin bedded Huğlu-type re-deposited green tuffites showing flute-casts, load-casts and also Bouma sequences. The geochemical signature is of arc-type (VAB), suggesting a possible derivation from an eroding arc. The thickness of these deposits varies from section to section, and they may be associated with highly altered brownish lavas and tuffs separated by numerous faults. The tuffites may have acted as a preferential level for interslicing or thrusting. The tuffitic series is interspersed with alternations of micritic limestone and calciturbidites. One micritic limestone level (Sample G11) contains conodonts, sponge spicules, ostracods and a well-preserved radiolarian fauna of the early Tuvalian *Spongotortilispinus moixi* Zone (Kozur et al. 2007a, b, c, 2009; Moix et al. 2007b).

The tuffitic episode is followed by 300 m of pelagic limestone, calciturbidites, bioclastic limestone and debris-flows. The pelagic limestone sedimentation usually started during the upper Carnian, continues during the Norian and most probably ended during the early Rhaetian (?). The early Rhaetian (?) limestone is overlain by a breccia, followed by late Bajocian brownish radiolarian cherts.

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. All the taxa described in the next section are from a single radiolarian-rich sample (G11) belonging to the lower Tuvalian *Spongotortilispinus moixi* radiolarian zone (Moix et al. 2007).

4. The radiolarian fauna

Sample G11 contained new material of the genus *Triassobullasphaera*. Due to the excellent preservation, all specimens present have a relatively large, circular opening surrounded by a small tubular extension (pylome?). This opening may represent a relevant structure of the skeleton for the axoflagellum shaping

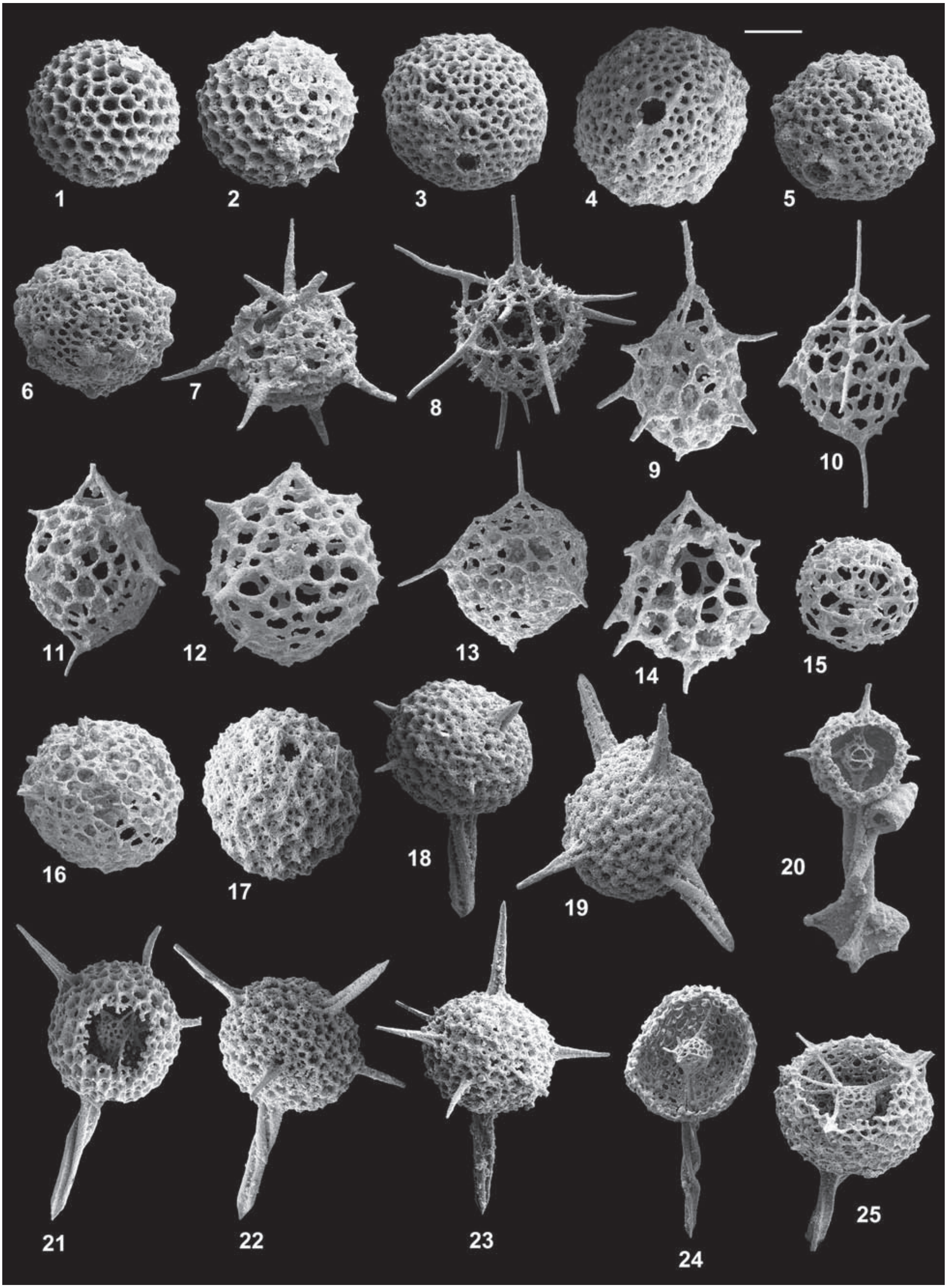

Fig. 5.

the general skeletal morphology. Kozur & Mostler (2006) assumed that *Triassobullasphaera* might belong to the collodarians, and that they appeared in the fossil record much earlier than previously thought (Tertiary). Recent collodarians are the only colonial lifestyle radiolarians. This group wears distinct globular latticed shells with relatively large pores surrounded by tubular extensions or spines (De Wever et al. 2001). This group is particularly important in the fossil record because its large biomass and bioproductivity may have effected organic carbon production in ancient oceans (Ishitani et al. 2012).

The oldest known unequivocal collodarian organisms appeared in the fossil record around the Middle Eocene. Kozur & Mostler (2006) documented a new putative collodarian species (*Triassobullasphaera hemisphaerica* Kozur & Mostler, 2006) from the well preserved and diverse Longobardian (Ladinian, Middle Triassic) radiolarian fauna from the Varoški Creek, Fojnica (Bosnia and Herzegovina). This uncertain classification is based on the incomplete opening of the test. They assumed that this opening was filled, but it cannot be clearly seen on the illustrated pictures. More recently, this genus was classified as a member of the family *Xiphostylidae* Haeckel, 1881 (Spumellaria) by O'Dogherty et al. (2009).

Additional important species from sample G11 are represented by *Parentactinia pugnax* Dumitrica and *Pentactinorbis pessagnoi* Kozur & Mostler, because these species were only known from the Anisian (Illyrian). Originally, these species were reported from the "Buchenstein-Schichten" of the Vicentinian Alps and from Felsőörs, Balaton Highland (Hungary). However, many comprehensive studies have been published from Anisian, Ladinian and lower Carnian around the world, and these "Lazarus taxa" disappeared from the palaeontological record until the lower Tuvalian. They appeared again in the lower Tuvalian *a*ssemblage from sample G11. Consequently, their range can be updated and now expands from the lower Illyrian (*Tetraspinocyrtis laevis* Radiolaria Zone) to the lower Tuvalian (*Spongotortilispinus moixi* Radiolaria Zone).

An additional important and interesting palaeontological element among the radiolarians from sample G11 is the *Hindeosphaeridae* group. Indeed, the secondary spines appear on the polar spines at the same time and are present in two different taxa (e.g., *Spinostylosphaera* n. gen., *Spinoparasepsagon* n. gen.). It is the first time that this feature is recorded in this group. The presence of secondary spines could be related to environmental stress (e.g. salinity or other chemical parameters or palaeoclimatic changes such as the Middle Carnian wet intermezzo) or to genetic modifications.

In addition, some taxa from the *Hindeosphaeridae* group (e.g., *Spinostylosphaera andrasi* n. gen. n. sp.) represent good examples for rapid evolution (see Fig. 5.18-5.23) where the size of the secondary spines increase quickly. This is demonstrated by the fact that all specimens illustrated were extracted from the same sample (G11).

Fig. 5. 1 – *Archaeocenosphaera clathrata* (Parona, 1890), INV 2014.78.5. **2** – *Archaeocenosphaera parvispinosa* (Kozur, Krainer & Mostler, 1996), INV 2014.79. **3** – *Triassobullasphaera hemisphaerica* Kozur & Mostler, 2006, INV 2014.80.1. **4** – *Triassobullasphaera hemisphaerica* Kozur & Mostler, 2006, INV 2014.80.2. **5** – *Triassobullasphaera miriae* n. sp., holotype, PAL 2014.125.1. **6** – *Triassobullasphaera miriae* n. sp., paratype, PAL 2014.125.2. **7** – *Parentactinia pugnax* Dumitrica, 1978, INV 2014.81. **8** – *Pentactinocarpus acanthicus* Dumitrica, 1978, INV 2014.82.1. **9** – *Pentactinocarpus acanthicus* Dumitrica, 1978, INV 2014.82.2. **10:** *Pentactinocarpus acanthicus* Dumitrica, 1978, INV 2014.82.3. **11** – *Pentactinocarpus tetracanthus* Dumitrica, 1978, INV 2014.83.1. **12** – *Pentactinocarpus tetracanthus* Dumitrica, 1978, INV 2014.83.2. **13** – *Pentactinocarpus tetracanthus* Dumitrica, 1978, INV 2014.83.3. **14** – *Pentactinocarpus magnus* (Kozur & Mostler, 1979), INV 2014.84. **15** – *Pentactinorbis pessagnoi* Kozur & Mostler, 1994, INV 2014.85. **16** – *Pentactinorbis* cf. *megasphaera* (Sugiyama, 1997), INV 2014.86 **17** – *Hexapylomella carnica* Kozur & Mostler, 1979, INV 2014.87. **18** – *Hindeosphaera foremanae* Kozur & Mostler, 1979, INV 2014.89. **19** – *Hindeosphaera naomiae* n. sp., holotype, PAL 2014.134. **20** – *Hindeosphaera djani* n. sp., holotype, PAL 2014.135. **21** – *Hindeosphaera burrii* n. sp., paratype, PAL 2014.136.3.**22** – *Hindeosphaera burrii* n. sp., paratype, PAL 2014.136.2. **23** – *Hindeosphaera burrii* n. sp., holotype, PAL 2014.136.1.**24** – *Hindeosphaera* cf. *goestlingensis* Kozur & Mostler, 1979, INV 2014.90.2. **25** – *Hindeosphaera* sp., INV 2014.91.1.

5. Systematic palaeontology

Order Spumellaria Ehrenberg, 1875
Family Xiphostylidae Haeckel, 1881
Genus *Archaeocenosphaera* Pessagno & Yang, 1989

Type species: *Archaeocenosphaera ruesti* Pessagno & Yang, 1989.

Archaeocenosphaera clathrata (Parona, 1890)
Fig. 5.1

1880 ?*Heliosphaera echinoidites* n. sp. – Pantanelli, p. 46, fig. 8.
1890 *Cenosphaera clathrata* n. sp. – Parona, p. 19, pl. 1, fig. 5.
1892 *Cenosphaera clathrata* Parona. – Parona, pl. 1, fig. 2.
1892 *Cenosphaera apiaria* n. sp. – Rüst, p. 135, pl. 6, fig. 6.
1979 *Cenosphaera clathrata* Parona. – Kozur & Mostler, p. 69, pl. 4, fig. 1.
1984 *Cenosphaera clathrata* Parona. – Lahm, p. 15, pl. 1, figs. 1-2.
1989 *Archaeocenosphaera ruesti* n. sp. – Pessagno & Yang, p. 203, pl. 1, fig. 9; pl. 9, fig. 23.
1996 *Cenosphaera clathrata* Parona. – Chiari et al., pl. 1, fig. 19.
1996 *Cenosphaera parvispinosa* n. sp. – Kozur et al., pp. 222-223, pl. 9, fig. 12.
1997 *Cenosphaera* sp. A. – Yao, pl. 1, figs. 2, 4-5, 11.
1997 *Archaeocenosphaera clathrata* (Parona). – Dumitrica et al., p. 17, pl. 1, fig. 2.
2000 *Cenosphaera igoi* n. sp. – Sashida et al., p. 804, fig. 10.7-10.8.
2009 *Archaeocenosphaera clathrata* (Parona). – Feng et al., p. 585, fig. 3(1-4).
2011 *Archaeocenosphaera* sp. – Thassanapak et al., p. 188. fig. 4C, D.

Occurrence: Lower Devonian of the southern Ural, Anisian to Ladinian from Italy, Austria, Hungary and Thailand; Carnian of Albania, Lower Tuvalian of the Sorgun Ophiolitic Mélange, Turkey and Middle Late Triassic of Tibet. The species is also recorded from the Berriasian in Masirah Island, Oman and from the Eocene in Italy.

Remarks: The original illustration of *A. clathrata* (Parona, 1890) is very schematic. Therefore, it is almost impossible to identify the original structure of the cortical shell and the pore frames of the holotype. The specimen illustrated by Parona wears relatively large and hexagonal pores. The specimen from the Sorgun Ophiolitic Mélange differs in having circular, hexagonal and polygonal pores.

Archaeocenosphaera parvispinosa (Kozur, Krainer & Mostler, 1996)
Fig. 5.2

1996 *Cenosphaera parvispinosa* n. sp. – Kozur et al., pp. 222-223, pl. 9, fig. 13.
2002 *Cenosphaera clathrata* Parona. – Suzuki et al., p. 170, fig. 4C.

Occurrence: Basal Tuvalian of the Sorgun Ophiolitic Mélange, southern Turkey, Upper Anisian and Lower Ladinian of Austria, Hungary and Italy, Lower Jurassic of N Peru.

Genus *Triassobullasphaera* Kozur & Mostler, 2006

Type species: *Triassobullasphaera hemisphaerica* Kozur & Mostler, 2006.

Triassobullasphaera hemisphaerica Kozur & Mostler, 2006
Fig. 5.3-5.4

2006 *Triassobullasphaera hemisphaerica* n. sp. – Kozur & Mostler, p. 42, pl. 1, figs. 5-6, 8, 11-12.

Remarks: The original description of *Triassobullasphaera hemisphaerica* Kozur & Mostler (2006) stated clearly that the opening of the test is completely missing, although these authors supposed the presence of an opening (aperture). In contrast, all the investigated specimens from the Sorgun Ophiolitic Mélange present a relatively large, well-defined circular opening. While the specimens of *Triassobullasphaera miriae* n. sp. have small tubular extensions around the opening, *T. hemisphaerica* Kozur & Mostler, 2006 has no such extensions.

Occurrence: Upper Longobardian (Bosnia and Herzegovina) to Lower Tuvalian of the Sorgun Ophiolitic Mélange, S Turkey.

Triassobullasphaera miriae n. sp.
Fig. 5.5-5.6

Etymology: In honor of Nathalie Miria Schmidhauser.

Holotype: The specimen illustrated in Fig. 5.5.

Material: More than 50 specimens.

Diagnosis: Spherical or slightly ellipsoidal, single layered shell with polygonal to mostly circular pore frames. Meshwork with elevated nodes (Diameter = 20-30 µm). The hemisphere-like nodes are positioned uniformly and relatively densely on the test. 12 to 15 nodes can be seen on one half of the test. Shell bearing relatively large (diameter = 30-40 µm), well-defined, circular opening surrounded by a small tubular extension.

Occurrence: Lower Tuvalian of the Sorgun Ophiolitic Mélange, S Turkey.

Remarks: *Triassobullasphaera miriae* n. sp. differs from *T. hemisphaerica* Kozur & Mostler, 2006 by the existing opening, the smaller sized and the more densely located nodes.

Order Entactinaria Kozur & Mostler, 1982
Family Palaeoscenidiidae Riedel, 1967
Genus *Parentactinia* Dumitrica, 1978

Type species: *Parentactinia pugnax* Dumitrica, 1978.

Parentactinia pugnax Dumitrica, 1978
Fig. 5.7

1978 *Parentactinia pugnax* n. sp. – Dumitrica, p. 50, pl. 4, figs. 4?, 5, pl. 5, figs. 1-3.
1990 *Parentactinia pugnax* Dumitrica. – Yeh, p. 13, pl. 4. fig.19.
1990 *Parentactinia pugnax* Dumitrica. – Goričan & Buser, p. 149, pl. 7, fig. 6.
1994 *Parentactinia pugnax* Dumitrica. – Kozur & Mostler, p. 45, pl. 1, figs. 11-12.
1995 *Parentactinia pugnax* Dumitrica. – Ramovs & Goričan, p. 187, pl. 4, fig. 7.

Occurrence: ?Olenekian of New Zealand, Middle Triassic (Illyrian – ?Fassanian) in the southern Alps, Hungary and the Philippines. Upper Triassic (lower Tuvaluan) of the Sorgun Ophiolitic Mélange, S Turkey.

Family Pentactinocarpidae Dumitrica, 1978
Genus *Pentactinocarpus* Dumitrica, 1978

1979 *Praedruppatractylis* n. gen. – Kozur & Mostler, p. 82.
1979 *Oertlisphaera* n. gen. – Kozur & Mostler, p. 53.

Type species: *Pentactinocarpus fusiformis* Dumitrica, 1978.

Pentactinocarpus acanthicus Dumitrica, 1978
Fig. 5.8-5.10

1978 *Pentactinocarpus acanthicus* n. sp. – Dumitrica, p. 44, pl. 3, fig. 3.
1980 *Pentactinocarpus acanthicus* Dumitrica. – Dumitrica et al., p. 7, pl. 4, fig. 7.
1984 *Pentactinocarpus acanthicus* Dumitrica. – Lahm, p. 22, pl. 2, figs. 9-10.
1990 *Pentactinocarpus acanthicus* Dumitrica. – Goričan & Buser, p. 149, pl. 7, fig. 12.
1994 *Pentactinocarpus acanthicus* Dumitrica. – Kozur & Mostler, p. 46, pl. 2, figs. 3, 5.
1999 *Pentactinocarpus acanthicus* Dumitrica. – Tekin, p. 133, pl. 27, fig. 6.
2000 *Pentactinocarpus acanthicus* Dumitrica. – Carter & Orchard, pl. 2, fig. 4.
2012 *Pentactinocarpus acanthicus* Dumitrica. – Stockar et al., p. 388, pl. 1, figs. 8-10.

Occurrence: Middle to Late Triassic in the Tethyan Realm.

Pentactinocarpus tetracanthus Dumitrica, 1978
Fig. 5.11-5.13

1978 *Pentactinocarpus tetracanthus* n. sp. – Dumitrica, p. 43, pl. 1, fig. 1.
1979 *Sethophaena* (?) sp. A. – Nakaseko & Nishimura, p. 79, pl. 8, fig. 7.
1980 *Pentactinocarpus tetracanthus* Dumitrica. – Dumitrica et al., p. 8, pl. 4, figs. 1-4
1981 *Pentactinocarpus austriacus* n. sp. – Kozur & Mostler, p. 20, pl. 53, fig. 4.
1984 *Pentactinocarpus tetracanthus* Dumitrica. – Lahm, p. 23, pl. 2, fig. 11;
1990 *Pentactinocarpus tetracanthus* Dumitrica. – Goričan & Buser, p. 150, pl. 7, figs. 8-10;
1994 *Pentactinocarpus tetracanthus* Dumitrica. – Kozur & Mostler, p. 46, pl. 2, figs. 6-7, 13.
1995 *Pentactinocarpus tetracanthus* Dumitrica. – Kellici & De Wever, p. 153, pl. 3, fig. 20.
1997 *Pentactinocarpus tetracanthus* Dumitrica. – Sugiyama, p. 184. fig. 49-23.
1999 *Pentactinocarpus* sp. aff. *P. tetracanthus* Dumitrica. – Bragin & Krylov, p. 544. fig. 7D.
1999 *Pentactinocarpus tetracanthus* Dumitrica. – Tekin, p. 134, pl. 27, figs. 9-10.
2006 *Pentactinocarpus tetracanthus* Dumitrica. – et al., pl. 2, fig. 30.
2007 *Pentactinocarpus tetracanthus* Dumitrica. – Bragin, p. 967, pl. 1, fig. 1.
2010 *Pentactinocarpus tetracanthus* Dumitrica. – Tekin & Sönmez, fig. 8N-O.

Occurrence: Middle to Late Triassic of the Tethyan Realm.

Pentactinocarpus magnus (Kozur & Mostler, 1979)
Fig. 5.14

1979 *Oertlisphaera magna* n. sp. – Kozur & Mostler, p. 53, pl. 10, fig. 1.
1990 *Pentactinocarpus magnus* (Kozur & Mostler). – Yeh, p. 13, pl. 4, fig. 22, pl. 5, fig. 17, pl. 11, fig. 19.

Occurrence: Middle (Ladinian) to Late (Carnian) Triassic of the Philippines, Carnian in the Tethyan Realm.

Genus *Pentactinorbis* Dumitrica, 1978

Type species: *Pentactinorbis kozuri* Dumitrica, 1978.

Pentactinorbis pessagnoi Kozur & Mostler, 1994
Fig. 5.15

1994 *Pentactinorbis pessagnoi* n. sp. – Kozur & Mostler, p. 48, pl. 4, figs. 3-4.

Occurrence: Illyrian of the Balaton Highland, Hungary and Upper Triassic (lower Tuvalian) from the Sorgun Ophiolitic Mélange, S Turkey.

Pentactinorbis cf. *P. megasphaera* (Sugiyama, 1997)
Fig. 5.16

Remarks: The specimen resembles *P. megasphaera* but it has larger circular to polygonal pore frames. Small tricarinate (?) spines connected to cortical shell. Inner structure is hidden.

Family Hexapylomellidae Kozur & Mostler, 1979
Genus *Hexapylomella* Kozur & Mostler, 1979

Type species: *Hexapylomella carnica* Kozur & Mostler, 1979.

Hexapylomella carnica Kozur & Mostler, 1979
Fig. 5.17

1979 *Hexapylomella carnica* n. sp. – Kozur & Mostler, p. 69. pl. 3, fig. 2.

Occurrence: Carnian in the Tethyan Realm.

Family Hindeosphaeridae Kozur & Mostler, 1981
Genus *Hindeosphaera* Kozur & Mostler, 1979

Type species: *Hindeosphaera foremanae* Kozur & Mostler, 1979.

Hindeosphaera burrii n. sp.
Fig. 5.21-5.23

Etymology: In honor of Georges Burri.

Holotype: The specimen illustrated in Fig. 5.23.

Material: More than 100 specimens.

Diagnosis: Large, spherical or ellipsoidal, double-layered cortical shell with circular and mostly polygonal pore frames on outer layer and very small, circular pores on inner layer. Thick tricarinate, straight or twisted lateral spines with wide ridges and relatively deep grooves. In addition, 4-5 long (200-250 μm), tricarinate and 2-3 needle-like, pointed spines connected to the cortical shell. Spherical or subspherical medullary shell with large mostly polygonal or circular pore frames. Reduced median bar with three needle-like or tricarinate apical spines. Two lateral spines, one of them tricarinate that continues into large spine on the cortical shell.

Occurrence: Lower Tuvalian of the Sorgun Ophiolitic Mélange, S Turkey.

Remarks: *Hindeosphaera burrii* n. sp. is distinguished from all other species of the genera *Hindeosphaera* by having long spines.

Hindeosphaera djani n. sp.
Fig. 5.20

Etymology: In honor of Djan Moix.

Holotype: The specimen illustrated in Fig 5.20.

Material: More than 5 specimens.

Diagnosis: Spherical or slightly compressed, double layered cortical shell with circular to polygonal pore frames on the outer layer and very small pores on the inner layer. Medullary shell spherically connected with 5 to 6 spines

Fig. 6. 1 – *Pseudostylosphaera dumitricai* n. sp., holotype, PAL 2014.128.1. **2** – *Pseudostylosphaera dumitricai* n. sp., paratype, PAL 2014.128.2. **3** – *Pseudostylosphaera dumitricai* n. sp., paratype, PAL 2014.128.3. **4** – *Pseudostylosphaera dumitricai* n. sp., paratype, PAL 2014.128.4. **5** – Presumably pathological specimen of *Pseudostylosphaera* cf. P. *dumitricai* n. sp., paratype, PAL 2014.128.5. **6** – *Pseudostylosphaera longispinosa* Kozur & Mostler, 1981, INV 2014.88. **7** – *Spinostylosphaera andrasi* n. gen. n. sp., holotype, PAL 2014.126.1. **8** – *Spinostylosphaera andrasi* n. gen. n. sp., paratype, PAL 2014.127.1. **9** – *Spinostylosphaera andrasi* n. gen. n. sp., paratype, PAL 2014.126.2. **10** – *Spinostylosphaera andrasi* n. gen. n. sp., paratype, PAL 2014.126.3. **11** – *Spinostylosphaera andrasi* n. gen. n. sp., paratype, PAL 2014.127.2. **12.1** – *Spinostylosphaera andrasi* n. gen. n. sp., paratype, PAL 2014.127.3.6. **12.2** – *Spinostylosphaera andrasi* n. gen. n. sp., paratype, PAL 2014.127.3. **13.1** – *Spinostylosphaera vachardi* n. gen. n. sp., paratype, PAL 2014.131.2. **13.2** – *Spinostylosphaera vachardi* n. gen. n. sp., paratype, PAL 2014.131.2. **14** – *Spinostylosphaera vachardi* n. gen. n. sp., paratype, PAL 2014.131.2. **15** – *Spinostylosphaera vachardi* n. gen. n. sp., holotype, PAL 2014.131.1.

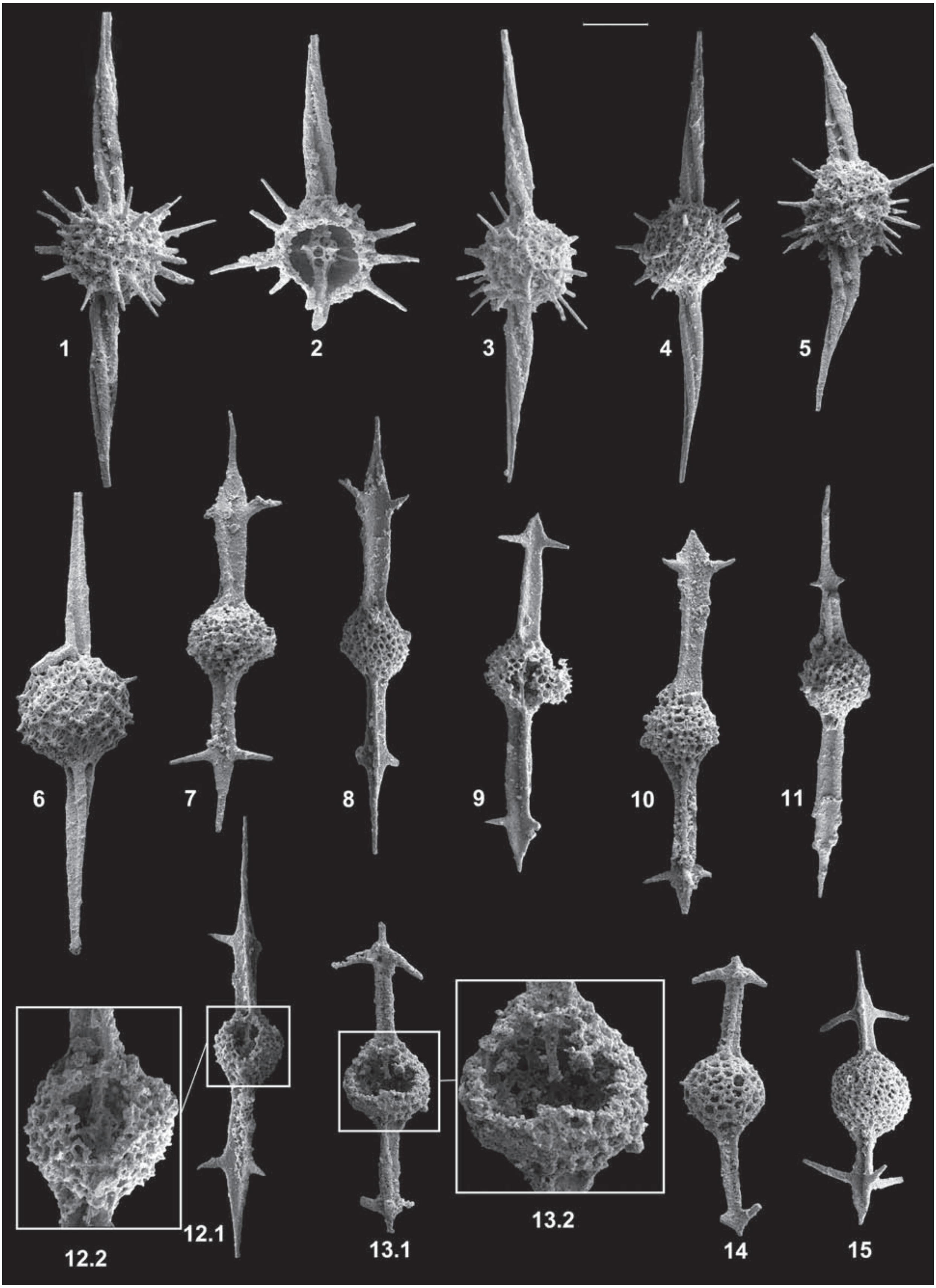

Fig. 6.

to the cortical shell, which continue in outer spines. Two lateral spines are three or four-bladed and one of them continues in a massive, large, twisted spine. The others are needle-like and continue in smaller, pointed spines (Fig. 6.22). Arch of medullary shell connected in nodes around lateral and apical spines. Sagittal ring formed in central part of the medullary shell and its plan is perpendicular to the direction of lateral spines. The most characteristic element of the species is the very large, massive spine connected to the cortical shell. It is four-bladed with deep grooves and high ridges. Terminal part of the spine is expanded and the connecting edges of ridges are slightly curved.

Occurrence: Lower Tuvalian of the Sorgun Ophiolitic Mélange, S Turkey.

Remarks: *Hindeosphaera djani* n. sp. is distinguished from all other species of the genera *Hindeosphaera* by the massive spines with four ridges, deep grooves and expanded terminal part.

Hindeosphaera foremanae Kozur & Mostler, 1979
Fig. 5.18

1979 *Hindeosphaera foremanae* n. sp. – Kozur & Mostler, p. 62, pl. 5, fig. 6.
1984 *Hindeosphaera foremanae* Kozur & Mostler. – Lahm, p. 38, pl. 5, figs. 11-12.

Occurrence: Carnian of the Tethyan Realm.

Hindeosphaera naomiae n. sp.
Fig. 5.19

Etymology: In honor of Naomi Tafelmacher.

Holotype: The specimen illustrated in Fig. 5.19.

Material: More than 5 specimens.

Diagnosis: Spherical or subspherical double-layered cortical shell. Small circular or polygonal pore frames on inner layer which is covered by spongy mantle. The outer spongy mantle is in nodes. Two approximately equal, tricarinate, twisted spines and 3-4 significantly shorter, tricarinate, pointed spines connected to the cortical shell.

Occurrence: Lower Tuvalian of the Sorgun Ophiolitic Mélange, S Turkey.

Remarks: *Hindeosphaera naomiae* n. sp. is distinguished from all other species of *Hindeosphaera* by having two identical tricarinate and twisted lateral spines.

Hindeosphaera cf. *H. goestlingensis* Kozur & Mostler, 1979
Fig. 5.24

Remarks: The cortical shell is spherical with polygonal pore frames and one significantly larger, tricarinate, twisted spine and three smaller pointed, tricarinate spines. Due to the good preservation, the inner structure can be studied. Very small median bar at the pointed part of the medullary shell with three, needle-like apical spines (Fig. 6.18). Two lateral spines, one of them tricarinate and continues in a large, strongly twisted spine which is connected to the cortical shell. The other spine is significantly thinner, needle-like and continues into a smaller, tricarinate outer spine. The medullary shell is ellipsoidal with large polygonal pore frames.

Hindeosphaera sp.
Fig. 5.25

Remarks: This specimen resembles *H. austriaca* Kozur & Mostler, 1979 and *H. goestlingensis* Kozur & Mostler, 1979. Because of the broken shell, it cannot be assigned accurately. The cortical shell is globular and double-layered. The outer layer bears mostly polygonal pore frames, the inner layer has very small circular pores. The medullary shell is ellipsoidal or irregular shaped, with large polygonal pore frames. Three slender, slightly curved apical spines. Two massive, tricarinate, lateral spines, which continue into larger spines that are connected to the cortical shell.

Genus *Pseudostylosphaera* Kozur & Mostler, 1981

Type species: *Pseudostylosphaera gracilis* Kozur & Mostler, 1981.

Pseudostylosphaera dumitricai n. sp.
Fig. 6.1-6.5.

Etymology: In honor of Dr. Paulian Dumitrica, for his outstanding work on radiolarian taxonomy.

Holotype: The specimen illustrated in Fig. 6.1.

Material: More than 100 specimens.

Diagnosis: Test is composed of spherical cortical shell and two, equal, twisted polar spines. The cortical shell is double-layered: outer layer with polygonal pore frames, inner layer contains small, circular pores. The shell includes many, radial, pointed, needle-like spines (length 40-70 µm). Relatively small (diameter = 50-55 µm), ellipsoidal medullary shell with large, circular or polygonal pore frames. In the specimen illustrated, the median bar is hidden by sediment or calcite (Fig. 6.2). Poorly preserved apical and ventral spines. Three or four rod-shaped basal spines. Two, three-bladed, massive lateral spines connected to the medullary shell which continue in polar spines. Pointed polar spines are long, straight or slightly curved and twisted, tricarinate with wide ridges and deep or narrow grooves.

Occurrence: Lower Tuvalian of the Sorgun Ophiolitic Mélange, S Turkey.

Remarks: The new species describe here differs from *Pseudostylosphaera multispinata* Tekin & Mostler, 2005 in the shape of the tricarinate polar and radial spines (strongly twisted, thin ridges, less radial).

Pseudostylosphaera longispinosa Kozur & Mostler, 1981
Fig. 6.6

1981 *Pseudostylosphaera longispinosa* n. sp. – Kozur & Mostler, p. 32, pl. 1, fig. 6.
1981 *Pseudostylosphaera longobardica* n. sp. – Kozur & Mostler, p. 33, pl. 49, fig. 3.
1984 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Lahm, pp. 34-35, pl. 4, figs. 11-12.
1986 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Kozur & Réti, fig. 6D
1990 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Goričan & Buser, p. 155, pl. 5, fig. 4.
1990 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Kolar-Jurkovšek, p. 76, pl. 5, fig. 6a-b.
1990 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Yeh, p. 15, pl. 4, fig. 2.
1997 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Sugiyama, p. 188, fig. 48.16.
1998 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Takahashi et al., pl. 1, fig. 4.
1999 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Tekin, p. 129., pl. 25, fig. 14.
2001 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Feng et al. p. 190, pl. 5, figs. 22-24.
2006 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Marquez et al., pl. 2, fig. 13.
2007 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Tekin & Göncüoglu, pl. 2, fig. 25.
2010 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Tekin & Sönmez, fig. 7R.
2011 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Thassanapak et al., p. 195, fig. 6T.
2012 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Ozsvárt et al., fig. 9.7.
2012 *Pseudostylosphaera longobardica* Kozur & Mostler. – Ozsvárt et al., fig. 9.8.
2012 *Pseudostylosphaera longispinosa* Kozur & Mostler. – Stockar et al., p. 397, pl. 4, figs. 16-24.

Occurrence: Anisian to Norian of the Tethyan Realm.

Remarks: The original description of *P. longispinosa* Kozur & Mostler, 1981 does not contain any information about tiny, pointed and needle-like spines on the outer pore frames. This specimen bears several very short spines (15-20 µm), but most of them are probably broken.

Genus *Spinostylosphaera* nov.

Etymology: In allusion to its similarities to the genera *Pseudostylosphaera,* but with secondary spines on the polar spines.

Type species: *Spinostylosphaera andrasi* n. gen. n. sp.

Included species: *Spinostylosphaera andrasi* n. gen. n. sp., *Spinostylosphaera mesotriassica* (Dumitrica, Kozur & Mostler, 1980), *Spinostylosphaera vachardi* n. gen. n. sp.

Diagnosis: Relatively small spherical to ellipsoidal, single layered cortical shell. From tiny to relatively large-sized pentagonal to mostly polygonal pore frames. Two long, three bladed polar spines are broad or wear furrows. They can be straight or twisted. Polar spines wear three pointed, straight or distally slightly curved secondary spines. Short to long terminal spine present, slightly curved, proximally tricarinate, distally pointed.

Remarks: The genus *Spinostylosphaera* differs from the *Pseudostylosphaera* by its single layered cortical shell and by having three secondary spines on the polar spines. These secondary spines are unknown among the species of the genus *Pseudostylosphaera*.

Occurrence: From Middle Triassic (?) of the southern Alps to Late Triassic (Julian to lower Tuvalian) in the northern Alps and the Sorgun Ophiolitic Mélange, S-Turkey.

Spinostylosphaera andrasi n. gen. n. sp.
Fig. 6.7-6.12

Etymology: For András Ozsvárt, Luxembourg.

Holotype: The specimen illustrated in Fig. 6.7

Material: More than 50 specimens.

Diagnosis: Relatively small, spherical to ellipsoidal, single layered cortical shell. Pentagonal to mostly polygonal pore frames. Presumably, with a small spherical or ellipsoidal medullary shell. Initial spicule hardly visible, very small median bar with one or two apical and basal spines. Two, equal, tricarinate polar spines with three, pointed, straight or distally slightly upward curved secondary spines. Terminal spine very long, slightly curved, proximally tricarinate, distally pointed.

Occurrence: Lower Tuvalian of the Sorgun Ophiolitic Mélange, S Turkey.

Spinostylosphaera vachardi n. gen., n. sp.
Fig. 6.13-6.15

2011 *Dumitricasphaera simplex* Tekin. – Bragin, p. 755, pl. 10, fig. 6.

Etymology: In honor of Dr. Daniel Vachard, Lille, for his outstanding work on Palaeozoic microbiotas.

Holotype: The specimen in Fig 6.15.

Material: More than 50 specimens.

Diagnosis: Large, spherical single-layered cortical shell with mostly polygonal pore frames. Two equal, tricarinate polar spines with furrows and with three, pointed, straight or distally slightly downward curved secondary spines. Terminal spine long, slightly curved, proximally tricarinate, distally pointed.

Occurrence: Upper Julian (*Tetraporobrachia haeckeli* Radiolaria Zone) of the Northern Calcareous Alps (Großreifling section) and Lower Tuvalian of the Sorgun Ophiolitic Mélange.

Remarks: *Spinostylosphaera vachardi* n. gen., n. sp. has significantly longer polar spines and terminal spines than *Spinostylosphaera mesotriassica* (Dumitrica, Kozur & Mostler, 1980).

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