Geol. Paläont. Mitt. Innsbruck, ISSN 0378–6870, Sonderband 4, S. 271–285, 1996

FIRST EVIDENCE OF LOWER TO MIDDLE SCYTHIAN (DIENERIAN – LOWER OLENEKIAN) RADIOLARIANS FROM THE KARAKAYA ZONE OF NORTHWESTERN TURKEY

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With 1 figure and 2 plates

Abstract:
Stigmosphaerostylus turkensis n. sp., a new entactinarian radiolarian species, is described from Dienerian to lower Smithian (Lower to lower Middle Scythian) limestones from the Karakaya Zone of northwestern Turkey. It is the oldest known Triassic radiolarian species. The nearly complete disappearance of Radiolaria at the Permian-Triassic boundary and the development of the Lower Triassic radiolarian faunas is discussed. Nassellaria have obviously evolved during the Spathian (Upper Scythian) from spicular Entactinaria without shell, but also many shell-bearing Triassic Entactinaria evolved during that time from spicular Entactinaria. The radiolarians and conodonts are accompanied by the oldest siliceous sponge spicule fauna of the Triassic. As the radiolarian fauna, only a very monotonous fauna with pentactine and very rare hexactine spicules (Hexactinellida, Lyssakida) is present that can be regarded as a pioneer fauna belonging probably only to one species.

Zusammenfassung:
Stigmosphaerostylus turkensis n. sp., eine neue Entactinaria-Radiolarienart aus dem Dienerian bis unteren Smithian (Unterskyth bis tieferes Mittelskyth) der Karakaya-Zone (nordwestliche Türkei) wird beschrieben. Das nahezu vollständige Aussterben der Radiolarien and der Perm-Trias-Grenze und die Entwicklung der untertriassischen Radiolarienfaunen wird diskutiert. Nassellaria haben sich offensichtlich erst während des Spathian (Oberskyth) aus spicularen Entactinaria ohne Schale entwickelt, aber auch viele Schalen-tragende triassische Entactinatinaria entwickelten sich in diesem Zeitraum aus spicularen Entactiniaria. Die Radiolarien und Conodonten werden von der ältesten bekannten triassischen Kieselschwammspiculae-Fauna begleitet. Wie die Radiolarienfauna sind auch die Schwammspiculae sehr monoton und bestehen im wesentlichen aus glatten Pentactinen und sehr wenigen glatten Hexactinen von Hexactinellida (Lyssakida). Sie repräsentieren eine Pionierfauna, die vielleicht nur aus einer Art besteht.

1. Introduction

Radiolarians are still very common in the Upper Changxingian, but nearly disappeared near the P/T boundary. In Sicily, a very rich Upper Changxingian radiolarian fauna occurs in red deep water clays with *Clarkina changxingensis* (Wang & Wang), *C. sosioensis* Gullo & Kozur and *Hindeodus latidentatus* Kozur, Mostler & Rahimi-Yazd (Kozur, 1993, 1995 a, b). Red deep water clays of that age contain up to several 10 000 radiolarians per kg clay. Pelagic Lower Scythian (Brahmanian) beds of Sicily did not yield radiolarians; also calcified radiolarians are absent in pelagic Lower Scythian limestones. Radiolarians re-appear in this area only in the upper Scythian (Upper Olenekian, Spathian)

Rich radiolarian faunas occur also in the uppermost Changxingian of southwest China (Feng, Qinglai, 1992, Feng, Qinglai & Liu, Benpei, 1993 a). In the Shangsi section, one of the present authors (Kozur) found rich radiolarian faunas in Upper Changxingian siliceous limestones immediately below the Transitional Beds. In the Transitional Beds suddenly the radiolarians disappeared and, as in the Lower Scythian (Brahmanian), even siliceous rocks are absent; also thin sections of Lower Scythian pelagic limestones did not show any radiolarian remains. Assumed Lower Scythian radiolarites of southwest China are of Middle Triassic age (see chapter 4.).

In Japan and SE Siberia the stratigraphic control of the youngest Permian faunas is not so good as in China and Sicily. However, the *Neoalbaillella ornithoformis* Zone can be well dated in China as Lower Changxingian (FENG, QINGLAI & LIU, BENPEI, 1993 b). For this reasons, the *Neoalbaillella grypus* Zone of Japan (KOZUR & MOSTLER, 1989; for range chart of the species, see ISHIGA, 1990) probably corresponds to the Upper Changxingian. Both in Japan and in SE Siberia, the Changxingian radiolarites are overlain by black anoxic shales. The boundary between the hard radiolarites and the soft black shales is always strongly tectonized, but the entire Lower Scythian is free of radiolarians and even siliceous intercalations are missing. Only a few spherical microradiolarians (shells with about 40 µm diameter) were found in these beds.

The youngest Permian radiolarian faunas from the Grindstone terrane in Oregon (USA) may also belong to the Upper Changxingian, because *Neoalbaillella grypus* ISHIGA, KITO & IMOTO was reported (BLOME & REED, 1992).

The oldest Triassic radiolarians and shale-radiolarite sequences are known from the Upper Scythian (Upper Olenekian, Spathian) of the Circum-Pacific realm, especially from Japan and SE Siberia (SASHIDA, 1983, 1991, BRAGIN, 1991 SUGIYAMA, 1992, NAGAI & MITZUANI, 1993). Only in the Grindstone terrane, Smithian (Lower Olenekian) radiolarians were found in limestones, but not yet described (BLOME & REED, 1992). The only Scythian radiolarians outside the Circum-Pacific realm have been found in the Monte Facito Formation of the Lagonegro Basin in southern Italy (MARSELLA et al., 1993). There, the radiolarian-bearing limestones occur in the uppermost Spathian *Chiosella gondolelloides* Zone. Radiolarians are common also in Spathian pelagic micritic limestones of the Sosio Valley (Sicily, Italy), but all are calcified and cannot by dissolved from these limestones.

In western Turkey, two areas were investigated for Scythian radiolarians. In the Karaburun peninsula well dated Spathian to Ladinian red and gray pelagic limestones (partly with intraformational breccia or conglomeratic), red shales, in the Anisian and Ladinian additionally reddish and greenish radiolarites and intermediate volcanics are present. The red radiolarites yielded rich Lower Anisian to Ladinian radiolarian faunas. As in other areas, the Lower Anisian radiolarians are not much diversified, but Entactinaria, Spumellaria and Nassellaria are present. Scythian radiolarians were not found. According to ERDOĞAN et al. (1990, 1995) this well dated sequence (their Gerence Formation) interfingers with a "Scythian-Anisian" clastic sequence (Karaeis Formation sensu ERDOĞAN et al., 1990, 1995) that is rich in black and greenish gray radiolarites. These radiolarites were investigated for radiolarians and other microfossils, but they yielded only Silurian to Lower Carboniferous radiolarians, conodonts and Muellerisphaerida (KOZUR, in press). No evidence for a sedimentological interfingering between these Paleozoic radiolarites and the well dated Spathian to Ladinian rocks of the Gerence Formation can be found.

The second studied area for Scythian radiolarians is situated in the Karakaya Zone. WIEDMANN et al. (1992) proved there the presence of a pelagic, partly oceanic Scythian and Middle Triassic rocks and KOZUR & KAYA (1994) found latest Permian pelagic conodonts. In this area the search for Scythian conodonts was successful and in limestones the oldest Scythian radiolarians and siliceous sponge spicule associations of Dienerian to Smithian (Late Brahmanian to Early Olenekian) age were discovered that are well dated by conodonts.

2. Locality data and geological setting

The investigated area lies in northwestern Turkey, NE of Bursa (Fig. 1 A). It belongs to the Karakaya Zone that is interpreted in different manner. According to ŞENGÖR et al. (1980), ŞENGÖR (1984, 1985) it is the main suture zone of the Paleozoic to

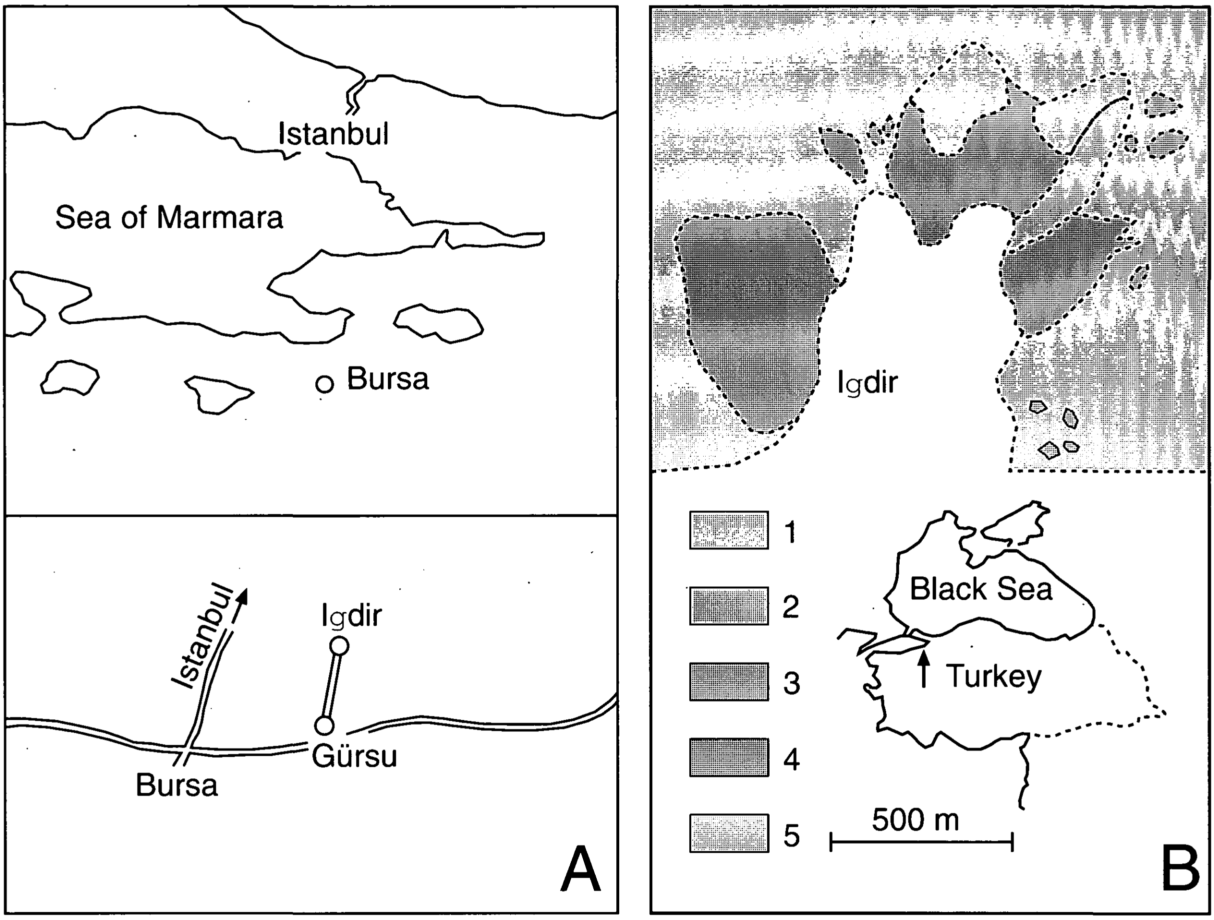

Fig. 1: Location map.
A: Geographic location of Igdir, NE of Bursa, northwestern Turkey.
B: Geological situation in the locality with Scythian radiolarians: 1 = Upper Triassic turbidite-olistostrome unit (turbiditic sandstones and shales; supporting matrix for the older blocks). 2 = Block of *Halobia* bearing Lower Norian limey lithic sandstones and shales, contemporaneous with parts of the turbidite-olistostrome unit. 3 = Scythian block of pelagic shales, thinly bedded, dark, marly limestones, lithic sandstones and minor fine-grained lithic conglomerates. the limestones contain conodonts, radiolarians and sponge spicules. 4 = Blocks of pelagic Upper Scythian and Middle Triassic limestones, partly Hallstatt Limestones with ammonoids. 5 = Blocks of limey lithic sandstones, age undated.

Middle Jurassic Paleotethys. The Upper Triassic turbidite-olistostrome unit was interpreted as a subduction-related unit indicating the closing of the Karakaya branch of the Paleotethys during the end of the Triassic.

KOZUR (1991 a, b, and in press) regarded also the Karakaya Zone as a suture zone and the Upper Triassic turbidite-olistostrome unit with blocks of ultrabasites, basic volcanics, radiolarites and Middle Triassic to Cordevolian metamorphics as subduction related accretionary complex of an oceanic sequence that contains also blocks of pelagic slope limestones as well as extrabasinal limestones. Middle Triassic metamorphic rocks (KAYA & MOSTLER, 1992) and Lower Carnian metamorphic rocks (KAYA & KOZUR, in prep.) were regarded as subduction related metamorphics. The closing of the Karakaya oceanic branch was assumed at the end of the Triassic. However, according to KOZUR (1991 a, b, and in press), the Karakaya oceanic branch was not part of a Paleozoic-Triassic Paleotethys, but part of the southern branch of Cimmerian Ocean that opened in western Turkey in the uppermost Permian, had the fastest sea-floor spreading in the Middle Triassic and closed in the Karakaya branch during the

Upper Triassic, in the northern branch during the Upper Jurassic. Blocks of pelagic Paleozoic beds within the Upper Triassic turbidite-olistostrome unit of the Karakaya Zone have a Silurian to Early Carboniferous age. No Middle and Upper Carboniferous and Lower Permian rocks are known, Middle Permian olistoliths are extrabasinal shallow water carbonates (fusulinid limestones). The breaking up of this carbonate platform is indicated by uppermost Dzhulfian and Changxingian pelagic limestones (KOZUR & KAYA, 1994). Toward the margin of the Istanbul block (that separated the Karakaya Zone from the northern branch of the Cimmerian Ocean), the entire Permian was missing and the Lower Triassic began with an onlap sequence to which belong also the investigated Scythian rocks with radiolarians.

In this connection, some remarks to the paper OKAY & MOSTLER (1994) are necessary. Despite the fact that H. MOSTLER is listed as co-author, he has neither got the manuscript nor the printed paper. We have learned about the existence of this paper from a paper of STAMPFLI (1966), but were not yet able to get this paper. From the title of the paper and the paper of STAMPFLI (1996) we know that in this paper the existence of Carboniferous and Permian radiolarite blocks in the Karakaya Zone was indicated. Two of the co-authors (KOZUR & MOSTLER) have seen the material (pelagic limestones and radiolarites) of OKAY (sent by L. KRYSTYN, Vienna) and together determined the age. In a part of the material Lower Carboniferous conodonts and indeterminable radiolarians are present that belong to unspecific, poorly preserved Entactinaria with genera that could occur in the long time span at least from the Devonian to Lower Triassic. Because of the presence of Lower Carboniferous conodonts they are of Mississippian age. In some radiolarites only these radiolarians were present. From the fact that the radiolarian faunas of the conodont-bearing rocks (Lower Carboniferous) and conodont free radiolarites (probably also Lower Carboniferous, but with indeterminable radiolarians) consist of Entactinarian genera that have a long range from the Devonian to the Lower or Middle Triassic, OKAY seemingly concluded that they are (Devonian) early Carboniferous to Permian in age which is not the case. Permian radiolarites contain always (beside the mentioned long-ranging Entactinaria genera) specific Permian radiolarians (mostly advanced Albaillellacea, Ruzhencevicea, advanced Entactinaria), well known to the present authors. Such radiolarians were not present in the material of OKAY, and this excludes the presence of Permian radiolarites in his material. Because this manuscript was not sent to the co-author, MOSTLER, this serious mistake was not corrected and lead by STAMPFLI (1996) to the incorrect correlation of the Karakaya Zone of northwestern Turkey (with assumed, but really not present Lower Permian radiolarites) and the Sicanian Zone of western Sicily with Lower Permian deep sea sediments (even with deep-sea trace fossils, KOZUR, KRAINER & Mostler, 1996). In the Lower Permian, the Karakaya Zone was a subaerial denudation area without sediments and nowhere in western Turkey Lower Permian deepwater sediments are known. Few areas (Ankara-Izmir Zone) have yielded shallow-water fusulinid limestones from the upper part of the Lower Permian.

According to KAYA (1992) the entire area of western Turkey was regionally metamorphosed during the Middle Triassic and the Upper Triassic turbidite-olistostrome unit is an onlap sequence.

The investigated area lies at the northern margin of the Karakaya Zone at the margin of the Istanbul block. Like on the Istanbul block, the Middle Carboniferous to Permian interval is missing and the Triassic is transgressive. The oldest block in the Upper Triassic turbidite-olistostrome unit is a Lower Triassic block (Fig. 1 B) that begins with sandstones, siltstones, shales and conglomerates overlain by shales and thin dark, marly and silty sandstone. It is a typical transgressive onlap series different from the central Karakaya Zone, where Middle and Upper Permian shallow water limestones are followed by Upper Dzhulfian and Changxingian (uppermost Permian) pelagic limestones and Lower Triassic pelagic limestones that are intercalated with basic volcanics during the Upper Scythian (Spathian = Upper Olenekian).

Middle Triassic blocks that are adjacent to the lower Triassic block of the investigated area consists of ammonoid-bearing Hallstatt Limestones and other pelagic limestones, whereas blocks of Middle Triassic radiolarites, pillow lavas and ultrabasites are missing in that area. Consequently, the investigated area belong to the northern slope of the Karakaya Basin or at least the blocks within the Upper Triassic turbidite-olistostrome sequence have been derived exclusively from the northern slope of the Karakaya Basin adjacent to the Istanbul Block.

The radiolarian-bearing Scythian limestones are dark gray to black, marly to silty limestones. They are well dated by conodonts. Sample K 7324 contains *Neospathodus dieneri* SWEET (Pl. 2, Figs. 11, 12) and *Clarkina procerocarinata* KOZUR (Pl. 2, Fig. 10) and can be dated as lower Dienerian (Brahmanian). Sample K 7323 (with the richest radiolarian fauna) yielded *N. dieneri* and *N. conservativus* (MÜLLER) (Pl. 2, Fig. 9), and can be dated as Dienerian to lower Smithian (uppermost Brahmanian to lowermost Olenekian). The present, mostly poorly preserved radiolarians are the oldest known Triassic radiolarians of the world. Their diversity is very low, but also all other faunas have a low diversity as typical for the Lower Scythian faunas. Beside radiolarians there are pelagic conodonts, ostracods (Pl. 1, Fig. 9) and siliceous sponge spicules.

3. Systematic descriptions

Subclass Radiolaria MÜLLER, 1858
Order Polycystida EHRENBERG, 1838
Suborder Entactinaria
KOZUR & MOSTLER, 1982
Superfamily Hexastylacea HAECKEL, 1882
emend. PETRUSHEVSKAYA, 1979

Family Triposphaeridae
VINASSA DE REGNY 1898,
emend. Kozur & Mostler, 1981

Synonyma:
Dorysphaeridae VINASSA DE REGNY, 1898
Entactiniidae RIEDEL, 1967

Genus *Stigmosphaerostylus* RÜST, 1892

Type species: *Stigmosphaerostylus notabilis* RÜST, 1892
Synonyma:
Ellipsostigma HINDE, 1899
Centrolonche POPOFSKY, 1912
Entactinia FOREMAN, 1963

***Stigmosphaerostylus turkensis* n. sp.**
(Pl. 1, Figs. 1–6)

Derivatio nominis: According to the occurrence in Turkey.
Holotypus: The specimen on Pl. 1, Fig. 1; rep.-no. 4-8-95/I-11
Locus typicus: Scythian block 500 NE of Igdir (NE of Bursa, northwestern Turkey).
Stratum typicum: Thin-bedded black marly limestone within dark shales and siltstones, upper Dienerian or lower Smithian; sample K 7323.
Material: More than 100, mostly badly preserved specimens.
Diagnosis: The shell is coarsely latticed and has triangular to hexagonal pores. The 7 three-bladed main spines are as long as the shell diameter or somewhat shorter to somewhat longer. The vertices of the pore frames have needle-like by-spines. The internal spicular system is very robust, point-centred and consists of 7 tricarinate spines that are connected with the main spines.
Description: The single spherical, coarsely latticed shell has pores of irregular size and shape. Most of the pores are very large, but some are small. The outline of the pores differs from triangular to pentagonal, partly also hexagonal. All different pore outlines occur in one specimen. The main spines are tricarinate, long, slender, nearly of the same width throughout their length. The furrows between their three blades are deep and narrow. The length of the main spines varies. They are somewhat shorter to somewhat longer as the shell diameter. The vertices of the pore frames bear needle-like spinules of different length. The internal spicular system is very robust, point-centred and somewhat eccentric. It consists of 7 spines

that are connected with the 7 main spines. The spines of the spicular system are tricarinate (except their needle-like innermost parts) and become distinctly wider toward the base of the main spines.

Measurements:
Diameter of shell. 200-280 µm
Length of the main spines: 150-320 µm
Length of the by-spines: 28-60 µm

Occurrence: Dienerian and lower Smithian of the type locality.

Remarks: *Stigmosphaerostylus turkensis* n.sp. has a robust spicular system that is rather typical or Paleozoic Hexastylacea, whereas Mesozoic and Cenozoic Hexastylacea have in general a fragile, needle-like internal spicular system.

Most similar is *Stigmosphaerostylus nikorni* (SASHIDA & IGO, 1992) from the basal Anisian *Chiosella timorensis* Zone of Thailand. In this species the internal spicular system is more fragile (needle-like throughout their length, not distinctly broader near the base of the main spines). Moreover, the spicule is six-rayed. The 6–8 main spines taper gradually in distal direction.

Stigmosphaerostylus recticulata (SASHIDA & TONISHI, 1985) from the Upper Permian of Japan has similar pore frames, but the shell is smaller, the spicular system is bar-centred and displays only 6 rays that are connected to 6 main spines.

Suborder Spumellaria EHRENBERG, 1875
Superfamily Sponguracea HAECKEL, 1862
emend. KOZUR & MOSTLER, 1981

Family, genus and spec. inc.
(Pl. 1; Figs. 7,8)

Remarks: Several spherical and ellipsoidal spongy radiolarians occur that have no external spines. Their shell consists of a thick spongy meshwork that fills nearly the entire test. The spherical and ellipsoidal forms belong probably to two different taxa. *Cenosphaera* sp. aff. *andoi* SUGIYAMA from the Spathian of Japan (NAGAI & MIZUTANI, 1993) may be identical with the spherical forms.

Arrangement in spongy shells cannot be observed in the present material (? because of the bad preservation) and consequently an assignment to the Oertlispongidae KOZUR & MOSTLER, 1980 (in DUMITRICĂ et al., 1980) is not possible. But they may be the ancestral forms of both the Oertlispongidae and Archaeospongoprunidae that begin both in the Lower Anisian.

Phylum Porifera GRANT, 1836
Class Hexactinellida SCHMIDT, 1870
Order Lyssakida ZITTEL, 1877

Pentactine spicules
(Pl. 2, Figs. 1–7)

Description: Smooth pentactine spicule. The four cross-like arranged paratangential rays (arranged in one plane) differs in their length. The proximal ray (rhabd) is broader and longer. It is situated perpendicular to the paratangential rays. Sometimes the paratangential rays are curved in direction to the rhabd (Pl. 2, Fig. 7). All spines become slowly, but continuously narrower from their common base to their distal ends.

Hexactine spicules
(Pl. 2, Fig. 8)

Remarks: Except the very short sixth spine opposite to the rhabd, this very rare spicule is very similar to the common pentactine spicule.

4. Discussion

Radiolaria were very strongly affected by the Permian-Triassic biotic crisis. Whereas radiolarians are still common and divers in the uppermost Changxingian, they are nearly missing in the Lower Scythian. Even in the Panthalassa Ocean, the organic silica production was interrupted during the Lower and Middle Scythian. The only reported exception from the absolute minimum in radiolarian diversity and the absence of cherts is southwest Yunnan of southwest China (FENG,

QINGLAI, 1992, FENG, QUINGLAI & LIU, BENPEI, 1993 a). According to these authors, the Muyinhe Formation of latest Permian to Middle Triassic age consists of radiolarites that are also uninterrupted present at the Permian-Triassic boundary and in the lower Scythian. Between the Upper Changxingian radiolarian fauna of sample My 30 and the assumed earliest Scythian sample My 27 are less than 20 cm of bedded cherts and shales. However, the *"Shengia yini* assemblage" of assumed lowermost Scythian is a typical Middle Triassic assemble. *Shengia yini* (FENG) is a specifically indeterminable totally recystallized *Triassocampe. Triassocampe soror* FENG & LIU that is rarely present in the "*Shengia yini* assemblage" and *Shengia nanpanensis* FENG & LIU that was reported from the upper part of the "*Shengia yini* assemblage", are both junior synonyma of *Triassocampe scalaris* DUMITRICĂ, KOZUR & MOSTLER. This species begins in the upper subzone of the uppermost Anisian *Spongosilicarmiger transitus* Zone (*Yeharaia annulata* Subzone). *Shengia solida* FENG that occurs in the "*Shengia yini* assemblage" and in the overlying assemblage, is a junior synonym of *Triassocampe deweveri* (NAKASEKO & NISHIMURA), a typical *Triassocampe* of the *S. transita* Zone that occurs also in the next younger zone, but not yet in the underlying *Tetraspinocyrtis laevis* Zone. *Yangia* sp. B from the lower "*Shengia yini* assemblage" is a *Paroertlispongus raridentatus* KOZUR & MOSTLER that also begins in the basal part of the *S. transitus* Zone and continues in the overlying *S. italicus* Zone. *Palaeoeucyrtis elongata* FENG comprises isolated main spines of *Paroertlispongus multispinosus* KOZUR & MOSTLER that typically becomes somewhat broader in distal direction. This species occurs in the uppermost Anisian *S. transita* Zone and in the Lower Ladinian. The isolated occurrence of the main spines of *Oertlispongus* and *Paroertlispongus* is a very typical preservation of oertlispongids. The more tumid isolated spines that were described as *Palaeoeucyrtis fusina* FENG are isolated spines of intermediellids (also a frequent preservation of different Intermediellidae taxa). A part of these spines can be assigned to *Paurinella* because *P. fusina* with corroded, but still present shell was found in the *Tiborella florida* Subzone of the *Spongosilicarmiger transitus* Zone of late Illyrian age. The oldest *Paroertlispongus* (*P. diacanthus* SUGIYAMA, 1992) is known from the Lower Anisian of Karaburun peninsula (Turkey), but species in which the main polar spine that becomes broader in distal direction (*P. multispinosus*) appeared only in the upper Illyrian *S. transitus* Zone. Also *Paurinella* with *P. fusina* (FENG) and the perhaps partly identical *P. sinensis* (FENG) begins in the *S. transitus* Zone. *Praeyeharaia japonica* (NAKASEKO & NISHIMURA) from the lower „*Shengia yini* assemblage" occurs in the latest Anisian *S. transita* Zone and in the Lower Ladinian. A similar range has *Paroertlispongus chinensis* (FENG) that occurs in the upper "*Shengia yini* assemblage" and in the next younger assemblage of southwest Yunnan. In the European Tethys it occurs in the *S. transitus* Zone and in the lower part of the *Spongosilicarmiger italicus* Zone. Consequently, all determinable species of the "*Shengia yini* assemblage" occur in well dated radiolarian associations in the uppermost Anisian *S. transita* Zone and in the Lower Ladinian *S. italicus* Zone; partly they range to the middle Fassanian. *Paurinella fusina* seems to be restricted to the *S. transitus* Zone and therefore a latest Anisian age can be assumed for the "*Shengia yini* assemblage".

An assignment of the "*Shengia yini* assemblage" to the *S. transitus* Zone and not to the Lower Ladinian *S. italicus* Zone is confirmed by the age of the overlying "*Pseudoeucyrtis liui* assemblage" that belongs definitely to the upper *S. transita* Zone. *Pseudoeucyrtis liui* FENG is a junior synonym of *Archaeospongoprunum mesotriassicum* KOZUR & MOSTLER that has its uppermost range in the *S. transita* Zone, as *Tiborella anisica* (determined as *Cecrops floridus* NAKASEKO & NISHIMURA). *Paurinella sinensis* (FENG) is so far only known from the *S. transita* Zone and several species of the „*Pseudoeucyrtis liui* assemblage" have their first appearance in the *S. transita* Zone, as *Triassocampe deweveri*, *T. scalaris*, *Paroertlispongus hermi* (junior synonyma are discussed under "*Shengia yini* assemblage") and *Eptingium manfredi manfredi* DUMITRICĂ, all present in the „*Pseudoeucyrtis liui* assemblage". This is a typical association of the uppermost Anisian upper *S. transita* Zone (see KOZUR, 1995 c). The "*Pseudoeucyrtis liui* assemblage" was assigned by FENG, QINGLAI (1992) and FENG, QINGLAI & LIU, BENPEI (1993 a) to the late Early Triassic.

As pointed out above, both the assumed lowermost Scythian "*Shengia yini* assemblage"" and the assumed Upper Scythian "*Pseudoeucyrtis liui* assemblage" belong to the uppermost Anisian *S. transitus* Zone sensu Kozur (1995 c). Consequently, upper Changxingian radiolarites are immediately overlain by Upper Anisian radiolarites in the Muyinhe Formation. An other possibility is that the entire Muyinhe Formation is Middle Triassic and the uppermost Changxingian radiolarian fauna at the base of this formation is reworked. In any case, the so-called "early Early Triassic" *Shengia yini* assemblage is in reality a typical uppermost Anisian fauna. As clearly recognizable in the Shangsi section, also in southwest China the rich uppermost Changxingian radiolarian faunas disappear suddenly at the base of the Transitional Beds somewhat below the P/T boundary and the Lower Scythian sediments have not yielded any radiolarians and radiolarites.

The first Dienerian and lower Smithian Radiolaria that were found in Turkey fits well in this picture of a strong crisis in the radiolarian evolution at the P/T boundary and of a very slowly recovery of the radiolarian fauna after this crisis. Only primitive Entactinaria and Spumellaria are present and no more than 3 taxa were found. Only one species, the entactinarian *Stigmosphaerostylus turkensis*, is common.

All characteristic Upper Paleozoic radiolarians except Entactinaria and primitive Spumellaria disappeared at the P/T boundary. The presence of Albaillellacea in the Upper Scythian of the Sichote Alin (BRAGIN 1991) could not be confirmed. Reexamination of the locality with Spathian Albaillellacea by one of the authors (KOZUR) has shown that the radiolarites show strong reworking of older radiolarites and contain Permian-Triassic mixed faunas as known also from several Triassic radiolarites of Japan.

Especially important is the absence of Nassellaria in the Lower and Middle Scythian of Turkey, but also in the Middle Scythian of Oregon (BLOOME & REED, 1992). As discussed below, the Nassellaria have evolved within the Upper Scythian from spicular radiolarians without shell. Nassellaria-like radiolarians from the Carboniferous are probably pylomate Entactinaria. For multicyrtide forms this explanation is not sure, but they are absent not only in nearly the entire Scythian (except rare occurrences of one multicyrtid radiolarian genus in the uppermost Scythian of Japan), but also in very rich radiolarian associations of the Permian.

Only in the Upper Scythian (Spathian), the first radiolarites were found in shale-radiolarite sequences of Panthalassa. However, still in that time the radiolarian fauna was not very diverse and consists mainly of Entactinaria (with and without shell, moderately diverse fauna). *Archaeosemantis* DUMITRICĂ, *Archaeothamnulus* DUMITRICĂ, *Cryptostephanidium* DUMITRICĂ, *Tiborella* DUMITRICĂ, KOZUR & MOSTLER, primitive *Parasepsagon* KOZUR & MOSTLER, primitive *Parentactinia* DUMITRICĂ, *Pentabelus* SUGIYAMA, primitive *Pseudostylosphaera* KOZUR & MOSTLER, *Stigmosphaerostylus* and *Tetrarhopalus* SUGIYAMA are present among the Entactinaria and all these genera are also present in the Anisian. Spumellarian and nassellarian Radiolaria are still rare, have a low diversity and are represented by primitive forms. Typical Oertlispongidae are still missing and the Spumellarian fauna is represented by primitive Pantanelliidae PESSAGNO (*Ellipsoxiphus* DUNIKOWSKI), primitive Actinommidae (*Pegoxystris* SUGIYAMA), *Plafkerium* ? *antiquum* SUGIYAMA and the above mentioned primitive Sponguracea (fam. et gen. inc., see chapter 3.).

The Spathian Nassellaria are represented by *Poulpus* DE WEVER, *Hozmadia* DUMITRICĂ, KOZUR & MOSTLER, and very rarely primitive *Hinedorcus* DUMITRICĂ, KOZUR & MOSTLER, *Tripedocorbis* DUMITRICĂ and *Zevius* SUGIYAMA are present, all also known from the Anisian. The first Nassellaria of the lower Spathian are primitive monocyrtid Sanfilippoellidae KOZUR & MOSTLER, 1979 (= Poulpidae DE WEVER, 1981, see KOZUR & MOSTLER, 1994). They often have a very loose shell and derived apparently from spicular Entactinaria and not from the Carboniferous Pylentonemidae DEFLANDRE as formerly assumed. This is in agreement with the presence of a medullary shell in *Pylentonema* DEFLANDRE (CHENG, 1986, SUGIYAMA, 1992). A medullary shell is absent in all Nassellaria, but present in many Entactinaria. Consequently, the similarities between the Sanfilippoellidae and the Pylentonemidae indicate only homeomorphy. The Pylentonemidae are therefore pylomate Entactinaria. This explains the total absence of Nassellaria during the Upper Carboniferous, Permian, Lower and Middle Scythian.

Also a part of the Spathian and younger Entactinaria evolved during the Spathian from spicular Entactinaria without shell. This is the case for *Parasepsagon leptaleus* SUGIYAMA, *Parentactinia nakatsugawaensis* SASHIDA, *P. ramosa* (SASHIDA), *P. okuchichibuensis* (SASHIDA), *Pentabelus furutanii* SUGIYAMA, *Pentactinorbis ? biacus* (SUGIYAMA), *P. ? crux*, (SUGIYAMA), *Tetrarhopalus itoigawai* SASHIDA and *Pseudostylosphaera kozuri* SUGIYAMA. But also *Spongostephanidium longispinosum* SASHIDA has a rather loose shell. For this reason, *Stigmosphaerostylus* is apparently the only Entactinaria genus with shell that survived the Permian-Triassic boundary.

The siliceous sponge spicules are as monotonous as the radiolarian fauna. They represent exclusively Hexactinellida (Lyssakida) with very low diversity. May be only one species is present.

The oldest Triassic siliceous sponge faunas of the Southern Alps and Northern Alps (Middle Triassic) consists always exclusively of Hexactinellida, independent from their age. They are always smooth hexactine spicules or smooth pentactine spicules with few hexactine spicules, like our fauna from the Lower Scythian of Turkey. Fully preserved Hexactinellida consist of dictyonal fused skeletons.

These hexactinellid sponges of the Triassic are pioneer faunas among the siliceous sponges at the beginning of a new siliceous sponge settlement after destruction of the former sponge communities due to tectonic or other events or by forming of a new marine sedimentation area. Only in an advanced stage of the pioneer settlement the first Demospongia appeared in these communities.

The Dienerian to lower Smithian siliceous sponges of Igdir (Turkey) are such a typical pioneer fauna after the strong faunal crises in the siliceous sponges near the P/T boundary. They are the oldest known Triassic siliceous sponge faunas after the Permian-Triassic biotic crisis. A similar siliceous sponge pioneer fauna in the western USA is of Spathian age (RIGBY & GOSNEY, 1983).

Acknowledgements

The investigations by H. KOZUR were sponsored by the Deutsche Forschungsgemeinschaft. We thank very much for this important help. We gratefully acknowledge the Jubiläumsfonds of the Österr. Nationalbank (Project No. 5065) for financial support.

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Plate 1

All figured specimens are from sample K 7323, a thin-bedded black marly limestone within dark shales and siltstones from a Scythian block of a locality 500 NE of Igdir (NE of Bursa, northwestern Turkey); upper Dienerian or lower Smithian.

Figs. 1–6: *Stigmosphaerostylus turkensis* n. sp.; Fig. 1: holotype, x 100, rep.-no. 4-8-95/I-11; Fig. 2: x 150, rep.-no. 4-8-95/I-22; Fig. 3: x 100, rep.-no. 4-8-95/I-19; Fig. 4: opened specimen with visible spicular system, x 200, rep.-no. 4-8-95/I-24; Fig. 5: opened specimen with well visible spicular system, x 200, rep.-no. 4-8-95/I-12; Fig. 6: fragment with visible spicular system, x 250, rep.-no. 4-8-95/I-13.

Fig. 7: Sponguracea, gen. et spec. indet., subspherical morphotype, x 200, rep.-no. 4-8-95/I-15.

Fig. 8: Sponguracea, gen. et spec. indet., ellipsoidal morphotype, x 200, rep.-no. 4-8-95/I-16.

Fig. 9: *Spinotriassocypris* sp., carapace from right, anterior end above, x 100, rep.-no. 4-8-95/I-25.

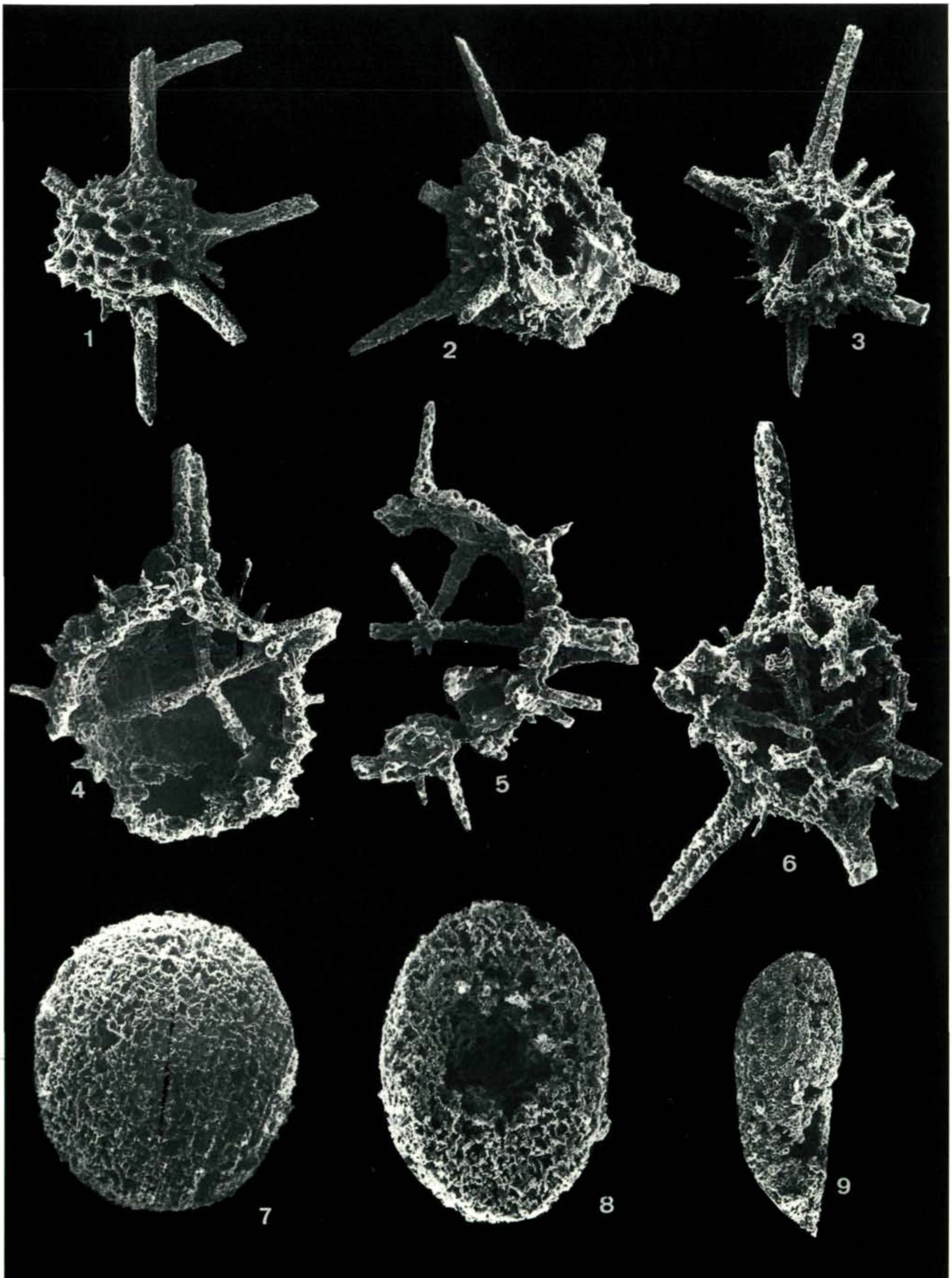
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Plate 2

All figured specimens are from thin-bedded black marly limestone within dark shales and siltstones, from a Scythian block of a locality 500 NE of Igdir (NE of Bursa, northwestern Turkey). Figs. 1–9: Sample sample K 7323, upper Dienerian or lower Smithian; Figs. 10-12: sample K 7324, Dienerian.

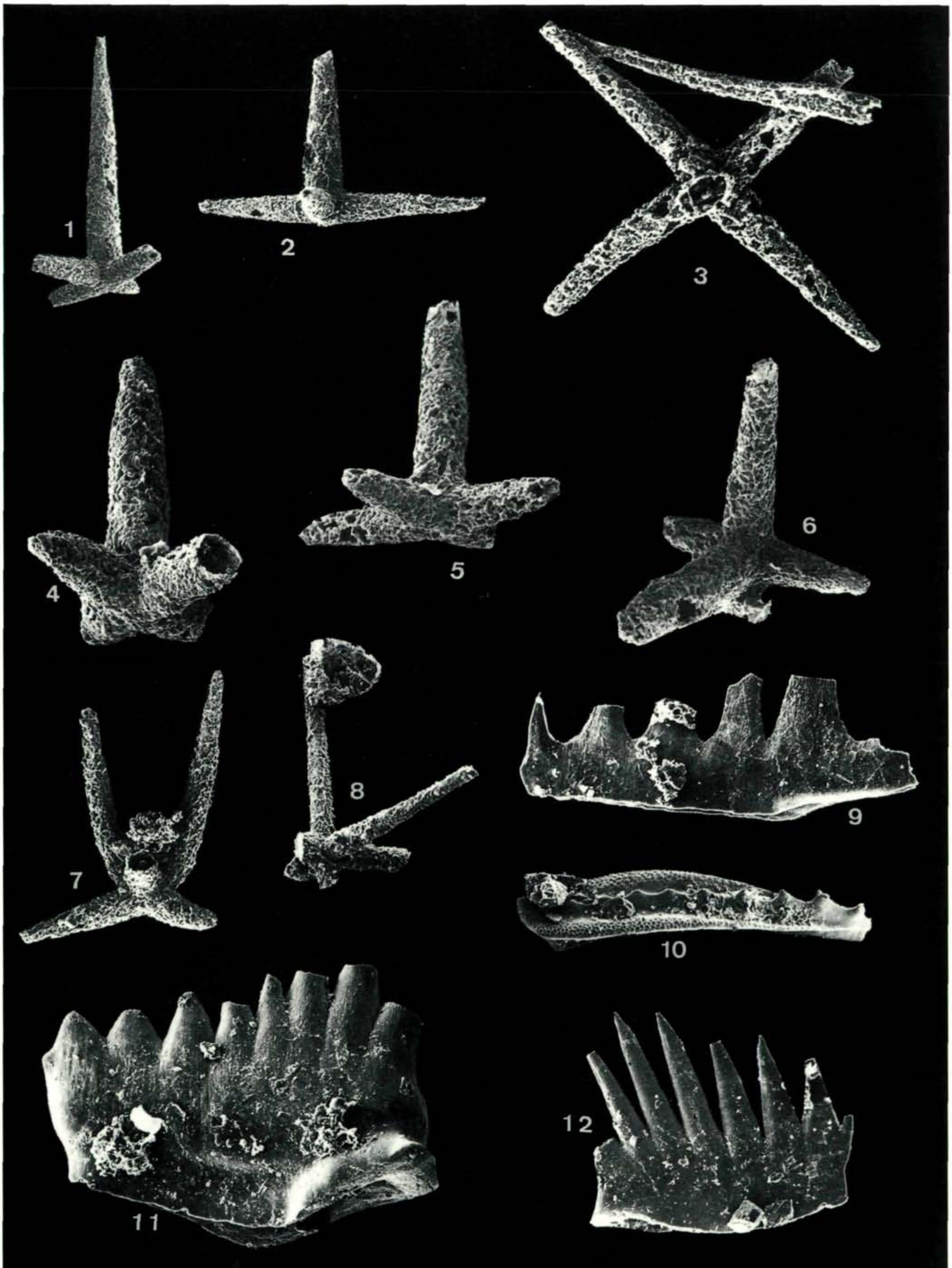
Figs. 1–7: Pentactine spicule of Lyssakida; Fig. 1, x 100, rep.-no. 4-8-95/I-32; Fig. 2: x 100, rep.-no. 4-8-95/I-27; Fig. 3: x 170, rep.-no. 4-8-95/I-20; Fig. 4: x 200, rep.-no. 4-8-95/I-30; Fig. 5: x 200, rep.-no. 4-8-95/I-31; Fig. 6: x 200, rep.-no. 4-8-95/I-26; Fig. 7: specimen, in which the paratangential rays are curved in direction of the rhabd, x 100, rep.-no. 4-8-95/I-26.

Fig. 8: Hexactine spicule of Lyssakida, x 100, rep.-no. 4-8-95/I-29.

Fig. 9: *Neospathodus conservativus* (MÜLLER), Pa element, x 150, rep.-no. 4-8-95/I-18.

Fig. 10: *Clarkina procerocarinata* KOZUR, oblique lateral-upper view, x 100, rep.-no. 4-8-95/V-12.

Figs. 11–12: *Neospathodus dieneri* SWEET, Pa element; Fig. 10: x 150, rep.-no. 4-8-95/I-5; Fig. 11: x 150, rep.-no. 4-8-95/I-9.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