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UPPER JURASSIC RADIOLARITES OF THE CZERTEZIC SUCCESSION AND COMPARISON WITH THE KYSUCA SUCCESSION IN THE EAST-SLOVAK PART OF THE PIENINY KLIPPEN BELT (WESTERN CARPATHIANS, SLOVAKIA)

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Abstract: In the more shallow-water Czertezic Succession, the stratigraphical interval of maximum deepening of the Pieniny sedimentary basin in the Upper Jurassic is not represented by typical radiolarite sequences with radiolarians, representing middle Callovian–early Oxfordian to late Oxfordian–early Kimmeridgian (U.A.Zone 8–U.A.Zone 10), as we can observe in the deep-water Kysuca Succession, but by radiolarian limestones with radiolarian cherts and irregular layers of radiolarites. Their sedimentation began here only in the Oxfordian. The radiolarian microfauna is of middle-late Oxfordian to late Oxfordian–early Kimmeridgian age (U.A.Z.9–U.A.Z.10). In four sections in the locality Litmanová fifty-eight taxons and one new species *Archaeospongoprunum mizutanii* Ožvoldová, n.sp. were identified in the assemblages. The high content of spumellarians (70–80 %) could reflect the paleogeographical and paleoceanographical conditions of sedimentation.

Key words: Jurassic, Western Carpathians, Pieniny Klippen Belt, radiolarian limestones, radiolarites, radiolarians.

Introduction

The first data on radiolarian microfauna from radiolarites of the studied area were provided during the geological research of Nemčok et al. (1986) by Ondrejíčková (1985). The radiolarian assemblages were regarded as late Middle Jurassic–early Late Jurassic in age.

Further investigation was performed by Ožvoldová & Frantová (1997) in the Podsadek locality near Stará Ľubovňa in the Pieniny part and the Šarišské Jastrabie, Kyjov, Lúčka and Milpoš localities in the Šariš part of the Pieniny Klippen Belt (Fig. 1b,c).

The study of the Litmanová locality sections (Fig. 1c,d) described in this paper is further continuation of the radiolarian research in this area.

Geological setting

The Pieniny Klippen Belt is an unusually long zone of complicated structure, separating the Flysh Belt of the Outer Carpathians from the Inner Carpathians. This zone is marked by rigid blocks of Jurassic-Lower Cretaceous rocks, flowing in a soft Late Cretaceous-Paleogene matrix. The Jurassic/Lower Cretaceous Kysuca-Pieniny Succession is developed in pelagic facies, while the Czorsztyn Succession is represented by a swell facies suite. The Czertezic and Pruské (Niedzica) Successions with slope deposits are the transitional successions between these two units.

The radiolarites in the studied area occur in the Kysuca and Czertezic Successions. According to the determination of Birkenmajer (1977) they can be assigned to the Sokolica Radiolarite Formation (grey-green, dark-grey or black radiolarites with typical coatings of Mn-minerals) and to the Czajakowa Radiolarite Formation (the middle part — green radiolarites of Podmajerz Radiolarite Member and the upper part — upper red radiolarites of Buwald Radiolarite Member). They underlie the Czorzstyn Limestone Formation.

Lithostratigraphy

Ožvoldová & Frantová (1997) studied radiolarites in the Lúčka, Šarišské Jastrabie and Kyjov localities, belonging to the Kysuca Succession and in the Podsadek near Stará Ľubovňa and Milpoš localities, representing the Czertezic Succession (Fig. 1b,c).

The radiolarites of the Kysuca Succession are non-calcareous or slightly calcareous (max. 0.36 % of CaO) and separated by thin shale intercalations. In the lower part they are of a brown-grey and green-grey colour, sometimes with a rusty-red part, with black-blue coatings of Mn minerals (max. value 3.16 % of Mn), typical for the Sokolica Radiolarite Formation. The Mn coatings disappear in the upper part and green-grey radiolarites (Podmajerz Radiolarite Member) and rusty red radiolarites (Buwald Radiolarite Member) of the Czajakowa Radiolarite Formation overlie them. They are overlain by Kimmeridgian red nodular limestones of the Czorsztyn Limestone Formation. Underlying rocks are not exposed in this area.

Radiolarites of the Czertezic Succession, representing the Czajakowa Radiolarite Formation include a large quantity of radiolarian limestone layers and the irregular layers of radiolarites mostly have a fair calcareous admixture. They overlie crinoidal limestones and underlie Kimmeridgian-Tithonian limestones.

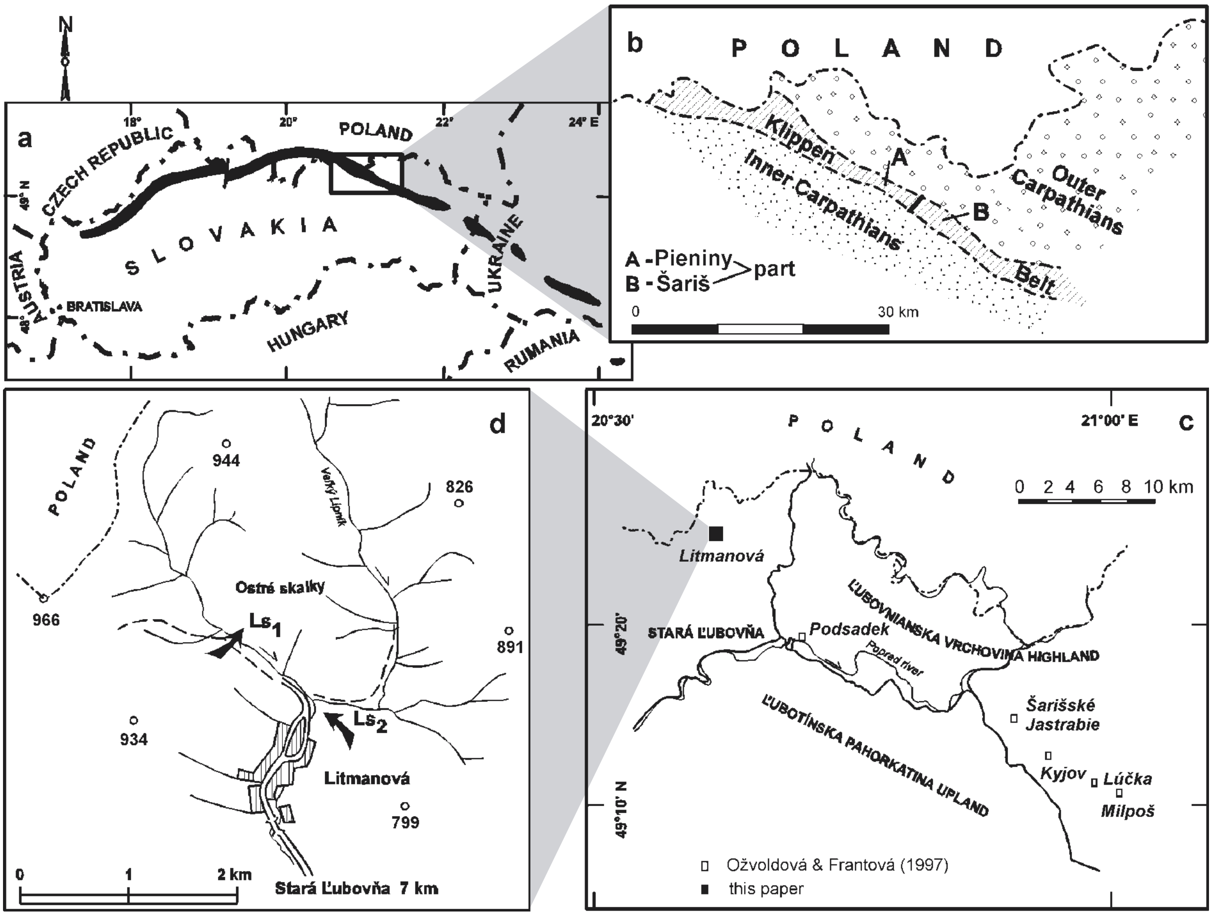


Fig. 1. a — Location of the investigated area, **b** — geological outline of this area, **c** — situation of the studied localities, **d** — location of Litmanová sections (Ls_1, Ls_2).

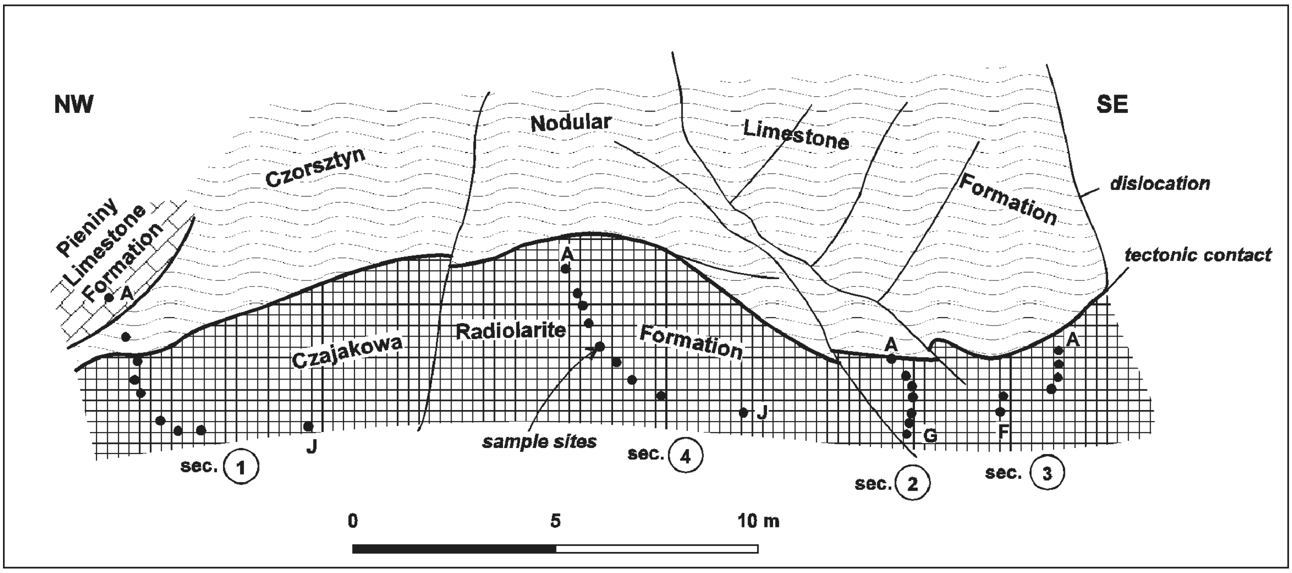


Fig. 2. Location of the sections and sampling in Litmanová Ls_1.

The next locality with the occurrence of radiolarites of the Czertezic Succession is Litmanová, situated in the Pieniny part of the Pieniny Klippen Belt (Fig. 1b), ca. 10 km North of Stará Ľubovňa. The lithostratigraphical character of the sequences of the Czertezic Succession in this locality was described by Scheibner (1966).

In the klippe Ls_1 (Fig. 1d), which occurs ca. 1 km NW from the Litmanová village radiolarian limestones and radiolarites

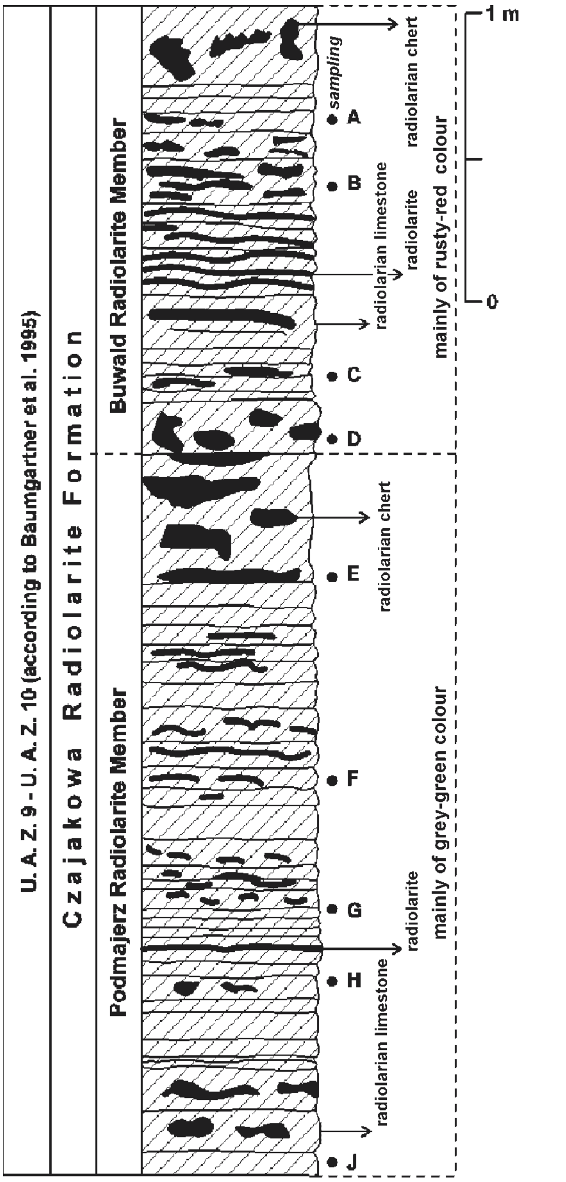


Fig. 3. Lithostratigraphical column of section 4 in Litmanová Ls_1.

(the Czajakowa Radiolarite Formation) underlie Kimmeridgian red nodular limestones of the Czorsztyn Limestone Formation. The underlying strata are not exposed in this klippe, but the same radiolarites overlie crinoidal limestones (Krupianka Limestone Formation according to Birkenmajer 1977) at the northern end of Litmanová village (Fig. 1d–Ls_2). Red nodular limestones are overlain by Tithonian pelagic limestones of the Pieniny Limestone Formation (according to Birkenmajer 1977), occurring in the left part of the outcrop only (Fig. 2, section 1).

Samples for the radiolarian research (38) were taken from four sections (nos. 1, 2, 3, 4 — Fig. 2). The Czajakowa Radiolarite Formation is formed by silicified marly limestones with radiolarians (radiolarian wackestone-packstone) and with radiolarian cherts and irregular layers (3–5 cm, max.15 cm) of mostly calcareous radiolarites. The lower part of this strata is mainly of a grey-green or pink-grey colour (Podmajerz Radiolarite Member) and the upper part has a rusty-red colour (Buwald Radiolarite Member). The border between these two members is not sharp. The max. thickeness of the exposed part of these layers is approx. 4 m (section 4, Fig. 2). The lithostratigraphical column of the section 4 is shown in Fig. 3.

Overlying Kimmeridgian red nodular limestones with nodules and irregular layers of a rusty-red radiolarite (Fig. 2, sec. 1, samp. C) contain filaments (juvenile shells of *Bositra),* *Saccocoma*, mainly calcified radiolarians, aptychi and juvenile amonites (filament-*Saccocoma*-radiolarian packstone).

The whole complex, as well as the contacts between individual lithological parts are affected by tectonic movements.

The largest tectonic reduction of the thickness of radiolarian limestones with radiolarites is in the section 3, where only the lower part of the strata of grey-green colour occurs.

The lithostratigraphical correlation of the Litmanová sections (L4, L1) of the Czertezic Succession and Šarišské Jastrabie sections (ŠJP, ŠJDD) of the Kysuca Succession is shown in Fig. 4.

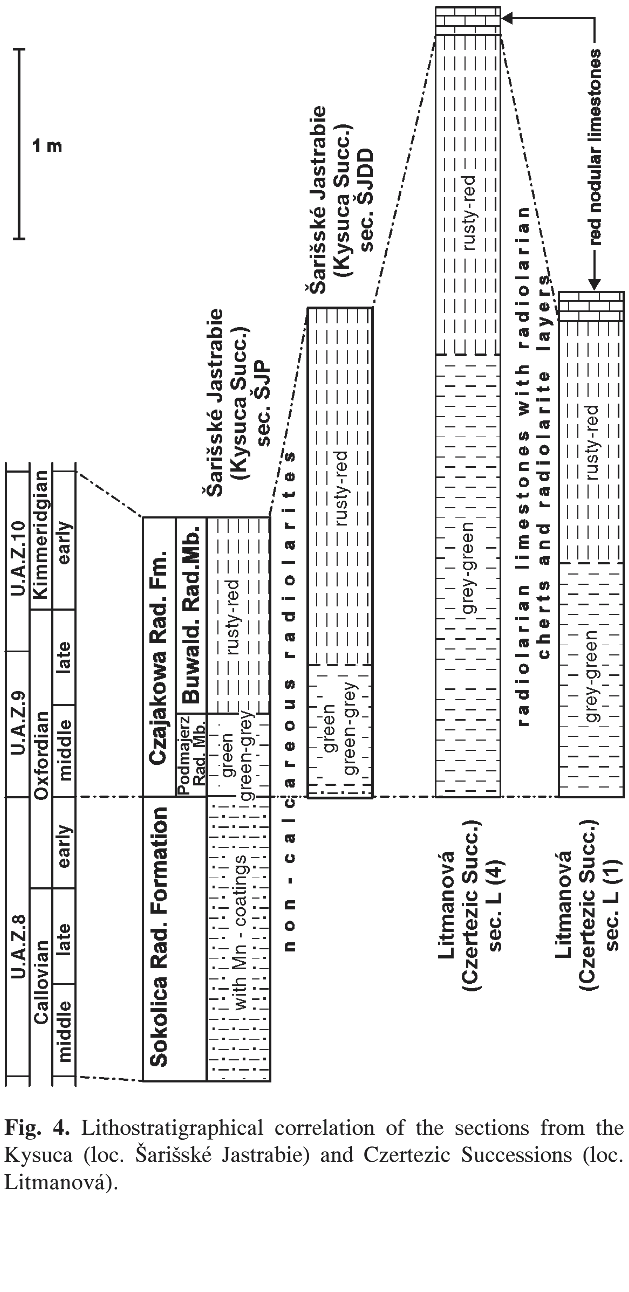


Fig. 4. Lithostratigraphical correlation of the sections from the Kysuca (loc. Šarišské Jastrabie) and Czertezic Successions (loc. Litmanová).

Biostratigraphy

Radiolarians from the siliceous and siliceous-calcareous samples were extracted with 5 % HF (1–2 days). Calcareous samples were treated with 5 % HCl or 12 % acetic acid. After sieving through 40 μm screen and drying residue was prepared for picking up of specimens under the binocular microscope. Species determination was made by SEM.

The biostratigraphical evaluation of radiolarian assemblages was based on the biozonation of Baumgartner et al. (1995).

Well preserved radiolarians from radiolarites of the Kysuca Succession in the locality Šarišské Jastrabie represent U.A.Z.8 — middle Callovian–early Oxfordian in the lower part and U.A.Z.9–U.A.Z.10 — middle-late Oxfordian to late Oxfordian–early Kimmeridgian in the upper part of the sections. A poor radiolarian assemblage from the locality Lúčka shows the stratigraphical range — U.A.Z.9–U.A.Z.10 — middle-late Oxfordian to late Oxfordian–early Kimmeridgian. The important result is the fact, that the radiolarites with the Mn coatings (Sokolica Radiolarite Formation) extend in the section ŠJDD (loc. of Šarišské Jastrabie) (Fig. 4) to middle Oxfordian (on the basis of the presence of the species *Podocapsa amphitreptera* Foreman). If we compare the composition of assemblages, we can observe the gradual increase of spumellarian abundance from the stratigraphic interval U.A.Z.8 to U.A.Z.10 — middle Callovian–early Oxfordian to late Oxfordian–early Kimmeridgian. In the locality Kyjov, sample from a scree contain radiolarians, representing U.A.Z.8–U.A.Z.10.

Radiolarian limestones with radiolarite layers of the Czertezic Succession in the Podsadek locality near Stará Ľubovňa contain radiolarians, which indicate the middle-late Oxfordian to late Oxfordian–early Kimmeridgian age (U.A.Z.9–U.A.Z.10). A very poor radiolarian assemblage from the Milpoš locality shows, that it is not older than U.A.Z.9 ranging from middle to late Oxfordian.

In the Litmanová locality radiolarians occur in all the samples taken (38), but the possibility of their preparation was complicated by frequent calcification of the tests or occurrence of molds only.

In the klippe Ls_1, sections no. 4 and no. 1 (Fig. 1d, Fig. 2) were the most suitable for the study of radiolarian microfauna. Spumellarians strongly prevail in the assemblages (70–80 %) (Pls. I–III). The quantitative composition of sample 4A from section no. 4 shows, that *Emiluvia*, a representative of the *Hagiastridae* family and *Archaeospongoprunum* are dominant (Fig. 5). In the last mentioned genus, *Archaeospongoprunum mizutanii* Ožvoldová, n.sp. is relatively abundant. In section 1, radiolarian microfauna is much more poorly preserved.

The assemblages in sections 4 and 1 (Fig. 6) represent the following U.A.Zones and the stratigraphic ranges in order from the lower to the upper part of the sections:

Section 4

Sample 4J — U.A.Z.9–U.A.Z.10 — middle-late Oxfordian to late Oxfordian–early Kimmeridgian, (the species *Emiluvia ordinaria* Ožvoldová with *Paronaella mulleri* Pessagno and *Tritrabs casmaliaensis* (Pessagno));

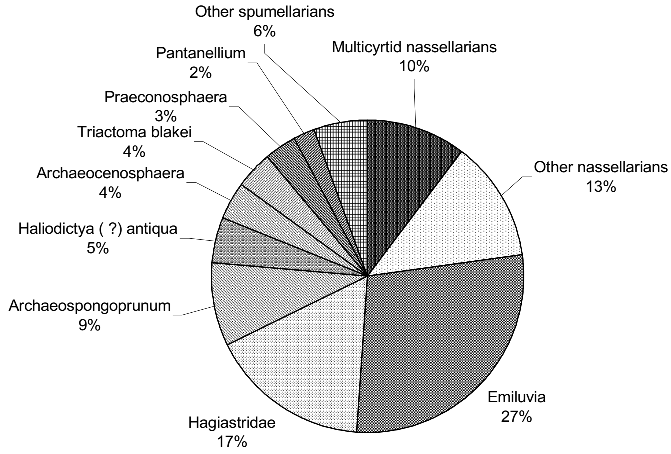


Fig. 5. Quantitative composition of radiolarians in the assemblage of sample 4A (Litmanová — Ls_1, sec. 4).

Sample 4G — U.A.Z.9–U.A.Z.10 — middle-late Oxfordian to late Oxfordian–early Kimmeridgian, (the species *Fultacapsa sphaerica* (Ožvoldová) with *Tritrabs casmaliaensis* (Pessagno));

Sample 4F — U.A.Z.8–U.A.Z.10 — middle Callovian–early Oxfordian to late Oxfordian–early Kimmeridgian (the species *Paronaella broennimanni* Pessagno with *Emiluvia orea* Baumgartner);

Sample 4D — U.A.Z.10–U.A.Z.11 — late Oxfordian–early Kimmeridgian to late Kimmeridgian–early Tithonian (the species *Paronaella pristidentata* Baumgartner with *Crucella theokaftensis* Baumgartner and *Haliodictya* (?) *antiqua* (Rüst));

Sample 4A — U.A.Z.10 — late Oxfordian–early Kimmeridgian (the species *Paronaella pristidentata* Baumgartner with *Pseudocrucella adriani* Baumgartner, *Paronaella mulleri* Pessagno, *Paronaella broennimanni* Pessagno and *Tritrabs casmaliaensis* (Pessagno)). The new species *Archaeospongoprunum mizutanii* Ožvoldová, n.sp. was described in the sample.

Section 1

Sample 1J — U.A.Z.9–U.A.Z.10 — middle-late Oxfordian to late Oxfordian–early Kimmeridgian (the species *Fultacapsa sphaerica* (Ožvoldová) with *Paronaella broennimanni* Pessagno);

Sample 1G — U.A.Z.8–U.A.Z.10 — middle Callovian–early Oxfordian to late Oxfordian–early Kimmeridgian (the species *Emiluvia orea* Baumgartner with *Paronaella mulleri* Pessagno);

Sample 1D — U.A.Z.9–U.A.Z.10 — middle-late Oxfordian to late Oxfordian–early Kimmeridgian (the species *Emiluvia ordinaria* Ožvoldová with *Paronaella mulleri* Pessagno);

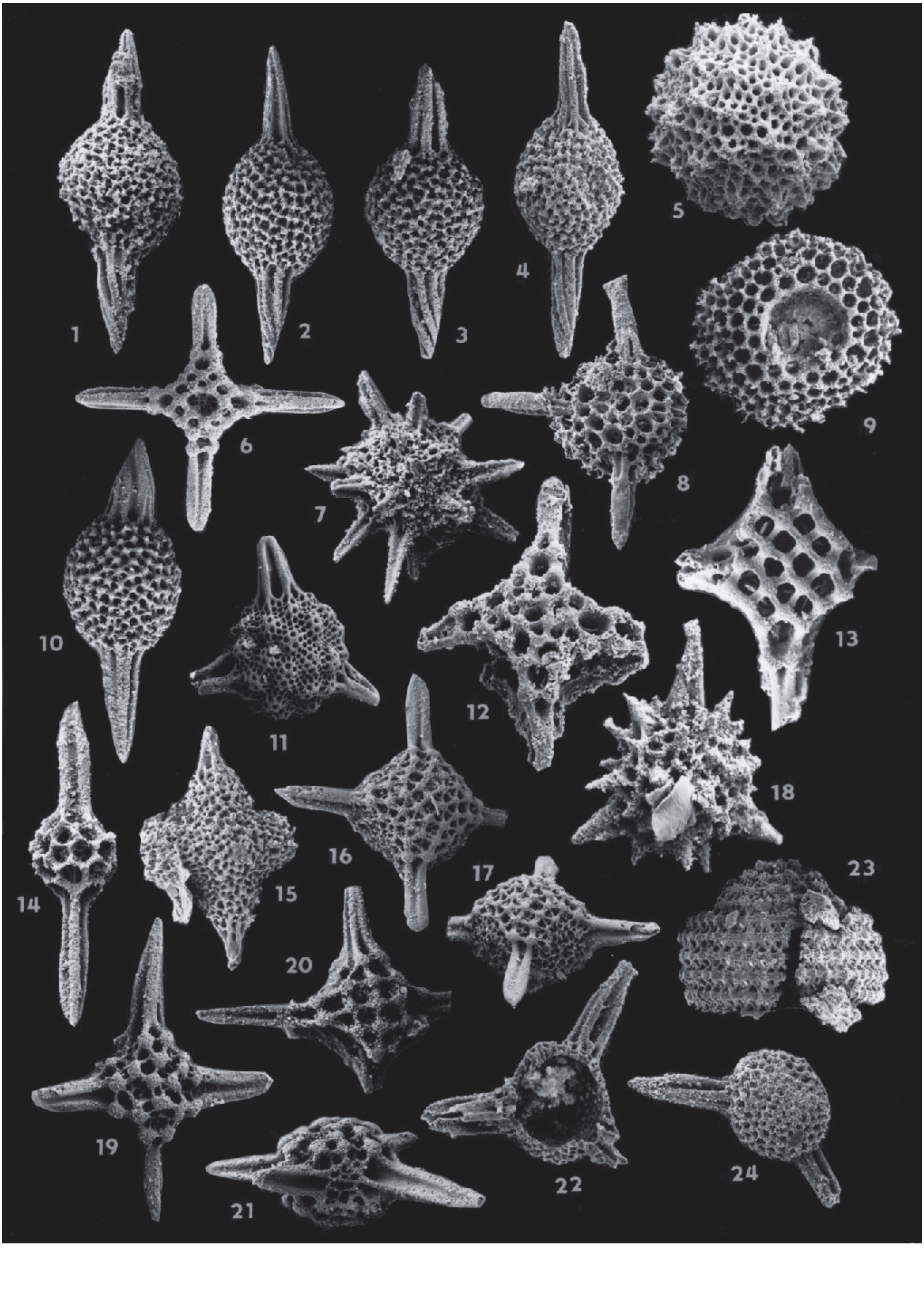
Sample 1A — U.A.Z.9–U.A.Z.10 — middle-late Oxfordian to late Oxfordian–early Kimmeridgian (the species *Angulobracchia biordinalis* Ožvoldová with *Paronaella broennimanni* Pessagno);

			Section n.4					Section n.1				
Samples / **Radiolarian fauna**	**4A**	**4D**	**4F**	**4G**	**4H**	**4J**	**1C**	**1D**	**1F**	**1G**	**1H**	**1J**
Acastea diaphorogona (Foreman)	rare					rare			*			
Acanthocircus trizonalis (Rüst)	rare		rare			rare		*			*	
Actinomma siciliensis Kito et De Wever	rare					rare	*					
Alievium (?) echinus Dumitrica	rare					rare						
Angulobracchia biordinalis Ožvoldová	common	rare										
Archaeocenosphaera sp.	common	rare	rare		rare	common	*	*		*		
Archaeodictyomitra patricki Kocher	rare											
Archaeospongoprunum imlayi Pessagno	common	common				common	*		*	*		*
Archaeospongoprunum mizutanii n.sp.	abundant	common	rare		common	abundant						
Archaeospongoprunum sp.	abundant	common	rare	rare		common						
Complexapora tirolica Kiessling	rare	rare										
Crucella angulata Yang	rare											
Crucella theokaftensis Baumgartner	common	rare										
Crucella sp.	common			rare								
Emiluvia grandipora (Ožvoldová)	common								*			
Emiluvia chica Foreman	rare	common			rare	common						
Emiluvia ordinaria Ožvoldová	common	rare			rare	common		*				
Emiluvia orea Baumgartner	common	common	common	rare		common	*		*	*		*
Emiluvia cf. *orea* Baumgartner	rare											
Emiluvia salensis Pessagno	abundant	abundant	common	common	common	abundant	*	*		*		*
Emiluvia sedecimporata (Rüst)	common	rare		rare				*				*
Emiluvia cf. *omanensis* Kiessling	rare											
Fultacapsa sphaerica (Ožvoldová)	rare			rare		rare				*		*
Haliodictya (?) antiqua (Rüst)	common	common	rare		rare	abundant			*			*
Loopus primitivus (Matsuoka et Yao)	rare											
Mirifusus dianae s.l. (Karrer)	rare	rare										
Napora lospensis Pessagno	common											
Obesacapsula sp. A sensu Widz 1991	rare											
Pantanellium aff. *riedeli* Pessagno	abundant			rare	rare	common	*					
Paronaella broennimanni Pessagno	common	common										*
Paronaella mulleri Pessagno	common					common		*		*		
Paronaella pristidentata Baumgartner		common										
Paronaella sp.	common				rare			*				
Parvicingula cf. *elegans* Pessagno et Whalen	rare											
Perispyridium ordinarium s.l. (Pessagno)	rare					rare				*		
Podobursa spinosa (Ožvoldová)						rare		*				
Podobursa triacantha (Fischli)			rare			rare	*					
Praecanetta (?) sp.	rare											
Praeconosphaera sphaeroconus (Rüst)	common					common						
Praeconosphaera spinosa Yang	common		rare			common						
Protunuma cf. *multicostata* (Heitzer)	rare											
Pseudocrucella adriani Baumgartner	rare											
Pseudodictyomitrella sp.	rare	rare										
Saitoum dercourti Widz et De Wever	common			rare					*			*
Sethocapsa leiostraca Foreman	rare					rare	*					
Spongocapsula perampla (Rüst)		rare				rare					*	
Syringocapsa spinellifera Baumgartner	rare											
Syringocapsa sp.	rare											
Teichertus (?) catenarius (Ožvoldová)	common		rare									
Tethysetta dhimenaensis (Baumgartner)						rare						
Tetraditryma cf. *pseudoplena* Baumgartner	rare											
Tetratrabs bulbosa Baumgartner								*				
Triactoma jonesi (Pessagno)	common	common	rare	rare	rare	common					*	
Tripocyclia trigonum (Rüst)	rare						*					*
Tritrabs casmaliaensis (Pessagno)	common			rare		common						
Tritrabs ewingi (Pessagno)	common	common			rare	common		*				
Tritrabs ewingi worzeli (Pessagno)							*					
Tritrabs exotica (Pessagno)	common		rare	rare		common	*					

abundant common rare absent present (*)

Fig. 6. Distribution of radiolarians in the samples from the sections in the Litmanová locality (Ls_1, sections 4 and 1) with their relative abundance in richer assemblages (abundant — more than 7 specimens., common — 3–7 spec., rare — 2 spec.).

PLATE I



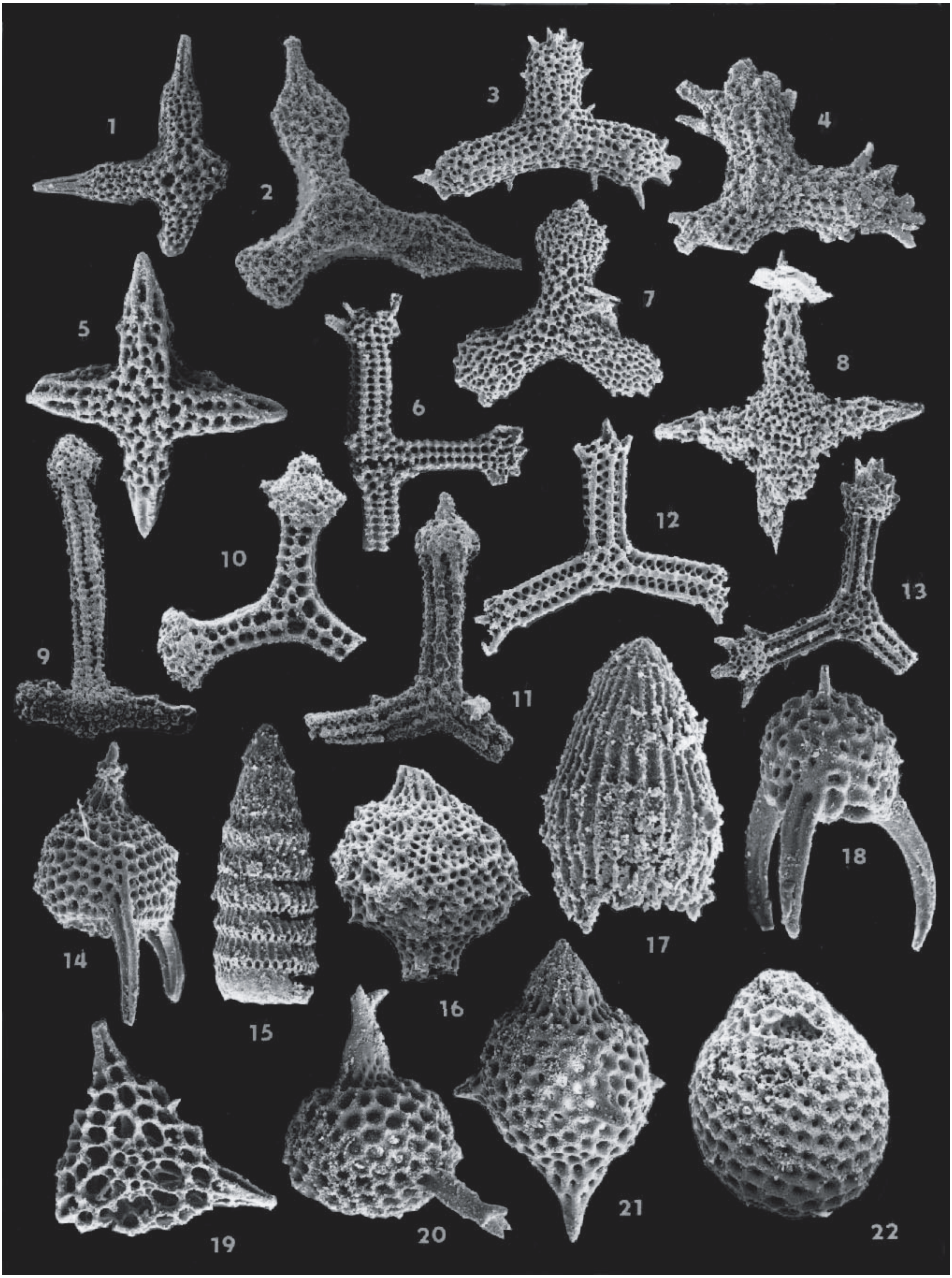

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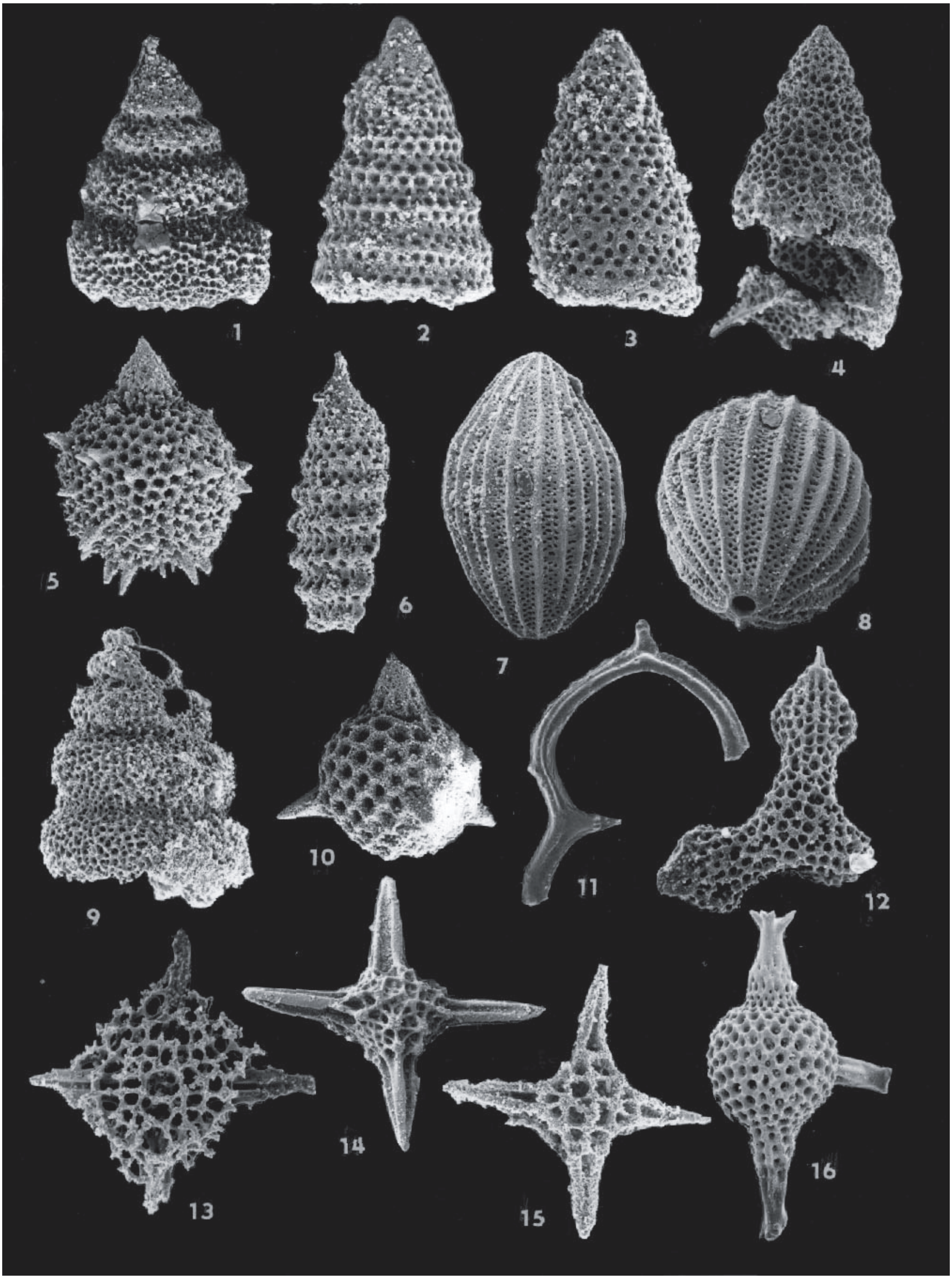
PLATE III



On the basis of these data the studied strata represent the stratigraphic range — middle-late Oxfordian to late Oxfordian–early Kimmeridgian (U.A.Z.9–U.A.Z.10).

The samples from the klippe Ls_2 at the northern end of the village (Fig. 1d) provided only very poor radiolarian fauna, but in the sample, taken 1.5 m above the contact of the radiolarian limestones with the underlying crinoidal limestones the determinable species *Fultacapsa sphaerica* (Ožvoldová) occurs. This indicates, that the assemblage is not older than U.A.Z.9 (middle-late Oxfordian).

Conclusions

In the studied area the results from radiolarite research in the Kysuca and Czertezic Successions show the following data:

In the Kysuca Succession, the maximum deepening of the sedimentary basin in the Middle–Upper Jurassic is manifested by non-calcareous or slightly calcareous brown-grey, green-grey radiolarites with black-blue Mn coatings (Sokolica Radiolarite Formation) in the lower part and grey-green and rusty-red ones (Czajakowa Radiolarite Formation) in the upper part of the sequence. The radiolarian assemblages represent the stratigraphic interval — middle Callovian–early Oxfordian to late Oxfordian–early Kimmeridgian (U.A.Z.8–U.A.Z.10).

In the more shalow-water Czertezic Succession sedimentation of radiolarian limestones with radiolarian cherts and irregular layers of radiolarites, representing the Czajakowa Radiolarite Formation began only in the Oxfordian. The radiolarian assemblages correspond to the stratigraphic interval — middle-late Oxfordian to late Oxfordian–early Kimmeridgian (U.A.Z.9–U.A.Z.10). In the assemblages of this interval in the locality Litmanová (sample 4A, section 4, Ls_1) the new species *Archaeospongoprunum mizutanii* Ožvoldová, n.sp. was described.

Radiolarians of both successions were evaluated using the biozonation of Baumgartner et al. (1995).

If we compare the composition of assemblages in the Kysuca Succession, gradual increasing of spumellarian abundance from the stratigraphic interval U.A.Z.8–U.A.Z.10 — middle Callovian–early Oxfordian to late Oxfordian–early Kimmeridgian can be observed. In the more shallow-water Czertezic Succession the abundance of spumellarians in the range of U.A.Z.9–U.A.Z.10 is as much as 70–80 %. The stratigraphic interval U.A.Z.8 (middle Callovian–early Oxfordian) does not contain favourable lithology for the finding of radiolarians in this succession.

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Plate I: Litmanová (Ls_1) Fig. 1. *Archaeospongoprunum mizutanii* Ožvoldová, n.sp. — 4A, 5739, 170×. **Fig. 2.** *Archaeospongoprunum mizutanii* Ožvoldová, n.sp. — holotype, 4A, 5683, 140×. **Fig. 3.** *Archaeospongoprunum mizutanii* Ožvoldová, n.sp. — 4A, 5740, 170×. **Fig. 4.** *Archaeospongoprunum mizutanii* Ožvoldová, n.sp. — 4A, 5669, 170×. **Fig. 5.** *Praeconosphaera spinosa* Yang — 4A, 5736, 200×. **Fig. 6.** *Emiluvia grandipora* (Ožvoldová) — 4A, 5764, 190×. **Fig. 7.** *Actinomma siciliensis* Kito & De Wever — 4A, 5700, 200×. **Fig. 8.** *Haliodictya* (?) *antiqua* (Rüst) — 4A, 5751, 100×. **Fig. 9.** *Teichertus* (?) *catenarius* (Ožvoldová) — 4A, 5689, 150×. **Fig. 10.** *Archaeospongoprunum* sp. A — 4A, 5712, 165×. **Fig. 11.** *Acastea diaphorogona* (Foreman) — 4A, 5696, 140×. **Fig. 12.** *Emiluvia salensis* Pessagno — 4A, 5731, 200×. **Fig. 13.** *Emiluvia sedecimporata* (Rüst) — 4A, 5690, 220×. **Fig. 14.** *Pantanellium* aff. *riedeli* Pessagno — 4A, 5697, 170×. **Fig. 15.** *Crucella* sp. A— 4A, 5762, 140×. **Fig. 16.** *Emiluvia* cf. *orea* Baumgartner — 4A, 5685, 110×. **Fig. 17.** *Emiluvia* cf. *orea* Baumgartner — lateral view of Fig. 16, 4A, 5686, 100×. **Fig. 18.** *Alievium* (?) *echinus* Dumitrică — 4A, 5711, 250×. **Fig. 19.** *Emiluvia orea* Baumgartner — 4A, 5743, 135×. **Fig. 20.** *Emiluvia ordinaria* Ožvoldová — 4A, 5749, 150×. **Fig. 21.** *Emiluvia orea* Baumgartner — lateral view of Fig.19, 4A, 5744, 150×. **Fig. 22.** *Triactoma jonesi* (Pessagno) — 4H, 4863, 150×. **Fig. 23.** *Mirifusus dianae* s.l. (Karrer) — 4A, 5672,120×. **Fig. 24.** *Triactoma jonesi* (Pessagno) — 4A, 5753, 110×.

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Plate II: Litmanová (Ls_1) Fig. 1. *Crucella angulata* Yang — 4A, 5688, 110×. **Fig. 2.** *Paronaella mulleri* Pessagno — 4A, 4875, 140×. **Fig. 3.** *Paronaella broennimanni* Pessagno — 4A, 5755, 130×. **Fig. 4.** *Paronaella pristidentata* Baumgartner — 4D, 5677, 150×. **Fig. 5.** *Pseudocrucella adriani* Baumgartner — 4A, 5738, 195×. **Fig. 6.** *Tetraditryma* cf. *pseudoplena* Baumgartner — 4A, 5691, 125×. **Fig. 7.** *Paronaella* sp. A — 4A, 5681, 125×. **Fig. 8.** *Crucella theokaftensis* Baumgartner — 4A, 5722, 185×. **Fig. 9.** *Tetratrabs bulbosa* Baumgartner — 4A, 4896, 80×. **Fig. 10.** *Angulobracchia biordinalis* Ožvoldová — 4A, 5767, 150×. **Fig. 11.** *Tritrabs ewingi worzeli* (Pessagno) — 1C, 4888, 110×. **Fig. 12.** *Tritrabs casmaliaensis* (Pessagno) — 4A, 5726,140×. **Fig. 13.** *Tritrabs exotica* (Pessagno) — 1C, 4891, 100×. **Fig. 14.** *Napora lospensis* Pessagno — 4A, 5756, 125×. **Fig. 15.** *Loopus primitivus* (Matsuoka & Yao) — 4A, 5747, 250×. **Fig. 16.** *Syringocapsa spinellifera* Baumgartner — 4A, 5737, 150×. **Fig. 17.** *Archaeodictyomitra patricki* Kocher — 4A, 5758, 350×. **Fig. 18.** *Saitoum dercourti* Widz & De Wever — 4A, 5773, 300×. **Fig. 19.** *Perispyridium ordinarium* s.l. (Pessagno) — 4A, 5703, 180×. **Fig. 20.** *Fultacapsa sphaerica* (Ožvoldová) — 4A, 5702, 125×. **Fig. 21.** *Syringocapsa* sp. — 4A, 5777, 165×. **Fig. 22.** *Complexapora tirolica* Kiessling — 4A, 5706, 250×.

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Plate III: Litmanová (Ls_1) Fig. 1. *Obesacapsula* sp. A sensu Widz 1991 — 4A, 5748, 135×. **Fig. 2.** *Praecanetta* (?) sp. — 4A, 5704, 250×. **Fig. 3.** *Pseudodictyomitrella* sp. — 4A, 5775, 350×. **Fig. 4.** *Spongocapsula perampla* (Rüst) — 1H, 4862, 140×. **Fig. 5.** *Sethocapsa leiostraca* Foreman — 4A, 5732, 150×. **Fig. 6.** *Parvicingula* cf. *elegans* Pessagno & Whalen — 4A, 5785, 200×. **Fig. 7.** *Protunuma* cf. *multicostata* (Heitzer) — 4A, 5769, 200×. **Fig. 8.** *Protunuma* cf. *multicostata* (Heitzer) — lateral view of Fig. 7, 5771, 250×. **Fig. 9.** *Spongocapsula* sp. — 4A, 5723, 135×. **Fig. 10.** *Fultacapsa sphaerica* (Ožvoldová) — 4G, 5778, 150×. **Fig. 11.** *Acanthocircus trizonalis* (Rüst) — 4J, 4853, 130×. **Fig. 12.** *Paronaella mulleri* Pessagno — 4J, 4847, 195×. **Fig. 13.** *Haliodictya* (?) cf. *antiqua* (Rüst) — 4J, 4868, 150×. **Fig. 14.** *Emiluvia* cf. *omanensis* Kiessling — 4A, 5684, 150×. **Fig. 15.** *Emiluvia chica* Foreman — 4D, 5668, 205×. **Fig. 16.** *Podobursa spinosa* (Ožvoldová) — 4J, 4854, 110×.

Kiessling (1996), who first evaluated the importance of nassellarian-spumellarian ratio (N/S) in pre-Cretaceous sediments in Tethyan localities, proved that the N/S ratio is positively correlated with the bathymetry (or with the distance from the shelf).
On the basis of these data, increasing trend observed in spumellarian abundance from U.A.Zone 8 to U.A.Zone 10 can be explained by continual shallowing of the sedimentary area, which is in a good accordance with the paleogeographical and paleoceanographical conditions.

Systematic Paleontology

Subclass **Radiolaria** Müller 1858
Order **Polycystina** Ehrenberg 1838, emend. Riedel 1967
Suborder **Spumellaria** Ehrenberg 1875
Family **Sponguridae** Haeckel 1862
Genus ***Archaeospongoprunum*** Pessagno 1973
Type species: *A. venadoensis* Pessagno 1973

Archaeospongoprunum mizutanii Ožvoldová, n.sp.
(Pl. I: Figs.1–4)

1981 *Archaeospongoprunum* sp. A — S. Mizutani, p. 171, pl. 57, figs. 2, 3
1997 *Archaeospongoprunum* sp. — L. Ožvoldová & L. Frantová, pl. 3, fig. 4

Holotype: No. 5683, Pl. 1, Fig. 2, deposited in the Slovak National Museum in Bratislava (SNM-21803).
Type locality: Litmanová village — Ľubovnianská vrchovina Highland.
Stratotype: middle Oxfordian–early Kimmeridgian of the Czajakowa Radiolarite Formation.
Denomination: This species is named in honour of S. Mizutani for his contribution to radiolarian research.
Description: A spongy, broad ellipsoidal to subspherical test with tetragonal to polygonal pore frames. Stout, bipolar spines, nearly equal in length with six grooves and six ridges. One spine is straight with three primary grooves and three secondary grooves between six ridges. The other spine is stouter with six grooves and six ridges, twisted in the clockwise direction in the distal part.
Comparison: This species differs from *A. patricki* Jud (Jud 1994, p. 63, pl. 4, figs. 2–4) by being stouter and having shorter spines and by the spines twisted in the clockwise direction. It differs from *A. cortinaensis* Pessagno (Pessagno 1973, p. 60, pl. 9, figs. 4–6, 1977, p. 29, pl. 1, fig. 8) by having a more spherical test and stouter spines and from *A. carrierensis* Pessagno (Pessagno 1977, p. 29, pl. 1, figs. 6, 7, 9) by stouter and shorter spines.
Dimensions (mm): (based on 9 specimens)

	holotype	av.	min.	max.
Total length	0.427	0.384	0.364	0.427
Length test	0.178	0.145	0.129	0.178
Width test	0.150	0.124	0.105	0.150
Length straight spine	0.128	0.117	0.111	0.128
Length twisted spine	0.121	0.122	0.117	0.121

Genus ***Emiluvia*** Foreman 1973, emend. Foreman 1975, emend. Pessagno 1977
Type species: *E. chica* Foreman 1973

Emiluvia grandipora (Ožvoldová 1975) nov.comb.
(Pl. I: Fig. 6)

1975 *Staurolonche grandipora* n.sp. — Ožvoldová, p. 76, pl. 100, fig. 1

Remark: The species was described in the locality Keblie in the Kysuca Succession of the Pieniny Klippen Belt (Ožvoldová 1975). On the basis of the genus signs of this species we can assign it to the genus *Emiluvia* Foreman.
Stratigraphical range: Up to now known — U.A.Z.9–UA.Z.10 — middle-late Oxfordian to late Oxfordian–early Kimmeridgian (according to Baumgartner et al. 1995).

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