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Lithobiostratigraphy of the Ždiar Formation of the Krížna nappe (Tatry Mts.)

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Abstract: On the basis of lithobiostratgraphical study in Tatra Mts. (and Veľká Fatra and Malá Fatra Mts., Strážovské vrchy, Chočské vrchy and Nízke Tatry Mts.) the formation of Middle and Upper Jurassic radiolarian limestones and radiolarites in the Krížna nappe was distinguished as a new lithostratigraphic unit - the ŽDIAR Formation. The stratigraphic range of the Ždiar Formation was established as Upper Bathonian - Lower Kimmeridgian on the basis of radiiolarian microfauna.

Key words: Ždiar Formation, radiolarian limestones, radiolarites, microfacies, radiolarians, age, Krížna nappe, Tatry Mts., West Carpathians, Slovakia and Poland.

Introduction

Several sections through the radiolarian limestones and radiolarites of the Krížna nappe in the Tatry Mts. were recently investigated and recorded as part of the project Geodynamic model of the Western Carpathians. This allowed us to obtain a direct paleontological information on the stratigrafic range of this Krížna nappe formation in almost all core mountains of the Western Carpathians.

As early as in 1925 Rabowski & Goetel and in 1932 Sujkowski assigned the Doggerian age to the radiolarite formation. This formation of the Tatra Mts. was studied in more detail by Lefeld (1974, 1981). Lefeld et al. (1985) accepted the concept of Birkenmajer (1977) who distinguished two formal stratigraphic radiolarite units in the Klippen belt, the lower - Sokolice Unit of probable Upper Bajocian - Bathonian age and the upper unit - the Czajakowa radiolarites of the Callovian - Oxfordian age. On the basis of these assumptions this author adopted a similar scheme for the whole Western Carpathian region and for the northern Tethyan margin. Most newer lithostratigraphic and biostratigraphic data refer to the Krížna nappe of the Western Carpathians (Polák & Ondrejičková 1993a, 1993b,1995).

Lithology

We investigated several sections through the Upper Jurassic radiolarian limestones and radiolarites of the Krížna nappe in the Tatry Mts. Our attempt to find and to classify the radiolaria microfauna was succesful in the following sections:

- on the SE ridge of the Ždiarska vidla (the Havran partial tectonic unit),
- in the section Banie Huciska (Bobrovec tektonic unit) and
- in the section Gladki Uplaziańskie tectonic unit).

Section: **Ždiarska vidla**

On the south-eastern ridge of the Ždiarska vidla there is a complete section through the formation of radiolarian limestones and radiolarites, which we refer to as the **type section of the Ždiar Formation**. (Fig. 2).

The immediate underlier is composed of a formation of dark-grey, marly, mottled limestones with scarce dark chert nodules, alternating with the dark-grey shales - (the Allgäu Member - Fleckenmergel). The age of the formation corresponds to the Sinemurian to Toarcian (Gaździcki et al., 1979, Lefeld et al., 1985).

The lower, some 50 cm thick part is made up of grey-green radiolarian limestones with a black radiolarite intercalation and noduless. It is suceded by a bed consisting of three thin strata (as much as 10 cm thick) of greenish radiolarites. The formation continues with the grey-greenish, bench-like (10 - 15 cm thick) radiolarian limestones that contain small black chert nodules. Another part (some 2 m thick) is composed of the red-violet friable radiolarites, grading into pink, green and pale-grey radiolarites with pale-grey limestone intercalations. The overlying part is made up of pale-grey, compact radiolarian limestones with small nodules of green-black cherts. After an interruption there follow thin-bedded to slab-like (5 - 10 cm thick) green-grey radiolarites with thin, grey limestone and shale intercalations. These are overlain by an about 1 m thick bed of green-grey, slab-like, partly desintegrating radiolarite, which ends with a bed of grey limestones with radiolarite nodules. The subsequent suite

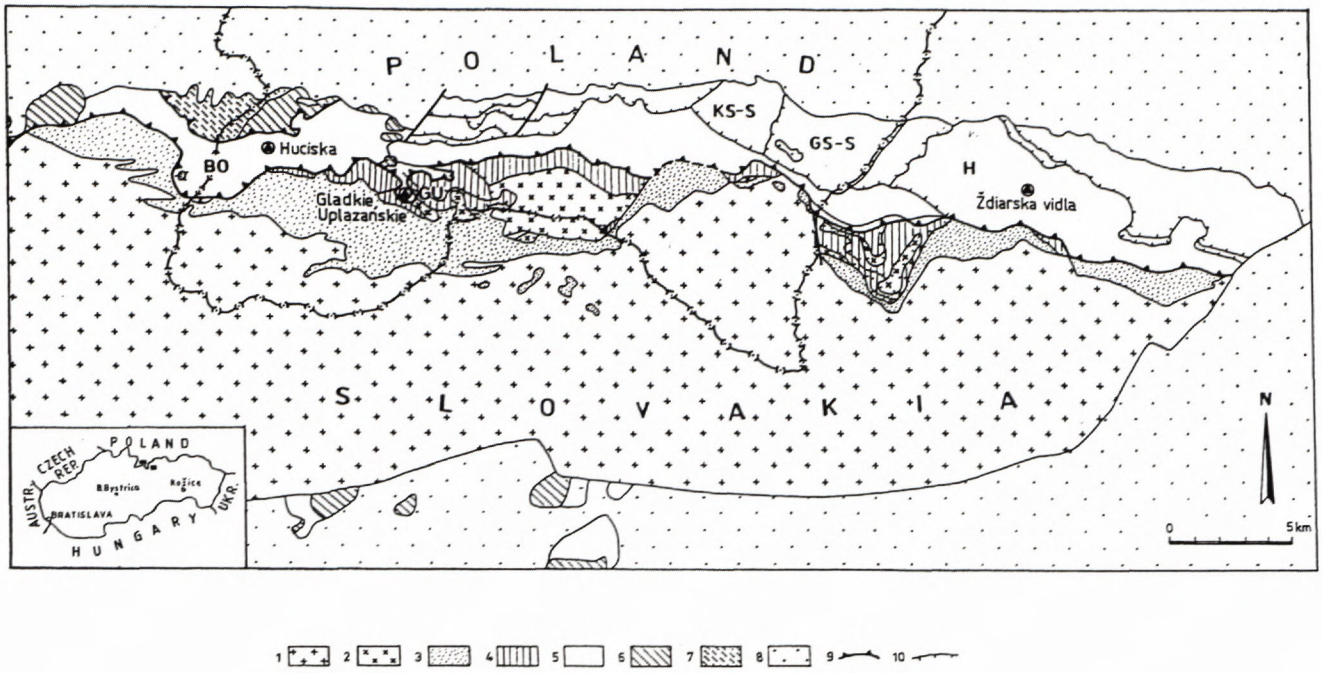


Fig. 1 Localization of studied radiolarian-bearing profiles of Tatra Mts.
1 - *Crystalline core of the Tatra Mts.*, 2 - *Crystalline rocks of allochthonous High Tatric units*, 3 - *Sedimentary cover of crystalline massif*, 4 - *Sedimentary rocks of allochthonous High Tatric units*, **5** - *Tectonic units of Krížna nappe (radiolarite bearing units):* Bo - *Bobrowiec unit*, GU - *Gladkie Uplaziańskie unit*, KS-S *Kopy Soltysie-Siodlo unit*, GS-S - *Gesia Szyja-Skalki unit*, H - *Havran unit*, 6 - *Choč nappe*, 7 - *Furkaska-Koryciska unit (the highest tectonic unit of the Tatra Mts., ? Choč nappe)*, 8 - *Paleogene*, 9 - *Overthrust of the Krížna nappe*, 10 - *Other overthrusts*

is composed of the grey-green desintegrating radiolarites that end-up with the beds of grey limestones. The uppermost part of the formation (about 3 m thick) is composed of thin bedded to slab-like, grey-green, in its upper part even black radiolarites, with irregular grey limestone intercalationsf. These are overlain by red nodular limestones of the Jaseniny Formation (Kimmeridgian).

Banie Huciska section

The section occurs on the eastern slopes of Chocholowska dolina, on the south-western slope of the Kliny hill (1275 m). The whole section is part of the Homola Formation (Lefeld et al., 1985). In the lower part of the section there occur the Allgäu Member rocks (Fleckenmergel) of the Lotharingian age, which are overlain by the crinoid limestones with spongoliths and with Fe–Mn mineralized beds that were mined in the past (Krajewski & Myszka, 1958). The overlying, 3 - 4 meters thick suite is composed of the red, nodular, Adnet limestones of Toarcian age (Sokolowski, 1925).

The Adnet limestones are overlain by about 1 m thick grey-green, slab-like crinoid limestones with thin shale intercalations and with small chert nodules. The formation continues by an about 3 m thick assemblage of red, violet, slab-like radiolarian limestones that locally contain the green radiolarite bands. The next assemblage (about 9 m thick), is made up of green, grey-green, slab-like, 5 - 10 cm thick radiolarian limestones. In the lower part there occur beds and intercalations grey-green shales. Most radiolarites occur as nodules of elliptic shapes, oriented parallel to the bedding. Their size is as much as 30 cm across. The next assemblage (some 4 m thick) is represented by red, violet, slab-like, 10 - 25 cm thick radiolarian limestones alternating with beds and bands of red and pink radiolarites.

The whole section ends up with the red, violet, nodular, Kimmeridgian limestones and shales and with the Osnica Formation rocks.

Gladkie Uplaziańskie section

In this section, the condensed Jurassic - Lower Cretaceous sedimentation appears in full. The Allgäu Formation (Fleckenmergel) of Lotharingian - Toarcian age (Lefeld et al., 1985) and the crinoid limestones of Lower Liassic age directly overlie the radiolarian limestones and the radiolarites. The formation proper is in its lower part (about 2 m tick) composed of green radiolarian limestones with green radiolarite intercalations. These grade into a bed of red radiolarian limestones and radiolarites (some 2 m). Next bed is made up of grey, slab-like, pelitic limestones with green radiolarite intercalations. These are overlain by red, bedded, nodular limestones, grading into pseudonodular, red, marly limestones, probably of Kimmeridgian age. The upper part is made up of the Osnica Formation rocks of Tithonian - Lower Valanginian age.

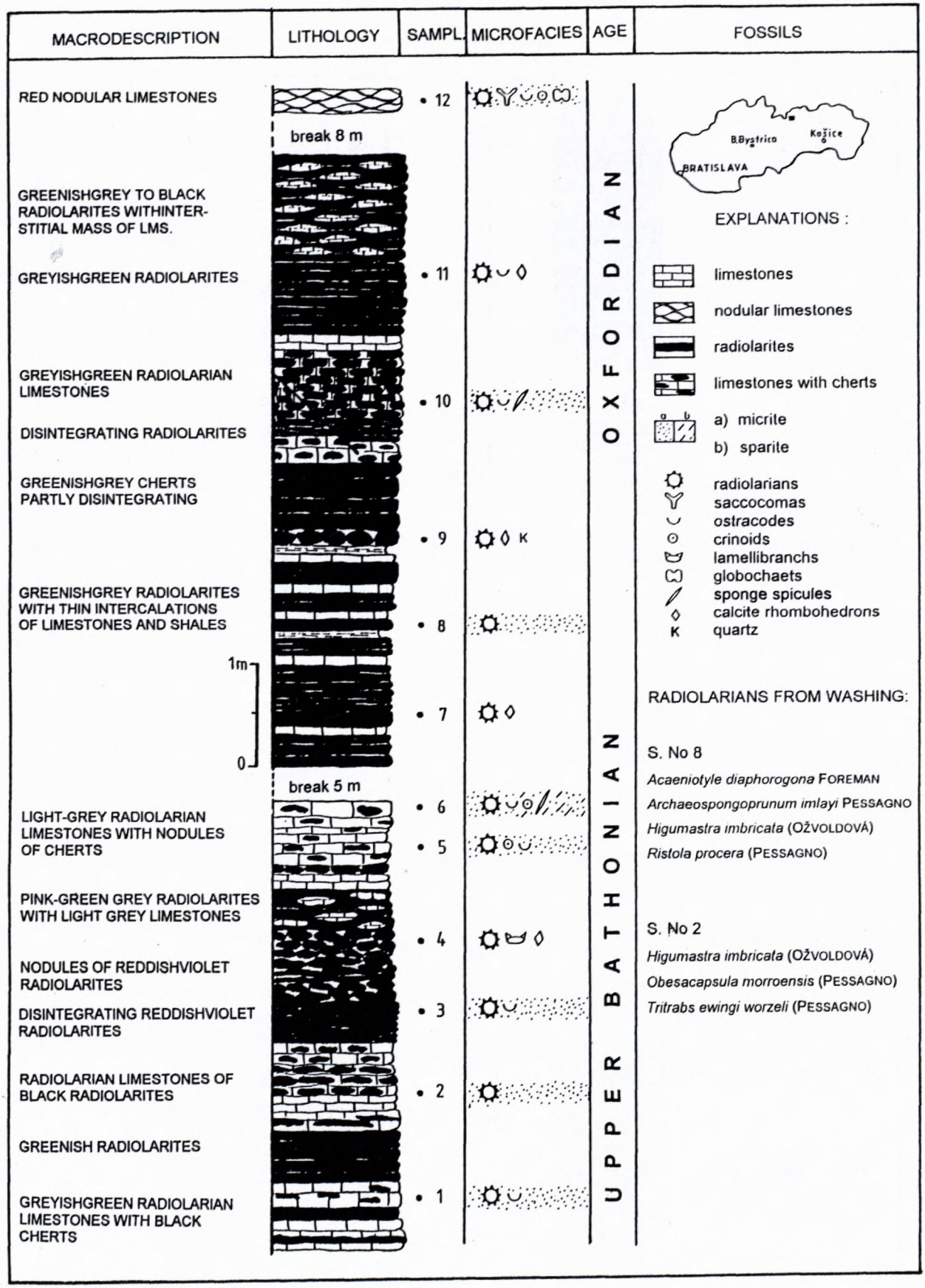


Fig. 2 Type lithostratigraphical profile through the Ždiar Formation of the Krížna nappe.
Locality: SE ridge of Ždiarska vidla - Belianske Tatry Mts.

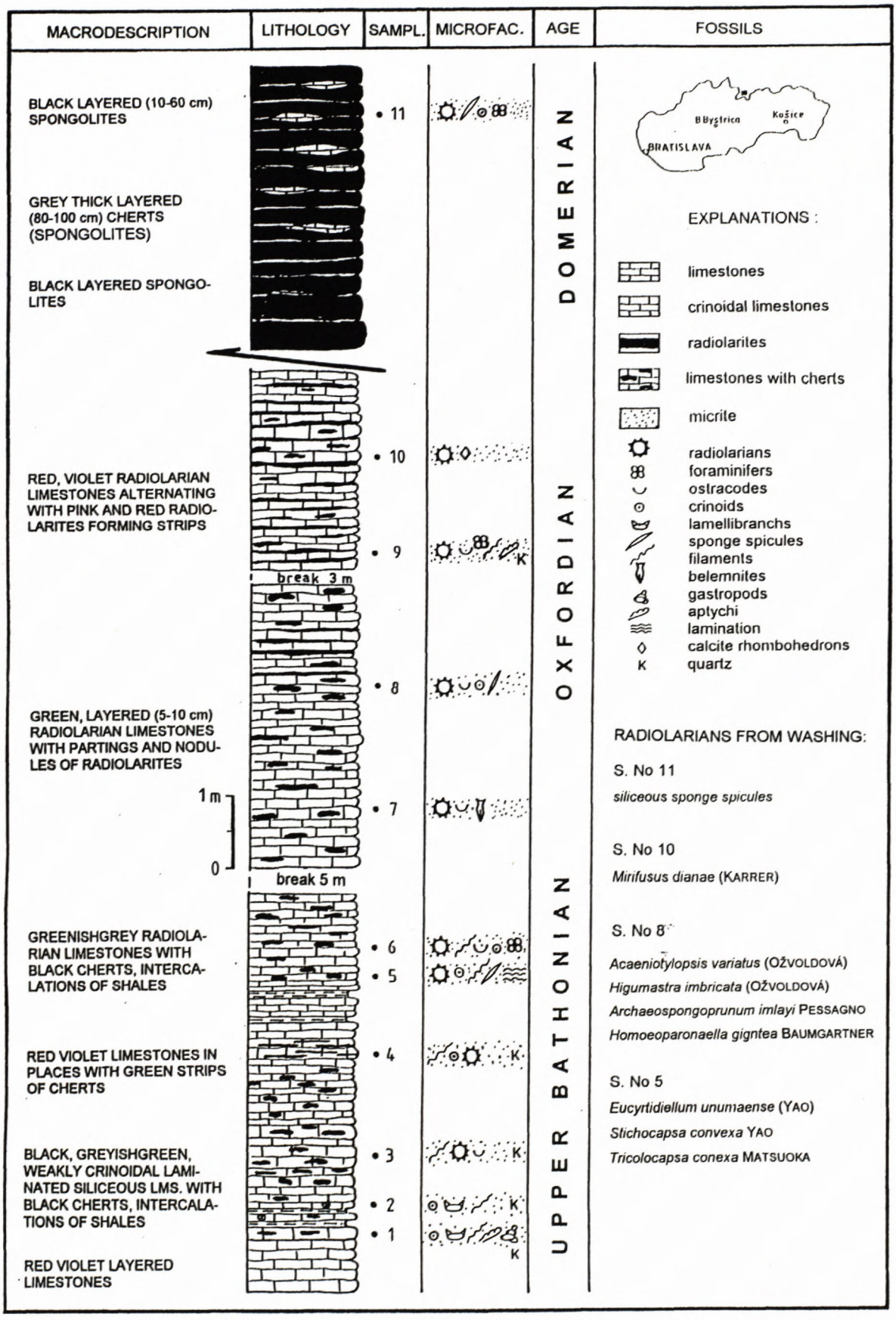


Fig. 3 Lithostratigraphical profile through the Ždiar Formation of the Krížna nappe. Locality: Banie Huciska - Vysoké Tatry Mts.

Lithostratigraphy and microfacies

THE ŽDIAR FORMATION (new name of the lithostratigraphic unit)

Name: borrowed from the hilltop of the Ždiarska vidla (2146.0 m) in the Belianske Tatry Mts. On the south-eastern ridge there is a very well exposed sequence of Jurassic sedimentary beds of the Krížna nappe.

The type locality: any part of the area underlain by Middle to Upper Jurassic radiolarian limestones and radiolarites of the Krížna nappe, in any core mountain of the Western Carpathians.

Type section: south-eastern ridge of the Ždiarska vidla.

Reference sections: Banie Huciska, Gladkie Uplaziańskie (Polish part of the Tatry Mts.) Zázrivská dolina (Malá Fatra Mts.), Trlenská dolina (Veľká Fatra Mts.), Lúčky (Chočské vrchy hills), Zliechovská dolina (Strážovské vrchy hills).

The formations are predominated by the radiolarian, partly quartzose, mostly bedded, variegated limestones (grey, black, green, red, or violet). The SiO_2 contents range between 15 and 45 %.

Structurally, most of them are biomicrites, while biomicrosparites of the wackestone type are less common. The most common microfacies in the limestones of the above mentioned formation is the radiolarian microfacies. The ratio of radiolarians, which are a rock-forming component, ranges between 40 and 85 %. Most radiolarians are calcified, but a small ratio preserved their original siliceous tests. The probability of finding suitable micropaleontological material also depends on the rate of preservation of the original composition. Almost 60 % of the radiolarians are the *Spumellaria* forms, and the rest are the *Nasellaria* forms.

Both, the form and the mode of preservation of the radiolarians are subject to strong variation (see Polák & Ondrejičková, 1993b). While the ostracods, and the globochaetes are commonly present, the crinoid segments, apart from some basal parts of the section Huciska, where they may represent as much as 50 % of the total fossil remnants, are less abundant. Here, the lamellibranchiata fragments and the aptychi also occur. In the upper parts of the sections, the ratio of filaments, of the detritic aptychi and of the segments of planktonic crinoids *Saccocoma* sp. increases. In the section Huciska the ratio of sponge spicule sections distinctly increases upwards. Less common are the foraminifera (*Frondicularia* sp., *Nodosaria* sp.) segments. In one case a segment of the belemnite rostrum was encountered. Sporadically occurs the clastic admixture in the form of angular quartz fragments of aleuritic size.

The radiolarites represent the second most important rock- forming component of the Ždiar Formation. In the Ždiarska vidla section they make up some 65 % of the rock. However, in the other sections their presence is much lower. Most radiolarites in limestones have a form of irregular elliptic nodules of various size. Almost all are oriented parallel to the bedding. Many nodules coalescce to produce the radiolarite beds and bands.

The radiolarites, as well as the limestones, have various colours ranging from black, through grey and green to red and violet tints.

As far as their microfacies classification is concerned, we assign them to the silicic-calcitic biomicrites with a high frequency of radiolarians, predominantly of the *Spumellaria* type, composed mainly of the original, fine-grained quartzose matrix. Of the organic remnants there occur scarce ostracods and very scarce sponge-spicules. The presence of euhedral, autigenic rhomboids, made up of calcite, or dolomite, respectively, is a characteristic feature. These rhomboids are almost always bound to the organic remnants, which commonly make up their central part.

In the basal part of the Huciska section (HC-5) the laminated textures composed of the fagments of miscellaneous organic detritus, mainly of the Crinoid segments and filaments, with the indications of gradational bedding, were encountered. These alodapic components represent the distal turbidite (Walker, 1967), or the microturbidites (Schläger & Schläger, 1969), remnants, respectively.

Biostratigraphic assessment

The study of radiolarites and of the radiolarian limestones from the Krížna nappe of the Tatry Mts. is a follow-up of the previous studies that focused on their origin, biostratigraphy and lithostratigrafic position in the different Western Carpathian tectonic units (Polák & Ondrejičková, 1993b).

Generally, a conclusion may be drown that despite their frequency in the sediments studied only a few gave such an extractable association that can be unequivocally biostratigraphically interpreted. The reason is poor preservation of their tests, which is due to calcification, fragmentation and deformation of the host rock.

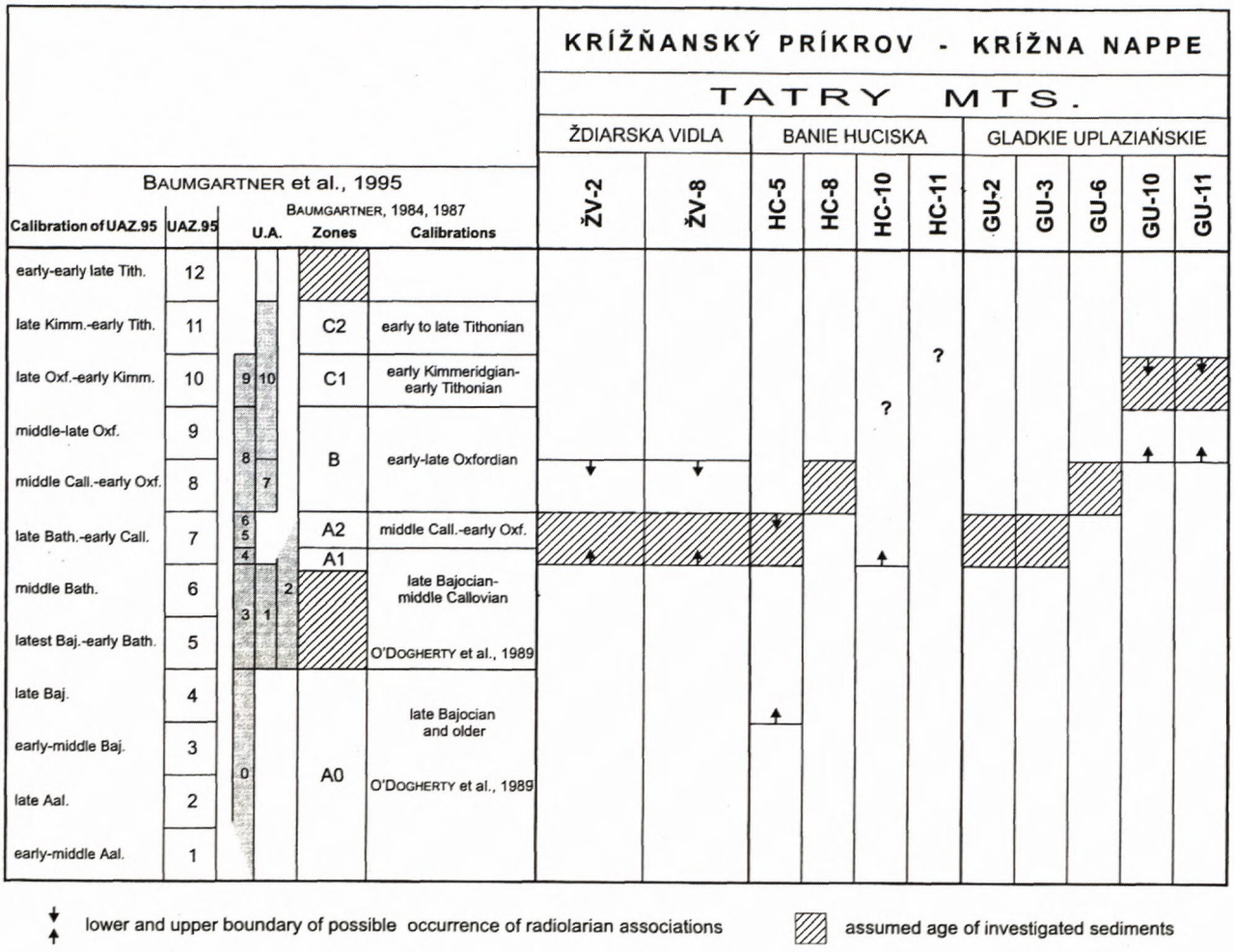
Biostratigraphic assessment of radiolarian associations is supported by their presence in the zones (UAZ) that correspond to appropriate periods in the chronostratigraphic range, as referred to by Baumgartner et al. (1995) in their latest paper.

It must be noted that the zoning and its sequential order underwent (since its establishment) several modifications (Baumgartner, 1984, 1987, O'Dogherty et al., 1989) and if the latest zoning is to be applied (Baumgartner et al., l.c.), then the previous age interpretations of the radiolarian limestones and radiolarites of the Western Carpathians must be revised.

The most striking difference in age assignment occurs for Zone A2 (middle Callovian - early Oxfordian), (Baumgartner, 1987), correlative with the UAZ.7 (late Bathonian - early Callovian). This older age assignment is the result of new Ammonite data from the Subbetic (Baumgartner et al., 1995).

Ždiarska vidla (samples ŽV-2 and ŽV-8)

A radiolarian assemblage, in which the *Spumellaria* predominate, was encountered in the green-grey radiolarian limestones (sample ŽV-2). Biostratigrafically, they



comprise the species that cover a wide stratigraphic range (Text. Table) (UAZ.4, late Bajocian), such as the *Higumastra imbricata* (OŽVOLDOVÁ), *Homoeoparonaella argolidensis* BAUMGARTNER, *Paronaella broennimanni* PESSAGNO, *Triactoma blakei* (PESSAGNO), etc. that start to appear in the upper part of the Middle Jurassic period the highest position occupies the *Tritrabs ewingi worzeli* (PESSAGNO), in the UAZ.7, late Bathonian - early Callovian. The upper boundary of a possible occurrence of this association is determined by the *Higumastra imbricata* (OŽVOLDOVÁ), which occurrence of which terminates in UAZ.8, middle Callovian - early Oxfordian.

The radiolarian association in the green-grey radiolarites in the sample ŽV-8 is composed of similar genus and species and is predominated by the *Spumellaria* (Text. Table). The lower boundary is determined by the species *Archaeospongoprunum imlayi* PESSAGNO, which first appears in UAZ.7, late Bathonian - early Callovian. We assume that the upper boundary is in UAZ.8, in which the occurrence of species *Higumastra imbricata* (OŽVOLDOVÁ) and *Tricolocapsa plicarum* YAO terminates. In conclusion we may state that the sediments in the Ždiarska vidla section, represented by the samples ŽV-2 and ŽV-8 may have sedimented during the period between the Upper Bathonian and the Lower Oxfordian. Most probable is the late Bathonian - early Callovian age (UAZ.7), because UAZ.8, middle Callovian - early Oxfordian, is not represented by the new species characteristic for this zone, but instead, by fading-out of certain species.

Banie Huciska

The collected samples contained radiolarians and siliceous sponge spicules. Fairly numerous associations were extracted from the samples HC-5 and HC-8.

In the green-grey radiolarian limestones (HC-5) a little diversified radiolarian association, predominated by *Nasellaria*, was found. Of the determined species (Text. Table) of the lower part of the Middle Jurassic period, the *Stichocapsa convexa* YAO, (UAZ.1 — 11) and *Eucyrtidium unumaense* (YAO) (UAZ.3 — 8) appear. The *Tricolocapsa conexa* MATSUOKA first occurs in UAZ.4, late Bajocian, and terminate in UAZ.7, late Bathonian - early Callovian. Inasmuch as no such species were found in this association, which would determine a narrower time range, we can only conclude that the sedimentation took place sometimes between the Upper Bajocian and the Lower Callovian stages.

A radiolarian association, predominated by *Spumellaria*, was found in the green-grey radiolarian limestones (HC-8). Of the determined species (Text Table), the *Ho-*

Text. tab. Occurrence of radiolarians in the sections

SPUMELLARIA NASSELLARIA	**UAZ**	**SECTIONS**							
Genus species		**Ždiarska vidla**		**Banie Huciska**		**Gladkie Uplaziańskie**			
		ŽV-2	**ŽV-8**	**HC-5**	**HC-8**	**GU-2**	**GU-3**	**GU-6**	**GU-10, 11**
Acaeniotyle diaphorogona FOREMAN	4-22		+						
Acaeniotyle sp.		+							
Acaeniotylopsis variatus s.l. (OŽVOLDOVÁ)	1-8				+	cf.			
Acanthocircus trizonalis angustus BAUMGARTNER	6-10	+							
Alievum sp. A	8-9							+	+
Angulobracchia biordinalis OŽVOLDOVÁ	9-11								+
Archaeospongoprunum imlayi PESSAGNO	7-12		+		+	+		+	+
Archaeospongoprunum sp.						+			+
Emiluvia chica FOREMAN	3-18					+		+	
Emiluvia hopsoni PESSAGNO	6-15								+
Emiluvia orea BAUMGARTNER	8-11							+	
Emiluvia pessagnoi s.l. FOREMAN	4-17					+			
Emiluvia premyogii BAUMGARTNER	3-10	+			+			+	+
Emiluvia salensis PESSAGNO	4-13				cf.	+		+	+
Emiluvia sp.		+			+	+		+	
Haliodictya hojnosi RIEDEL et SANFILIPPO	3-10								+
Higumastra imbricata (OŽVOLDOVÁ)	4-8	+	+		+				
Higumastra wintereri BAUMGARTNER	1-8					+			
Homoeoparonaella cf. *argolidensis* BAUMGARTNER		+	+		+				
Homoeoparonaella elegans (PESSAGNO)	4-10	+							
Homoeoparonaella gigantea BAUMGARTNER	8-10				+				+
Homoeoparonaella pseudoewingi BAUMGARTNER	3-7				+				
Monotrabs plenoides BAUMGARTNER	5-8					+	+		
Orbiculiforma catenaria OŽVOLDOVÁ	7-9								+
Orbiculiforma sp.				+					
Paronaella broennimanni PESSAGNO	4-10	cf.	cf.			+		+	+
Paronaella cf. *kotura* BAUMGARTNER	3-10	+							
Paronaella muelleri PESSAGNO	6-10					+	cf.	+	
Paronaella pristidentata BAUMGARTNER	10-11								+
Paronaella sp.					+				+
Tetraditryma corralitosensis bifida CONTI et MARCUCCI	5-7					+			
Tetraditryma pseudoplena BAUMGARTNER	4-11								+
Tetratrabs bulbosa BAUMGARTNER	7-11							+	
Tetratrabs zealis (OŽVOLDOVÁ)	4-13		+		+	+		+	+
Triactoma blakei (PESSAGNO)	4-11	cf.						+	
Triactoma jonesi (PESSAGNO)	2-13	+			+				
Triactoma mexicana PESSAGNO et YANG	5-9				+				
Triactoma parablakei YANG et WANG	4-7	+				+			
Tripocyclia cf. *trigonum* RÜST		+						+	
Tritrabs casmaliaensis (PESSAGNO)	4-10		+					+	+
Tritrabs exotica (PESSAGNO)	4-11	cf.			+			+	
Tritrabs ewingi s.l. (PESSAGNO)	4-22		+						
Tritrabs ewingi worzeli (PESSAGNO)	7-12	+			+		+	+	
Tritrabs hayi (PESSAGNO)	3-10				+				
Tritrabs rhododactylus BAUMGARTNER	3-13		cf.			+		+	+
Archaeodictyomitra sp.					+				
Dibolachras chandrica KOCHER	7-11					cf.			+
Eucyrtidiellum unumaense s.l. (YAO)	3-8			+					
Cinguloturris carpatica DUMITRICĂ	7-11							+	
Cinguloturris sp.								+	
Mirifusus dianae s.l. (KARRER) /section HC-10/	7-12								
Napora lospensis PESSAGNO	8-13								+
Obesacapsula morroensis (PESSAGNO)	5-21	+			+				
Parahsuum sp.			+						
Parvicingula dhimenaensis ssp. A BAUMGARTNER	3-8							+	
Parvicingula sp.								+	
Perispyridium ordinarium (PESSAGNO)	5-11				+	+			

SPUMELLARIA NASSELLARIA Genus species	UAZ	SECTIONS							
		Ždiarska vidla		Banie Huciska		Gladkie Uplaziańske			
		ŽV-2	ŽV-8	HC-5	HC-8	GU-2	GU-3	GU-6	GU-10, 11
Perispyridium cf. *tamanense* PESSAGNO et BLOME									+
Podobursa helvetica (RÜST)	3-10		cf.		cf.	+			
Podobursa polyacantha (FISCHLI)	5-8							+	
Podobursa quadriaculeata (STEIGER)	9-17								+
Podobursa triacantha (FISCHLI)	5-8	cf.			+				+
Poliandromeda podbielensis (OŽVOLDOVÁ)	1-7						+		
Ristola procera (PESSAGNO)	5-9		+						
Sethocapsa sphaerica (OŽVOLDOVÁ)	9-11								+
Sethocapsa sp. 1									+
Sethocapsa sp. 2									+
Spongocapsula perampla (RÜST)	6-11							+	
Stichocapsa convexa YAO	1-11			+					
Transhsuum brevicostatum (OŽVOLDOVÁ)	3-11	cf.	+		+		+	+	+
Transhsuum maxwelli (PESSAGNO)	3-10					cf.	+		
Transhsuum cf. *okamurai* (MIZUTANI)					+				
Tricolocapsa conexa MATSUOKA	4-7			+					
Tricolocapsa plicarum s.l. YAO	3-8		+	+					
Tricolocapsa cf. *yaoi* MATSUOKA			+						
Tricolocapsa sp.			+					+	
Xitus sp.								+	

moeoparonaella gigantea BAUMGARTNER, which first appears in UAZ.8, middle Callovian - early Oxfordian, as well as the fading-out species, such as the *Acaeniotylopsis variatus* (OŽVOLDOVÁ) and *Higumastra imbricata* (OŽVOLDOVÁ), are important. The absence in this zone of the other important species is questionable. From the above it follows that for the sediments represented by the sample HC-8, a Middle Callovian to Lower Oxfordian age may be assumed.

In the red radiolarian limestones (HC-10) only three pieces of *Nassellaria* genus were encountered. The only determinable species is *Mirifusus dianae* (KARRER), which has a wide range of occurrence in the UAZ.7 — 12, thus, their age ranges from the Upper Bajocian to the Upper Tithonian.

No radiolarians were found in the overlying, slab-like, black spongolites (HC-11). However, they do contain abundant of siliceous sponge spicules.

Gladkie Uplaziańskie

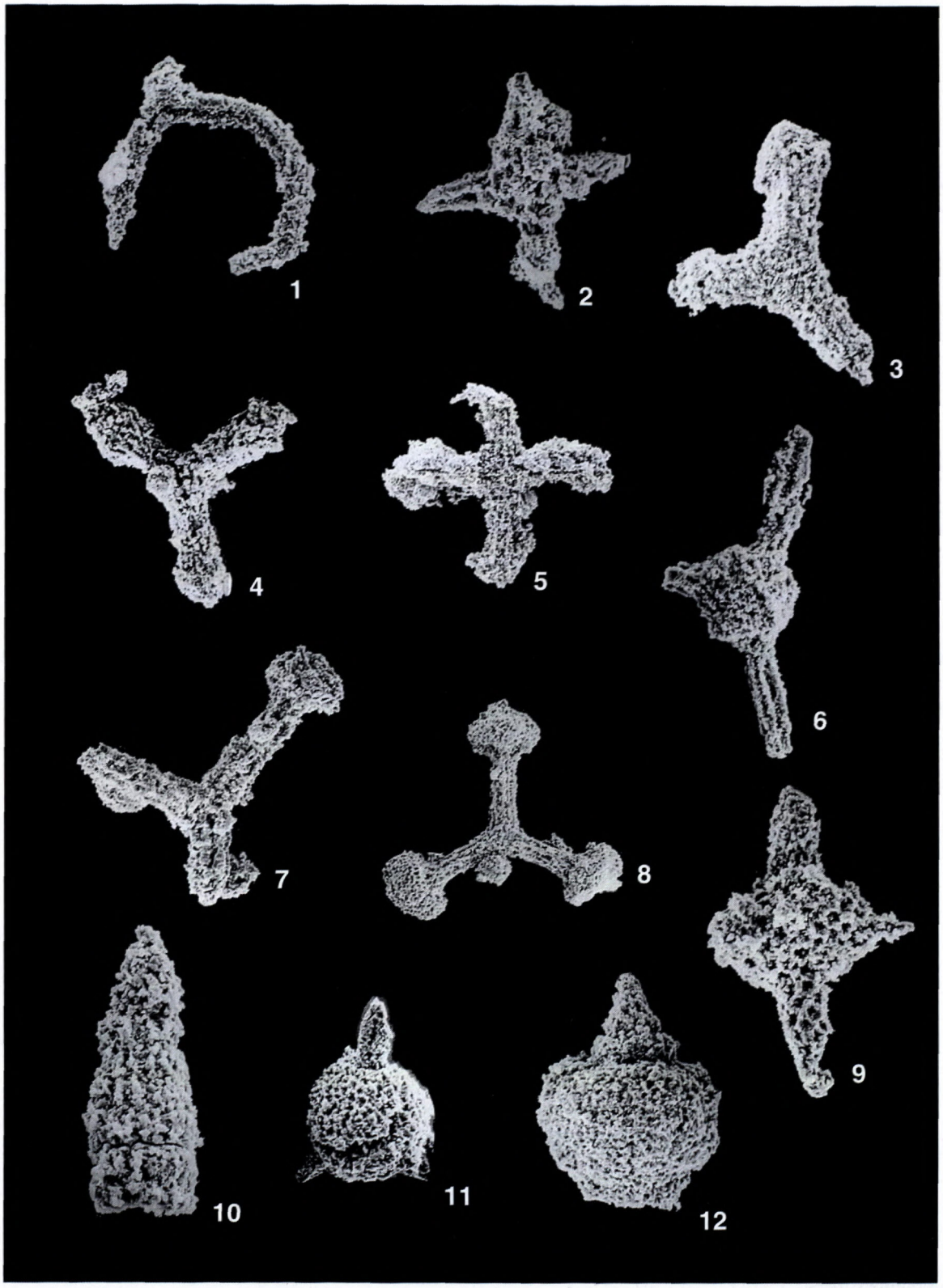
11 samples were collected from this section, in which the radiolarians of various abundances and degree of preservation were found. The richest samples GU-2, GU-6, and GU-10 were evaluated.

Quite poorly preserved radiolarian tests, most of them *Spumellaria*, were found in the green-grey radiolarites (samples GU-2 and GU-3). Most evaluated species (Text Table) first appear in the upper part of the Middle Jurassic. In UAZ.7, which corresponds to the late Bathonian - early Callovian, there appear *Dibolachtras chandrica* KOCHER, *Archaeospongoprunum imlayi* PESSAGNO and *Tritrabs ewingi worzeli* (PESSAGNO). In turn, the species *Tetraditryma corralitosensis bifida* CONTI et MARCUCCI and *Triactoma parablakei* YANG et WANG occurrence of which terminate in this zone. We assume that this time span (late Bathonian to early Callovian) corresponds to the period of sedimentation of the rocks represented by the samples GU-2 and GU-3.

In the green-grey radiolarites (sample GU-6) a more varied and better preserved radiolarian association, predominated by *Spumellaria*, was found. To assign an age to a certain zone, it must contain the species and they first and final occurrence. In UAZ.8 (middle Callovian - early Oxfordian) the species: *Parvicingula dhimenensis* BAUMGARTNER, *Podobrusa polyacantha* (FISCHLI) and *Tetratrabs zealis* (OŽVOLDOVÁ) terminate while the species *Alievum* sp. A (BAUMGARTNER et al., 1995) and *Emiluvia orea* BAUMGARTNER. *Emiluvia ordinaria* OŽVOLDOVÁ appear. We presume that the radiolarian assemblage in the sample GU-6 represents UAZ.8, middle Callovian - early Oxfordian, which, corresponds to the assumed age of the sediments under study.

In the grey and red radiolarites (samples GU-10 and GU-11), the radiolarian associations, predominated by *Spumellaria*, were found. Among them, the species that first appear in the Middle Oxfordian (UAZ.9 middle and late Oxfordian), such as the *Sethocapsa sphaerica* (OŽVOLDOVÁ), *Angulobracchia biordinalis* OŽVOLDOVÁ and the *Podobursa quadriaculeata* (STEIGER). In UAZ.10 (late Oxfordian - early Kimmeridgian) the species *Emiluvia premyogii* BAUGARTNER, *Haliodictya hojnosi* RIEDEL et SANFILIPPO, *Paronaella broennimann* PESSAGNO and *Tritrabs casmaliaensis* (PESSAGNO) and they first and final occurrence.

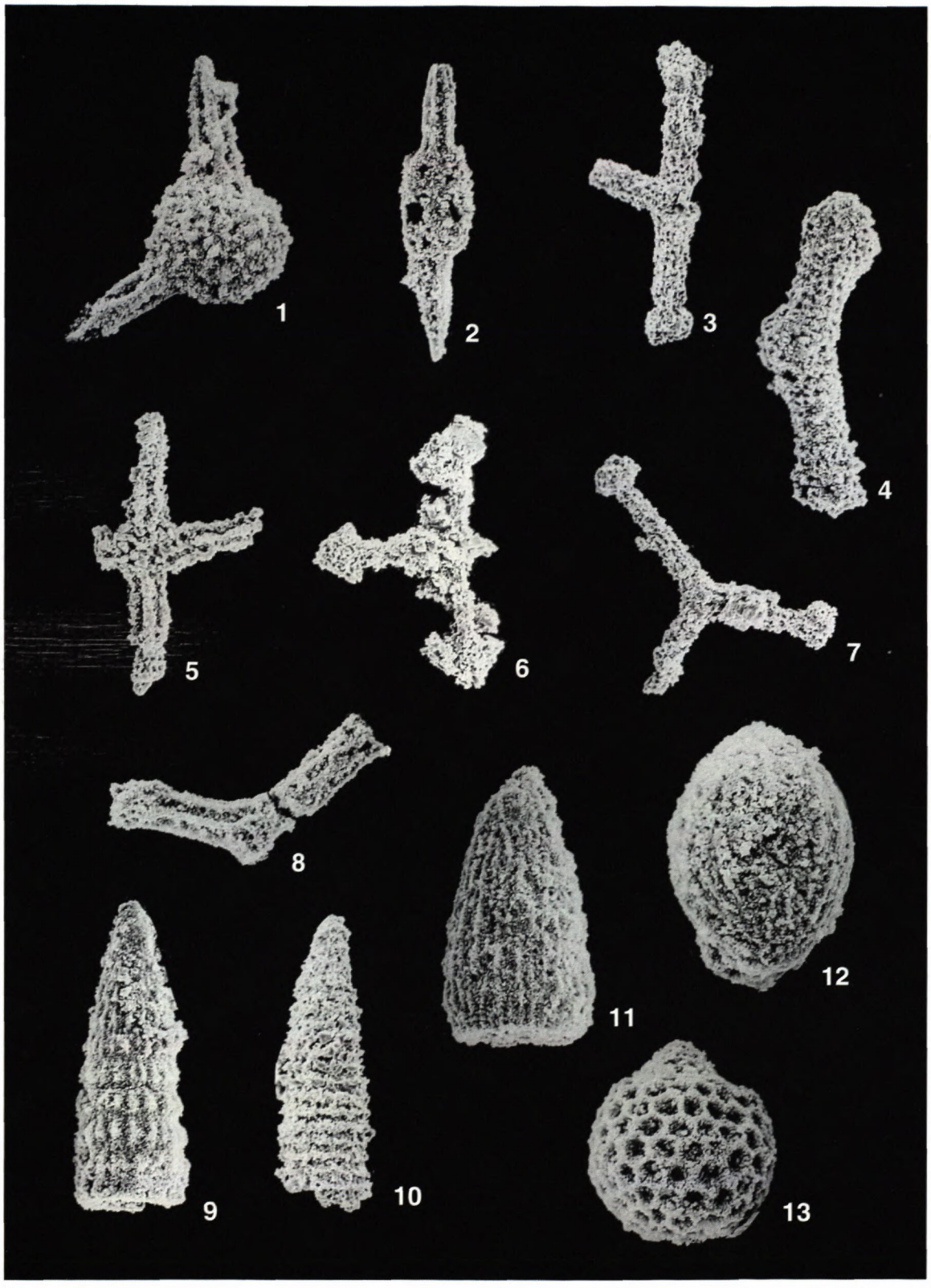
However, the *Paronaella pristidentata* BAUMGARTNER appears in this zone. We assume that the associations under studiy represent UAZ.10.- late Oxfordian - early Kimmeridgian.



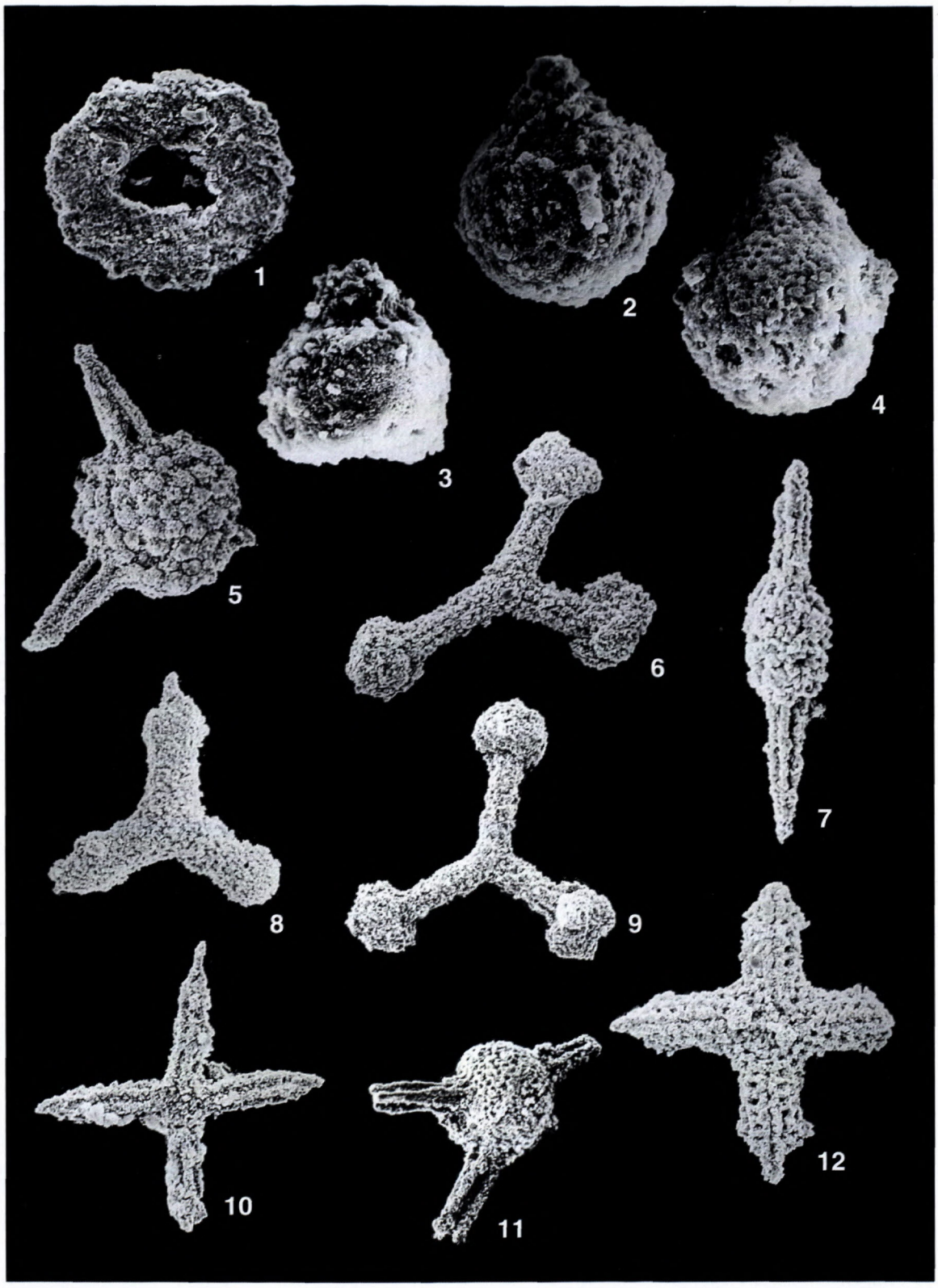
Pl. 1. Ždiarska vidla.

Sample ŽV-2, Figs. 1 - 12:

1 - *Acanthocircus trizonalis angustus* BAUMGARTNER - 4789, 120 x, 2 - *Emiluvia premyogii* BAUMGARTNER - 4798, 110 x, 3 - *Paronaella* cf. *broennimanni* PESSAGNO - 4864, 150 x, 4 - *Homoeoparonaella elegans* (PESSAGNO) - 4797, 120 x, 5 - *Higumastra imbricata* (OŽVOLDOVÁ) - 4802, 70 x, 6 - *Triactoma jonesi* (PESSAGNO) - 4800, 110 x, 7 - *Tritrabs ewingi worzeli* (PESSAGNO) - 4801, 90 x, 8 - *Tritrabs ewingi worzeli* (PESSAGNO) - 4786, 60 x, 9 - *Podobursa* cf. *triacantha* (FISCHLI) - 4794, 150 x, 10 - *Transhsuum* cf. *brevicostatum* (OŽVOLDOVÁ) - 4811, 170 x, 11 - *Triactoma* cf. *blakei* (PESSAGNO) - 4807, 100 x, 12 - *Obesacapsula morroensis* (PESSAGNO) - 4805, 90 x.



Pl. 2. Ždiarska vidla.
Sample ŽV-8, Figs. 1 - 13:
1 - *Acaeniotyle diaphorogona* FOREMAN - 4862, 210 x, 2 - *Archaeospongoprunum imlayi* PESSAGNO - 4865, 140 x, 3 - *Homoeoparonaella* cf. *argolidensis* BAUMGARTNER - 4871, 90 x, 4 - *Paronaella* cf. *broennimanni* PESSAGNO - 4874, 130 x, 5 - *Tetratrabs zealis* (OŽVOLDOVÁ) - 4888, 100 x, 6 - *Higumastra imbricata* (OŽVOLDOVÁ) - 4880, 80 x, 7 - *Tritrabs ewingi* s.l. (PESSAGNO) - 4870, 80 x, 8 - *Tritrabs casmaliaensis* (PESSAGNO) - 4867, 150 x, 9 - *Transhsuum brevicostatum* (OŽVOLDOVÁ) - 4873, 175 x, 10 - *Ristola procera* (PESSAGNO) - 4879, 110 x, 11 - *Parahsuum* sp. - 4872, 185 x, 12 - *Tricolocapsa* cf. *plicarum* YAO - 4875, 300 x, 13 - *Tricolocapsa* sp. - 4885, 300 x.



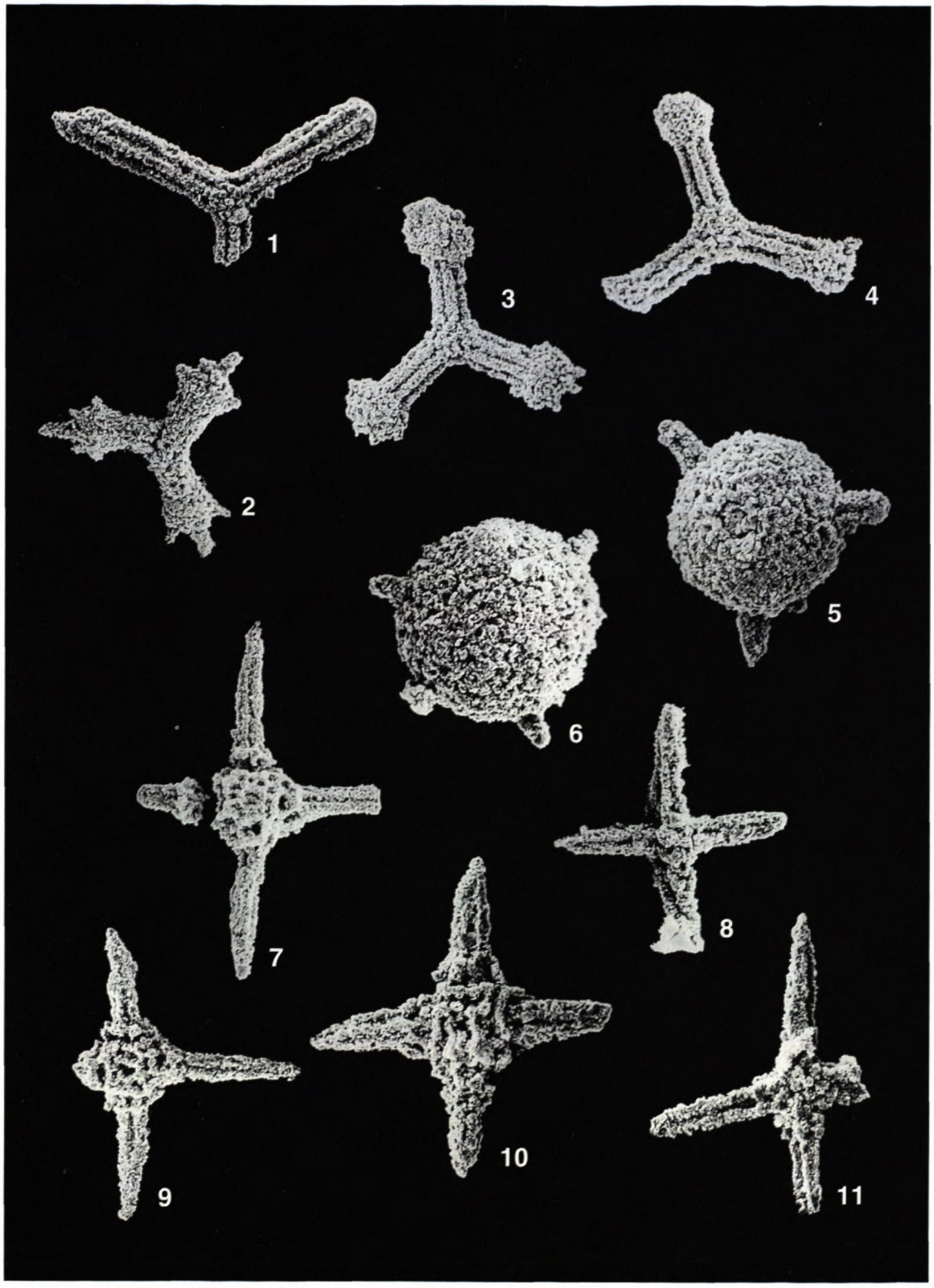
Pl. 3. Banie Huciska.

Sample HC-5, Figs. 1 - 4:

1 - *Orbiculiforma* sp. - 0043, 145 x, 2 - *Tricolocapsa conexa* MATSUOKA - 0045, 300 x, 3 - *Eucyrtidiellum unumaense* s.l. (YAO) - 1075, 400 x, 4 - *Stichocapsa convexa* YAO - 0046, 300 x.

Sample HC-8, Figs. 5 - 12:

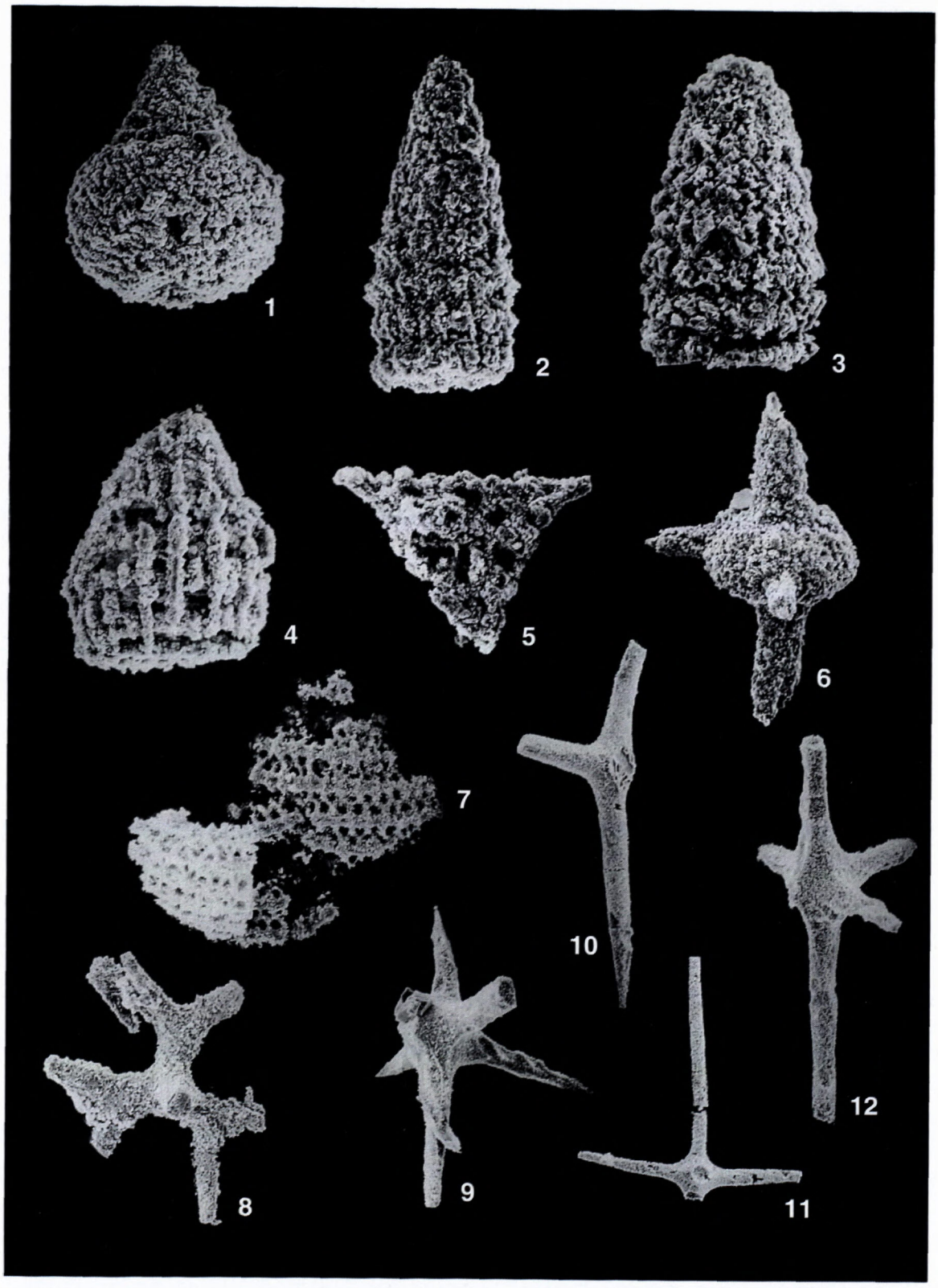
5 - *Acaeniotylopsis variatus* s. l. (OŽVOLDOVÁ) - 1035, 110 x, 6 - *Homoeoparonaella* cf. *argolidensis* BAUMGARTNER - 1041, 100 x, 7 - *Archaeospongoprunum imlayi* PESSAGNO - 1030, 165 x, 8 - *Homoeoparonaella gigantea* BAUMGRARTNER - 1027, 100 x, 9 - *?Homoeoparonaella pseudoewingi* BAUMGARTNER - 1059, 75 x, 10 - *Tetratrabs zealis* (OŽVOLDOVÁ) - 1033, 80 x, 11 - *Triactoma jonesi* (PESSAGNO) - 10044, 100 x, 12 - *Higumastra imbricata* (OŽVOLDOVÁ) - 1026, 100 x.



Pl. 4. Banie Huciska.

Sample HC-8, Figs. 1 - 11:

1 - *Tritrabs hayi* (PESSAGNO) - 1066, 90 x, 2 - *?Paronaella* sp. - 1051, 90 x, 3 - *Tritrabs exotica* (PESSAGNO) - 1039, 115 x, 4 - *Tritrabs exotica* (PESSAGNO) - 1036, 80 x, 5 - *Triactoma mexicana* PESSAGNO et YANG - 1037, 130 x, 6 - *Triactoma mexicana* PESSAGNO et YANG - 1043, 110 x, 7 - *Emiluvia* sp. - 1031, 100 x, 8 - *Emiluvia* sp. - 1038, 115 x, 9 - *Emiluvia chica* s.l. FOREMAN - 1058, 85 x, 10 - *Emiluvia premyogii* BAUMGARTNER - 1067, 130 x, 11 - *Emiluvia* cf. *salensis* PESSAGNO - 1071, 110 x



Pl. 5. Banie Huciska.

Sample HC-8, Figs. 1 - 6:

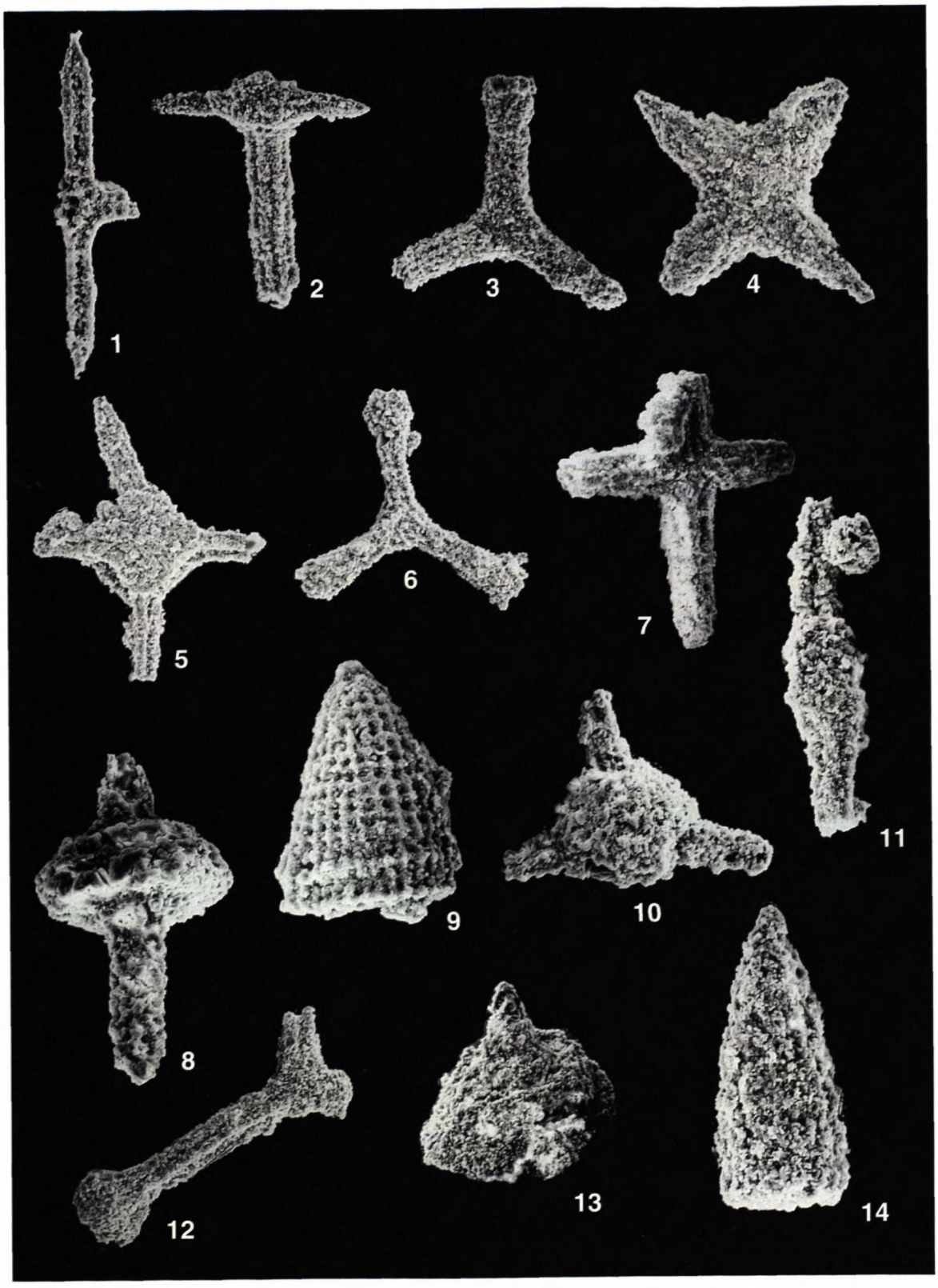
1 - *Obesacapsula morroensis* (PESSAGNO) - 1034, 115 x, 2 - *Transhsuum brevicostatum* (OŽVOLDOVÁ) - 1054, 185 x, 3 - *Transhsuum* cf. *okamurai* (MIZUTANI) - 1048, 225 x, 4 - *Archaeodictyomitra* sp. - 1028, 200 x, 5 - *Perispyridium ordinarium* (PESSAGNO) - 1047, 160 x, 6 - *Podobursa triacantha* s.l. (FISCHLI) - 1057, 120 x.

Sample HC-10, Fig. 7:

7 - *Mirifusus dianae* s.l. (KARRER) - 1082, 160 x.

Sample HC-11, Figs. 8 - 12:

8 - 12 - *Sponge spicules:* 8 - 1085, 70 x; 9 - 1089, 115 x; 10 - 1087, 90 x; 11 - 1088, 70 x; 12 - 1084, 105 x.



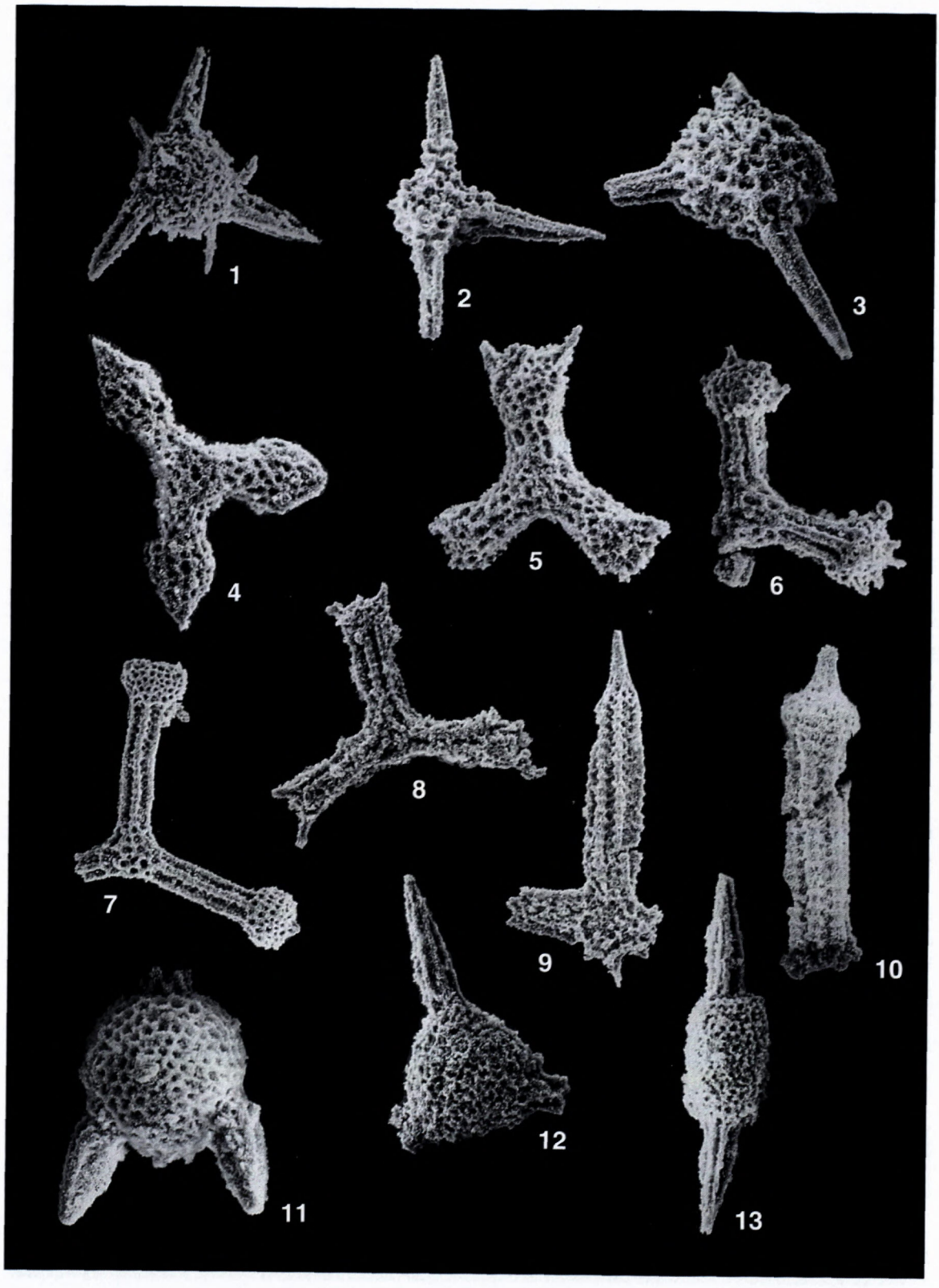
Pl. 6. Gladkie Uplaziańskie.

Sample GU-2, Figs. 1 - 11:

1 - *Tetraditryma corralitosensis bifida* CONTI et MARCUCCI - 1381, 110 x, 2 - *Monotrabs plenoides* gr. BAUMGARTNER - 1393, 120 x, 3 - *Paronaella* cf. *broennimanni* PESSAGNO - 1367, 100 x, 4 - *Pseudocrucella* cf. *sanfilippoae* (PESSAGNO) - 1373, 140 x, 5 - *Emiluvia pessagnoi* s.l. FOREMAN - 1364, 120 x, 6 - *Tritrabs rhododactylus* BAUMGARTNER - 1371, 110 x, 7 - *Tetratrabs zealis* (OŽVOLDOVÁ) - 1376, 120 x, 8 - *Podobursa helvetica* (RÜST) - 1391, 120 x, 9 - *Parahsuum* sp. - 1370, 190 x, 10 - *Triactoma parablakei* YANG et WANG - 1388, 170 x, 11 - *Archaeospongoprunum imlayi* PESSAGNO - 1372, 140 x.

Sample GU-3, Figs. 12 - 14:

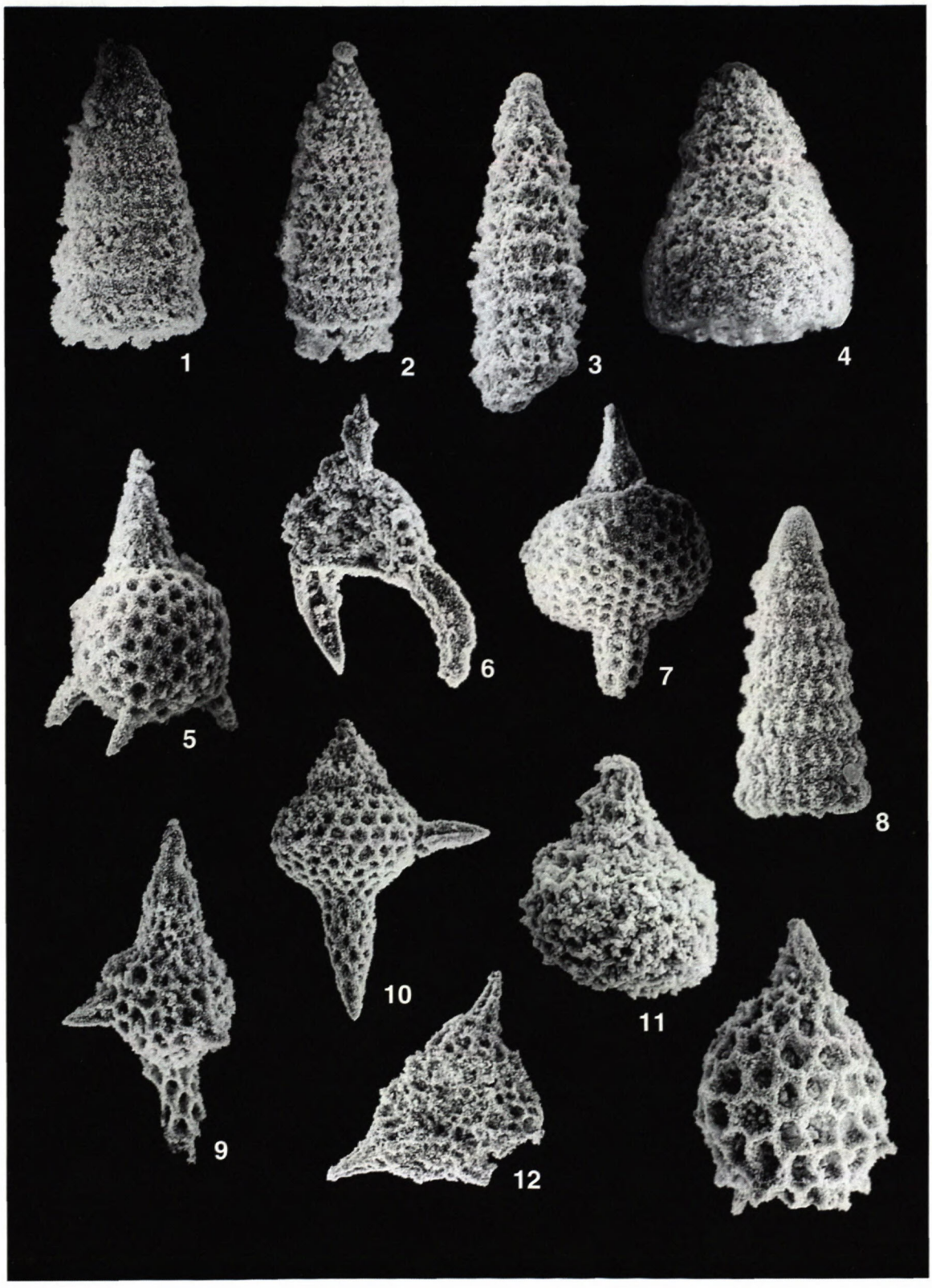
12 - *Tritrabs ewingi worzeli* (PESSAGNO) - 1445, 90 x, 13 - *Poliandromeda podbielensis* (OŽVOLDOVÁ) - 1447, 100 x, 14 - *Transhsuum* cf. *maxwelli* (PESSAGNO)- 1454, 200 x.



Pl. 7. Gladkie Uplaziańskie.

Sample GU-6, Figs. 1 - 13:

1 - *Alievum* sp. A - 1395, 140 x, 2 - *Emiluvia salensis* PESSAGNO - 1346, 120 x, 3 - *Emiluvia orea* BAUMGARTNER - 1402, 150 x, 4 - *Paronaella muelleri* PESSAGNO - 1349, 170 x, 5 - *Paronaella* sp. - 1358, 170 x; 1397, 120 x, 6 - *Tritrabs exotica* (PESSAGNO) - 1397, 120 x, 7 - *Tritrabs ewingi worzeli* (PESSAGNO) - 1332, 90 x, 8 - *Tritrabs casmaliaensis* (PESSAGNO) - 1403, 120 x, 9 - *Tetratrabs zealis* (OŽVOLDOVÁ) - 1335, 100 x, 10 - *Tetratrabs bulbosa* BAUMGARTNER - 1341, 120 x, 11 - *Triactoma blakei* (PESSAGNO) - 1334, 155 x, 12 - *Tripocyclia* cf. *trigonum* RÜST - 1519, 160 x, 13 - *Archaeospongoprunum imlayi* PESSAGNO - 1337, 150 x.



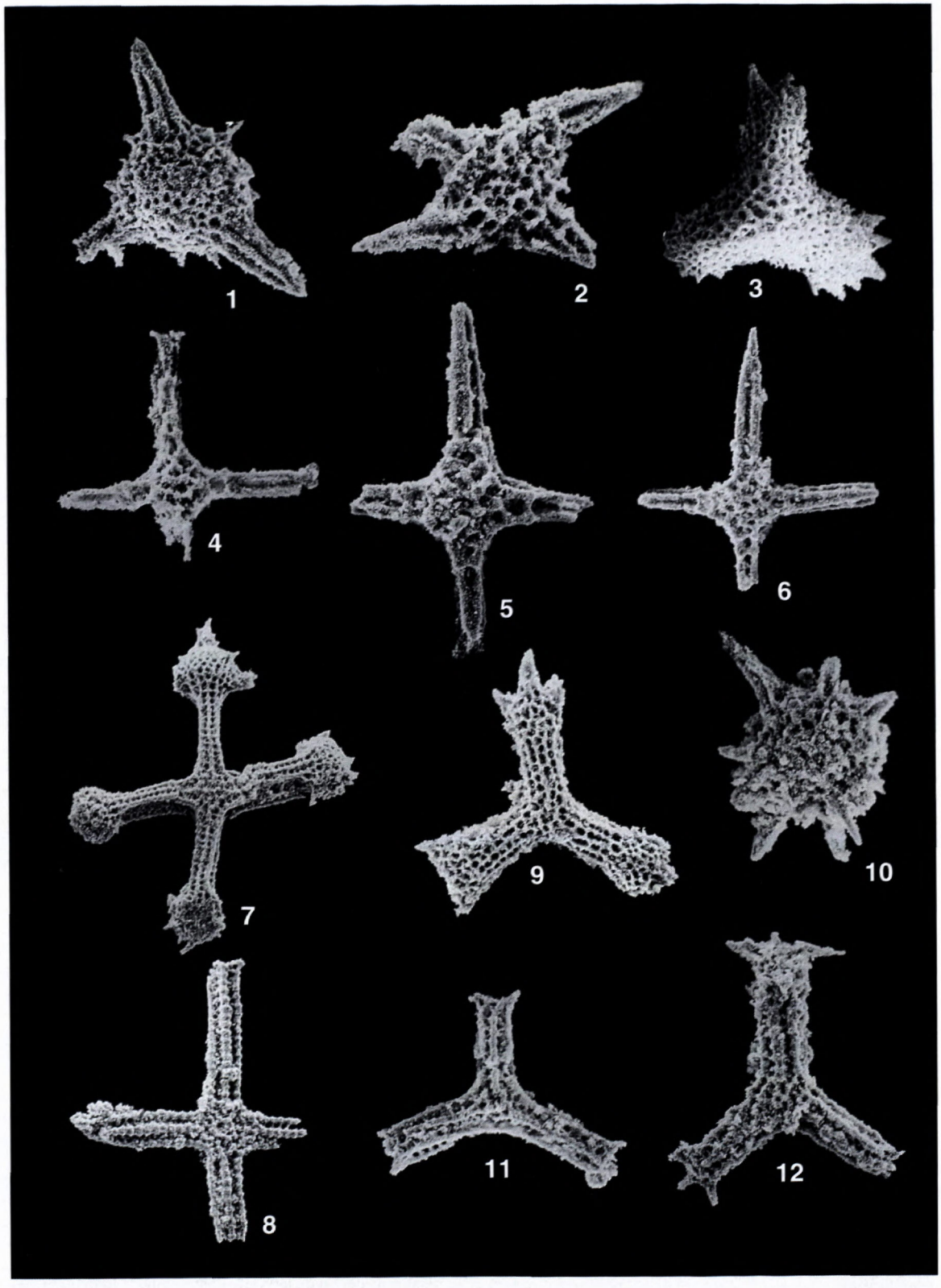
Pl. 8. Gladkie Uplaziańskie.

Sample GU-6, Figs. 1 - 4:

1 - *Cinguloturris carpatica* DUMITRICĂ - 1429, 260 x, 2 - *Parvicingula* sp. - 1339, 230 x, 2 - *Parvicingula dhimenaensis* ssp. A BAUMGARTNER - 1344, 210 x, 4 - *Spongocapsula perampla* (RÜST) - 1338, 170 x.

Sample GU-10, Figs. 5 - 13:

5 - *Sethocapsa sphaerica* (OŽVOLDOVÁ) - 1406, 220 x, 6 - *Napora lospensis* PESSAGNO - 1409, 100 x, 7 - *Dibolachras chandrica* KOCHER - 1441, 125 x, 8 - *Transhsuum brevicostatum* (OŽVOLDOVÁ) - 1412, 170 x, 9 - *Podobursa quadriaculeata* (STEIGER) - 1440, 190 x, 10 - *Podobursa triacantha* (FISCHLI) - 1416, 160 x, 11 - *Sethocapsa* sp. 1 - 1433, 200 x, 12 - *Perispyridium* cf. *tamanense* PESSAGNO et BLOME - 1432, 120 x, 13 - *Sethocapsa* sp. 2 - 1428, 250 x.



Pl. 9. Gladkie Uplaziańskie.

Sample GU-10, Figs. 1 - 12:

1 - *Alievum* sp. A - 1420, 160 x, 2 - *Haliodictya hojnosi* RIEDEL et SANFILIPPO - 1339, 230 x, 3 - *Paronaella pristidentata* BAUMGARTNER - 1424, 125 x, 4 - *Emiluvia hopsoni* PESSAGNO - 1443, 130 x, 5 - *Emiluvia salensis* PESSAGNO - 1419, 150 x, 6 - *Emiluvia salensis* PESSAGNO - 1438, 120 x, 7 - *Tetraditryma pseudoplena* BAUMGARTNER - 1414, 90 x, 8 - *Tetratrabs zealis* (OŽVOLDOVÁ) - 1417, 80 x, 9 - *Paronaella* sp. - 1426, 130 x, 10 - Gen. et sp. indet. - 1413, 170 x, 11 - *Tritrabs casmaliaensis* (PESSAGNO) - 1360, 130 x, 12 - *Tritrabs casmaliaensis* (PESSAGNO) - 1442, 140 x.

Discussion

The Middle to Upper Jurassic radiolarian limestones and radiolarite sequences in the Pieniny section of the Klippen belt were classified by Birkenmajer (1977) as the lower radiolarites of the Sokolica formation, which the author assigned to the Bathonian - Callovian stages, while the upper radiolarites of the Czajakowa he assigns to the Oxfordian - Kimmeridgian stages. Stratigraphically, the same view held Lefeld et al. (1985) and Lefeld (1988).

However, our correlation of the stratigraphic position of radiolarian asociations of the Middle - Upper Jurassic sequences of the Krížna nappe in almost all Western Carpathian core mountains has shown that it does not comply with the Lefeld's (1988) classification of radiolarites of the Krížna nappe, which he divided into lower (predominantly green), correlable with the Sokolica radiolarites and the upper (predominantly red) analogous to the Czajakowa radiolarites. Having evaluated the samples from almost 20 compete sections through the Middle and Upper Jurassic radiolarian limestones and radiolarites we can conclude that there exists no objective and exact reason for dividing this formation in two. Thus, we consider it necessary to define a new lithostratigraphic unit - **the Ždiar Formation** - comprising the Upper Bathonian - Lower Kimmeridgian assemblage of the radiolarian limestones and radiolarites of the Krížna nappe.

The results of analyses of the Western Carpathian, Krížna nappe, Ždiar Formation sediments show that their origin is bound to the onset of the post-riftogenic process, which that took place in a typically basinal environment of the Tethyan passive margin.

Conclusion

The presented contribution supplements and extends the knowledge of radiolarian limestones and radiolarites in another Western Carpathian core mountains - the Tatry Mts..

A new lithostratigraphic unit - the **Ždiar Formation** was determined and characterized.

The stratigraphic range of the Ždiar Formation was assessed on the basis of radiolarian microfauna, which represents the zones UAZ.7, UAZ.8, UAZ.9 and UAZ.10 of BAUMGARTNER et al. (1995). In conclusion we can state that the age of the Ždiar Formation corresponds to the Upper Bathonian - Lower Kimmeridgian.

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