GEOLOGICA CARPATHICA, AUGUST 2007, 58, 4, 305–320

Oxfordian and Callovian radiolarians from the Bucegi Massif and Piatra Craiului Mountains (Southern Carpathians, Romania)

PAOLA BECCARO[1] and IULIANA LAZĂR[2]

[1]Università degli Studi di Torino, Dipartimento di Scienze della Terra, Via Valperga Caluso 35, 10125 Torino, Italy; paola.beccaro@unito.it
[2]University of Bucharest, Faculty of Geology and Geophysics, N. Balcescu Ave., RO-010041 Bucharest, Romania; iul_lazar@yahoo.com

(Manuscript received August 10, 2006; accepted in revised form December 7, 2006)

Abstract: This paper regards the description and the first dating of the radiolarian assemblages of the Jurassic siliceous successions in the Bucegi and Piatra Craiului Mts (Southern Carpathians, Romania). The most representative Jurassic outcrops for this area have been sampled: La Poliţie, Strunga, Strunguliţa, Rătei Valley and Sfânta Ana Olistolith (Bucegi Massif), and Şirnea, Umeri and Vladuşca (Piatra Craiului Mts). The investigated successions are formed by a great variety of sediments, most of them characterized by a large amount of siliciclastic admixture. The sampled layers are constituted by well stratified siliceous limestone or chert, and their thickness usually ranges between 0.5 and 1 m. The Sfânta Ana sample comes from a Jurassic olistolith included in a Lower Cretaceous flysch. The Nassellaria/Spumellaria and sponge spicules/radiolarians ratios provided information about the depositional environments. In well-preserved samples the N/S ratio varies from 1.7 to 2.8, and the spicules/radiolarians ratio is around 0.6: this means that the siliceous sediments were deposited in distal or relatively deep waters. The biostratigraphical analysis has been carried out by applying two radiolarian zonations based on the Unitary Associations method: most samples are referred to the middle-late Oxfordian. The only exception is represented by the Rătei sample that is assigned to the Callovian. The Romanian successions are easily comparable with other Tethyan sections where the Oxfordian levels are generally the richest in radiolarians. Even in environments with siliciclastic supply (Southern Carpathians) the sedimentation drastically changed during the Oxfordian and became siliceous.

Key words: Jurassic, Southern Carpathians, Romania, biostratigraphy, siliceous sediments, micropaleontology, radiolarians, Unitary Associations Zones.

Introduction

Well-preserved radiolarians have been discovered in the Jurassic siliceous sediments of the Bucegi Massif and Piatra Craiului Mts (Southern Carpathians, Romania), and the investigated sections are the most representative Jurassic outcrops for that area. During the Jurassic time, this region of the Carpathian chain was characterized by basins and narrow sectors of platform. The studied successions contain a large amount of siliciclastic admixture. The layers sampled for radiolarians are well stratified siliceous limestone and radiolarian chert whose thickness usually ranges between 0.5 and 1 m.

Radiolarian faunas from the Romanian Carpathians have been previously studied by Dumitrica (1970, 1991, 1995a,b), Dumitrica & Dumitrica-Jud (1995, 2005) and Dumitrica & Carter (1999). Dumitrica also examined the fauna from the Bucegi Massif and Piatra Craiului Mts for describing the new genus *Pterotrabs* (Dumitrica et al. 1997) and the internal structure of some Radiolaria (Dumitrica 1999). So far, no biostratigraphical analyses of radiolarian assemblages have been published for the studied sections in the Bucegi Massif and Piatra Craiului Mts.

Previous researches concerning the geology and the paleontology of the Mesozoic deposits in the investigated outcrops of the Bucegi Massif and Piatra Craiului Mts were accomplished by Herbich (1888), Jekelius (1916, 1928, 1938), Oncescu (1943), Patrulius (1957, 1962, 1969), Popescu (1966), Lazăr (2000, 2004), Lazăr & Barbu (2004).

This paper represents the first attempt to date the Southern Carpathians siliceous sediments directly by radiolarians. The purposes are to provide the description of the radiolarian assemblages of the Bucegi and Piatra Craiului sections (also considering the preservation status, and the Nassellaria/Spumellaria and spicules/radiolarians ratios), to date the studied successions by two radiolarian zonations (Baumgartner et al. 1995a and Beccaro 2006) and to compare the studied siliceous facies with coeval Tethyan facies. An overview on Carpathian siliceous sediments outside Romania is also given.

Geological setting

The Bucegi Massif and Piatra Craiului Mts are located in the eastern end of the Southern Carpathians in the junction area between the structural units of the Eastern and Southern Carpathians (Fig. 1). From the paleogeographical viewpoint the Bucegi Massif and Piatra Craiului Mts belong to the Getic Carbonate Platform. Triassic deposits lie transgressively on the pre-Alpine crystalline basement and the Jurassic sedimentation started with continental deposits (conglomerate, sandstone, bituminous clay) (Patrulius et al. 1980). During the Middle Jurassic, narrow faulted shelves

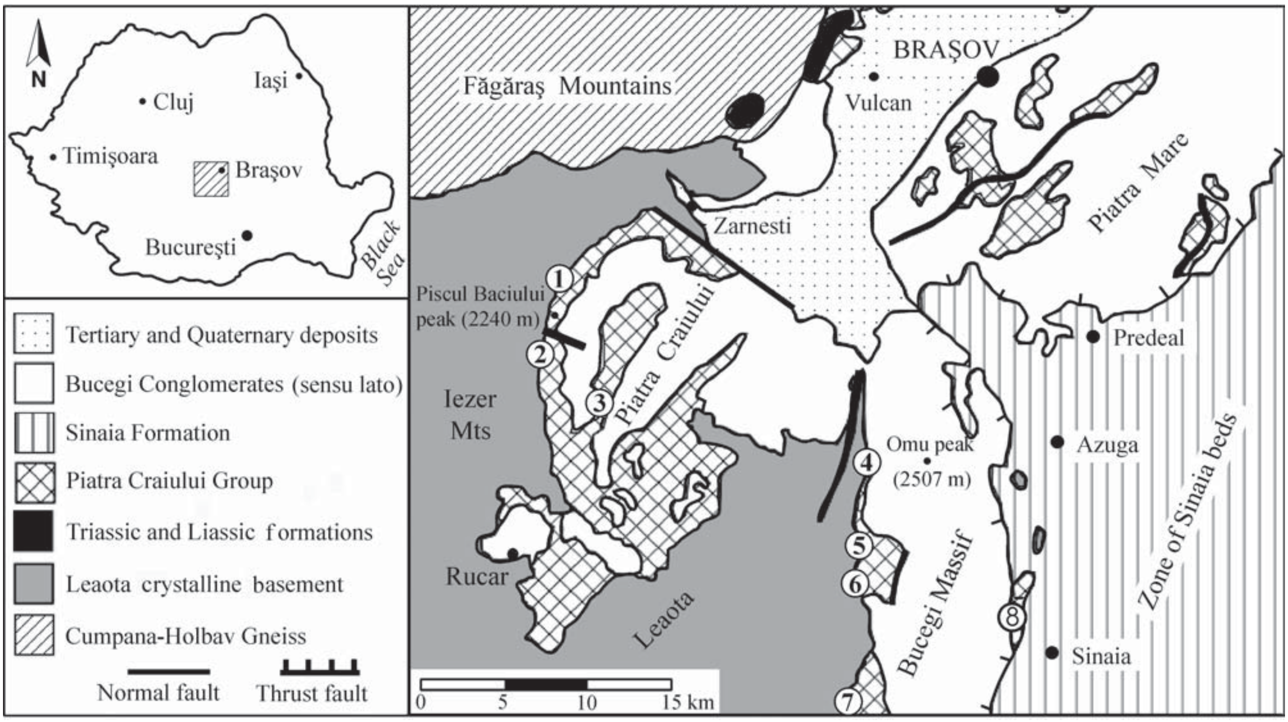

Fig. 1. Geological sketch map of the studied area (Southern Carpathians, Romania) and the geographical location of the stratigraphical sections at the Piatra Craiului Mts (1 — Vladuşca, 2 — Umeri, 3 — Şirnea) and in the Bucegi Massif (4 — La Poliţie, 5 — Strunga, 6 — Strunguliţa, 7 — Rătei, 8 — Sfânta Ana).

with siliciclastic and carbonate deposits developed. Between these sediments, a continuous unit of radiolarites can be identified at the top of a condensed sequence (sometimes displaying mineralized hardgrounds). During the Late Jurassic, carbonate sedimentation became more widespread with the deposition of pelagic limestone (micrite containing ammonites alternated with siliceous levels). In the Early Cretaceous, differential block-tilting drowned some parts of the former Getic Platform while other parts emerged: deep water sedimentation was contemporaneous with some patch reefs and karstification processes (Patrulius et al. 1980). Tertiary deposits are mainly siliciclastics and occur only sporadically in this sector of the Southern Carpathians.

The Bucegi Massif contains several olistoliths which are embedded in the Piscul cu Brazi Formation, a Lower Cretaceous (Barremian–Aptian) flysch constituted by conglomerate, sandstones, siltstones and marls (Patrulius 1969). One of these olistoliths is the Sfânta Ana Olistolith: it is Middle-Late Jurassic in age and has been sampled for this research.

Geographical location and lithological description of the sections

Stratigraphical sections at the Bucegi Massif

The location of the sections in the Bucegi Massif (Southern Carpathians, Romania) are shown in the Fig. 1. From North to South, the outcrops are: La Poliţie Saddle, Strunga Pass, Strunguliţa Pass, Rătei Valley, Sfânta Ana Olistolith (Peleş Valley). The stratigraphical logs are illustrated in Fig. 2. The ages of the siliceous levels are based on the radiolarian data that will be subsequently discussed in detail (see chapter regarding the radiolarian biostratigraphy).

La Poliţie Saddle is situated in the northern extremity of the Bucegi Massif at approximately 1730 m in altitude. The sedimentary rocks are represented by Middle-Upper Jurassic and Lower Cretaceous deposits with a total thickness of around 150 m. The complete succession can be seen only by the junction of the outcrops of the La Poliţie Saddle, Gaura Valley and of the small trail between these two locations. The succession cropping out at La Poliţie Saddle is illustrated in Fig. 2a. In the lower part of the section there are siliceous limestones (1–1.3 m the visible thickness), where the studied samples come from; the age of the upper part of such limestones is referred to middle-late Oxfordian by radiolarians. The Kimmeridgian-lower Tithonian deposits are represented by reddish-green limestone (sometimes nodular) with poorly preserved ammonites in the lower part (Jekelius 1916; Patrulius 1969) and fine granular white limestone in the upper part of the section. The Bajocian-Bathonian deposits (3 m thick), represented by calcareous sandstone and bioclastic calcarenites alternating with thin sandy levels can be observed on a small right affluent of the Gaura Valley. This outcrop was described in detail by Lazăr & Barbu (2004), and bivalves, brachiopods, rare gastropods and echinoids were collected from the sandstones.

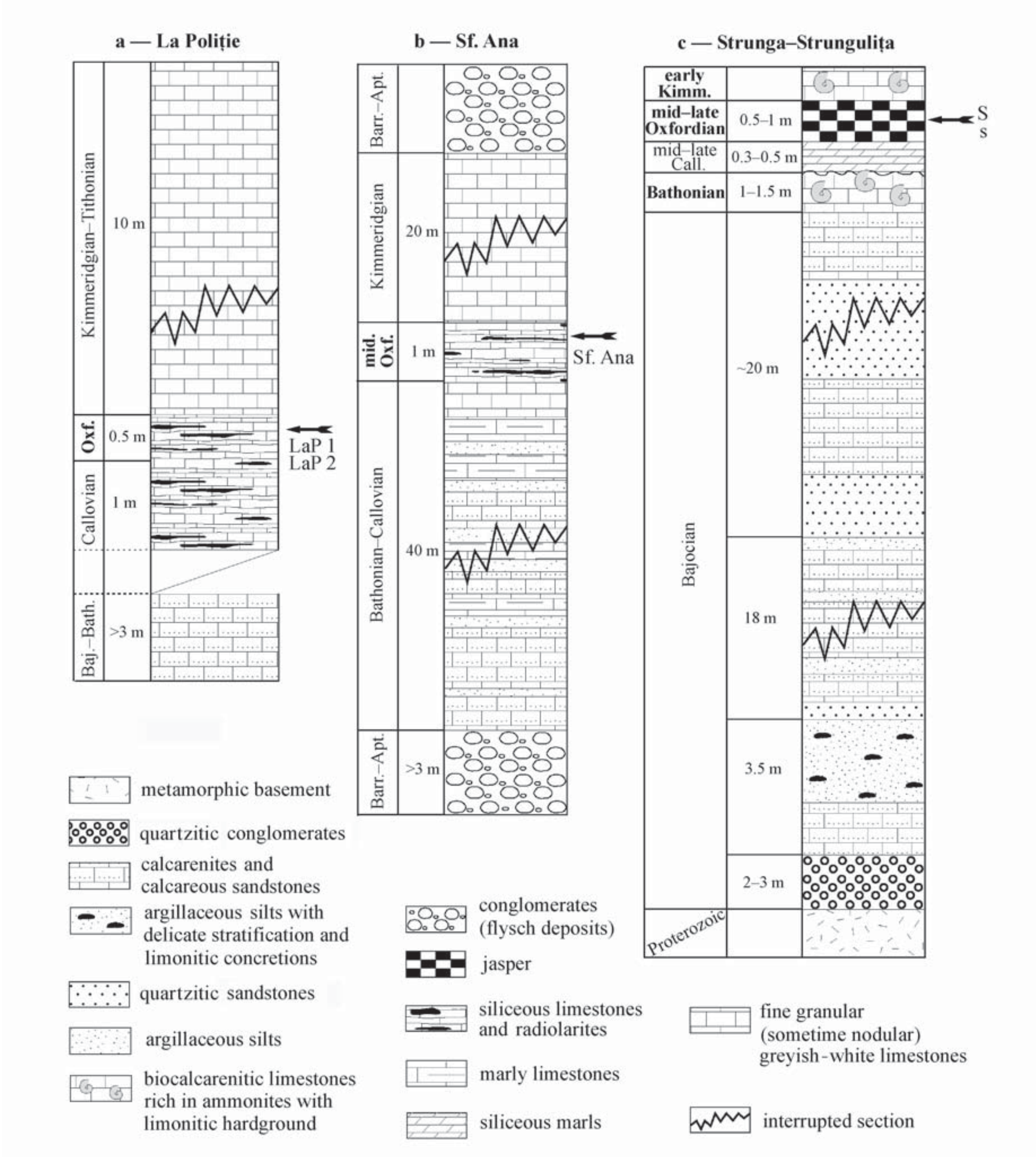

Fig. 2. Stratigraphical columns of the La Poliţie (**a**), Sfânta Ana (**b**) and Strunga–Strunguliţa (**c**) sections (Bucegi Massif, Southern Carpathians, Romania). The Sfânta Ana succession is a Jurassic olistolith included in the Lower Cretaceous flysch. On the left of the logs are reported the ranges: the ages in bold are based on radiolarians (this paper) and ammonites (Patrulius 1969; Mutihac & Ionesi 1973), the other ages are only hypothesized in the literature. The arrows indicate the position of the samples; LaP 1 and LaP 2 come from the same layer; "S" refers to the Strunga sample and "s" to the Strunguliţa sample.

Sfânta Ana Olistolith is located in the Peleş Valley (eastern flank of the Bucegi Massif) near Sinaia, at about 1110 m altitude. The stratigraphical log of this area is illustrated in the Fig. 2b. The olistolith is constituted by Middle-Upper Jurassic siliciclastic and carbonate deposits, and it is included within Barremian-Aptian conglomerates. The Bathonian-lower Callovian deposits are represented by calcareous sandstone alternating with silts, marls and biocalcarenites with poorly preserved macrofauna (ammonites, aptychi, belemnites, bivalves, rare brachiopods). The siliceous limestones are 1 m thick and are referred to the middle Oxfordian by radiolarians. They are followed by grey massive nodular limestone Kimmeridgian in age.

At the **Strunga Pass** (1904 m altitude) and **Strunguliţa Pass-Tataru Peak** (1998 m altitude) the most typical section for the Jurassic of the Getic Nappe sedimentary cover can be observed. The stratigraphical log of this area is shown in the Fig. 2c. Quartzitic conglomerates, calcarenites, argillaceous silts, biocalcarenites and calcareous sandstone mainly represent the lower part of the succession. From these deposits, Lazăr (2000, 2002, 2004) described numerous species of bivalves. From the top of the siliciclastic sediments Patrulius (1969) described ammonite associations that refer to early Bathonian (*Zigzag* Zone), early late Bathonian (*Retrocostatum* Zone) and late Bathonian (*Aspidoides* and *Discus* Zones). The successive sediments are constituted by reddish siliceous marls and jasper less than 1 m thick and assigned to Oxfordian by radiolarians. The jasper is topped by nodular limestones rich in ammonites: Patrulius (1969) described a good ammonites assemblage that refers the sediments to the Kimmeridgian-Tithonian. Mutihac & Ionesi (1973) reported an *Aspidoceras acanthicum* ammonite fauna that refers to the upper part of the lower Kimmeridgian.

The **Rătei Valley** is a right side tributary of the Ialomita Valley on the western flank of the Bucegi Massif. The succession is similar to Strunga–Strungulița section and, due to poor exposure, the stratigraphical column is not illustrated. In the Rătei Valley, quartzitic conglomerate, calcareous sandstone and calcarenites occur, and the total thickness of these deposits is much smaller than at Strunga–Strungulița (where it exceeds 40 m). In the Rătei Valley, owing to the scanty exposure of the outcrops, the stratigraphical position of the sediments is questionable. Patrulius (1969) assumed that the middle-upper Callovian is represented by grey and green jasper, and that the presence of the Oxfordian is limited to resedimented clasts in the Kimmeridgian limestone. The samples for radiolarians were collected from a thin (0.1 m thick) Callovian jasper at the top of the Bajocian-Bathonian sandstones.

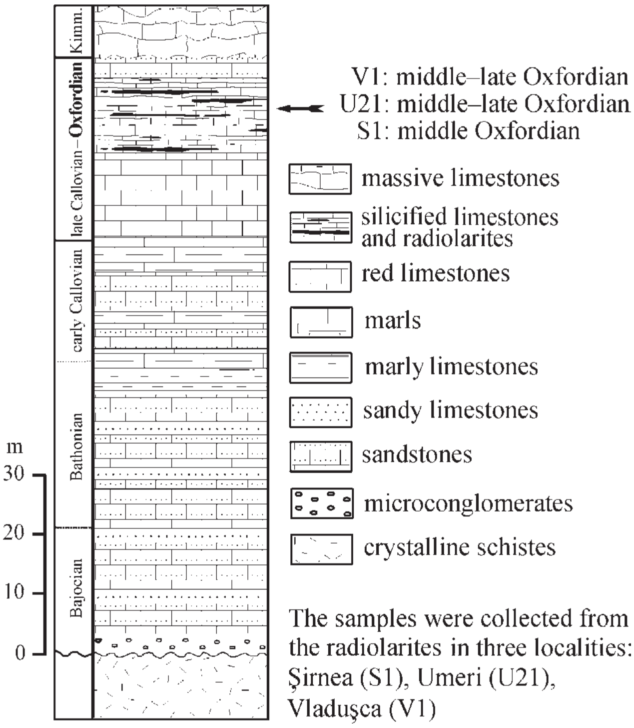

Fig. 3. Stratigraphical column of the Vladușca section (Piatra Craiului Mts, Southern Carpathians, Romania). The most continuous and well developed Middle Jurassic deposits of the Piatra Craiului Mts are exposed in the Vladușca Valley and this log (redrawn after Bucur 1980) is representative also for the Șirnea and Umeri sections. The ages defined in this research by radiolarians are indicated in bold.

Stratigraphical sections at the Piatra Craiului Mts

In the Piatra Craiului Mts (Southern Carpathians, Romania) three stratigraphical sections have been studied: Vladușca, Umeri and Șirnea (Fig. 1). The most continuous and well developed Middle Jurassic deposits of the Piatra Craiului Mts are exposed in the Vladușca Valley and a synthetic log from this locality is illustrated for all three sections (Fig. 3). The ages of the siliceous levels are based on the radiolarian data that will be subsequently discussed in detail (see chapter regarding the radiolarian biostratigraphy).

The **Vladușca** section is located in the upper part of the Vladușca Valley, a few kilometers northwest of Umeri. Over the metamorphic basement, a succession composed of basal conglomerates and graywackes/sandstones occurs, followed by a thick sandstone/siltstone unit containing molluscs. The radiolarites occur at the top of the siliciclastic sequence. Bucur (1980) described some radiolarians in thin sections and assumed a Bajocian to Oxfordian age. On the basis of new radiolarian data (this paper) the siliceous sediments are assigned to middle-late Oxfordian.

The **Umeri** section is situated in the upper part of Bârsa Tămașului Valley at 1600 m in altitude, along the footpath from the base of the limestone cliffs of Piatra Craiului Mts. Here, the entire Jurassic succession crops out, starting with thin microconglomerates overlying the metamorphic basement, and then followed by sandstones and siltstones. The radiolarites occur as thin beds (1–1.5 m in total thickness) with transitional lower and upper boundaries towards bioclastic red limestones. The siliceous sediments are dated by radiolarians as middle-late Oxfordian, and are followed by up to 900 m of shallow-water Kimmeridgian-Tithonian limestones.

The **Șirnea** section is located in the area between the Bucegi Massif and Piatra Craiului Mts. Here, the Middle Jurassic deposits are very thin (5–10 m) and lie directly on the metamorphic basement. The base of the Jurassic succession is composed of sandstones which rapidly pass into sandy oolitic limestone and marls. The radiolarites occur as nodular beds in the red mudstone, and are middle Oxfordian in age (this paper). White massive Kimmeridgian limestone follows the siliceous deposits.

Methods

The laboratory treatments followed the standard methods using hydrochloric acid first, and hydrofluoric acid afterwards (Dumitrica 1970; Pessagno & Newport 1972; De Wever 1982; De Wever et al. 2001).

The following indices have been estimated: Preservation Index (PI), Nassellaria/Spumellaria ratio (N/S), and sponge spicules/radiolarians ratio. The PI evaluates the preservation status of the radiolarians: it ranges from 1 (excellent) to 8 (extremely poor), and refers to recrystallization and corrosion but not to fragmentation (Kiessling 1996).

The biostratigraphical analysis has been carried out by applying the radiolarian zonations of Baumgartner et al. (1995a) and Beccaro (2006). The zonation UAZ95 of Baumgartner et al. (1995a) refers to a world correlation for the Middle Jurassic–Early Cretaceous Tethyan Realm and spans the Aalenian to early Aptian time through 22 UAZones. The database of the UAZ95 contains more than 160 stratigraphical sections: the sacrifice of vertical resolution was unavoidable and the ranges expressed by the UAZ95 are quite long. The zonation UAZ-SA of Beccaro (2006) refers to the Unitary Association Zones defined for Sicily and the Southern Alps (Italy). The database of the UAZ-SA contains the stratigraphical distributions of the radiolarians in 9 Italian sections: it provides a more precise vertical resolution but a more local zonation in comparison with Baumgartner et al. (1995a). The zonation of Beccaro (2006) ranges from early Bathonian to late Kimmeridgian through 6 UAZones.

Some considerations about radiolarian and spicule abundances

The ratios Nassellaria/Spumellaria (N/S) and sponge spicules/radiolarians are well known to have a high paleoecological potential: they provide a significant tool for determining the distance from the shelf and suggesting fluctuations in sea level (Casey 1993). The N/S is positively correlated with the bathymetry: Nassellaria increase in relative abundance in deeper water sediments or at great distance from the shelf (N/S is very high in distal basins and around one in open oceanic plateaux or proximal slopes) while Spumellaria dominate in shallow waters (Kiessling 1996). The morphological diversity of the species is also positively correlated with the bathymetry: the number and diversity of species in oceanic sediments are much higher than in coastal sediments (Kruglikova 1989). On the contrary, the relative abundance of sponge spicules is inversely correlated with bathymetry: the spicules only make a significant contribution to the siliceous microfossil content in slope or proximal environment sediments, especially those with a high turbiditic influence (Kiessling 1996). Nevertheless, before any paleoenvironmental considerations, we must consider the role of the preservation status on the faunal ratios. Sponge spicules have a higher preservation potential in comparison with radiolarians and high spicule abundance in poorly preserved material has a very limited paleoecological meaning (Kiessling 1996).

In the samples of the Bucegi and Piatra Craiului sections (Southern Carpathians, Romania), an evaluation of the faunal ratios based on 300 specimens has been provided in order to get some information about the relative abundance of radiolarians and sponge spicules, and afterwards on the depositional environments. The preservation status is indicated by the Preservation Index (PI) as described by Kiessling (1996). The N/S and spicules/radiolarians ratios, and the PI are reported in the Figs. 4–5.

In most samples Nassellaria are more abundant than Spumellaria and the spicules/radiolarians ratio is close to 1: these data suggest the deposition in distal or relatively deep waters. Especially the assemblages of La Poliţie (Bucegi Massif) and Umeri (Piatra Craiului Mts) are the most reliable thanks to their good preservation (PI ranging 2 to 4). In Strunga and Strunguliţa (Bucegi Massif) and Vladuşca (Piatra Craiului Mts) assemblages, the preservation is poor and the ratios among Nassellaria, Spumellaria and spicules probably do not reflect the primary composition of the thanatocoenosis.

The radiolarian assemblage of Sfânta Ana (Bucegi Massif) indicates the deposition in proximal waters or slope environment due to the abundant occurrence of Spumellaria and sponge spicules. Amongst the studied samples, this radiolarian assemblage is the only one in which Spumellaria clearly dominate over Nassellaria (N/S = 0.3) and the spicules represent 60 % of the siliceous content. The preservation is generally moderate (PI = 4) and most of the smallest radiolarians are well preserved (PI = 3).

In the Rătei sample (Bucegi Massif) Nassellaria strongly dominate over Spumellaria (N/S is around 9) and the spicules/radiolarians ratio is close to 1. Even though the preservation is poor (PI = 6), these data could be reliable because the spicules (whose preservation potential is higher than radiolarians) do not dominate the assemblage and the Nassellaria are indeed more abundant than Spumellaria. It is reasonable to suppose that the Rătei sediments were deposited in distal or relatively deep environments.

The paleoenvironmental considerations based on the N/S and the spicules/radiolarians ratios agree well with the geological setting of the studied sections: during Middle and Late Jurassic the siliceous sediments were deposited on fragments of the former carbonate platform located in different environments (proximal and distal waters).

Radiolarian biostratigraphy of the Bucegi Massif and Piatra Craiului Mountains

The radiolarian assemblages of nine samples from eight sections of the Bucegi Massif (La Poliţie Saddle, Strunga Pass, Strunguliţa Pass, Rătei Valley and Sfânta Ana Olistolith) and Piatra Craiului Mts (Vladuşca, Umeri, Şirnea) have been studied. Most of the samples are rich in taxa: the lists of species are reported in the Figs. 4–5.

Each taxon is marked by a code: the species carrying a numerical code are illustrated in the catalogue of Baumgartner et al. (1995b) and used for building the UAZ95 biozonation (Baumgartner et al. 1995a); the species carrying a lettered code were only used in the UAZ-SA biozonation (Beccaro 2006); the species marked with an asterisk were not used for building the UAZ-SA zonation.

The stratigraphical distributions of *Eucyrtidiellum unumaense* s.l. (Yao) and *Williriedellum* (?) *marcucciae* Cortese were stated to end in UAZ 8 (middle Callovian-early Oxfordian) by Baumgartner et al. (1995a) and these taxa have been proved to continue up to middle Oxfordian (Beccaro 2004). The biostratigraphical value of some spe-

Radiolarian assemblages at the Bucegi Mts	Code	UAZ95	UAZ-SA	LaP 1	LaP 2	Sf. Ana	Strunga	Strungulița	Rătei
Angulobracchia biordinalis Ožvoldová	3145	9–11	D–F	●	●				
Archaeodictyomitra apiarium (Rüst)	3263	8–22	D–F					●	
Archaeodictyomitra shengi * Yang				●					
Archaeospongoprunum imlayi * Pessagno				●					
Archaeospongoprunum elegans * Wu				●					
Archaeospongoprunum sp. aff. *A. elegans* * Wu				●	●	●			●
Bernoullius dicera (Baumgartner)	3223	3–10	A–F			●			●
Cinguloturris carpatica Dumitrica	3193	7–11	D–F			●			●
Dicerosaturnalis angustus (Baumgartner)	3082	6–10	B–E	●				●	●
Emiluvia hopsoni Pessagno	3225	6–15	D–F	●	●				
Emiluvia nana * Baumgartner	3212	6–9				●		●	
Emiluvia orea Baumgartner	3224	8–11	C–F			●		●	
Emiluvia peteri Beccaro	EMPT		D–F	●	●				
Emiluvia premyogii Baumgartner	3210	3–10	A–E	●	●				
Emiluvia sedecimporata * (Rüst)	3216	3–11		●	●				
Emiluvia ultima Baumgartner et Dumitrica	4070	10–11	E–F		●				
Eospongosaturnalis protoformis * (Yao)	2021	3–8							●
Eucyrtidiellum ptyctum (Riedel et Sanfilippo)	3017	5–11	B–F	●		●			●
Eucyrtidiellum unumaense (Yao) s.l.	3052	3–8	A–C			●	●		●
Gongylothorax favosus Dumitrica	6131	8–10	B–F	●		●			
Gorgansium spp. *	3076	3–8		●	●			●	
Haliodictya (?) *hojnosi* * Riedel et Sanfilippo	3254	3–10		●					
Hexasaturnalis minor (Baumgartner)	3085	3–11	B–F	●	●	●		●	
Hexasaturnalis nakasekoi Dumitrica et Dumitrica-Jud				●	●	●	●	●	●
Higumastra wintereri * Baumgartner et Kito	3148	1–8		●					
Homoeoparoanella argolidensis Baumgartner	3103	4–11	B–D			●			
Hsuum speciosum * Hull									●
Loopus doliolum Dumitrica	LPDL		B–E	●	●	●			
Mirifusus dianae dianae (Karrer)	3274	7–12	E			●		●	
Napora deweveri Baumgartner	3035	7–11	D–F	●					
Napora lospensis Pessagno	3036	8–13	D–F			●			
Palinandromeda spp.	PLMD	1–10	A–D					■	
Palinandromeda podbielensis * (Ožvoldová)	3008	5–9						●	
Pantanellium josephinense * Pessagno, Blome et Hull					●				
Pantanellium riedeli Pessagno	3078	7–12	B–F			●			
Parahsuum carpathicum Widz et De Wever	3240	7–11	A–E	●	●	●		●	
Paronaella mulleri * Pessagno	3139	6–10		●					
Paronaella sp. aff. *P. bandyi* * Pessagno						●			
Perispyridium ordinarium (Pessagno) gr.	3100	5–11	A–E	●	●				
Podobursa chandrika (Kocher)	3265	7–11	B–F	●				●	
Podobursa polyacantha (Fischli)	3174	5–8	A–D			●			
Podobursa spinosa (Ožvoldová)	3230	8–13	C–F	●	●			●	
Podobursa triacantha (Fischli) gr.	PDTC		B–F	●	●			●	
Podobursa vannae Beccaro	PDVN		C–F	●	●			●	
Praeconocaryomma sp. *				●	●				
Protunuma japonicus Matsuoka et Yao	3292	7–12	B–F	●	●	●		●	
Pseudocrucella sanfilippoae * (Pessagno)	3126	7–10			●				
Pterotrabs arcuballista * Dumitrica, Baumgartner et Goričan						●			
Pterotrabs victoria * Dumitrica, Baumgartner et Goričan								●	
Sethocapsa sp. aff. *S. exagona* * Hori									●
Stichocapsa naradaniensis * Matsuoka	3045	6–7							●
Stichocapsa tuscanica * Chiari, Cortese et Marcucci				●					●
Tethysetta dhimenaensis dhimenaensis (Baumgartner)	4072	3–11	B						●
Tethysetta dhimenaensis ssp. A sensu Baumgartner et al. 1995b	4071	3–8	A–B		●				
Tetraditryma emilei * Hull					●				
Tetratrabs bulbosa Baumgartner	3122	7–11	D–F	●	●			●	
Tetratrabs zealis (Ožvoldová)	3121	4–13	B–E	●				●	

Fig. 4. Stratigraphical distribution of radiolarian taxa in the Bucegi Massif sections (Southern Carpathians, Romania). The species carrying a numerical code are illustrated in Baumgartner et al. (1995b); the species carrying a lettered code are not included in that volume; taxa carrying an asterisk have not been used for building the UAZ-SA zonation of Beccaro (2006). The black square indicates the occurrence of a group of species for biostratigraphical purposes. The ages of the samples are given by the Unitary Association Zones of Baumgartner et al. (1995a) (UAZ95) and by the Unitary Association Zones for Sicily and the Southern Alps (Italy) of Beccaro (2006) (UAZ-SA). The Preservation Index ranges from 3 (good) to 7 (very poor) (Kiessling 1996). *Continued on next page.*

Radiolarian assemblages at the Bucegi Mts	**Code**	**UAZ95**	**UAZ-SA**	**LaP 1**	**LaP 2**	**Sf. Ana**	**Strunga**	**Strunguliţa**	**Rătei**
Transhsuum brevicostatum (Ožvoldová) gr.	3181	3–11	A–E		●	●		●	●
Transhsuum maxwelli * (Pessagno) gr.	3180	3–10						●	●
Triactoma blakei (Pessagno)	3095	4–11	C–F	●	●	●	●	●	●
Triactoma enzoi Beccaro	TCEZ		B–D						
Triactoma mexicana * Pessagno et Yang	3412	5–9					●	●	
Tripocyclia brooksi * Pessagno et Yang				●	●	●		●	
Tritrabs casmaliaensis (Pessagno)	3117	4–10	B–F	●	●				
Tritrabs ewingi (Pessagno) s.l.	3113	4–22	B–F	●		●			
Tritrabs exotica (Pessagno)	3119	4–11	C–F	●	●				
Tritrabs rhododactylus Baumgartner	3118	3–13	E–F		●				
Tritrabid gen. et sp. indet.				●	●				
Williriedellum carpathicum Dumitrica	4055	7–11	B–E	●	●	●			●
Williriedellum crystallinum * Dumitrica	3069	7–11		●					
Williriedellum (?) *marcucciae* Cortese	4060	4–8	B–C						●
Zhamoidellum (?) *exquisitum* Hull	ZHE0		D	●					
Zhamoidellum ovum Dumitrica	4079	9–11	D–F	●	●				
Age of the samples by UAZ95 (Baumgartner et al. 1995a) 7: late Bathonian–early Callovian 8: middle Callovian–early Oxfordian 9: middle–late Oxfordian 10: late Oxfordian–early Kimmeridgian				**9–10**	**10**	**8**	**8**	**8–9**	**7**
Age of the samples by UAZ–SA (Beccaro 2006) B: early Callovian *pars*–early Oxfordian C: middle Oxfordian D: ?middle–?late Oxfordian E: ?late Oxfordian –?early Kimmeridgian *pars*				**D–E**	**E**	**C**	**C**	**D**	**B–C**
Preservation Index (Kiessling 1996)				3	3–4	4	7	4–5	6
Nassellaria / Spumellaria ratio				1.7	1.7	0.3	3.6	3.8	9.2
Sponge spicules / radiolarians ratio				0.6	0.6	1.7	2.6	1.2	0.9

Fig. 4. *Continued from previous page.*

cies (**Gorgansium* spp. sensu Baumgartner et al. (1995b), **Higumastra wintereri* Baumgartner et Kito, *Tethysetta dhimenaensis* ssp. A sensu Baumgartner et al. (1995b), *Zhamoidellum* (?) *exquisitum* Hull) are still questionable because of their sparse occurrence, and it is likely that their ranges are slightly different from what is stated in Baumgartner et al. (1995a). The stratigraphical distributions expressed by UAZ-SA for some species (*Cinguloturris carpatica* Dumitrica, *Homoeoparonaella argolidensis* Baumgartner, *Loopus primitivus* (Matsuoka et Yao), *Mirifusus dianae dianae* (Karrer), *Napora lospensis* Pessagno, *Triactoma blakei* (Pessagno), *Tritrabs rhododactylus* Baumgartner) are not in disagreement with other taxa of the same assemblage because it is known from other sections (Baumgartner et al. 1995a) that they have longer ranges than those expressed by the UAZ-SA. For building the UAZ-SA zonation, the species **Palinandromeda podbielensis* (Ožvoldová) was included under "*Palinandromeda* spp.", which refers to a group of *Palinandromeda* Pessagno, Blome et Hull in order to give a biostratigraphical potential also to those species that are easily recognizable but show low frequency along the sections (Beccaro 2006).

Hexasaturnalis nakasekoi Dumitrica et Dumitrica-Jud was included under *Hexasaturnalis suboblongus* (Yao) at the time of the UAZ95 (Baumgartner et al. 1995a). Recently, *H. suboblongus* (Yao) has been split in two species: *H. suboblongus* (Yao) and *H. nakasekoi* Dumitrica et Dumitrica-Jud (Dumitrica & Dumitrica-Jud 2005). Dumitrica et Dumitrica-Jud (2005) assert that *H. suboblongus* spans the Bajocian and *H. nakasekoi* ranges within the Bathonian–Kimmeridgian interval.

Below follow the description of the radiolarian assemblages and the biostratigraphical considerations for each sample.

La Poliţie (Bucegi Massif) — The samples LaP 1 and LaP 2 have been collected from the same layer at the La Poliţie section. By applying the UAZ95 zonation, the age of the layer seems assignable to UAZ 10 (late Oxfordian-early Kimmeridgian) for the presence of *Emiluvia ultima* Baumgartner et Dumitrica (UAZ 10–11; Fig. 6.20), *Emiluvia premyogii* Baumgartner (UAZ 3–10) (Fig. 6.21), *Gongylothorax favosus* Dumitrica (UAZ 8–10) and *Tritrabs casmaliaensis* (Pessagno) (UAZ 4–10; Fig. 6.10). The age of LaP 1 also includes UAZ 9 (middle–late Oxfordian) by **Emiluvia nana* Baumgartner (UAZ 6–9), **Palinandromeda podbielensis* (Ožvoldová) (UAZ 5–9), and **Triactoma mexicana* Pessagno et Yang (UAZ 5–9). By means of UAZ-SA zonation, the age of the layer is referred to UAZ E (?late Oxfordian-early Kimmeridgian *pars*) thanks to the occurrence of *Emiluvia ultima* Baumgartner et Dumitrica (UAZ E–F), *Emiluvia premyogii* Baumgartner (UAZ A–E), *Perispyridium ordinarium* gr. (Pessagno) (UAZ A–E; Fig. 6.7), *Tetratrabs zealis* (Ožvoldová) (UAZ B–E) and *Williriedellum carpathicum* Dumitrica (UAZ B–E). The age of LaP 1 also includes UAZ D (?middle–?late Oxfordian) for the presence of *Palinandromeda* spp. (UAZ A–D), *Podobursa polyacantha* (Fischli) (UAZ A–D), *Triactoma enzoi* Beccaro (UAZ B–D). The genus *Palinandromeda* is a good marker for the Oxfordian (UAZ 9 and UAZ D) and only *Emiluvia ultima* Baumgartner et Dumitrica goes up to late Oxfordian-early Kimmeridgian (UAZ 10 and UAZ E). Furthermore, some species typically associated with *E. ultima* (such as *Acaeniotyle umbilicata*

Radiolarian assemblages at the Piatra Craiului Mts	**Code**	**UAZ95**	**UAZ-SA**	**Vladușca**	**Umeri**	**Șirnea**
Amphipyndax * sp.					●	
Archaeodictyomitra apiarium (Rüst)	3263	8–22	D–F		●	
Archaeodictyomitra inornata * Hull					●	●
Archaeodictyomitra rigida * Pessagno					●	●
Archaeodictyomitra shengi * Yang				●	●	●
Archaeodictyomitra wangi * Yang					●	●
Archaeospongoprunum sp. aff. *A. elegans* * Wu				●	●	
Bernoullius dicera (Baumgartner)	3223	3–10	A–F	●	●	
Cinguloturris carpatica Dumitrica	3193	7–11	D–F	●	●	●
Dicerosaturnalis angustus (Baumgartner)	3082	6–10	B–E	●	●	
Eucyrtidiellum nodosum Wakita	3014	3–10	B–E		●	●
Eucyrtidiellum ptyctum (Riedel et Sanfilippo)	3017	5–11	B–F		●	●
Eucyrtidiellum unumaense (Yao) s.l.	3052	3–8	A–C			●
Gongylothorax favosus Dumitrica	6131	8–10	B–F	●		●
Hexasaturnalis minor (Baumgartner)	3085	3–11	B–F	●	●	
Homoeoparoanella argolidensis Baumgartner	3103	4–11	B–D			●
Loopus doliolum Dumitrica	LPDL		B–E		●	
Loopus doliolum martae Beccaro	LPMT		C–F		●	●
Loopus sp. aff. *L. doliolum martae* * Beccaro					●	
Loopus sp. aff. *L. primitivus* (Matsuoka et Yao)	3189	7–12	D–F		●	●
Napora lospensis Pessagno	3036	8–13	D–F		●	
Pantanellium riedeli Pessagno	3078	7–12	B–F		●	●
Parahsuum carpathicum Widz et De Wever	3240	7–11	A–E			●
Podobursa chandrika (Kocher)	3265	7–11	B–F		●	
Podobursa triacantha (Fischli) gr.	PDTC		B–F	●	●	
Podobursa vannae Beccaro	PDVN		C–F			●
Protunuma japonicus Matsuoka et Yao	3292	7–12	B–F	●		
Ristola procera * (Pessagno)	3163	5–9			●	
Sethocapsa funatoensis * Aita	3070	3–11			●	
Stichocapsa tuscanica * Chiari, Cortese et Marcucci					●	
Tethysetta dhimenaensis dhimenaensis (Baumgartner)	4072	3–11	B		●	
Tethysetta dhimenaensis ssp. A sensu Baumgartner et al. 1995b	4071	3–8	A–B		●	
Tetratrabs zealis (Ožvoldová)	3121	4–13	B–E	●	●	●
Transhsuum brevicostatum (Ožvoldová) gr.	3181	3–11	A–E	●	●	●
Transhsuum maxwelli * (Pessagno) gr.	3180	3–10			●	
Triactoma blakei (Pessagno)	3095	4–11	C–F	●	●	
Tripocyclia brooksi * Pessagno et Yang					●	
Tritrabs casmaliaensis (Pessagno)	3117	4–10	B–F	●	●	●
Tritrabs ewingi (Pessagno) s.l.	3113	4–22	B–F	●		
Tritrabs ewingi worzeli (Pessagno)	3115	7–12	D–F		●	
Tritrabs exotica (Pessagno)	3119	4–11	C–F		●	
Williriedellum carpathicum Dumitrica	4055	7–11	B–E		●	●
Zhamoidellum ventricosum Dumitrica	3308	8–11	C–F		●	●
Age of the samples by UAZ95 (Baumgartner et al. 1995a) 8: middle Callovian–early Oxfordian 9: middle–late Oxfordian 10: late Oxfordian–early Kimm.				**8–10**	**8–9**	**8–10**
Age of the samples by UAZ–SA (Beccaro 2006) C: middle Oxfordian D: ?middle–?late Oxfordian E: ?late Oxfordian–?early Kimm. *pars*				**D–E**	**D–E**	**C**
Preservation Index (Kiessling 1996)				5	2	5
Nassellaria / Spumellaria ratio				1	2.8	4
Sponge spicules / radiolarians ratio				1	0.6	1

Fig. 5. Stratigraphical distribution of radiolarian taxa in the Piatra Craiului sections (Southern Carpathians, Romania). The species carrying a numerical code are illustrated in Baumgartner et al. (1995b); the species carrying a letter code are not included in that volume; taxa carrying an asterisk have not been used for building the UAZ-SA zonation of Beccaro (2006). The ages of the samples are given by the Unitary Association Zones of Baumgartner et al. (1995a) (UAZ95) and by the Unitary Association Zones for Sicily and the Southern Alps (Italy) of Beccaro (2006) (UAZ-SA). The Preservation Index ranges from 2 (very good) to 5 (moderate) (Kiessling 1996).

Fig. 6. Upper Jurassic radiolarians from the Bucegi Massif (Southern Carpathians, Romania). The samples LaP 1 and LaP 2 come from the same layer of the La Poliție section. The species carrying an asterisk have not been used for building the UAZ-SA zonation (Beccaro 2006). The scale bar A corresponds to 200 μm for photos at ×100 and to 100 μm for photos at ×200; the scale bar B corresponds to 100 μm for images at ×150 and to 50 μm for images at ×300. **1** — **Archaeospongoprunum elegans* Wu, LaP 1, ×150; **2** — **Archaeospongoprunum* sp. aff. *A. elegans* Wu, LaP 2, ×150; **3** — **Pantanellium josephinense* Pessagno, Blome et Hull, LaP 2, ×150; **4** — **Archaeospongoprunum imlayi* Pessagno, LaP 1, ×150; **5** — *Triactoma blakei* (Pessagno), LaP 1, ×100; **6** — **Gorgansium* spp., LaP 1, ×300; **7** — *Perispyridium ordinarium* (Pessagno) gr., LaP 2, ×100; **8** — **Praeconocaryomma* sp., LaP 2, ×100; **9** — **Higumastra wintereri* Baumgartner et Kito, LaP 1, ×150;

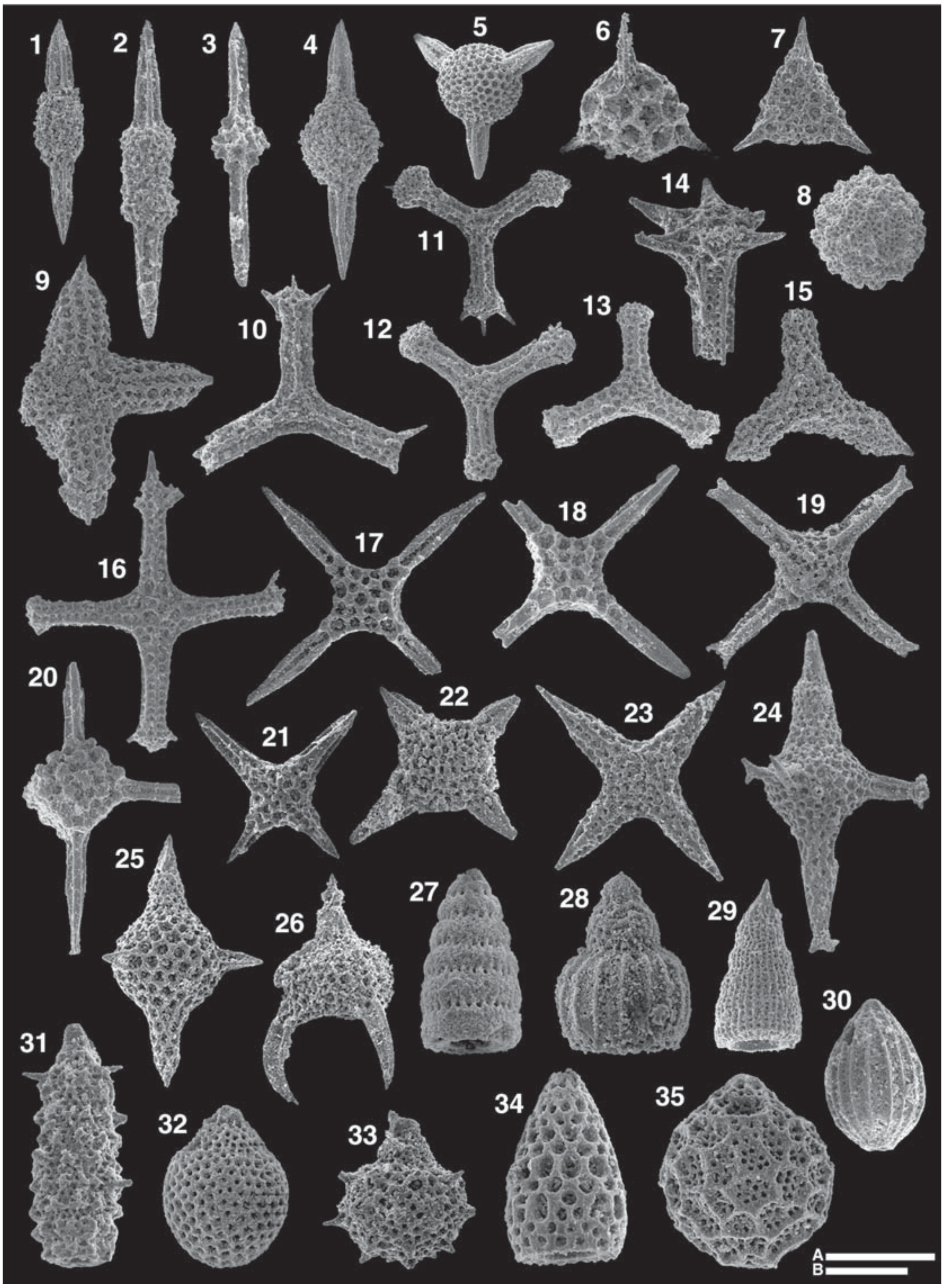

Fig. 6. *Continued from previous page.* **10** — *Tritrabs casmaliaensis* (Pessagno), LaP 2, ×150; **11** — *Tritrabs rhododactylus* Baumgartner, LaP 2, ×100; **12** — *Tritrabs exotica* (Pessagno), LaP 1, ×100; **13** — *Angulobracchia biordinalis* Ožvoldová, LaP 2, ×100; **14** — *Tritrabid gen. et sp. indet., LaP 2, ×150; **15** — **Paronaella mulleri* Pessagno, LaP 1, ×150; **16** — **Tetraditryma emilei* Hull, LaP 2, ×150; **17** — *Emiluvia peteri* Beccaro, LaP 1, ×150; **18** — **Emiluvia sedecimporata* (Rüst), LaP 2, ×150; **19** — *Emiluvia hopsoni* Pessagno, LaP 1, ×150; **20** — *Emiluvia ultima* Baumgartner et Dumitrica, LaP 2, ×100; **21** — *Emiluvia premyogii* Baumgartner, LaP 2, ×150; **22** — **Haliodictya* (?) *hojnosi* Riedel et Sanfilippo, LaP 1, ×200; **23** — **Pseudocrucella sanfilippoae* (Pessagno), LaP 2, ×150; **24** — *Podobursa spinosa* (Ožvoldová), LaP 2, ×150; **25** — *Podobursa vannae* Beccaro, LaP 1, ×150; **26** — *Napora deweveri* Baumgartner, LaP 1, ×150; **27** — *Loopus doliolum* Dumitrica, LaP 1, ×300; **28** — *Eucyrtidiellum ptyctum* (Riedel et Sanfilippo), LaP 1, ×200; **29** — *Parahsuum carpathicum* Widz et De Wever, LaP 2, ×150; **30** — *Protunuma japonicus* Matsuoka et Yao, LaP 2, ×200; **31** — *Tethysetta dhimenaensis* ssp. A sensu Baumgartner et al. 1995b, LaP 2, ×200; **32** — *Zhamoidellum ovum* Dumitrica, LaP 1, ×200; **33** — *Zhamoidellum* (?) *exquisitum* Hull, LaP 1, ×200; **34** — **Stichocapsa tuscanica* Chiari, Cortese et Marcucci, LaP 1, ×300; **35** — **Williriedellum crystallinum* Dumitrica, LaP 1, ×300.

(Rüst), *Podocapsa amphitreptera* Foreman, *Syringocapsa spinellifera* Baumgartner) are absent. It could be possible that La Poliţie samples are not restricted to UAZ 10 and UAZ E (as *E. ultima* seems to indicate) but extended to middle Oxfordian (UAZ 9 and UAZ D), as suggested by many species occurring in LaP 1.

Strunga (Bucegi Massif) — Through the UAZ95 zonation, the radiolarian assemblage is referred to UAZ 5–8 (latest Bajocian–early Bathonian to middle Callovian–early Oxfordian) for the presence of **Triactoma mexicana* Pessagno et Yang (UAZ 5–9) and *Eucyrtidiellum unumaense* s.l. (Yao) (UAZ 3–8). By applying the UAZ-SA zonation, the age spans UAZ C (middle Oxfordian) due to *Eucyrtidiellum unumaense* s.l. (Yao) (UAZ A–C) and *Triactoma blakei* (Pessagno) (UAZ C–F). The sample can be referred to middle Oxfordian.

Strunguliţa (Bucegi Massif) — By way of UAZ95 zonation, the age is referred to UAZ 8–9 (middle Callovian–early Oxfordian to middle–late Oxfordian) by the presence of *Archaeodictyomitra apiarium* (Rüst) (UAZ 8–22), *Emiluvia orea* Baumgartner (UAZ 8–11; Fig. 7.2), *Podobursa spinosa* (Ožvoldová) (UAZ 8–13), **Emiluvia nana* Baumgartner (UAZ 6–9; Fig. 7.3), **Palinandromeda podbielensis* (Ožvoldová) (UAZ 5–9; Fig. 7.19) and **Triactoma mexicana* Pessagno et Yang (UAZ 5–9; Fig. 7.5). Through the UAZ-SA zonation, the age of the sample is constricted to UAZ D (?middle–?late Oxfordian) due to *Archaeodictyomitra apiarium* (Rüst) (UAZ D–F), *Tetratrabs bulbosa* Baumgartner (UAZ D–F; Fig. 7.1), *Palinandromeda* spp. (UAZ D). The sample is assigned to middle-late Oxfordian.

Rătei (Bucegi Massif) — Through the UAZ95 zonation, the sample is assigned to UAZ 7 (late Bathonian–early Callovian) by the presence of *Cinguloturris carpatica* Dumitrica (UAZ 7–11), *Williriedellum carpathicum* Dumitrica (UAZ 7–11; Fig. 7.33) and **Stichocapsa naradaniensis* Matsuoka (UAZ 6–7; Fig. 7.31). By way of UAZ-SA zonation, the assemblage dates from the UAZ B–C (early Callovian *pars*–early Oxfordian to middle Oxfordian) thanks to *Dicerosaturnalis angustus* (Baumgartner) (UAZ B–E), *Triactoma enzoi* Beccaro (UAZ B–D), *Williriedellum carpathicum* Dumitrica (UAZ B–E), *Eucyrtidiellum unumaense* s.l. (Yao) (UAZ A–C) and *Williriedellum* (?) *marcucciae* Cortese (UAZ B–C). Considering that **Stichocapsa naradaniensis* Matsuoka is a good marker for the Callovian time and that no species quite typical of Oxfordian age (like *Gongylothorax favosus* Dumitrica and **Williriedellum crystallinum* Dumitrica) have been found, the most probable age for this sample is the Callovian. This inference agrees with the fact that a layer of Callovian jasper occurs at the Rătei section whereas the Oxfordian deposits are represented only by resedimented clasts in the Kimmeridgian limestone.

Sfânta Ana (Bucegi Massif) — By applying the UAZ95 zonation, the sample can be assigned to the UAZ 8 (middle Callovian–early Oxfordian) due to *Gongylothorax favosus* Dumitrica (UAZ 8–10), *Eucyrtidiellum unumaense* s.l. (Yao) (UAZ 3–8; Fig. 7.29) and *Podobursa polyacantha* (Fischli) (UAZ 5–8; Fig. 7.18). By means of UAZ-SA, the age spans the UAZ C (middle Oxfordian) for the presence of *Emiluvia orea* Baumgartner (UAZ C–F) and *Eucyrtidiellum unumaense* s.l. (Yao) (UAZ A–C). The sample spans the middle Oxfordian.

Şirnea (Piatra Craiului Mts) — By applying the UAZ95 zonation, the resulting age spans UAZ 8–10 (middle Callovian–early Oxfordian to late Oxfordian–early Kimmeridgian) by the presence of *Gongylothorax favosus* Dumitrica (UAZ 8–10), *Zhamoidellum ventricosum* Dumitrica (UAZ 8–11), *Eucyrtidiellum nodosum* Wakita (UAZ 3–10) and *Tritrabs casmaliaensis* (Pessagno) (UAZ 4–10). Through the UAZ-SA, the sample is assigned to the UAZ C (middle Oxfordian) by the presence of *Zhamoidellum ventricosum* Dumitrica (UAZ C–F) and *Eucyrtidiellum unumaense* s.l. (Yao) (UAZ A–C; Fig. 8.21). The age assignment of Şirnea is middle Oxfordian.

Umeri (Piatra Craiului Mts) — By way of UAZ95 zonation, the age is referred to the UAZ 8–9 (middle Callovian–early Oxfordian to middle–late Oxfordian) for the occurrence of *Archaeodictyomitra apiarium* (Rüst) (UAZ 8–22; Fig. 8.10), *Zhamoidellum ventricosum* Dumitrica (UAZ 8–11; Fig. 8.23) and **Ristola procera* (Pessagno) (UAZ 5–9; Fig. 8.4). By applying the UAZ-SA zonation, the age is stated as the UAZ D–E (?middle–?late Oxfordian to ?late Oxfordian–early Kimmeridgian *pars*) by the presence of *Archaeodictyomitra apiarium* (Rüst) (UAZ D–F), *Cinguloturris carpatica* Dumitrica (UAZ D–F; Fig. 8.12), *Eucyrtidiellum nodosum* Wakita (UAZ B–E; Fig. 8.20), *Tetratrabs zealis* (Ožvoldová) (UAZ B–E; Fig. 8.1), *Transhsuum brevicostatum* gr. (Ožvoldová) (UAZ A–E; Fig. 8.5) and *Williriedellum carpathicum* Dumitrica (UAZ B–E; Fig. 8.24). The sample can be assigned to middle-late Oxfordian.

Vladuşca (Piatra Craiului Mts) — By means of UAZ95, the age of the sample is assigned to the UAZ 8–10 (middle Callovian–early Oxfordian to late Oxfordian–early Kim-

Fig. 7. Middle-Upper Jurassic radiolarians from the Bucegi Massif (Southern Carpathians, Romania). The taxa illustrated come from the Strunguliţa, Sf. Ana and Rătei sections. The species carrying an asterisk have not been used for building the UAZ-SA zonation (Beccaro 2006). The scale bar A corresponds to 200 µm for photos at ×100 and to 100 µm for photos at ×200; the scale bar B corresponds to 400 µm for images at ×75, to 100 µm for images at ×150 and to 50 µm for images at ×300; the scale bar C corresponds to 100 µm for photos at ×250. **1** — *Tetratrabs bulbosa* Baumgartner, Strunguliţa, ×75; **2** — *Emiluvia orea* Baumgartner, Strunguliţa, ×100; **3** — **Emiluvia nana* Baumgartner, Strunguliţa, ×150; **4** — *Homoeoparonaella argolidensis* Baumgartner, Sf. Ana, ×100; **5** — **Triactoma mexicana* Pessagno et Yang, Strunguliţa, ×100; **6** — *Hexasaturnalis minor* (Baumgartner), Strunguliţa, ×100; **7** — *Hexasaturnalis nakasekoi* Dumitrica et Dumitrica-Jud, Strunguliţa, ×100; **8** — **Tripocyclia brooksi* Pessagno et Yang, Sf. Ana, ×100; **9** — *Triactoma enzoi* Beccaro, Sf. Ana, ×100; **10** — *Dicerosaturnalis angustus* (Baumgartner), Strunguliţa, ×100; **11** — **Paronaella* sp. aff. *P. bandyi* Pessagno, Sf. Ana, ×150; **12** — **Eospongosaturnalis protoformis* (Yao), Rătei, ×100; **13** — **Acanthocircus* sp., Strunguliţa, ×100; **14** — *Bernoullius dicera* (Baumgartner), Sf. Ana, ×150. **15** — **Pterotrabs victoria* Dumitrica, Baumgartner et Goričan, Strunguliţa, ×150.

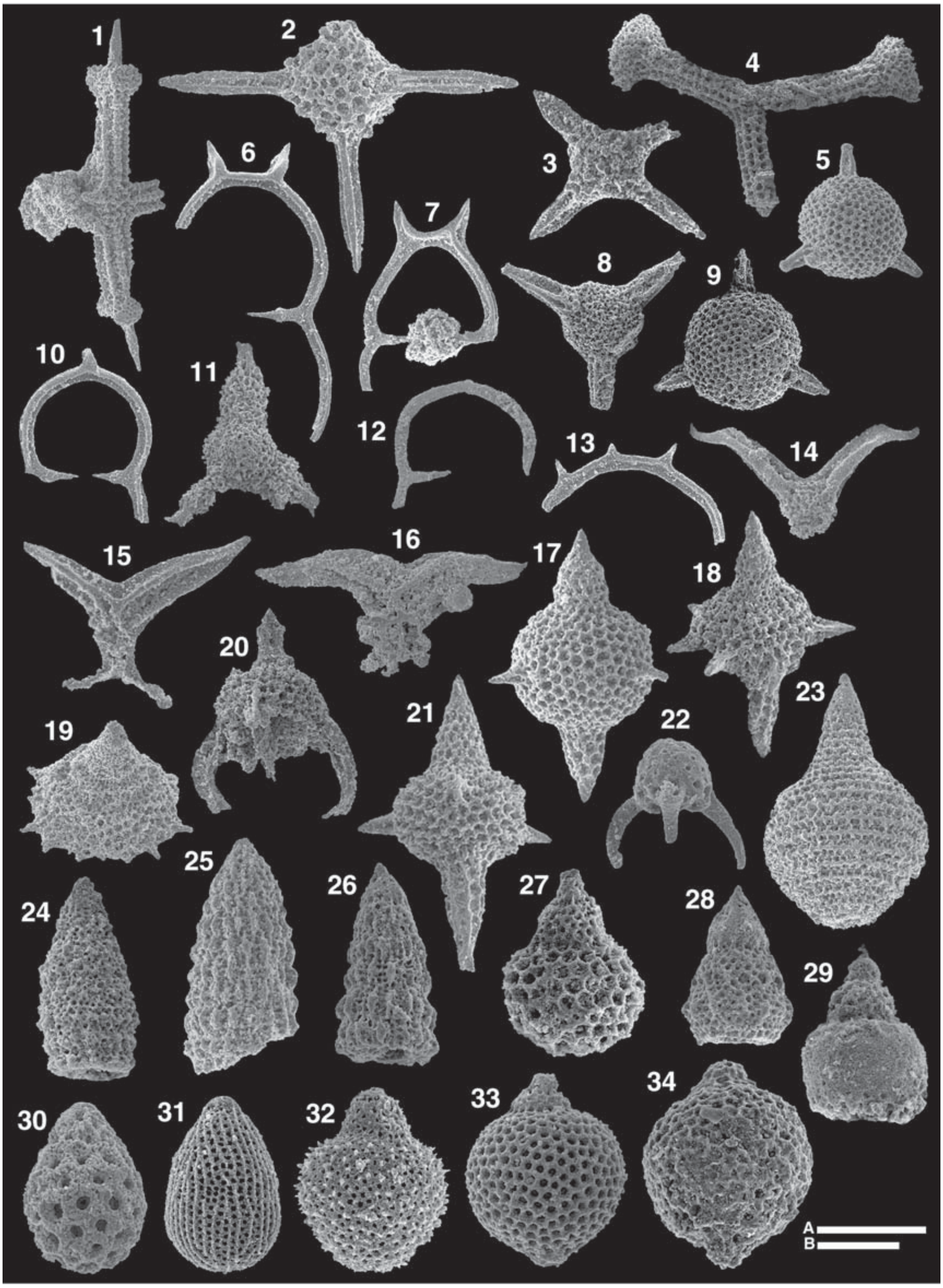

Fig. 7. *Continued from previous page.* **16** — **Pterotrabs arcuballista* Dumitrica, Baumgartner et Goričan, Sf. Ana, ×150; **17** — *Podobursa chandrika* (Kocher), Strungulița, ×150; **18** — *Podobursa polyacantha* (Fischli), Sf. Ana, ×150; **19** — **Palinandromeda podbielensis* (Ožvoldová), Strungulița, ×100; **20** — *Napora lospensis* Pessagno, Sf. Ana, ×150; **21** — *Podobursa triacantha* (Fischli) gr., Strungulița, ×150; **22** — **Saitoum* sp., Sf. Ana, ×200; **23** — *Mirifusus dianae dianae* (Karrer), Strungulița, ×100; **24** — *Tethysetta dhimenaensis dhimenaensis* Baumgartner, Rătei, ×200; **25** — **Transhsuum maxwelli* (Pessagno) gr., Strungulița, ×150; **26** — **Hsuum speciosum* Hull, Rătei, ×150; **27** — **Sethocapsa* sp. aff. *S. exagona* Hori, Rătei, ×300; **28** — **Xitus* sp., Sf. Ana, ×200; **29** — *Eucyrtidiellum unumaense* (Yao) s.l., Sf. Ana, ×300; **30** — **Arcanicapsa* sp., Sf. Ana, ×300; **31** — **Stichocapsa naradaniensis* Matsuoka, Rătei, ×300; **32** — **Praewilliriedellum* sp. aff. *P. spinosum* Kozur, Rătei, ×300; **33** — *Williriedellum carpathicum* Dumitrica, Rătei, ×300; **34** — *Williriedellum* (?) *marcucciae* Cortese, Rătei, ×300.

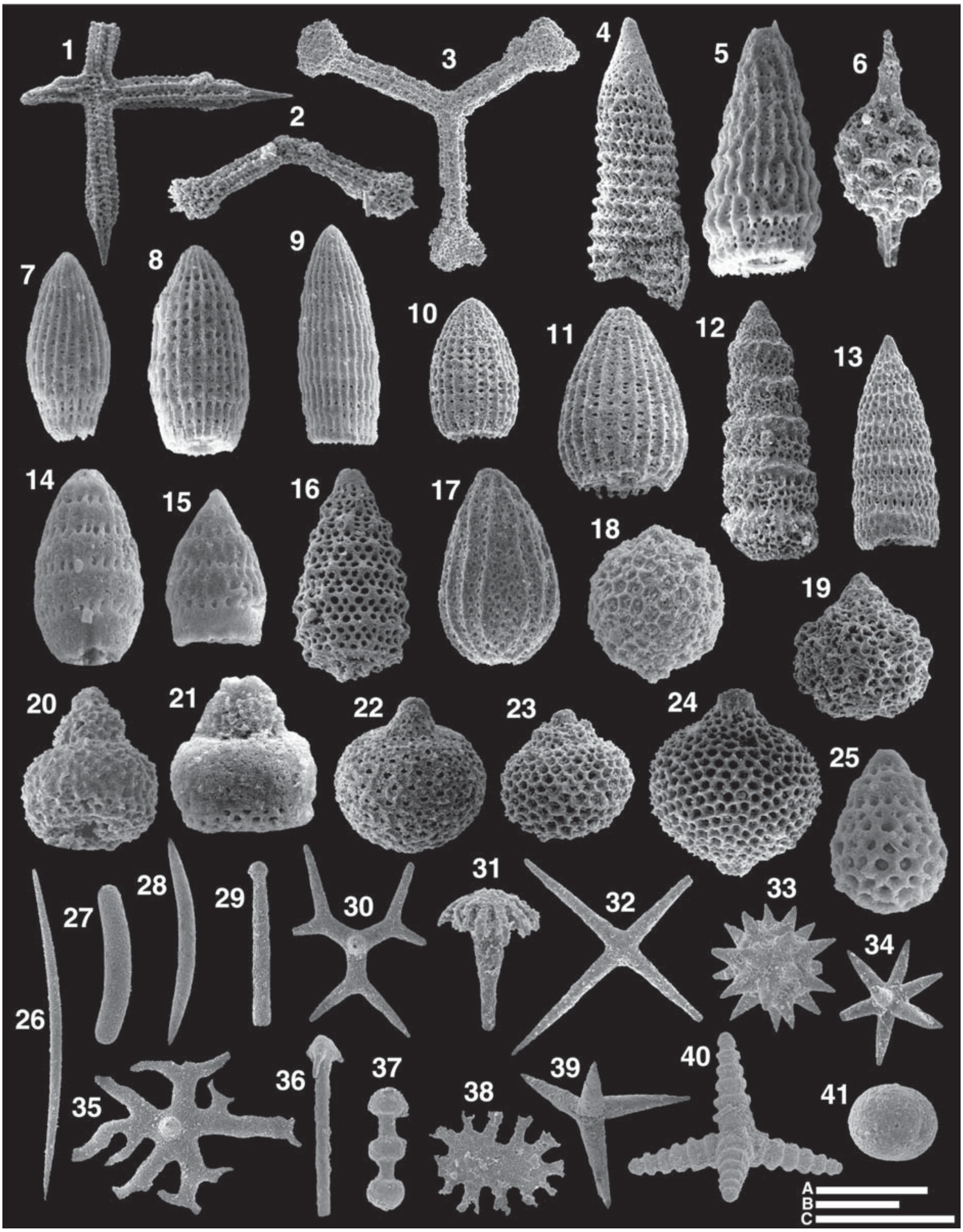

Fig. 8. Upper Jurassic radiolarians (1–25) and sponge spicules (26–37) from the Piatra Craiului Mts (Southern Carpathians, Romania). The taxa illustrated come from the Vladușca, Umeri and Șirnea sections. The species carrying an asterisk have not been used for building the UAZ-SA zonation (Beccaro 2006). The scale bar A corresponds to 200 μm for photos at ×100 and to 100 μm for photos at ×200; the scale bar B corresponds to 400 μm for images at ×75, to 100 μm for images at ×150 and to 50 μm for images at ×300; the scale bar C corresponds to 100 μm for photos at ×250. **1** — *Tetratrabs zealis* (Ožvoldová), Umeri, ×75; **2** — *Tritrabs ewingi worzeli* (Pessagno), Umeri, ×100; **3** — *Tritrabs ewingi* (Pessagno) s.l., Vladușca, ×75; **4** — **Ristola procera* (Pessagno), Umeri, ×150; **5** — *Transhsuum brevicostatum* (Ožvoldová) gr., Umeri, ×200; **6** — *Pantanellium riedeli* Pessagno, Umeri, ×200; **7** — **Archaeodictyomitra inornata* Hull, Șirnea, ×250; **8** — **Archaeodictyomitra wangi* Yang, Șirnea, ×250; **9** — **Archaeodictyomitra shengi* Yang, Umeri, ×200;

meridgian) for the presence of *Gongylothorax favosus* Dumitrica (UAZ 8–10; Fig. 8.18), *Bernoullius dicera* (Baumgartner) (UAZ 3–10) and *Tritrabs casmaliaensis* (Pessagno) (UAZ 4–10). Through the UAZ-SA the age spans the UAZ D–E (?middle–?late Oxfordian to ?late Oxfordian–early Kimmeridgian *pars*) thanks to the presence of *Cinguloturris carpatica* Dumitrica (UAZ D–F), *Tetratrabs zealis* (Ožvoldová) (UAZ B–E) and *Transhsuum brevicostatum* gr. (Ožvoldová) (UAZ A–E). The radiolarian assemblages of Vladuşca is more probably referred to middle–late Oxfordian, in accordance with the other samples of the Piatra Craiului area.

In summary, the samples from the Bucegi Massif and Piatra Craiului Mts are assigned to biozones that include the UAZ 8–10 (middle Callovian–early Oxfordian) and the UAZ C–E (middle Oxfordian to ?late Oxfordian–early Kimmeridgian *pars*). The most probable age for these samples is the middle Oxfordian. The only exception is represented by the Rătei sample that is assigned to the Callovian.

Overview on Jurassic siliceous sediments in the Carpathian chain

The geological setting of the Southern Carpathians (Romania) is very similar to other regions of the Carpathian chain and to the Northern Calcareous Alps. Jurassic siliceous sediments occur in the Silica Nappe and Pieniny Klippen Belt (Slovakia), in the Tatra Mts (Poland) and in the Eastern Carpathians (Romania). The radiolarian content of these sediments were studied by Ožvoldová (1979, 1988, 1998), Widz (1991), Dumitrica (1995a,b), Ožvoldová & Frantová (1997), Ožvoldová et al. (2000), Suzuki & Gawlick (2003).

In the Pieniny Klippen Belt (Slovakia) the radiolarites are generally bracketed by red nodular limestones and the age spans Bathonian–early Kimmeridgian depending on the sections (Ožvoldová 1979, 1988; Ožvoldová & Frantová 1997; Ožvoldová et al. 2000). In the Silica Nappe (Slovakia) the radiolarites occur as lithoclasts within carbonate breccias and their age is late Bathonian–upper Callovian (Sýkora & Ožvoldová 1996; Ožvoldová 1998). In the Tatra Mts (Poland) the radiolarites are underlain by nodular limestones and overlain by either nodular limestones or marly shales or limestones; their age ranges from Bajocian to Oxfordian (Widz 1991). In the northern part of the Eastern Carpathians (Bucovina Nappe, Romania) the radiolarites are underlain by dolomite and overlain by shales; the age is late Callovian to Oxfordian (Dumitrica 1995a). In the western end of the Southern Carpathians (Svinita area, Danube Valley, Romania) radiolarites occur in the upper Oxfordian–lowermost Kimmeridgian cherty limestones (Dumitrica 1995b). The siliceous facies of the Northern Calcareous Alps (Austria) is hightly calcareous and bracketed by red calcareous beds; the age spans Toarcian–early Tithonian (Suzuki & Gawlick 2003).

Suzuki & Gawlick (2003) defined their own zonation for the Northern Calcareous Alps (Austria) while the UAZ95 zonation of Baumgartner et al. (1995a) was successfully applied to some radiolarian assemblages from the Carpathian chain. The radiolarites of the Silica Nappe (Slovakia) represent the youngest preserved member of the Jurassic sequence in the Slovak Karst and contain the oldest Jurassic radiolarian assemblages from the Slovak Western Carpathians: such assemblages are referred to the UAZ 5–7 (latest Bajocian–early Bathonian to late Bathonian–early Callovian) (Ožvoldová 1998). In the Pieniny Klippen Belt (Slovakia), the green-grey radiolarites of the Kysuca Succession are assigned to the UAZ 8–10 (middle Callovian–early Oxfordian to late Oxfordian–early Kimmeridgian), and the radiolarian limestones of the Czertezic Succession began only in the Oxfordian (UAZ 9–10: middle–late Oxfordian to late Oxfordian–early Kimmeridgian) (Ožvoldová et al. 2000).

The new radiolarian data from the Bucegi and Piatra Craiului Mts (Southern Carpathians; this paper) refer all siliceous sediments to Oxfordian, and are in agreement with the analogous facies of other Carpathian areas. The Rătei sample (Bucegi Massif) is the only one assigned to late Bathonian-middle Oxfordian (more likely Callovian), and this age also agrees with other Carpathian siliceous deposits.

Comparison between the Jurassic siliceous sediments in the Southern Carpathians (Romania) and other Tethyan sections

The radiolarian assemblages of the Bucegi Massif and Piatra Craiului Mts (Southern Carpathians, Romania) are equivalent to coeval assemblages from other Tethyan sections. The siliceous sediments are widespread in the basins

Fig. 8. *Continued from previous page.* **10** — *Archaeodictyomitra apiarium* (Rüst), Umeri, ×250; **11** — **Archaeodictyomitra rigida* Pessagno, Umeri, ×250; **12** — *Cinguloturris carpatica* Dumitrica, Umeri, ×200; **13** — *Loopus* sp. aff. *L. primitivus* (Matsuoka et Yao), Umeri, ×250; **14** — *Loopus doliolum martae* Beccaro, Umeri, ×300; **15** — **Loopus* sp. aff. *L. doliolum martae* Beccaro, Umeri, ×300; **16** — *Tethysetta dhimenaensis* ssp. A sensu Baumgartner et al. (1995b), Umeri, ×250; **17** — **Protunuma* sp., Şirnea, ×300; **18** — *Gongylothorax favosus* Dumitrica, Vladuşca, ×300; **19** — **Sethocapsa funatoensis* Aita, Umeri, ×200; **20** — *Eucyrtidiellum nodosum* Wakita, Umeri, ×300; **21** — *Eucyrtidiellum unumaense* (Yao) s.l., Şirnea, ×300; **22** — **Praezhamoidellum* sp. cf. *P. yaoi* Kozur, Şirnea, ×250; **23** — *Zhamoidellum ventricosum* Dumitrica, Umeri, ×200; **24** — *Williriedellum carpathicum* Dumitrica, Umeri, ×250; **25** — **Amphipyndax* sp., Umeri, ×300; **26** — Amphiox (Diactine), Strungulița, ×50; **27** — Strongyle (Diactine), LaP 1, ×100; **28** — Amphiox (Diactine), LaP 1, ×100; **29** — Tylostyle (Monoactine), LaP 1, ×100; **30** — Dichotriaene (Tetractine), LaP 1, ×100; **31** — Amphidiscae (Diactine), LaP 1, ×250; **32** — Oxycalthrop (Tetractine), LaP 2, ×100; **33** — Oxysphaeraster (Polyactine), LaP 1, ×200; **34** — Oxyaster (Polyactine), LaP 2, ×100; **35** — Phyllotriaene (Tetractine), Strungulița, ×75; **36** — Anatriaene (Tetractine), Strunga, ×100; **37** — Cricorhabds (Diactine), Strunga, ×100; **38** — Pinakid (Tetractine), Sf. Ana, ×200; **39** — Oxycalthrop (Tetractine), Rătei, ×100; **40** — Criccalthrop (Tetractine), Rătei, ×100; **41** — Rhax, Vladuşca, ×100.

of the Hellenides, Dinarides, Julian Alps, Southern Alps and Sicily. In the Pindos-Olonos Zone (Hellenides, Greece) the siliceous sediments are represented by shales, marls and radiolarites; the age ranges from Early Jurassic to Turonian (De Wever & Cordey 1995). In the Budva Zone (Dinarides, Montenegro), the siliceous sediments are represented by cherty limestones and shales alternated with resedimented carbonates; the age spans the Triassic/Jurassic boundary until the Turonian (Goričan 1994, 1995). In the Mangart area (Julian Alps, Slovenia), the basins were filled by biogenic material coming from the adjacent carbonate platform, and the siliceous sediments are Toarcian–early Kimmeridgian in age (Šmuc & Goričan 2005). In the Lombardian Basin (Southern Alps, Italy), the radiolarites are alternated with shales and marls, and the first radiolarians are Bajocian in age (Baumgartner et al. 1995c). In the Belluno Trough (Southern Alps, Italy), the siliceous deposits are constituted by chert and limestones intercalated with platform-derived material, and range Toarcian–Kimmeridgian (Baumgartner et al. 1995c). In the Sicanian Basin (Sicily, Italy), the siliceous sediments are the most widespread during the Middle Jurassic, followed by deep water limestones and marls (De Wever 1995).

The siliceous sediments abundantly occur also on the submarine plateaux of the Southern Alps and Sicily (Italy) where the Rosso Ammonitico Medio (RAM) represents the intermediate pelagic siliceous member of the Rosso Ammonitico Formation. On the Trento Plateau (Southern Alps), the first siliceous deposition started in the Toarcian and reached its maximum with the deposition of RAM during the Callovian–Oxfordian; some platform-derived oolitic grainstones are intercalated in the successions at different levels (Baumgartner et al. 1995c). In the Trapanese Domain (Sicily), the siliceous sediments of RAM appear in the middle Oxfordian and last till Kimmeridgian; they are alternated with limestones and marls (Beccaro 2006).

Even though the lower and the upper limits of the siliceous facies in all the cited localities are diachronous, the siliceous sediments are the most widespread everywhere (in basins as well as on topographic highs) during the Oxfordian. In the Southern Carpathians (Getic Domain) the siliceous facies is almost only restricted to the Oxfordian (this paper). The radiolarian assemblage of Rătei (Bucegi Massif, Southern Carpathians) is the only one referred to late Bathonian–middle Oxfordian (more likely Callovian): this sample is coeval with the basinal siliceous successions of the Southern Alps, Julian Alps, Dinarides and Hellenides.

As we can infer from the above discussion, the siliceous sediments are mostly intercalated with resedimented carbonates only: this marks a strong difference in comparison with the Romanian successions in which the siliciclastic component is abundant. In spite of this clastic abundance, the Oxfordian levels are truly siliceous and rich in radiolarians. Furthermore, no evidence of interrupted sedimentation has been found in the Romanian sections, and the radiolarians are mostly restricted to the middle Oxfordian, which probably records the maximum of the siliceous sedimentation in the Tethys.

The siliceous sediments are easy recognizable in all investigated sections in Italy (Beccaro et al. 2002; Beccaro 2006) and in Romania (this paper) but a clear feature characterizes the Romanian successions: almost all the siliceous facies at the Bucegi Massif and Piatra Craiului Mts are not more than 1 m thick. Conversely, in the Southern Alps, the thickness ranges from 9 m at Ceniga to 100 m at Coston delle Vette (Trento Plateau), and it is around 40 m in the Lombardian Basin; in Sicily the average thickness is approximately 20 m. It seems that the paleoenviromental conditions favoured the siliceous deposition in Italy (as proved by thick deposits) and that only the siliceous maximum was recorded in the Southern Carpathians area.

A common element between the Italian and the Romanian siliceous sediments is that they often occur at the top of condensed sequences sometimes displaying mineralized hardgrounds: Strunga and Strunguliţa (Southern Carpathians), Ceniga and Coston delle Vette (Southern Alps), Fornazzo Strada and Fornazzo Cava (north-western Sicily). The Strunga–Strunguliţa (Bucegi Massif) and Piatra Craiului sections are the most similar to the Italian ones. At Strunga–Strunguliţa the jaspers are comprised between limestones containing ammonites, and at Piatra Craiului the siliceous sediments occur between red bioclastic limestone very similar to the Rosso Ammonitico Formation.

The radiolarian assemblages of the Romanian and Italian samples (this paper and Beccaro 2006, respectively) are altogether analogous from the taxonomical viewpoint and also the sponge spicule content from the submarine plateaux is similar in the studied samples.

Conclusions

The most representative Jurassic outcrops of the Bucegi Massif and Piatra Craiului Mts (Southern Carpathians, Romania) have been studied for radiolarians.

Evaluation of the Preservation Index (PI), the Nassellaria/Spumellaria ratio (N/S), and the sponge spicules/radiolarians ratio shows that the siliceous sediments of Piatra Craiului (Şirnea, Umeri, Vladuşca) and La Poliţie (Bucegi Massif) were deposited in distal or relatively deep waters, and that the cherty limestones of the Sfânta Ana Olistolith were deposited in shallower waters or slope environment. Concerning the other radiolarian assemblages (Strunga, Strunguliţa, Rătei) of the Bucegi Massif, the poor preservation and the scarce radiolarian content did not allow a good interpretation of the estimated indices.

The radiolarian assemblages are equivalent to coeval assemblages of other Tethyan sections and this allowed the application of two radiolarian biozonations (UAZ95 of Baumgartner et al. 1995a and UAZ-SA of Beccaro 2006) in order to date directly the siliceous sediments for the first time. The studied successions are mostly assigned to the Oxfordian: UAZ 8–10 (middle Callovian–early Oxfordian) of Baumgartner et al. (1995a) and UAZ C–E (middle Oxfordian to ?late Oxfordian–early Kimmeridgian *pars*) of Beccaro (2006). The only exception is represented by the radiolarian assemblage of the Rătei Valley that is very probably assigned to the Callovian.

Comparison of the siliceous interval in the Southern Carpathians with the analogous ones of other Tethyan sections suggests that even in environments with abundant siliciclastic supply, the sedimentation drastically changed during the Oxfordian and became siliceous.

The radiolarian data from the Bucegi Massif and Piatra Craiului Mts (Southern Carpathians, Romania) has provided new information about the radiolarian assemblages in Romania, enriched the knowledge about the Oxfordian siliceous deposition in the Mediterranean area and increased the database of the INTERRAD Jurassic-Cretaceous Working Group (Baumgartner et al. 1995c). All this has contributed to creat new and better-defined radiolarian biozones for the Jurassic Mediterranean Tethys.

Acknowledgments: This research has been carried out during a post-doc fellowship provided to Paola Beccaro by the Ministry for Foreign Affairs (Italy) within the Program of Cultural Exchanges of the Ministry for Education and Research (Romania). Paola Beccaro is grateful to Dr. Cristina Panaiotu (Faculty of Geology and Geophysics, University of Bucharest, Romania) for her support during the stay in Bucharest. The scanning electron micrographs have been taken at the Ivan Rakovec Institute of Paleontology ZRC SAZU (Ljubljana, Slovenia) and at the Earth Sciences Department of the University of Turin (Italy). Travel and field work in Romania was funded to Dr. Lazăr by the National University Research Council of Romania (CNCSIS Romania) Grant 304 (2003–2005).

References

Baumgartner P.O., Bartolini A., Carter E.S., Conti M., Cortese G., Danelian T., De Wever P., Dumitrica P., Dumitrica-Jud R., Goričan Š., Guex J., Hull D.M., Kito N., Marcucci M., Matsuoka A., Murchey B., O'Dogherty L., Savary J., Vishnevskaya V., Widz D. & Yao A. 1995a: Middle Jurassic to Early Cretaceous radiolarian biochronology of Tethys based on Unitary Associations. In: Baumgartner P.O. et al. (Eds.): Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. *Mém. Géol. Lausanne* 23, 1013–1043.

Baumgartner P.O., O'Dogherty L., Goričan Š., Dumitrica-Jud R., Dumitrica P., Pillevuit A., Urquhart E., Matsuoka A., Danelian T., Bartolini A., Carter E.S., De Wever P., Kito N., Marcucci M. & Steiger T. 1995b: Radiolarian catalogue and systematics of Middle Jurassic to Early Cretaceous Tethyan genera and species. In: Baumgartner P.O. et al. (Eds.): Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. *Mém. Géol. Lausanne* 23, 37–685.

Baumgartner P.O., Martire L., Goričan Š., O'Dogherty L., Erba E. & Pillevuit A. 1995c: New Middle and Upper Jurassic radiolarian assemblages co-occurring with ammonites and nannofossils from the Southern Alps (Northern Italy). In: Baumgartner P.O. et al. (Eds.): Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. *Mém. Géol. Lausanne* 23, 737–749.

Baumgartner P.O., O'Dogherty L., Goričan Š., Urquhart E., Pillevuit A. & De Wever P. (Eds.) 1995d: Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. *Mém. Géol. Lausanne* 23, 1–1172.

Beccaro P. 2004: Upper Jurassic radiolarians from Inici Mt. area (North-western Sicily, Italy): biochronology and calibration by ammonites. *Riv. Ital. Paleont. Stratigr.* 110, 1, 289–301.

Beccaro P. 2006: Radiolarian biostratigraphy of Middle-Upper Jurassic pelagic siliceous successions of Western Sicily and the Southern Alps (Italy). *Mém. Géol. Lausanne* 45, 1–114.

Beccaro P., Baumgartner P.O. & Martire L. 2002: Radiolarian biostratigraphy of the Fonzaso Formation, Middle–Upper Jurassic, Southern Alps, Italy. *Micropaleontology* 48, Suppl. 1, 43–60.

Bucur I. 1980: *Rhaxella sorbiana* (Blake) in Oxfordian radiolarites from Piatra Craiului. *Dari de Seama ale Sedintelor* LXV/3 (1977–1978), 31–35 (in Romanian).

Casey R.E. 1993: Radiolaria. In: Lipps J.H. (Ed.): Fossil Prokaryotes and Protists. *Blackwell*, Berkeley, California, 249–284.

De Wever P. 1982: Radiolaires du Trias et du Lias de la Tethys (Systématique, Stratigraphie). *Soc. Géol. Nord* 7, 1–599.

De Wever P. 1995: Radiolarians from the Sciacca Zone, Santa Anna, Sicily (Italy). In: Baumgartner P.O. et al. (Eds.): Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. *Mém. Géol. Lausanne* 23, 839–845.

De Wever P. & Cordey F. 1995: Radiolarians from the Radiolarites Formation (s.s.), Pindos-Olonos Zone (Greece): Bajocian (?) to Tithonian. In: Baumgartner P.O. et al. (Eds.): Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. *Mém. Géol. Lausanne* 23, 881–887.

De Wever P., Dumitrica P., Caulet J.P., Nigrini C. & Caridroit M. (Eds.) 2001: Radiolarians in the sedimentary record. *Gordon and Breach Science Publishers*, 1–533.

Dumitrica P. 1970: Cryptocephalic and cryptothoracic Nassellaria in some Mesozoic deposits of Romania. *Rev. Roum. Géol., Géophys. Géogr.*, *Série de Géologie* 14, 1, 45–124.

Dumitrica P. 1991: Middle Triassic Tripedurnulidae, n. fam. (Radiolaria) from the Eastern Carpathians (Romania) and Vicentinian Alps (Italy). *Rev. Micropal.* 34, 4, 261–678.

Dumitrica P. 1995a: Biostratigraphy of the radiolarites at Pojorita (Rarau Syncline, East Carpathians). In: Baumgartner P.O. et al. (Eds.): Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. *Mém. Géol. Lausanne* 23, 897–905.

Dumitrica P. 1995b: Upper Jurassic and Lower Cretaceous radiolarians at Svinita (Romania). In: Baumgartner P.O. et al. (Eds.): Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. *Mém. Géol. Lausanne* 23, 907–914.

Dumitrica P. 1999: On the presence of central capsular membranes of Radiolaria in fossils state. *Rev. Esp. Micropal.* 31, 2, 155–183.

Dumitrica P. & Carter E.S. 1999: Family Kungulariidae, n. fam., new Mesozoic entactinarian Radiolaria with a nassellarian-type initial spicule. *Micropaleontology* 45, 4, 418–428.

Dumitrica P. & Dumitrica-Jud R. 1995: *Aurisaturnalis carinatus* (Foreman), an example of phyletic gradualism among Saturnalid-type radiolarians. *Rev. Micropal.* 38, 3, 195–216.

Dumitrica P. & Dumitrica-Jud R. 2005: *Hexasaturnalis nakasekoi* nov. sp., a Jurassic saturnalid radiolarian species frequently confounded with *Hexasaturnalis suboblongus* (Yao). *Rev. Micropal.* 48, 159–168.

Dumitrica P., Baumgartner P.O. & Goričan Š. 1997: *Pterotrabs* n. gen., a new genus of Jurassic Hagiastridae (Radiolaria). *Rev. Micropal.* 40, 2, 167–179.

Goričan Š. 1994: Jurassic and Cretaceous radiolarian biostratigraphy and sedimentary evolution of the Budva Zone (Dinarides, Montenegro). *Mém. Géol. Lausanne* 18, 1–177.

Goričan Š. 1995: Middle Jurassic to Early Cretaceous radiolarian biochronology of the Budva Zone (Dinarides, Montenegro).

In: Baumgartner P.O. et al. (Eds.): Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. *Mém. Géol. Lausanne* 23, 847–863.

Herbich F. 1888: Données paléontologiques sur les Carpathes Roumaines. *Anuarul Biroului Geologic*, anul III, 1, Bucharest, 12–339.

Jacob D. & Nicorici E. 1957: Some radiolarians from chert levels in the Tămăşeşti area. *Stud. Cerc. Geol. Geofiz. Geogr. (Bucuresti)* VIII/1–2, 31–35 (in Romanian).

Jekelius E. 1916: Mesozoic fauna of the Braşov Mountains. *Földt. Intézet Évkönyve (Budapest)* 24, 3, 222–314 (in Hungarian).

Jekelius E. 1928: Géologie du Col de Bran. *Comptes Rend. Inst. Geol. (Bucharest)* 8, 186–207.

Jekelius E. 1938: Das Gebirge von Braşov. *Ann. Inst. Geol. (Bucharest)* 19, 379–408.

Jud R. 1994: Biochronology and systematics of Early Cretaceous Radiolaria of the Western Tethys. *Mém. Géol. Lausanne* 19, 1–147.

Kiessling W. 1996: Facies characterization of Mid-Mesozoic deep water sediments by quantitative analysis of siliceous microfaunas. *Facies* 35, 237–274.

Kruglikova S.B. 1989: Certain aspects of radiolarian data as evidence of the paleoenvironment. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 69, 303–320.

Lazăr I. 2000: Middle Jurassic anomalodesmatan bivalves from Strunga-Tătaru, Bucegi Mountains. *Acta Palaeont. Romaniae* 2, 237–250.

Lazăr I. 2002: Bivalves (Subclass Anomalodesmata) from Middle Jurassic deposits of the western flank of Bucegi Mountains. *Acta Palaeont. Romaniae* 3, 241–256.

Lazăr I. 2004: The Jurassic bivalve fauna from the western side of the Bucegi Mountains. Part I. Subclasses Palaeotaxodonta and Pteriomorphia (Orders Arcoida, Pterioida, Limoida). *Acta Palaeont. Romaniae* 4, 217–231.

Lazăr I. & Barbu V. 2004: A new species of the brachiopod genus *Sphaeroidothyris* from the Middle Jurassic (Bajocian) of Bucegi Mountains (Romania). *Proc. Romanian Acad., Ser. B: Chemistry, Life Sci. Geosci.*, 1–10.

Mutihac V. & Ionesi L. 1973: Geology of Romania. *Ed. Tehnica*, Bucharest, 1–642 (in Romanian).

Oncescu N. 1943: Région de Piatra Craiului–Bucegi. Étude géologique. *Ann. Inst. Geol. (Bucharest)* 22, 1–124.

Ožvoldová L. 1979: Radiolarian assemblage of radiolarian cherts at Podbiel locality (Slovakia). *Časopis pro mineralogii a geologii, roč.* 24, č. 3/1979, 249–261.

Ožvoldová L. 1988: Radiolarian associations from radiolarites of the Kysuca Succession of the Klippen Belt in the vicinity of Myjava-Tura Luka (West Carpathians). *Geol. Carpathica* 39, 3, 369–392.

Ožvoldová L. 1998: Middle Jurassic radiolarian assemblages from radiolarites of the Silica Nappe (Slovak Karst, Western Carpathians). *Geol. Carpathica* 49, 4, 289–296.

Ožvoldová L. & Frantová L. 1997: Jurassic radiolarites from the eastern part of the Pieniny Klippen Belt (Western Carpathians). *Geol. Carpathica* 48, 1, 49–61.

Ožvoldová L., Jablonský J. & Frantová L. 2000: 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). *Geol. Carpathica* 51, 2, 109–119.

Patrulius D. 1957: Correlation of the Dogger and Malm deposits from Eastern Carpathians. *Bul. Stiint. Sect. Geol. Geogr. Acad. R.P.R.* II, 2, 261–273 (in Romanian).

Patrulius D. 1962: Affinités provinciales et voies de migration de quelques faunes jurassiques des Carpates roumaines et de l'avant-pays carpatique. Colloque du Jurassique, Luxembourg, volume de *Comptes Rendus et Mémoires*, *Section des Sciences Naturelles, Physiques et Mathématiques*, 519–525.

Patrulius D. 1969: Geology of the Bucegi Massif and Damboviciara Basin. *Ed. Acad. RSR*, Bucharest, 1–321 (in Romanian).

Patrulius D., Popa E., Avram E., Baltreş A., Pop G., Iva M., Antonescu E., Dumitrica P. & Iordan M. 1980: Petrographical and stratigraphical study of the Jurassic and Neocomian formations from Carpathians and Dobrogea to evaluate the mineral resource potential. Leaota–Braşov–Perşani Mts sector. *Raport I.G.G. — Tema Nr. 47/1979*, 1–180 (in Romanian).

Pessagno E.A. Jr. & Newport R.L. 1972: A technique for extracting Radiolaria from radiolarian cherts. *Micropaleontology* 18, 2, 231–234.

Popescu I. 1966: Contributions to the knowledge of the stratigraphical and structural geology of the Piatra Craiului Massif. *Dări de Seamă. Com. Stat. Geol. (Bucharest)* 52, 2, 157–176 (in Romanian).

Suzuki H. & Gawlick H-J. 2003: The Jurassic radiolarian zones of the Northern Calcareous Alps. In: Weidinger J.T., Lobitzer H. & Spitzbart I. (Eds.): Beiträge zur Geologie des Salzkammerguts. *Gmundner Geo-Studien 2*, *Erkudok Institut Museum*, Gmunden, 115–122.

Sýkora M. & Ožvoldová L. 1996: Lithoclasts of Middle Jurassic radiolarites in debris flow sediments from Silica Nappe (locality Bleskovy pramen, Slovak Karst, Western Carpathians). *Miner. Slovaca* 28, 21–25.

Šmuc A. & Goričan Š. 2005: Jurassic sedimentary evolution of a carbonate platform into a deep-water basin, Mt. Mangart (Slovenian-Italian border). *Riv. Ital. Paleont. Stratigr.* 111, 1, 45–70.

Widz D. 1991: Les radiolaires du Jurassique supérieur des radiolarites de la Zone des Klippes de Pieniny (Carpathes occidentales, Pologne). *Rev. Micropal.* 34, 3, 231–260.