GEOLOGICA CARPATHICA, FEBRUARY 2009, 60, 1, 35–41 doi: 10.2478/v10096-009-0004-5

Early Senonian radiolarian microfauna and biostratigraphy from the Western Vardar Zone (Western Serbia)

NEVENKA DJERIĆ[1], NATAŠA GERZINA[2], VIOLETA GAJIĆ[3] and NEBOJŠA VASIĆ[3]

[1]Department of Paleontology, Faculty of Mining and Geology, University of Belgrade, Kamenička 6, 11000 Belgrade, Serbia; djeranen@eunet.yu
[2]Department of Geology, Faculty of Mining and Geology, University of Belgrade, Kamenička 6, 11000 Belgrade, Serbia; nacy@nadlanu.com
[3]Department of Petrology and Geochemistry, Faculty of Mining and Geology, University of Belgrade, Djušina 7, 11000 Belgrade, Serbia; sedimentologija@yahoo.com

(Manuscript received February 21, 2008; accepted in revised form June 12, 2008)

Abstract: The studied deposits represent the sedimentary cover of ophiolitic mélange of the Western Vardar Zone Belt. An association of sediments that correspond to a primary pyroclastic material occurs in the Upper Cretaceous carbonate sediments near the village of Struganik (Western Serbia). This is an interlayer within mainly carbonate sediments represented by limestone, clayey limestone and marlstone. It is made of the following succession: a lamina made of crystalline quartz, sanidine, plagioclase and biotite and a layer of clay. The clay is of the smectite type, highly crystalline. The age of the radiolarian assemblage from the clay layer is assigned to Early Senonian, based on the co-occurrence of radiolarian taxa: *Dictyomitra formosa* Squinabol, *Dictyomitra koslovae* Foreman, *Dictyomitra torquata* Foreman, *Alievium* sp. cf. *A. superbum* (Squinabol) and *Pseudoaulophacus* sp. cf. *P. venadoensis* Pessagno. The pyroclastic material was brought into the water environment by a cloud that was formed after an explosive eruption whose exact location cannot be determined at the moment. According to geological data, there are no indications of volcanic activity before the Late Cretaceous in the wider studied area. Marine sedimentation continued after gravitational differentiation of pyroclastic material. The results of petrological and sedimentological investigations reveal that Struganik Limestone originated in a deep-water environment and that the sedimentation area was on the continental slope.

Key words: Upper Cretaceous, NW Serbia, Vardar Zone Western Belt, Radiolaria, pyroclastic, smectite.

Introduction

The investigated area is situated in western Serbia, in an extremely complex geotectonic setting (Fig. 1). In the territory of western Serbia, there are two belts of ophiolitic mélange overlain by large ultramafic massifs. The more external belt is known as the Dinaridic Ophiolites or Dinaridic Ophiolite Belt (Pamić et al. 2002; Karamata 2006) or as the Central Dinaridic Ophiolite belt (Lugović et al. 1991). The more internal belt is referred to as the Vardar Zone Western Belt by Karamata (2006), but also referred to under a variety of names such as Inner Dinaridic ophiolite belt (Lugović et al. 1991), External Vardar Subzone (Dimitrijević 1997, 2001) or simply Vardar Zone (Pamić et al. 2002). These ophiolite belts are separated by the Drina-Ivanjica Element. The majority of authors regarded the Drina-Ivanjica Unit as a continental terrane that was originally located between two separate oceanic basins (Dimitrijević & Dimitrijević 1973; Robertson & Karamata 1994; Dimitrijević 2001; Karamata 2006). Others postulated that this element was formed by out-of-sequence thrusting from the European margin (Pamić et al. 1998; Hrvatović & Pamić 2005). According to Schmid et al. (2008), Drina-Ivanjica is a thrust sheet which was probably emplaced in Early to mid-Cretaceous times on top of the East Bosnian–Durmitor thrust sheet. Like the East Bosnian-Durmitor composite thrust sheet, the Drina-Ivanjica thrust sheet also carried passively the previously obducted Western Vardar ophiolites (Zlatibor ophiolites).

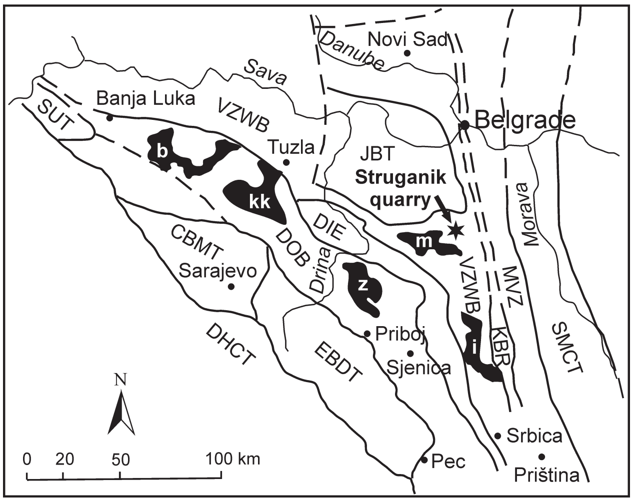

Fig. 1. Sketch of the terranes of central and western Serbia (according to Karamata et al. 2000) with the position of the studied locality. **DHCT** — Dalmatian-Herzegovinian Composite Terrane; **CBMT** — Mid-Bosnian Mountains Terrane; **EBDT** — East-Bosnian-Durmitor Terrane; **SUT** — Sana-Una Terrane; **DOB** — Dinaridic Ophiolite Belt (Terrane); **DIE** — Drina-Ivanjica Element (Terrane); **VZWB** — Vardar Zone Western Belt; **JBT** — Jadar Block Terrane; **KBR** — Kopaonik Block and Ridge; **MVZ** — Main Vardar Zone; **SMCT** — Serbo-Macedonian Composite Terrane; **black** — ophiolite massifs: **b** — Borje; **i** — Ibar; **Kk** — Krivaja-Konjuh; **m** — Maljen; **o** — Ozren; **z** — Zlatibor.

The Jadar Block is considered (by the majority of Serbian geologists) to be either an integral part of the Vardar Zone (Dimitrijević 1997) or an exotic body pushed into the Vardar Zone in the Late Cretaceous (Karamata et al. 1994). According to some recent interpretations, the Drina-Ivanjica and Jadar units structurally underlie Neotethyan ophiolites of Jurassic age that were obducted onto the Adria margin during the Late Jurassic (Schmid et al. 2008).

The present-day tectonic contact between the Drina-Ivanjica and the Jadar Block is very steep and has a strong dextral strike-slip component (Gerzina & Csontos 2003). In the literature, this contact is referred to as the "Zvornik suture" (Dimitrijević 1997) that is supposed to mark the ophiolitic suture between the continental Drina-Ivanjica and Jadar Block Terranes (Karamata 2006). According to Schmid et al. (2008), the Zvornik "suture" simply represents the northwestern continuation of the long belt of Senonian flysch, which marks the tectonic boundary between the Drina-Ivanjica and Jadar-Kopaonik thrust sheets.

There are opinions that the ophiolites in these two ophiolite belts resulted from the obduction of just one ocean (Pamić 1998; Pamić et al. 2000; Csontos et al. 2003; Schmid et al. 2008). The occurrence of ophiolites in two and not only in one belt is due to out-of-sequence thrusting and later nappe refolding during Cretaceous and Cenozoic orogenic phases (Csontos et al. 2003). The majority of Serbian geologists, however, are of the opinion that these ophiolitic belts represent remnants of two different oceanic environments.

In the wider studied area, Cretaceous sedimentation begins with the Albian transgression. Terrigenous-carbonate and carbonate sedimentation continued from the Albian to the Maastrichtian, while flysch sediments were deposited during the latest Senonian (Filipović et al. 1978).

The aim of this study was to present information on the Upper Cretaceous radiolarian assemblage from the rocks which cover the ophiolites of the Vardar Zone Western Belt.

The clay in which radiolarians were found is of volcanic origin and this is the first finding of smectite clay in Upper Cretaceous sediments of Serbia. Due to the tectonic position of the investigated area, we consider that this paper is an important contribution to better understanding of the geological evolution of the area during the Cretaceous, which will enable comparison with similar rocks in the surrounding regions.

Geological setting

The wider investigated area is situated in the Vardar Zone Western Belt (Western Serbia), north of the large ophiolitic complex of Maljen and Suvobor (Fig. 2). The underlying ophiolitic mélange was formed due to the closure of the oceanic area during the Late Jurassic to Early Cretaceous (Csontos et al. 2003, 2004; Schmid et al. 2008).

The sedimentary cover of the ophiolites in the wider area of the village of Struganik is represented by the Albian-Cenom-

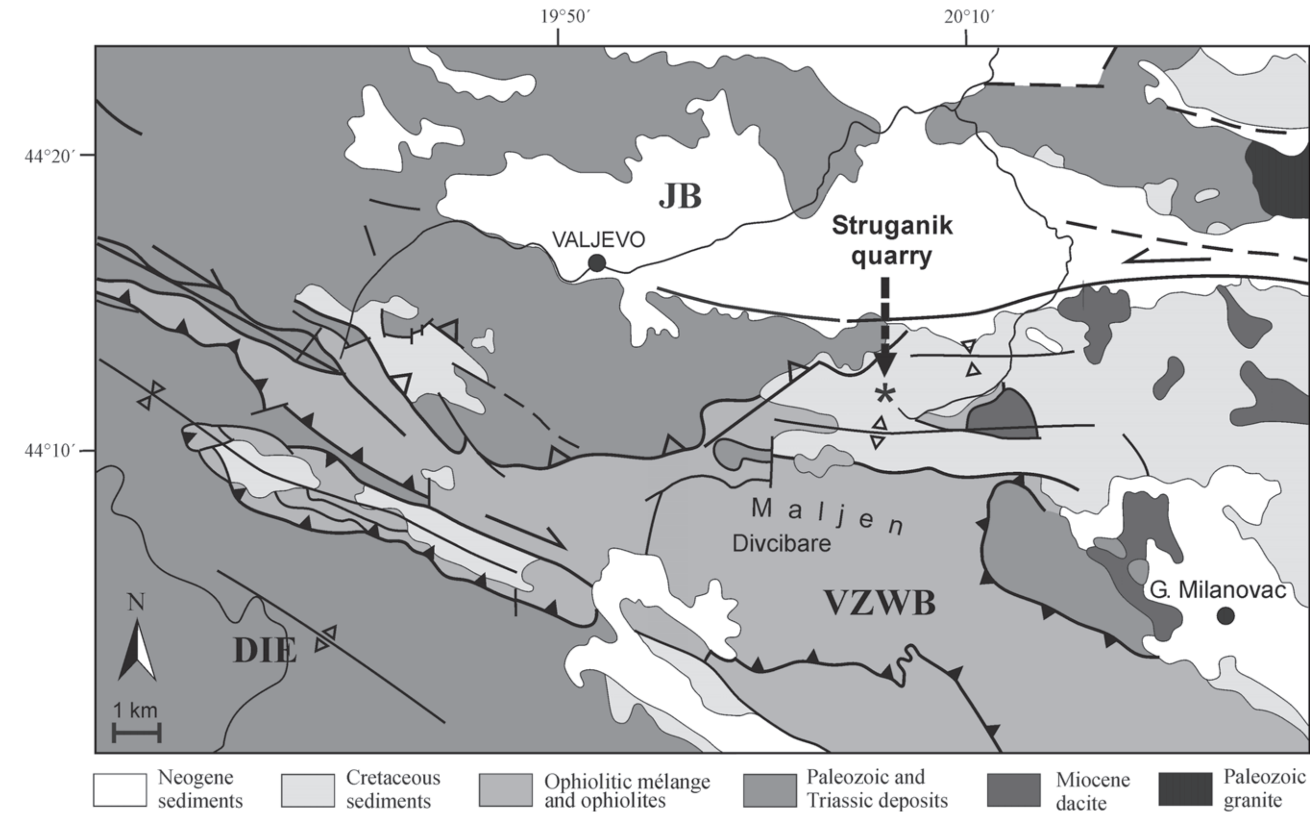

Fig. 2. Simplified and modified geological map of the wider surroundings of the investigated area with the position of the studied locality (Struganik quarry), based on the Geological Map of Former Yugoslavia 1 : 500,000. **VZWB** — Vardar Zone Western Belt, **JB** — Jadar Block, **DIE** — Drina-Ivanjica Element.

anian conglomerates, conglomeratic limestone and sandstone (Filipović et al. 1978; Rabrenović et al. 2002). Cenomanian sediments in the area of Struganik are represented by conglomerate, conglomeratic-sandy limestone and sandstone. These sediments are concordantly overlain by grey and bluish marlstone with abundant floral detritus, limestone and marly sandstone. The uppermost part of the Cenomanian is mostly made of marlstone with rare intercalations of limestone. The Cenomanian age of the sediments was documented paleontologically and it was based on macrofauna (*Ostrea carinata*, *Caprinella triangularis*, *Puzosia planulata*, *Acanthoceras mantelli*, *Turilites costatus*, etc.; Marković & Anđelković 1953) and microfauna (*Rotalipora appenninica*, *R. cushmani*, *Praeglobotruncana stephani*, *Globigerina infracretacea*; Filipović et al. 1978). Turonian sediments are represented by detritic limestone with intercalations of marlstone, reddish layered cherty limestone, marly-sandy conglomeratic limestone and reddish marly claystone with limestone intercalations. Their Turonian age was documented by microfauna (*Praeglobotruncana helvetica*, *Rotalipora* sp., *Globotruncana laparenti coronata* etc.; Filipović et al. 1978). Senonian sediments are best exposed in the village of Struganik. They are represented by the so-called Struganik Limestone, a series mostly made of thin-layered limestone, clayey limestone and marlstone. Chert concretions are present in all levels. The Senonian age was documented on the basis of macrofauna (*Inoceramus balticus*, *Inoceramus lamarcki*; Marković & Anđelković 1953) and microfauna (*Globotruncana stuarti*, *G. tricarinata*; Filipović et al. 1978). A layer of green-grey pelitic sediments, which correspond to a primary pyroclastic material, occurs within the Senonian limestone and marlstone (Vasić et al. 2005).

The pyroclastic material was brought into the aquatic environment most probably by a cloud that was formed after a volcanic eruption. Crystalloclasts, as the largest clasts, were the first deposited from the cloud by gravitational differentiation, forming a lamina. Finer grains, fragments of volcanic glass in the first place, formed the overlying layer. The volcanic glass was transformed into smectite clay by diagenetic processes (Vasić et al. 2001, 2005).

Petrological characteristics of the Struganik quarry section

The local lithological column, in which a layer of primary pyroclastic sediments was noticed, was measured on the lower level of a quarry in Struganik (coordinates: x — 7428643, y — 4894326, z — 366 m). The thickness of the column is 11.5 m (Fig. 3).

The autochthonous sediments are platy and bedded carbonate rocks with contents of $CaCO_3$ (calcite) from 50 to 88 %, which classifies them as marlstone-marly limestone in the Bart classification. According to the Folk classification (Folk 1959), the sediments correspond to micrite, fossiliferous micrite and biomicrite with an association in which globotruncanas, poorly preserved radiolarians and silicisponge spicules (calcified) are conspicuous. Laminas (up to 5 mm thick) that represent biomicrite with dominant globotruncanas were found in marly limestone and marlstone in the lower part of the column made of micrite. Traces of life activity, namely biogenic structural forms, are present on bedding surfaces in these rocks.

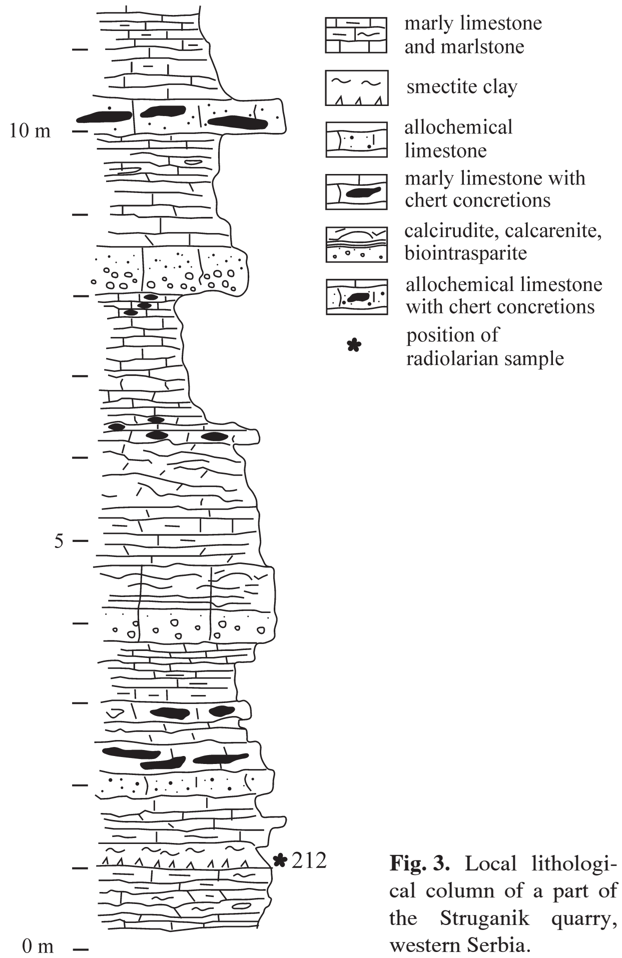

Fig. 3. Local lithological column of a part of the Struganik quarry, western Serbia.

The column is composed of four beds (30–75 cm) of limestone, which is defined as biosparite, biointrasparite, calcarenite and calcirudite (Fig. 2). These limestones are characterized by gradation, horizontal and wavy lamination. A thick limestone bad is characterized by continuity of the structures from the lower to the upper bedding surface, which corresponds to the Tb-c succession of the Bouma sequence (Bouma 1962) (Fig. 4).

In a lithological sense, graded limestone begins with coarse-grained varieties (calcirudite-calcarenite), and ends with fine-grained allochemical-sparry varieties (biosparite and biointrasparite). *Paleodictyon* structure (Seilacher 2007) was noticed on the lower surface of a layer made of allochemical-sparry limestone (Fig. 5). All the types of carbonate rocks contain concretionary cherts in the form of lumps, lenses and concretionary interlayers (Fig. 3).

In the lower part of the column, within the sequence of marly limestone, there is an association of sediments, which, according to all its characteristics, corresponds to primary pyroclastic material. The association is composed of a lamina (1 mm) made of crystalloclasts (crystalloclastic tuff) and a layer of clay (10 cm) (Fig. 6).

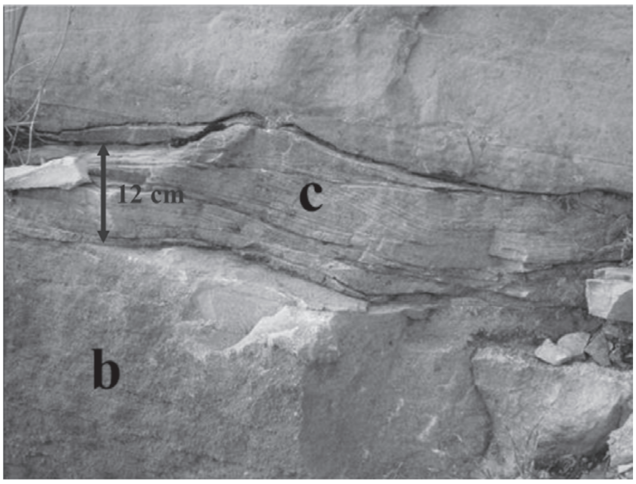

Fig. 4. Bouma sequence in allochemical-sparite: interval of parallel lamination (**b**) and interval of wavy lamination (**c**), Struganik quarry, western Serbia (photo V. Gajić).

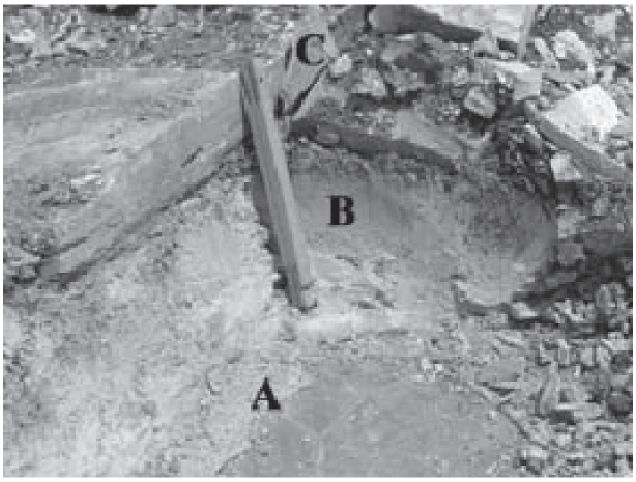

Fig. 6. Upper Cretaceous layers in the Struganik quarry: **A** — Crystalloclastic tuff laminae; **B** — Smectite clay and **C** — Marly limestone Struganik, western Serbia (photo V. Gajić).

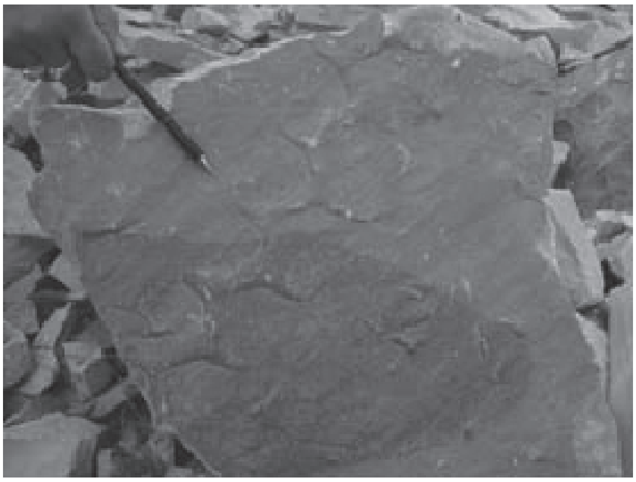

Fig. 5. *Paleodictyon* structure in allochemical-sparry limestone, Struganik quarry, western Serbia (photo V. Gajić).

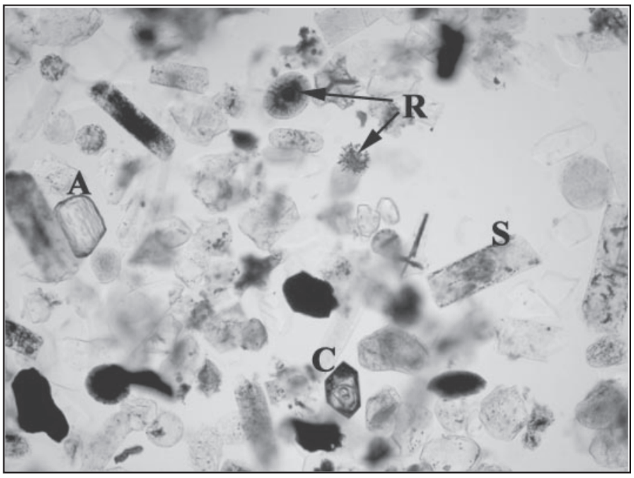

Fig. 7. Microphotograph of 0.063–0.125 mm fraction separated from smectite clay, Struganik quarry, western Serbia. **A** — Apatite; **R** — Radiolarians; **S** — Spongi spicules, and **C** — Zircon.

Crystalloclasts of quartz, feldspars, and biotite are petrogenetic components in the lamina of crystalloclastic tuff. Quartz is completely transparent (vitrified). Quartz grains are usually broken. Bipyramidal grains, which undoubtedly point to the volcanic origin, are present as well. Feldspars are represented by transparent sanidine with clearly visible fissility and acid to intermediate plagioclases of milky-white colour. The most abundant coloured mineral is biotite.

Clay occurs in the form of a 10 cm thick layer which directly overlies the lamina of crystalloclastic tuff. XRF analyses identified three crystal phases. Clay minerals of the smectite group prevail, while calcite and quartz are subordinate. The results of differential thermal and thermal gravimetric investigations show that the clay is made of smectite and about 10 % of calcite. The analysed smectite corresponds to Al-montmorillonite with Ca and Mg, as interlayer cations, which was confirmed by chemical analyses (Table 1).

Table 1: Chemical composition of smectite clay (fraction separated minor off 5 μm) from the Struganik quarry section.

Oxides	Weight %
SiO_2	48.67
TiO_2	0.13
Al_2O_3	21.51
Fe_2O_3	2.03
MnO	*
MgO	4.16
CaO	4.27
Na_2O	0.05
K_2O	2.09
CO_2	tr.
CO_3	tr.
Org. mat.	0.10
H_2O^-	11.72
H_2O^+	5.73
Sum.	100.46

Optical analysis of the fraction separated from the clay by wet sieve analysis (sieve size 0.063 mm) was performed. The content of this fraction is smaller than 5 %. About 80 % of the fraction is made of tiny monoclinic crystals of calcite. A concentrate of non-carbonate constituents, composed of organic and inorganic part, was attained by removal of calcite (quick treatment by dilute hydrochloric acid). The inorganic part is mostly made of quartz crystalloclasts and smaller amounts of sanidine and plagioclase. Accessory minerals are represented by zircon, apatite, amphibole and tourmaline. The organic part is made of silicisponge spicules and of broken (to a lesser extent) or well-preserved radiolarians (Fig. 7). It is important to emphasize that the size of crystalloclasts in the clayey layer decreases in the upward direction.

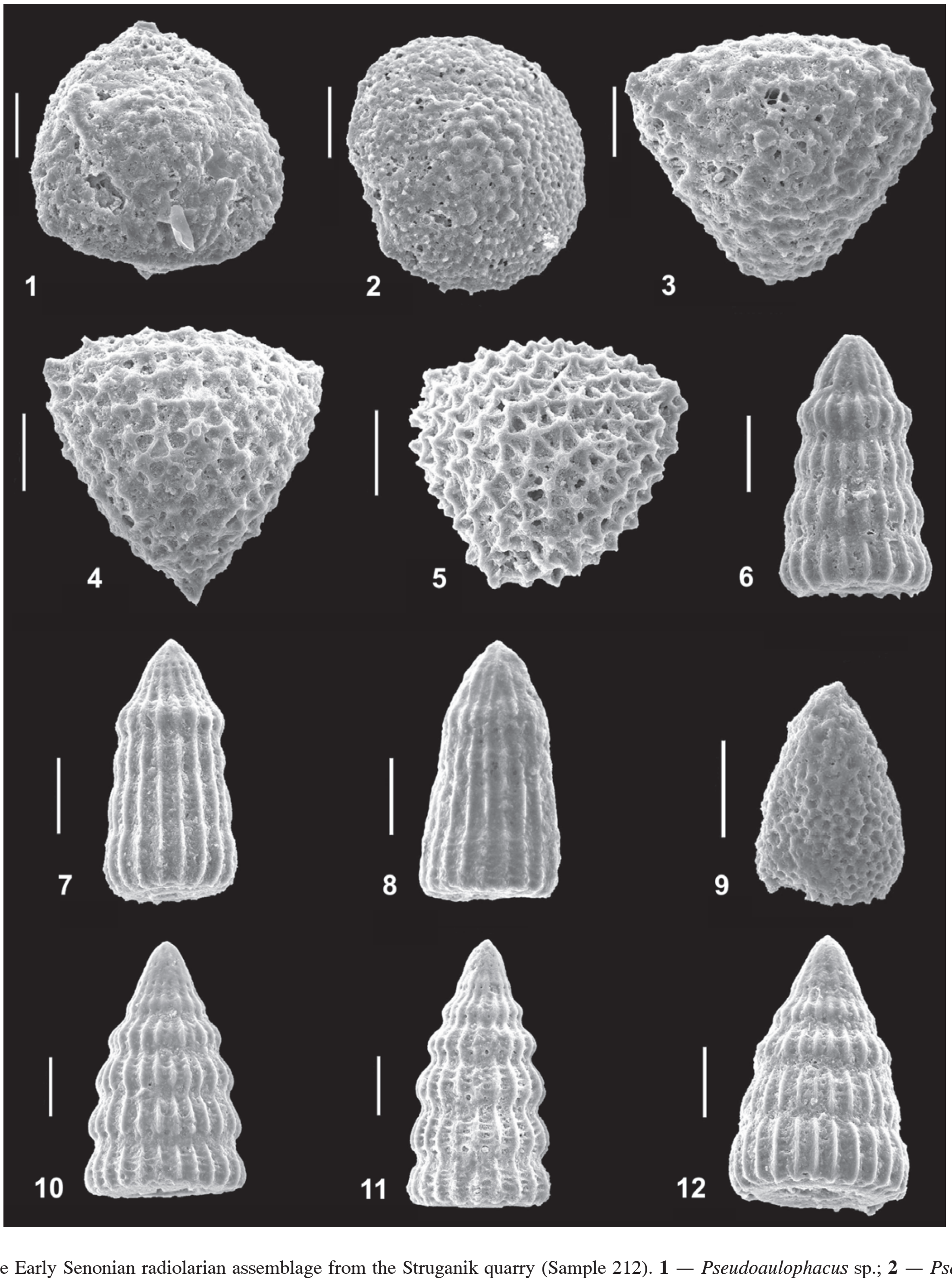

Fig. 8. The Early Senonian radiolarian assemblage from the Struganik quarry (Sample 212). **1** — *Pseudoaulophacus* sp.; **2** — *Pseudoaulophacus* sp. cf. *P. venadoensis* Pessagno; **3–5** — *Alievium* sp. cf. *A. superbum* (Squinabol); **6–8** — *Dictyomitra koslovae* Foreman; **9** — *Stichomitra* sp.; **10–11** — *Dictyomitra formosa* Squinabol; **12** — *Dictyomitra* sp. cf. *D. formosa* Squinabol. Scale bar for all specimens = 50 μm.

Radiolarian dating

All the radiolarian specimens presented in this study were obtained from a single clay sample (Figs. 3, 6). The productive sample 212 is from grey, soft clay and it was treated only with water. The clay intercalations of carbonate sediments from Struganik contain well preserved but relatively diverse radiolarian fauna. Radiolarians occur together with abundant sponge spicule fragments and sponge carcasses. The radiolarian fauna of sample 212 comprises (Fig. 8): *Dictyomitra formosa* Squinabol, *Dictyomitra koslovae* Foreman, *Dictyomitra torquata* Foreman, *Alievium* sp. cf. *A. superbum* (Squinabol), *Pseudoaulophacus* sp. cf. *P. venadoensis* Pessagno, *Pseudoaulophacus* sp. and *Stichomitra* sp.

According to Schaaf (1985) and Bandini et al. (2006) the range of *Dictyomitra formosa* Squinabol is Late Albian to Early Campanian. According to several authors (Nakaseko & Nishimura 1981; Mizutani et al. 1982 and San Filippo & Riedel 1985) *Dictyomitra koslovae* Foreman characterizes the interval Santonian–Campanian. However, data of Vishnevskaya (2001) and Deschamps et al. (2000) suggest that *Dictyomitra koslovae* Foreman indicates the interval Coniacian–Early Campanian. The presence of *Dictyomitra torquata* Foreman and *Pseudoaulophacus* sp. cf. *P. venadoensis* Pessagno, confirms that the fauna cannot be younger than the Early Campanian (O'Dogherty 1994; Vishnevskaya 2001). Ohmert (2006) suggested that *Alievium superbum* (Squinabol) indicates the interval Turonian to Coniacian, sometimes to Santonian. Therefore the age of the fauna could be assigned to Early Senonian.

This assemblage is similar to the Late Cretaceous assemblage of Romania (Vishnevskaya 2001), Great Caucasus (Vishnevskaya 2001) and Nicoya Complex, Costa Rica (Denyer & Baumgartner 2006).

The radiolarian assemblage derived from a single sample, thus the vertical distribution of radiolarian taxa in the section could not be studied. Therefore, only basic data on these fossils are presented here and they were used for new biostratigraphic interpretations.

Conclusions

When we talk about the environment of deposition of the investigated rocks and marine sediments, there could be two explanations. The first refers to the environment and conditions of deposition of the autochthonous rocks in which the lamina made of crystalloclastic tuff and the layer of clay are found. The mechanism of inflow and deposition of pyroclastic material should also be explained.

Autochthonous sediments are represented by marly limestone and marlstone of micritic to biomicritic composition, in which badly preserved radiolarians and silicisponges are found. The presence of well-preserved silicisponge spicules and radiolarians in clay should also be mentioned. The Early Senonian age of the analysed clay is based on radiolarians.

Concretionary cherts indicate the presence of organogenic siliceous remains. Such an association of rocks and fossils is characteristic for a deep-marine sedimentation area. The distinct predomination of silicisponge spicules over radiolarians in clay (noticed in carbonate sediments and particularly in clay) points to a moderately deep-water environment (Vishnevskaya 1984). A finding of *Paleodictyon* is another indicator of a deep-water environment, to the boundary of bathyal-abyssal. Presence of layers of allochemical-sparite, calcarenite and calcirudite with the characteristic textures from the Bouma sequence points to occasional inflow of shallow-water material by turbiditic flows along the continental slope, that is through the bathyal zone. According to these data, it can be concluded that the Struganik Limestone originated in a deep-water environment, in a sedimentation area on the continental slope.

The mineralogical characteristics of the crystalloclastic tuff and clay show that the primary material was of volcanic origin — the pyroclastic material, from which these sediments originated, was a product of acid-to-intermediary volcanism (quartz-sanidine-plagioclase-biotite). The pyroclastic material is, for the most part, made of fragments of volcanic glass (vitroclasts) with some crystalloclasts (fragments, most probably of phenocrysts). The largest crystalloclasts occur in the lamina made of crystalloclastic tuff, while smaller crystalloclasts are present in the layer of clay with a tendency towards upwardly decreasing grain-size. This fact is very important because it indicates that the primary accumulated pyroclastic sediment was graded. Differentiation of the pyroclastic material by size was gravitational, that is the largest clasts were deposited first and accumulation of finer clasts followed. A rather transparent pyroclastic cloud was blown by wind above the Upper Cretaceous Ocean. Due to slower movement of the cloud, gravitationally differentiated fall of clasts started and it continued through the aqueous environment all the way to the sedimentation area on the continental slope where the material was eventually deposited as a graded layer. This event was very short in a geological sense and it was followed by sustained deep-water sedimentation. In an early phase of diagenesis, fragments of volcanic glass were transformed into clay minerals from the smectite group due to reaction with the intergranular sea water. Geochemical characteristics of the environment in which the transformation occurred, resulted in the formation of montmorillonite with Ca and Mg, as interlayer cations.

Acknowledgments: We wish to thank Prof. Valentina Vishnevskaya for her kind contributions during the preparation of this paper. The authors gratefully acknowledge Ugur Kagan Tekin and Jozef Michalík for their constructive comments on the manuscript. The work was supported by the Serbian Ministry of Science and Technological Development (Projects No. 146009 and 146013).

References

Bandini A., Baumgartner O.P. & Caron M. 2006: Turonian radiolarians from Karnezeika, Argolis Peninsula, Peloponnesus (Greece). *Eclogae Geol. Helv.* 99, 1, 1–20.

Bouma A.H. 1962: Sedimentology of some flysch deposits. *Elsevier*, Amsterdam, 1–168.

Csontos L., Gerzina N., Hrvatović H., Schmid S. & Tomljenović B.

2003: Structure of the Dinarides: a working model. *Ann. Univ. Sci. Budapest., Sect. Geol.* 35, 143–144,

Csontos L., Gerzina N., Hrvatović H., Schmidt S. & Tomljenović B. 2004: Structural evolution of the Internal Dinarides: a preliminary study based on selected regions. *Procc. 5th International Symposium on Eastern Mediterranean Geology*, 377–380, Thessaloniki, Greece, 14–20 April 2004.

Denyer P. & Baumgartner O.P. 2006: Emplacement of Jurassic-Lower Cretaceous radiolarites of the Nicoya Complex (Costa Rica). *Geol. Acta* 4, 1–2, 203–218.

Deschamps A., Monié P., Lallemand S., Hsu S.K. & Yeh K.Y. 2000: Evidence for Early Cretaceous oceanic crust trapped in the Philippine Sea Plate. *Earth Planet. Sci. Lett.* 179, 3–4, 503–516.

Dimitrijević M.D. 1997: Geology of Yugoslavia. *Geol. Inst. GEMINI Spec. Publ.*, Belgrade, 1–187.

Dimitrijević M.D. 2001: Dinarides and the Vardar Zone: a short review of the geology. *Acta Vulcanol.* 13, 1–8.

Dimitrijević M.N. & Dimitrijević M.D. 1973: Olistostrome mélange in the Yugoslavian Dinarides and late Mesozoic plate tectonics. *J. Geol.* 81, 3, 328–340.

Filipović I., Marković B., Pavlović Z., Rodin V. & Marković O. 1978: Explanatory booklet for the Sheet Gornji Milanovac (Basic Geologic Map of Former Yugoslavia 1:100,000). *Federal Geol. Survey,* Belgrade, 71.

Folk R.L. 1959: Practical petrographic classification of limestone. *AAPG Bull.* 43, 1, 1–38.

Gerzina N. & Csontos L. 2003: Deformation sequence in the Vardar Zone: surroundings of Jadar Block; Serbia. *Ann. Univ. Sci. Budapestinensis*, *Sect. Geol.* 35, 139–140.

Hrvatović H. & Pamić J. 2005: Principal thrust-nappe structures of the Dinarides. *Acta Geol. Hung.* 48, 2, 133–151.

Karamata S. 2006: The geological development of the Balkan Peninsula related to the approach, collision and compression of Gondwana and Eurasian units. In: Robertson A.H.F. & Mountrakis D. (Eds.): Tectonic development of the Eastern Mediterranean Region. *Geol. Soc. London*, *Spec. Publ.* 260, 155–178.

Karamata S., Knežević V., Memović E. & Popević A. 1994: The evolution of the Northern Part of the Vardar Zone in Mesozoic. *Bull. Geol. Soc. Greece* XXX/2, 479–486.

Karamata S., Olujić J., Protić Lj., Milovanović D., Vujinović L., Popević A., Memović E., Radovanović Z. & Resimić-Šarić K. 2000: The western belt of the Vardar Zone — the remnant of a marginal sea. In: Karamata S. & Janković S. (Eds.): Proceedings of the International Symposium on "Geology and Metallogeny of the Dinarides and the Vardar Zone". *Acad. Sci. Arts Rep. Srpska, Collect. Monogr., Dep. Nat., Math., Tech. Sci.* I, Banja Luka/Serbian Sarajevo, 131–135.

Lugović B., Altherr R., Raczek I., Hofmann A.W. & Majer V. 1991: Geochemistry of peridotites and mafic igneous rocks from the Central Dinaric Ophiolite Belt, Yugoslavia. *Contr. Mineral. Petrology* 106, 201–216.

Marković O. & Anđelković M. 1953: Geological composition and tectonics of wider surroundings of villages Osečenica, Brežde and Struganik (West Serbia). *Zbornik radova SAN* 32, 5, 111–150 (in Serbian).

Mizutani S., Nishiyama H. & Ito T. 1982: Radiolarian biostratigraphic study of the Shimanto Group in the Nanto-Nansei Area, Mie Prefecture, Kii Peninsula, Central Japan. *J. Earth Sci. Nagoya Univ.* 30, 31–107.

Nakaseko K. & Nishimura A. 1981: Upper Jurassic and Cretaceous Radiolaria from the Shimanto Group in Southwest Japan. *Science Reports, College of General Education Osaka University* 30, 2, 133–203.

O'Dogherty L. 1994: Biochronology and Paleontology of Mid-Cretaceous Radiolarians from Northern Apennines (Italy) and Betic Cordillera (Spain). *Mém. Géol.* 21, 1–415.

Ohmert W. 2006: Radiolarien-Faunen und Obergrenze der Amden-Formation (Coniacium-Santonium) im Tölzer Helvetikum (Oberbayern). *Zitteliana* A46, 3–40.

Pamić J. 1998: North Dinaridic Late Cretaceous-Paleogene subduction-related tectonostratigraphic units of southern Tisia, Croatia. *Geol. Carpathica* 49, 5, 341–350.

Pamić J., Gušić I. & Jelaska V. 1998: Geodynamic evolution of the Central Dinarides. *Tectonophysics* 297, 251–268.100

Pamić J., Gušić I. & Jelaska V. 2000: Alpine tectonostratigraphic units and their geodynamic evolution. *Proc. 2nd Croatian Geological Congress* (Cavtat-Dubrovnik, 17–20. 5. 2000), Zagreb, 15–21.

Pamić J., Tomljenović B. & Balen D. 2002: Geodynamic and petrogenetic evolution of Alpine ophiolites from the central and NW Dinarides: an overview. *Lithos* 65, 113–142.

Rabrenovic D., Vasic N., Mitrovic-Petrovic J., Radulovic V., Radulovic B. & Srecković-Batočanin D. 2002: The Middle Cenomanian basal series of Planinica, Eastern Serbia. *Ann. Géol. Penins. Balk.* 64, 13–43.

Robertson A.H.F. & Karamata S. 1994: The role of subduction-accretion processes in the tectonic evolution of the Mesozoic Tethys in Serbia. *Tectonophysics* 234, 73–94.

Sanfilippo A. & Riedel W.R. 1985: Cretaceous Radiolaria. Plankton stratigraphy. In: Bolli H.M., Saunders J.B. & Perch-Nielsen K. (Eds.): Plankton stratigraphy. *Cambridge University Press*, Cambridge, 631–712.

Schaaf A. 1985: Un nouveau canevas biochronologique du Crétacé inférieur et moyen: les biozones à radiolaires. *Sci. Geol. Bull.* 38, 2, 227–269.

Schmid M.S., Bernoulli D., Fügenschuh B., Matenco L., Schefer S., Schuster R., Tischler M. & Ustaszewski K. 2008: The Alpine-Carpathian-Dinaridic orogenic system: correlation and evolution of tectonic units. *Swiss J. Geosci.* 101, 1, 139–183. doi 10.1007/s00015-008-1247-3.

Seilacher A. 2007: Trace fossil analysis. *Springer-Verlag*, Berlin, Heldelberg, 145–158.

Vasić N., Kostić M., Djurić S. & Rabrenović D. 2001: Highly magnesian smectite clay in the basal series of the Albian-Cenomanian of Planinica (West Serbia). *Mineralogy, Godišnjak JAM* III, Beograd 3, 78–84.

Vasić N., Gajić V., Rabrenović D., Milovanović D., Djerić N. & Kostić M. 2005: Pyroclastic rock in the Upper Cretaceous carbonate sediments from Struganik. *XIV Congress of Geologists of Serbia and Montenegro. Novi Sad, October 18–20, 2005*, 113–114.

Vishnevskaya V.S. 1984: Radolariti kak analogi sovremennih radiolaritovih ilov. *Akademija Nauk SSSR, Institut litosferi*, *Izdateljstvo "Nauka"*, Moskva, 1–120 (in Russian).

Vishnevskaya V.S. 2001: Jurassic to Cretaceous radiolarian biostratigraphy of Russia. *GEOS*, Moscow, 140, 1–376.