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New data on the age of an Upper Cretaceous clastic-carbonate succession in Brežđe (Western Serbia)

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ABSTRACT

Radiolarian assemblages of Late Cretaceous age were studied in a carbonate-clastic section from the Cretaceous sedimentary cover that unconformably overlies Triassic sediments of the Jadar Block. According to the identified radiolarian associations, the studied limestone is of Santonian age. Considering the fact that these sediments belong to a broadly defined Turonian-Senonian geologic map unit, the obtained data are important for further more detailed biostratigraphic assignment of Late Cretaceous rocks in Western Serbia. Moreover, the obtained data are very important for interregional correlations.

Keywords: Upper Cretaceous, Radiolaria, Jadar Block, Vardar Zone Western Belt, Western Serbia

1. INTRODUCTION

Brežđe village is situated in Western Serbia, at the foothills of the Maljen Mountain. The geological setting of the area is extremely complicated, considering the fact that this is a contact zone between the continental Jadar Block and the Western Vardar ophiolites (Figs. 1, 2). Both units are overlain by transgressive Cretaceous sediments.

In the wider studied area, Cretaceous sedimentation begins with the Albian Cenomanian transgressive sediments (FILIPOVIĆ et al., 1978). Terrigenous-carbonate and carbonate sedimentation continued to the end of the Upper Santonian (BRAGINA et al., 2014) or Campanian (GAJIĆ et al., 2011), while the overlying flysch sediments were deposited during the Campanian-Maastrichtian (FILIPOVIĆ et al., 1978).

According to bivalve species (MARKOVIĆ & ANĐELKOVIĆ, 1953) and the identified fossil foraminifers (FILIPOVIĆ et al., 1978), the age of the studied sediments in the wider surroundings of Brežđe was determined as Senonian, without any further division. On the geologic map of Serbia (FILIPOVIĆ et al., 1977), these sediments are not even separated from Turonian sediments, but are together marked as a single unit of Turonian-Senonian age. During the last few years, however, radiolarian investigations have been focused on the Struganik locality in the vicinity of Brežđe village. These investigations enabled a more detailed biostratigraphic assignment of the rocks that belong to the Turonian-Senonian map unit. The lowermost part of the clastic-carbonate succession was assigned an Early Senonian age (DJERIĆ et al., 2009). Further investigations enabled a more precise age determination (Early Santonian) of these sediments, while the radiolarian associations from the overlying beds indicate a Santonian age (BRAGINA et al., 2014). The data presented in this paper will enable comparison with similar rocks in the wider surroundings, which should be an important contribution to better understanding of geology of Western Serbia.

2. GEOLOGICAL SETTING

The studied locality is situated in Western Serbia, 17 km southeast of Valjevo and 7 km south of Mionica, along the Struganik-Brežđe road (GPS N44°11’30’’, E20°04’16.4’’) (Figs. 1, 2).

The investigated area is characterized by extremely complex geology. On the geologic map of western and south-

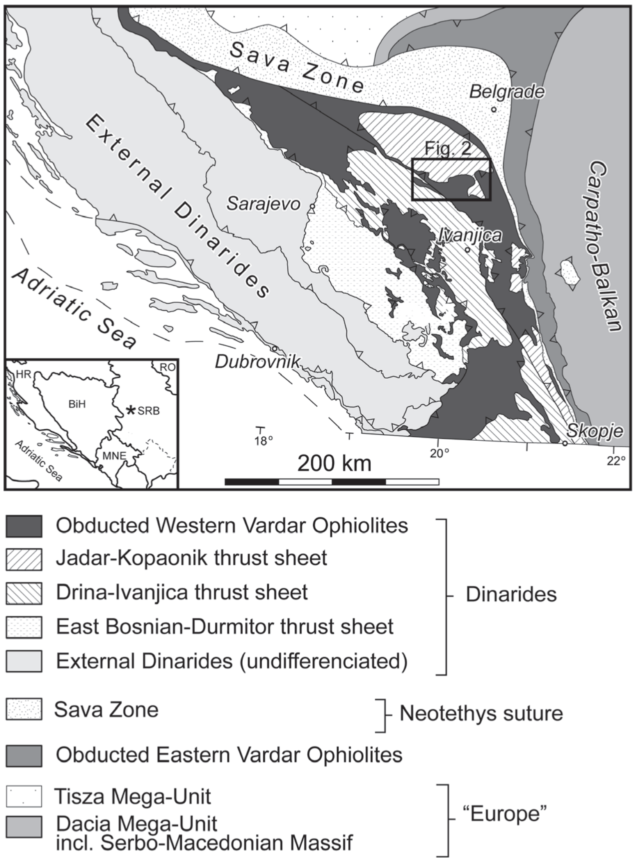

Figure 1: Tectonic sketch of the Dinarides, modified after SCHMID et al. (2008).

western Serbia, there are two conspicuous, more or less parallel, NW-SE oriented belts of ophiolitic mélange overlain by large ultramafic massifs. The southwestern belt is known as the Dinaridic Ophiolite Belt (PAMIĆ et al., 2002; KARAMATA, 2006), the Central Dinaridic Ophiolite Belt (LUGOVIĆ et al., 1991) or the Ophiolite Belt (DIMITRIJEVIĆ, 1997). The ophiolite belt in the northeast is referred to as the Vardar Zone Western Belt (KARAMATA, 2006), but also referred to under a variety of names such as the Inner Dinaridic Ophiolite belt (LUGOVIĆ et al., 1991), the External Vardar Subzone (DIMITRIJEVIĆ, 1997, 2001) or simply the Vardar Zone (PAMIĆ et al., 2002).

There are opinions that ophiolites in these two belts resulted from obduction of just one ocean (PAMIĆ, 1998; PAMIĆ et al., 2000; CSONTOS et al., 2003; SCHMID et al., 2008). Occurrence of ophiolites in two rather than only one belt is due to out-of-sequence thrusting and later nappe refolding during Cretaceous and Tertiary orogenic phases (CSONTOS et al., 2003). A majority of Serbian geologists, however, are of the opinion that these ophiolitic belts represent remnants of two different oceanic realms separated by the Drina-Ivanjica continental block (DIMITRIJEVIĆ & DIMITRIJEVIĆ, 1973; ROBERTSON & KARAMATA, 1994; KARAMATA et al. 1999, DIMITRIJEVIĆ, 2001).

Another continental unit, i.e. the Jadar Block, is situated north of the Vardar Zone Western Belt. It is considered (by the majority of Serbian geologists) to be either an integral part of the Vardar Zone (DIMITRIJEVIĆ, 1997) or an exotic

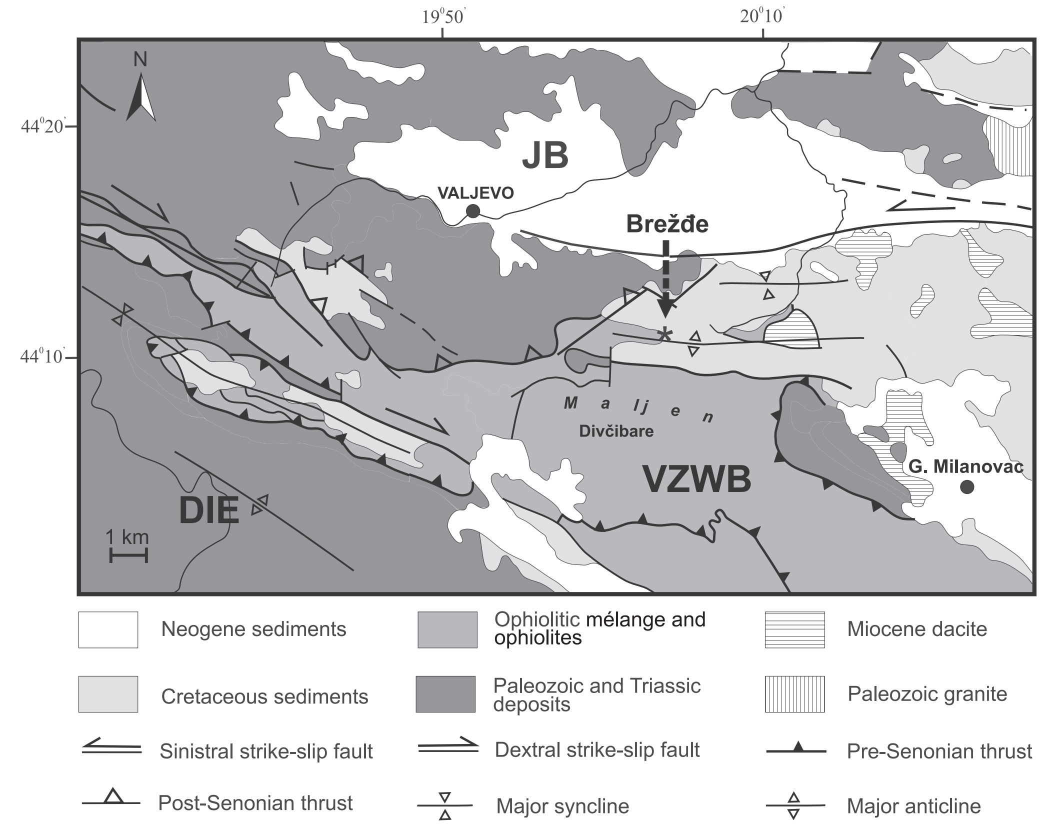

Figure 2: A simplified and modified geological map of the wider surroundings of the investigated area, based on the Geological Map of SFR Yugoslavia 1:500 000 (SAVEZNI GEOLOŠKI ZAVOD, 1970); VZWB – Vardar Zone Western Belt, JB – Jadar Block, DIE – Drina-Ivanjica Element

Table 1: Distribution of radiolarian taxa in the studied samples.

Species	Samples BR1/1	BR1/2	BR1/3
Alievium gallowayi (White)	•		•
Alievium sp.	•		•
Amphipyndax stocki (Cambell & Clark)	cf.		cf.
Amphipyndax sp.	•		•
Cryptamphorella ? sp.	•		
Dictyomitra formosa Squinabol	•	•	•
Dictyomitra koslovae Foreman	•	•	•
Dictyomitra multicostata Zittel	cf.		
Dictyomitra sp.		•	•
Patellula euessceei Empson-Morin	cf.	•	
Patellula helios (Squinabol) *sensu* O'Dogherty		cf.	
Patellula sp.	•	•	•
Praeconocaryomma universa Pessagno	cf.		cf.
Xitus asymbatos (Foreman)	•		
Xitus sp.	•		

body pushed into the Vardar Zone in the Late Cretaceous (KARAMATA et al., 1994).

The present-day tectonic contact between the Drina-Ivanjica and the Jadar Block (Fig. 2) is very steep and with 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 Drina-Ivanjica and Jadar Blocks (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 the Jadar-Kopaonik thrust sheets.

According to 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). However, the original position of the Jadar block below the ophiolitic mélange is visible only in the area of Takovo. In other places, however, the Jadar block seems to be thrust over the mélange and ophiolites (south of Valjevo) and partly over the Late Cretaceous sediments (in the area of Poćuta). Such a position of the Jadar block is probably a consequence of the post-Senonian (Paleogene?) collision-related thrusting and folding (GERZINA & CSONTOS, 2003; CSONTOS et al., 2004).

The Late Jurassic to Early Cretaceous transgressive phase, characterized predominantly by alluvial to neritic sedimentation, started after the obduction and the subsequent erosion in the Dinaridic-Hellenic belt (PAMIĆ et al., 1998; PAMIĆ & HRVATOVIĆ, 2000; SCHMID et al., 2008). In Western Serbia, however, these sediments are absent, possibly due to Early to mid-Cretaceous collisional processes (Schmid et al., 2008). In the wider research area, both Triassic sediments of the Jadar Block and Jurassic rocks of oceanic origin that belong to the Vardar Zone are both unconformably overlain by transgressive Albian-Cenomanian clastic sediments containing redeposited ophiolite fragments. Terrigenous-carbonate and carbonate sedimentation followed through the Cretaceous until the Campanian when flysch sedimentation began (FILIPOVIĆ et al., 1978).

3. MATERIALS AND METHODS

The described radiolarian assemblages originate from a section in Brežđe village (Fig. 3). Four samples, three of which produced positive results (BR 1/1, BR 1/2 and BR 1/3) were taken from marly limestone. The samples were treated with 7–15% acetic acid (CH_3COOH), utilizing the standard methods.

The residues of the acid treatment, which yielded a well preserved fauna, were studied for biostratigraphic purposes. A SEM microscope JEOL JSM-6610LV SEM at the Faculty of Mining and Geology, University of Belgrade was utilized for precise identification of the radiolarians shown in Pls. 1–2.

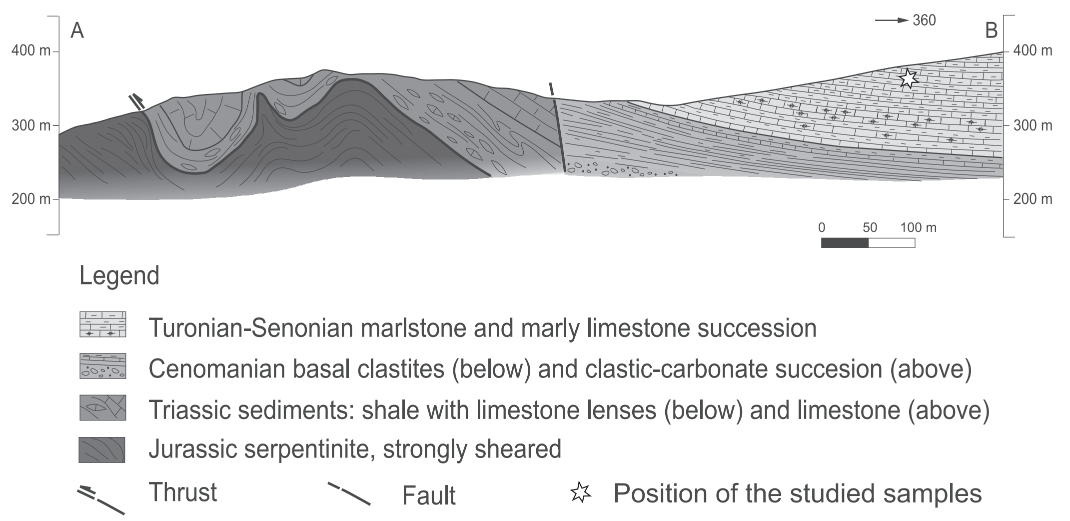

Figure 3: A Simplified geological profile in Brežđe village.

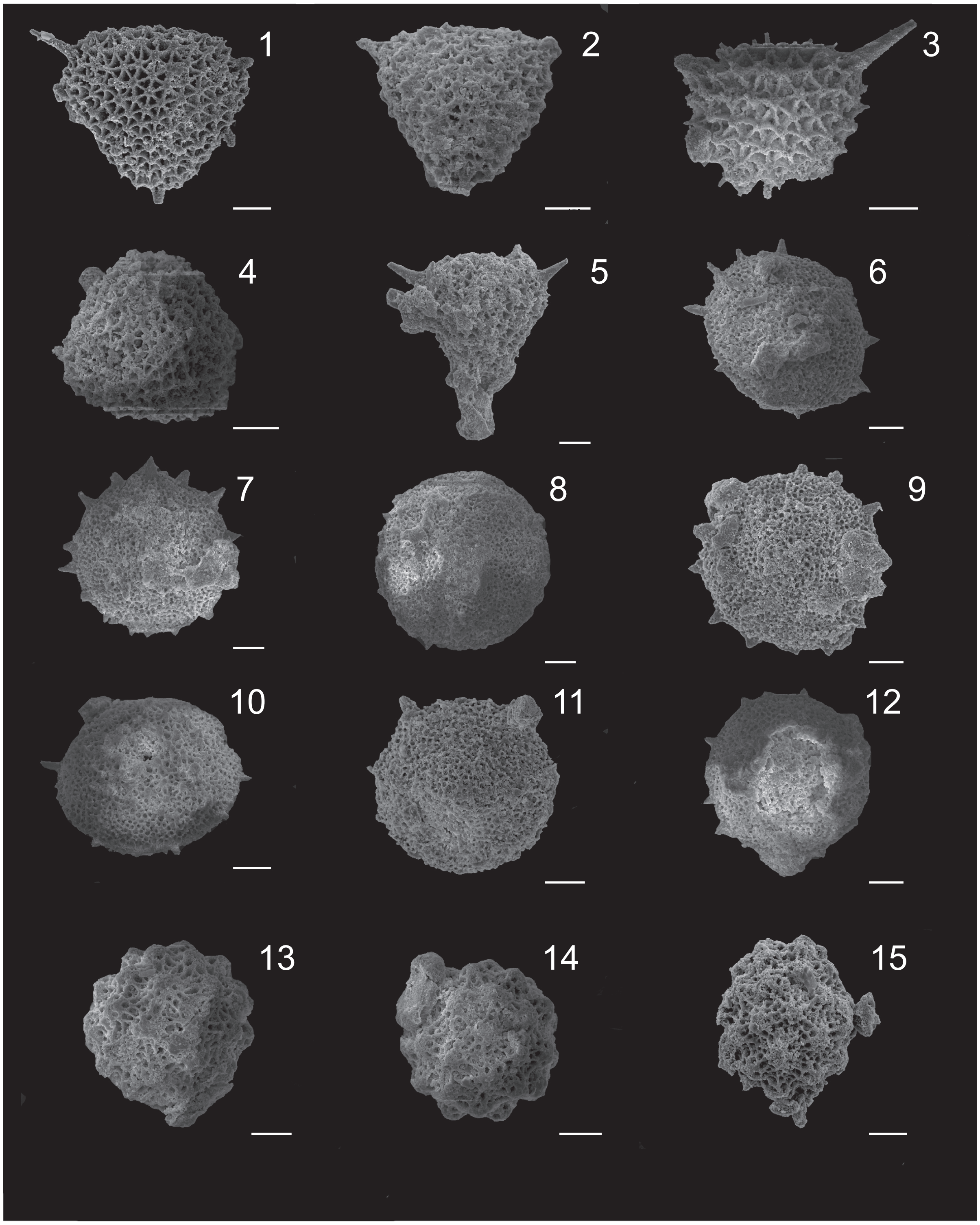

Plate I

Santonian radiolarians from the Brežđe section, Western Serbia

1–3 – *Alievium gallowayi* (White).
4, 5 – *Alievium* sp.
6 – *Patellula* sp. cf. *P. helios* (Squinabol) *sensu* O'Dogherty
7, 8 – *Patellula* sp.
9, 10 – *Patellula euessceei* Empson-Morin
11, 12 – *Patellula* sp.
13, 14, 15 – *Praeconocaryomma* sp. cf. *P. universa* Pessagno.

Specimens illustrated in Figs. 1, 2, 4, 7-9, 13, 14 originate from Sample BR 1/1; specimens in Figs. 6, 10 are from Sample BR 1/2; specimens in Figs. 3, 5, 11, 12, 15 are from Sample BR 1/3. Scale bar length for all images is 50μm.

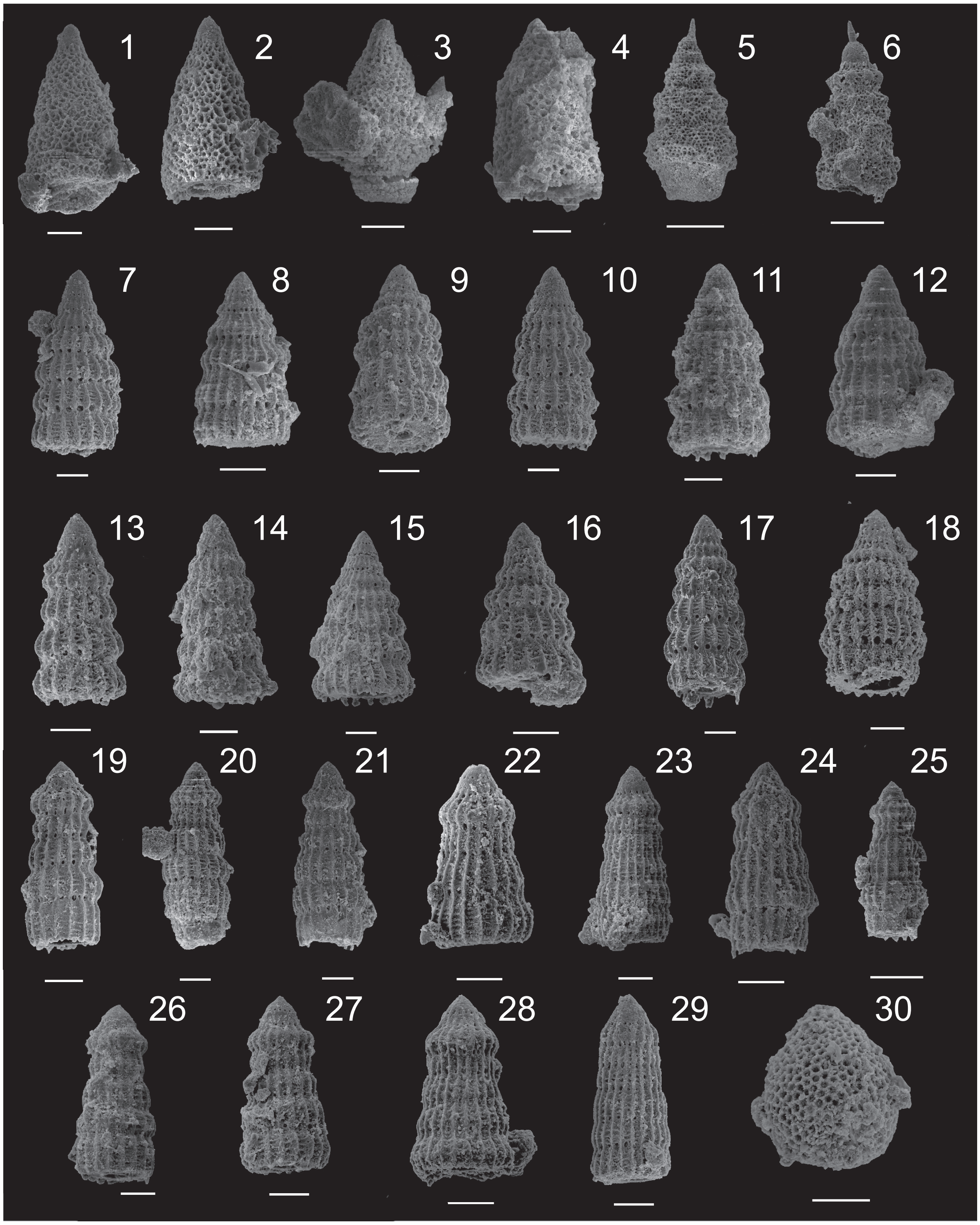

Plate II
Santonian radiolarians from the Brežđe section, Western Serbia

1, 2 – *Amphipyndax* sp.
3, 4 – *Amphipyndax* sp. cf. *A. stocki* (Campbell & Clark)
5, 6 – *Xitus asymbatos* (Foreman)
7-18 – *Dictyomitra formosa* Squinabol
19-28 – *Dictyomitra koslovae* Foreman
29 – *Dictyomitra* sp.
30 – *Cryptamphorella* ? sp.

Specimens illustrated in Figs. 1-3, 5-10, 18-22, 29, 30 originate from Sample BR 1/1; specimens in Figs. 11-13, 23-25 are from Sample BR 1/2; specimens in Figs. 4, 14-17, 26-28 are from Sample BR 1/3. Scale bar length for images 1-4, 7-24, 26-30 is 50µm; for images 5, 6, 25 is 100µm.

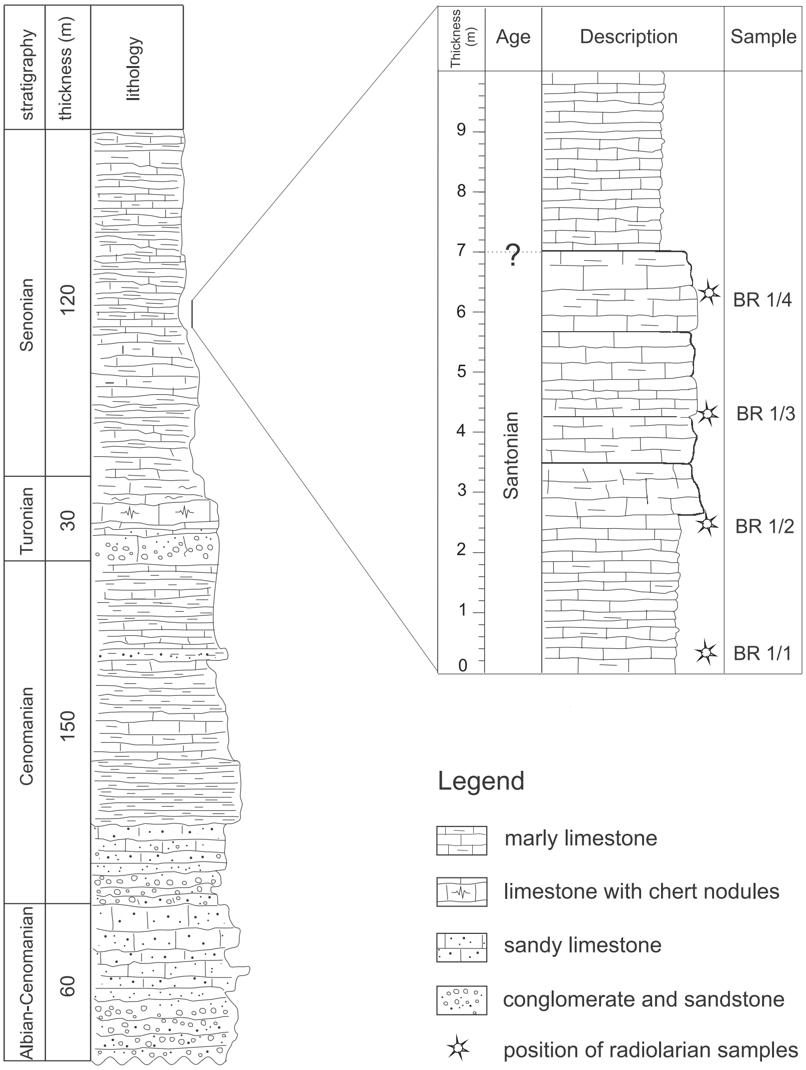

Figure 4: A Generalized columnar section of the Cretaceous in the studied area. The inset to the right shows the column interval studied for radiolarians, with the sample locations indicated.

The micropaleontological material is housed at the Faculty of Mining and Geology in Belgrade (registration numbers BR 1/1, BR 1/2 and BR 1/3).

4. SECTION DESCRIPTION AND BIOSTRATIGRAPHY

In the wider area of Brežđe, MARKOVIĆ & ANĐELKOVIĆ (1953) distinguished Albian-Cenomanian, Cenomanian, Turonian and Senonian sediments. According to FILIPOVIĆ et al. (1978), Turonian sediments are represented by detrital limestone with marlstone interlayers, reddish bedded silicified limestone, marly-sandy conglomeratic limestone and reddish marly claystone. Senonian sediments are best exposed in Struganik village. They are represented by a sequence predominantly made up of thin-bedded limestone, clayey limestone and marlstone (the so-called Struganik Limestone). Chert concretions are present throughout the sequence. Based on the identified radiolarian association, the Lower Senonian age of grayish clay intercalations in limestone of the Struganik quarry was determined by DJERIĆ et al. (2009), while BRAGINA et al. (2014) distinguished several bed-ranked units, ranging from the Lower to the Upper Santonian, in a carbonate-flyschoid section near Struganik village.

The profile in Brežđe village (Fig. 3) starts with strongly sheared serpentinite in the footwall of slightly metamorphic Triassic platform carbonates. The footwall of the serpentinite is not visible along the profile but, according to the observations in the immediate surroundings, serpentinite is in a tectonic contact with the underlying ophiolitic mélange. This original tectonic sandwich was possibly folded and certainly slightly metamorphosed and cleaved prior to the Senonian and also strongly folded after the Senonian (GERZINA & CSONTOS, 2003). The Triassic carbonates are preserved in synforms, while the serpentinite forms the cores of antiforms. Finally, the whole tectonic assemblage is unconformably overlain by an Albian-Cenomanian shaley, marly and carbonate succession grading to Senonian, which has a shallowing-upward tendency (Fig. 4). The original transgressive relationships are disturbed by a steep-dipping fault along which Triassic limestone is in contact with Late

Cretaceous marlstone. The section terminates with shallow-marine carbonates.

Four samples were taken for micropaleontological investigations from gray-yellowish limestone, about 10 m thick at the Brežđe section (Fig. 4). Associations of Late Cretaceous radiolarians are identified from three positive samples (Table 1).

All three samples are characterized by the common presence of *Dictyomitra formosa* Squinabol and *Dictyomitra koslovae* Foreman. The species *Dictyomitra formosa* Squinabol is distributed from the Albian to the lower Campanian (SCHAAF, 1985; BANDINI et al., 2006). *Dictyomitra koslovae* Foreman is characteristic of the Campanian and the Lower Maastrichtian oceanic sediments (SANFILIPPO and RIEDEL, 1985). It has also recently been reported from the Santonian rocks (KORCHAGIN et al., 2012, BRAGINA et al., 2014).

Samples BR 1/1 and BR 1/3 also contain the species *Alievium gallowayi* (White), which is the index species of the synonymous Santonian zone of California (PESSAGNO, 1976). It should be noted that the joint occurrence of radiolarian species *Dictyomitra koslovae* and *Alievium gallowayi* is also known from Santonian strata of the Crimean Mountains (KORCHAGIN et al., 2012) and Struganik village in West Serbia (BRAGINA et al., 2014).

The radiolarian association from sample BR 1/1 also contains *Cryptamphorella macropora* Dumitrica which, according to the available published data, had its last appearance in the Campanian (DUMITRICA, 1970; EMPSON-MORIN, 1984; URQUHART, 1994), while the radiolarian assemblage in sample BR 1/3 contains *Pseudoaulophacus lenticulatus* (White) (LAD in the Campanian; PESSAGNO, 1976; URQUHART, 1994).

In summary, the samples are certainly Santonian in age, but a more precise dating is difficult to establish with the existing zonations. Beside the radiolarians, the microfauna is surprisingly rich in sponge spicules. Notable amounts of sponge spicule fragments together with abundant radiolarians are conspicuous features in all the three studied samples. Monaxones predominate, but hexactines are frequent as well. A significant amount of sponge spicules together with abundant radiolarians in the studied samples indicate a relatively proximal slope environment (KIESSLING, 1996).

5. DISCUSSION AND CONCLUSIONS

After the Late Jurassic obduction and subsequent erosion in the Dinaridic-Hellenic belt, Cretaceous synorogenic basins were formed and filled with clastic material composed of variable amounts of ophiolitic, terrigenous and carbonate detritus (LUŽAR-OBERITER et al., 2012). Therefore, the obducted ophiolitic sheets of the Dinarides are in many places unconformably overlain with Late Jurassic to Early Cretaceous shallow and/or deep marine sediments (PAMIĆ et al., 1998; PAMIĆ & HRVATOVIĆ, 2000; SCHMID et al., 2008). In Western Serbia, however, early Cretaceous sediments are missing and transgression did not start prior to the end of the Lower Cretaceous, thus both Triassic sediments of the passive margin of the Adria and Jurassic rocks of oceanic origin are both unconformably overlain by a transgressive succession that starts with Albian-Cenomanian clastites. The studied sediments of Santonian age are parts of this Late Cretaceous terrigenous-carbonate sequence which was continuously deposited until the Campanian, when flysch sedimentation began and the so-called Ljig Flysch of Campanian-Maastrichtian age was formed.

In order to enable more detailed stratigraphic division of the Turonian-Senonian terrigenous-carbonate sequence in Western Serbia, Late Cretaceous radiolarians have been extensively studied during the last five years (DJERIĆ et al., 2009; BRAGINA et al., 2014). According to lithostratigraphic correlation and the identified radiolarian association, the studied limestone corresponds to the Struganik Limestone which originated on the continental slope, in a relatively proximal slope environment which is indicated by a significant amount of sponge spicules together with abundant radiolarians.

The Santonian age of the analyzed sediments is based on radiolarians. Similar Santonian radiolarian assemblages are known from deposits of the Mt. Ak-Kaya, Crimean Mountains (KORCHAGIN et al., 2012) and from Struganik village in Western Serbia (DJERIĆ et al., 2009; BRAGINA et al., 2014). Despite the almost identical stratigraphic relationships observed in the Struganik and Brežđe villages, the differences between the radiolarian associations are quite obvious. The Brežđe radiolarian assemblages are far less taxonomically diverse in comparison with the radiolarian assemblages in Struganik. Moreover, the radiolarian association in Brežđe is characterized by an absolute predomination of the species *Dictyomitra koslovae* and *Dictyomitra formosa*, which are also present also in the Struganik associations, but in far lesser amounts. Therefore, the radiolarian assemblages from Struganik enabled more detailed biostratigraphic division of the host sediments (the lower Santonian, uppermost lower Santonian - basal upper Santonian and upper Santonian; BRAGINA et al., 2014). A Santonian age is established for the studied radiolarians in Brežđe, but the taxonomic composition of the assemblages does not allow any further division.

Geographically, the nearest similar radiolarian assemblages, although younger (Campanian) are known from Romania (VISHNEVSKAYA, 2001) and from southern Cyprus, where they occur in the sedimentary cover of the Troodos ophiolite and the associated mélange units (URQUHART, 1994; BRAGINA & BRAGIN, 1995, 1996, 2006) as well as an assemblage from southern Turkey from Scaglia-type pelagic limestones of the Upper Antalya nappes (MOIX et al., 2009).

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