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Age of the Jurassic hemipelagic sediments from the Ljubiš area (Zlatibor Mt., SW Serbia)

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Abstract

The type section of the Ljubiš Formation, (Djokov Potok, Zlatibor area, western Serbia) is characterized by abundant poorly-to-moderately preserved radiolarians. The lower part of the type section is characterized by Middle Jurassic (?Bajocian to Bathonian) radiolarian assemblages with *Japonocapsa fusiformis* (YAO), *Takemuraella weghae* (GRILL & KOZUR), *Eoxitus hungaricus* KOZUR, *E. baloghi* KOZUR, *Helvetocapsa matsuokai* (SASHIDA), *Quarkus japonicus* (YAO), *Hexasaturnalis suboblongus* (YAO), *H. tetraspinus* (YAO). Taking into account previous data from the upper part of the Ljubiš Formation, the age of the formation can be estimated to be in the interval from the ?Bajocian to Bathonian-Oxfordian. The new biostratigraphic data clearly show the onset of tectonic motion in the Middle Jurassic, documented by the presence of mass transport deposits intercalated in the radiolarite successions. This suggests a Middle Jurassic onset of ophiolite obduction which triggered the rapid deepening of the Adria margin, documented by the abrupt change from carbonate to radiolarite deposition.

1. INTRODUCTION

Various Mesozoic radiolarite deposits are common and widespread in the territory of western and southwestern Serbia. Mesozoic radiolaria are found in pelagic and hemipelagic sediments deposited on the Neo-Tethys ocean floor, intercalated between Triassic shallow-water carbonate ramp and platform sediments, and are widespread in Jurassic times on the Adriatic margin. Their age determination, stratigraphy, and facies are important for the reconstruction of tectonic motion and the arrangement of palaeo-oceanic basins and continental blocks. Due to the highly complicated structure of this territory, each palaeontological datum from radiolarite deposits and from carbonate clasts of the intercalated turbidites is highly important.

Radiolarians are the most often utilized fossils in such biostratigraphic studies, due to their common presence in the Mesozoic radiolarites. Mesozoic radiolarian biochronology is essential for the understanding of the palaeogeography and overall tectonic structure of the Dinarides. There are numerous data on siliceous sedimentary rocks associated with the ophiolite belts in the Dinarides, Albanides and Hellenides which are often Middle to Late Triassic, Middle Jurassic, or late Middle Jurassic to Late Jurassic in age (OBRADOVIĆ & GORIČAN, 1988; DJERIĆ et al., 2007; CHIARI et al., 2011; FERRIÈRE et al., 2015; GAWLICK et al., 2017; BRAGIN et al., 2019b). It is very rarely possible to obtain Early Jurassic ages, and radiolarites of Early Jurassic age were only discovered in two sections, at Angelokastron and Vothiki (Argolis), (CHIARI et al., 2013).

Numerous radiolarian studies have been carried out in Serbia during the last two decades (e.g. GORIČAN et al., 1999; DJERIĆ et al., 2007, 2012; GAWLICK et al., 2009, 2016, 2018; VISHNEVSKAYA et al., 2009; CHIARI et al., 2011; BRAGIN et al., 2011, 2019a, b) but a lot of the biostratigraphic age dating has still to be undertaken to solve the remaining open questions. The difficult reconstruction of the geodynamic history of the Adriatic passive margin and the ophiolite belts in the Dinarides needs careful analysis of all sedimentary deposits, including their biostratigraphy, facies, history of deposition, and tectonic events.

In recent work GAWLICK et al. (2017), SUDAR & GAWLICK (2018) and GAWLICK & MISSONI (2019) propose a new stratigraphic scheme for the Triassic and Jurassic of the Inner Dinarides. Numerous stratigraphic series (formations) were analyzed: some of them were revised, others were established for the first time. Radiolarite formations in this scheme are most common in the Middle and Upper Jurassic deposits. Biostratigraphic data of these numerous formations are variable. In some instances they are very comprehensive, while in the other cases they are scarce or rare. Some formations still have only limited biostratigraphic control and their stratigraphic positions were determined by indirect methods. GAWLICK et al. (2017) recently proposed a late Middle Jurassic to Late Jurassic age for the Ljubiš Formation, but the dating was not precise due to poor preservation of the radiolarians.

During the 2015 field season, we studied the reference section of the Ljubiš Formation (sensu GAWLICK et al., 2017) in Djokov Potok, and present here the first biostratigraphic data from these sedimentary rocks based on radiolarians.

2. GEOLOGICAL OVERVIEW

The research area is situated in SW Serbia, in Ljubiš Village on the eastern flanks of Mt. Zlatibor. The wider area is characterized by a rather complicated structure. According to SCHMID et al. (2008), it comprises the Adria-derived Drina-Ivanjica (DIU) and East Bosnian-Durmitor Units (EBDU), with the West Vardar ophiolites superimposed on top, i.e. presently located between the DIU to the northeast and the EDBU to the southwest (Fig.1). Both Adria-derived units (Drina-Ivanjica and East Bosnian-Durmitor) being thrust by the ophiolitic mélange during the Late Jurassic (SCHMID et al., 2008). The present-day position of the Drina-Ivanjica above the East Bosnian-Durmitor unit is a result of out-of-sequence thrusting during the Cretaceous (SCHMID et

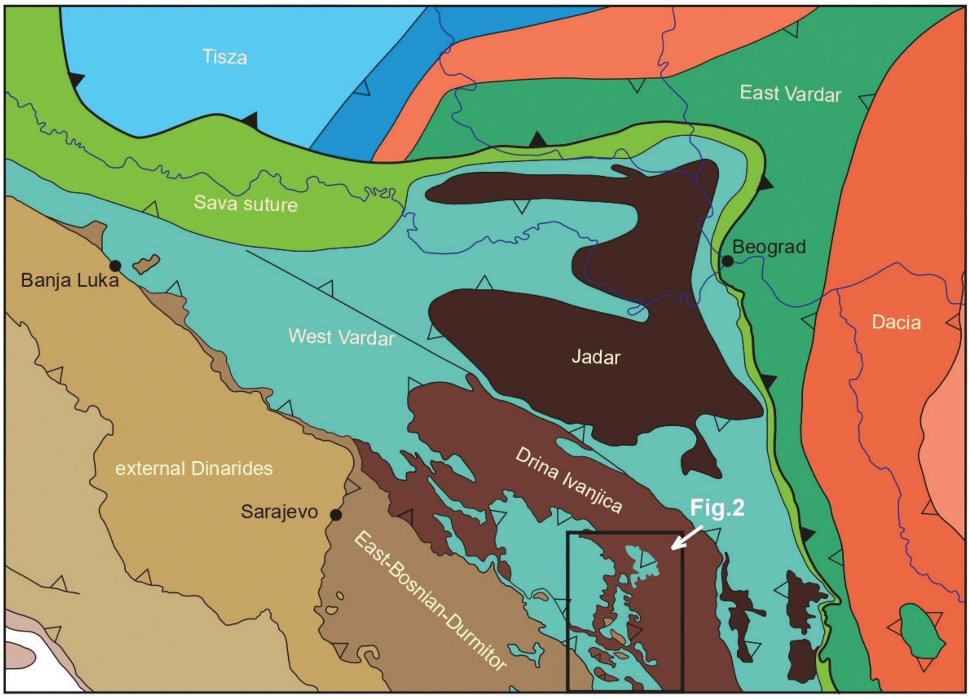

Figure 1. The main tectonic units of Serbia and adjacent territories (modified after SCHMID et al., 2008).

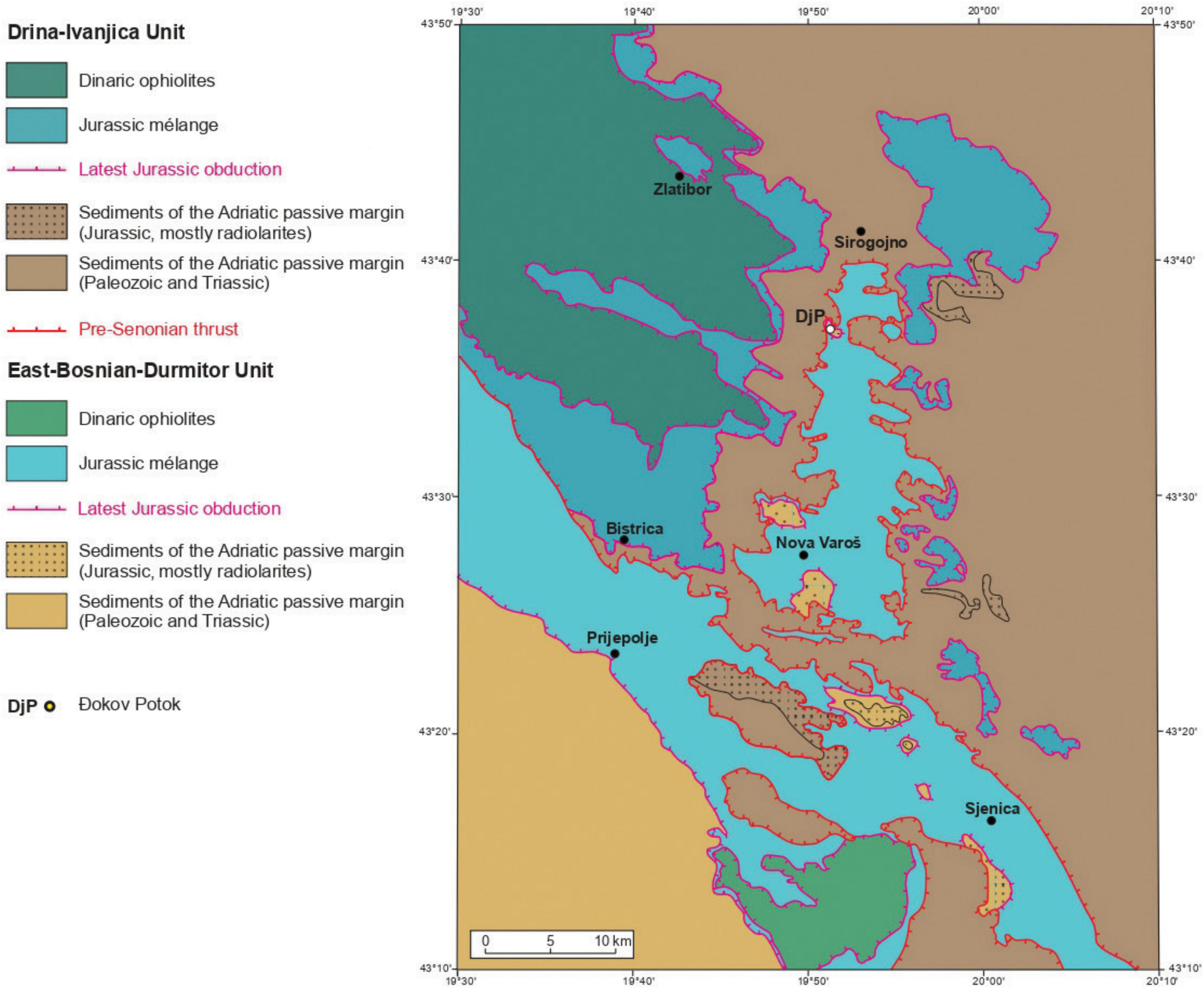

Figure 2. A simplified geologic map of the Zlatibor-Zlatar area with the position of the Djokov Potok section (modified after DJERIĆ et al., 2012).

al., 2008) or Late Jurassic (Tithonian; GAWLICK & MISSONI, 2019). GAWLICK et al. (2017) note that in Triassic-Jurassic times these two units (Drina–Ivanjica and East-Bosnian Durmitor) were part of the same shelf – the Drina–Ivanjica Unit (slightly metamorphosed) represents a more distal shelf area than the East Bosnian-Durmitor Unit (unmetamorphosed).

According to DJERIĆ et al. (2007), radiolarites of the Djokov Potok section, as a part of the Triassic-Jurassic sedimentary succession formed along the Adriatic passive margin, belong to the East Bosnian-Durmitor Unit (Fig. 2).

The East Bosnian-Durmitor Unit was defined by DIMITRIJEVIĆ (1974) and corresponds to the "Zone Serbe" of RAMPNOUX (1970) and AUBOUIN et al. (1970). According to SCHMID et al. (2008) the East Bosnian Durmitor Unit comprises two sub-units, the more external Durmitor sub-unit (Montenegro) and the more internal Lim sub-unit (SW Serbia). The Triassic of the Durmitor sub-unit is characterized by thick carbonate platform sediments (RAMPNOUX, 1970; PANTIĆ & RAMPNOUX, 1972), while the more internal Lim sub-unit is characterized by a more distal slope or basinal facies represented by cherty limestones (the "Grivska Formation", DIMITRIJEVIĆ & DIMITRIJEVIĆ, 1991) and a Late Triassic reefal and slope facies (DIMITRIJEVIĆ, 1997). Recently, all Grivska Formation occurrences are attributed to the allochthonous and far-travelled nappe with a palaeogeographic derivation far to the east (GAWLICK et al., 2017). At the beginning of the Jurassic, the carbonate platforms in the Inner Dinarides were drowned and a relatively sudden deepening of the Adriatic shelf in the Middle Jurassic resulted in widespread deposition of radiolarites (DJERIĆ et al., 2012; VISHNEVSKAYA et al., 2009). All these sediments were overthrust by the ophiolitic mélange and overlying ophiolites in the Late Jurassic (Fig. 2).

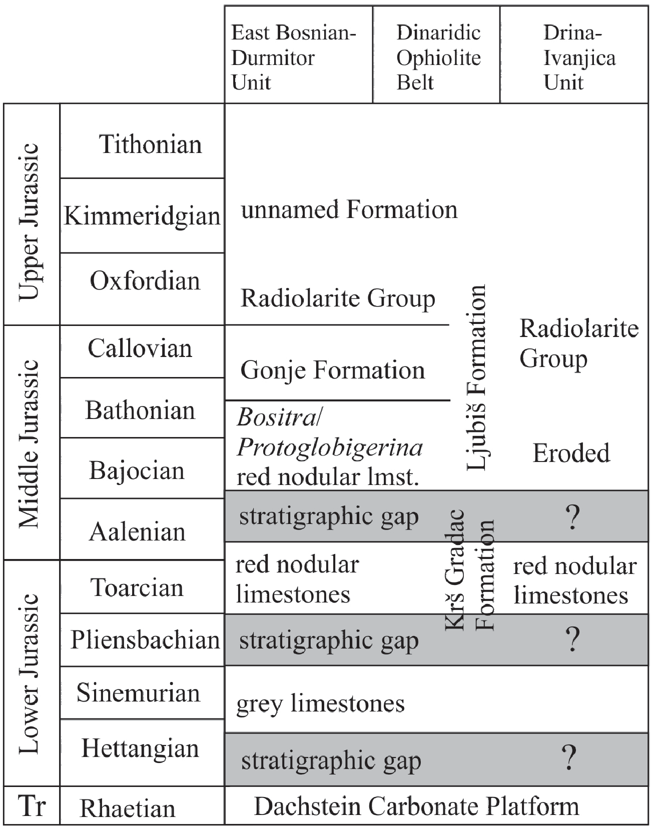

Figure 3. The main Jurassic lithostratigraphic units of the Inner Dinarides (GAWLICK et al., 2017).

In contrast to these interpretations GAWLICK et al. (2017) excluded the Late Triassic reefal and slope facies as remnants of an overthrust nappe. During the last few years investigations carried on in SW Serbia (GAWLICK et al., 2017 and references therein) have been focused on the litho- and microfacies analysis, and biostratigraphic analysis of the components of the mélanges. Based on the data obtained, GAWLICK et al. (2017, p. 4) concluded: "*The ophiolite and distal continental margin nappes including different mélanges rest today as polyphase far travelled transported nappe stack on an parautochthonous Triassic-Jurassic sedimentary sequence that was palaeogeographically situated between the East Bosnian Durmitor Unit and Drina–Ivanjica Unit*".

In the Inner Dinarides, besides the sub-ophiolitic mélange, these authors also distinguish different parautochthonous sequences below the overthrust units. According to GAWLICK & MISSONI (2019 and references therein) sedimentary mélanges derived from sedimentation processes in deep-water trench-like foreland basins in front of the propagating nappes triggered by ophiolite obduction. These deep-water basins were supplied by the erosional products of the advancing nappe stack and embedded in a radiolarite bearing argillaceous matrix. According to these authors, the Djokov Potok locality in the Ljubiš village is the type section of the newly established Ljubiš Formation (Fig. 3). These Jurassic radiolarites intercalated with calciturbidites deposited in a trench-like basin (Ljubiš Basin) outcrop in a tectonic window below the overthrust allochthonous units (ophiolitic mélange and Sirogojno Mélange), and belong to the parautochthonous sequences between the Drina–Ivanjica Unit to the east and the East Bosnian Durmitor Unit to the west (GAWLICK et al., 2017).

3. SECTION DESCRIPTION AND BIOSTRATIGRAPHY

The studied section is located in Donji Ljubiš Village and starts from the lower flow of Djokov Potok creek to the west and uphill. The coordinates of the starting point of the section are N 43° 37' 14.0" E 19° 50' 56.1". We studied and sampled the lower part of this section up to the point N 43° 37' 16.0" E 19° 50' 54.5". The underlying formation is not visible at the surface. A geological column of the section is shown in Fig. 4. The section begins with a two-metre thick unit consisting of calcareous mass transport deposits and turbidites intercalated with dark-grey radiolarites (GAWLICK et al., 2017) (Unit 1). Five metres of dark greenish-grey thin-bedded radiolarites intercalated with greenish-grey cherty claystone follow (Unit 2) (Fig. 5A, B). The next unit in the column is a 0.5 m thick grey massive calcarenite (Unit 3). Further up in the column, there are dark greenish-grey thin-bedded radiolarites intercalated with greenish-grey cherty mudstone. Thin calcarenite beds appear 3 m above the base of this unit. The whole unit (Unit 4) is 8 m thick. Unit 5 comprises 1 m of a grey massive calcarenite (Fig. 5C). The section ends with 12 m of dark greenish-grey thin-bedded radiolarites intercalated with greenish-grey cherty mudstones (Unit 6) (Fig. 5D).

Radiolarites of this formation are characterized by an abundance of radiolarian tests, but they are generally strongly recrystallized and very poorly preserved. Sometimes the radiolarians cannot be extracted from the rock: they become partly or completely dissolved during the maceration process. Radiolarites were sampled and processed by the traditional method. Small (100 g) pieces of rocks were etched by diluted (5-10%) hydrofluoric acid (HF) for 12 hours. Then the residue was washed with water and dried.

Table 1. Species occurrence list of radiolarians from the Middle Jurassic Djokov Potok section.

Samples / Radiolarian taxa	15-10-7	15-10-8	15-10-10	15-10-11
Japonocapsa fusiformis (YAO)	R			R
Eoxitus hungaricus KOZUR	C			
Parahsuum sp.	R			
Quarkus japonicus (YAO)	C			
Helvetocapsa matsuokai (SASHIDA)	C			
Eucyrtidiellum sp. cf. *E. unumaense* s.l. (YAO)	R			
Quarticella sp.	C			
Parvimitrella sp.	R			
Campanomitra? sp. A sensu O'Dogherty, Goričan & Gawlick, 2017	R			
Praewilliriedellum sp.	C	C		
Hsuum sp. cf. *H. matsuokai* ISOZAKI & MATSUDA		R		
Praewilliriedellum convexum (YAO)			C	
Parahsuum sp. cf. *P. izeense* (PESSAGNO & WHALEN)			C	
Parahsuum sp.			R	
Takemuraella veghae (GRILL & KOZUR)			R	R
Hsuum sp. cf. *H. baloghi* GRILL & KOZUR			C	
Quarticella sp. D sensu O'DOGHERTY, GORIČAN & GAWLICK, 2017			R	
Hexasaturnalis suboblongus (YAO)			R	
Hexasaturnalis tetraspinus (YAO)			R	
Transhsuum sp.	R		R	C
Eoxitus baloghi KOZUR				C
Parahsuum sp. cf. *P. indomitum* (PESSAGNO & WHALEN)				R
Mizukidella sp.				R
Hsuum sp.				R
Theocapsomella sp.				R

Unit 4 is characterized by poorly preserved specimens. Some of them can be identified to generic level or in open nomenclature (Table 1, Fig. 6, Plate 1, Figs. A-C, E-K). The fourth unit, consisting of dark greenish-grey, thin-bedded radiolarite, contains the next datable samples:

Sample 15-10-7 contains the following radiolarian assemblage: *Japonocapsa fusiformis* (YAO) (= *Tricolocapsa fusiformis*, in BAUMGARTNER et al., 1995a), *Eoxitus hungaricus* Kozur, *Helvetocapsa matsuokai* (SASHIDA), *Quarkus japonicus* (YAO) (= *Stichocapsa japonica*, in BAUMGARTNER et al., 1995a), *Eucyrtidiellum* sp. cf. *E. unumaense* s.l. (YAO), *Quarticella* sp., *Hsuum* sp., *Parahsuum* sp., *Parvimitrella* sp. (Plate 1, Table 1). On the basis of the presence of *Japonocapsa fusiformis* (YAO), an early-middle Bajocian to late Bajocian-early Bathonian (UAZs 3-5; BAUMGARTNER et al., 1995b) age can be inferred. However, SUZUKI & GAWLICK (2009) found this species also in association with younger radiolarians in several samples indicating that this species may also be present in younger deposits – Callovian and even in the lower Oxfordian (GAWLICK, pers. comm.). Other taxa have broad stratigraphic ranges: *Helvetocapsa matsuokai* was found in the middle-late Callovian (SUZUKI & GAWLICK, 2009), and *Quarticella* sp. is present in the Callovian (GAWLICK et al., 2009). Therefore, we have to estimate a wide stratigraphic range for this sample – Bajocian to Callovian.

Sample 15-10-8 is characterized by a poor and badly preserved radiolarian assemblage. The age could not be determined because it contains only *Campanomitra*? sp. A sensu O'DOGHERTY, GORIČAN & GAWLICK, 2017 and *Praewilliriedellum* sp.

Radiolarites from Unit 6 are characterized by better preservation of the radiolarians (Table 1, Fig. 6, Plate 1, Figs. D, L-P, Plate 2). Samples 15-10-10 and 15-10-11 were taken from the sixth unit (made up of dark greenish-grey thin-bedded radiolarites, with interlayers of greenish-grey cherty mudstones).

Sample 15-10-10 yields several radiolarian species with concurrent stratigraphic ranges that allow us to date them. The most important feature of sample 15-10-10 is the co-occurrence of *Hexasaturnalis suboblongus* (YAO) (= *Acanthocircus suboblongus*, in BAUMGARTNER et al., 1995a) and *H. tetraspinus* (YAO) which suggests the interval from UAZ 3 to UAZ 6 (early-middle Bajocian to middle Bathonian) (BAUMGARTNER et al., 1995b). Additionally, the presence of *Takemuraella weghae* (GRILL & KOZUR) and *Hsuum* sp. cf. *H. baloghi* GRILL & KOZUR confirms the Bajocian-Bathonian age determination (GRILL & KOZUR, 1986; O'DOGHERTY et al., 2006; 2017).

Considering the stratigraphic position of sample 15-10-10 within the entire section (see Fig. 4) and the age of sample 15-10-11

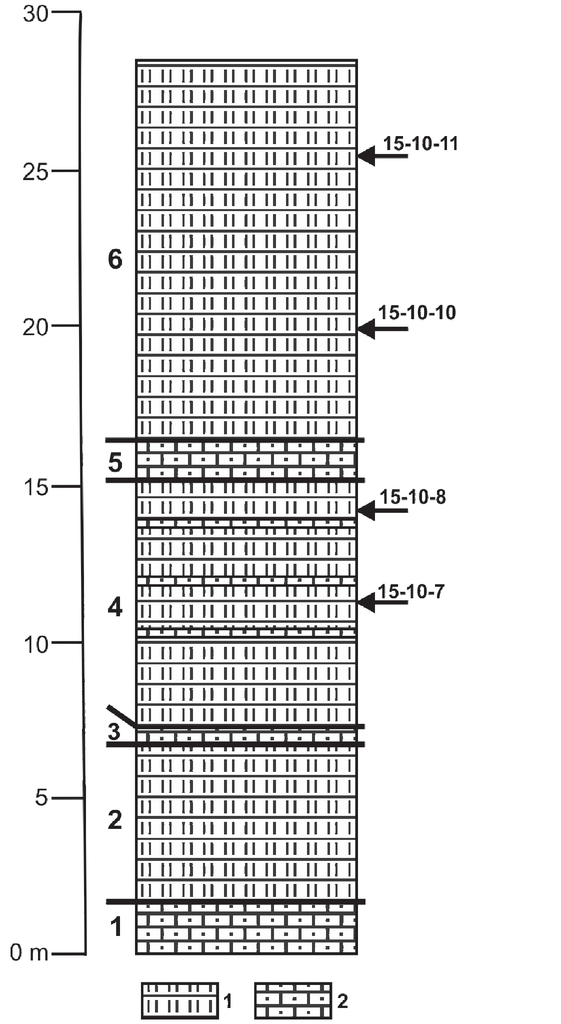

Figure 4. A lithological column of the lower part of the Djokov Potok section (Ljubiš Formation). The numbers of units are shown to the left of the column. Positions of samples with radiolarians are indicated on the right of the column by arrows. 1 – radiolarites and mudstones; 2 – limestones and calcarenites.

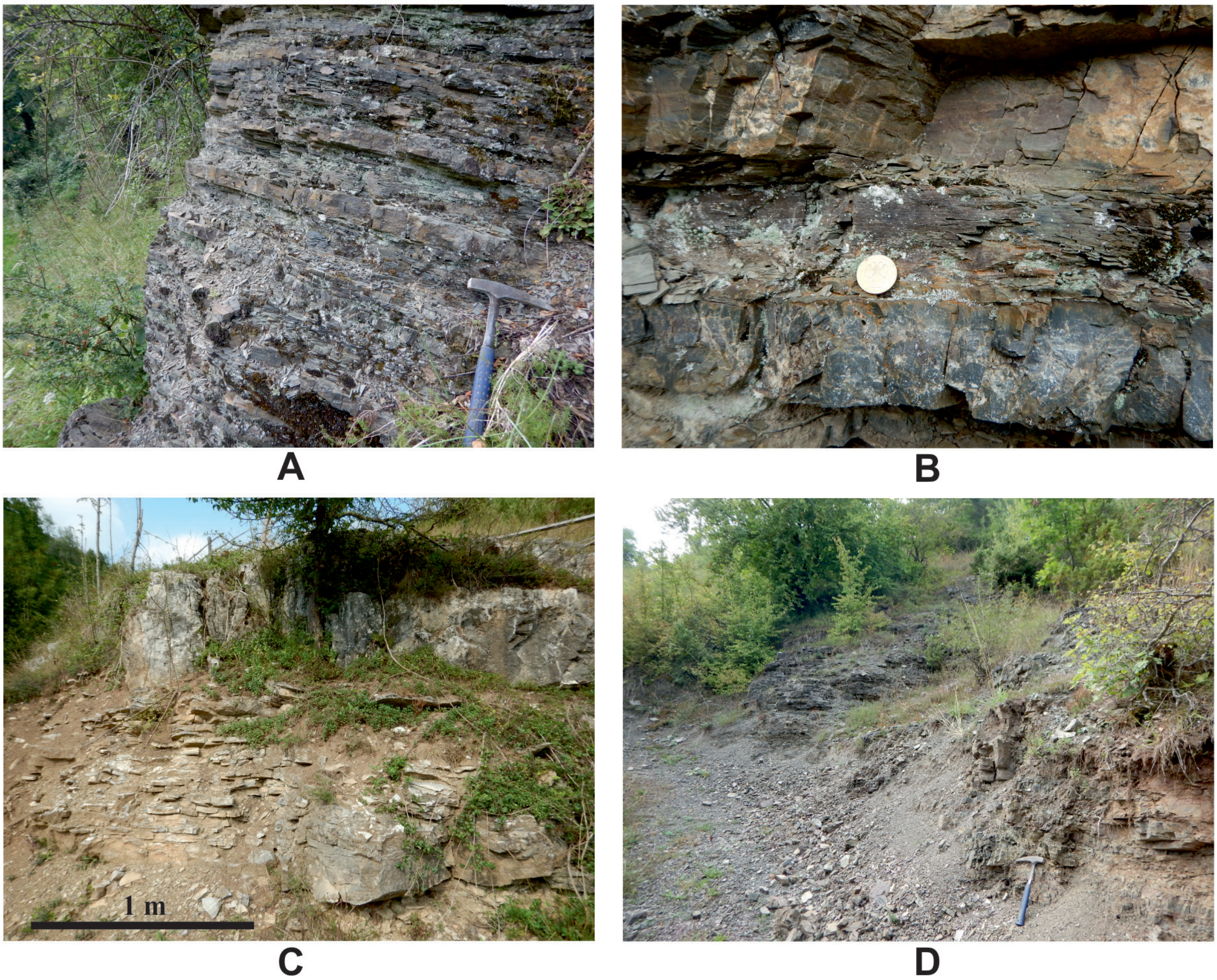

Figure 5. Outcrops of the Ljubiš Formation in Djokov Potok. A – grey bedded radiolarites intercalated with grey cherty mudstones, unit 2; B – detail of radiolarite-mudstone intercalation, unit 2; C – grey massive calcarenite, unit 5, below are radiolarites of unit 4; D – bedded radiolarites of unit 6.

discussed below, the age of this sample ranges from the Bajocian to the Bathonian (UAZs 3-6). The Bathonian age seems to be more likely due to previous studies (GAWLICK et al., 2017).

Sample 15-10-11 was taken from the uppermost layers of this unit. The following species were identified from the radiolarian association: *Takemuraella weghae* (GRILL & KOZUR), *Eoxitus baloghi* KOZUR, *Japonocapsa fusiformis* (YAO), *Pseudoristola* sp. cf. *P. durisaeptum* (AITA) (= *Amphipyndax durisaeptum*, in BAUMGARTNER et al., 1995a), *Parahsuum* sp. cf. *P. indomitum* (PESSAGNO & WHALEN), *Mizukidella* sp., *Hsuum* sp., *Transhsuum* sp., *Theocapsomella* sp. Due to the presence of *Takemuraella weghae* the assemblage is compatible with UAZs 3 to 6, covering the time span from the Bajocian to the Bathonian.

As some taxa were determined in open nomenclature and their data adequacy is relatively low, we can conclude that the lower part of the Ljubiš Formation has a Middle Jurassic, ?Bajocian to Bathonian age.

4. DISCUSSION

The Ljubiš Formation was proposed by GAWLICK et al. (2017) as a possible age equivalent of the Middle to Upper Jurassic (Bathonian-Tithonian) Gonje Formation (VISHNEVSKAYA et al., 2009) developed in the western part of the Dinaridic Ophiolite belt (Fig. 3). The Gonje Formation is represented by various coloured radiolarites with intercalated mass transport deposits and turbidites in the upper part and dated by radiolarians and foraminifers (RADOIĆIĆ et al., 2009). According to GAWLICK et al. (2017) the mass transport deposits in the upper part of the Gonje Formation (Kimmeridgian-Tithonian age) have a completely different component spectrum to that of the Ljubiš Formation. In contrast to the Gonje Formation the Ljubis Fm. contains Late Triassic lagoonal and back-reefal Dachstein Limestone and some condensed Early and Middle Jurassic components from the overlying of the Dachstein Limestone in the lower part, and in the upper part additional Late Jurassic shallow-water components; the Gonje Fm. contains various clasts, e.g. Late Jurassic shallow-water clasts; open-marine Late Triassic limestone clasts, various heavy minerals and others (GAWLICK et al., 2017). The Ljubiš Formation was dated at the type-locality only by the presence of the radiolarian specimen *Eucyrtidiellum* sp. cf. *E. unumaense* (GAWLICK et al., 2017). Also, bedded greenish-grey radiolarites with intercalated turbidites of the Ljubiš Formation are preserved below the overthrust ophiolitic mélange in the double road curve south of Ljubiš (between Ljubiš and Jasenovo). These radiolarites from the ophiolitic mélange, GAWLICK et al. (2016), were dated by a better preserved radiolarian assemblage (Callovian to Middle Oxfordian age). GAWLICK et al. (2017) reported a latest Bajocian to middle Oxfordian age from the Ljubiš

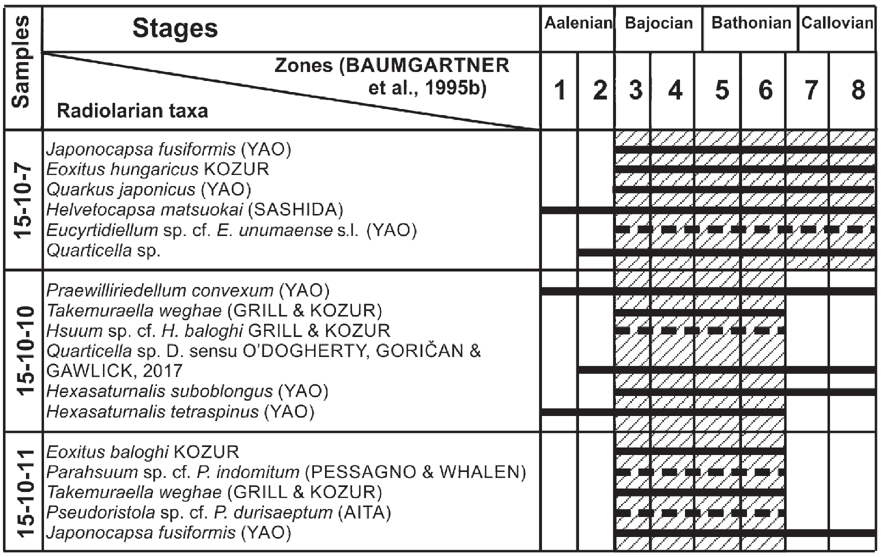

Figure 6. The stratigraphic ranges of selected radiolarian taxa and the stratigraphic position of the studied samples. Dotted lines show the stratigraphic ranges of taxa determined in open nomenclature and taxa for which the stratigraphic range needs more detailed study. Stratigraphic ranges were attributed according to BAUMGARTNER et al. (1995b) with additional data from SUZUKI & GAWLICK (2009) and GAWLICK et al. (2009).

Formation on the western slope of Vis Mountain. According to GAWLICK et al. (2017) the preserved part of the Ljubiš basin represents a more proximal part of the basin and the thickness of this basin fill is at least 400 m. In the currently uninvestigated most proximal parts of this basin the authors expected a much thicker sequence (up to 1000m). It should be mentioned that in the type area, the underlying *Bositra* limestones do not outcrop. Also, it is important to note that turbiditic layers, common in the Ljubiš Formation, yield Upper Triassic to Middle Jurassic components (GAWLICK et al., 2017): the Triassic components were derived from the lagoonal Dachstein carbonate platform, while the Lower and Middle Jurassic clasts are represented by red nodular limestone and *Bositra*-limestone. GAWLICK et al. (2017) supposed that this turbidite material was derived from the Upper Triassic-Middle Jurassic sedimentary succession of the DIU, however, the Krš Gradac quarry contains only Late Triassic clasts from the fore-reef.

On the basis of our new data the analyzed radiolarites (the lower part of Ljubiš Formation) were deposited in the time period of the Bajocian to the Bathonian. The Ljubiš Formation above our samples contains reworked Middle Jurassic *Bositra* limestone clasts (GAWLICK et al., 2017), known mainly from the Bajocian-Bathonian, so these radiolarites should be younger than the reworked clasts. Anyway, the deposition of the Ljubiš Formation could have started earlier than previously thought – in the early Bathonian or even in the late Bajocian. Further study of the biostratigraphy and detailed analysis of the sections would be needed to achieve a better understanding of the composition and nature of the Ljubiš Formation.

5. CONCLUSIONS

Middle Jurassic (Bajocian-Bathonian) radiolarian assemblages were discovered in radiolarites of the lower part of the Ljubiš Formation in the type section in Djokov Potok (Ljubiš village, SW Serbia). The age of the samples cannot be assigned very precisely due to the poor preservation of the radiolarians. The whole stratigraphic range of the Ljubiš Formation could range from the lower-middle Bajocian to the Oxfordian if we take into account previous Bathonian-Oxfordian radiolarian data from the upper part of the formation (GAWLICK et al., 2017). The newly determined biostratigraphic ages based on radiolarian faunas clearly show the onset of tectonic motion in the Middle Jurassic, documented by the deposition of mass transport deposits intercalated in thick radiolarite successions. This suggests the Middle Jurassic onset of ophiolite obduction which triggered the drag down of the Adria margin documented by the abrupt change from carbonate to radiolarite deposition.

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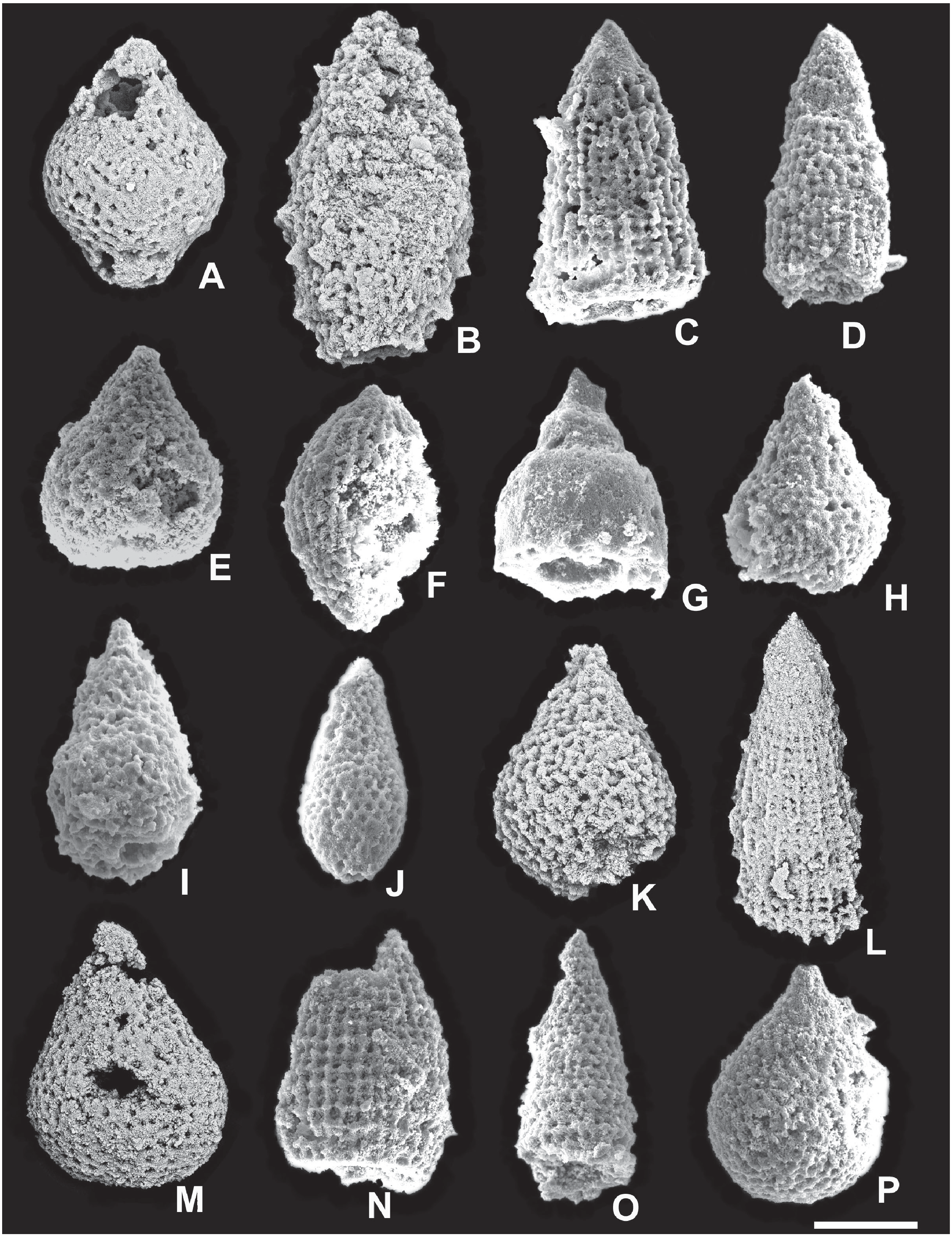

Plate 1. Middle Jurassic (Bajocian to Bathonian) radiolarians from the Djokov Potok section (Samples 15-10-7, 15-10-8 and 15-10-10). **A** – *Japonocapsa fusiformis* (YAO); **B** – *Eoxitus hungaricus* KOZUR; **C** – *Parahsuum* sp.; **D** – *Parahsuum* sp.; **E** – *Quarkus japonicus* (YAO); **F** – *Helvetocapsa matsuokai* (SASHIDA); **G** – *Eucyrtidiellum* sp. cf. *E. unumaense* s.l. (YAO); **H** – *Quarticella* sp.; **I** – *Parvimitrella* sp.; **J** – *Campanomitra?* sp. A sensu O'DOGHERTY, GORIČAN & GAWLICK, 2017; **K** – *Praewilliriedellum* sp.; **L** – *Hsuum* sp. cf. *H. matsuokai* ISOZAKI & MATSUDA; **M** – *Praewilliriedellum convexum* (YAO); **N** – *Parahsuum* sp. cf. *P. izeense* (PESSAGNO & WHALEN); **O** – *Takemuraella veghae* (GRILL & KOZUR); **P** – *Praewilliriedellum convexum* (YAO). Figs. **A-C**, **E-I** – sample 15-10-7; Figs. **J**, **K** – sample 15-10-8; Figs. **D**, **L-P** – sample 15-10-10. Scale bar – 80 μm for figs. **C**, **N** and **P**; 50 μm for figs. **A**, **B**, **D-M**, **O**.

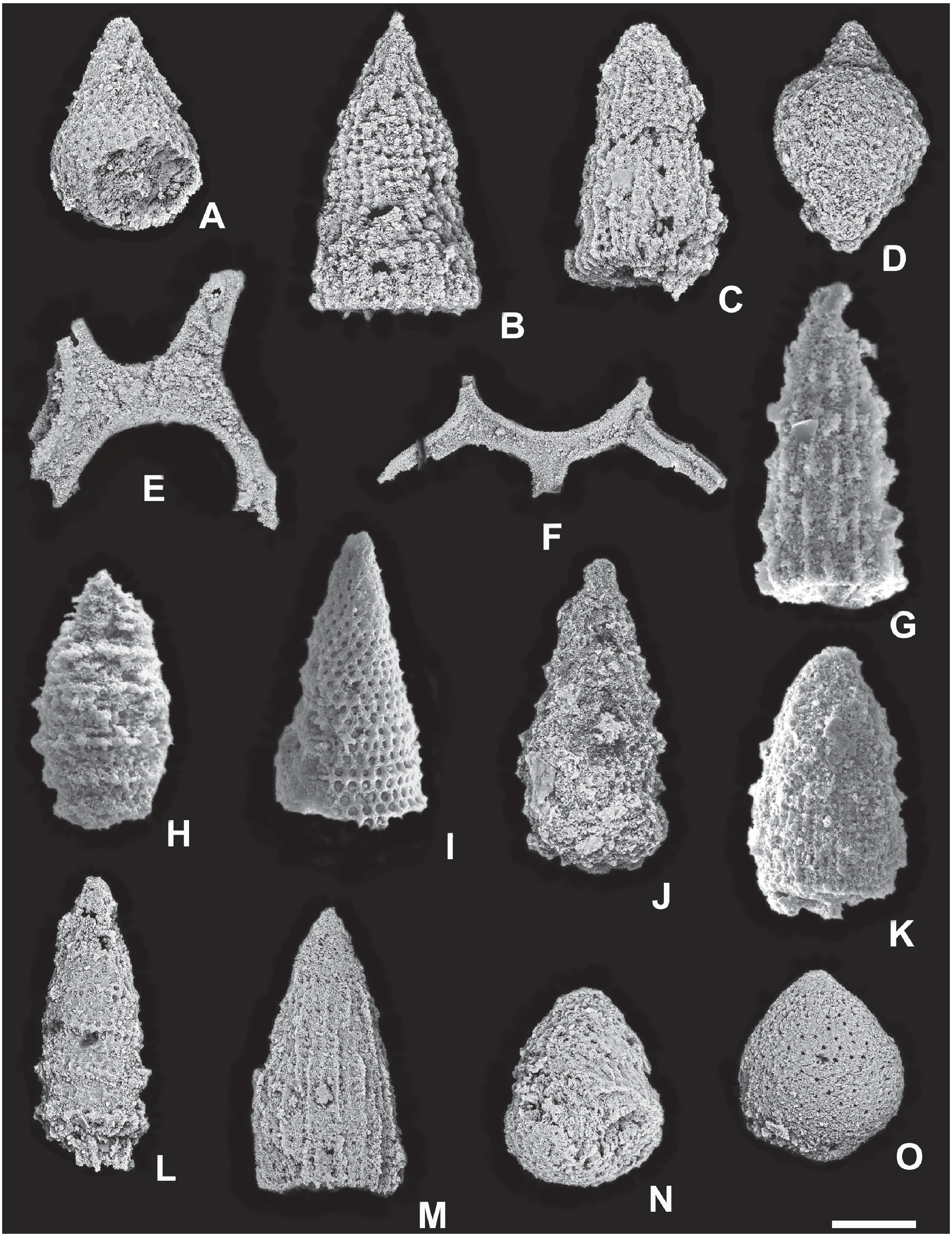

Plate 2. Middle Jurassic (Bajocian to Bathonian) radiolarians from the Djokov Potok section (samples 15-10-10 and 15-10-11). **A** – *Praewilliriedellum convexum* (YAO); **B** – *Parahsuum* sp.; **C** – *Hsuum* sp. cf. *H. baloghi* GRILL & KOZUR; **D** – *Quarticella* sp. D sensu O'DOGHERTY, GORIČAN & GAWLICK, 2017: **E** – *Hexasaturnalis suboblongus* (YAO); **F** – *Hexasaturnalis tetraspinus* (YAO); **G** – *Transhsuum* sp.; **H** – *Eoxitus baloghi* KOZUR; **I** – *Takemuraella veghae* (GRILL & KOZUR); **J** – *Pseudoristola* sp. cf. *P. durisaeptum* (AITA); **K** – *Parahsuum* sp. cf. *P. indomitum* (PESSAGNO & WHALEN); **L** – *Mizukidella* sp.; **M** – *Hsuum* sp.; **N** – *Theocapsomella* sp.; **O** – *Japonocapsa fusiformis* (YAO). Figs. **A-F** – sample 15-10-10: figs. **G-O** – sample 15-10-11. Scale bar – **F** – 100 µm, other figures – 50 µm.