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Ophiolitic mélange with components of the Middle Triassic, Lower and Middle Jurassic radiolarites in the Ozren and Borja-Mahnjača massifs (Central Dinarides, Bosnia and Herzegovina): Impact on Neotethys evolution

JÁN SOTÁK[1,2,✉] SAMIR USTALIĆ[3], MARIÁN PUTIŠ[3], ELVIR BABAJIĆ[4], PETER RUŽIČKA[3] and ONDREJ NEMEC[3]

[1]Earth Science Institute, Slovak Academy of Sciences, Ďumbierska 1, 974 11 Banská Bystrica, Slovakia
[2]Department of Geography, Faculty of Education, Catholic University in Ružomberok, Hrabovská cesta 1, 031 04 Ružomberok, Slovakia
[3]Department of Mineralogy, Petrology and Economic Geology, Faculty of Natural Sciences, Comenius University, Ilkovičova 6, 842 15 Bratislava, Slovakia
[4]Department of Mineralogy and Petrology, Faculty of Mining, Geology and Civil Engineering, University of Tuzla Urfeta Vejzagića 2, 75 000 Tuzla, Bosnia and Herzegovina

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Abstract: Ophiolitic mélanges of the Ozren and Borja-Mahnjača massifs comprise Middle Triassic, Lower Jurassic, and Middle Jurassic radiolarites. The Middle Triassic radiolarites from clastic components in the mélange of the Ozren ophiolite complex (OOC) predominantly contain the species *Annulotriassocampe* and *Triassocampe* species, together with marker species of the *Ladinocampe multiperforata* Zone, belonging to the Illyrian. These Middle Triassic radiolarites are remnants of the Maliac Ocean, which opened during the Late Anisian. The inferred continuation of the Middle Triassic radiolarian sedimentation to the Early Jurassic is recorded by radiolarites from block-in-matrix in the mélange of the Borja-Mahnjača ophiolite complex (BMOC). Their Sinemurian–Pliensbachian age is indicated by species of the genera *Canoptum, Katroma, Droltus*, *Lantus, Gorgasium*, *Charlottea*, *Bipetis*, *Paleosaturnalis* and *Paroanella*. Such Lower Jurassic radiolarites were so far unknown from the Dinaric ophiolite complexes. The Middle Jurassic radiolarites cover the pillow basalts of the OOC. Their microfauna indicates the Bathonian–early Callovian age based on the LADs of *Mizukidella kamoensis* and *Hemicyrtocapsa carpathica* and FADs of *Transhuum brevicostatum*, *Cinguloturris* cf. *carpathica*, *Loopus venustus* and *Protunuma turbo* within the UAZ 6–7 Zone. The Middle Jurassic radiolarites are also interbedded in the pillow lavas of the BMOC. In addition to common species of the UAZ 6–7 Zone (e.g., *Transhuum maxwelli*, *Eucyrtidiellum unumaense*, *Unuma gordus*), they also contain the species *Takemuraella veghae* and *Eoxitus* cf. *baloghi,* which are limited to the Bathonian. Considering the radiolarites from the pillow basalts, the OOC and BMOC are interpreted as the mélanges with the reworked clasts of the Middle Triassic to Lower Jurassic radiolarites, but also with the Middle Jurassic radiolarites. The Middle Triassic radiolarites of the OOC and the Lower Jurassic radiolarites of the BMOC represent rare remnants after the closure of the Middle Triassic to Lower Jurassic Maliac Ocean of the Neotethys. The newly-formed Neotethyan oceanic crust was terminated by the Middle Jurassic radiolarian deposition in an inferred fore-arc/back-arc basin until the Bathonian to early Callovian.

Keywords: radiolarites, pillow basalts, ophiolitic mélange, Ozren and Borja-Mahnjača massifs, Bosnia and Herzegovina

Introduction

Ophiolitic fragments usually occur in mélanges of a very complicated tectonic structure, thereby reflecting the closure of an oceanic basin and its subsequent inclusion into orogenic wedges (e.g., Barbero et al. 2023). The ophiolites may record their origin in spreading ridges, which can be related or unrelated to subduction processes (Dilek & Furnes 2011, 2014; Saccani & Tassinari 2015; Furnes & Dilek 2022).

The Dinarides of the Balkan Peninsula are characterized by a very complex geology because the area is located at or near the suture zone between the European and the Adriatic plates (Bragin et al. 2018; Maffione & van Hinsbergen 2018). This complexity is also reflected in the presence of ophiolitic complexes. The Triassic–Jurassic ophiolites found in narrow zones of the Dinarides are part of the Alpine–Himalayan Tethyan orogenic belt (Dilek & Robinson 2003) and are characterized by two belts of ophiolites: (1) the Central Dinaridic Ophiolite Belt (CDOB), and (2) the Vardar Zone (VZ; Fig. 1), which can be continuously traced to the south in Albania, North Macedonia, and Greece (e.g., Morishita et al. 2011; Šegvić et al. 2014; Putiš et al. 2022). Within these complexes, radiolarians are a great tool for stratigraphic and geologic studies, as well as the reconstruction of oceanic domains and determination of the provenance of obducted ophiolites. The obtained ages from radiolarians have great

✉ corresponding author: Ján Soták
sotak@savbb.sk

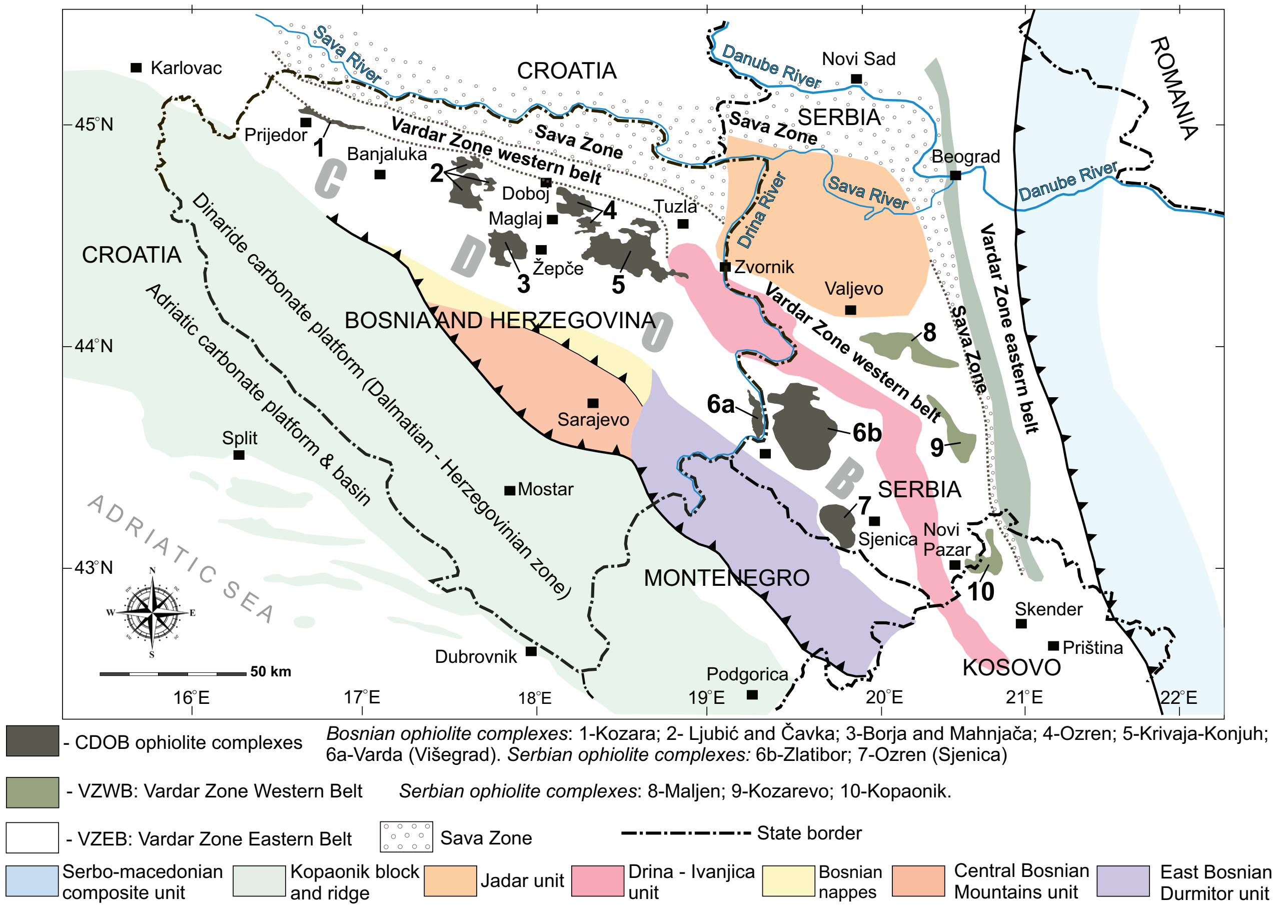

Fig. 1. Borja-Mahnjača (3) and Ozren (4) ophiolite complexes in the Central Dinaridic Ophiolite Belt (map modified from Schmid et al. 2008; Robertson et al. 2009; Putiš et al. 2022).

significance for determining the age of ophiolitic complexes and mélanges.

Previous papers on radiolarians from the CDOB and VZ reported predominantly their the Middle Triassic to the Middle Jurassic age (Bragin et al. 2011, 2018; Gawlick et al. 2016; Sudar & Gawlick 2018; Djerić et al. 2024). However, biostratigraphic data of CDOB radiolarians in Bosnia and Herzegovina are rare. The first record on the age of radiolarians from an ophiolitic mélange sequence from the Bosnian (central) part of the CDOB was reported by Šegvić et al. (2014). The analyzed radiolarians from the Krivaja–Konjuh ophiolite complex (KKOC) yielded the biostratigraphic age corresponding to the latest Bajocian to early Bathonian. Assuming the formation of the mélange to be primarily a tectonic event, the reported period thus documents the likely minimum ages of sedimentation of a siliceous sequence that made up the mélange.

The OOC and neighboring BMOC in Bosnia and Herzegovina are part of the Central Dinaridic Triassic–Jurassic ophiolite belt (Fig. 1). The aim of this paper is the biostratigraphic age determination of the studied radiolarite layers from pillow basalts and the ophiolitic mélange fragments (Fig. 2). The first group of samples with the detected Middle Jurassic ages approximately limits the maximum age of the studied ophiolitic complexes or the minimum age of the closure of the inferred fore-arc/back-arc ophiolite basin. The second group of samples revealed the Triassic to Early Jurassic ages and indicates a closed Triassic–Early Jurassic part of the Neotethys in this part of the Dinarides. The first discovery of Sinemurian–Pliensbachian radiolarians in the Central Dinarides corroborates the radiolarian stratigraphy of the Maliac Ocean in the Hellenides. Both the Triassic and Jurassic ages are consistent with the obtained new radiometric ages from the Ozren and Borja-Mahnjača OC (Putiš et al. 2024).

Geological setting

The Dinaride ophiolite belt is one of the most remarkable tectonic units along the entire Balkans, representing a branch of the Alpine–Himalayan Tethyan orogenic belt (Dilek & Robinson 2003). The Dinaridic segment of the Neotethys was affected by widespread shortening and related subduction–obduction–accretion processes that commenced in the Middle Jurassic. The Dinaride ophiolites belong either to the Central Dinaridic Ophiolite Belt (CDOB) or to the Vardar zone (VZ,

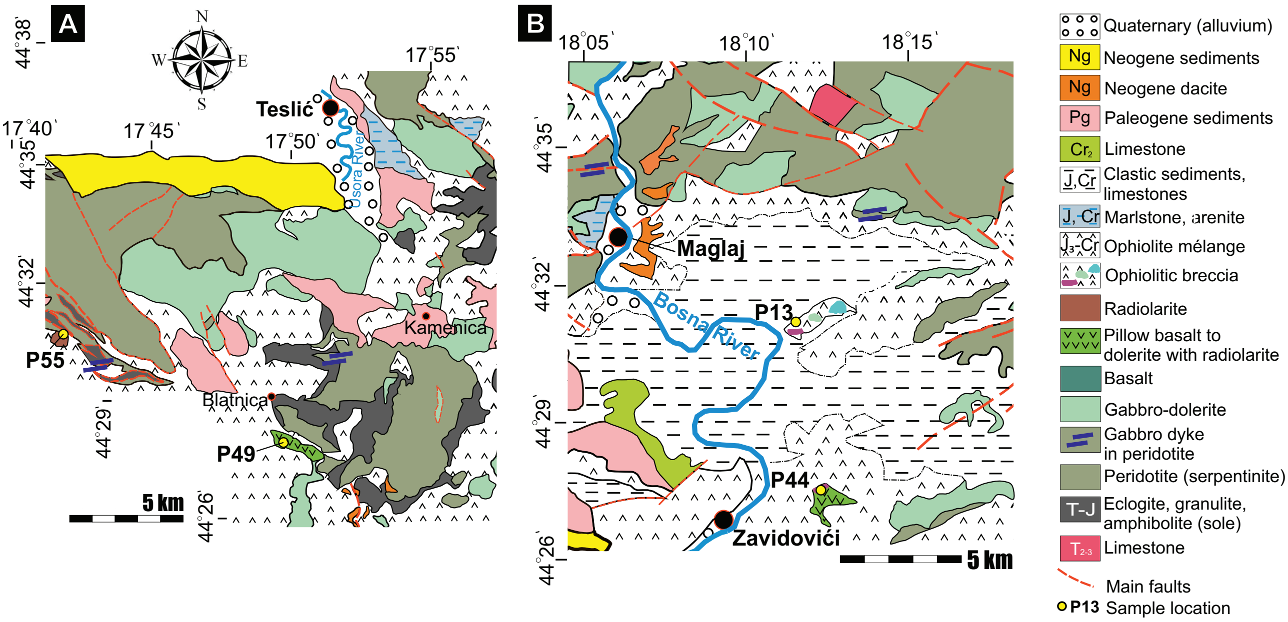

Fig. 2. Selected parts of geological maps of the Borja-Mahnjača (**A**) and Ozren (**B**) ophiolitic complexes. Geological maps compiled from the basic geological maps of the SFR Yugoslavia 1:100,000, with the investigated sample numbers (maps modified after Trubelja & Pamić 1965; Sunarić-Pamić et al. 1971; Olujić et al. 1980; Laušević & Jovanović 1982; Putiš et al. 2022; Ustalić et al. 2024).

also called IDOB = Inner Dinaridic Ophiolite Belt). While areas of the VZ ophiolites are of supra-subduction origin, the dismembered CDOB ophiolites are associated with the ocean-ridge geotectonic environment. The CDOB and VZ Western Belt are collectively referred to as the Western Vardar Ophiolite Unit (Robertson et al. 2009) in order to distinguish them from the ophiolites of the Eastern Vardar Ophiolite Unit (or Main Vardar Belt), which is separated from the Western Unit by the Sava Zone (Fig. 1).

The Ozren ophiolitic complex (OOC) and Borja-Mahnjača ophiolitic complex (BMOC) in Bosnia and Herzegovina are part of the Dinaridic Ophiolite Belt (Trubelja & Pamić 1965; Lugović et al. 1991; Pamić et al. 2002; Karamata 2006; Schmid et al. 2008; Bazylev et al. 2009; Robertson et al. 2009; Ustaszewski et al. 2010; Faul et al. 2014; Šegvić et al. 2020; Balen & Massonne 2021; Putiš et al. 2022; Ustalić et al. 2023, 2024). These complexes show a polystage mantle evolution and revealed an almost completely developed ophiolitic cross-section composed of peridotites, plagioclase peridotites, plagiogranites, troctolites, and other gabbros, gabbroic, doleritic, and fewer basaltic dykes (Soták et al. 2023; Ustalić et al. 2023). As one of the remarkable features of the CDOB, the oceanic units consist of an ophiolite mélange overthrust by an ophiolite unit with a metamorphic sole at its base (Šegvić et al. 2019).

The investigated ophiolitic mélanges represent a significant component of the OOC and BMOC. The oceanic units of the study area occur in two different massifs, the Ozren and Borja-Mahnjača, which belong to the CDOB (Schmid et al. 2008; Robertson et al. 2009). Extrusive rocks are either alternate or are covered by Middle Jurassic radiolarites, whereas Middle Triassic and Early Jurassic radiolarites exclusively occur as fragments in the ophiolitic mélange blocks. Metamorphic sole with HP/HT rocks, such as eclogites or granulites to amphibolites likely indicate intra-oceanic subduction (Putiš et al. 2022, 2024; Ustalić et al. 2024). The sheeted dyke layer is absent in these ophiolite complexes (Figs. 2, 3).

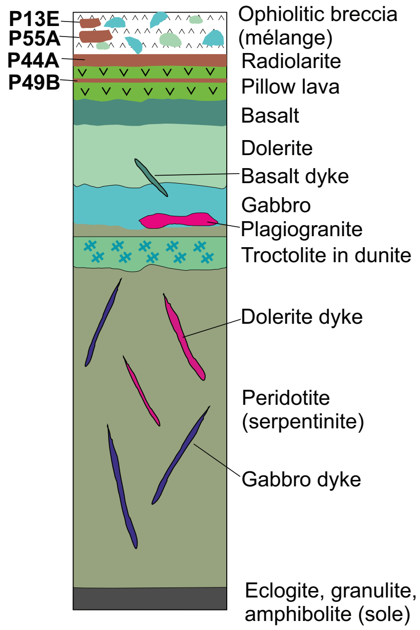

Fig. 3. Schematic lithological column of the Ozren and Borja-Mahnjača ophiolitic complexes with the position of investigated radiolarite samples.

Material and methods

The fieldwork was focused on finding relatively well-preserved representative radiolarite samples suitable for further laboratory analyses (Fig. 2; see GPS of the sample location in Table 1). During the two fieldwork seasons (2021–2022), radiolarians were collected from the two locations (P49B, P55A) of the Borja-Mahnjača ophiolitic complex and the two locations (P13E, P44A) of the Ozren ophiolitic complex.

Radiolarites were crushed into 2–3 cm pieces and treated with 3–5 % hydrofluoric acid for 48 to 72 hours. The samples showing higher effects of dissolution were treated again for a shorter period of 24 hours. Nevertheless, the residues of some problematic samples (e.g., P55A) still contained some indeterminable internal moulds of radiolarians, mainly canoptid species that commonly lacked microgranular silica layers and pore frames (see Fig. 8, A3). Therefore, some poorly-preserved radiolarians may have already been diagenetically altered. Besides some inner moulds, the shortly-treated samples also contained moderately preserved specimens, which allowed their taxonomic determination (e.g., Fig. 8, A1–A2, C, D). The Middle Jurassic radiolarians exhibited better preservation than the radiolarians from the Middle Triassic and Lower Jurassic radiolarites.

The acid residues were sieved and collected from 63 to 350 µm size fractions. Radiolarians were picked and photographed by a scanning electron microscope at the Earth Science Institute of the Slovak Academy of Sciences in Banská Bystrica. More than 380 SEM images were taken from radiolarian microfauna of the OOC and BMOC.

The classification of radiolarian species follows the most important publications, which examined and reviewed radiolarian taxonomy. Triassic radiolarians were determined based on studies notable for their systematics (e.g., Dumitrica et al. 1980; Goričan & Buser 1990; Kozur & Mostler 1994, 2006; Tekin 1999; Feng et al. 2001, 2009; Tekin & Göncüoglu 2007; O'Dogherty et al. 2009a; Bragin 2011; Thassanapak et al. 2011; Gawlick et al. 2016; Ozsvárt et al. 2023).

Lower Jurassic radiolarian fauna was elaborated using original descriptions, complete taxonomic nomenclature, and new revisions from published papers (Pessagno & Poisson 1981; Pessagno & Whalen 1982; Carter et al. 1998; Gawlick et al. 2001; Tekin 2002, 2020; Whalen & Carter 2002; Goričan et al. 2003, 2006, 2013; Bragin & Bragin 2017; Cifer et al. 2020, 2024; Cifer & Goričan 2023a, b).

The classification and determination of Middle Jurasic radiolarians in this paper is based on comprehensive systematics from published papers (Baumgartner et al. 1995a; Goričan 1987, 1994; Matsuoka 1995; Chiari et al. 2002, 2023; Pessagno & Hull 2002; Suzuki & Gawlick 2003, 2009, 2020; O'Dogherty et al. 2006, 2009b, 2017; Gawlick et al. 2009b, 2018; Vishnevskaya et al. 2009; Djerić et al. 2012; Goričan et al. 2012; Yeh & Pessagno 2013; Bragin & Djerić 2020) and other taxonomical studies.

The stratigraphic age was determined according to radiolarian zonations (Kozur & Mostler 1994; Baumgartner et al. 1995b; Sugiyama 1997; Prela et al. 2000; O'Dogherty et al. 2006, 2010; Gawlick et al. 2009a; Carter et al. 2010; Chiari et al. 2012; Goričan et al. 2018; Matsuoka & Ito 2019) and other schemes for radiolarian dating.

Table 1: GPS coordinates of investigated samples in Fig. 2.

Samples – Location	GPS Coordinates
P13E – Bočinja village	N 44°30'40.86", E 18°11'29.58"
P44A – Činovići village	N 44°27'20.59", E 18°12'12.24"
P49A, B – Blatnica village	N 44°27'59.03", E 17°49'44.28"
P55A – Donji Očauš village	N 44°30'44.76", E 17°42'5.94"

Results

Lithology of sampled radiolarian localities

Rare, decametric fragments of radiolarites (including the investigated reddish radiolarite P13E sample) were found in an ophiolitic breccia (Fig. 4A, B) within the mélange (Fig. 2) in the central part of the OOC, southeast of the Maglaj town (in the village of Bočinja). The ophiolitic breccia also contains tiny clasts to metric blocks of gabbros and dolerites (Fig. 4C). These rock fragments are separated by the matrix of the same rock composition.

Another, at least 1.5-metre-thick investigated radiolarite layer (Fig. 4D, E) with greenish radiolarite sample P44A (Fig. 4F) covers the basaltic pillow lavas (Fig. 4G, H) exposed in the ophiolitic mélange in the southern part of the OOC, east of the Zadovići town (in the village of Činovići). This radiolarite layer occurs above a ten-meter thick exposed pillow layer in a nearby country road cut (Fig. 4G, H).

Radiolarite samples of the BMOC were investigated in two localities (Fig. 5A–E). Radiolarite sample P49B was collected from a layer in the pillow basalts in the Blatnica village in the BMOC. Here, only one decametric, reddish radiolarite layer was found within the pillow basalts (Fig. 5A–D).

A larger, 10 m-size block of reddish radiolarites (Fig. 5B, E) was identified in the mélange from the BMOC from the Donji Očauš village. The investigated reddish radiolarite sample P55A occurs within the host fine-grained dark to black sandy shale (Fig. 5C) without fossils.

Radiolarites from the Ozren ophiolitic complex

Reddish and greenish radiolarites from the Ozren ophiolitic complex differ in stratigraphic age. Reddish radiolarite of the P13E sample contains the Middle Triassic species belonging to *Triassocampidae*, such as *Triassocampe deweveri* (Nakasenko and Nishimura), *Triassocampe scalaris* Dumitrica, Kozur and Mostler, *Annulotriassocampe campanilis* Kozur and Mostler, and *Striatotriassocampe yini* (Feng) – Fig. 6. The association is completed by the species *Ladinocampe* cf. *multiperforata* Kozur, *Eptingium manfredi* Dumitrica), *Anisicyrtis* sp., *Pseudostylosphaera japonica* (Nakasenko and

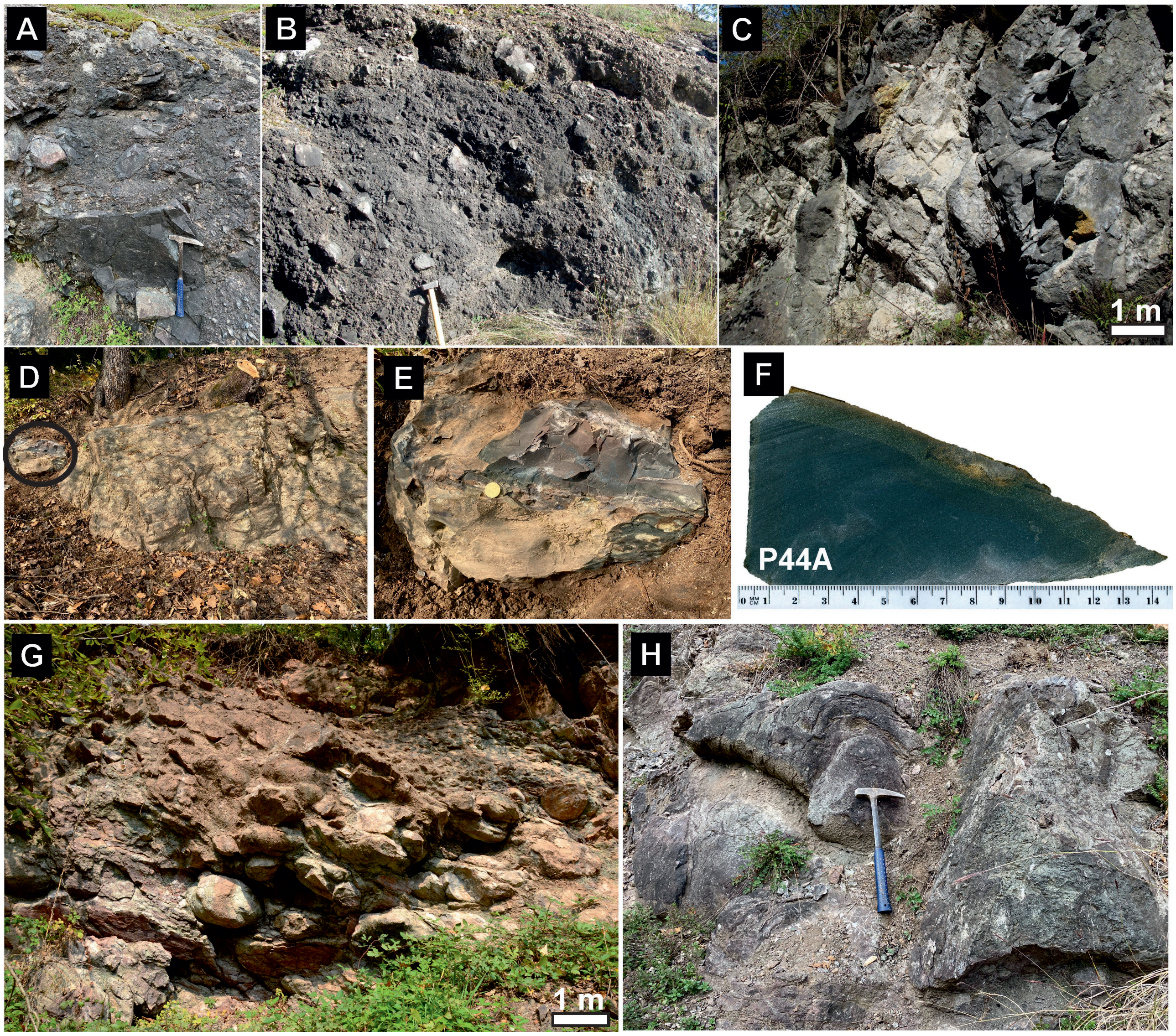

Fig. 4. The upper part of the Ozren ophiolitic sequence in Fig. 2B, 3. **A–C** — A road cut in the ophiolitic breccia composed of centimetric to metric fragments of gabbros, dolerites, and rare centimetric to decametric radiolarite fragments, including one decimetre-size investigated reddish P13E radiolarite sample released from the mélange matrix; **D** — A 10-metre-wide outcrop of radiolarite layer with P44A sample in the circle; **E** — Close-up of Fig. 4D; **F** — Cut surface of greenish radiolarite of investigated P44A sample; **G–H** — Outcrops of pillow basalts in a road cut below the radiolarite layer in Fig. 4D.

Nishimura), *Spongostephanidium* sp. and *Archaeosphaera ingoi* (Parona). The abundance of *Triassocampe* species in co-occurrence with *Annulotriassocampe* species is most characteristic for the Early Ladinian radiolarian fauna (Kozur & Mostler 1994).

The Early Ladinian age of the P13E sample is documented by the characteristic Fassanian species *Triassocampe deweveri* (Nakasenko and Nishimura) and *T. scalaris* Dumitrica, Kozur and Mostler (Kozur & Mostler 1994). This age is also proven by the species *Ladinocampe multiperforata* Kozur, which was introduced as a guideform of the Fassanian radiolarian zone between the *Reitzii* and *Curioni* Ammonoid Zones (*Ladinocampe multiperforata* Zone *sensu* Kozur & Mostler 1994). However, the base of the *Curioni* Zone was placed at the Anisian–Ladinian boundary by redefinition of the GSSP section (Brack et al 2003, 2005). Considering that, the *Ladinocampe multiperforata* Zone was also moved down to the uppermost Anisian stage – Illyrian (*cf.* Goričan et al. 2018). It is also in agreement with the presence of *Anisicyrtis* in the P13E sample, which did not extend above the Anisian (O'Dogherty et al. 2009a; Goričan et al. 2022). Therefore, the radiolarites of the P13E sample belong to the late Illyrian.

Greenish radiolarites from the Ozren ophiolitic complex (P44A sample) contains the Middle Jurassic species *Mizukidella kamoensis* (Mizutani and Kido), *Loopus venustus* (Chiari, Cortese and Marcucci), *Transhuum brevicostatum*

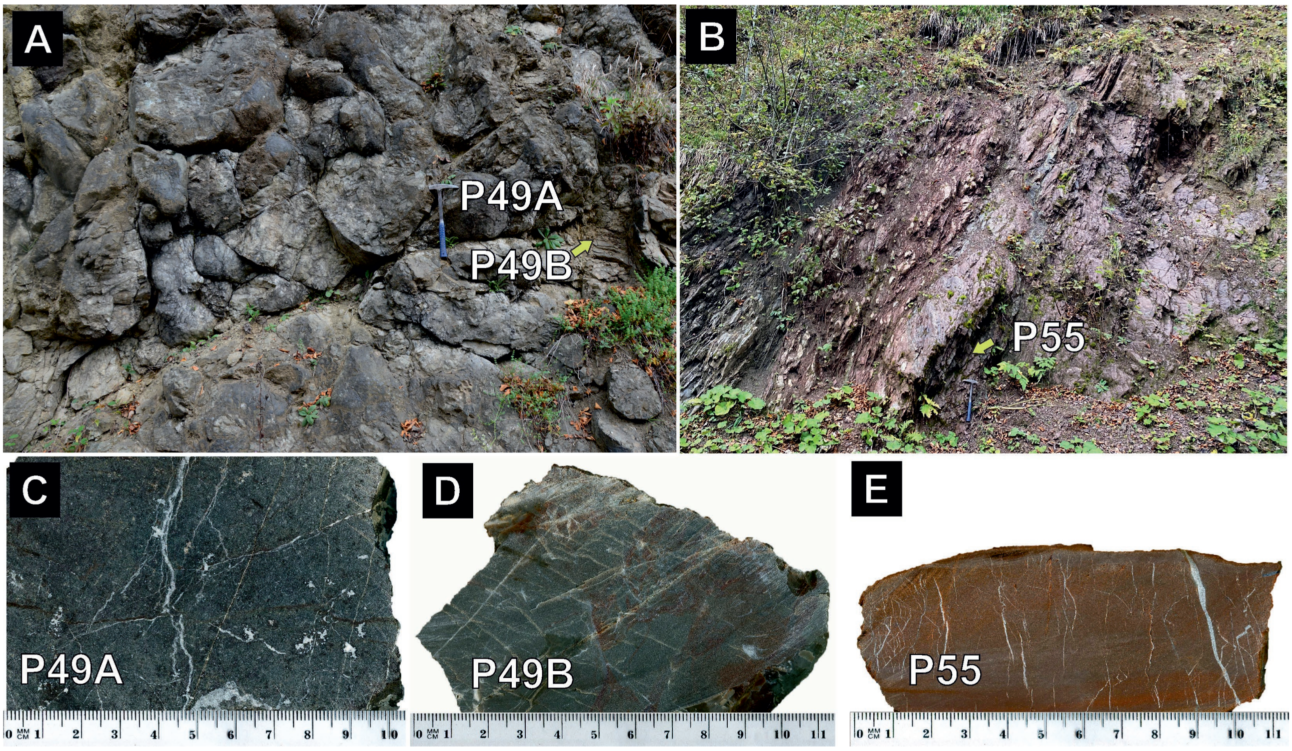

Fig. 5. The upper part of the Borja-Mahnjača ophiolitic sequence in Figs. 2A and 3. **A** — Field aspect of the pillow basalts (P49A) with a Jurassic radiolarite layer close to the fracture (P49B); **B** — Outcrop of the mélange with Lower Jurassic radiolarite block ~10 m (P55A); **C–E** — Cut surfaces of investigated samples.

(Ožvoldová), *Thanarla patricki* (Kocher), *Cinguloturris* cf. *carpathica* Dumitrica, *Eucyrtidiellum unumaense* (Yao), *E. circumperforatum* Chiari, Marcucci and Prela, *Plicaforacapsa catenarum* (Matsuoka), *Protunuma turbo* Matsuoka, *Hemicyrtocapsa carpathica* (Dumitrica), *H. buekkensis* (Kozur), *Cyrtocapsa mastoidea* Yao, *Japonocapsa fusiformis* (Yao), *Crocapsa* cf. *hexagona* (Hori) and *Archaeosphaera* sp. (Fig. 7). The radiolarian assemblage of the P44A sample indicates the Bathonian–early Callovian age, based on the LADs of *Mizukidella kamoensis* (Mizutani and Kido), *Hemicyrtocapsa carpathica* (Dumitrica) and *Plicaforacapsa catenarum* (Matsuoka), and the appearance of the species *Transhuum brevicostatum* (Ožvoldová), *Cinguloturris* cf. *carpathica* Dumitrica, *Loopus venustus* (Chiari, Cortese and Marcucci), and *Protunuma turbo* Matsuoka within the UAZ 6–7 (Matsuoka & Yao 1986; Ožvoldová 1998; O'Dogherty et al. 2006, 2017; Goričan et al. 2022). This radiolarian fauna also corresponds to the upper part of *Eucyrtidiellum unumaense* zone and *Protunuma lanosus* subzone (*sensu* Gawlick et al. 2009a; Suzuki & Gawlick 2009).

Radiolarites from the Borja-Mahnjača ophiolitic complex

The Borja-Mahnjača ophiolitic complex contains the Jurassic radiolarites, whose samples differ in colour (reddish P55A and greenish P49B samples), extracted microfauna, and stratigraphic age. The radiolarian microfauna of the P55A sample consists predominantly of *Canoptidae* preserved mostly as moulds without any outer microgranular layer and pore frames (Fig. 8, A3, see methods). Nevertheless, some better preserved tests allow to determine species *Canoptum reefense* (Pessagno and Whalen), *Canoptum anulatum* Pessagno and Poisson, *Canoptum poissoni* Possagno, *Canoptum artum* Yeh and *Canoptum rugosum* Pessagno and Poisson (Fig. 8). The radiolarian fauna of the P55A sample is also rich in *Katroma* species, comprising of *Katroma ninstintsi* Carter, *Katroma elongata* Carter, *Katroma brevitubus* Dumitrica & Goričan and *Katroma* cf. *bicornus* De We. Another nasselarian radiolarians are assigned to species *Parahsuum simplum* Yao, *Droltus hecatensis* Pessagno and Whalen, *Droltus* cf. *sanignacioensis* Whalen and Carter, *Lantus praeobesus* Carter, *Bipedis fannini* Carter and *Bipedis hannai* Whalen and Carter and *Zhamoidellum* cf. *yehae* Dumitrica (Fig. 8).

Radiolarian assemblages of the P55A sample are completed by spumellarian species such as *Gorgansium alpinum* Kozur and Mostler, *Gorgansium gongyloideum* Kishida & Hisada, *Charlottea penderi* Carter, *Ch. weedensis* Whalen and Carter, *Tetracoma tollmani* Cifer and *Praeconocaryomma sarahae Carter*. Spongy sumellarians are represented by *Palaeosaturnalis subovalis* Kozur and Mostler, *P. fragilis* Kuzur & Mostler, *Paronaella grahamensis* Carter, *Orbiculiforma* sp. and *Orbiculiformella* aff. *callosa* (Yeh).

The species of the genus *Canoptum*, *Katroma*, *Droltus*, *Gorgasium, Lantus, Bipetis* and *Paleosaturnalis* are commonly

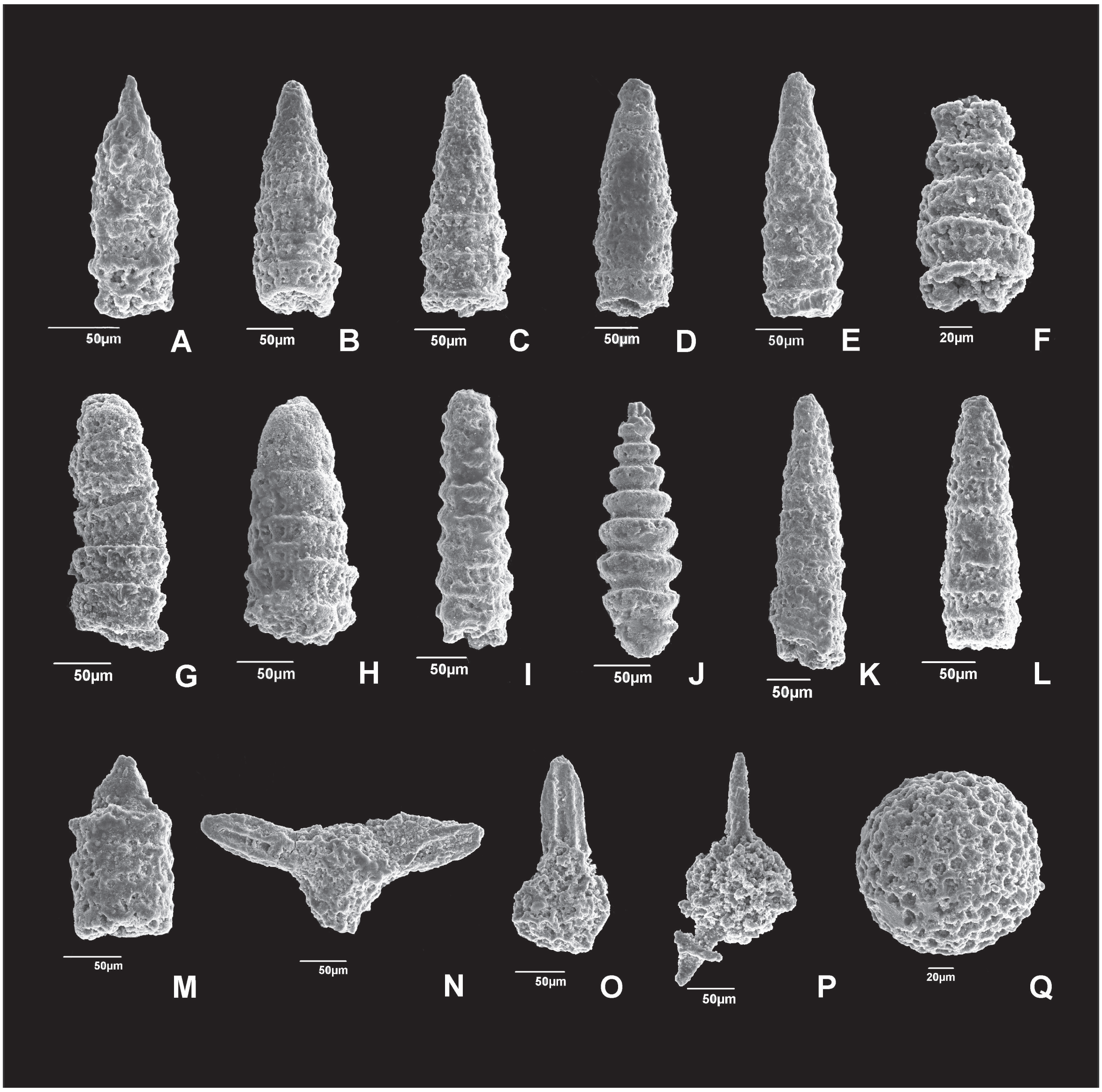

Fig. 6. Middle Triassic radiolarians from the Ozren ophiolitic complex (P13E sample). A: *Ladinocampe* cf. *multiperforata* Kozur; B–E: *Triassocampe deweveri* (Nakasenko and Nishimura); F–H: *Triassocampe scalaris* Dumitrica, Kozur and Mostler; I–J: *Annulotriassocampe campanilis* Kozur and Mostler; K–L: *Striatotriassocampe yini* (Feng); M: *Anisicyrtis* sp. *gen* Kozur and Mostler; N: *Eptingium manfredi* Dumitrica; O: *Pseudostylosphaera japonica* (Nakasenko and Nishimura); P: *Spongostephanidium* sp.; Q: *Archaeosphaera ingoi* (Parona).

associated in the Lower Jurassic radiolarian fauna (e.g. Pessagno & Poisson 1981; Pessagno & Whalen 1982; Carter et al. 1998; Kozur & Mostler 1990; Tekin 2002; Whalen & Carter 2002; Goričan et al. 2006; Cifer & Goričan 2023a, b). Based on the presence of species *Canoptum reefense* (Pessagno and Whalen), *Lantus praeobesus* Carter, *Parahsuum simplum* Yao, *Katroma ninstintsi* Carter, *Gorgansium alpinum* Kozur and Mostler, *Palaeosaturnalis subovalis* Kozur and Mostler and *Orbiculiformella* aff. *callosa*, the P55A sample belongs to the Late Sinemurian–Pliensbachian. This age is also inferred from numerous saturnalids in the Late Sinemurian (Cifer et al. 2024) and abundance of *Katroma* species during the Pliensbachian (Goričan et al. 2013). Other radiolarians like *Charlottea, Gorgansium* and *Paroanella* species disappeared in the Late Pliensbachian (Goričan et al. 2013), and *Canoptum*, *Lantus, Parahsuum* and *Praeconocaryomma* species ranged within the UA 1–18 Zone (*sensu* Carter et al. 2010; Cifer et al. 2020). Considering the radiolarian data, the age of the P55A sample corresponds to the Late Sinemurian–Pliensbachian.

Middle Jurassic radiolarites were also identified in the Borja-Mahnjača ophiolitic complex (P49B sample, Fig. 9). Their microfauna comprises mostly characteristic radiolarians of the UAZ 6–7 Zone, such as species *Transhuum maxwelli*

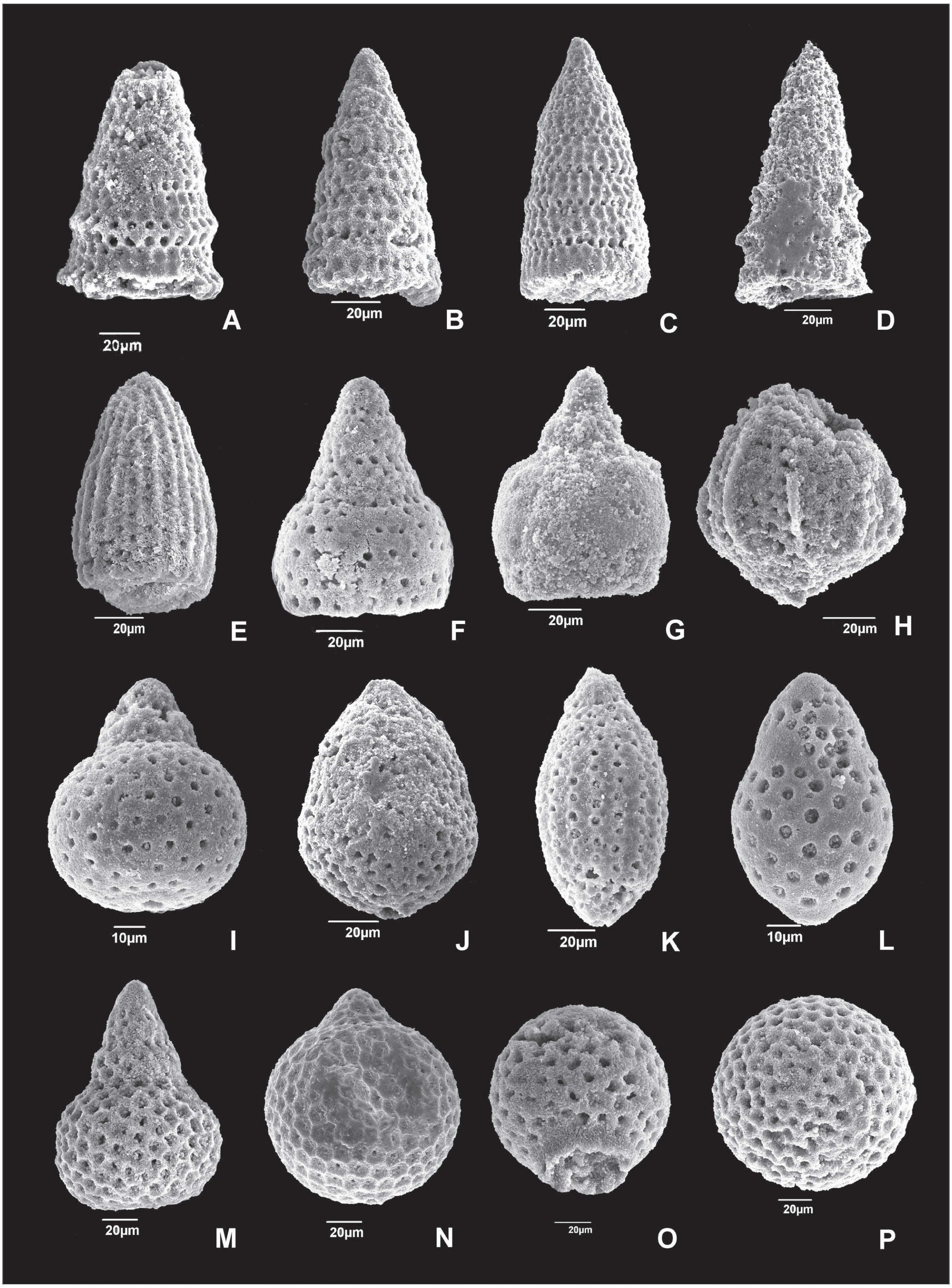

Fig. 7. Middle Jurassic radiolarians from the UAZ 6–7 Zone of the Ozren ophiolitic complex (P44A sample). A–B: *Mizukidella kamoensis* (Mizutani and Kido); C: *Loopus venustus* (Chiari, Cortese and Marcucci); D: *Transhuum brevicostatum* (Ožvoldová); E: *Thanarla patricki* (Kocher); F: *Eucyrtidiellum (?) circumperforatum* Chiari, Marcucci and Prela; G: *Eucyrtidiellum unumaense* (Yao); H: *Protunuma turbo* Matsuoka; I: *Hemicyrtocapsa buekkensis* (Kozur); J: *Cyrtocapsa mastoidea* Yao; K: *Plicaforacapsa catenarum* (Matsuoka); L: *Japonocapsa fusiformis* (Yao); M: *Crocapsa* cf. *hexagona* (Hori); N–O: *Hemicryptocapsa carpathica* (Dumitrica) with hexagonal pore frame (N) and antapical view to aperture (O); P: *Archaeosphaera* sp.

Pessagno, *Parahsuum carpathicum* Widdz and De Wever, *Thanarla* cf. *patrici* (Kocher), *Eucyrtidiellum unumaense* (Yao), *Unuma gordus* Hull, *U.* cf. *typicus* Ichikawa and Yao, *Quarkus madstonensis* Pessagno, Blome and Hull and *Hemicryptocapsa* aff. *buekkensis*. Specific components of the P49B sample are parvicingulids species *Takemuraella veghae* (Grill and Kozur), *Eoxitus* cf. *dhimenaensis* (Baumgartner) and *Eoxitus* cf. *baloghi* Kozur. Besides nasselarian radiolarians, the association is completed by spummelarian species like *Pantanellium riedeli* Pessagno and *Paronaella* cf. *kotura* Baumgartner.

Radiolarian microfauna of the P49B sample contains species that disappeared or appeared in the UAZ 6–7 (LADs *Unuma gordus* Hull, *Hemicryptocapsa* aff. *buekkensis* (Kozur), FADs *Eucyrtidiellum unumaense* (Yao), *Transhuum maxwelli* Pessagno, *Parahsuum carpathicum* Witz and De Wever; *see* O'Dogherty et al. 2006; Gawlick et al. 2009a; Goričan et al. 2018; Matsuoka & Ito 2019; Bragin & Djerić 2020). Nevertheless, the presence of *Takemuraella* and *Eoxitus* species indicates, that the stratigraphic range is limited to the Bathonian (*cf.* O'Dogherty et al. 2017). Considering that, the Middle Jurassic radiolarites from the Borja-Mahnjača ophiolitic complex belong to the Bathonian within the UAZ 6–7 (=*Eucyrtidiellum unumaense* Zone *sensu* Gawlick et al. 2009a).

Discussion

The investigated area belongs to an intraoceanic plate boundary between Adria and Eurasia inside the Middle Jurassic Neotethyan Ocean in the present-day Dinaride region (Bragin et al. 2018; Maffione & van Hinsbergen 2018).

Determined Middle Triassic and Middle Jurassic radiolarians in the OOC and BMOC are consistent with other ages reported from radiolarian-bearing rocks in the Dinaride ophiolite complexes (Goričan et al. 1999, 2005; Gawlick et al. 2009b, 2016, 2018; Vishnevskaya et al. 2009; Vishnevskaya & Djerić 2009; Chiari et al. 2011, 2023; Ozsvárt & Kovács 2012; Ozsvárt et al. 2011; Šegvić et al. 2014; Djerić et al. 2024). In these complexes, Triassic and Jurassic radiolarites were found in ophiolitic mélanges, as well as in direct stratigraphic contact with pillow basalts.

The Middle Triassic radiolarites of the OOC may represent rare remnants after the closure of the Middle Triassic part of the Neotethys, which is, for example, known from the Maliac Ocean (*cf.* Schmid et al. 2020), the Western Vardar Ophiolitic Unit (*cf.* Kukoč et al. 2023), or from the Meliata Unit of the Inner Western Carpathians (Kozur et al. 1996; Putiš et al. 2019 and references therein). The investigated area of the BMOC also provided another direct evidence on the age of the Triassic oceanic crust from the subducted sole eclogites to layered amphibolites (a Middle Triassic magmatic age determined by Putiš et al. 2024).

However, the BMOC also contains the Lower Jurassic radiolarites, which were identified for the first time in the Dinaridic ophiolitic mélanges. Based on the radiolarians, their stratigraphic age corresponds to the late Sinemurian–Pliensbachian. These reddish radiolarian strata occur in the Liassic (Toarcian?) dark shales, both embedded as block in the mélange matrix and thus may suggest a prolongation of radiolarian sedimentation from the Middle Triassic to the Early Jurassic. Nevertheless, the radiolarites are relatively older than the dated lower oceanic crust gabbro layer (~178–174 Ma) by Putiš et al. (2024).

The Lower Jurassic radiolarites are unknown from the Dinaridic ophiolite zone (Djerić et al. 2024), with an exception in the BMOC. However, they were reported from the Hellenic ophiolite complexes derived from the Maliac Ocean of the Neotethys (Bortolotti et al. 2003; Chiari et al 2013). In the BMOC, radiolarian sedimentation ceased since the Pliensbachian, being replaced by trench-like deposition and formation of the ophiolite-radiolarite mélanges (Fig. 10). The mélange matrix of the BMCO is composed of dark grey shales, revealing anoxic conditions probably related to the Toarcian oceanic anoxic event.

The Middle Jurassic radiolarite layers occur in two different positions within the ophiolitic complexes: (1) rare thin layers interbedding the pillow lavas (BMOC, P49B sample), or (2) an individual, relatively thicker (1.5 m exposed) layer on the top of the pillow lavas (OOC, P44A sample). The first case yielded relatively older radiolarian ages (Bathonian), indicating an incipient stage of inferred fore-arc/back-arc basin. The latter case yielded younger ages (late Bathonian–early Callovian), which are consistent with the termination of the basaltic eruptions most likely in the final stage of this basin.

The newly-formed Jurassic oceanic crust was terminated by the pillow basalts and associated radiolarites analogue to the neighbouring KKOC (Šegvić et al. 2020). The determined upper age limit from the Bathonian to early Callovian in the OOC and the BMOC may indicate the closure of the Jurassic part of the Neotethys from the Late Jurassic, which is consistent with the youngest magmatic (~168–163 Ma) and metamorphic (~170–160 Ma) ages determined in the West Vardar ophiolites (Maffione & van Hinsbergen 2018). The neighbouring KKOC yielded the Sm–Nd isochron ages of 162±14, 160±7, or 162±5 Ma for the sole granulite facies metamorphic event (Šegvić et al. 2020). According to the reconstruction of Maffione & van Hinsbergen (2018) and the reviewed available ophiolite and metamorphic sole ages by these authors, the West Vardar Jurassic ophiolites formed above an early Middle Jurassic subduction zone. However, the magmatic ages of Triassic ophiolites were missing until now (Putiš et al. 2024), or those from the Jurassic ophiolitic crust are rare in the West Vardar or lacking in the Central Dinaridic ophiolite belt (Maffione & van Hinsbergen 2018). The first determined Early to Middle Jurassic zircon U/Pb radiometric ages of ~178–174 Ma by Putiš et al. (2024) from the lower oceanic crust gabbro layer and the crosscutting dykes in the OOC predated the Middle Jurassic (~170–164 Ma) ages of the investigated radiolarites from both the Ozren and Borja-Mahnjača

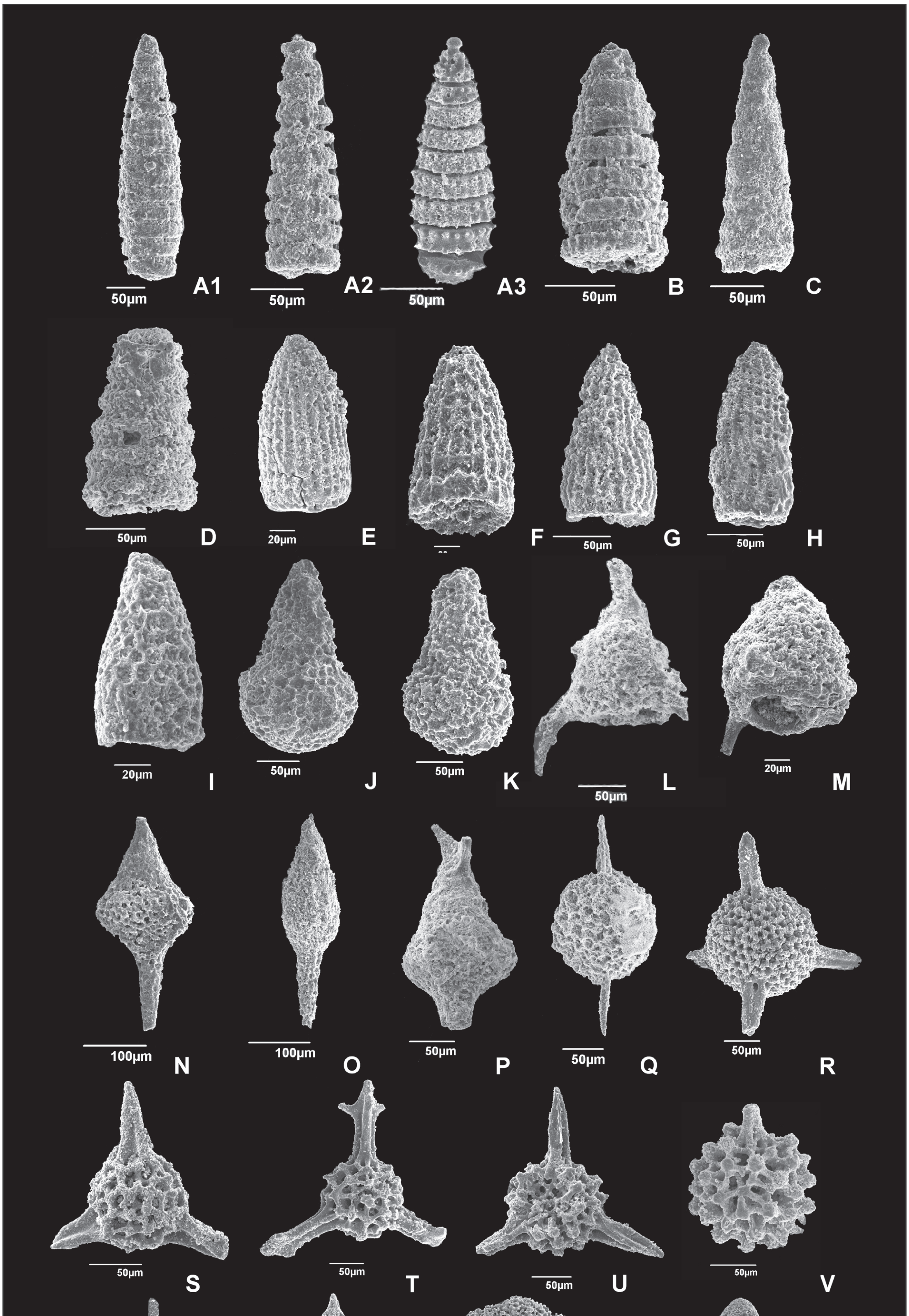
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Fig. 8. Lower Jurassic radiolarians from the Borja-Mahnjača ophiolitic complex (P55A sample). A: *Canoptum reefense* (Pessagno and Whalen), A1–A2 specimens with outer microgranular layer and hoop-like segments, A3 mostly stripped specimen with internal constrictions, ridges and horn; B: *Canoptum anulatum* Pessagno and Poisson; C: *Canoptum poissoni*; D: *Canoptum artum*; E–F: *Parahsuum simplum* Yao; G–H: *Droltus hecatensis* Pessagno & Whalen; I: *Droltus* cf. *sanignacioensis* Whalen and Carter; J–K: *Lantus praeobesus* Carter; L: *Bipedis fannini* Carter; M: *Bipedis hannai* Whalen and Carter; N: *Katroma ninstintsi* Carter; O: *Katroma elongata* Carter; P: *Katroma* cf. *bicornus* De We (species with bifurcating horn); Q: *Pantanellium tanuense* Pessagno and Blome; R: *Tetracoma tollmani* Cifer; S: *Gorgansium alpinum* Kozur and Mostler; T: *Charlottea weedensis* Whalen and Carter; U: *Charlottea penderi* Carter; V: *Praeconocaryomma sarahae* Carter; W: *Palaeosaturnalis subovalis* Kozur and Mostler; X: *Paronaella grahamensis* Carter; Y: *Orbiculiforma* sp.; Z: *Zhamoidellum* cf. *yehae* Dumitrica.

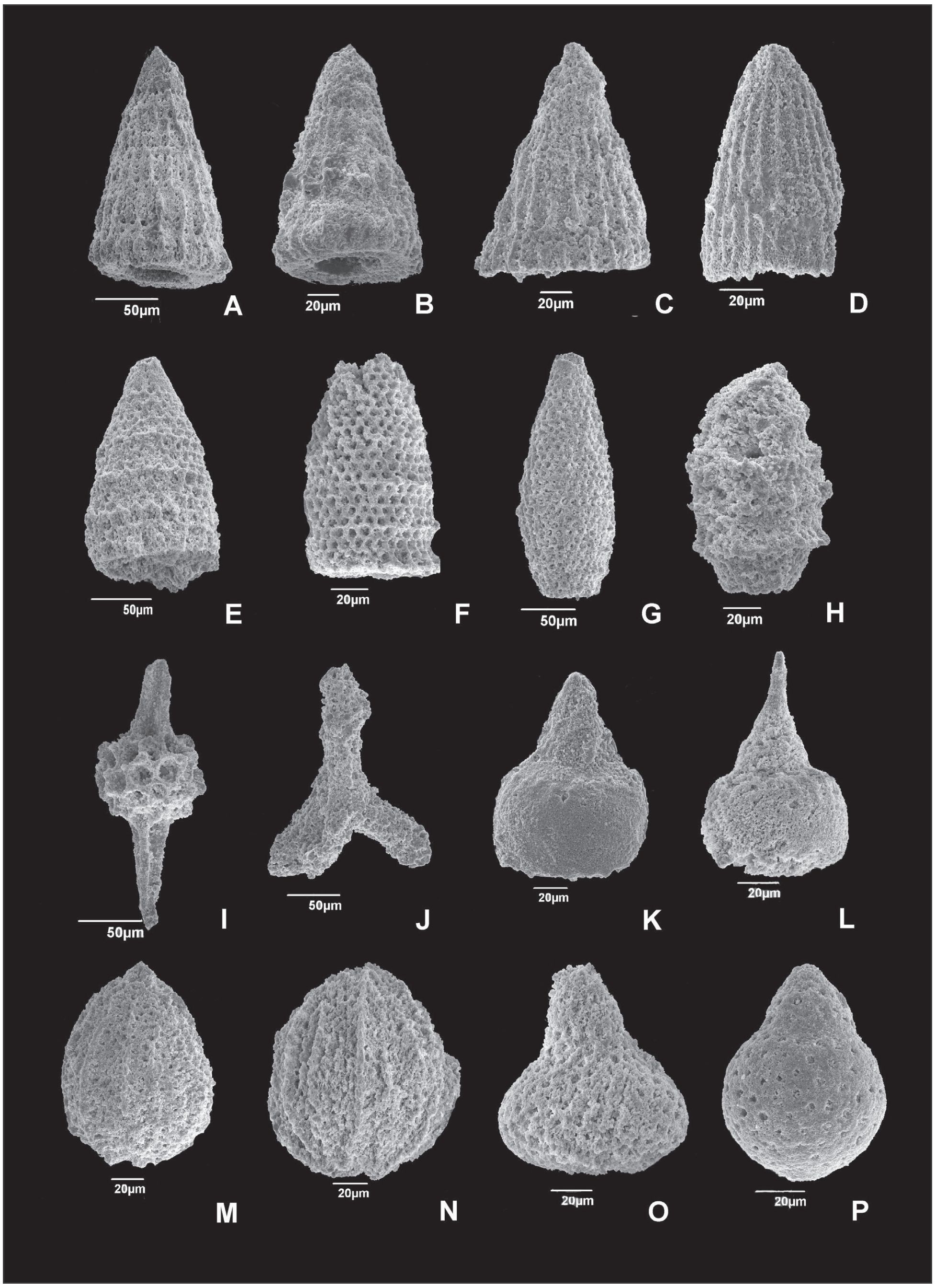

Fig. 9. Late Bathonian radiolarians from the UAZ 7 Zone of the Borja-Mahnjača ophiolitic complex (P49B sample). A–B: *Transhsuum maxwelli* Pessagno; C: *Parahsuum carpathicum* Widdz and De Wever; D: *Thanarla* cf. *patrici* (Kocher); E–F: *Takenamuraella veghae* (Grill and Kozur); G: *Eoxitus* cf. *dhimenaensis* (Baumgartner); H: *Eoxitus* cf. *baloghi* Kozur; I: *Pantanellium riedeli* Pessagno; J: *Paronaella* cf. *kotura* Baumgartner; K–L: *Eucyrtidiellum unumaense* (Yao); M: *Unuma gordus* Hull; N: *Unuma* cf. *typicus* Ichikawa and Yao; O: *Quarkcus madstonensis* Pessagno, Blome and Hull; P: *Hemicryptocapsa* aff. *buekkensis* (Kozur).

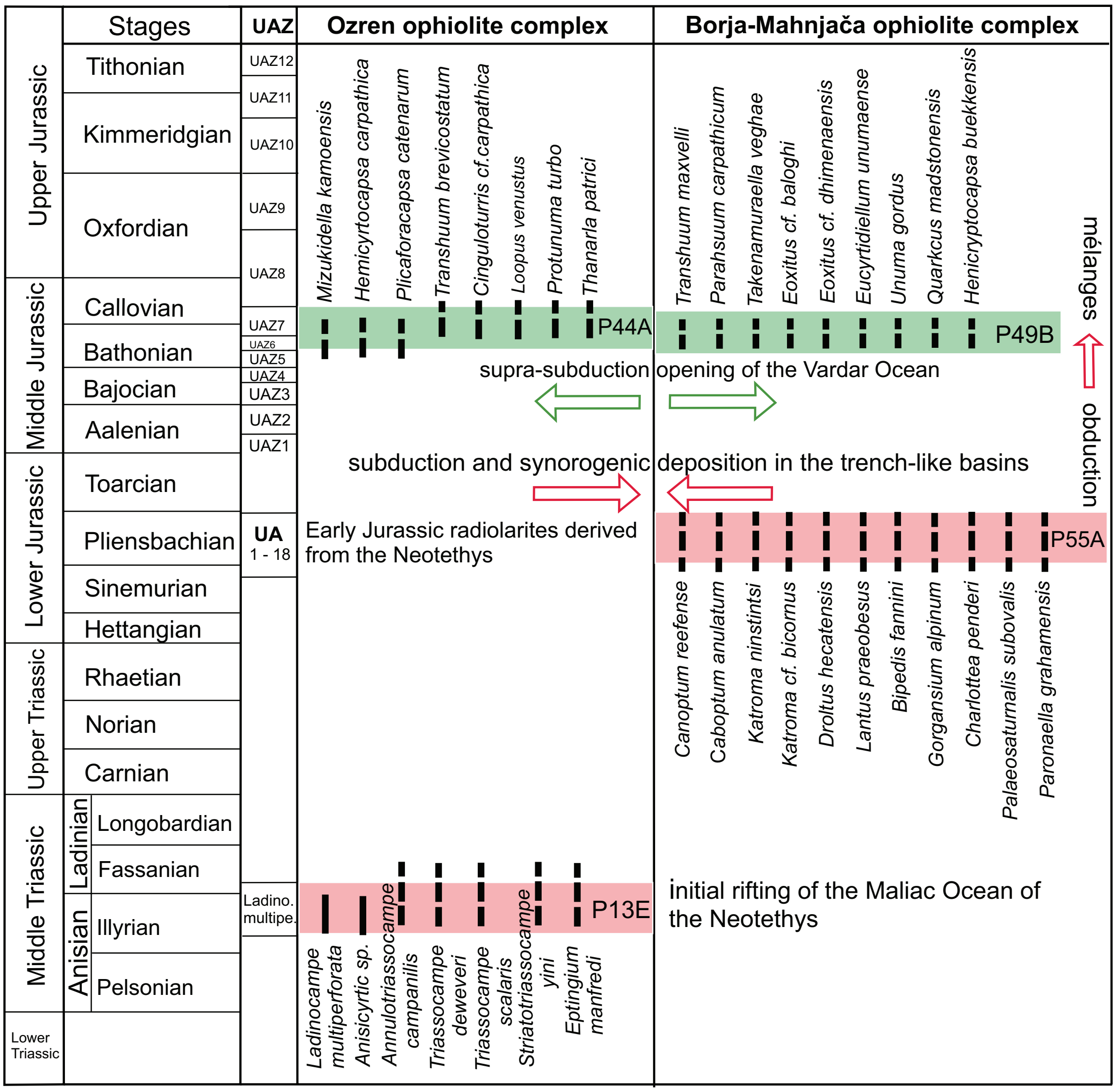

Fig. 10. Stratigraphic distribution of the radiolarian species from radiolarites of the Ozren and Borja-Mahnjača ophiolitic complexes. The Middle Triassic radiolarites (P13E, red field) contain the Illyrian to Fassanian? species, the Lower Jurassic radiolarites (P55A, red field) contain the Late Sinemurian–Pliensbachian species and the Middle Jurassic radiolarites (green fields) contain the Bathonian species (P49B) or Late Bathonian to early Callovian species). UAZ – Unitary Association Zones *sensu* Baumgartner et al. 1995a; UA 1–18 – Lower Jurassic zonation *sensu* Carter et al. 2010, *Ladinocampe multiperforata* Zone *sensu* Kozur & Mostler 1994. The distribution allows to interpret the onset of radiolarian sedimentation with the Middle Triassic rifting and ceassion during Early Jurassic inversion of the Neotethys, which from the Toarcian were replaced by subduction and synorogenic deposition and later by opening of supra-subduction basins with the oceanic crust of pillow lavas and the Middle Jurassic radiolarites. During the late Middle Jurassic, the obduction of oceanic crust led to formation of the radiolaritic – ophiolitic mélanges (*cf.* Robertson & Karamata 1994; Gawlick et al. 2008, 2016, 2018; Ozsvárt et al. 2011; Šegvić et al. 2014; Ferriere et al. 2016; Goričan et al. 2022; Kukoč et al. 2023; Djerić et al. 2024, and others).

massifs upper oceanic crust sections. Therefore, the upper oceanic crust section, with the Middle Jurassic radiolarians associated with the pillow basalts, may have formed in a fore-arc/back-arc setting. This is consistent with mineralogical and geochemical data (Putiš et al. 2022, 2024; Ustalić et al. 2024) implying a transition from MOR to SSZ setting during the formation of newly formed late Early Jurassic to Middle Jurassic oceanic crust. Considering that, early Middle Jurassic subduction is inferred to the closure of the Middle Triassic to Early Jurassic part of the Neotethys Ocean (Putiš et al. 2024).

Conclusions

Radiolarian data from the Ozren and Borja-Mahnjača ophiolitic complexes allow to distinguish the Middle Triassic, Lower Jurassic, and Middle Jurassic radiolarites. The Middle Triassic radiolarites (P13 sample) occur as clastic components in a mélange of the Ozren ophiolitic complex (OOC). Their microfauna comprises mostly Ladinian *Triassocampe* species, including *Triassocampe deweveri* (Nakaseko and Nishimura), *T. scalaris* Dumitrica, Kozur and Mostler, and *Annulo-*

triassocampe campanilis Kozur and Mostler. The early Ladinian age is also indicated by the presence of marker species of *Ladinocampe multiperforata*, which zone was previously placed to Fassanian, but currently redefined to Illyrian (latest Anisian). The OOC pillow basalts are also embedded or covered with the Middle Jurassic radiolarites. Their microfauna from the top of the pillow basalts (P44A sample) indicates the Bathonian–early Callovian age based on co-occurrence of species of the UAZ 6–7 Zone, such as *Mizukidella kamoensis* (Mizutani and Kido), *Loopus venustus* (Chiari, Cortese and Marcucci), *Cinguloturris* cf. *carpathica* Dumitrica, *Transhuum brevicostatum*, (Ožvoldová), *Plicaforacapsa catenarum* (Matsuoka), *Hemicyrtocapsa carpathica* (Dumitrica) and *Protunuma turbo* Matsuoka. Considering these radiolarite components, the Ozren ophiolite complex is a part of the Late Jurassic mélange with the reworked clasts of the Middle Triassic and Middle Jurassic radiolarites.

The Borja-Mahnjača ophiolitic complex (BMOC) contains radiolarite blocks in ophiolitic mélange and radiolarites interbedding the pillow lavas. The mélange radiolarite blocks (P55 sample) from the BMOC contain rich microfauna of the Lower Jurassic radiolarians. Their Late Sinemurian to Pliensbachian age is indicated by the species *Canoptum reefense* (Pessagno and Whalen), *Katroma ninstintsi* Carter, *Droltus hecatensis* Pessagno and Whalen, *Parahsuum simplum* Yao, *Lantus praeobesus* Carter, *Gorgasium alpinum* Kozur and Mostler, *Charlottea penderi* Carter, *Paleosaturnalis subovalis* Kozur and Mostler, and another marker taxa. The Lower Jurassic radiolarites of the BMOC were recorded in the Dinaridic ophiolitic complexes for the first time.

The pillow lavas of the BMOC are interbedded by the Middle Jurassic radiolarites (P49B sample). Besides of common species of the UAZ 6–7 Zone, e.g., *Transhuum maxwelli* Pessagno, *Parahsuum carpathicum* Widdz and De Wever, *Eucyrtidiellum unumaense* (Yao), *Unuma gordus* Hull, they also contain species *Takemuraella veghae* (Grill and Kozur) and *Eoxitus cf. baloghi* Kozur, which are limited to the Bathonian. Therefore, the Borja-Mahnjača ophiolitic complex is a part of the mélange with reworked blocks of the Lower and Middle Jurassic radiolarites.

Triassic radiolarites of the OOC and Lower Jurassic radiolarites of the BMOC represent rare remnants after the closure of the Middle Triassic to Early Jurassic Maliac Ocean of the Neotethys. Radiolarites, overlaying basaltic pillow lavas in the OOC (P44A sample), dated an upper age limit of the newly-formed oceanic crust in a supra-subduction basin (inferred fore-arc/back-arc) to the Bathonian to early Callovian (Fig. 10).

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References

Balen D. & Massonne H.J. 2021: Two contrasting P–T paths for metamorphic sole amphibolites of the Dinaride Ophiolite Zone (Krivaja-Konjuh ultramafic massif, Central Bosnia and Herzegovina) and their geodynamic implications. *Lithos* 394, 106184. https://doi.org/10.1016/j.lithos.2021.106184

Barbero E., Dilek Y., Festa A. & Saccani E. 2023: Ophiolites and ophiolitic mélanges: Archives of Precambrian and Phanerozoic plate tectonics in orogenic belts. *Geosystems and Geoenvironment* 2, 100191. https://doi.org/10.1016/j.geogeo.2023.100191

Baumgartner P.O., O'Dogherty L., Goričan Š., Dumitrica-Jud R., Dumitrica P., Pillevuit, A., Urquhart, E., Matsuoka A., Danellian T., Bartolini, A., Carter, E.S., De Wewer P., Kito N., Marcucci, N. & Steiger T. 1995a: Radiolarian catalogue and systematics of Middle Jurassic to Early Cretaceous Tethyan genera and species. *Mémoires de Géologie (Lausanne)* 23, 37–685.

Baumgartner P.O., Bartolini A., Carter E.S., Conti M., Cortese G., Danelian T., De Wever P., Dumitrica P., Dumitrica-Jud R., Gorican S., Guex J., Hull D.M., Kito N., Marcucci M., Matsuoka A., Murchey B., O'Dogherty L., Savary J., Vishnevskaya V., Widz D. & Yao A. 1995b: Middle Jurassic to Early Cretaceous Radiolaria Biochronology of Tethys based on Unitary Associations. In: Baumgartner P.O. et al. (Eds.): *Mémoires de Géologie (Lausanne)* 23, 1013–1048.

Bazylev B.A., Popević A., Karamata S., Kononkova N.N., Simakin S.G., Olujić J., Vujnović L. & Memović E. 2009: Mantle peridotites from the Dinaridic ophiolite belt and the Vardar zone western belt, Central Balkan. *Lithos* 108, 37–71. https://doi.org/10.1016/j.lithos.2008.09.011

Bortolotti V., Carras N., Chiari M., Fazzuoli M., Marcucci M., Phiotiades A. & Principi G. 2003: The Argolis peninsula in the palaeogeographic and geodynamic frame of the Hellenides. *Ofioliti* 28, 79–94. https://doi.org/10.4454/ofioliti.v28i2.196

Brack P., Rieber H. & Nicora A. 2003: The Global Stratigraphic Section and Point (GSSP) of the base of the Ladinian Stage (Middle Triassic). *Albertiana* 28, 13–25.

Brack P., Rieber H., Nicora A. & Mundil R. 2005: The Global boundary Stratotype Section and Point (GSSP) of the Ladinian Stage (Middle Triasic) at Bagolino (Southern Alps, Northern Italy) and Its Implications for the Triassic time scale. *Episodes* 28, 233–244. https://doi.org/10.18814/epiiugs/2005/v28i4/001

Bragin N.Y. 2011: Triassic radiolarians of Kostel'nyi Island (New Siberian Islands, Arctic). *Paleontological Journal* 45, 711–778. https://doi.org/10.1134/S003103011107001X

Bragin N. & Bragin L. 2017: Early and Middle Jurassic (Pliensbachian to Bajocian) radiolarian from cherts of Kiselevka–Manoma accretionary complex (Amur River, Eastern Russia). *Ofioliti* 42, 1–19. https://doi.org/10.4454/ofioliti.v42i1.466

Bragin N. & Djerić N. 2020: Age of the Jurassic hemipelagic sediments from the Ljubiš area (Zlatibor Mt., SW Serbia). *Geologia Croatica* 73, 143–151. https://doi.org/10.4154/gc.2020.11

Bragin N.Y., Bragina L.G., Djerić N. & Toljić M. 2011: Triassic and Jurassic radiolarians from sedimentary blocks of ophiolite mélange in the Avala Gora area (Belgrade surroundings, Serbia). *Stratigraphy and Geological Correlations* 19, 631–640. https://doi.org/10.1134/S0869593811050030

Bragin N.Y., Bragina L., Gerzina N., Djerić N. & Schmid S. 2018: New radiolarian data from the Jurassic ophiolitic mélange of Avala Mountain (Serbia, Belgrade Region). *Swiss Journal of Geosciences* 112, 235–249. https://doi.org/10.1007/s00015-018-0313-8

Carter E.S., Whalen P.A. & Guex J. 1998: Biochronology and paleontology of Lower Jurassic (Hettangian and Sinumurian) radiolarians, Queen Charlotte Island, British Columbia. *Geological Survey of Canada Bulletin* 496, 1–162. https://doi.org/10.13140/2.1.4593.1203

Carter E.S., Goričan Š., Guex J., O'Dogherty L., De Wever P., Dumitrica P., Hori R.S., Matsuoka A. & Whalen P.A. 2010: Global radiolarian zonation for the Pliensbachian, Toarcian and Aalenian. *Palaeogeography, Palaeoclimatology, Palaeoecology* 297, 401–419. https://doi.org/10.1016/j.palaeo.2010.08.024

Chiari M., Marcucci M. & Prela M. 2002: New species of Jurassic radiolarians in the sedimentary cover of ophiolites in the Mirdita area, Albania. *Micropaleontology* 48, 61–87.

Chiari M., Djerić N., Garfagnoli F., Hrvatović H., Krstić M., Levi N., Malasoma A., Marroni M., Menna F., Nirta G., Pandolfi L., Principi G., Saccani E., Stojadinović U. & Trivić B. 2011: The geology of the Zlatibor-Maljen area (Western Serbia): A geotraverse across the ophiolites of the Dinaric-Hellenic collisional belt. *Ofioliti* 36, 139–166. https://doi.org/10.4454/ofioliti.v36i2.399

Chiari M., Bortolotti V., Marcucci M., Photiades A., Principi G. & Saccani E. 2012: Radiolarian biostratigraphy and geochemistry of the Koziakaz massif ophiolites (Greece). *Bulletin de la Société Géologique de France* 183, 287–306. https://doi.org/10.2113/gssgfbull.183.4.287

Chiari M., Baumgartner P.O., Bernoulli D., Bortolotti V., Marcucci M., Photiades A. & Principi G. 2013: Late Triassic, Early and Middle Jurassic radiolaria from feromanganese-chert „nodules" (Angelokastron, Argolis, Greece): evidence for prolonged radiolarite sedimentation in the Maliac-Vardar Ocean. *Facies* 59, 391–424. https://doi.org/10.1007/s10347-012-0314-4

Chiari M., Saccani E., Prela M., Bortolotti V., Marcucci M. & Matsuoka A. 2023: Radiolarian biostratigraphy of the Northern Albania Ophiolites: new data from the sub-ophiolitic mélange and Eastern Mirdita ophiolites. *Ofioliti* 48, 137–151. https://doi.org/10.4454/ofioliti.v48i2.566

Cifer T. & Goričan Š. 2023a: Late Sinemurian and Early Pliensbachian radiolaria from Mount Rettenstein (Northern Calcareous Alps, Austria). Part 1. Nassellaria. *Revue de Micropaléontologie* 79, 100717. https://doi.org/10.1016/j.revmic.2023.100717

Cifer T. & Goričan Š. 2023b: Late Sinemurian and Early Pliensbachian radiolaria from Mount Rettenstein (Northern Calcareous Alps, Austria). Part 2. Entactinaria and Spumellaria. *Revue de Micropaléontologie* 81, 100752. https://doi.org/10.1016/j.revmic.2023.100752

Cifer T. Goričan Š. Gawlick H-J. & Auer M. 2020: Pliensbachian, Early Jurassic radiolarians from Mount Rettenstein in the Northern Calcareous Alps, Austria. *Acta Palaeontologica Polonica* 65, 167–207. https://doi.org/10.4202/app.00618.2019

Cifer T., Goričan Š., Demény A. & Gawlick H-J. 2024: Radiolarian response to environmental changes at the Sinemurian-Pliensbachian transition in the Northern Calcareous Alps, Austria. *Papers in Paleontology* 10, e1581. https://doi.org/10.1002/spp2.1581

Dilek Y. & Furnes H. 2011: Ophiolite genesis and global tectonics: Geochemical and tectonic fingerprinting of ancient oceanic lithosphere. *Geological Society of America Bulletin* 123, 387–411. https://doi.org/10.1130/B30446.1

Dilek Y. & Furnes H. 2014: Ophiolites and their origin. *Elements* 10, 93–100. https://doi.org/10.2113/gselements.10.2.93

Dilek Y. & Robinson P.T. 2003: Ophiolites in Earth history: Introduction. Geological Society London Special Publications. In: Dilek Y. & Robinson P.T. (Eds.): Ophiolites in Earth History. *Geological Society, London, Special Publications* 218, 1–8. https://doi.org/10.1144/GSL.SP.2003.218.01.01

Djerić N., Schmid S. & Gerzina N. 2012: Middle Jurassic radiolarian assemblages from sedimentary cover of the Adriatic margin (Zlatar Mountain, SW Serbia). *Bulletin de la Société Géologique de France* 183, 359–368. https://doi.org/10.2113/gssgfbull.183.4.359

Djerić N., Gawlick H-J. & Sudar M. 2024: The Jurassic ophiolitic mélanges in Serbia: a review and new insights. *Journal of the Geological Society* 181, 1–23. https://doi.org/10.1144/jgs2023-165

Dumitrica P., Kozur H. & Mostler H. 1980: Contribution to the radiolarian fauna of the Middle Triassic of the Southern Alps. *Geologisch-Paläontologische Mitteilungen Innsbruck* 10, 1–46.

Faul U.H., Garapić G. & Lugović B. 2014: Subcontinental rift initiation and ocean-continent transitional setting of the Dinarides and Vardar zone: Evidence from the Krivaja–Konjuh Massif, Bosnia and Herzegovina. *Lithos* 202–203, 283–299. https://doi.org/10.1016/j.lithos.2014.05.026

Feng Q, Zhang Z. & Ye M. 2001: Middle Triassic radiolarian fauna southwest Yunnan, China. *Micropaleontology* 47, 173–204. https://doi.org/10.2113/47.3.173

Feng Q., Yang Z., Li X. & Crasquin S. 2009: Middle and Late Triassic radiolarians from Tibet: implications for the Bayan Har Basin evolution. *Geobios* 42, 581–601. https://doi.org/10.1016/j.geobios.2009.02.002

Ferriere J., Baumgartner P.O. & Chanier F. 2016: The Maliac Ocean: the origin of the Tethyan Hellenic ophiolites. *International Journal of Earth Sciences (Geolgische Rundschau)* 105, 1941–1963. https://doi.org/10.1007/s00531-016-1303-6

Furnes H. & Dilek Y. 2022: Archean versus Phanerozoic oceanic crust formation and tectonics: Ophiolites through time. *Geosystems and Geoenvironment* 1, 100004. https://doi.org/10.1016/j.geogeo.2021.09.004

Gawlick H-J. & Missoni S. 2019: Middle-Late Jurassic sedimentary mélange formation related to ophiolite obduction in the Alpine–Carpathian–Dinaridic Mountain Range. *Gondwana Research* 74, 144–172. https://doi.org/10.1016/j.gr.2019.03.003

Gawlick H-J., Suzuki H. & Missoni S. 2001: Nachweis von unterliassischen beckensedimenten in Hallstätter Facies (Dürrnberg-Formation) im Bereich der Hallein – Berchtesgadener Hallstätter Zone und des Lammer Beckens (Hettangium–Sinemurium). *Mitteilungen der Gesellschaft der Geologie und Bergbaustudenten in Österreich* 45, 39–55.

Gawlick H-J., Frisch W., Hoxha L., Dumitrica P., Krystyn L., Lein R., Missoni S. & Schlagintweit F. 2008: Mirdita Zone ophiolites and associated sediments in Albania reveal Neotethys Ocean origin. *International Journal of Earth Sciences (Geolgische Rundschau)* 97, 865–881. https://doi.org/10.1007/s00531-007-0193-z

Gawlick H-J., Missoni S., Schlagintweit F., Suzuki H., Frisch W., Krystyn L., Blau J. & Lein R. 2009a: Jurassic Tectonostratigraphy of the Austroalpine Domain. *Journal of Alpine Geology* 50, 1–152.

Gawlick H-J., Sudar M., Suzuki H., Derić N., Missoni S., Lein R. & Jovanović D. 2009b: Upper Triassic and Middle Jurassic radiolarians from the ophiolitic mélange of the Dinaric Ophiolite Belt, SW Serbia. *Neues Jahrbuch für Geologie und Paläontologie – Abhandlungen* 253, 293–311. https://doi.org/10.1127/0077-7749/2009/0253-0293

Gawlick H-J., Missoni S., Suzuki H., Sudar M., Lein R. & Jovanović D. 2016: Triassic radiolarite and carbonate components from a Jurassic ophiolitic mélange (Dinaridic Ophiolite Belt). *Swiss Journal of Geosciences* 109, 473–494. https://doi.org/10.1007/s00015-016-0232-5

Gawlick H-J., Missoni S., Sudar M.N., Suzuki H., Méres Š., Lein R. & Jovanović D. 2018: The Jurassic Hallstatt Mélange of the Inner Dinarides (SW Serbia): implications for Triassic–Jurassic geodynamic and palaeogeographic reconstructions of the Western Tethyan realm. *Neues Jahrbuch für Geologie und Paläontologie – Abhandlungen* 288, 1–47. https://doi.org/10.1127/njgpa/2018/0721

Goričan Š. 1987: Jurassic and Cretaceous radiolarians from the Budva zone (Montenegro, Yugoslavia). *Revue de Micropaléontologie* 30, 177–196.

Goričan Š. 1994: Jurassic and Cretacous radiolarian biostratigraphy and sedimentary evolution of the Budva Zone (Montenegro). *Mémoires de Géologie* 18, 1–177.

Goričan Š. & Buser S. 1990: Middle Triassic radiolarians from Slovenia (Yugoslavia). *Geologija* 31–32, 133–197

Goričan Š., Karamata S. & Batočanin-Srećkovič D. 1999: Upper Triasic (Carnian–Norian) radiolarians in cherts of Sjenica (SW Serbia) and the time span of the oceanic realm ancestor of the Dinaridic Ophiolite Belt. *Bulletin de l'Académie Serbe des Sciences et des Arts. CXIX. Classe des Sciences Mathématique et Naturelles* 39, 141–150

Goričan Š., Šmuc A. & Baumgartner P.O. 2003: Toarcian radiolaria from Mt. Mangat (Slovenian-Italian border) and their paleoecological implications. *Marine micropaleontology* 49, 275–301. https://doi.org/10.1016/S0377-8398(03)00034-3

Goričan Š., Halamić J., Grgasović T. & Kolar-Jurkovšek T. 2005: Stratigraphic evolution of Triassic arc-backarc system in Northwestern Croatia. *Bulletin de la Societe Geologique de France* 176, 3–22. https://doi.org/10.2113/176.1.3

Goričan Š., Carter E.S., Dumitrică P., Whalen P.A., Hori R.S., De Wever P., O'Dogherty L., Matsuoka A. & Guex J. 2006: Catalogue and systematics of Pliensbachian, Toarcian and Aalenian radiolarian genera and species. *ZRC SAZU*, Ljubljana, 1–446. https://doi.org/10.3986/9789612545192

Goričan Š., Pavšič J. & Rožič B. 2012: Bajocian to Tithonian age of radiolarian cherts in the Tolmin basin (NW Slovenia). *Bulletin de la Societe Geologique de France* 183, 369–382. https://doi.org/10.2113/gssgfbull.183.4.369

Goričan Š., Carter E.S., Guex J., O'Dogherty L., De Wever P., Dumitrica P., Hori R.S. & Whalen P. 2013: Evolutionary patterns and palaeobiogeography of Pliensbachian and Toarcian (Early Jurassic) Radiolaria. *Palaeogeography, Palaeoclimatology, Palaeoecology* 386, 620–636. https://doi.org/10.1016/j.palaeo.2013.06.028

Goričan Š., O'Dogherty L., Baumgartner P.O., Carter E.S. & Matsuoka A. 2018: Mesozoic radiolarian biochronology – current status and future directions. *Revue de Micropaléontologie* 61, 165–189. https://doi.org/10.1016/j.revmic.2018.08.001

Goričan Š., Dakovič M., Baumgartner P.O., Gawlick H-J., Cifer T., Djerić N., Horvat A., Kocjančić A., Kokoč D. & Mrdak M. 2022: Mesozoic basins on the Adriatic continental margin – a cross-section through the Dinarides in Montenegro. *Folia biologica et geologica* 63, 85–150. https://doi.org/10.3986/fbg0099

Karamata S. 2006: The geological development of the Balkan Peninsula related to the approach, collision and compression of Gondwanan and Eurasian units. *Geological Society, London, Special Publications* 260, 155–178. https://doi.org/10.1144/gsl.sp.2006.260.01.07

Kozur H. & Mostler H. 1990: *Saturnaliacea* Deflandre and some stratigraphically important radiolaria from the Hettangian of Lenggries/Isar (Bavaria, Northern Calvareous Alps). *Geologisch–Paläontologische Mitteilungen Innsbruck* 17, 179–248

Kozur H. & Mostler H. 1994: Anisian to Middle Carnian radiolarian zonation and description of some stratigraphically important radiolarians. *Geologisch–Paläontologische Mitteilungen Innsbruck* 3, 39–255

Kozur H. & Mostler H. 2006: Radiolarien aus dem Longobard der Dinariden. *Hallesches Jahrbuch für Geowissenschaften* 28, 23–91

Kozur H.W., Mock R. & Ožvoldová L. 1996: New biostratigraphic results in the Meliaticum in its type area around Meliata village (Slovakia) and their tectonic and paleogeographic significance. *Geologisch–Paläontologische Mitteilungen Innsbruck* 21, 89–121.

Kukoč D., Slovenec D., Šengvić B., Vukovski M., Belak M., Grgasović T., Horvath M. & Smirčić D. 2023: The early history of the Neotethys archived in the ophiolitic mélanges of Northwestern Croatia. *Journal of the Geological Society* 181. https://doi.org/10.1144/jgs2023-143

Laušević M. & Jovanović Č. 1982: The basic geological map of the Former SFR Yugoslavia 1:100,000, Geological sheet Doboj Republic. *Geological Survey, Geoinženjering Institute Sarajevo*, Sarajevo, Bosnia and Herzegovina.

Lugović B., Altherr R., Raczek I., Hoffmann A. & Majer V. 1991: Geochemistry of peridotites and mafic igneous rocks from the Central Dinaric ophiolite belt, Yugoslavia. *Contributions to Mineralogy and Petrology* 106, 201–216. https://doi.org/10.1007/BF00306434

Maffione M. & van Hinsbergen D.J.J. 2018: Reconstructing plate boundaries in the Jurassic Neo-Tethys from the East and West Vardar Ophiolites (Greece and Serbia). *Tectonics* 37, 858–887. https://doi.org/10.1002/2017TC004790

Matsuoka A. 1995: Middle Jurassic to early Cretaceous radiolarian occurrences in Japan and Western Pacific (ODP Sites 800-801). In: Baumgartner P.O., O'Dogherty L., Goričan Š., Urguhart E., Pillevnuit A. & De Wever P. (Eds.): *Mémoires de Géologie (Lausanne)* 23, 937–966.

Matsuoka A. & Ito T. 2019: Updated radiolarian zonation fro the Jurassic in Japan and western Pacific. *Science Reports of Niigata Univerity (Geology)* 34, 49–57.

Matsuoka A. & Yao A. 1986: A newly proposed radiolarian zonation for Jurassic of Japan. *Marine Micropaleontology* 11), 91–106. https://doi.org/10.1016/0377-8398(86)90006-X

Morishita T., Dilek Y., Shallo M., Tamura A. & Arai S. 2011: Insight into the uppermost mantle section of a maturing arc: The eastern Mirdita ophiolite, Albania. *Lithos* 124, 215–226. https://doi.org/10.1016/j.lithos.2010.10.003

O'Dogherty L., Bill M., Goričan Š., Dumitrica P. & Masson H. 2006: Bathonian radiolarians from an ophiotitic mélange of the Alpine Tethys (Gets Nappe, Swiss-French Alps). *Micropaleontology* 51, 425–485. https://doi.org/10.2113/gsmicropal.51.6.425

O'Dogherty L., Carter E.S., Dumitrica P., Goričan Š., De Wever P., Hungerbühler A., Bandini A.N. & Takemura A. 2009a: Catalogue of Mesozoic radiolarian genera. Part: 1: Triassic. *Geodiversitas* 31, 213–270. https://doi.org/10.5252/g2009n2a3

O'Dogherty L., Carter E.S., Dumitrica P., Goričan Š., De Wever P., Bandini A.N., Baumgartner P.O. & Matsuoka A. 2009b: Catalogue of Mesozoic radiolarian genera. Part: 2: Jurassic–Cretaceous. *Geodiversitas* 31, 271–356. https://doi.org/10.5252/g2009n2a4

O'Dogherty L., Carter, E.S., Goričan, Š. & Dumitrica P. 2010: Triassic radiolarian biostratigraphy. In: Lucas S.G. (Ed.): Triassic Timescale. *Geological Society, London, Special Publications* 334, 163–200. https://doi.org/10.1144/SP334.8

O'Dogherty L., Goričan Š. & Gawlick H-J. 2017: Middle and Late Jurassic radiolarians from the Neotethys suture in the Eastern Alps. *Journal of Paleontology* 91, 25–72. https://doi.org/10.1017/jpa.2016.96

Olujić J., Sunarić-Pamić O. & Pamić J. 1980: The basic geological map of the former SFR Yugoslavia 1:100 000, Geological sheet Teslić. *Republic Geological Survey, Geoinženjering Institute Sarajevo*, Belgrade.

Ozsvárt P. & Kovács S. 2012: Revised Middle and Late Triassic radiolarian ages for ophiolite mélanges: implications for the geodynamic evolution of the northern part of the early Mesozoic

Neotethyan subbasins. *Bulletin de la Société Géologique de France* 183, 273–286. https://doi.org/10.2113/gssgfbull.183.4.273

Ozsvárt P., Dosztály L., Migiros G., Tselepidis V. & Kovács S. 2011: New radiolarian biostratigraphic age constraints on Middle Triassic basalts and radiolarites from the Inner Hellenides (northern Pindos and Othris mountains, northern Greece) and their implications for the geodynamic evolution of the early Mesozoic Neotethys. *International Journal of Earth Sciences* 101, 1487–1501. https://doi.org/10.1007/s00531-010-0628-9

Ozsvárt P., Rieber H. & Brack P. 2023: Middle Triassic radiolarians from the Dolomites, Southern Alps, Italy. *Geo. Alp* 20, 5–74. https://doi.org/10.5281/zenodo.10389921

Ožvoldová L. 1998: Middle Jurassic radiolarian assemblages from radiolarites of the Silica nappe (Slovak karst, Western Carpathians). *Geologica Carpathica* 49, 289–296.

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. https://doi.org/10.1016/S0024-4937(02)00162-7

Pessagno E.A. & Hull D.M. 2002: Upper Jurassic (Oxfordian) radiolaria from the Sula Islands (East Indies): their taxonomic, biostratigraphic, chronostratigraphic and paleobiogeographic significance. *Micropaleontology* 48, 229–256. https://doi.org/10.2113/48.3.229

Pessagno E.A. & Poisson A. 1981: Lower Jurassic radiolaria from the Gümüşlü Allochton of southwestern Turkey (Taurides occidentales). *Bulletin of the Mineral Research and Exproration Institute of Turkey* 92, 47–69

Pessagno E.A. & Whalen P.A. 1982: Lower and Middle Jurassic Radiolaria (multicyrtid Nassellarina), Oregon and the Queen Charlotte, B.C. *Micropaleontology* 28, 111–169.

Prela M., Chiari M. & Marcucci M. 2000: Jurassic radiolarian biostratigraphy of the sedimentary cover of ophiolites in the Mirdita area, Albania. *Ofioliti* 25, 55–62. https://doi.org/10.4454/ofioliti.v25i1.114

Putiš M., Soták J., Li Q.-L., Ondrejka M., Li X.H., Hu Z., Ling X., Nemec O., Németh Z. & Ružička P. 2019: Origin and age determination of the Neotethys Meliata Basin ophiolite fragments in the Late Jurassic–Early Cretaceous accretionary wedge mélange (Inner Western Carpathians, Slovakia). *Minerals* 9, 652. https://doi.org/10.3390/min9110652

Putiš M., Nemec O., Ustalić S., Babajić E., Ružička P., Koller F., Kurylo S. & Katanić P. 2022: Mineralogical-Petrographical Record of Melt-Rock Interaction and P–T Estimates from the Ozren Massif Ophiolites (Bosnia and Herzegovina). *Minerals* 12, 1108. https://doi.org/10.3390/min12091108

Putiš M., Nemec O., Ustalić S., Sláma J., Balen D., Babajić E., Soták J. & Ružička P. 2024: Triassic-Jurassic ophiolites of Dinaridic Ozren and Borja–Mahnjača massifs in Bosnia and Herzegovina: Mineralogy, geochronology, and P–T estimates from subducted sole. *EGU General Assembly 2024, Vienna, Austria, 14–19 April 2024, EGU24-1504*. https://doi.org/10.5194/egusphere-egu24-1504, 2024

Robertson A.H.F. & Karamata S. 1994: The role of the subduction–accretion process in the tectonic evolution of the Mesozoic Tethys in Serbia. *Tectonophysics* 234, 73–94, https://doi.org/10.1016/0040-1951(94)90205-4

Robertson A.H.F., Karamata S. & Šarić K. 2009: Overview of ophiolites and related units in the late Palaeozoic–early Cenozoic magmatic and tectonic development of Tethys in the northern part of the Balkan region. *Lithos* 108, 1–36. https://doi.org/10.1016/j.lithos.2008.09.007

Saccani E. & Tassinari R. 2015: The role of morb and ssz magma-types in the formation of jurassic ultramafic cumulates in the Mirdita ophiolites (Albania) as deduced from chromian spinel and olivine chemistry. *Ofioliti* 40, 37–56. https://doi.org/10.4454/ofioliti.v40i1.434

Schmid S.M., Bernoulli D., Fügenshuh B., Matenco L., Schefer S., Schuster R., Tischler M. & Ustaszewski K. 2008: The Alpine–Carparthian–Dinaric orogenic system: Compilation and evolution of tectonic units. *Swiss Journal of Geosciences* 101, 139–183. https://doi.org/10.1007/s00015-008-1247-3

Schmid S.M., Fügenschuh B., Kounov A., Matenco L., Nievergelt P., Oberhänsli R., Pleuger J., Schefer S., Schuster R., Tomljenović B., Ustaszewski K. & van Hinsbergen D.J.J. 2020: Tectonic units of the Alpine collision zone between Eastern Alps and western Turkey. *Gondwana Research* 78, 308–374. https://doi.org/10.1016/j.gr.2019.07.005

Soták J., Ustalić S., Putiš M., Babajić E. & Ružička P. 2023: New radiolarian data from the Ozren ophiolite complex in Bosnia and Herzegovina. In: Proceedings of the III Congress of Geologists of Bosnia and Herzegovina with International Participation, Neum, Bosnia and Herzegovina, 21–23 September 2023. *Association of geologists in Bosnia and Herzegovina,* 38–41.

Sudar M. & Gawlick H-J. 2018: Emendation of the Grivska formation in its type area (Dinaridic Ophiolite Belt, SW Serbia). *Geoloski anali Balkanskoga poluostrva* 79, 1–19. https://doi.org/10.2298/GABP1879001S

Sugiyama K. 1997: Triassic and Lower Jurasic radiolarian biostratigraphy in the siliceous claystone and bedded chert units of the southeastern Mino Terrane, Central Japan. *Bulletin of the Mizunami Fossil Museum* 24, 79–193

Sunarić-Pamić O., Pamić J., Kapelar I., Olujić J. & Zec F. 1971: The Basic Geological Map of the Former SFR Yugoslavia 1:100,000, Geological Sheet Zavidovići. *Republic Geological Survey, Geological Survey Sarajevo*, Bosnia and Herzegovina.

Suzuki H. & Gawlick H-J. 2003: Biostratigraphy und taxonomie der radiolarien aus den Kieselsedimenten der Blaa Alm und nördlich des Losser (Nördliche Kalkalpen, Callovium-Exfordium). *Mitteilungen der Gesellschaft der Geologie- und Bergbaustudenten* 46, 137–228

Suzuki H. & Gawlick H-J. 2009: Jurassic radiolarians from cherty limestones below the Hallstatt salt mine (Northern Calcareous Alps, Austria). *Neues Jahrbuch für Geologie und Paläontologie* 251, 155–197. https://doi.org/10.1127/0077-7749/2009/0251-0155

Suzuki H. & Gawlick H-J. 2020: Early Oxfordian radiolarians from the ammonite-bearing Fludergraben section (Northern Calcareous Alps, Austria). *Bulletin of the Geological Survey of Japan* 71, 243–280. https://doi.org/10.9795/bullgsj.71.243

Šegvić B., Kukoč D., Dragičević I., Vranjković A., Brčić V., Goričan Š., Babajić E. & Hrvatović H. 2014: New record of Middle Jurassic radiolarians and evidence of Neotethyan dynamics documented in a mélange from the Central Dinaridic Ophiolite Belt (CDOB, NE Bosnia and Herzegovina). *Ofioliti* 39, 33–43. https://doi.org/10.4454/ofioliti.v39i1.427

Šegvić B., Slovenec D., Altherr R., Babajić E., Ferreiro Mählmann R. & Lugović B. 2019: Petrogenesis of high-grade metamorphic soles from the Central Dinaric Ophiolite belt and their significance for the Neotethyan evolution in the Dinarides. *Ofioliti* 44, 1–30. https://doi.org/10.4454/ofioliti.v44i1.462

Šegvić B., Slovenec D., Schuster R., Babajić E., Badurina L. & Lugović B. 2020: Sm–Nd geochronology and petrologic investigation of a sub-ophiolite metamorphic sole from the Dinarides (Krivaja-Konjuh Ophiolite Complex, Bosnia and Herzegovina). *Geologia Croatica* 73, 119–130. https://doi.org/10.4154/gc.2020.09

Tekin K.U. 1999: Biostratigraphy and systematics of the late Middle to Late Triassic radiolarians from the Taurus Mountains and Ankara Region, Turkey. *Geologisch-Paläontologische Mitteilungen Innsbruck* 5, 1–296.

Tekin K. U. 2002: Lower Jurassic (Hettangian–Sinemurian) radiolarians from the Antalya Nappes, Central Taurids, Southern Turkey. *Micropaleontology* 48, 177–205. https://doi.org/10.2113/48.2.177

Tekin K.U. 2020: Late Triassic to Early Jurassic radiolarian, conodont and ammonite assemblages from the Tavuscayiri block, Mersin Mélang, souther Turkey: Time constraints for the T/J boundary and sedimentary evolution of the southern margin of the northern Neotethys. *Geodiversitas* 42, 493–537. https://doi.org/10.5252/geodiversitas2020v42a27

Tekin K.U. & Göncüoglu C.M. 2007: Discovery of the oldest (Upper Ladinian to Middle Carnian) radiolarian assemblages from the Bornova Flysch Zone in western Turkey: implications for the evolution of the Neotethyan Izmir-Ankara Ocean. *Ofioliti* 32, 131–150. https://doi.org/10.4454/ofioliti.v32i2.353

Thassanapak H., Feng Q-L., Grant-Mackie J., Chonglakmani Ch. & Thanee N. 2011: Middle Triassic radiolarian fauna from Chiang Dao, Northern Thailand. *Paleoworld* 20, 179–202. https://doi.org/10.1016/j.palwor.2010.11.001

Trubelja F. & Pamić J. 1965: Petrologic study of mountain Ozren in the north of Bosnia. *Acta Geologica* IV, 265–314.

Ustalić S., Soták J., Putiš M., Babajić E. & Ružička P. 2023: Comparative study of radiolarians from the Ozren and Borja–Mahnjača Dinaridic ophiolitic massifs in Bosnia and Herzegovina. *Scientific Conference of Slovak Geological Society Newsletter SGS Mente et Malleo 2/2023*, Abstracts, 29.

Ustalić S., Nemec O., Milovská S., Putiš M., Babajić E., Kurylo S. & Ružička P. 2024: Amphibole Group Minerals in the Ozren Massif Ophiolites of Bosnia and Herzegovina as Petrogenetic Indicators. *Minerals* 14, 239. https://doi.org/10.3390/min14030239

Ustaszewski K., Kounov A., Schmid S.M., Schaltegger U., Krenn E., Frank W. & Fügenschuh B. 2010: Evolution of the Adria–Europe plate boundary in the northern Dinarides: From continent–continent collision to back-arc extension. *Tectonics* 29, TC6017. https://doi.org/10.1029/2010TC002668

Vishnevskaya V.S. & Djerić N. 2009: Mesozoic radiolaria of Bosnia and Serbia: new data. *Paleontological journal* 43, 1513–1568. https://doi.org/10.1134/S0031030109120016

Vishnevskaya V.S., Djerić N. & Zakariadze G.S. 2009: New data on Mesozoic Radiolaria of Serbia and Bosnia, an implication for the age and evolution of oceanic volcanic rocks in the Central and Northern Balkans. *Lithos* 108, 72–105. https://doi.org/10.1016/j.lithos.2008.10.015

Whalen P.A. & Carter E.S. 2002: Pliensbachian (Lower Jurassic) Radiolaria from Baja California Sur, Mexico. *Micropaleontology* 48, 97–151. https://doi.org/10.2113/48.2.97

Yeh K. & Pessagno E.A. 2013: Upper Bathonian (Middle Jurassic) radiolarians from Snowshoe Formation, east-central Oregon, USA. *Collection and Research* 26, 51–175.