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Triassic radiolarite and carbonate components from a Jurassic ophiolitic mélange (Dinaridic Ophiolite Belt)

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Abstract The late Middle to early Late Jurassic mélange of the eastern Zlatibor Mountain (Gostilje–Ljubiš–Visoka–Radoševo areas) in the Dinaridic Ophiolite Belt contains a mixture of (A) blocks of Triassic oceanic crust and radiolarites, and (B) open marine limestone and radiolarite blocks of the overthrusted distal Adria margin. We describe the microfacies and present biostratigraphic data from radiolarite and carbonate clasts and blocks and the radiolaritic-argillaceous matrix. The radiolarians and conodonts yield Middle to Late Triassic (Ladinian to Norian) ages for the provenance areas from which the ophiolite, radiolarite and carbonate blocks and clasts derived. The provenance areas of the components in the Gostilje–Ljubiš–Visoka–Radoševo mélange are determined as (1) the ocean floor of the Neo-Tethys, and (2) the continental slope/distal parts of the shelf. In the course of ophiolite obduction, the continental slope and the ocean floor components were transported by mass movements into newly-formed, trench-like basins in front of the westward propagating obduction of the Dinaridic ophiolite nappe stack. These basins were later incorporated in the nappe stack forming the typical features of a syntectonic mélange. The new radiolarian biostratigraphic data confirm Middle Triassic formation of the Neo-Tethys Ocean, parts of which were closed during obduction commencing in the late Early or early Middle Jurassic. The data clearly speak in favour of one Neo-Tethys Ocean to the east, from which the ophiolites of the Dinaridic Ophiolite Belt derived as far-travelled ophiolitic sheets.

Keywords Eastern Mediterranean · Western Tethys · Biostratigraphy · Distal passive margin and oceanic deposition · Ophiolite obduction

1 Introduction

To date there is little consensus on the Mesozoic regional plate tectonic development of the eastern Mediterranean orogenic belt and the arrangement of oceanic realms in the western Tethys system (Fig. 1). Palaeogeographic reconstructions contrast significantly (see Robertson 2012; for a review). One of the problems is the still poorly-known stratigraphic and facies evolution of the Triassic and Jurassic sedimentary sequences, very often only preserved as clasts and blocks in mélanges.

The Inner Dinarides and the Dinaridic Ophiolite Belt (Fig. 2a) as a crucial part of the Inner Dinarides experienced a long and controversial interpretation. Various models were invented to interpret the complex and polyphase tectonic history. It is out of our scope here to give a complete overview about the different views during the history of investigations. Today two main contrasting

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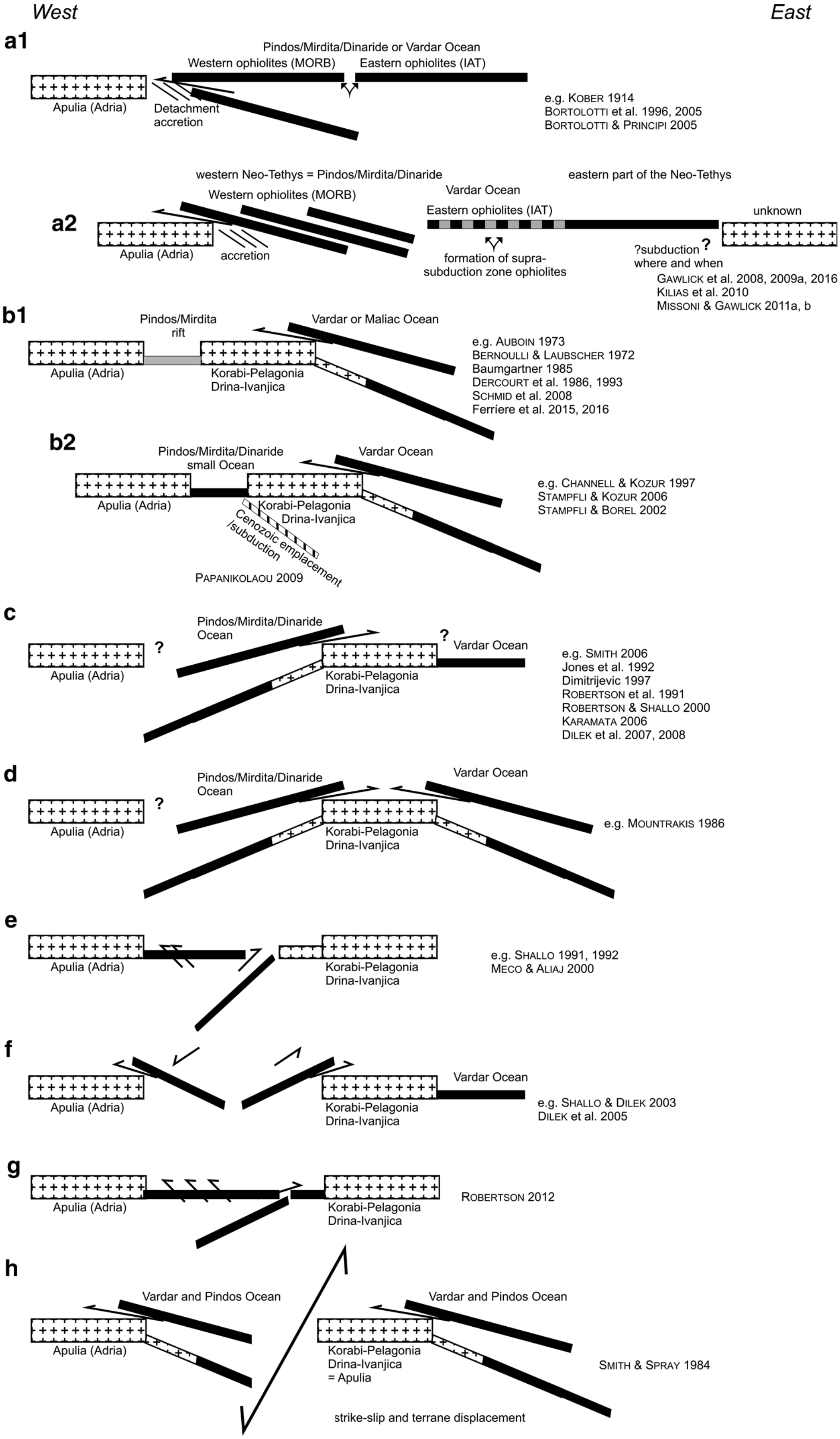


Fig. 1 Recently discussed models of the age, emplacement and palaeogeographic position of the Pindos/Mirdita/Dinaridic Ocean (ophiolites) following in general Robertson (2012), simplified and modified. Most references for discussion are available for the Mirdita ophiolites in Albania or the Pindos ophiolites in northern Greece. These discussed models are also valid for the Dinaridic Ophiolite Belt. For further discussion of the different models see Robertson (2012). Whereas several models favoured a Jurassic to Early Cretaceous emplacement of the ophiolites [Middle Jurassic or Late(st) Jurassic, or Early(iest) Cretaceous] the opening of the oceanic basin is still a matter of debate: Middle Triassic, Late Triassic, Early Jurassic, Middle or !Late Jurassic. The most common interpretation at the moment consider the Pindos/Mirdita/Dinaridic Ocean as a newly formed Jurassic oceanic basin between the Apulian/Adria plate to the west and the Korabi–Pelagonian–Drina–Ivanjica microcontinent to the east (in situ ocean—e.g., Stampfli et al. 2001, 2003; Shallo and Dilek 2003; Csontos and Vörös 2004; Dilek et al. 2008; Stampfli and Kozur 2006; Karamata 2006; Robertson 2012) is not even more valid due to a lot of findings of Triassic oceanic remnants (for recent reviews see Ozsvárt et al. 2012; Gawlick et al. 2016). References not complete. See text for further explanation

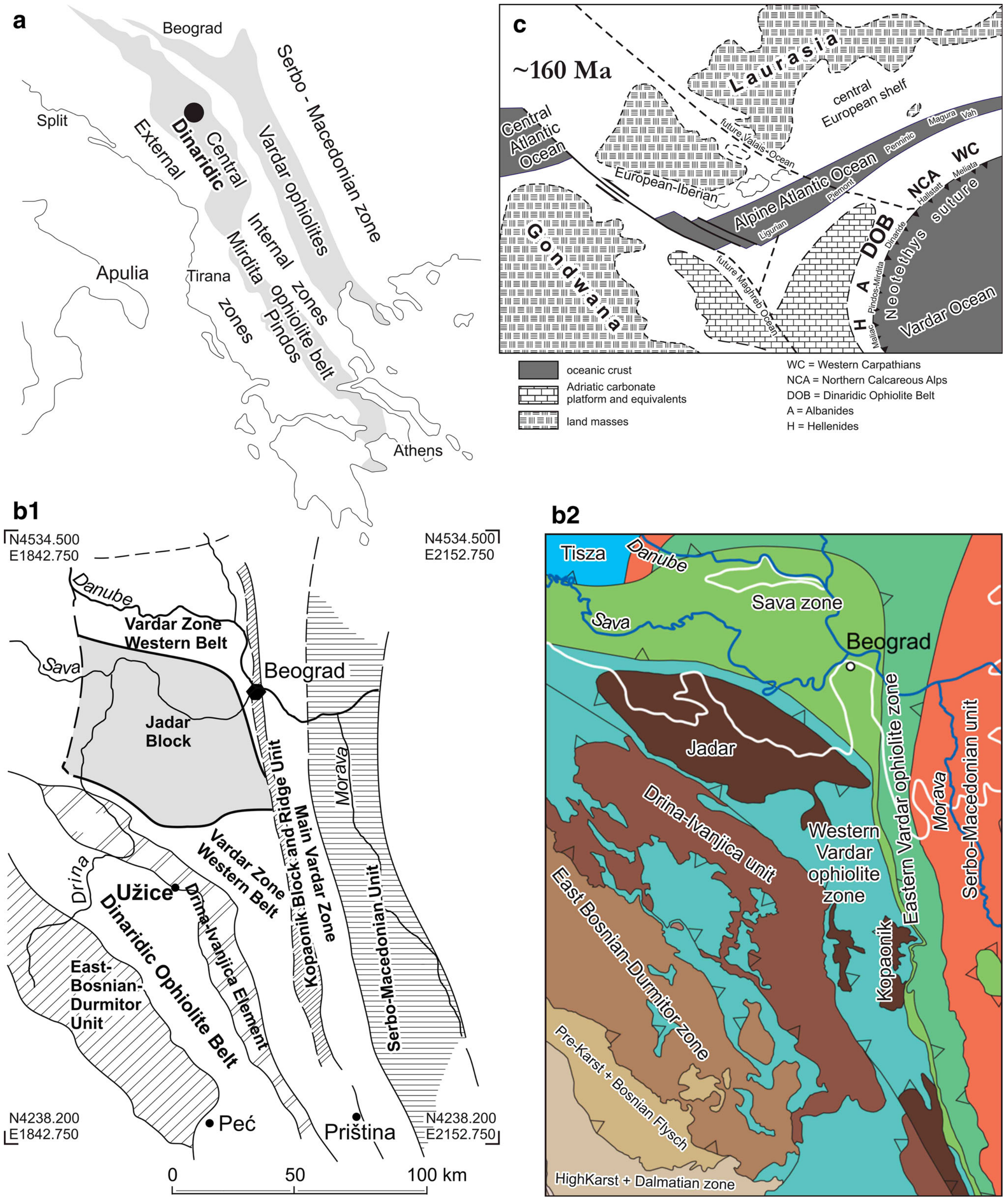


Fig. 2 Study area. **a** Regional geological setting showing the external zones, the central ophiolite zone (Dinaridic–Mirdita–Pindos ophiolites), the Internal zones (Pelagonian zone, Korabi zone, Drina-Ivanjica element) and the Vardar ophiolites. For details, e.g.: Aubouin 1973; Dimitrijević 1997; Karamata 2006). **b1** Tectonic units and terranes of the central Balkan Peninsula in the sense of Karamata (2006). **b2** Tectonic units of the central Balkan Peninsula according to Schmid et al. (2008) (from Schmid et al. 2008, modified). For detailed explanation see Schmid et al. (2008). **c** Palaeogeographic position of the Dinaridic Ophiolite Belt (DOB) as part of the Neotethyan Belt (modified after Frisch 1979; Missoni and Gawlick 2011a, b)

interpretations remain (see Schmid et al. 2008; Chiari et al. 2011; for a review):

1. Autochthonous models with several oceanic domains between continental blocks (Fig. 1). In this model, the Dinaridic Ophiolite Belt is the remnant of the Pindos–Mirdita–Dinaridic Ocean between Adria to the west (external zones, Fig. 2a) and Drina-Ivanjica as northern part of Pelagonia/Korabi to the east (internal zones, Fig. 2a, b1),
2. Allochthonous models (Fig. 1), which interpret the Dinaridic Ophiolite Belt as an obducted ophiolitic nappe stack from the east from one oceanic suture with different names in the literature: Vardar Ocean, Maliac Ocean, or Neo-Tethys Ocean. In this model the Dinaridic Ophiolite Belt is seen as part of the Neo-Tethys suture, i.e. the Neotethyan Belt (Missoni and Gawlick 2011a, b) (Fig. 2c).

The Dinaridic Ophiolite Belt of western and southwestern Serbia is made of ophiolites that largely consist of serpentinites and widespread mélanges containing different components up to nappe-size (e.g., Dimitrijević et al. 2003). The analysis of the constituents of a mélange generally provides good opportunities to unravel the geodynamic history of their formation and to reconstruct mountain building processes.

Since Hsü (1968, 1974) defined the term mélange (compare Sengör 2003) and distinguished clearly the terms mélange and olistostrome, a lot of controversial discussions and a plethora of definitions exist (summarized in Festa et al. 2010a, b, 2016; compare Dimitrijević et al. 2003). Mélanges are defined as of tectonic (tectonic mélange), or sedimentary (sedimentary mélange), or diapiric (diapiric mélange) origin (Silver and Beutner 1980), but this may increase confusion of an exact definition. Important is to note, that the classical mélange feature is deformation. As melanges typically occur in deformation zones and are very widespread in collisional belts, also intense deformation can completely destroy the original sedimentary structures, extremely complicating their distinction from tectonic mélanges. First deposited in trenches or trench-like basins such basin fills become later sheared and incorporated in the nappe stack, forming the typical features of a mélange. A pure sedimentary mélange is in fact not a mélange in the strict sense, and could be therefore used in the genetically sense of Shanmugam (2016): debrite = olistostrome = sedimentary mélange.

As mélanges typically occur in collisional settings, the analysis of the different components can reveal the often complex history of collisional events. Mélanges are frequently formed in several stages: In front of a propagating ophiolitic nappe stack deep-water basins are formed that are supplied with material from the advancing nappes, and the basin fill is typically a coarsening-upward cycle. Later these basin fills will be incorporated in the nappe stack, imbricated and tectonically sheared. Exotic blocks from the overridden units may be tectonically incorporated. The result is the typical block-in-matrix feature of a mélange. For recent reviews of Mediterranean mélange sequences see Festa et al. (2010a, b) and Plasienka (2012), and the references therein.

Biostratigraphic dating of radiolarite clasts and blocks in a mélange are crucial for the reconstruction and the age determination of consumed ocean-floor, since radiolarites in the blocks partly represent the original sedimentary cover on the basaltic crust. In the eastern Mediterranean orogen, Triassic radiolarites were deposited on ocean floor or on subsided passive continental margins. In the Middle Triassic (Late Anisian to Early Ladinian), radiolarites were widespread and also formed in relatively shallow water depths (>100 and <300 m; Gawlick et al. 2012; Gawlick and Missoni 2015). In contrast, Late Ladinian to Rhaetian radiolarites were absent in continental-margin settings and clearly indicate deposition on the ocean floor (Krische et al. 2014; Gawlick and Missoni 2015).

We present data from radiolarians and conodonts of Middle and Late Triassic radiolarite and carbonate clasts and blocks from the Gostilje-Ljubiš-Visoka-Radoševo mélange south of Užice (Figs. 2, 3) as well as Middle Jurassic matrix ages as a contribution to the still controversially discussed questions:

1. Is there a separate “Dinaridic Ocean” between Adria and Drina-Ivanjica, two separated realms with continental crust; or are the ophiolites of the Dinaridic Ophiolite Belt far-travelled nappes (obducted ophiolite sheets) derived from the Neo-Tethys (Vardar) Ocean to the east, and are, consequently, Adria and Drina-Ivanjica originally both part of the same continental realm west of the Neo-Tethys Ocean?
2. Is the mélange formation of Middle to early Late Jurassic age, or alternatively, of Late Jurassic to Early Cretaceous age, and what is the age of the final emplacement of the ophiolites west of the Drina-Ivanjica unit?
3. Alternatively, starts mélange formation in the Middle Jurassic and continues until the Jurassic/Cretaceous boundary with the final emplacement of the ophiolites west of Drina-Ivanjica?

Ophiolite obduction onto the former passive Neo-Tethys (Adria) margin is thought to be of latest Jurassic to earliest Cretaceous age in the Dinarides (e.g., Schmid et al. 2008; Djerić et al. 2012). Schmid et al. (2008) considered mélange formation in the course of the Late Jurassic to Early Cretaceous westward obduction of the ophiolites. This age contrasts with results from other areas all along the Neotethyan Belt extending from the Western Carpathians to the

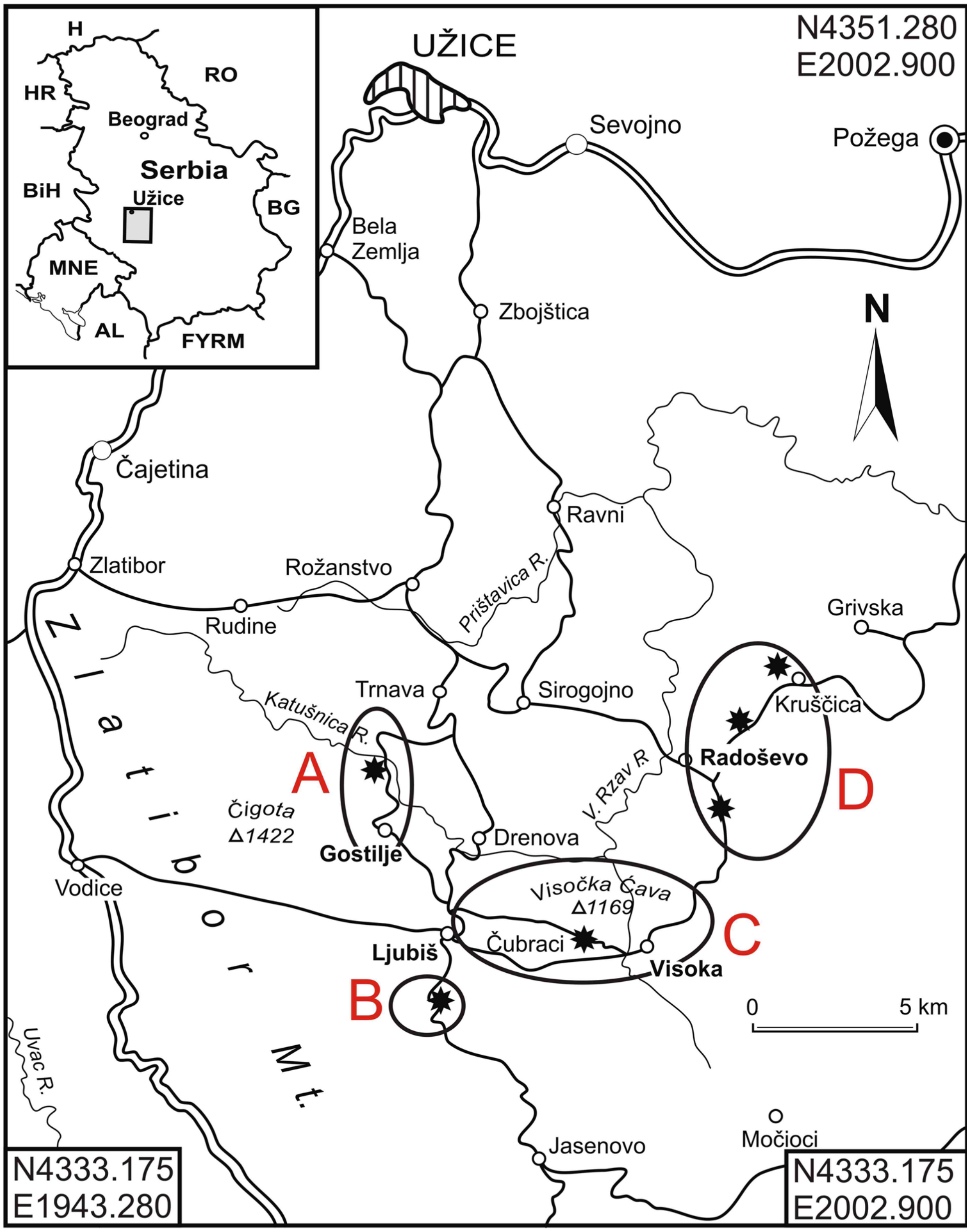


Fig. 3 Geographic sketch map showing the main study areas (marked by a *circle*) of the Gostilje–Ljubiš–Visoka–Radoševo mélange in southwest Serbia. *A* Gostilje area: Katušnica River direction Gostilje, *B* Ljubiš area in direction Jasenovo, *C* Visoka area, *D* Radoševo area on the road Visoka–Kruščica

Hellenides, were all mélanges with oceanic components and/or distal margin derived carbonate clasts are dated as Middle Jurassic to early Late Jurassic (e.g., Baumgartner 1985; Kozur and Mostler 1992; Mock et al. 1998; Gawlick et al. 2008, 2009a, b; Missoni and Gawlick 2011a; Ozsvárt et al. 2012; Ferriére et al. 2015, 2016). Gawlick et al. (2009b, 2010), however, showed that the mélange formation in the Dinarides also started earlier: Bathonian/Callovian to Oxfordian dated by means of radiolarians from the matrix of several sedimentary mélange bodies in the Dinaridic Ophiolite Belt and contemporaneous with mélange formation all over northern Albania (Gawlick et al. 2008, 2016). Therefore, mélange formation is contemporaneous with the formation of the metamorphic sole (Karamata 2006) indicating late Early Jurassic to Middle Jurassic convergence. The metamorphic sole was formed during intra-oceanic subduction, but contemporaneously formed (late Early to early Middle Jurassic) intra-oceanic mélanges were not dated so far. The onset of obduction is indicated by the incorporation of continental slope and distal shelf sediments and is Middle Jurassic in age. Ongoing westward-directed ophiolite obduction is accompanied by continuous mélange formation until the latest Jurassic to Early Cretaceous.

2 Geological overview

The ophiolites in Serbia occur in three geographically-separated belts (Fig. 2b1), ages of ocean-floor formation and consumption of these three different ophiolite belts, which should represent different oceans according to some authors, are controversially discussed (summarized in Kovács et al. 2011; Haas et al. 2011). The ophiolite suite is closely-associated with radiolarites and ophiolitic mélanges containing blocks up to one kilometre in size. These belts are:

1. Vardar Zone: Main Vardar Zone and Vardar Zone Western Belt according to Karamata (2006) and Robertson et al. (2009). These two Belts are assumed to represent two different oceanic basins with the Jadar/Kopaonik microcontinent in between. The opening of the Main Vardar Zone was in the Late Palaeozoic and closure in the late Early to early Late Jurassic (Karamata 2006). Vardar Zone Western Belt starts to open in the Late Triassic, and its closure started in the Middle Jurassic and continued until the latest Cretaceous (Karamata 2006).
2. Dinaridic Ophiolite Belt. According to Schmid et al. (2008): West Vardar ophiolites = Dinaridic Ophiolite Belt. Opening in the Middle Triassic and closure in the Middle to Late Jurassic.

Another group of authors favour a Middle Triassic opening of one oceanic domain in the east (ages of the ocean floor summarized in Schmid et al. 2008; Chiari et al. 2011; Ozsvárt et al. 2012; Ferriére et al. 2015, 2016), and a Middle-Late Jurassic closure.

The studied localities of the Gostilje–Ljubiš–Visoka–Radoševo mélange are located in southwestern Serbia (Fig. 3). Originally, the mélange can be considered as a sedimentary trench-like basin fill (sedimentary mélange), the components rest in an argillaceous-radiolaritic and sandy (consisting of basaltic detritus) matrix (Kossmat 1924; exotic blocks in a radiolaritic matrix deposited as turbidity currents: Gawlick et al. 2008). A lot of earlier authors (since Ampferer and Hammer 1918, 1923) interpreted the Triassic slides and blocks together with the (Jurassic) cherty matrix as a Triassic or Triassic to Jurassic coherent sequence consisting of siliceous limestones, radiolarites, sandstones, ultramafic rocks, and pelagic and neritic limestones, i.e. "Diabas-Hornstein Formation", occurring in two distinct Triassic levels (Ampferer and Hammer 1923). In contrast, Kossmat (1924) attributed most of the occurrences to the Jurassic, others to the Middle Triassic. Later, Ćirić (1954) termed the Triassic occurrences Porphyrite-Chert Formation, and the Jurassic ones Diabase-Chert Formation. Others noticed for parts of the "Diabas-Hornstein Formation" a block in matrix structure and termed it mélange, but without a genetic interpretation (e.g., Ćirić 1984). Since Obradović and Goričan (1988) this discussion became obsolete, and at least since Dimitrijević et al. (2003) the mélange character of these deposits was accepted, but far from being understood due to the lack of matrix ages and detailed component analysis.

Gawlick et al. (2009b), Lein et al. (2010), Sudar et al. (2013) and Missoni et al. (2012) showed in a first detailed component analysis that the limestone blocks were originally deposited in an outer shelf area. From their lithostratigraphy, microfacies, and tectonostratigraphic evolution they exactly resemble the distal passive margin sequences also known from the Eastern Alps, the Western Carpathians, several units in the Circum-Pannonian realm, or the Albanides (e.g., Gawlick et al. 1999, 2008; Kovács et al. 2011; Missoni and Gawlick 2011a, b). The provenance area of these limestone blocks is therefore the distal passive margin facing the Neo-Tethys Ocean to the east. The sub-ophiolitic Gostilje–Ljubiš–Visoka–Radoševo mélange contains blocks from the distal shelf area and the oceanic realm, the latter so far only proven by ophiolitic rocks but not by the ocean-floor sedimentary cover.

3 Materials and methods

From the Gostilje–Ljubiš–Visoka–Radoševo mélange about 50 samples of the turbiditic radiolaritic or radiolaritic-argillaceous to fine-grained sandstone matrix as well of radiolarites from clasts and blocks were processed in diluted (3%) hydrofluoric acid. Only a few samples yielded identifiable radiolarians. The ~55 conodont samples were processed in diluted acidic acid. Only a few samples yielded identifiable conodonts. The microfacies of the different limestones and radiolarites and the preservation of radiolarians were studied in thin sections. Here, we only present the results of the Triassic radiolarite clasts and the Jurassic matrix radiolarians in a detailed documentation, because they are of special importance for the reconstruction of the consumed oceanic domain in the Dinarides. For the shallow- and deep-water Triassic limestone blocks, the microfacies characteristics are documented.

Rock samples, thin sections, and photographed radiolarian samples named with 'SRB', are stored at the University of Leoben, Department of Applied Geosciences and Geophysics, Chair of Petroleum Geology. The conodont samples and thin sections named with 'MS', are archived at the University of Belgrade, Faculty of Mining and Geology.

4 Results: biostratigraphy and microfacies

Beside the biostratigraphic age, microfacies analysis of both radiolarites and limestones provides information about their depositional setting (e.g., relative water depth, transport regime, environment—e.g., bioturbating biota,

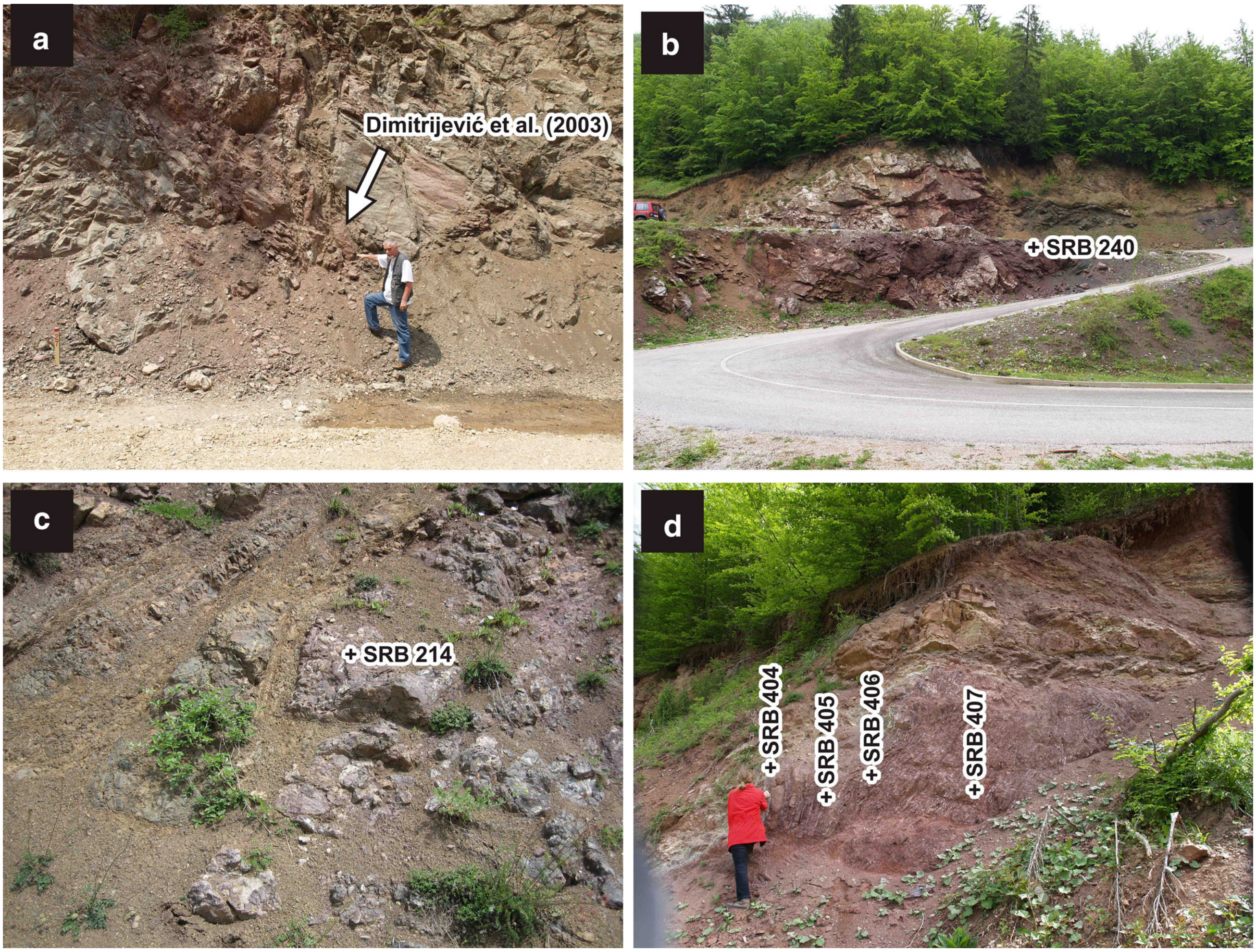


Fig. 4 Characteristic features of the Gostilje–Ljubiš–Visoka–Radoševo mélange. **a** Ophiolitic mélange with Late Triassic red calcareous-radiolarite blocks (see Dimitrijević et al. 2003) on the road from Katušnica River torwards Gostilje. **b** Double curve south of Ljubiš in direction to Jasenovo. Carbonate and ophiolite blocks in a radiolaritic-argillaceous matrix. The sample SRB 240 yield Callovian—Middle Oxfordian radiolarians. **c** Thinly-bedded radiolarite block together with blocks from the ophiolite suite in a radiolaritic-argillaceous matrix with turbidites consisting of ophiolitic sand. The sample SRB 214 yielded Norian radiolarians. **d** Block of a Late Ladinian to ?earliest Carnian radiolarite-limestone succession in the Visoka mélange. The sample SRB 405 yielded Longobardian to earliest Carnian radiolarians

oxygen content) and diagenetic overprint. Whereas microfacies analysis of limestones is a common tool to describe their depositional setting (Flügel 2004), microfacies analyses of radiolarites remain rare but provide besides the overall lithofacies and the sedimentation rate (Jenkyns and Winterer 1982; De Wever et al. 2001; Baumgartner 2013) a powerful tool for the reconstruction of the depositional realm of radiolaritic sequences (Gawlick and Missoni 2015; Gawlick et al. 2016). Particular radiolarite microfacies are typical for certain age ranges, as differences in microfacies not only reflect the relative water depth (deposition on shelf areas versus deposition on oceanic crust), but also as the size of the radiolarians and accompanying organisms (filaments, shells) differ in relation to their age (Figs. 4, 5, 6, 7, 9, 10).

4.1 Triassic radiolarites

The samples SRB 212–215 derive from different radiolarite blocks and clasts in the Gostilje area, south of the Katušnica River on the road in direction to Gostilje (A in Figs. 3, 4a, c). The radiolarite sample SRB 403-407 derive from the Visoka area (locality Čubraci, C in Figs. 3, 4d) and are from a block with red laminated radiolarites at the base and increasing carbonate content upsection. Samples SRB 408–409 derive from a basalt-radiolarite block from the Radoševo area (D in Fig. 3), along the road from Visoka to Kruščica. This block is most probably the same basalt-radiolarite block from the Visoka section, which was dated by Vishnevskaya et al. (2009) as late Ladinian to Carnian, because it seems to

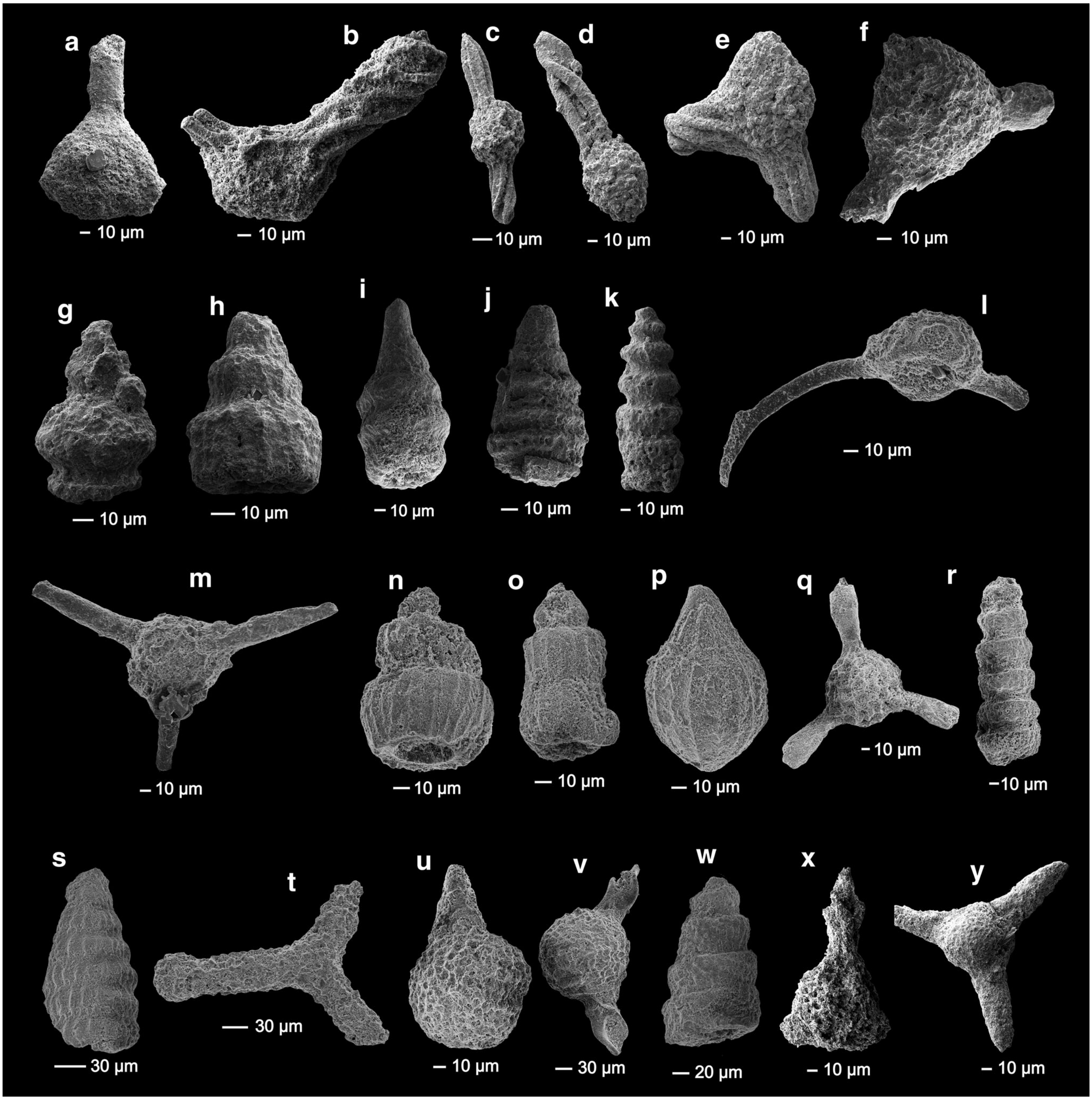
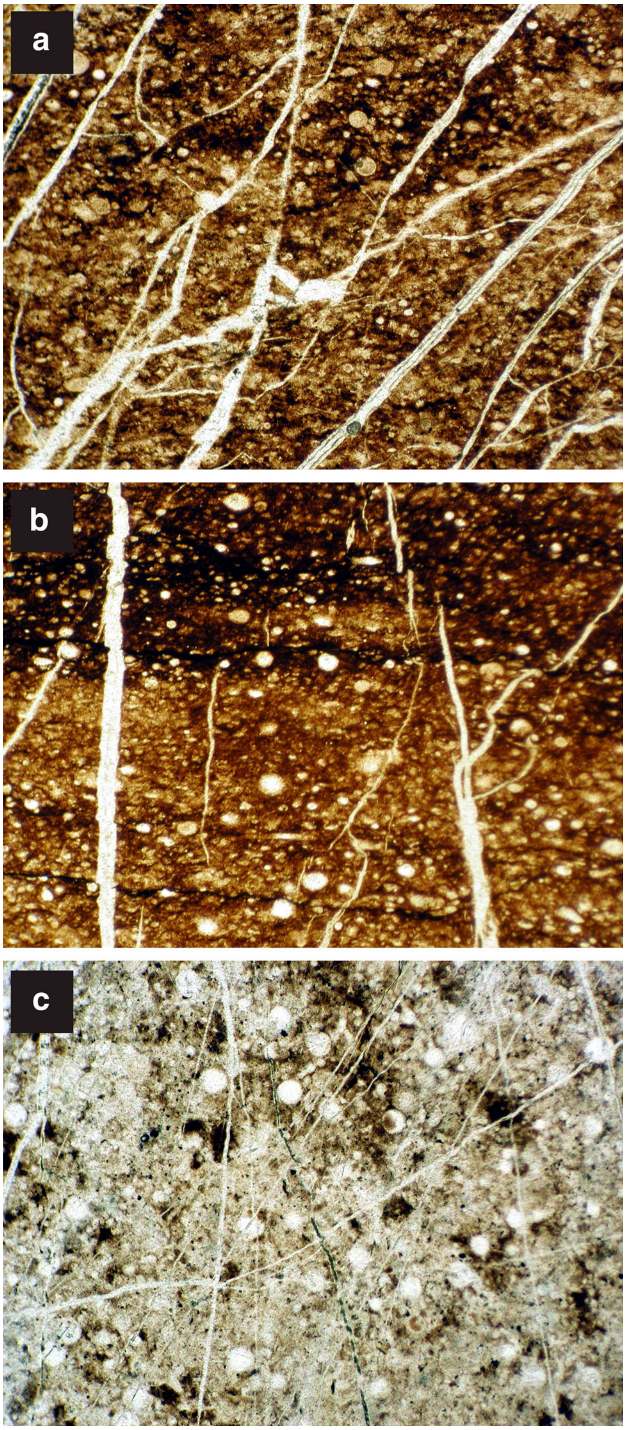


Fig. 5 Middle to Late Triassic (?Late Anisian to Norian) radiolarians from the Gostilje–Ljubiš–Visoka–Radoševo mélange. Samples SRB 212–215 stem from the road south of the Katušnica River (Gostilje area), sample SRB 405 from the Visoka area. Radiolarians of sample SRB 212 (most probably Late Ladinian–Early Carnian): **a** Capnuchosphaeridae, gen. et sp. indet. **b** Muelleritortiidae, gen. et sp. indet. Radiolarians of sample SRB 405 (Late Ladinian–?earliest Carnian). **c** *Ditortis recskensis* Kozur. **d** *Pseudostylosphaera* sp. (cf. *nazarovi* Kozur & Mostler). **e** *Muelleritortis* sp. Radiolarians of sample SRB 215 (Carnian): **f** ?*Capnuchosphaera* sp. **g** ?*Yeharaia* sp. **h** *Nakasekoellus* sp. **i** *Spinotriassocampe* sp. **j** *Triassocampe* cf. *sulovensis* Kozur & Mock. **k** *Triassocampe* sp. Radiolarians of sample SRB 213 (Carnian/Norian-boundary). **l** *Poulpus piabyx* De Wever. **m** *Capnodoce sarisa* De Wever. **n** *Nakasekoellus inkensis* Kozur. **o** *Nakasekoellus* sp. **p** *Praeprotunuma* cf. *antiqua* Tekin. **q** *Capnodoce anapetes* De Wever. **r**? *Pararuesticyrtium* sp. **s** *Corum regium* Blome. **t** *Paronaella* sp. **u** *Stichocapsa* sp. **v** *Capnuchosphaera* cf. *triassica* De Wever. **w** *Pachus* sp. Radiolarians of sample SRB 214 (Norian): **x** ?*Cantalum* sp. **y** *Livarella* sp

be the only basalt-radiolarite block in the area. In general, the preservation of radiolarians, from the studied samples, is very poor, and only a few of them could be identified at species level (Fig. 5). Nonetheless, a closer age determination was possible in five samples: SRB 212–215, and SRB 405.



◀**Fig. 6** Microfacies of the Triassic ribbon radiolarites south of Katušnica River on the road towards Gostilje. **a** Reddish unlaminated radiolarian wackestone, most probably of Middle Triassic age. All radiolarians are recrystallized to quartz. Sample SRB 212. **b** Reddish-brownish slightly bioturbated and clayey radiolarite around the Carnian/Norian-boundary (radiolarian wacke- to packstone). The preservation of the radiolarians is moderate; the inner parts of the tests are filled with quartz. Sample SRB 213. **c** Massive chertified Norian red-grey radiolarian packstone. Nearly all radiolarians are recrystallized to quartz. Due to intense recrystallization the preservation of the radiolarians is very poor. Sample SRB 214. Width of all photos: 0.5 cm

4.1.1 Sample SRB 212

Bedded red radiolarite. Non-laminated radiolarian wackestone (Fig. 6). The radiolarians are completely recrystallized. The microfacies resembles Middle Triassic oceanic radiolarites as described by Gawlick et al. (2008, 2016). Radiolarians can be determined only at family level, i.e. Capnuchosphaeridae gen. et sp. indet. and Muelleritortiidae gen. et sp. indet. The family Muelleritortidae occurs in the Longobardian (Upper Ladinian) to Cordevolian (Early Carnian) (Kozur and Mostler 1996). The occurrence of Capnuchosphaeridae is consistent with this stratigraphic range.

4.1.2 Sample SRB 213

Bedded reddish-brownish radiolarite. Slightly-bioturbated radiolarian wackestone with relative good preservation of the radiolarians with following radiolarian taxa: *Capnodoce anapetes* De Wever, *Capnodoce sarisa* De Wever, *Capnuchosphaera* cf. triassica De Wever, *Corum regium* Blome, *Nakasekoellus inkensis* Kozur, *Poulpus piabyx* De Wever, *Praeprotunuma* cf. *antiqua* Tekin, *Pachus* sp., ?*Pararuesticyrtium* sp., *Paronaella* sp., *Stichocapsa* sp. *Nakasekoellus inkensis* occur in the Late Carnian (Middle Carnian cannot be excluded according to Kozur and Mostler 1994). Other species like *Capnuchosphaera triassica*, *Poulpus piabyx*, *Capnodoce sarisa* and *Capnodoce anapetes* (≈*Capnodoce ruesti*) indicate an Early Norian age. Therefore the age of this sample is around the Carnian/Norian boundary.

4.1.3 Sample SRB 214

Thinly-bedded reddish-grey radiolarite. The microfacies shows a bioturbated, massive chertified radiolarian wacke- to packstone (Fig. 6). The sample is characterized by the occurrence of *Livarella* sp., ?*Cantalum* sp. and Capnuchosphaeridae. The genus *Livarella* is typical for the Middle Norian to Rhaetian (Sugiyama 1997). Other authors assign the first occurrence of the genus *Livarella* to the Late Norian (Yeh 1992; Tekin 1999; Bragin 2007; O'Dogherty et al. 2009a, 2010), Capnuchosphaeridae occur in the time span Ladinian to Norian (De Wever et al. 2001). The age of the sample is therefore Norian.

4.1.4 Sample SRB 215

Bedded reddish-grey radiolarian wackestone containing *Nakasekoellus* sp., *Triassocampe* cf. *sulovensis* Kozur &

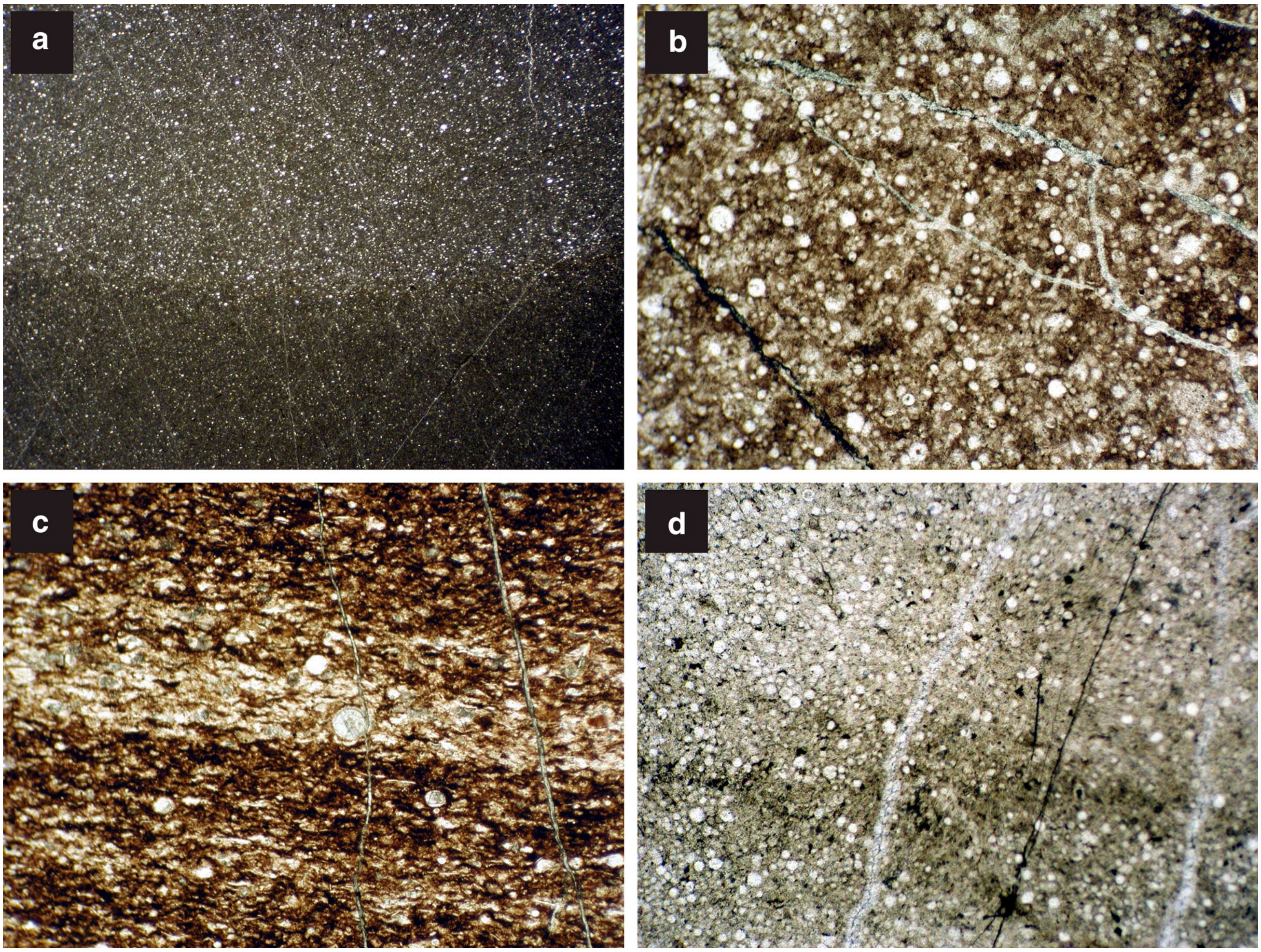


Fig. 7 Microfacies of a Longobardian to ?earliest Carnian distal shelf radiolarite-limestone succession in the Visoka mélange (samples SRB 403–407) and a Carnian ribbon radiolarite from a basalt-radiolarite block (Radoševo area, samples SRB 408, SRB 409). **a** Layered Late Ladinian to ?Early Carnian pelagic cherty limestone with recrystallized radiolarians. Wackestone in the lower part a (*dark grey*) layer overlain by a turbiditic radiolarian packstone in the upper part. Sample SRB 404. Width of the photo: 1.4 cm. **b** Late Ladinian to Early Carnian reddish bioturbated radiolarian packstone. All radiolarians were silicified by silicate-rich pore fluids. Sample SRB 406. Width of the photo: 0.5 cm. **c** Laminated late Middle Triassic red radiolarite, radiolarian wacke- to packstone with filaments, partly broken. Nearly all radiolarians were silicified by silicate-rich pore fluids. Sample SRB 407. Width of the photo: 0.5 cm. **d** Grey Early Carnian ribbon radiolarite from the sedimentary cover of a radiolarite-basalt block. Massive chertified radiolarian packstone. Nearly all radiolarians are recrystallized to quartz. Sample SRB 408. Width of the photo: 0.5 cm

Mock, ?*Triassocampe* sp., *Spinotriassocampe* sp., ?*Yeharaia* sp., ?*Capnuchosphaera* sp. The genus *Nakasekoellus* occurs in the Late Carnian to the Middle Norian (Tekin 1999), *Triassocampe sulovensis* has an age range from the Late Ladinian to the Middle Carnian (Tekin 1999). Therefore, the age of this sample is most probably Middle-Late Carnian. The other taxa in the assemblage are in agreement with this age assignment but have longer ranges.

4.1.5 Sample SRB 405

Middle part of an approximately 9–10 m thick block with a preserved Late Ladinian to ?earliest Carnian radiolarite-limestone sequence. This sample contains *Ditortis recskensis* Kozur, ?*Pseudostylosphaera* sp. (cf. *nazarovi* Kozur & Mostler), and *Muelleritortis* sp. *Ditortis recskensis* should be restricted to the Longobardian to earliest Carnian (Kozur 1988).

The microfacies of the radiolarites and limestones of this block from the Visoka area (sample SRB 405), are: bioturbated massive radiolarian wacke- to packstones and layered radiolarian- and filament-bearing radiolarite (Fig. 7a–c). This radiolarite type, beside the intercalations of open-marine limestone layers in the upper part of the section, is typical for a distal shelf environment as described by Gawlick and Missoni (2015) and Gawlick et al. (2016).

A similar section of reddish cherty limestones and cherts associated with basalt and basalt breccia was described and dated by Vishnevskaya and Djerić (2009) and Vishnevskaya et al. (2009) along the road between Visoka and Radoševo (?Radoševo area). From the lower part of the radiolarite-limestone sequence these authors dated radiolarians as Ladinian, or even Late Ladinian. From the uppermost part of same section (radiolarite-basalt block) a well-preserved radiolarian assemblage was assigned to the Late Ladinian-Carnian.

The microfacies of Late Ladinian–Early Carnian radiolarites from our radiolarite-basalt block along the road Visoka to Kruščica (Radoševo area) is quite different from the radiolarite-limestone succession describe above and is typical for oceanic ribbon radiolarites (Fig. 7d).

4.2 Triassic limestones

Triassic limestone samples derive from limestone blocks and clasts. Most of the carbonate blocks show intense fracturing or shearing, and conodonts are therefore extremely scarce. Only a few of the numerous samples from the limestones yielded identifiable conodonts in the areas around Visoka and Radoševo; two samples in the Visoka area (C in Fig. 3) around Čubraci (SRB 488), on the road from Gostilje to Visoka (SRB 565); and two samples in the Radoševo area (D in Fig. 3), i.e. north of the school in Kruščica (SRB 557, SRB 558). Around the summit of Visočka Ćava (1169 m) (C in Fig. 3) many blocks of cherty limestones of different size also occur. Their microfacies corresponds to the limestones of types 1–3, described below. Radiolarian filament-wackestones dominate, while fine-grained turbiditic layers rarely occur. From these limestones only 11 out of 35 samples yielded determinable conodonts: MS 1612, MS 1614, MS 1615, MS 1618, MS 1622, MS 1625, MS 1630, MS 1646, MS 1647, MS 1648, and MS 1649. Age ranges of these conodonts are given according to Budurov and Sudar (1990), Orchard (2010) and Noyan and Kozur (2007).

4.2.1 Sample SRB 488

Bedded cherty limestone (radiolarian wacke- to packstone). Thin limestone beds alternate with thick chert layers and greenish-grey marl intercalations. The radiolarians are enriched in turbiditic layers. The sample contains *Epigondolella* sp., a not exactly determinable form but typical for the late Middle to Late Norian.

4.2.2 Sample SRB 565

Bedded cherty limestone (radiolarian wackestone) with fine-grained turbidite layers consisting of filaments with crinoid debris. The sample contains *Epigondolella quadrata* Orchard. The age is Early Norian (late Early Lacian).

4.2.3 Sample SRB 557

Bedded cherty limestone (radiolarian-filament wackestone) with fine-grained turbidite layers consisting of filaments. The sample contains *Epigondolella rigoi* Kozur. The age is middle Early Norian (Middle Lacian).

4.2.4 Sample SRB 558

Bedded cherty limestone (radiolarian wackestone) with fine-grained turbidite layers consisting of filaments with fine-grained crinoid debris and radiolarians. The sample contains *Epigondolella rigoi* Kozur. The age is middle Early Norian (Middle Lacian).

4.2.5 Samples MS 1647, MS 1649

These samples contain *Paragondolella nodosa* (Hayashi) and *Paragondolella polygnathiformis* (Budurov & Stefanov). The age is latest Carnian to Late Tuvalian.

4.2.6 Samples MS 1615, MS 1618, MS 1646

They yield an assemblage consisting of *Epigondolella abneptis* (Huckriede), *Epigondolella echinata* (Hayashi), and *Metapolygnathus communisti* Hayshi. The age is earliest Norian (Early Lacian).

4.2.7 Samples MS 1625, MS 1648

These samples contain *Epigondolella abneptis* (Huckriede), *Norigondolella hallstattensis* Mosher and *Norigondolella navicula* (Huckriede). The age of this assemblage is middle Early Norian (late Middle Lacian).

4.2.8 Samples MS 1612, MS 1622

In these samples *Ancyrogondolella triangularis* Budurov, *Epigondolella abneptis* (Huckriede), and *Norigondolella hallstattensis* Mosher occur. The age is Early Norian (late Middle Lacian to early Late Lacian).

4.2.9 Samples MS 1614, MS 1630

These samples contain *Epigondolella abneptis* (Huckriede) and *Epigondolella postera* (Kozur & Mostler). The age is Middle Norian (Middle–Late Alaunian).

The lithologies and microfacies of the different limestone blocks can be grouped as follows (Figs. 8, 9):

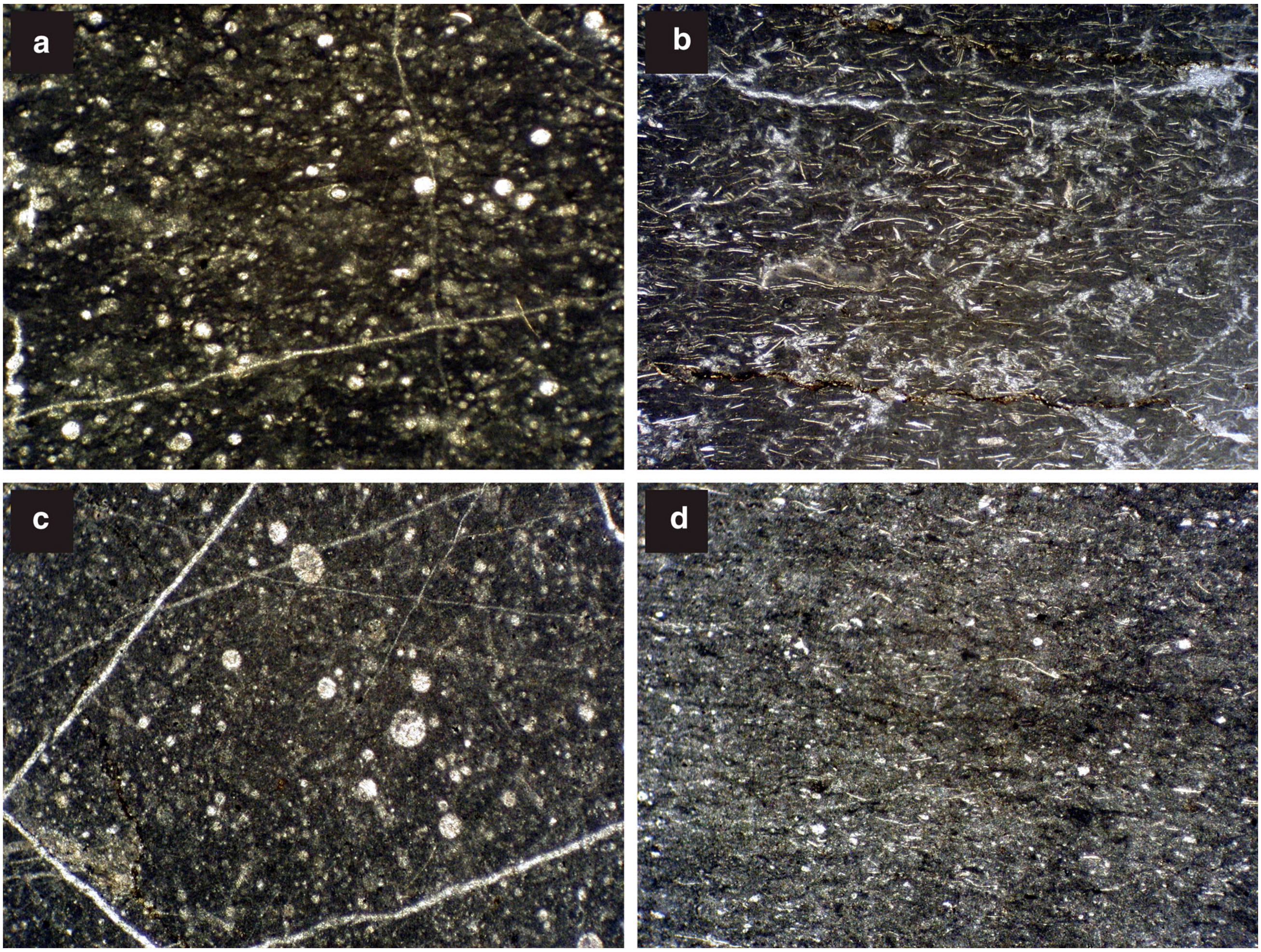
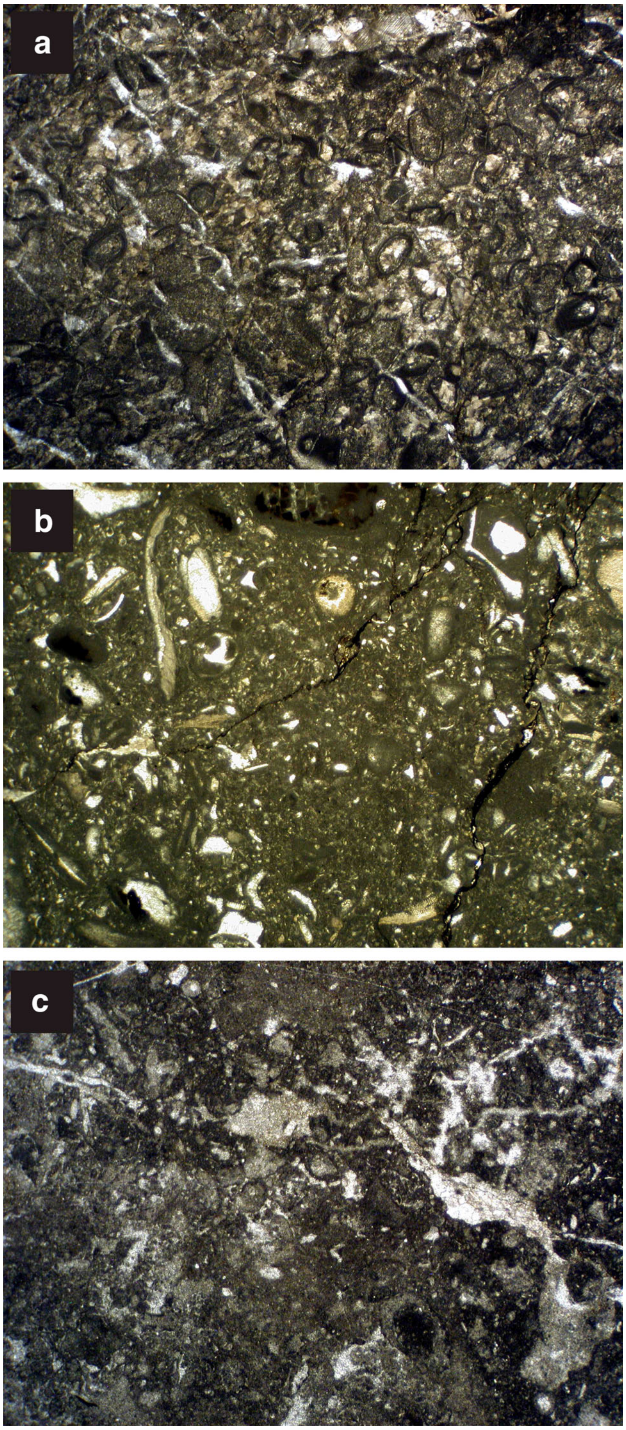


Fig. 8 Microfacies characteristics of the Late Triassic grey cherty limestones. All samples are from the Radoševo area. **a** Middle to Late Norian radiolarian wackestone to packstone. Sample SRB 489. Width of the photo: 0.5 cm. **b** Middle Early Norian filament limestone with radiolarians. The filament layers occur as turbiditic intercalations in radiolarian wackestones. Sample SRB 557. Width of the photo: 1.4 cm. **c** Earliest Early Norian radiolarian wacke- to packstone. Sample SRB 565. Width of the photo: 0.5 cm. **d** Marly radiolarian and filament layered wackestone below SRB 565, most probably Carnian. Sample SRB 564. Width of the photo: 0.5 cm

1. Dm-bedded, micritic cherty limestones, occasionally with very fine-grained turbiditic layers or marly layers. This limestone type either occurs as several metres thick blocks or as tens of metres thick blocks with preserved slump folds. This limestone type is the most common in the Visoka mélange area and of Early Norian age. The microfacies resembles exactly the microfacies known from the Early Norian Massiger Hellkalk of the Hallstatt Facies Zone, or the Pötschen Limestone of the Meliata Facies Zone (Fig. 8). Lithology and microfacies combined point to an intermediate type between Hallstatt and Pötschen facies, i.e. deposition on the continental slope.
2. Grey, thilny-bedded cherty limestones with intercalated turbidites with filaments and radiolarians. Similar to (1). Age most probably Late Triassic.
3. Bedded, micritic cherty limestones with thick chert layers and greenish-grey marls. Middle to Late Norian. Lithology and microfacies resembles the Pötschen Limestone of the Meliata Facies Zone.
4. Dark grey dolomitic limestones either with a mudstone or a microbial fabric. In rare cases ghosts of single-ooids occur. This microfacies is characteristic for the latest Early Triassic to Early Anisian shallow ramp deposits and is identical with the upper part of the Werfen Formation or the lower part of the Gutenstein Formation as known everywhere in the western Tethyan realm.
5. Light-grey, massive shallow-water limestones, often recrystallized, with ooids and small pieces of calcareous algae, in cases with a few crinoids. Lithology and microfacies of these limestones are typical for the Middle Pelsonian Ravni Formation.



◀**Fig. 9** Microfacies of the Anisian shallow-water carbonates and their drowning sequence. **a** Ooidal grainstone with shell and algae fragments. Most probably Middle Anisian. Sample SRB 486 from the Katušnica River. Width of the photo: 1.4 cm. **b** Marly packstone with shells and gastropods, crinoids, echinoids, microbial encrusted components and other components from a shallow-water area. This facies type could represent the drowning sequence of the Middle Anisian Ravni (Steinalm) carbonate ramp. Sample SRB 485 from the Katušnica River. Width of the photo: 1.4 cm. **c** Microbial slightly dolomitic limestone with few shell fragments. This microfacies is typical for the late Early to Middle Anisian (upper Gutenstein type) carbonate ramp. Sample SRB 560 from Radoševo area. Width of the photo: 1.4 cm

6. Dark grey marly limestones intercalated with dark grey marl- and claystones. Crinoids are the dominating organisms beside broken shells and echinoid fragments; components with encrusting organisms occur rarely besides broken foraminifera and gastropods. Age: unknown, probably early Late Anisian.

4.3 Middle to early Late Jurassic radiolarites

All described Triassic clasts and blocks in the Gostilje–Ljubiš–Visoka–Radoševo mélange (Fig. 3) occur in a Middle to early Late Jurassic radiolaritic-argillaceous to sandstone matrix. The matrix is mainly turbiditic, but the lamination of the radiolarites is mostly destroyed by bioturbation. First rough biostratigraphic age data (Middle Jurassic) were given by Lein et al. (2010). Only two radiolarian samples yield radiolarians (Figs. 10, 11), one sample (SRB 216) from the radiolaritic-argillaceous matrix near Katušnica River on the road direction Gostilje (A in Fig. 3) and the other sample (SRB 240) from the double curve south of Ljubiš in direction Jasenovo (B in Fig. 3).

The dating is based on Baumgartner et al. (1995) and Suzuki and Gawlick (2003a). We also considered publications, in which the proposed ranges of some species were extended (e.g., Suzuki et al. 2001; O'Dogherty et al. 2006, 2009b; Suzuki and Gawlick 2009; Auer et al. 2009; Goričan et al. 2012), but we still follow the nomenclature of Suzuki and Gawlick (2003b).

4.3.1 Sample SRB 216

Greenish-grey slightly sheared radiolarite near Katušnica River on the road towards Gostilje. The microfacies shows a bioturbated radiolarite (Fig. 10). Several radiolarians are filled with glauconitic material. The sample contains *Tritrabs* sp., *Archaeodictyomitra* cf. *rigida* Pessagno, *Eucyrtidiellum* cf. *unumaense* (Yao), *Gongylothorax* cf. *favosus* Dumitrica, and *Williriedellum dierschei* Suzuki & Gawlick. The age of the assemblage is late Middle to early Late Jurassic (Callovian to Middle Oxfordian).

4.3.2 Sample SRB 240

Bedded reddish radiolarites with intercalated turbidites consisting of ophiolitic sand, on a double curve of the road between Ljubiš and Jasenovo (see Fig. 4d). This sample yields following radiolarian taxa:

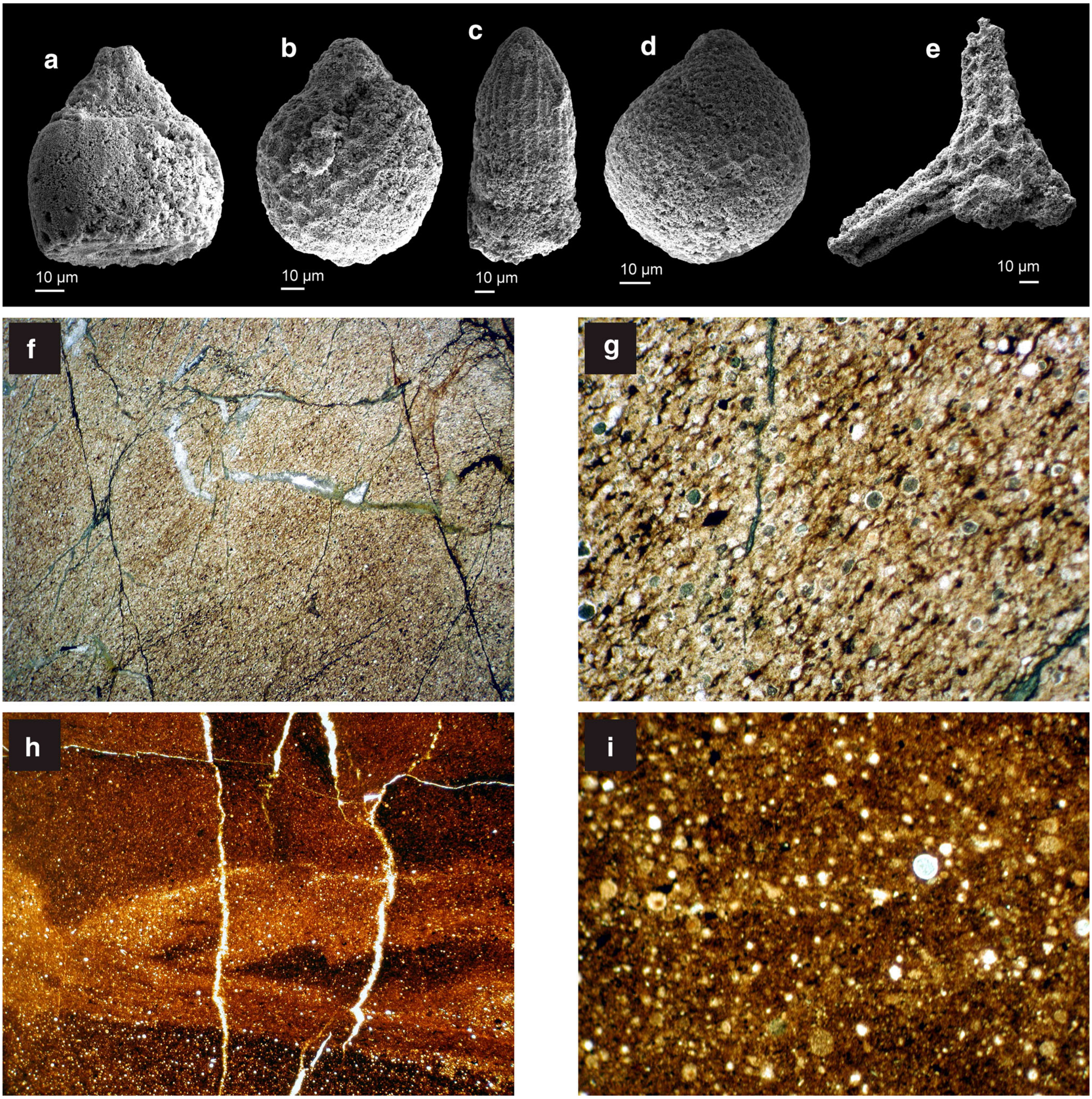


Fig. 10 Late Middle to early Late Jurassic (Callovian to Middle Oxfordian) radiolarians and microfacies from the road south of the Katušnica River. Under low temperature suboxic conditions in the sediment, ferric hydroxides were converted to iron sulphides through various reductive processes associated with organic matter degradation. **a** *Eucyrtidiellum* cf. *unumaense* (Yao). **b** *Williriedellum dierschei* Suzuki & Gawlick. **c** *Archaeodictyomitra* cf. *rigida* Pessagno. **d** *Gongylothorax* cf. *favosus* Dumitrica. **e** *Tritrabs* sp. Sample SRB 216. **f** Greenish-grey massive radiolarite of Callovian to Middle Oxfordian age. The fissures and partly also the radiolarians are filled by glauconite. Changing fluid chemistry in the factures and the radiolarian tests leads to an increase in the alkalinity with subsequent precipitation of glauconite cement and a degradation of the organic matter. Sample SRB 216. Width of the photo: 1.4 cm. **g** Magnification of **f**. Fissures and most radiolaria are filled with glauconite. These radiolaria have only a moderate preservation. The other radiolarians are recrystallized to quartz. Width of the photo: 0.25 cm. **h** Slightly bioturbated Middle Jurassic red layered radiolarian wackestone in gradual change to layers of biomineralized iron sulphides with altered organic matter. Sample SRB 217. Width of the photo: 1.4 cm. **i** Magnification of **h**. Bioturbated radiolarian packstone. All radiolarians are recrystallized. Width of the photo: 0.25 cm

Archaeodictyomitra rigida Pessagno, Eucyrtidiellum *unumaense* (Yao), *Eucyrtidiellum unumaense unumaense* (Yao), *Gongylothorax favosus* Dumitrica, *Gongylothorax* sp. C sensu Suzuki & Gawlick, *Helvetocapsa* cf. *matsuokai* (Sashida), *Praezhamoidellum* aff. *buekkense* Kozur, *Striatojaponocapsa conexa* (Matsuoka),

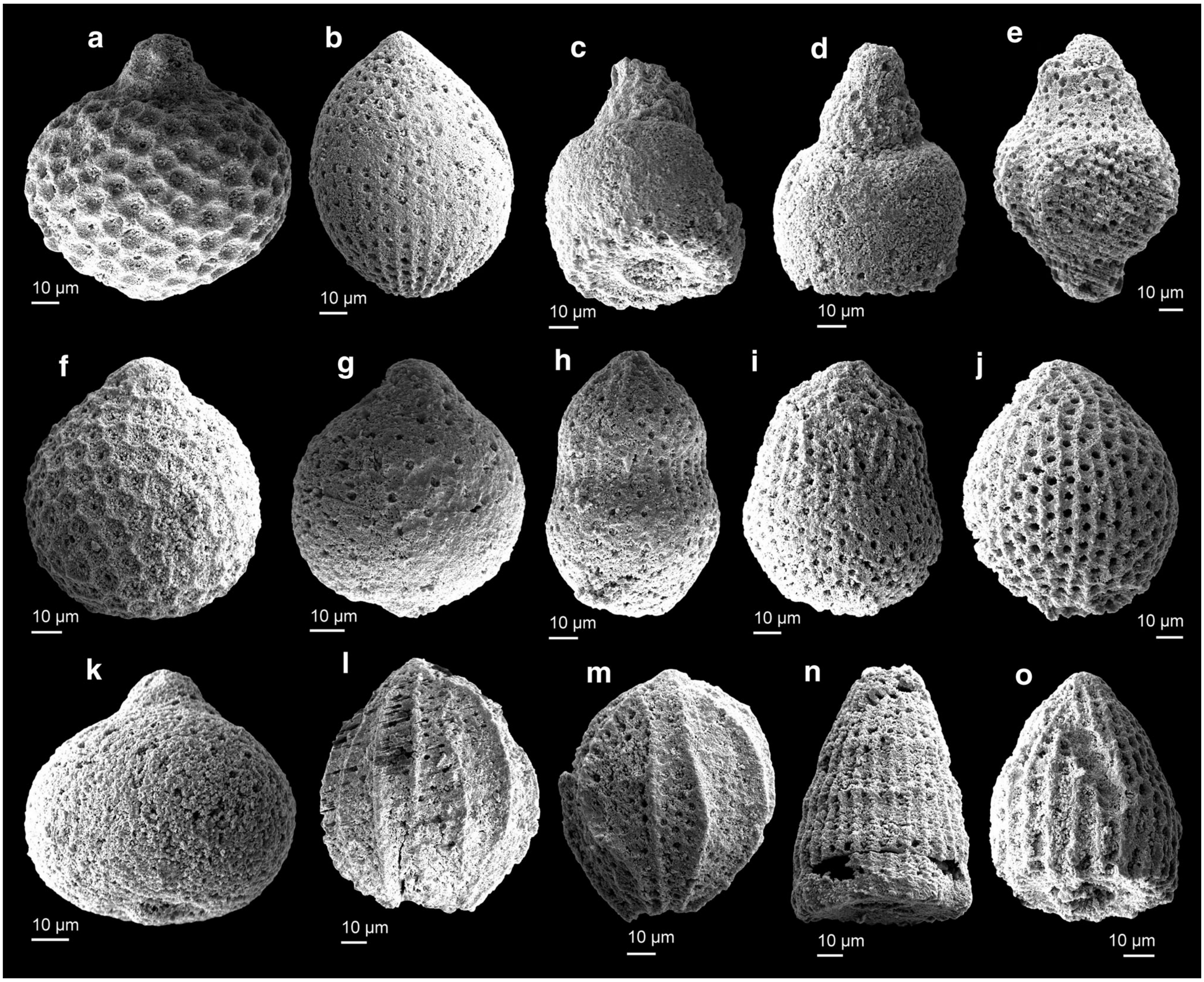


Fig. 11 Late Middle to early Late Jurassic (Callovian to Middle Oxfordian) radiolarians from sample SRB 240 from the double bend south of Ljubiš in direction Jasenovo. **a** *Williriedellum dierschei* Suzuki & Gawlick. **b** *Helvetocapsa* cf. *matsuokai* (Sashida). **c** *Eucyrtidiellum unumaense* (Yao). **d** *Eucyrtidiellum unumaense unumaense* (Yao). **e** *Unuma latusicostatus* (Aita). **f** *Gongylothorax favosus* Dumitrica. **g** *Gongylothorax* sp. C sensu Suzuki & Gawlick. **h** *Theocapsomma* cf. *cucurbiformis* Baumgartner. **i** *Theocapsomma medvednicensis* Goričan. **j** *Striatojaponocapsa conexa* (Matsuoka). **k** *Praezhamoidellum* aff. *buekkense* Kozur. **l** *Unuma* cf. *gordus* Hull. **m** *Unuma* sp. **n** *Archaeodictyomitra rigida* Pessagno. **o** *Archaeodictyomitra* sp

Theocapsomma cf *cucurbiformis* Baumgartner, *Theocapsomma medvednicensis* Goričan, *Unuma latusicostatus* (Aita), *Unuma* cf. *gordus* Hull, *Williriedellum dierschei* Suzuki & Gawlick.

Important for age determination for both samples is the occurrence of *Gongylothorax favosus* (Late Bathonian to Early Kimmeridgian) and *Eucyrtidiellum unumaense* (Bajocian to Middle/Late Oxfordian). Therefore, the age of this sample is Callovian to Middle Oxfordian. The other taxa in the assemblage are in agreement with this age assignment but have longer ranges.

5 Discussion

Although there are contrasting models about the palaeogeography in Triassic–Jurassic times in the western Tethyan realm (e.g., Stampfli and Kozur 2006; Schmid et al. 2008; Missoni and Gawlick 2011b; Robertson 2012), there is progress in the reconstruction of the age of lost oceanic domains and in the understanding of geodynamic processes in the Tethyan realm. Many new biostratigraphic data on Triassic and Jurassic radiolarites in mélange areas have recently been obtained in the Dinarides, Albanides and

Hellenides (e.g., Gawlick et al. 2008, 2016; Vishnevskaya et al. 2009; Djerić et al. 2010, 2012; Ozsvárt et al. 2012; Chiari et al. 2011, 2013; Bragin et al. 2014; Gawlick and Missoni 2015; Ferriére et al. 2015, 2016), but a lot of questions still remain open. Detailed microfacies investigations and biostratigraphic data allow detailed information about the depositional history for both the carbonate (e.g., Flügel 2004) and the radiolarite sequences. Such combined investigations on radiolarites are still rare (e.g., Gawlick et al. 2012, 2016; Gawlick and Missoni 2015), but the reconstruction of the depositional environment of radiolarites provides a number of answers for the open questions.

The investigations of the resedimented Middle to Late Triassic clasts in the late Middle to early Late Jurassic Gostilje–Ljubiš–Visoka–Radoševo mélange result in a reconstruction of their primary depositional realm and give further evidence on the Triassic–Jurassic geodynamic history as well as on the palaeogeographic evolution of the Dinarides, especially the Dinaridic Ophiolite Belt.

Blocks from the Neo-Tethys ocean floor with the preserved sedimentary cover rarely occur in the different mélanges of the Dinaridic Ophiolite Belt. One Late Ladinian (to Carnian) basalt-radiolarite block was described by Vishnevskaya et al. (2009), whereas younger ocean floor blocks were not detected. Also descriptions of Late Triassic ribbon radiolarites from the ocean floor remain rare (Goričan et al. 1999; Vishnevskaya et al. 2009; Gawlick et al. 2009b). Middle Triassic radiolarite blocks are more common (summarized in Chiari et al. 2011).

Ladinian, Late Ladinian, Carnian and Norian radiolarites occur in the blocks and clasts of the Gostilje–Ljubiš–Visoka–Radoševo mélange (Vishnevskaya et al. 2009; Fig. 12). Late Anisian to early Late Ladinian radiolarites either derive from the distal shelf to continental slope region or the oceanic realm, as expressed in a characteristic microfacies (e.g., Gawlick and Missoni 2015; Gawlick et al. 2016). Late Ladinian–earliest Carnian blocks either derive from the continental slope region (radiolarite-limestone sequence block; Fig. 4d) or the oceanic realm (basalt-radiolarite block—Vishnevskaya et al. 2009), as expressed in the characteristic microfacies (Fig. 7). All other latest Ladinian and Late Triassic radiolarite clasts derive from the oceanic realm. The absence of ribbon radiolarites on the continental margin is due to the fact that supply from shallow-water carbonate ramps and platforms led to the accumulation of a thick pile of carbonate mud on the distal shelf and partly even in the oceanic domain (Gawlick and Böhm 2000). This is valid for the late Middle and Late Triassic except the Julian stage. Accordingly, radiolarites of this age can only be expected in distal oceanic areas (Gawlick et al. 2008; Krische et al. 2014). For this reason, latest Ladinian to Late Triassic ribbon radiolarites are of special interest because only these indicate fragments of the Neo-Tethys oceanic realm (for review see Gawlick and Missoni 2015). In contrast, open marine, grey cherty limestones with some fine-grained shallow-water debris can derive either from an area between the distal passive margin or the continental slope near oceanic realm.

The palaeogeographic provenance of Triassic radiolarite clasts can therefore only be the continental slope or oceanic realm (Fig. 13) and not the central to distal shelf area (compare Gawlick et al. 2012; Gawlick and Missoni 2015). This is in accordance with the litho- und microfacies of the Late Triassic carbonate clasts and blocks in the Gostilje–Ljubiš–Visoka–Radoševo mélange, which derive exclusively from the continental slope or the continental slope near the oceanic realm (Meliata facies). These open marine limestone blocks occur together with late Early Triassic to early Middle Triassic (Pelsonian) shallow-water carbonates. Late Pelsonian drowning of the older shallow-water carbonate ramp sediments is contemporaneous with the break-up of the Neo-Tethys (see Sudar et al. 2013 for a review).

From the newly-discoverd and dated clasts with a continental slope provenance, the following Triassic sedimentary succession can be reconstructed: an Early–Middle Anisian shallow-water ramp, a Late Anisian drowning sequence (marly limestones), ?Late Anisian–Ladinian radiolarites, latest Ladinian/earliest Carnian to Late Norian grey cherty limestones. This sedimentary succession resembles exactly the reconstructed sedimentary sequence from the clasts in the Meliata mélange of the type-locality in the Western Carpathians (Gawlick and Missoni 2015).

The Late Triassic cherty limestones in the Gostilje–Ljubiš–Visoka–Radoševo mélange resemble the microfacies of the Pötschen Limestone in the Northern Calcareous Alps. The Pötschen Limestone sequence of the type locality was assumed by Missoni and Gawlick (2011a) as having been deposited on the continental slope and belonging therefore to the Meliata Facies Zone (Fig. 13) and not to the near reef Zlambach Facies Zone (grey Hallstatt facies: Lein 1987). In Serbia, this near reef open marine facies belt is preserved in the Kopaonik unit east of the Drina-Ivanjica unit (Schefer et al. 2010).

The Gostilje–Ljubiš–Visoka–Radoševo mélange is, according to recent descriptions and definitions (as summarized in Chiari et al. 2011), a typical sub-ophiolitic mélange and consist of a mixture of blocks and slices of the oceanic domain (e.g., oceanic rocks: ultramafic rocks, gabbroic and basaltic rocks; oceanic sediments: ophicalcites, radiolarites, deep-sea clays; amphibolites) and the obducted former distal passive margin, i.e. the continental slope (Meliata facies: Fig. 13). These blocks are incorporated in a sedimentary matrix, very often turbiditic argillaceous-radiolaritic sediments and coarser-grained

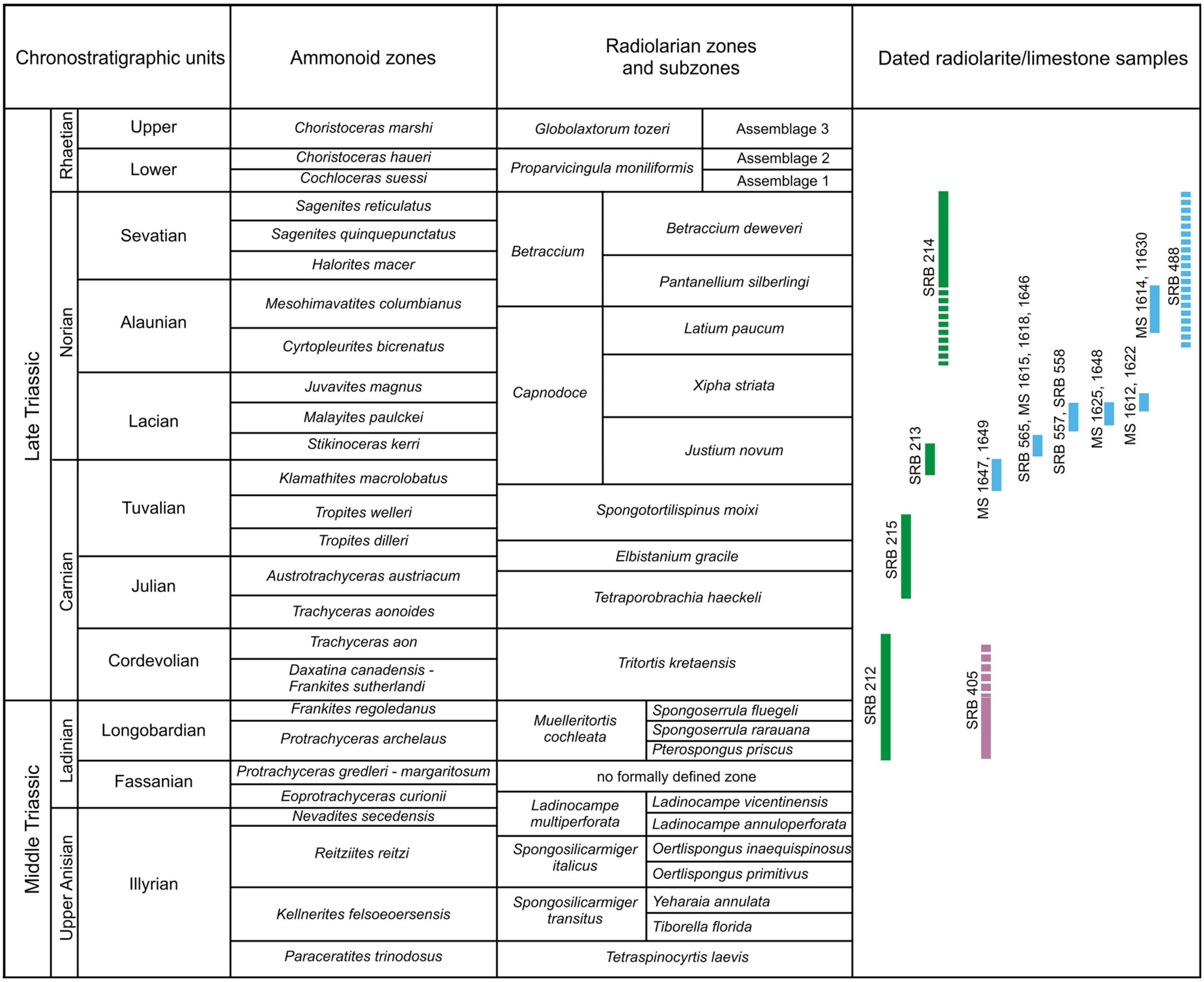


Fig. 12 Summarized age assignments of the studied oceanic ribbon radiolarites and open marine continental slope limestones/radiolarites in the Gostilje–Ljubiš–Visoka–Radoševo mélange. Middle Triassic and Carnian radiolarian zones and subzones according to Kozur and Mostler (1994, 1996), Kozur et al. (1996), Moix et al. (2007), Kozur et al. (2009), Norian from Blome (1984), Rhaetian from Carter (1993). Correlation with ammonoid zones based on Kozur (2003). *Green lines* oceanic ribbon radiolarites, *violet lines* radiolarites from the continental slope, *blue lines* limestones from the continental slope (compare with Fig. 13)

sands, consisting of erosional products of the ophiolite nappe stack. Such a mélange can incorporate fragments of the underlying sequences during the process of overthrusting. Therefore, such a sub-ophiolite mélange contains blocks from the lower plate and gravitationally emplaced blocks derived from the thick wedge of oceanic and continental crust at the front of the advancing nappe pile. In addition, as described by Gawlick et al. (2008) and Missoni and Gawlick (2011a), trench-like basins were formed in front of the advancing nappes. These deep-water basins were supplied by the erosional products of the advancing nappe stack. Several types of mass transport deposits (for a review on MTD's see: Shanmugam 2015) are incorporated in such a turbiditic radiolaritic-argillaceous matrix. Later, these trench-like basins were incorporated in the nappe stack and become partly sheared, forming the typical features of a mélange.

6 Conclusions

Litho- and microfacies analysis, and biostratigraphical analysis of the components in the Gostilje–Ljubiš–Visoka–Radoševo mélange as well of the matrix sediments give clear evidence that:

1. Spreading in the oceanic realm from where the ophiolites of the Dinaridic Ophiolite Belt derive, started in the Middle Triassic (?Late Anisian) and is contemporaneous with the onset of spreading in the

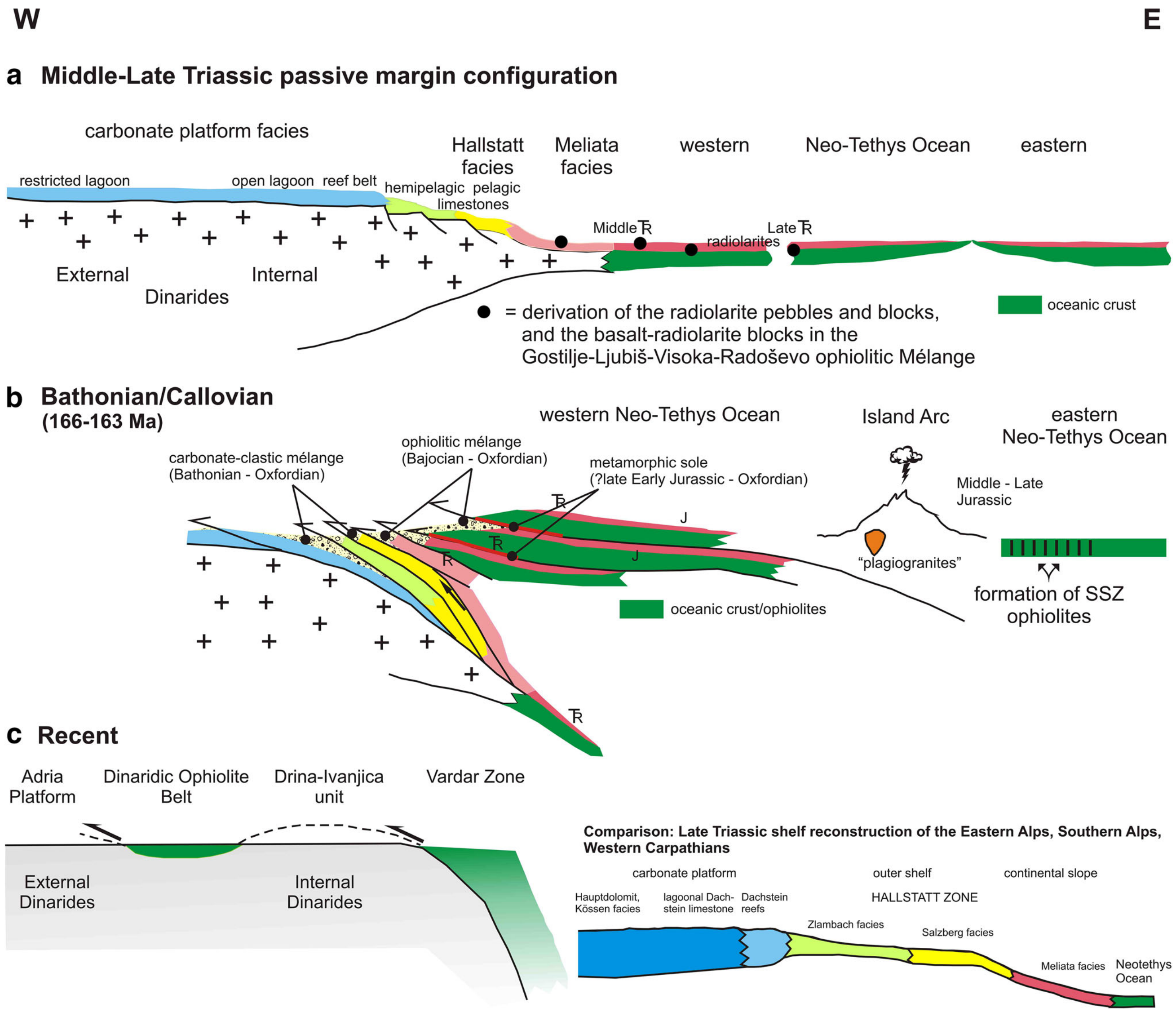


Fig. 13 Reconstruction of the Triassic shelf and provenance of the studied components and blocks in the Gostilje–Ljubiš–Visoka–Radoševo mélange. **a** Middle to Late Triassic passive margin configuration after Gawlick et al. (2008), and comparison with the Late Triassic shelf configuration of the Eastern and Southern Alps and the Western Carpathians modified after Gawlick et al. (1999). Generation of oceanic crust started in the Late Anisian in the Neo-Tethys realm. The formation of an oceanic basin (Dinaridic Ocean) between the External (Triassic restricted lagoon) and Internal Dinarides (Triassic open lagoon, reef belt and transitional facies) is not possible due to the facies transitions from the lagoon to the open marine environment. **b** Middle Jurassic westward directed ophiolite obduction, imbrication of the former passive margin and mélange formation. For the position of the formation of the plagiogranites see Michail et al. (2016). **c** Recent position of the Dinaridic Ophiolite Belt with its sub-ophiolitic mélanges on the basis of Kober (1914) concerning the genesis and emplacement of the ophiolites and related radiolaritic-ophiolitic trench fills

Neo-Tethys as proven in the Eastern Alps, the Western Carpathians, the units in the Circum-Pannonian realm, the Albanides, and the Hellenides.

2. Ophiolitic mélange formation is contemporaneous with the onset of intra-oceanic subduction (?late Early to early Middle Jurassic). Onset of obduction of the ophiolitic nappe stack is dated as Middle to early Late Jurassic. It is contemporaneous with the formation of mélanges in the Eastern Alps, the Western Carpathians, units in the Circum-Pannonian realm, and the Albanides/Hellenides. The mélanges were formed in response to the closure of the western part of the Neo-Tethys Ocean and contain everywhere a very similar component spectrum. For the Middle–Late Jurassic orogeny, the term Neotethyan Belt was introduced by Missoni and Gawlick (2011b).

3. The reconstructed Middle to Late Triassic sedimentary succession from the continental slope resembles exactly sedimentary sequences also known in the Eastern Alps, the Western Carpathians, and units in the Pannonian realm. An independent evolution of an autochthonous Pindos–Mirdita–Dinaridic Ocean between Adria and Drina-Ivanjica cannot be confirmed. The ophiolites of the Dinaridic Ophiolite Belt derived as far-travelled oceanic sheet from the Neo-Tethys Ocean to the east.

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