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The carbonate-clastic radiolaritic mélange of Pavlovica Cuprija: a key to solve the palaeogeography of the Hallstatt Limestones in the Zlatar Mountain (SW Serbia)

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Introduction

In south-western Serbia several mélange areas occur widespread. Of special interest are the carbonate-clastic radiolaritic mélange areas in the Zlatar Mountain below the ophiolite nappes including the ophiolitic mélange of the Dinaridic Ophiolite Belt. They represent a key for the solution of palaeogeographic questions and to reconstruct the passive margin arrangement of the Inner Dinarides facing the Neotethys Ocean to the east.

Mélange of Pavlovica Cuprija

The described mélange with radiolarite as matrix occur at the locality Pavlovica Cuprija in SW Serbia, on the eastern flanks of the Zlatar Mountain area, about 15 km SE of Nova Varos (Fig. 1). First investigations on the radiolarite sequence were carried out by DJERIC et al. (2007). According to them the age range of the siliceous sediments should be Aalenian to Callovian, although obviously typical Aalenian taxa are missing in the samples. These authors interpret the radiolarite succession as drowning sequence deposited on top of hemipelagic Late Triassic Hallstatt Limestones, which should represent the distal Adriatic margin.
Reinvestigation of the wider area (Fig. 2) proves the occurrence of different Middle Triassic slides incorporated in a late Middle to early Late Jurassic radiolaritic matrix: the shallow-water Ravni Formation with the Members: Utrina and Dedovici Limestones (equivalent to the Gutenstein and Steinalm Formations in the Eastern Alps) and a dismembered Late Anisian to Middle Norian Hallstatt Limestone succession, proved by conodont dating. These Hallstatt Limestones occur as big slides and as clasts in mass-flow deposits between the radiolarites, which form the matrix of the different blocks (Fig. 3, Fig. 4). Conodont dating proves the existence of various Hallstatt components in the different intercalated mass-flow deposits. Bigger blocks show partly well constrained parts of the original sedimentary succession, e.g. the Late Anisian drowning of the shallow-water Ravni carbonate ramp (dated by the occurrence of *Gladigondolella budurovi* KOVACS & KOZUR, *Gladigondolella tethydis* HUCKRIEDE and *Gondolella* cf. *cornuta* (BUDUROV & STEFANOV) - sample SRB 363). The overlying drowning sequence is represented by Late Anisian condensed red limestones similar to the Bulog/Schreyeralm Formation. These Late Anisian sediments are followed by Ladinian condensed grey and reddish limestones, in the lower part with some shallow-water debris. Typical, partly condensed various coloured Hallstatt Limestones occur from late Early Ladinian onwards (dated by following conodont faunas - late Early Ladinian: transitional form from *Gondolella excelsa* (MOSHER) to *Gondolella inclinata* KOVACS - sample SRB 272; Ladinian to Early Carnian: *Gladigondolella tethydis* HUCKRIEDE and *Gladigondolella*-ME - sample SRB 377; Late Ladinian to Early Carnian: *Gladigondolella*-ME and *Gondolella inclinata* KOVACS - sample SRB 271; Middle/Late Triassic boundary: *Gladigondolella tethydis* HUCKRIEDE and *Gladigondolella*-ME, *Budurovignathus mungoensis* (DIEBEL), *Gondolella inclinata* KOVACS - sample SRB 275 from a fissure in the Dedovici Limestone; Carnian: *Gondolella polygnathiformis* BUDUROV & STEFANOV, *Gondolella* sp. - sample MS 1830; latest Tuvalian: *Gondolella nodosa* (HAYASHI) and *Metapolygnathus communisti* HAYASHI - sample SRB 274, *Gondolella polygnathiformis* BUDUROV & STEFANOV, *Metapolygnathus communisti* HAYASHI and *Carnepigondolella* sp. - samples SRB 270 and with *Epigondolella abneptis* (HUCKRIEDE) in sample MS 1826; Early Norian (Lacian 2): *Epigondolella triangularis*

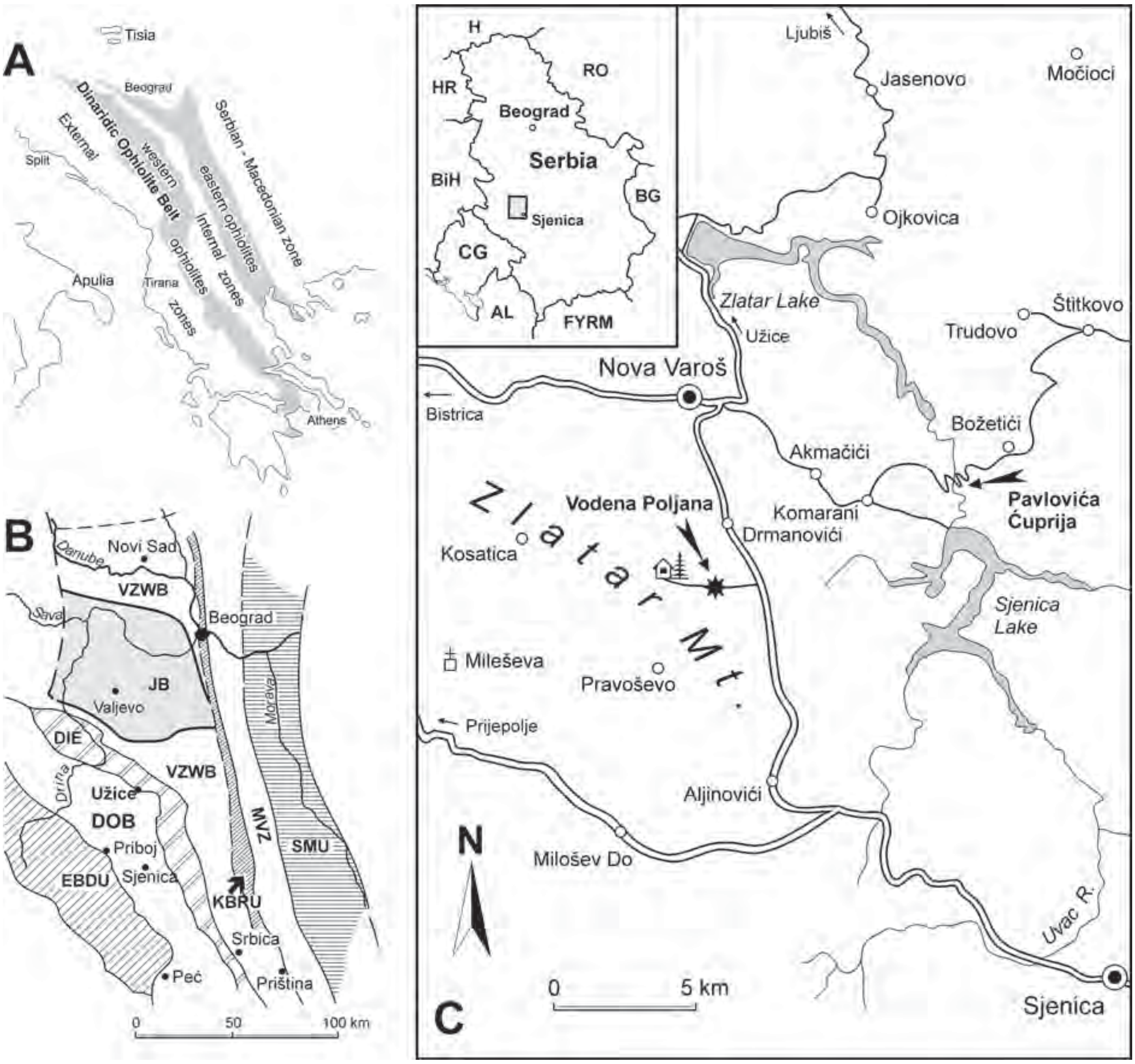

Fig. 1: **A.** Regional geological setting showing the External zones, the western ophiolites (Dinaridic, Mirdita, Hellenic ophiolites), the Internal zones (Korabi-Pelagonian Microcontinent = Pelagonian Zone, Korab Zone, Drina-Ivanjica Element) and the eastern ophiolites (Vardar Zone). **B.** Tectonic units and terranes of part of the Balkan Peninsula in the sense of KARAMATA et al. (2000) and KARAMATA (2006). **SMU** = Serbian-Macedonian Unit, **MVZ =** Main Vardar Zone, **KBRU =** Kopaonik Block and Ridge Unit, **VZWB =** Vardar Zone Western Belt, **JB =** Jadar Block, **DIE =** Drina-Ivanjica Element, **DOB =** Dinaridic Ophiolite Belt, **EBDU =** East Bosnian-Durmitor Unit. **C.** Location of the study area.

(BUDUROV) and *Norigondolella* sp. - sample SRB 366; Middle Norian (Alaunian 2): *Norigondolella steinbergensis* (MOSHER), *Epigondolella slovakensis* KOZUR, *Epigondolella postera* (KOZUR & MOSTLER) - samples SRB 381 and MS 1824 with *Norigondolella steinbergensis* (MOSHER), *Epigondolella postera* (KOZUR & MOSTLER); Middle Norian: *Norigondolella steinbergensis* (MOSHER), *Epigondolella* sp. - sample MS 1828 and *Norigondolella steinbergensis* (MOSHER), *Epigondolella postera* (KOZUR & MOSTLER), transitional form from *Epigondolella abneptis* (HUCKRIEDE) to *Epigondolella triangularis* (BUDUROV), and *Mosherella newpassensis* (MOSHER) in sample MS 1822. Late Norian: *Epigondolella bidentata* MOSHER - samples MS 1823, 1832). These Hallstatt Limestones occur as centimetre-, decimetre- and tens of metre-sized clasts and blocks in the siliceous matrix.

From black bioturbated cherty limestones to radiolarite from the basal series below the first blocks of Anisian limestones we isolated a Bajocian to Early Bathonian radiolarian fauna with following age relevant taxa (sample SRB 365): *Gorgansium morganense* PESSAGNO & BLOME, *Emiluvia nana* BAUMGARTNER, *Emiluvia premyogii* BAUMGARTNER, *Paronaella pygmaea* BAUMGARTNER 1980, *Spongotripus* sp. D sensu SUZUKI & GAWLICK, *Spongostaurus* sp. C, *Trillus elkhornensis* PESSAGNO & BLOME, *Zartus imlayi* PESSAGNO & BLOME, *Zartus dickinsoni* PESSAGNO & BLOME, *Acanthocircus suboblongus suboblongus* (YAO), *Archaeodictyomitra gifuensis* TAKEMURA, *Archaeodictyomitra rigida* PESSAGNO, *Cinguloturris* sp. A, *Dictyomitrella kamoensis* MIZUTANI

Fig. 2: The mélange area of Pavlovica Cuprija. Different blocks (arrows for some examples) and mass flows occur in a cherty matrix.

& Kido, *Droltus lyellensis* Pessagno & Whalen, *Eucyrtidiellum unumaense* (Yao), *Hsuum maxwelli* Pessagno, *Hsuum mirabundum* Pessagno & Whalen, *Praezhamoidellum buekkense* Kozur, *Praezhamoidellum yaoi* Kozur, *Saitoum levium* De Wever, *Saitoum pagei* Pessagno, *Stichocapsa tegiminis* Yao, *Striatojaponocapsa plicarum* (Yao), and *Triversus japonicus* Takemura. These species correspond to the *Eucyrtidiellum unumaense* Zone (Bajocian to Bathonian) according to Suzuki & Gawlick (2003) or fit the U.A.-zones 3-5 (Early Bajocian to Early Bathonian) of Baumgartner et al. (1995). These fauna contains well preserved radiolarians together with other diagnostic taxa, which clearly show a younger age as Aalenian, obviously several taxa occur also in the Aalenian.

The youngest radiolarite, found between huge slide blocks is of Early to Middle Oxfordian age (*Williriedellum dierschei* Subzone of the *Zhamoidellum ovum* Zone - Gawlick et al. 2009a), proven by following radiolarian taxa (samples SRB 277 and SRB 278): *Eucyrtidiellum unumaense* (Yao), *Eucyrtidiellum ptyctum* (Riedel & Sanfilippo), *Gongylothorax* cf. *favosus oviformis* (Suzuki & Gawlick), *Helvetocapsa matsuokai* (Sashida), *Striatojaponocapsa* sp., *Stichocapsa convexa* Yao, *Stichocapsa naradaniensis* Matsuoka, *Stylocapsa spiralis* Matsuoka, *Stylocapsa oblongula* Kocher, *Theocapsomma cordis* Kocher, *Williriedellum dierschei* Suzuki & Gawlick, and *Williriedellum marcucciae* Cortese.

Therefore the age of the carbonate-clastic mélange of Pavlovica Cuprija in SW Serbia can be dated as Bathonian/Callovian to Oxfordian. The succession starts with siliceous marls, limestones and radiolarites of Bajocian to Bathonian age (compare Djeric et al. 2007). In the upper part of these series the first polymictic mass-flow deposits occur (Fig. 4), which consist exclusively of Late Triassic Hallstatt Limestones. Upsection follow mass-flows and bigger slide blocks of Late Middle to Late Triassic Hallstatt Limestones with Callovian radiolarites as matrix. The topmost part of the succession is represented by up to kilometre-sized Middle Triassic shallow-water carbonate blocks, with the Oxfordian radiolarites as matrix between. In total the succession is characterized by a coarsening-upward trend, starting with mass-flow deposits, followed by tens-of-metres-sized blocks and topped by kilometre-sized blocks. Such successions are typical for deep-water basins formed in front of advancing nappes (trench-like basins).

These series is tectonically overlain by the radiolaritic-ophiolitic mélange, which shows in the area of Sjenica to the south as well as in the Zlatibor Mountain a Callovian to Oxfordian age range. Therefore the carbonate-clastic mélange starts to form slightly earlier but in more or less

Fig. 3: Mass-flow deposit consist of different Hallstatt Limestone in a radiolaritic matrix.

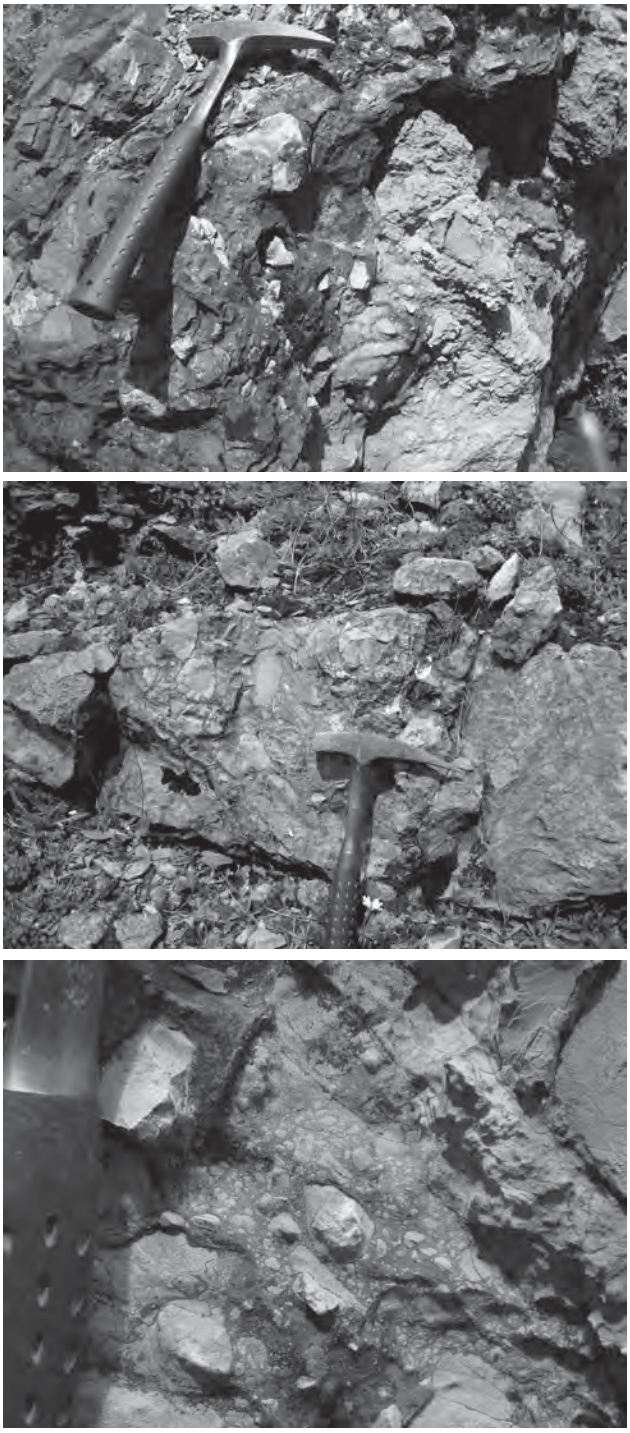

Fig. 4: Photos of different mass-flow deposit consist of different Hallstatt Limestone in a reddish radiolaritic matrix. In the mass-flow deposits occur predominantly red and grey Hallstatt Limestones of Late Triassic age.

the identical time span as the overlying ophiolitic mélange, which overthrust these carbonate-clastic mélange not earlier than in the Late Oxfordian. The ophiolitic mélange is interpreted to be a primary sedimentary synorogenic radiolaritic trench-fill sequence that formed simultaneously with ophiolite nappe stack/emplacement and later ophiolite obduction/accretion (Gawlick et al. 2009b, Gawlick et al. 2010).

Interpretation

The clasts and slides of the mélange in the study area derive from the outer shelf region of the passive margin facing the Neotethys Ocean to the east and resemble the known situations in the Eastern Alps (Gawlick et al. 2009a) or the Albanides (Gawlick et al. 2008). In parts the situation resembles of the Bathonian to Oxfordian Sandlingalm Formation (Hallstatt Mélange) in the Northern Calcareous Alps. The Hallstatt Mélange is interpreted to be formed in front of advancing nappes, formed in the outer shelf region due to the onset of ophiolite obduction in the Middle Jurassic. These nappes propagated during Middle to Early Late Jurassic from the outer to the inner shelf area (Late Triassic carbonate platform) forming a thin-skinned thrust belt. The early stage of this thrust propagation is represented by the nappe stack in the outer shelf region (Hallstatt Zone). In front of these Hallstatt nappes newly formed deep-water radiolarite basins contain the erosional products of these nappes, preserved here in south-west Serbia below the Dinaridic Ophiolite Belt.

We consider therefore westward transport of the carbonate-clastic Hallstatt mélange, the ophiolitic mélange and the ophiolite nappes on top in Middle to early Jurassic time. An autochthonous origin of a Triassic Ocean (Dinaridic Ocean or Pindos Ocean) between the Outer Dinarides and the Drina-Ivanjica Unit to the east as northward continuation of Pelagonia/Korabi Units, as proposed by another group of authors, can be excluded (e.g., Stampfli & Kozur 2006, Robertson et al. 2009). This ocean would have existed in the lagoonal area of the Triassic carbonate platforms in the Dinarides, separate for example in Late Triassic times the restricted lagoon (Hauptdolomit) from the open lagoon (lagoonal Dachstein Limestone).

The hemipelagic Triassic sediments (Hallstatt Limestones), which could have formed the passive margins facing this ocean, occur in a transported position below the west-directed obducted Dinaridic Ophiolite Belt (e.g., Schmid et al. 2008, Gawlick et al. 2008, 2009b), forming a far-travelled nappe and mélange complex. The situation in the Dinaridic Ophiolite Belt corresponds perfectly to the situation known further to the south in Albanides and to the north in the Eastern Alps and Western Carpathians, where identical mélanges were formed in Middle to early Late Jurassic times (e.g., Missoni & Gawlick 2010, Mock et al. 1998, Aubrecht et al. this volume).

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