GEOLOŠKI ANALI BALKANSKOGA POLUOSTRVA
Volume 81 (2), December 2020, 63–86
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https://doi.org/10.2298/GABP200918008S
Review Paper
Прегледни рад

The role of the 'Zvornik suture' for assessing the number of Neotethyan oceans: Surface – subsurface constraints on the fossil plate margin (Vardar Zone *vs.* Inner Dinarides)

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Abstract. The balancing exercise of the "single-ocean model" and reexamination of Jurassic paleogeographic conditions and tectonic interaction allowed the reconstruction of the mosaic of independent microplate margins and sutured northwestern Tethyan realm (Vardar Ocean). The overprinted Mesozoic convergent margin referred to as the 'Zvornik suture' was of special interest in the reconstruction of the displaced ophiolite belts of Dinarides and Vardar Zone. The surface–subsurface constraints of these mixed crustal units, in particular the polyphase strike-slip character of the 'Zvornik suture' yields the presence of at least two of Neotethyan basins extrapolated in the vicinity of the northwestern segment of this paleosuture - related fault system. The restoration and synopsis shows a limited capability for obduction-related emplacement of the Vardar oceanic lithosphere (West Vardar Zone) accounting the polyphased strike-slip tectonics. The balancing and the proposed tectonic/paleogeographic reconstruction does not exclude obduction, but it shows a limited capability with much shorter across-strike width of the highly-deformed West Vardar ophiolite. The presence of the two distinct autochthonous Tethyan oceans divided by this important dextral strike-slip fault zone is suggested: The Inner Dinaric–(Mirdita–Pindos) Ocean or Dinaric Tethys (identified by the Inner Dinaric Ophiolite Belt) and the Vardar Ocean (identified by the West Vardar Zone). The West Vardar Zone remains to be a subzone of the principal composite Neotethyan suture referred to as the Vardar Zone *s.s.*, whereas the Dinaric Tethys have been (re)incorporated to the area of Dinarides (Adria microplate). The northern segments of these two landlocked basins were on both sides of the Inner Dinaridic continental ridge (referred to as the Drina-Ivanjica block), divided by the protracted strike-slip activity of the 'Zvornik suture'.

Key words:
'Zvornik suture', Inner Dinarides, West Vardar Zone, Vardar Zone s.s., 'Dinaric Tethys', subsurface crustal faults.

Апстракт. Евалуација досадашњих резултата из домена јурских палеогеографских односа, тектонске интеракције као и просторне повезаности тектонских јединица омогућила је реконструкцију кинематике маргина микроплоча тј. дела сутуре северозападног Тетиса. Зворнички шав као маркантна регионална дисјунктивна мегаструктура представља полифазну оверпринтовану конвергентну зону која је од посебног значаја за реконструкцију измештених јурских офиолитских

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појаса Динарида и Вардарске зоне. Анализа површинских и потповршинских односа локално измештених различитих литосферних јединица указује на присуство најмање два океанска басена у ширем окружењу палеосутуре Зворничког шава. Сумаризацијом досадашњих истраживања се указује на присуство два самостална палеоокеанска домена тетиског океана која су раздвојена Зворничким шавом. Један од тетиских палеоокеана је Унутрашње динаридски– (Мирдита–Пиндос) или Динарски Тетис (документован на основу Унутрашњег динаридског офиолитског појаса); док други, главни јурски тетиски домен је Вардарски океан (документован на основу Западне вардарске зоне). Западна вардарска зона означава подзону основне композитне неотетиске сутуре која је именована као Вардарска зона у ужем (*Vardar Zone s.s.*); док је Динарски Тетис (ре)инкорпориран у област Динарида (Адрија или Јадранске литосфернце јединице). Северни сегменти ова два одвојена басена су оивичени (и раздвојени) унутрашње динаридским континенталним блоком (Дриниско-ивањички блок) и Зворничким шавом. У зони Зворничког шава услед дуготрајне и вишекратне доминантно транскурентне активности између различитих јединица, обудуковања великих размера (од преко 150 километара) су искључена на анализираном простору. Обдуковање океанске преко континенталне литосфере током јуре је очигледно, међутим, сам процес обдукције је био ограничене дужине и кратког трајања.

Кључне речи:
Зворнички шав, Унутрашњи Динариди, Западна вардарска зона, Вардарска зона у ужем смислу, Динаридски Тетис, потповршински литосферски раседи.

Introduction

The lithosphere of independent expanding oceans (150–200 km in width) bounded by the continental crust often elevate the conveyed ophiolite slices on top of the bordering passive margins (Pearce et al., 1984; Garfunkel, 2006; Doglioni et al., 2007; van Hinsbergen et al., 2015). These overriding segments of the oceanic crust have often been amalgamated (collisional orogens) with local continental margins (Beccaluva et al., 2004; Parlak, 2016). The continental margin ophiolites (mafic/ultramafic and sedimentary rock assemblages) are a continental breakup product representing (i) embryonic oceanic crust at ocean-continent transition zones (Dilek & Furnes, 2011, 2014) further (ii) marking a subduction initiation process (van Hinsbergen et al., 2015; Šegvić et al., 2019). The archetypes of these rather atypical cross-lithospheric thickening processes (Pearce, 2003; van Hinsbergen et al., 2015) are exposed within Dinaric-Hellenic orogen alongside the sliced north-eastern Apulia/Adria margin ('Greater Adria'; *sensu* Gaina et al., 2013; Fig. 1a, b, c). The interface area between this north-eastern ophiolite-bearing Adria margin (Inner Dinarides Ophiolite belt), the composite Vardar Zone and spatiotemporally unconnected Jadar block is represented by the complex fault system referred to as the *Zvornički šav* or "Zvornik suture" (hereinafter the 'Zvornik suture'; Dimitrijević, 1972, 1997; Dimitrijević & Dimitrijević, 1975, Gerzina, 2010; Figs. 1b, 1c, 2). The 'Zvornik suture' represents an overprinted segment of the larger "Periadriatic suture" (Grubić, 2002 and references therein). This zone at north connects the Eastern Alps with the exhumed Fruška Gora Mt. assembly, at east, strikes from the East Vardar Zone via comparable strike-slip / oblique crustal structures into Greece (e.g., Smith & Spray, 1984; Spahić et al., 2020 and references therein; Fig. 2).

The reconstruction of the original size and shape of the Neotethyan ophiolite-bearing basins nonetheless should incorporate a considerable sea-floor spreading prior and during the accretion/obduction onto the local margin (Garfunkel, 2006, Schettino & Turco, 2011; Hässig et al., 2015). The preserved two Neotethyan Dinaric-Hellenic oceanic seaways or trench-like basins (Stampfli, 2000; Gawlick & Missoni, 2019) have been advocated by the modeling

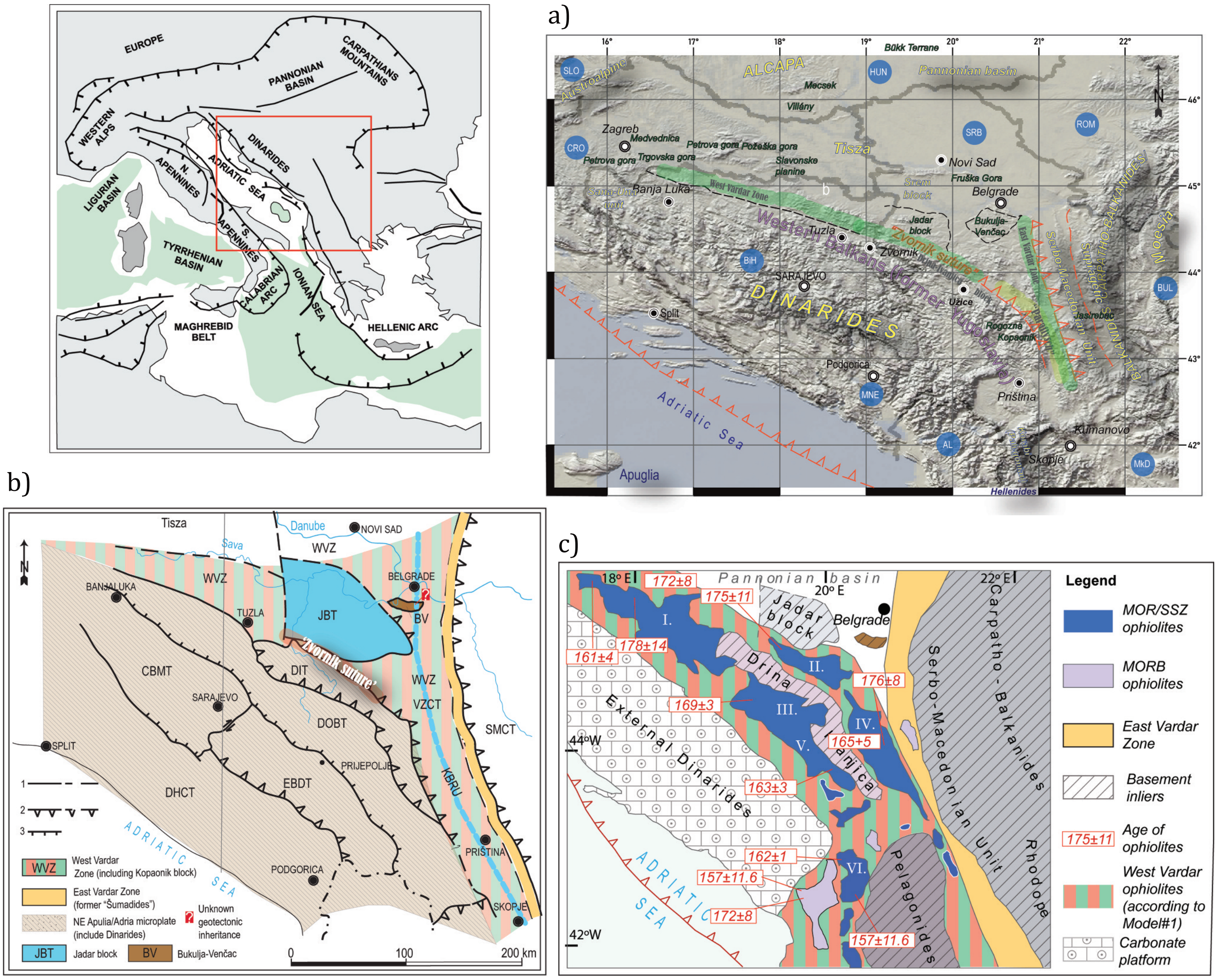


***Fig. 1**. **a.** Regional relief map including the position of the 'Zvornik suture' and the main tectonic units of the former Yugoslavia. **SRB,** Serbia; **MNE,** Montenegro; **CRO,** Croatia; **BiH,** Bosnia & Herzegovina; **MkD,** North Macedonia; **SLO,** Slovenia; **HUN,** Hungary; **ROM,** Romania; **BUL,** Bulgaria; **Al,** Albania; **b.** Tectonic sketch of Dinarides according to the Model#2 (according to concept of Karamata, 2006, modified). The main tectonic units are as follows: **DIT,** Drina–Ivanjica Terrane; **DOBT,** Dinaridic Ophiolite Belt Terrane; **EBDT,** East Bosnian–Durmitor Terrane; **CBMT,** Central Bosnian Mountains Terrane; **VZC,** Vardar Zone Composite Terrane; **SMCT,** Serbian-Macedonian Composite terrane; **JBT,** Jadar Block Terrane and **DHCT,** Dalmatian-Herzegovinian composite Terrane. The KBRU (blue dashed line, Kopaonik-block-and ridge Unit), Tisza and BV (Bukulja–Venčac crystalline) segment are also included. Question mark denotes unknown geotectonic inheritance (see text for details); **c.** Drina–Ivanjica block separating the two ophiolite belts: to the SW is Inner Dinaric Ophiolite Belt (I- Krivaja-Konjuh; III- Zlatibor; V- Bistrica) and to the NE–E is West Vardar- and East Vardar ophiolites (II- Maljen; IV- Troglav-Ibar). To the south of Dinaric ophiolites is VI- north Mirdita which is out of scope of this paper (inset and age data after Maffione & van Hinsbergen, 2018; slightly modified).*

framework, which either does or does not consider the 'Zvornik suture' as a relevant interrelated evolving plate boundary. By disregarding the 'Zvornik suture', the Adria microplate extents within the "remote" Jadar block hence placing the ophiolite roots to the north from the latter (Schmid et al., 2008, 2020; Maffione & van Hinsbergen, 2018; van Unen et al., 2019 and many others; Fig. 3). Consequently, the

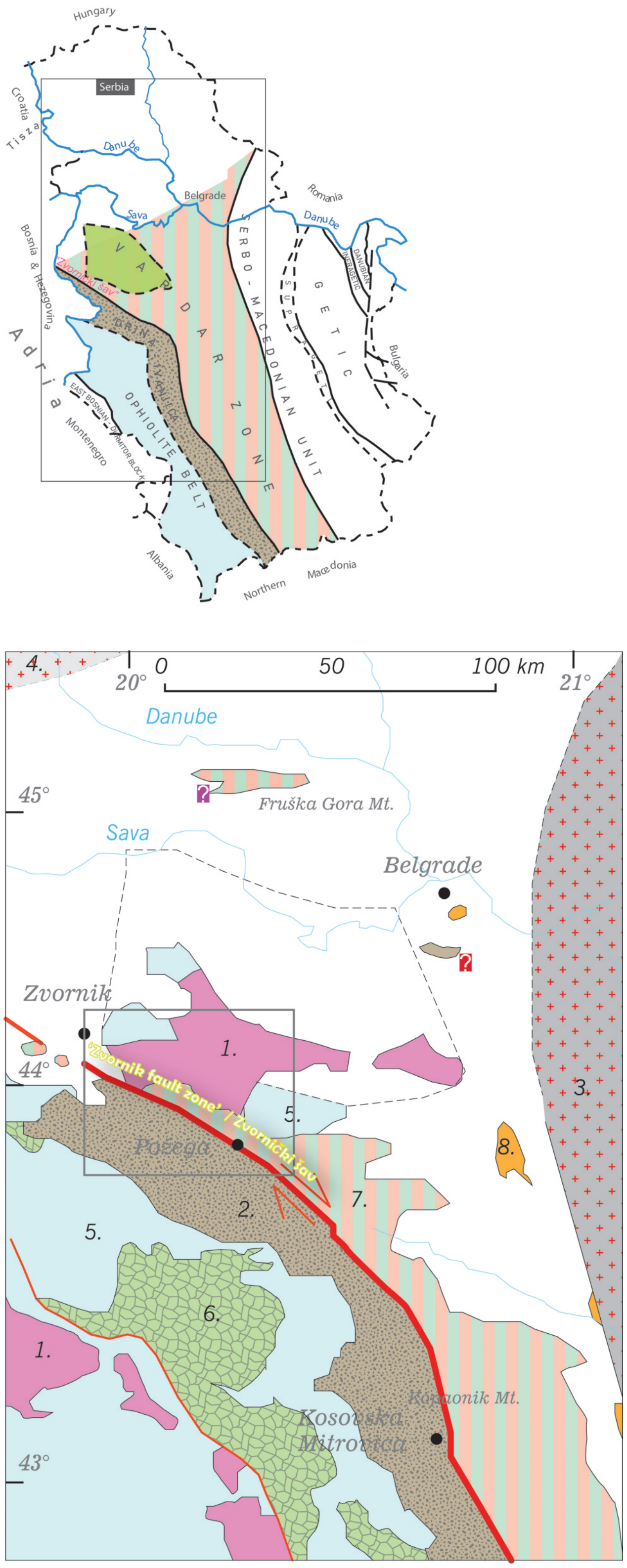
Drina–Ivanjica and Jadar blocks (separated by the 'Zvornik suture') are interpreted as having the underthrusting position beneath the far-travelled "Western Vardar Ophiolites". By considering the 'Zvornik suture' exclusively as the Late Cretaceous basal nappe (Schmid et al., 2008; Toljić et al., 2019), the 'single ocean' model explains the Tethyan realm derived from a landlocked Mesozoic ocean basin located east of the Drina–Ivanjica block (Fig. 1c). A widespread Permian–Triassic embayment involved the Anisian breakup (Ricou, 1996) along the local passive margin (Csontos & Vörös, 2004; Gawlick et al., 2017). The Late Triassic-born basins propagated further involving magma extrusion, sea-floor spreading (Djerić & Gerzina, 2008; Schettino & Turco, 2011) and closure marked by a westwards-directed far-reaching cross-lithospheric thrusting (Middle–Late Jurassic, contemporaneously with eastern Pelagonian margin; Scherreiks et al., 2014). As the result, hanging wall far-travelled ophiolite obducted onto this local continental margin over the lower continental units (Jadar and Drina-Ivanjica blocks) (*sensu* Schmid et al., 2008; see details in chapter 1.1). Second framework takes into account a similar scenario from the pre-collisional stage, implementing crustal geochemical properties with the differences in the Jurassic mélanges and their formation on both sides of the latter lithospheric scale "suture" (Dimitrijević & Dimitrijević, 1975; Dimitrijević et al., 2003, including many others studying its southern counterparts). The two autochthonous oceanic domains accommodated on both sides of the 'Zvornik suture' - the main northwestern Neotethys (Vardar Ocean or West Vardar Zone) and a regional oceanic seaway Dinaric Tethys/ Inner Dinaric Ophiolite belt (Robertson & Dixon, 1984; Robertson & Karamata, 1994; Goričan et al., 1999; Dimitrijević, 2001; Dimitrijević et al., 2003; Karamata et al., 2000; Karamata, 2006; Dilek et al., 2007).

The following report contributes the unresolved Triassic–Jurassic paleogeographic and tectonics issues (see e.g., Stampfli, 2000; Dilek et al., 2007; Schettino & Turco, 2011; Gawlick & Missoni, 2019, for a discussion) related to the three seemingly interlinked microplates intervened by a narrow north-eastern segment of the 'Zvornik suture'. The 'Zvornik suture' represents the overprinted relic of the principal cross-lithospheric boundary (fault zone, connecting the NE Drina–Ivanjica passive margin segment (Inner Dinarides) with the (West) Vardar Zone and Jadar block (Fig. 1a–c). The study emphasizes the kinematics and the interchanging activity of the 'Zvornik suture' affecting the paleogeographic evolution of the two Neotethyan marginal landlocked basins. We use observations from and around the extrusive ophiolite sequences in the West Vardar- and Inner Dinaric ophiolites and theirs Western Balkan counterparts to demonstrate the tectonic significance of the 'Zvornik suture'. Despite the close distance between the two basins (Fig. 2), the dominantly oblique motions of the 'Zvornik suture' provided no conditions for a rapid far-reaching Middle–Late Jurassic obduction sequencing over the entire Drina–Ivanjica segment.

Historical overview and definition of the two NW Neotethyan oceanic concepts

The ophiolite occurrences of Neotethyan- (Vardar Zone *s.s.* positioned to the north of 'Zvornik suture') and peri-Tethyan oceanic affinities (Vardar Zone *s.l.*), their plate-tectonic and paleogeographic/paleoceanographic evolution is elaborated within the two competing solutions alleviating these problematic lower crustal rock sequences: (1) widely accepted '*two ophiolites – one ocean*' (Model#1) and (2) '*two ophiolites – two oceans i.e. multiple oceans*' model (Model#2). The two contradictory hypotheses galvanized a long-standing controversy (see discussion in Schmid *et al*., 2020) inspiring a considerable international attention. A diversity of the published review studies exhibited a number of discussion points (*e.g.*, Robertson & Dixon, 1984; Robertson, 2002, 2012; Bortolotti et al., 2004, 2013; Bortolotti & Principi, 2005; Jurković, 2006; Robertson & Mountrakis, 2006; Dilek et al., 2007; Saccani et al., 2008; Robertson et al., 2009; Charvet, 2013; Cvetković et al., 2014; Jolivet et al., 2016; Gawlick & Missoni, 2019; Schmid et al., 2020).

The *'two ophiolites zones-one ocean*' (coined by Bernoulli & Laubscher, 1972; Model#1): According to the "single ocean" concept, the across strike-width of a preserved ophiolite is correlative with the



therein). The obduction either can be associated with the Jurassic/Cretaceous boundary (Argnani, 2018) or Middle–Late Jurassic (178 Ma; Srećković-Batoćanin et al., 2012; Fig. 1c). "Translated" into the local terminology, this model implies a single West Vardar Zone (WVZ at Fig. 1b, c) or "Western Vardar Ophiolites" obduction on top of the crystalline Paleozoic to carbonate platform Triassic sequence of Drina–Ivanjica block (Dimitrijević & Dimitrijević, 1991; DIT at Fig. 1b; Fig. 3). Consequently, the Model#1 interprets the (1) Inner Dinaridic Ophiolite Belt (DOBT at Fig. 1b) to be an external part of the latest Jurassic–early Cretaceous west (southwest)-verging suprasubduction sequence (Schmid et al., 2008).

The initial tectonic model of the Western Balkans is propounded by applying the geosyncline model of former Yugoslavia (Petković, 1958). A bit later, tectonic model was improved after the widespread confirmation of the actualistic sea floor spreading plate tectonics framework (Aubuin et al., 1970, Bernoulli & Laubscher, 1972). Recent (re)popularization of the 'single ocean' concept begun by the activity of Central European authors (Csontos et al., 2004) including those applying the experience col-

*Fig. 2. Tectonic sketch of Dimitrijević (1997 and references therein) and the position of the eastern boundary of the Dinarides or the 'Zvornik suture' towards the Vardar Zone (modified after Dimitrijević et al., 2003). The dextral strike-slip 'Zvornik suture' separates the Inner Dinaridic Ophiolite belt as a discrete ophiolite-bearing entity from the West Vardar Zone. Numbers: **1.** Paleozoic entity with documented Permian marine sequence (possible Paleotethys presence; Spahić & Gaudenyi, 2020a); **2.** Drina-Ivanjica block (no Permian sequence); **3.** Serbo-Macedonian Unit (segment of dismantled northern edge of western Eurasian margin); **4.** Tisza unit (segment of dismantled northern edge of western Eurasian margin); **5.** Displaced passive margin vestiges; **6.** Ophiolites of the Inner Dinaric Ophiolite belt; **7.** Ophiolites of West Vardar Zone; **8.** East Vardar Zone ophiolites; Red rectangle with question mark indicates uncertainty of the Bukulja-Venčac block; Violet rectangle with question mark indicates the questionable inheritance of the Fruška Gora assembly and uncertain position of the 'Zvornik suture'.*

distance over which the overriding oceanic crust was underthrusted by a buoyant continental margin. The maximum estimated values are ca. 200 km of throw (van Hinsbergen et al., 2015 and references lected in the Alpine segment of the orogen (Swiss Alps; *e.g.*, Schmid et al., 2004). The two ophiolite belts (West Vardar Zone and Inner Dinaridic Ophiolite Belt) yield the island arc signatures what led

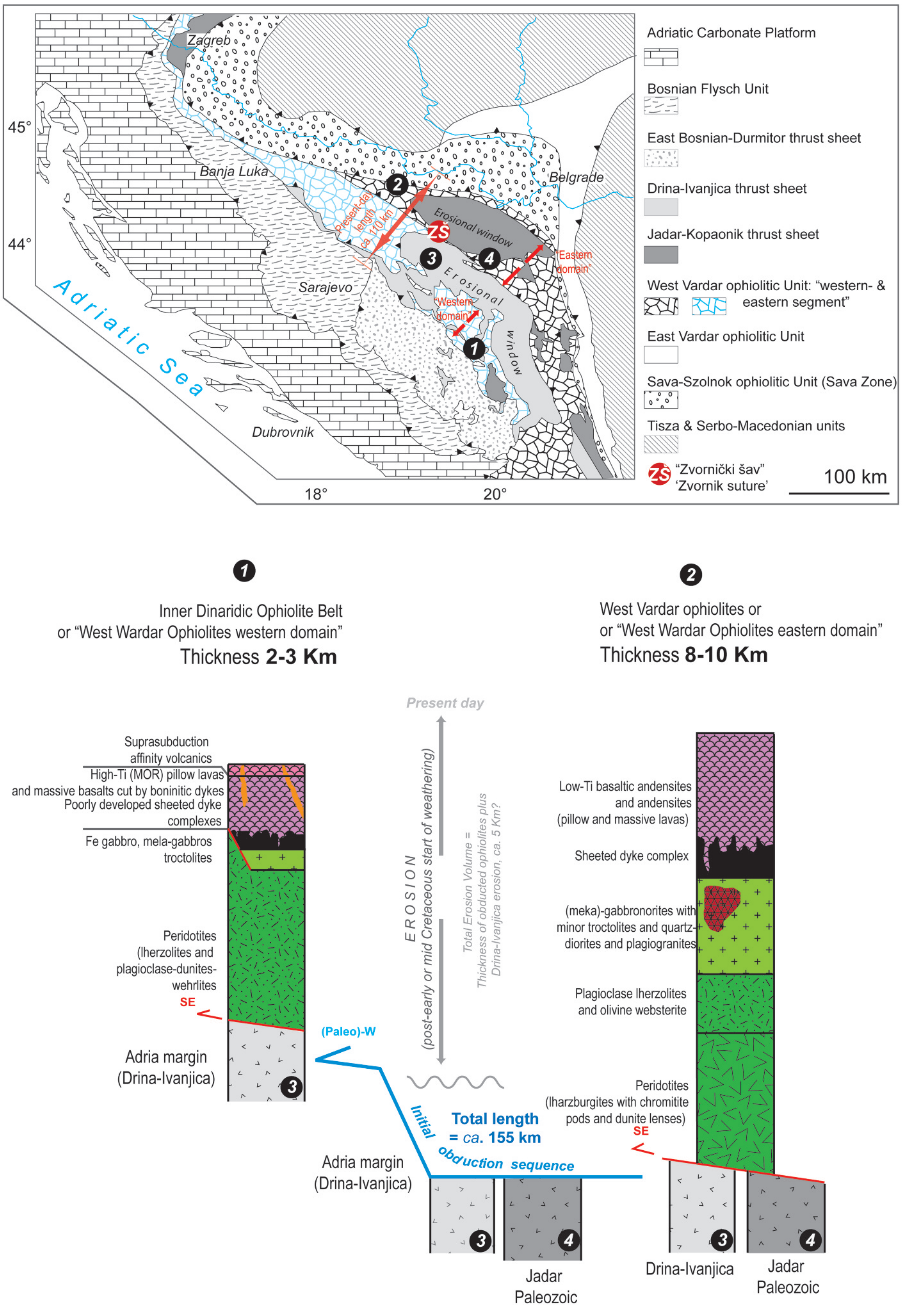


Fig. 3. *Tectonic model explaining the 'two ophiolites – one ocean' (location in Fig. 1a). The West Vardar Zone is obducted over Drina–Ivanjica, which is upthrusted over the initially obducted western segment of West Vardar Zone positioned between Durmitor sheet and Drina-Ivanjica (redrawn and modified after Mikes, 2008, concept of Schmid et al., 2008). The absence of rotation in the Dinarides during post-closure phase (Ustaszewski et al., 2008; de Leeuw et al., 2012) facilitated a simple semi-restoration. TS- Horizontal component (total slip) of the West Vardar ophiolite obduction length is a sum of the former trench obduction plus the amount of shortening due to the thrusting (early to mid-Cretaceous, Schmid et al., 2008) which is ca. 45 km (e.g., East Bosnian-Durmitor thrust sheet, Dimitrijević, 1997). The approximate amount of the ophiolite length i.e. obduction before is ca. 155 km. The value is based on the pure horizontal length, onto which a descending angle (passive margin) should be added (implying higher obduction length values). Lithological columns of the West Vardar Zone ("western domain", #1) with the thickness ca. 2–3 km, and "eastern ophiolite domain" (Inner Dinaridic Ophiolite Belt, #2) with the thickness of 10 km (corrected and modified from Maffione & van Hinsbergen, 2018). A crude estimation of the total estimated erosion on top of Drina-Ivanjica (#3) and Jadar Paleozoic unit (#4) is ca. 5 km.*

to the idea of an intra-oceanic suprasubduction zone (*e.g.*, Mikes, 2008; Schettino & Turco, 2011 and references therein). To the widespread popularization of the Model#1 contributed a rapid emplacement of the Omani ophiolites (cooling in 1–2 m.y; Hacker et al., 1996). The latter authors (Schmid et al., 2008) consider (2) a composite ophiolite- and flysch-bearing Vardar Zone (and their derivatives such as the "Sava–Vardar Zone"; Fig. 1a) being an integral part of Dinarides (Haas et al., 1995; Schmid et al., 2008; Saccani et al., 2011; Bortolotti et al., 2013).

'*Two ophiolite belts – two oceans model*'. In paleogeographic terms (Model#2), the Neotethys (Vardar Zone) comprises of the three contrasting Mesozoic affinities: (1) the Innerdinaric–(Mirdita–Pindos) ocean or Dinaric Tethys, (2) the main Vardar Ocean which later consumed/overlapped the marginal (3) (Meliata) Maliac ocean (Ferriére et al., 2012, 2016). The dominant Vardar Ocean (VZCT at Fig. 1b) includes the West Vardar Zone (WVZ at Fig. 1b) being the principal oceanic affinity, plus the East Vardar Zone (EVZ at Fig. 1b) or its intraoceanic-arc system (Spahić & Gaudenyi, 2019; Fig. 1b). Robertson & Karamata (1994), Channel & Kozur (1997), Dimitrijević (2001), Karamata (2006), Dilek et al., (2007) propose a similar concept (herein referred to as the Model#2). According to this concept, the cluster of Late Jurassic – Early Cretaceous ophiolite-bearing belts of Western Balkan countries is a derivation originating from the two discrete Mesozoic oceanic affinities. Located to the southwest is (1) the Intradinaric-(Mirdita-Pindos)/Dinaric Tethys ocean or Red-Sea type small ocean (Robertson & Karamata, 1994); (2) to the east of the Drina-Ivanjica- and Jadar Paleozoic crystalline blocks including the Jadar–Kopaonik unit is the Vardar Ocean. Therefore, the West Vardar Zone ophiolite belt has a limited extent of the obduction sequence thrusted upon the northeastern Drina-Ivanjica block (Mojsilović et al., 1975). Consequently, the Neotethyan Vardar Ocean is a separate oceanic affinity relative to the 'Dinaric Tethys' (Inner Dinaridic Ophiolite Belt of Dimitrijević, 2001 or Dinaridic Ophiolite Belt Terrane (DOBT) of Karamata, 2006; Fig. 1b). The two oceanic domains are considered as the northern- and southern Tethyan strands divided by the Drina-Ivanjica block (Robertson & Karamata, 1994).

Regional setting

The mountainous aggregations of the Western Balkan countries and Southeast Europe (SEE) represent a segment of Alpine-Himalayan mountain chain. The Dinaridic- and Vardar Zone ophiolite-bearing north-northwest–south-southeast–trending parallel crustal segments represent the vestiges composed of highly heterogeneous ophiolites and ophiolitic mélanges. The polymictic mélanges are consisting of magmatic blocks and a variety of associated sedimentary rocks derived by the activity of dominant tectonic or sedimentary mechanisms (Dimitrijević & Dimitrijević, 1973; Scherreiks et al., 2014; Gawlick & Missoni, 2019). The Vardar Zone and Inner Dinaric Ophiolite belt ultramafites and mélanges are distributed across both domains abutting the northwestern segment of the 'Zvornik suture' (Fig. 1c; Fig. 2). The 'Zvornik suture' as a complex plates boundary can also be marked as the Peri-Adriatic suture (Grubić, 2002).

The 'Zvornik suture' (originally Zvornik-Požega–Kosovska Mitrovica; Dimitrijević, 1972; Fig. 2) or "*Drinska geofraktura*" (Anđelković, 1982 p. 309) represents a complex "suture" (in Serbian: *šav*), an active margin segment characterized by multiple episodes of (re)activation. This zone is outcropping on its western tip near the city of Zvornik (Bosnia and Herzegovina), striking across Drina River into a complex Paleozoic–Mesozoic amalgamation of western Serbia (Mojsilović et al., 1975). In the Alpine configuration, the 'Zvornik suture' represents the basal thrust displacing ophiolites of the West Vardar Zone over the Paleozoic crystalline units (Mojsilović et al., 1975; Toljić et al., 2019). The important yet poorly understood pre-collisional (pre-Cretaceous–Paleogene) kinematic character was overprinted during the terminal shortening whereas the Eocene subsidence records a significant downlifting of the area accumulating over 1200 m of the deposited thickness (to the west of the fault zone, Bosnia & Herzegovina). To the east of the 'Zvornik suture', the Miocene deposition was of limited subsidence producing a thin veneer overlying the Paleozoic–Mesozoic basement segment of western Serbia (Anđelković, 1982). Altogether, the syn- and post-compressional movements obscured the behavior and interchanging character of this principal regional plates boundary. Nevertheless, the oblique, dextral crustal-scale motions are proposed by the local pioneering geologists (Dimitrijević & Dimitrijević, 1975; Grubić, 2002; Dimitrijević et al., 2003).

The origin of Western Balkan ophiolites is in the tight connection with a network of the Dinaric and the Hellenic basement suites (Dilek et al., 2007; Faul et al., 2014). These ophiolite belts are extending towards the external Inner Hellenides to the east-southeast, and the Mirdita, Subpelagonian/Pelagonian – Inner Dinaridic Ophiolite Belt zones of the Albanides (*e.g.*, Nance, 1981; Robertson & Karamata, 1994; Dilek et al., 2005, 2007; Saccani et al., 2008; 2011, 2017; Gaggero et al., 2009). External Inner Hellenides and Dinarides (respectively) are positioned to the west (Fig. 1c) of the Pelagonian block, whereas the Vardar/Axios Zone belongs to the Inner Hellenides (distributed along with the length of the western margin of the Serbo-Macedonian Unit). The compositions of these massifs range from Jurassic SSZ type-ophiolites formed along the entire length of the Dinarides towards Albania, and Greece (>1200 km). The subcontinental Inner Dinarides to depleted mid-ocean ridge/arc compositions have often been documented within the Vardar Zone (Fig. 1c).

Configuration of the Vardar Zone *s.s.*

The Vardar Zone *s.s.* (coined by Kossmat 1924) is a composite Neotethyan suture comprised of both, ophiolite- and flysch-bearing sequences of Mesozoic–early Cenozoic age. The Vardar Zone *s.s.* occupies the areas to the east-northeast of the external most Apulia/Adria microplate or from the 'Zvornik suture' up to the Serbo-Macedonian Unit ("Serbomacedonian Massif"; SMCT at Fig. 1b). This composite Neotethyan vestige is comprised of the Middle–Late Triassic assembly which occasionally includes metabasic crust of questionable paleogeographic inheritance (Kopaonik, Dimitrijević, 1997; Zelić et al., 2005). The Middle–Late Triassic passive margin setting (Đerić & Gerzina, 2008; Gawlick et al., 2017; Gawlick & Missoni, 2019) is succeeded by the developing Middle–Late Jurassic sedimentary mélange, ophiolites. Eventually, the interaction of local lithospheres is recorded by the Cretaceous flysch-bearing sequences (VZCT in Fig. 1b). The Vardar Zone *s.s.* combines the West Vardar Zone (the central oceanic segment), its back-arc to fore-arc composite ophiolite-bearing sequence referred to as the *East Vardar Zone* (Gallhofer et al., 2017; Toljić et al., 2019; *sensu* Spahić & Gaudenyi, 2019 and references therein; Fig. 1b).

The *West Vardar Zone* of Karamata (2006) is equivalent of the *External Vardar Zone* of Dimitrijević which includes the Jadar block (1997; Figs. 1b, 2). This zone is exposed between the Drina–Ivanjica Unit, Kopaonik and the Jadar crystalline entities (Serbia). The West Vardar Zone plus the Sava–Vardar Zone is bounded by the 'Zvornik suture' at northwest. This disjunctive 'Zvornik suture' disappears underneath the Jadar block and beneath a younger sedimentary cover in Mačva and Srem (*e.g.*, Srem block, Fruška Gora Mt.; Dimitrijević, 1972; 1997; Fig. 1b). The Jadar block has often been considered as a segment of the Bükk Terrane that crops out in northern Hungary (Filipović et al., 2003; Fig. 1a). In Serbia, the Jadar block is thrusted over the eastern realm of the West Vardar Zone (Fig. 1b). Its southeastern boundary has an inverted structural configuration (Filipović et al., 2003). To the north, the Neogene veneer being further truncated by the N-S striking normal fault of the Neoalpine age (Figs. 1b, 2) overlies this peculiar block. North of Belgrade, poorly exposed Vardar Zone (Fruška Gora Mts) beneath the Pannonian basin is composed of Triassic limestones, greenschist-facies rocks of the same age exposed (Dimitrijević, 1997; Fig. 2).

West Vardar Zone further towards northwest is in the contact with the "*Sava*- or *Sava-Vardar Zone*" in Bosnia and Herzegovina, Croatia (*sensu* PAmić, 2002; Schmid et al., 2008; Ustaszewski et al., 2009; Mészáros et al., 2019; Fig.1a) or "*Central Vardar Zone*" (Toljić et al., 2019). This recently reintroduced zone represents the relic of a subduction trench thus juxtaposing the West Vardar ophiolites (footwall) with the East Vardar Ophiolites in the hanging wall position (contact is in the form of thrust fault). As mentioned, the relationship of the 'Zvornik suture' with the Sava–Vardar Zone to the west of Drina River is obscured by the thick sedimentary veneer. This zone is characterized by a set of subduction related bimodal volcanics of Late Cretaceous to earliest Paleocene age *i.e.* 110 to 62 Ma (Pamić, 1998; Pamić et al., 2000). The presence of Late Cretaceous ophiolites in the Kozara Mountains (northern Bosnia and Herzegovina; Karamata et al. 2000; Ustaszewski et al. 2009, 2010) indicates the latest Cretaceous–Paleocene collision (onset during Late Cretaceous).

The *East Vardar Zone* in North Macedonia, Serbia, and the "Vardar–Mureş Zone" in Romania marks a northeastern branch, a continuation of this convergent margin (Fig.1b). In Apuseni Mts. (Romania), the Jurassic ophiolites interfingered with acidic synmagmatics are remnants of the East Vardar ophiolites of island arc affinity (Gallhofer et al., 2017). The assembly exposes the Lower Cretaceous "paraflysch" (Dimitrijević & Dimitrijević, 2009), Upper Cretaceous rudites, marine, limnic and brackish strata of the Maastrihtian age including the late Cretaceous Senonian flysch. This zone strikes alongside the Serbo-Macedonian crystalline entity depicted also by a deep-seated crustal fault (Vukašinović, 1973; Fig. 4). The subsurface configuration of the cross-lithospheric margin is visualized within a 3D model (Petrović et al., 2015; Petrović, 2015). The 3D subsurface model remarkably well depicted the underplating configuration of a descending oceanic slab positioned underneath the crystalline Serbo-Macedonian (former) continental margin (Fig. 1c; also in Spahić & Gaudenyi, 2019).

Moving southeastwards from the important 'Zvornik suture' (Fig. 1b), the West Vardar Zone stretches farther into the highly complex *Kopaonik block* (*sensu* Zelić et al., 2010). (Fig.1b). To the south of Kopaonik block, the Vardar Zone stretches farther in Albania, North Macedonia (*e.g.*, Robertson et al., 2013; Spahić et al., 2019), continuing towards the Hellenides in Greece (Vardar-Axios Zone; *e.g.*, Menant et al., 2016). A branch of this southern extension of the Vardar Zone *s.s.* is squeezed between the Pelagonian Massif and the Paikon unit (*e.g.*, Robertson et al., 1991, 2013). For details, see Fig. 2 of Robertson & Karamata (1994). In Greece, this zone is bending towards the east evolving into the Izmir-Ankara-Erzincan suture zone (Gürer& van Hinsbergen, 2019).

Dinarides

The term 'Adriatic plate' often refers to the undeformed lithospheric plate or "subplate" (Channell & Horvath, 1976). It includes the present day undeformed areas of the Istria and the Apulian carbonate platform framed by the external thrust belts of Southern Alps, Dinarides and Apennines. The original "Adria" term refers to a considerably large fragment of continental crust connecting the continental masses of Africa and Europe in the central Mediterranean (Rosenbaum et al., 2004 and references therein). The south of the Adria microplate or the Apulia/Adria microplate is the contact with the Nubian plate and the Aegean domain. This contact is aligned with the Apulian Escarpment and the Kefallinia fault (Battaglia et al., 2004). The northern margin of Apulia/Adria microplate acted as a rigid indenter during its collision with the Alpine and Dinaridic orogen to the north and east. The term "Adria" has often been used for: (i) the broader contexts of accommodated terranes southward of the "Alpine Tethys" (Schmid et al., 2008) or the Penninic–Wah–Magura Ocean (*e.g.*, Channel & Kozur, 1997). "Adria" also represents (ii) the name of the plate undethrusted below the Adriatic Sea (Channel & Horvath, 1976; Bennet et al., 2008). The same term refers to the (iii) "Periadriatic orogenic belt" (Channel et al., 1979). In order to avoid confusion, we will use the Apulia/Adria microplate to refer to the Dinarides in a broader sense.

Suess (1880) separated the three tectonic units coined the name *Dinarides*: Dinarides *s.s.*, Hellenides and Taurides. Modern-day Dinarides are referring to the Dinarides *s.s.* (the focus of this study is the eastern domain of the Dinarides *s.s.*). Dinarides *s.s.* as a southern limb of the Alpine orogenics span the far northwestern segment in Slovenia, crossing Croatia, Bosnia and Herzegovina, Montenegro and cropping out in western Serbia, altogether reaching up to ~1000 km in length (Fig. 1a). A widely accepted geotectonic subdivision of Dinarides is division in the *Inner*- (or Internal, *e.g.*, Hrvatović & Pamić, 2005) and the *External Dinarides* (*e.g.*, Royden, 1988; Pamić, 1998, 2002; Dimitrijević, 1997, 1999). Dinarides are comprised of the several thrust systems (Picha, 2002; Csontos et al., 2004; Fig. 1b) occupying eastern segment of the Apulia/Adria microplate (*e.g.*, Tomljenović et al., 2008). The following imbricated systems are stacked farther towards the southern Pannonian Basin (Fig. 1b):

(1) Adriatic–Dinaridic carbonate platform formations (External Dinarides), (2) Carbonate-clastic units of the passive continental margin referred to as the Bosnian Flysch, (3) (Inner) Dinaridic Ophiolite Zone and overstepping Late Jurassic to Cretaceous cover sequences (Csontos et al., 2004), (4) Active continental margin units represented by the Upper Cretaceous–Paleogene trench sediments with blueschists, tectonized ophiolite mélange, medium-grade metamorphic rocks originated from the Upper Cretaceous–Paleogene sediments including the granitoids of the late Alpine age, (5) The nappe consisting of the allochtonous Paleozoic–Triassic formations which is thrust onto the ophiolites and genetically related sedimentary formations. The exhumation times of the Dinaridic crystalline units records the both cycles, Variscan and Jurassic (Milovanović, 1984; Borojević Šoštarić et al., 2012).

The Drina–Ivanjica segment positioned as the southern boundary of the 'Zvornik suture' comprises the complex Paleozoic meta-sequences (no Permian recorded; Đoković & Pešić, 1985; Chiari et al., 2011; Spahić & Gaudenyi, 2020) and early Alpine sedimentary successions (Đoković, 1985; Spahić et al., 2018). This crystalline unit in the sliced Alpine configuration (Fig. 1b) separates the Inner Dinaric Ophiolite belt - the vestiges of the "Western Vardar Ophiolitic Belt", its remote segment (Model#1; Schmid et al., 2008) or "Dinaric Tethys" (Model#2; Dimitrijević, 2001).

The investigated plates margin and alternative models for the geodynamic evolution of Tethyan realm

Oblique kinematics of the 'Zvornik suture' vs. far-travelled Late Jurassic ophiolite obduction

The two stages of (oblique) convergence are recorded by the Jurassic and Upper Cretaceous mélanges of the Vardar Zone *s.s.* The intensive oblique motions (likely transpressive; Grubić, 2002 and references therein; Robertson, 2012 and references therein) are well-documented across and beneath western Mediterranean and, locally, in the vicinity of the investigated Neotethyan amalgamation (Dimitrijević & Dimitrijević, 1975 and references therein; Ricou, 1996; Ricou et al.,1998; Ilić & Neubauer, 2005; Korbar, 2009; Schettino & Turco, 2011; Spahić et al., 2020). The onset of Vardar oceanic subduction with a dominant transpressive-component is likely linked with the ENE–WSW-directed spreading of the Alpine Tethys relative to the laterally positioned trench. The squeezed crustal segments of Adria (continental crust) were pushed by the northward-positioned Alpine Tethys (spreading) moving towards the north-south striking trench. The latter short-lived plate boundary changed the kinematics from oceanic spreading, evolving from a mid-oceanic ridge to become an east-dipping subduction arc-trench (transition occurred somewhere during Middle–Late Jurassic; see Schettino & Turco, 2011). The oceanic lithosphere production stage of a such nascent arc-forearc crust was presumably short *ca*. 10–15 m.y. (Dilek et al., 2007). Moreover, there is no evidence supporting similar-type motions within the Inner Dinaric Ophiolites (Dimitrijević & Dimitrijević, 1975). The principal difference is imprinted within the ophiolite matrixes, barely preserved within West Vardar ophiolites (Dimitrijević et al., 2003; Dilek et al., 2007). The poorly preserved matrix bears the evidence of intensive transcurrent (transtensive) motions.

The second, well-exposed stage of undethrusting within the Vardar Zone *s.s* (Cretaceous) was driven by the oblique motions resulting in the intensive deformations recoded within the western segment of the "Central Vardar Zone" (Neotethyan foredeep; Dimitrijević et al., 2003). These oblique motions are in line with the *Adriatic lower plate* position in this segment of double-vergent Alpine orogen (Doglioni et al., 2007), directed to the northeast in Late Cretaceous reference (Schettino & Turco, 2011). The *upper plate* position is associated with the tip of the Alpine indenter during its collision with European margin. The oblique / transpressional kinematics kept the same character lasting up to the Eocene (Dimitrijević & Dimitrijević, 1975). The highly complex two-staged undethrusting, including the precursory Jurassic mélanges are considerably well-exposed near the 'Zvornik suture' and at Povlen and Kopaonik Mts. (see Dimitrijević et al., 2003, for a discussion).

The (i) slow-spreading West Vardar Zone-type ophiolites, (ii) oblique underthrusting and (iii) limited oceanic crustal production stages are not in line with the far-travelled scenario placing the latter ophiolites over the 'Zvornik suture' (or the Model#1). The strike-slip faulting is excluded as the mean driver capable to derive all the ophiolites from a single basin (Roberson & Dixon, 1984). Despite the hindering kinematics, a limited obduction with much shorter thrusting would be plausible. A good example is the ophiolite record observed in the field i.e. to the northeast of Drina-Ivanjica block (the narrow segment of 'Zvornik suture'; Mojsilović et al., 1975; Gerzina, 2010 (Figs. 1c, 2).

Geochemistry of ophiolites

There is a considerably large geochemistry database used for tectonic fitting of data collected from ophiolites along both sides of the 'Zvornik suture' (*e.g.*, Robertson & Karamata, 1994; Dilek et al., 2005, 2007; Gaggero et al., 2009; Bazylev et al., 2009; Šuica et al., 2009; Faul et al., 2014; Saccani et al., 2015, 2017). Often used geochemical fingerprinting derived from different tectonic settings has turned into irreplaceable tool in geodynamic studies (*e.g.*, Kearey et al., 2009; Saccani et al., 2015). However, these subcrustal interferences of the original magma-mantle structure may often generate confusion in the estimates of lithospheric conditions (*cf.* Safonova et al., 2016). Geochemical fingerprinting fitted into petrogenetic-geodynamic models barely focus on the important paleogeographic constraints.

Inner Dinaridic Ophiolite Belt and West Vardar Zone comprise a sub-ophiolite mélange overlain by the separate ophiolite units with a metamorphic sole in between (Srećković-Batočanin et al., 2012; Gawlick & Missoni, 2019; Šegvić et al., 2019). According to the geochemical data analyzed across the both ophiolite systems, these ultramafic massifs, however, belong to crustal systems produced by the different geodynamic settings (*e.g.*, Robertson, 2002; Bazylev et al., 2009; Faul et al., 2014; Maffione & van Hinsbergen, 2018; Fig. 1c). The West Vardar ophiolites positioned to the north of the 'Zvornik suture' have a suprasubduction zone geochemical signature (Fig.1c) whereas those belonging to the Inner Dinaridic Ophiolite Belt have also a continental rift setting (Bazylev et al., 2009) or within-plate (Karamata, 2006). Therefore, as mentioned earlier, it could be concluded that the difference in the geochemical signature of the ophiolitic fragments could not be used to distinguish separate Tethyan oceans.

The most external segment referred to as the Krivaja–Konjuh massif (Fig. 1c, massif #I) has similarities to those of the Inner Dinaridic Ophiolite Belt (subcontinental; Faul et al., 2014). To the south (Albanide-Hellenide ophiolites), the development of sub-continental heterogeneous mantle sources in alkaline basalts, alkaline basalts, normal- and enriched-type midocean ridge magmatities ended by the end of Triassic (Saccani et al., 2015). The successor Jurassic oceanic crust has normal-type midocean ridge basalt character developed in response to interference of sub-oceanic primitive mantle. Outcropping ophiolite succession does include upper mantle peridotites.

Across-strike width variations of the obducted ophiolites

The total obduction length or the across strike-width proposed by the Model#1 is over 70 km, completely overlaying the 'Zvornik suture'. 70 km is the difference between the West Vardar- and Inner Dinaridic Ophiolite Belt (Schmid et al., 2008; Model#1). In the Hellenides, finite obduction length reaches up to 200 km distancing the Budva–Pindos (Argolis) Zone and the Vardar–Axios Zone (Bortolotti et al., 2013). If so, there is a considerable difference in the displacement that supposable occurred during the same crustal shortening episode (also in Argnani, 2018). Another issue is whether the proposed obduction length could reach 200 km. The continuous outcrops (with no record of any significant km-scale ophiolite-clippen) connecting the Drina–Ivanjica-, the Jadar- and the (Korab-) Pelagonian block are often elaborated within the Model#1 as the large-scale tectonic windows exposed beneath the Neotethyan- or the West Vardar ophiolites (Fig. 3). In the case that the ophiolites travelled in such subhorizontal distances, it is to expect, at least, a minor presence of ophiolite clippen on top of the former continental margin. Several detail field-mapping campaigns covering these areas provided no evidence of clippen (Savezni Geološki Zavod, 1970; Fig. 2 of Dilek et al., 2007; Plate. 1 of Schmid et al., 2008; Fig. 2 of Maffione & van Hinsbergen, 2018; Fig. 2). Smaller in size clippen recorded on the top of the Pelagonian zone (Scherreiks *et al*., 2014) belonged to the Pindos Ocean (*sensu* Anders et al., 2005). This zone cannot be identified as a continuation of the West Vardar ophiolites.

On the ground of unresolved (geo)tectonic inheritance of the structures accommodated within the wider 'Zvornik suture', the Bukulja-Venčac crystalline complex stands out (Trivić et al., 2010; Figs. 1b, 2). This block has some similarities with the Drina-Ivanjica system, not with the Jadar block (Figs. 1, 2). These three Paleozoic–Mesozoic systems are positioned near the presumed ophiolite roots (West Vardar Zone). The West Vardar Zone containing no evidence of any significant ophiolite clippen on top of the eroded massifs (with exception of the aforementioned accommodated within the narrow segment of the 'Zvornik suture'; Figs. 1b, c, 2). If to consider that the Drina-Ivanjica block is out-of-sequence thrust (Schmid et al., 2008), the essential issue pending the explanation from those imposing the Model#1 is why there are no any ophiolite evidence left on top of Jadar- (only at its southwestern edge; Dimitrijević et al., 2003) and Bukulja-Venčac crystallines? There is a complete absence of the post-Liassic deposition, ultramafites, ophiolitic mélange within the Jadar block (Filipović et al., 2003).

In some segments of Inner Dinarides, the mid-Jurassic metamorphic sole formation should mark a geodynamic change and the initiation of the obduction processes (Šegvić et al., 2019). However, there is an absence of the metamorphic sole and associated metamorphic imprints near the southwestern edge of the Drina-Ivanjica block or a northern realm of the Zlatibor massif (in the vicinity of Užice; Savezni Geološki Zavod, 1970; Dimitrijević & Dimitrijević, 1979; Fig. 1c). Model#1 offers solution that this area should represent the early stage in which ophiolites crossed over the top of continental margin segment. The absence of the metamorphic sole and the presence of a Triassic succession (even accounting km-thick strongly differentiated weathering and erosion processes) are not in line with the suggested ophiolite emplacement path, suggesting that these have not surpassed the south-western edge of the Drina-Ivanjica block. Moreover, the extensive structural study of the metamorphic sole beneath the Zlatibor ophiolite massif (Inner Dinaridic Ophiolite Belt) pointed out the NE-directed movement (in the ductile conditions), whereas the entire ophiolite massif subsequently "slided" towards the south. This second event occurred in the cooler upper crustal conditions (Dimitrijević & Dimitrijević, 1979).

Buoyancy of continental lithosphere vs. obducted oceanic crust

Model#1 proposes a single ophiolite obduction sequence (latest Jurassic to the early Cretaceous) explained to be developed either above the intra-oceanic arc (*e.g*., Mikes, 2008; Schettino & Turco, 2011 and references therein; Maffione & van Hinsbergen, 2018) or above the underthrusting passive margin (Schmid et al., 2008, 2020; van Hinsbergen et al., 2020). A downgoing position of the entire Inner Dinarides (Drina-Ivanjica crystalline block including its Triassic succession) is required for underthrusting. This configuration involves a large portion of buoyant continental plate (in this case Inner Dinarides). Buoyant crustal segment should be beneath a developing oceanic trench. This trench took over the role of the former mid-oceanic ridge (Schettino & Turco, 2011) moving in front and towards the Sava–Vardar (back-arc position; Pamić, 2002) / East Vardar Zone (Spahić & Gaudenyi, 2019). However, the relative feasibility study of emplacing oceanic lithospheres (in the most favorable fore-arc scenario) suggests that subduction of a buoyant material commonly leads to failure of the subduction zone. Once the subduction zone fails, isostatic rebound lifts the oceanic crust on top of continental segment (Stern et al., 2012). The ophiolites mapped on top of the continental margin (Drina-Ivanjica block) have a limited extent, thrusted to a few km above northeastern edge of the block (Figs. 1c, 2). In addition, there is no evidence of the Jurassic magmatic arc-associated volcanism recorded within the Drina-Ivanjica crystalline entity (for a detail review of the geology of Drina-Ivanjica block see Savezni Geološki Zavod, 1970; Đoković, 1985; Gerzina, 2010; Spahić et al., 2019).

Subsurface configuration beneath the interface of the Dinarides and Vardar Zone

Configuration and crust structure beneath the investigated plate margins

One of the pioneering geophysical endeavors to decipher the complex subsurface crustal configuration beneath former Yugoslavia countries was of Vukašinović (1973; Fig. 4). Magnetic susceptibility depicted several large-scale crustal faults separating the Dinarides from the Vardar Zone *s.s.* (this holds particularly for the northwestern subsurface segment of the 'Zvornik suture', Fig. 4). 2D deep seismic data corroborated the south-north crustal thinning towards the Pannonian Basin System margin indicated by the shallower position of the Moho- (boundary lower crust-upper mantle) and the Conrad (boundary between lower – the upper crust) discontinuities (Pamić, 1998 and references therein). The high-resolution subsurface crustal models of the Moho depth outlined the new immersed plate referred to the "Pannonia" occupying the Moho depth range 26 to *ca*. 38 km (Brückl et al., 2000) thickened *circum*-Mediterranean crust matched with the surface topography (Facenna et al., 2014). The negative anomalies of the *P*-wave models at depth of 300 km depicts considerably well at the Adria/Apulia microplate subsided underneath the Adriatic Sea. The analog of the negative fields of the *P*-waves at the same depth conditionally mark the previously descended slab inside the crust of the Pannonian region (Li et al., 2008; Facenna et al., 2014).

Seismic tomography identifies a WNW–ESE striking high-velocity zone underneath the Central- and Southern Dinarides (reaching the depth of 160 km)

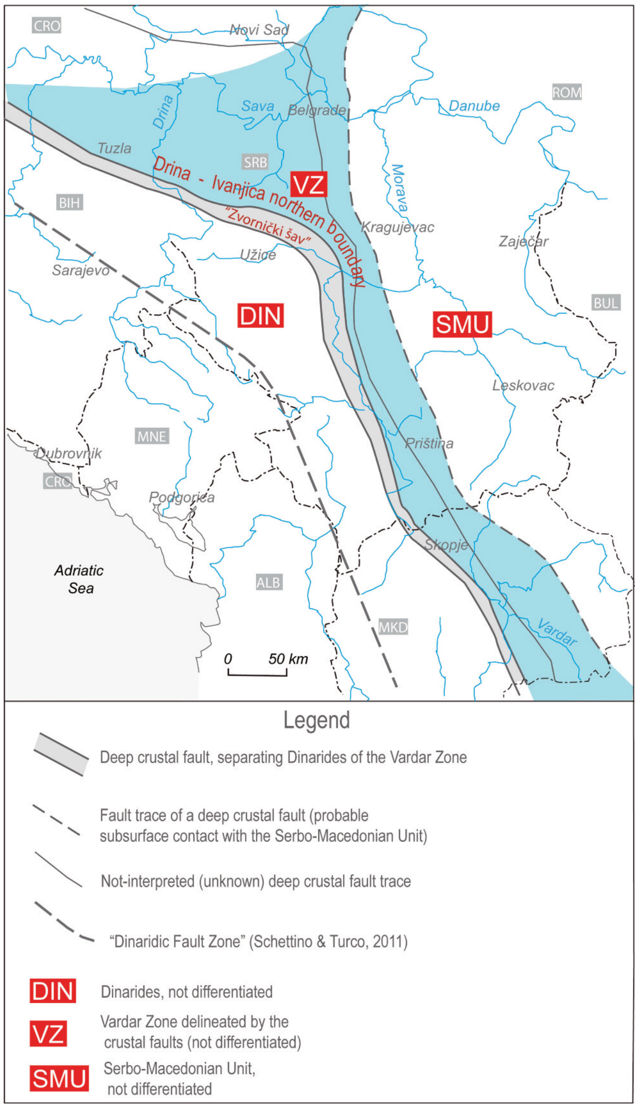


***Fig. 4**. The position of deep, crustal- scale fault separating the Dinarides of the Vardar Zone (modified after Vukašinović, 1973). It is obvious that the curved lineament follows the geometry of the separating fault line juxtaposing the Drina-Ivanjica and Vardar Zone. Tentatively we placed the other lineaments within the Vardar Zone as relics of Paleotethys suture.*

described over the subducted Adriatic lithosphere (Bijwaard & Spakman, 2000; Ustaszewski et al., 2008; Belinić et al., 2018b). The low-velocity increment observed underneath the Dinarides and central Greece fits the high-velocity anomalies associated with the Aegean subduction (Bijwaard & Spakman, 2000), thus interpreted as the descending Adria/Apulia slab. The tomography further reveals a large low-velocity anomaly beneath the northern Dinarides (Croatia), marking the "slab gap" between the Eastern Alps (Slovenia) and the central part of the External Dinarides (Bosnia and Herzegovina). In addition, the most recent geophysical study depicts the "transition zone" splitting the Dinaric (probably referring to the Adria/Apulia microplate) and the "Pannonian crust" (probably referring to the Tisza microplate; Kapuralić et al., 2019). The low-velocities anomaly is interpreted to reflect the thermally eroded Adriatic slab and lithosphere delaminated under the Dinarides and the southern parts of the Pannonian Basin System (Ustaszewski et al., 2010, Handy et al., 2014; Matenco & Radivojević, 2012). However, the same low-velocity area is attested by numerical means (2D finite difference approach and a marker in cell technique; Andrić et al., 2018), explaining a retreated slab scenario imposed a while ago by Royden (1993; Fig. 5). The 70 km of thickness in comparison to 40 km beneath Serbo–Macedonian Unit corroborates a displaced or retreated Vardar slab (Fig. 5). Farther towards the south, the active Hellenic subduction remains attached to the former Vardar oceanic subduction, being confirmed by the several 2D visualization tomographic models. The models interpreted a crustal connection of the Hellenic slab, (East) Vardar- and deeper most Triassic- and Jurassic Kure, Izmir-Ankara slabs (Hosseinpour et al., 2016).

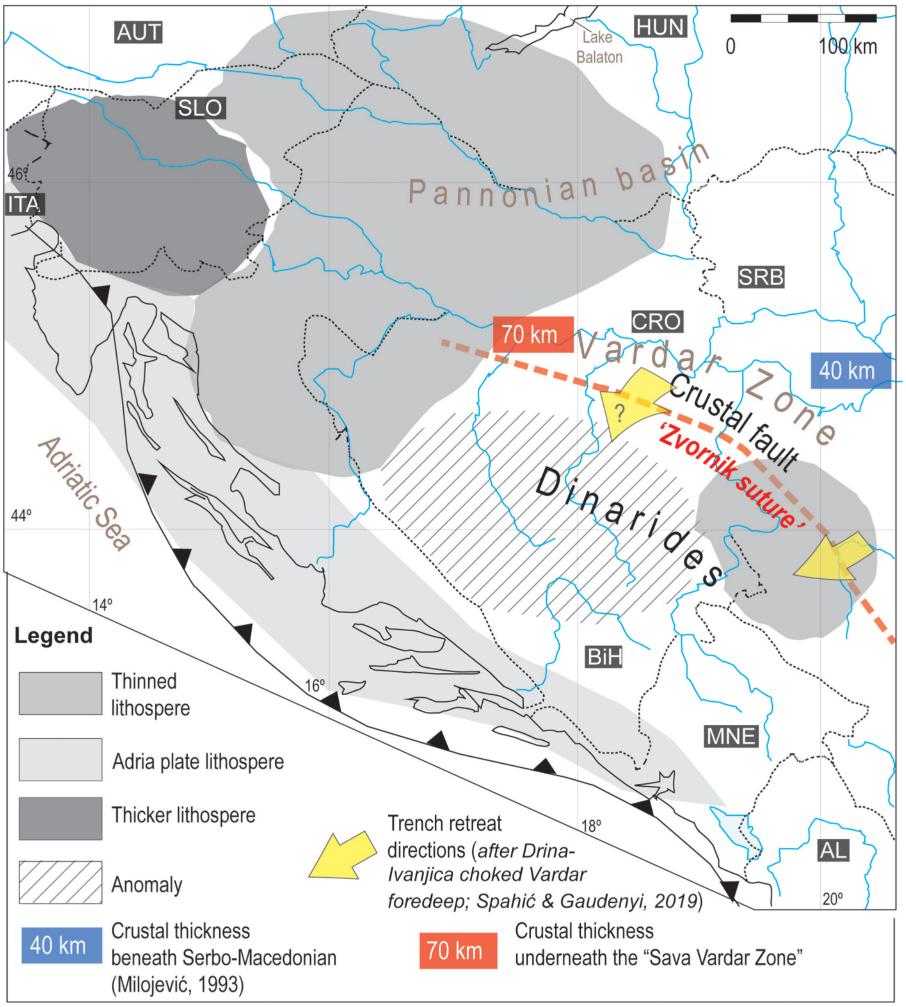


Fig. 5. Superimposed crustal fault (Vukašinović, 1973), with the asthenosphere thickness beneath the Dinarides and Vardar Zone (modified after Belinić et al., 2018a). Position of the crustal fault corresponds to the western–north-western edge of the Vardar Zone or the 'Zvornik suture'. Despite the orogenic configuration, the thinned lithosphere indicates a significant change in the crustal lithosphere. The thick segment represents the Dinarides whereas the thin belongs to the Vardar Zone.

Subsurface lineaments as conspicuous markers separating the Vardar Zone from the Dinarides

The along-strike geometry of the subsurface crustal fault (Vukašinović, 1973; Fig. 4) follows the surface truncations, thus outlining the interface between the Drina-Ivanjica block and Apulia/Adria as whole and the West Vardar Zone (beneath 'Zvornik suture'; compare Figs.1b,c, 2, 5). This subsurface fault system probably marks the tapering sliced continental ridge. The subsurface fault system precisely outlines a western boundary of the (West) Vardar Zone (towards the Inner Dinarides, 'Zvornik suture'; Fig. 1a,b). Farther towards the east, another subsurface crustal lineament (Central Serbia) outlines the interface towards the Serbo-Macedonian Unit *i.e.* former Euroasian foreland.

A comparison of the lithospheric thicknesses: Dinarides vs. Vardar Zone

The 2D and 3D tomography reveals a considerable low-velocity anomaly beneath northern Dinarides (Croatia, Bosnia and Herzegovina, and Serbia). This anomaly depicted a "slab gap", interpreted as thermal erosion of the local lithosphere (*e.g.*, Handy et al., 2014; Belinić et al., 2018a). Thinned lithosphere (lithosphere-asthenosphere boundary is at *ca*.70 km) underneath the northwestern edge of Dinarides (Belinić et al., 2018a; Fig. 5) is however, complementary with the surface area occupied by the Vardar Zone. The transition from a thick- towards a thin lithospheric segment marks the 'Zvornik suture', the difference between the remnants of a sunken oceanic- (northwestern Neotethys, Vardar Ocean) and sliced continental crust (Inner Dinarides). It though remains unclear whether the anomaly in the central segment (hatched ellipse) delineates a subsurface configuration of the former microbasin or Dinaric Tethys.

Conclusions

By building on in-depth composite Neotethyan geological constraints, the study filtered out important arguments aiding the hitherto reconstructions of the complex Tethyan Mesozoic paleogeographic and tectonic configuration in the area of Western Balkans. The competing tectonic and paleogeographic models are tested further imposing the role of the relevant principal plate boundary referred to as the 'Zvornik suture'. The study emphasizes the role of the 'Zvornik suture' in the configuration between the main Vardar Zone (West Vardar Zone), Drina-Ivanjica continental block (including its southern extension, Pelagonian basement) and the segment of Dinaric-Hellenic ophiolite belts.

- The 'Zvornik suture' marks a fossil lithospheric-scale plates boundary, it represents at least two principal Mesozoic convergent margins juxtaposed on top each other, (i) Middle–Late Jurassic overprinted by that of the (ii) Cretaceous–Paleogene age. The 'Zvornik suture' disconnected the Apulia/Adria microplate (its passive margin) from the Neotethyan oceanic lithosphere (West Vardar Zone) and the peculiar Jadar block;
- As the strike-slip faulting was excluded as a mean capable to derive all the ophiolites from a single basin, the solution proposing a number of inter-connected basins seems to be a more effective solution (similar as in Greece and Turkey, Roberson & Dixon, 1984). The oblique, dextral crustal-scale motions proposed earlier are in accord with the late Alpine (indenting) movements of, in this case, the *Adriatic lower plate* of the double-vergent behaviour (Doglioni et al., 2007);
- The distance over which the overriding West Vardar ophiolites were transported over a buoyant Apulia/Adria continental margin (vicinity of the Jurassic 'Zvornik suture') is of much shorter extent;
- The important set of differences between the Drina-Ivanjica- and Jadar block, as well as the tectonic inheritance of the Bukulja-Venčac block are not profoundly included into the "single-ocean" reconstruction (Model#1). It appears that a significantly different Jadar system has a cluster of pre-Alpine Variscan to Eocimmerian features (e.g., mild metamorphic overprint, Permian-Triassic sequence) relative to the Drina-Ivanjica block. The latter carrying the metamorphic Carboniferous but not Permian-Triassic (Spahić & Gaudenyi, 2020). The complex Bukulja-Venčac crystalline may be of same geotectonic inheritance as the Drina-Ivanjica block, however further study seems to be a valid option;
- The Dinarides including the Inner Dinaridic Ophiolite Belt (with its Cretaceous overstepping sequence; Savezni Geološki Zavod, 1970) represent a discrete (sub)zone of the Apulia/Adria microplate. These thick skinned units are distinctively separated from the West Vardar Zone and Cretaceous (Sava)Vardar Zone by the Drina-Ivanjica block and 'Zvornik suture'. The Inner Dinaridic Ophiolite Belt corresponds to a segment of the Inner Dinaride-(Mirdita-Pindos) oceanic system (as proposed earlier by Bazylev et al., 2009; Robertson et al., 2009), or Dinaric Tethys (*sensu* Dimitrijević, 2001) i.e. its northwestern domain. This subzone represents a vestige of a short-lived and narrow landlocked ocean (Upper Triassic – latest Jurassic, Robertson & Karamata, 1994; Pamić, 1998; Dimitrijević, 2001)

positioned to the southwest of the Drina-Ivanjica block or on top of the Apulia/Adria crustal microplate. Any application of the term *Dinarides* in the context of the *Vardar Zone* (as adopted recently) inflates an unnecessary confusion (see Dimitrijević & Dimitrijević, 2009, for a discussion). Thus, such terminological inconsistency should be omitted in the future investigations of the NW Neotethyan/Vardar oceanic realm. This particularly holds for the Vardar Zone, as this principal convergence margin stretches far-beyond the Dinarides into the Vardar–Izmir–Ankara–Erzincan suture of the eastern Neotethys.

Acknowledgement

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors. The paper benefited from the review of Prof. Dr Laura Gaggero from the University of Genoa. Authors would like to thank anonymous reviewer for the suggested improvements of the manuscript content. We are thankful on earlier discussions with Dr Bojan Glavaš-Trbić from Geological Survey of Serbia.

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Резиме

Значај Зворничког шава при одређивању броја неотетиских палеоокеанских ентитета: Површинска и потповршинска карактеризација дела фосилне маргине литосферних микроплоча (контакт Вардарске зоне и Унутрашњих Динарида)

Резултати комплексних регионално-тектонских и палеогеографских истраживања указују на значај Зворничког шава као некадашње мезозојске маргине са полифазном транскурентном активности. Најужи део Зворничког шава се налази између Западне вардарске зоне и Јадарског блока са једне стране, и Дринско-ивањичког блока са супротне тј. југозападне стране. Овај веома комлексан систем маркира некадашњу границу литосферсних микроплоча (Унутрашњи Динариди као некадашња пасивна маргина и офиолити Западне вардарске зоне) које су током средње- и касне јуре оверпринтоване доњо-кредно-палеогеном колизијом и навлачењем. Самим тим Зворнички шав представља вишекратну зону сучељавања литосферних локалних микроплоча тј. одваја пасивну маргину Апуљско-јадранске плоче од неотетиске океанске литосфере (Западна вардарска зона) и самосталног Јадарског блока.

Као вишекратно (ре)активирана расeдна зона са доминантно транскурентним кинематским карактеристикама, Зворнички шав искључује могућност навлачења тј. обдуковања океанске литосфере са великом дужином скока океанске литосфере. Узимајући у обзир доминантна транскурентна кретања, тектонско порекло офиолита који су се обдуковали из једног басена постаје упитно. С тога навлачење од више од стотину километара је мање вероватно. Самим тим иницијално предложена солуција која дефинише више повезаних басена у оквиру једног система се чини плаузибилнијом (слични примери постоје у Грчкој и Турској према Robertson & Dixon, 1984). Представљени покрети декстралне транскуренције су у сагласности са

карактером двовергентног орогена где је контакт на истраживаном простору у подређеном положају на Алпски индентер који је кретан ка северозападу (Doglioni et al.,2007). У складу са предложеном кинематиком Зворничког шава, као и подацима са терена (према картама Mojsilović et al., 1975, Gerzina, 2010), дужина навлачења Западновардарских офиолита и њихово транспортовање преко Апуљско-јадранске континенталне маргине (у окружењу јурског Зворничког шава) је била много краћа од вредности исказаних према моделу #1. Уз Зворнички шав јављају се и други аргументи који оспоравају навлачење тј. обдуковање од више стотина километара. Између осталих, истиче се скуп битних разлика између Дринско-ивањичког- и Јадарског блока, као и тектонско порекло Букуљско-венчачког блока (ове разлике нису објашњене у моделу #1). Постојање значајних разлика између Јадарског система, почев од преалпских/варисцијских до ео-кимеријских догађаја (благ метаморфни оверпринт, пермско-тријаске секвенце) у односу на Дринско-ивањички блок се мора узети у разматрање. Комплексни кристалин Букуља-Венчац највероватније је припадао Дринско-ивањичком блоку, међутим потврда ове констатације захтева даља истраживања.

У састав Динарида улази и Унутрашњодинаридски појас офиолита (са кредним оверстеп секвенцама; према Savezni geološki zavod, 1970) и представља (под)једницу Апуљско-јадранске микроплоче у ширем смислу. Офиолитске јединице истраживаног подручја су одвојене Зворничким шавом и Дринско-ивањичким блоком од Западне вардарске зоне и кредне (Савско-)Вардарске зоне. Унутрашњединаридски појас офиолита одговара делу Унутрашње Динаридског-(Мирдита-Пиндос) океанског система (према предлогу Bazylev et al, 2009; Robertson et al., 2009) тј. Динарском Тетису (према Dimitrijević, 2001) или северозападном делу Неотетиса. Ова палеогеографска јединица тј. Динарски Тетис представља релативно краткотрајно (у геолошком смислу) копном оивичен узани океански простор који је егизистовао од касног тријаса до краја јуре (према Karamata & Robertson, 1994; Pamić, 1998; Dimitrijević, 2001). Динарски Тетис се налазио југозападно од Дринско-ивањичког блока или северно од Апуљско-јадранске микроплоче.

Закључно, било каква имплементација тј. „прикључење“ Вардарске зоне у Динариде уноси даљу непотребну конфузију при већ многобројним истраживањима ионако комплексне геологије простора бивше Југославије (види коментаре од Dimitrijević & Dimitrijević, 2009). Вардарску зону и Динариде потребно је раздвојити као посебне геолошке ентитете, нарочито у будућим истраживањима. Ово се првенствено односи на Вардарску зону, чија се главна маргина конвергенције протеже изван Динарида и Хеленида (према истоку) као Вардар-Измир-Анкара-Ерзикан сутурна зона источног дела Неотетиса.

Manuscript recieved September 18, 2020
Revised manuscript accepted November 11, 2020