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Intraoceanic subduction of the northwestern Neotethys and geodynamic interaction with Serbo-Macedonian foreland: Descending *vs.* overriding near-trench dynamic constraints (East Vardar Zone, Jastrebac Mts., Serbia)

Darko Spahić[1] & Tivadar Gaudenyi[2]

Abstract. A composite paleogeographic and plate kinematic spatiotemporal reconstruction of the exhumed Neotethyan cross-lithospheric footwall amalgamation (Jastrebac dome) incorporates the two formerly underplating oceanic entities, West Vardar- and East Vardar Zone. These ophiolite-bearing agglomerations are unroofed within the accretionary Paleogene to Miocene core-complex, beneath the Serbo-Macedonian overriding plate. The exposed Neotethyan crustal amalgamation is comprised of: an *(i)* folded trench assemblage of uncertain Mesozoic? Paleogeographic affinity metamorphosed under a greenschist-grade (West- *vs.* East Vardar Zone or Neotethyan crust- *vs.* its back-arc system?) sandwiched beneath the overlying *(ii)* late Cretaceous – Paleogene (meta)turbidites. To make matters more intricate, at the closest proximity of the dome (Mali Jastrebac Mountain) there is a similar *(iii)* greenschist-facies amalgamation comprised of the Neoproterozoic – Lower Paleozoic ocean-floor assembly (Supragetic basement).

The interpretations of this rather controversial cross-lithospheric structure include a reassessment of the obduction sequence, and are underpinned by the restoration of the near-trench microplate motions. The study addresses the (1) local finite configuration (Serbo-Macedonian hanging wall *vs*. Neotethyan intraoceanic arc) and the (2) spatiotemporal geometry of the principal (micro)plate boundaries (Serbo-Macedonian Unit *vs.* Apulia/Adria). Unlike the earlier proposal of the ophiolite obduction onto the Serbo-Macedonian Unit onto the Apulia/Adria hinterland (or external segment of the "Dacia mega-terrane"), we here propose a west-vergent obduction of the East Vardar Zone ophiolites onto the descending Neotethyan lithosphere (West Vardar ophiolites) - a similar scenario to its continuation in Greece (Peonias subzone).

Key words:
Jastrebac metamorphic complex, East Vardar Zone, intraoceanic subduction, retreating collision, west-vergent nappe.

Апстракт. Временско-просторна структурно-геолошка и палеогеографска реконструкција неотетиског литосферног океанског система на примеру Јастребачког тектонског прозора обједињује два литосферна члана представљених офиолитима мезозојске старости: периферне Источне вардарске зоне (ИВЗ) и главне Западне вардарске зоне (ЗВЗ). Амалгамација две литосферске океанске јединице се одиграла пре ступања у конвергентне односе Алпског индентера (Апуљско-јадранска микроплоча) и Европског промонторијума тј. од горње јуре до доње креде. Овај литосферни агломерат је током, (и после) касноалпске конвер-

[1] Geological Survey of Serbia, Rovinjska 12, 11000 Belgrade, Serbia. E-mails: darkogeo2002@hotmail.com; darko.spahic@gzs.gov.rs
[2] Geographical Institute "Jovan Cvijić" of the Serbian Academy of Sciences and Arts, Djure Jakšića 9, 11000 Belgrade, Serbia.

генције ексхумиран и раскровљен у виду Јастребачке доме. Јастребачка дома представља сегмент акретоване коре која се налази унутар некадашње маргине Неотетиса тј. у оквиру Српско-македонске јединице (СМЈ). Ексхумација Великојастребачког мезозојског(?) комплекса указује на подински однос према некадашњој Српско-македонској континенталној маргини. Великојастребачки поликристаласти стенски комплекс је састављен од: (1) набраних јурских офиолитских асемблажа деформисаних до фације зелених шкриљаца унутар некадашњег океанског шава, са још увек нејасним мезозојским палеогеографским афинитетом ових стена. Изнад наведеног Великојастребачког пакета утврђени су анхиметаморфни (2) горњокредни до палеогени (мета)турбидити ("сенонски флиш" / "Савска зона"). Даљој стратиграфско-структурно-палеогеографској конфузији јастребачких зелених шкриљаца доприноси сличност са (3) фацијом истог нивоа метаморфизма (Супрагетик), која међутим припада некадашњем океанском асемблажу неопротерозојско-доње палеозојске старости (откривена на подручју Малог Јастрепца, источни део).
Током конвергенције поменутих микроплоча долазило је до вишекратног повлачења субдукционог рова и саме подинске литосфере (*retreating collision* или 'колизија субдукционим повлачењем') што је утицало на синколизионо истезање ригидног блока повлатне Српско-македонске маргине. Осим тектонског модела, изнети су закључци о дужини трајања и правцима обдуковања поменутих офиолита на Српско-македонску јединицу (деформациона фаза D1) тј. на залеђе Апуљско-јадранске микроплоче је: (1) иницијална просторно ограничена, са лимитираном дужином западно-вергентног обдуковања офиолита ИВЗ преко доњег- или Неотетиског (Западно вардарског тј. ЗВЗ) океанског литоферног сегмента (слично као и у наставку Вардарске зоне у Грчкој; Пеонијас зона). Такође, предложеним *retreating collision* системом се објашњава ексхумација тј. екстензија повлатног блока у конвергентном односу и резултујућим стварањем *core-complex* доме Великог Јастрепца (фаза D4).

Кључне речи:
Јастребачки полиметаморфни комплекс, Источна вардарска зона, интраокеанска субдукција, „колизија субдукционим подвлачењем", западно-вергентно навлачење.

Introduction

The conflicting Jastrebac accretionary assembly (central Serbia; Fig. 1a) have been interpreted either as a tectonic window exposing formerly underplating distal paleogeographic domains of the African Apulia/Adria microplate (Erak et al., 2016) or an outcropping segment of the Sava-Vardar back system of the main Neotethyan ocean (Marović et al., 2007). There is also an opinion that the latter core-complex (*sensu* Brunet al., 2018) exposing the greenschist level elements confirmed (Grubić et al., 1999) for the nearby Supragetic basement. Moreover, the intricacy multiplies because the nearby ophiolite-bearing segment of the East Vardar Zone (including Upper Cretaceous turbidites of western Veliki Jastrebac; Fig.1; Red question mark) has a set of conflicting structural-tectonic and paleogeographic reconstructions. The East Vardar Zone ophiolites can either be identified as (i) oceanic system overlain by a Serbo-Macedonian margin (gneiss-dominating crystalline rocks; Rakić et. al., 1969; Dimitrijević et. al., 2001; Petrović et al., 2015) or (ii) as ophiolite entity which overrode the Serbo-Macedonian continental margin. The latter concept is elaborated by the ophiolite obduction on top N–S to NW–SE trending subduction zone (Schmid et al., 2008, 2019; Erak et al., 2016; Maffione & van Hinsbergen, 2018). There is also an opinion that this zone can be qualified as a segment of mixed extensional and compressional pull-apart systems (Sokol et al., 2019). Such uncertainty of the reconstructed former cross-lithospheric orientations makes the paleogeographic inheritance of the exhumed Jastrebac agglomeration

***Fig. 1**. **a**. North Mediterranean including Alpine-Dinaride-Carpathian mobile belt and Jastrebac location; **b.** Geographical map showing position of the Jastrebac tectonic window protruding between the two arcuate morphotectonic systems (Dinarides and Serbo-Macedonian as European foreland including the Carpatho-Balkanides). The Vardar Zone includes its marginal system referred to as the East Vardar Zone stretching into North Macedonia and Greece.*

and this segment of the East Vardar Zone (Boev et al., 2018) highly ambiguous.

The Mediterranean crustal motions (*e.g.*, Okay & Türysüz, 2009; Şengor, 2009; Faccenna et al., 2014; Gürer et al., 2016; Menant et al., 2016; Le Breton et al., 2017) formerly controlling the complex geodynamic processess of Neotethyan (=Vardar) ocean are best revealed in an controversial geotectonic setting of Western Balkan countries (W–SW-vergent system of nappes; Dimitrijević, 1992, 1997, 1999, 2001; Karamata, 2006; Schmid et. al., 2008, 2019; Figs. 1, 2). Several essential outcrops allowing a better understanding of highly complex Mesozoic paleogeography (*e.g.*, Stampli, 2001; Csontos & Vörös, 2004; Stampfli & Hochard, 2009; van Hinsbergen et al., 2019) and associated cross-lithospheric configurations are those elevating the Neotethyan oceanic crust (exhumation via post-accretionary core-complex formation; *e.g.*, Marović et al., 2007; Stojadinović et al., 2013). The lithospheric remnants of northwestern Vardar/Neotethyan Ocean are consisting of the two elongated NNW–SSE-directed ophiolite-belts: West Vardar Zone or the main Vardar/Neotethys Ocean and the adjoining heavily disrupted East Vardar Zone representing its marginal basin (hereinafter EVZ; Dimitrijević & Dimitrijević, 1973, 1975; Dimitrijević, 2001; Karamata, 2006; Srećković-Batoćanin et. al., 2012; Fig. 2).

The investigated cross-lithospheric segment (vicinity of Jastrebac), in addition to these Upper Cretaceous to Paleogene turbidites has the record of late Jurassic - Lower Cretaceous shallow marine, clastic sequence with some turbidite features referred to as the "paraflysch" (after Dimitrijević & Dimitrijević, 2009).

The aims of this study are the (i) reassessment of the conflicting cross-lithospheric orientations reporting the interaction between the Neotethyan-, EVZ ophiolites and Serbo-Macedonian accretionary margin, whereas we further propose (ii) a geodynamic concept based on the intraoceanic subduction model (main West Vadar plate beneath the back-arc system). Importantly, the suggested cross-lithospheric kinematic model is autonomous of the uncertain age of the highly deformed Jastrebac greenschist package, which we moreover describe as the segment of oceanic lithosphere belonging to the EVZ.

Regional geological framework

The Dinarides-Hellenides sector extends N–S throughout former Yugoslavia, connecting Slovenia, Croatia, Bosnia and Herzegovina, Serbia, North Macedonia crossing over in Greece. This Alpine fold-and-thrust belt emerged at the expense of Mesozoic-Tertiary convergence between south European

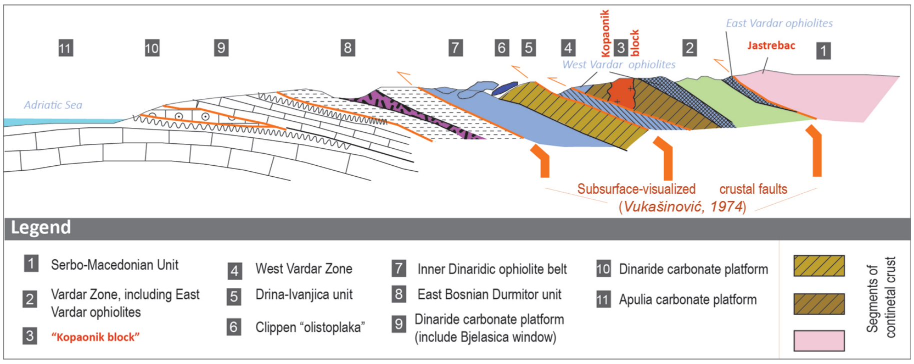

Fig. 2*. Simplified cross-section of central Serbia and Montenegro, modified from* DIMITRIJEVIĆ *(2001). The section includes the crustal faults taken from* VUKAŠINOVIĆ *(1973). The investigated area of Jastrebac Mts. is within the central Serbo-Macedonian Unit.*

foreland and Apulia/Adria indenter. Across the West Balkan countries, a shortlived Neotethyan ocean left several episodes of oceanic crust production and its debatable emplacement on local continental margins (*e.g.*, DIMITRIJEVIĆ, 1997; KARAMATA, 2006; SCHMID et al., 2008). In addition, its unconstrained basement remains to be a highly controversial topic (*e.g.*, VAN HINSBERGEN et al., 2019; SPAHIĆ et al., 2019b). The evidence of a principal Mesozoic- Cenozoic shortening event is best exposed in what is now SE Europe (SEE). The SEE is crosscut by a large mega-suture referred to as the Vardar Zone (DIMITRIJEVIĆ, 1997; KARAMATA, 2006; CVETKOVIĆ et al., 2014). This controversial suture is comprised of the remnants of the Neotethys or West Vardar Zone, and EVZ or its backarc system (MAROVIĆ et al., 2007; TOLJIĆ et al., 2016; TOLJIĆ, 2018). The Vardar (suture) Zone is sandwiched between the four distinct Neoproterozoic to Paleozoic-Mesozoic crystalline systems: (1) Drina-Ivanjica block (segment of Adria/Apulia passive margin; SCHMID et al., 2008) separated by the 'Zvornik suture' (DIMITRIJEVIĆ, 1997; GERZINA, 2010) from the peculiar (2) Jadar terrane (*sensu* FILIPOVIĆ et al., 2003). Towards the south, the Vardar Zone narrows near the intriguing "continental ridge-like" Triassic polymetamorphic entity referred to as the (3) "Kopaonik block" (KARAMATA et al., 1994; KARAMATA, 2006; ROBERTSON et al., 2009; ZELIĆ et al., 2008). This entity is characterized by Upper Triassic metalimestones, metarenites, metapelites and metadolomites, basaltic magmas connecting this area with the Alpine continental arc opening and subsequent onset of this segment of the Vardar Ocean (ZELIĆ et al., 2005, 2010). The eastern margin of the Vardar Zone is a (4) Serbo-Macedonian Unit or westernmost terrane of Dacia mega-agglomeration. Essentially, the Serbo-Macedonian Unit represents a segment of the European foreland (Mesozoic accretionary wedge) positioned in front of the Carpathian-Balkan fold-and-thrust belt (Fig. 1b). In its central segment, this former margin exposes a complex interplay of local Mesozoic microplates (DIMITRIJEVIĆ, 2001; BOEV et al., 2018) later displaced by the Alpine nappe stakjing (CSONTOS et al., 2004; SCHMID et al., 2008; Fig. 2). The cross-lithospheric agglomeration (Dinarides and Vardar Zone) was unconformably sealed by the late Cretaceous suture referred to as the "Sava Ocean" (*sensu* SCHMID et al., 2008) or "senonian flysch" (DIMITRIJEVIĆ, 1997; Fig. 4). The EVZ represents actually a marginal basin (*e.g.* RESIMIĆ-ŠARIĆ et al., 2005; SACCANI et al., 2008), an intraoceanic arc (GALLHOFER et al., 2017) probably developed on top of formerly subducting West Vardar plate. The EVZ or intraoceanic arc-related ophiolites contain no metamorphic sole (MAFFIONE & VAN HINSBERGEN, 2018 and references therein). The geochemical composition of the East Vardar Ophiolites varies from Serbia to Greece, exhibiting Back-Arc-Basin, mixture of Mid-Oceanic-Ridge- and Supra-Subduction-Zone-affinity including the confirmed presence of boninites.

A high-elevated site in central Serbia (horst structure of Jastrebac Mts.) is positioned just a few kilometers from the interface of the EVZ and former Serbo-Macedonian continental margin. The mentioned margin provides an exceptional exposure of the former Neotethyan trench assemblage (MAROVIĆ et al., 2007; ERAK et al., 2016; Fig. 1a, b). The Jastrebac tectonic window represents unique opportunity to glimpse into the complex subsurface configuration of the plate junction connecting NW Neotethyan lithosphere sandwiched between: (1) the

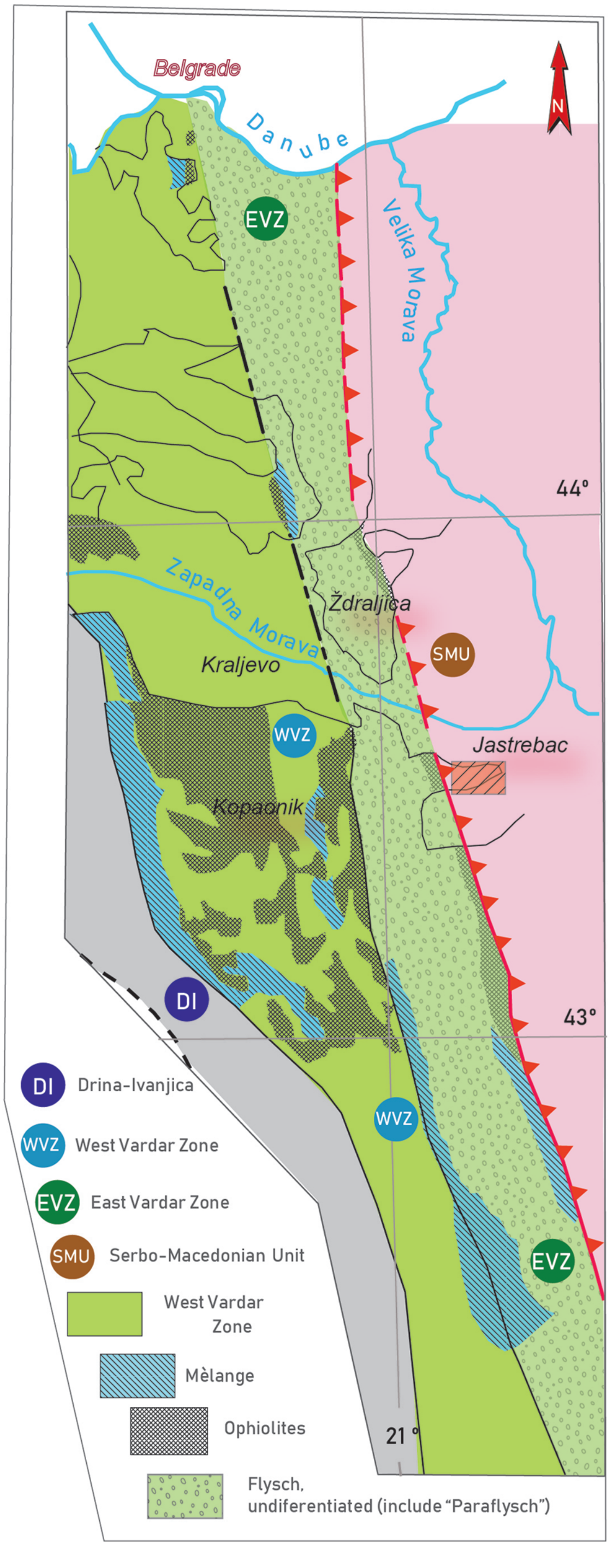

Fig. 3. *Position of the Jastrebac Mts. relative to the main ophiolite-bearing and mélange zones in the central and western Serbia. Towards the East Vardar zone, this oceanic entity is in a form of the narrow belt making the plate boundary with the Serbo-Macedonian Unit (inlet modified after* DIMITRIJEVIĆ *&* DIMITRIJEVIĆ*, 1973; modified).*

lower positioned passive margin of the Apulia/Adria microplate and (2) EVZ or former back-arc to fore-arc system (GALLHOFER et al., 2017; TOLJIĆ et al., 2018), including the (3) Serbo-Macedonian Unit (accretionary margin). The investigated cross-lithospheric assembly is unroofed in the central portion of the Serbo-Macedonian Unit (Figs. 2, 3) characterized by a ~15 km-wide tectonic window (Fig. 4). An array of extensional detachments (MAROVIĆ et al., 2007) and shear zones (SPAHIĆ, 2006; ERAK et al., 2016) uplifted a Jurassic (?) to Paleogene crustal sequence of disputed paleogeographic inheritance.

Geology of the Jastrebac mountains

Jastrebac is a prominent mountain of Central Serbia, positioned between the Dinarides and Serbo-Macedonian/Carpatho-Balkanides (Fig. 1a,b). The mountain ridge consists of the two discrete segments, Veliki- and Mali Jastrebac (Fig. 1a). The most elevated peaks (*Velika Đulica and Tri sestrice*; Fig. 5) reach an elevation of 1.491 m and 1.482 m respectively.

The investigated system of Veliki Jastrebac comprises of rocks of Paleozoic, Jurassic, and Cretaceous–Paleogene age (RAKIĆ et al., 1969). A Miocene and Pleistocene veneer covers the immediate surroundings of the mountain. The Eocene granodiorite core of Veliki Jastrebac unroofed Serbo-Macedonian Unit (Fig. 5, lithology#1) and several other formations. Veliki Jastrebac granodiorite have a radiometric age varying from 37 Ma (Rb-Sr; DIVLJAN, 1979) to 47.59 Ma (LA-ICPMS U-Pb zircon age; ERAK et al., 2016). The dominant late Cretaceous - Paleogene metaturbidites surrounding the core (Fig. 5, lithology #2) have an unclear relationship with the greenschist-facies assembly (Fig. 2; Fig. 5, lithologies #3,4,5; RAKIĆ et al., 1969). Greenschist assembly consists of actinolite-, chlorite-, epidote schists, chlorite-sericite-, sericite schists, calcschists, marbles, and metagabbro. The smaller-scale granitoid intrusion of Mali Jastrebac identified as Triassic age (229–192 Ma; Rb-Sr, DIVLJAN, 1979; Fig. 5, lithology#7). Eastern edge of Mali Jastrebac is another set of greenschist-facies rocks (Fig. 5, lithology#9; Supragetic) which is in the tectonic contact (ERAK et al., 2016) with the Serbo-Macedonian Unit (Fig. 5, lithology #10).

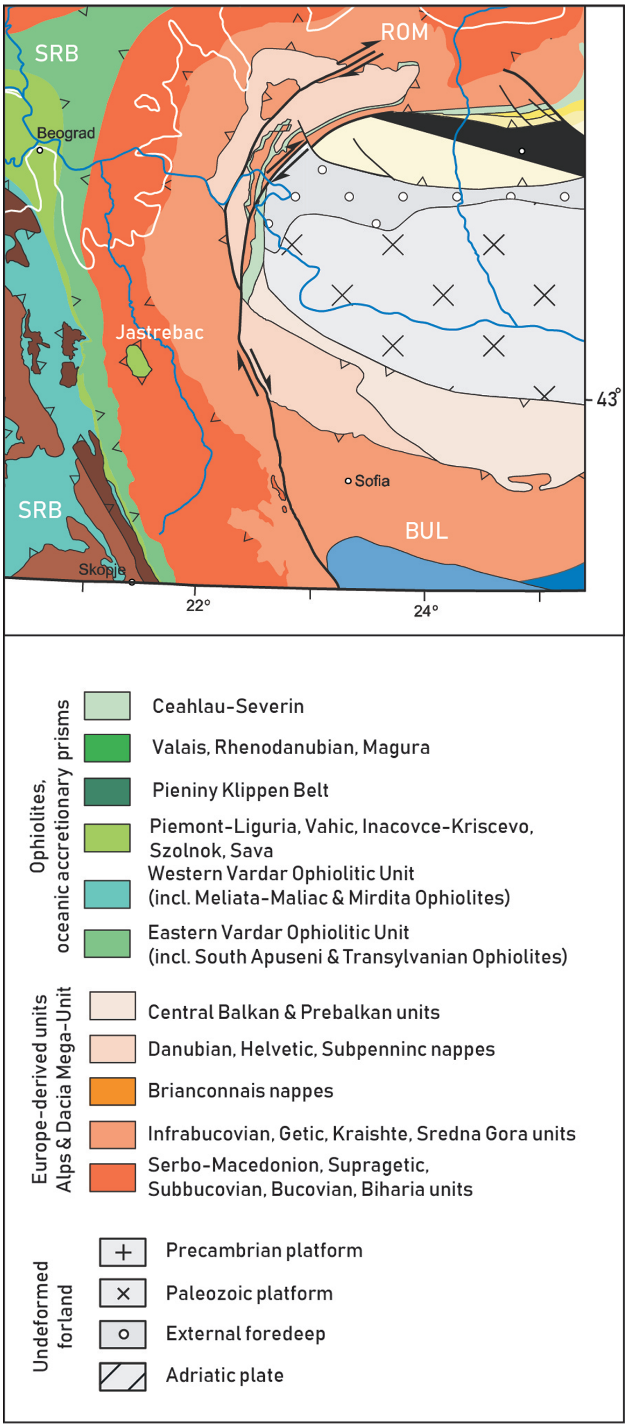

***Fig. 4**. The Jastrebac segment of the map "Major tectonic units of the Alps, Carpathians and Dinarides" (modified after* Schmid *et al., 2008).*

Serbo-Macedonian Unit (Veliki- and Mali Jastrebac)

The Serbo-Macedonian Unit ("Lower Complex" of the Serbo-Macedonian Unit *cf.* Dimitrijević, 1997) consits of dominant mica schists, gneisses with local migmatites, amphibolites and occasional marbles (Rakić et al., 1969). Locally, this crystalline basement unit overrides the entire Jastrebac system bearing the record of the late Alpine shortening (D3 – deformation phase; Fig. 5). In addition to the medium-to high-grade crystalline gneisses (Fig. 5, lithology #10, light yellow) and mica schist's (Fig. 5, lithology #10, dark yellow) this unit is comprised of amphibolites and graphitic schists (Rakić et al., 1969; Aleksić, 1977; Fig. 5, lithology #14). The thickness of this Neoproterozoic - early Paleozoic unit (Deleon et al., 1972; Balogh et al., 1994; Antić et al., 2016) reaches max 1800 m (Dimitrijević, 1997). The mylonitized rocks near the village Vukanja (major shear zone; Spahić, 2006; Erak et al., 2016; Fig. 5, lithology #8) exposed in the southeastern realm of the Veliki Jastrebac dome (Fig. 5) is abundant with the following late Neoproterozoic (Ediacarian) flora: *Protoleosphaeridium conglutinaum* Tim., *Leioligotriletum minutissimus* (Naumova) Timofeev (Aleksić & Kalenić, 1975). The Vukanja shear-zone is of Miocene age (Erak et al., 2016).

Supragetic basement (Mali Jastrebac)

The Supragetic basement is a crystalline rock assembly comprised of dominant greenschist-grade metamorphics (*sensu* Spahić et al., 2019a and references therein; Fig. 5, lithology#9). In eastern Serbia, the lower part of this unit is comprised of chlorite-muscovite-albite, chlorite-albite and biotite-chlorite-mica-albite gneisses, which are transitioning into the greenschist-facies rocks (actinolite, actinolite-epidote, albite-chlorite schist etc.; Pavlović, 1975, 1977). The vertical succession of the Supragetic basement continues by a presence of quartzite layers and a stratigraphically uppermost part, calcschist and marbles. The following spora associations characterize the younger stratigraphic sections of the Supragetic basement: *Trachyoligotrilletum magnetum* Timofeev, *Stenozonoligotriletum* sp., *Stenozonoligotriletum sokolovi* Timofeev, *Trachyoligotrilletum* cf. *laminarium* Timofeev. In the intervening part of the succession, spores reflect a Middle Cambrian age: *Stenozonoligotriletum* cf. *validum* Timofeev, *Stenozonoligotriletum*

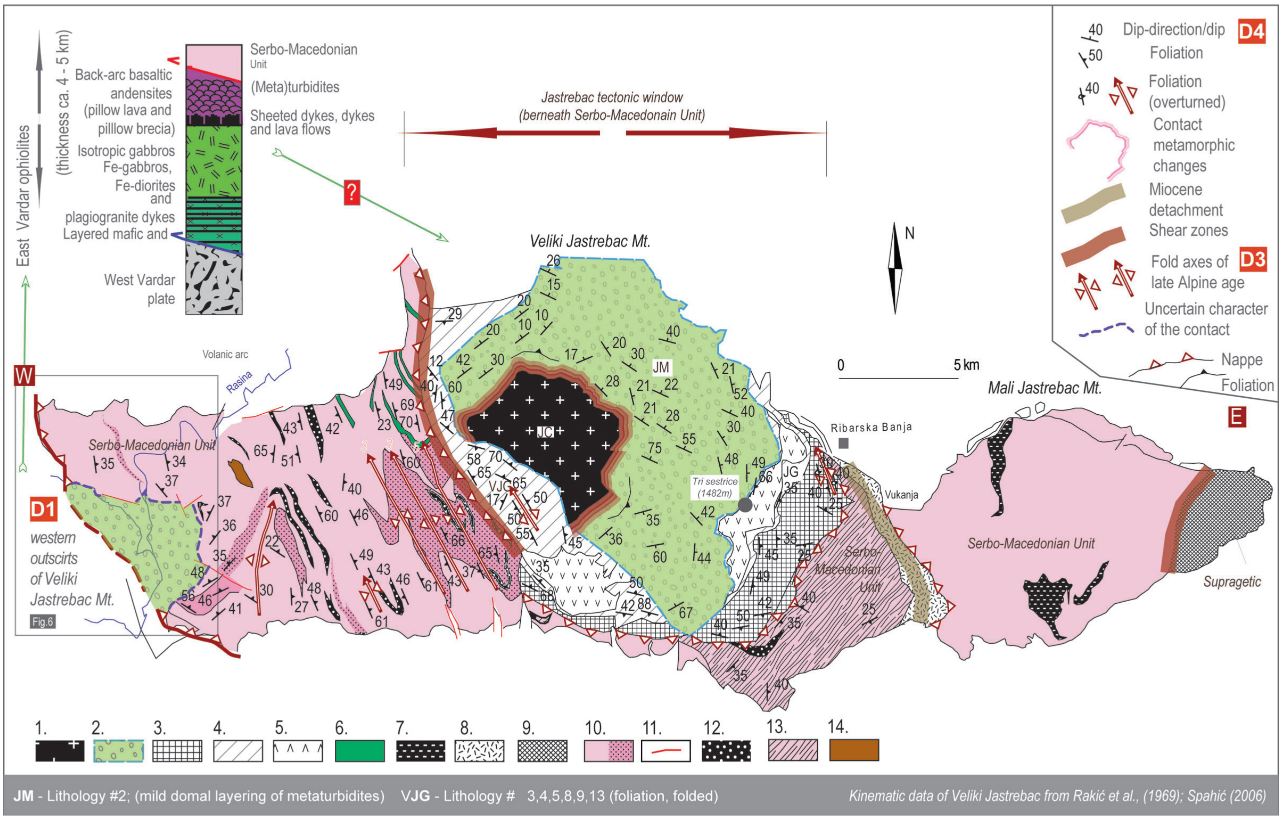

Fig. 5. ***Fig. 5.** Geological map highlighting the essential metamorphic lithotypes of the Jastrebac tectonic window (Veliki Jastrebac Mt., modified after* Aleksić*, 1975 and references therein). Metamorphic facies: **1.** Granodiorite of the Eocene age; **2.** Metaturbidites of Veliki Jastrebac (please note that for simplification purposes we use the same color and hatching for western Veliki Jastrebac Upper Cretaceous flysch-bearing system); **3.** Calcschists and marbles; **4.** Greenschists: Actinolite schists, phillites, marbles, calcschists, sericite schists, quartzites; **5.** Metagabbro; **6.** Amphibolite and amphibolitic schists; **7.** Granitoid of Triassic age; **8.** Mylonitic rocks; **9.** Greenschists: chloritic schists; **10.** Gneiss, mica schist with garnet and migmatite; **11**. Minor faults; **12.** Mica-rich quartzite; **13.** Gneiss with staurolite and mica schists; **14.** Graphite-bearing gneiss. Red rectangle white question mark denotes the issues of the paleogeographic inheritance of the “VJG” – whether the latter belong to the EVZ or not. Lithologic column of East Vardar ophiolites (top left corner) modified from* Maffione *&* van Hinsbergen*, (2018), for details see* Resimić-Šarić *et al., (2005). The lithostratigraphic and kinematic data (the latter are exclusively displayed for Veliki Jastrebac Mt.) depict four principal deformation phases: **D1.** Development of the ophiolites and mélange formation (see Fig.6 for configuration details); **D2.** Tight folding of former oceanic segment (VJG); **D3.** Tight folding and E–W compression and the formation a number of antoforms and synforms in Serbo-Macedonian; **D4.** Extension exhumation whereas the preserved layering around granodiorite core (JM) delineates a domal emplacement (periclinal distributing of direction-dip measurements).*

sp., *Stenozonoligotriletum sokolovi* Timofeev., *Protoleiosphaeridium* sp., *Dyctiotidium* sp (Aleksić & Kalenić, 1975). Biostratigraphic discoveries within sericite schists (upper stratigraphic levels) of brachiopod fauna, *Obolus* sp. and *Lingulella* sp. outlined an Ordovician age (Pavlović, 1975 and references therein). Chlorite schists are a dominant lithology in the Mali Jastrebac (Erak et al., 2016). It is to note that calcschist/marbles are a constitutive segment of both, the Supragetic basement in eastern Serbia (Spahić et al., 2019a) and greenschists-facies rocks of Veliki Jastrebac (Rakić et al., 1969; Marović et al., 2007).

Upper Jurassic ophiolitic mélange and Cretaceous turbidites (western and central Veliki Jastrebac Mt.)

The western slopes of the Veliki Jastrebac (Fig. 5) expose a typical accretionary wedge assemblage of the Middle–Upper Jurassic to late Cretaceous–Paleogene age (Rakić et al., 1969). This Neotethyan accretionary assemblage is in the contact (farther to the west) with late Jurassic–Lower Creatceous clays, sandstones, marls, turbidites (Rakić et al., 1969). This Lower Cretaceous affinity predates the Upper

Cretaceous turbites ("paraflysch", *sensu* Dimitrijević & Dimitrijević, 2009).

The investigated portion of the Neotethyan margin is comprised of EVZ segment including a Jastrebac system. The EVZ in its central segment (to the west of the Serbo-Macedonian Unit; Fig. 5) is comprised of:

(1) Heavily disrupted ophiolites and its mélange (a section of the fossilized Jurassic back-arc system; Fig. 5 and Fig. 6; D1 deformation phase) uncomformably overlain by the late Jurassic Tithonian reef limestones (Petrović & Jankićević, 1990) and late Jurassic–Lower Cretaceous "paraflysch". The Jastrebac segment of the EVZ is in a relationship with a better-constrained crustal segment exposed near Ždraljica (Fig. 2). The Ždraljica system is a metamorphosed tholeiitic suite (Resimić-Šarić et al., 2005) exposing nearly a complete section of the EVZ oceanic crust (serpentinized peridotites, gabbros, (meta)basalts and quite rare plagiogranites embedded into the matrix of the mélange, occasionally achieving greenschist-facies). The Neothetyan oceanic crust is characterized by Mid-Oceanic Ridge-basalts/Volcanic-Arc signatures. An emplaced quartz diorite body within basic rocks reflects a Volcanic-Arc-affinity magma signature. The age of quartz diorite is 168.4±6.7 Ma implying that the magmatic activity within this part of the EVZ predates the Middle Jurassic (before 168.4 Ma), even going in Triassic as suggested by Zelić et al. (2005). Similar tholeiitic MOR-type ophiolite suite probably formed in a marginal basin (Resimić-Šarić et al., 2005) are extending to south Apuseni Mountains (Romania; Gallhofer et al., 2017).

(2) Late Cretaceous turbidites (Rakić et al., 1969) incuding late Cretaceous–Paleogene black phyllites (Marović et al., 2007) recently constrained as the segment of the "Sava Zone" or Sava–Vardar zone (Pamić, 2002; Schmid et al., 2008; also in Prelević et al., 2017).

Central Veliki Jastrebac configuration consists of the following anchizone to greenschist-facies formations:

(3) 'Veliki Jastrebac greenschists', (herein after "VJG"; Fig. 5, lithologies #3,4,5; Fig. 5) comprised sericite-, actinolite-, chlorite-schists, calcschists, metagabbros, marbles of unknown age (formerly referred to as the "Boljevac" and "Vukanja subunits"). VJG system is comprised of the following two packages (Marović et al., 2007): (1) lower sequence comprised of epidote-actinolite, albite-chlorite schists with large and (ii) small lenses of metagabbro (southern and southeastern parts of the Veliki Jastrebac dome). The upper part consists of albite-sericite schists, calcschists and marbles. Heavily deformed areas are associated with its interface with the lower sequence. The age of this upper sequence remains ambiguous, though Marović et al. (2007) indicate presence of Paleogene paleopalynomorphs. Based on calcschists, Erak et al. (2016) indicate a similarity with the Triassic of Adria microplate. These rocks are intensely folded (D2 deformation phase). The exact age and geotectonic inheritance of these rocks remains undocumented. Thus, the "VJG" could either belong to a Neoproterozoic–Lower Paleozoic Supragetic basement, or to be a segment of the West Vardar Zone (Erak et al., 2016), or to have the EVZ affinity (Marović et al., 2007). To make this segment of Neotethyan margin more intricate, there is a presence of the late Paleozoic polymetamorphic 'Veles Series' (Spahić et al., 2019b and references therein) characterized by a lithological similarity. This peculiar Paleotethyan assembly include amphibolites, greenschist-facies rocks, marbles, metalimestones accommodated along this segment of the EVZ in central North Macedonia.

(4) 'Jastrebac metaturbidites' (herein after "JM"; Fig. 5, lithology #2; Fig. 5) of the Upper Cretaceous–Paleogene age (probably a sutured flysch assemblage of the EVZ), in literature referred to as the "Lomnica subunit" (Grubić et al., 1999; Erak et al., 2016) or as the "Sava Zone" (Schmid et al., 2008). Sedimentary to low-grade metamorphic rocks abutting the granodiorite core of Veliki Jastrebac (Fig. 5; lithology#2). According to Rakić et al. (1969), this unit has a mild bending induced by the emplacement of the Jastrebac granodiorite (Fig. 5). The dip direction measurements clearly indicate periclinal distribution of strata due to the granodiorite emplacement (D4 – deformation phase). The biostratigraphical record indicate the late Cretaceous - Paleogene age for the anchizonal turbidite succession reporting globotruncanids: *Contusotruncana cf. fornicata* (Plummer), *Globotruncana arca* (Cushman), *Globotruncana linneiana* (D'Or-

bigny) and palynomorph association with *Triporopollenites coryloides* (Pflug in Thomson and Pflug) and *Pityosporites cedroides* (Thierg) (Pantić et al., 1967; Anđelković, 1975). These metaturbidites seem to be some proximal trench equivalents (Erak et al., 2016).

Interpretation results

In order to better understand the investigated cross-lithospheric amalgamation exposed on Jastrebac Mts., the initial step is the review the structural-tectonic relationship of the entire interface zone (Romania to Greece) between the Neotethys and the European margin (Fig. 1).

Configuration of the northern Neotethyan margin with its European foreland (Apulia/Adria hinterland), short review

The Vardar megasuture zone arose at the expense of N–S-directed (in Mesozoic reference) convergence between the Apulia/Adria microplate and the former Eurasian margin (locally, Eurasian margin is represented by the Serbo-Macedonian Unit and Tisza microplate). The pre-convergence highly complex Neotethyan paleogeography (*e.g.*, Menant et al., 2016; Argnani, 2018; Spahić et al., 2020) is best illustrated by a conceptual debate revolving around the Mediterranean geodynamics: one ophiolite – one ocean (*e.g.*, Csontos & Vörös, 2004; Schmid et al., 2008; Bortolotti et al., 2013) *vs*. two ophiolites – one ocean model (Robertson et al., 1996; Dimitrijević, 2001; Stampfli & Kozur, 2006). Similarly, the complex Neotethyan plate motions towards the intervening EVZ and Serbo-Macedonian Unit including the interaction of the West Vardar ophiolites and Drina-Ivanjica block remain to be another topic of discussions.

The Vardar Zone as a cryptic Neotethyan megasuture traverses SEE, extending over 1000 km (Fig. 1). In SEE, the suture emerges from Aegean Sea in Greece, strikes towards North Macedonia, crossing in Serbia and splitting near Belgrade. NW limb strikes further towards Bosnia and Herzegovina/Croatia, and at north towards Romania. The NW limb (Fig. 1) is bounded by the Peri-Adriatic dextral strike-slip fault (Grubić, 2002) including a complex fault system in western Serbia referred to as the 'Zvornik suture' (Serbia; Dimitrijević, 1997; Gerzina, 2010). To remind, NE limb is referred to as the referred to as the Vardar-Mureş zone in Romania, central and southern parts are referred to as the Vardar Zone in Serbia, North Macedonia and Greece continuing into the Izmir-Ankara suture in Turkey (Amri et al., 1996; Anders et al., 2005; Stampfli & Hochard, 2009). Its peculiar nortwestern segment is the "Sava" or Sava-Vardar Zone (Pamić, 2002; Schmid et al., 2008) or the western belt of the Vardar Zone (Robertson et al., 2009).

Along-strike configuration of the East Vardar Zone (Romania-Greece)

The EVZ interface with the Serbo-Macedonian Unit and its analogue basement units is in the form of a principal fault zone striking from SW Romania crossing into Central Serbia, extending farther towards south, reaching the Inner Hellenides. In the Apuseni Mts. (Romania; Fig. 1b), the basement of the Transylvanian Depression is comprised of the East Vardar Zone obducted onto the Biharia nappe system during the Upper Cretaceous (Sandulescu, 1984; Ionescu & Höck, 2004; Saccani et al., 2011). The obducted South Apuseni ophiolites show the trace element signatures typifying a subduction-enrichment and no contamination from the local continental crust (Gallhofer et al., 2017).

An underplating position of the EVZ (Central Serbia) beneath the Serbo-Macedonian Unit is preferred interpretation of some early and a majority of recent authors (Rakić et al., 1969; Malešević et al., 1974; Karamata et al., 1994; Petrović et al., 2015; Boev et al., 2019). Dimitrijević & Dimitrijević (1975), moreover, indicated that a highly-tectonized mélange reflects the strike-slip nature of this suture. A northern segment of the Vardar Zone (vicinity of the Belgrade; Toljić et al., 2018; Fig. 1b) is outlined having an overriding position relative to the Serbo-Macedonian Unit.

Meager late Jurassic peraluminous granite magmas were emplaced into the ophiolitic mélange near

Ždraljica (Resimić-Šarić et al., 2005). This granite emplacement in the vicinity of the Serbo-Macedonian Unit describes the magma origin as a derivation of parental magma from the local gneiss (meaning that the magma interfered with a local Serbo-Macedonian crust). Towards the south, the slab polarity diverts having here a descending configuration, positioned underneath the Rhodopean unit (Burchfiel & Nakov, 2015). Recently, by the inference of the two "allochthony levels", the two positions of a single convergence zone are outlined by using the two different slab angles (Froitzheim et al., 2014). Despite the documented high-pressure-high-temperature conditions, another recent study imposes a Jurassic East Vardar ophiolites obduction onto the Rhodopean passive margin (Maffione & van Hinsbergen, 2018). Robertson et al. (2009, 2013) explain that the EVZ ophiolites were originally thrusted eastwards over the Serbo-Macedonian Unit and that both initiall thrusts were displaced once again towards the west in a course of late Jurassic.

The discussion further continues as Dilek & Flower (2003) indicated that the Jurassic Vardar Zone ophiolites and the volcanic-arc complexes in North Macedonia and Greece arose above a subduction zone. This zone, according to the authors, disappears towards NNE, beneath the Eurasian continental margin. However, here there is another neglected, this time a Paleotethyan system, referred to as the 'Veles Series' (*sensu* Spahić et al., 2019b and references therein). Another good illustration of the complexity of the alternating plate-tectonic stages within the Tethyan trench-type collision is the Guevgueli–Demir Kapija ophiolite in North Macedonia (Middle–Upper Jurassic, Kukoč et al., 2013). This entity is interpreted as both, a thrust sheet overriding the Serbo-Macedonian Unit (Lepitkova, 2002) and as an assembly tectonically overlaid by the Serbo-Macedonian Unit (Himmerkus et al., 2006). However, a recent study nicely elaborated the emplacement of the Fanos granite into the intraocanic arc (Michail et al., 2016). Towards the eastern segment of Inner Hellenides (northern Greece), the EVZ ophiolites include the Oraeokastro, Thessaloniki and Chalkidiki massifs (Fig.1b). The Oraeokastro ophiolites belong to the back-arc setting, whereas Chalkidiki characterizes a supra-subduction setting (Zachariadis et al., 2006; Zachariadis, 2007). This is correlative with the opinion of van Hinsbergen et al. (2005) who concluded that the EVZ oceanic lithosphere subducted beneath the European units.

Scrutinizing the conflicting configurations and peculiar paleogeographic affinities

A regional-scale tectonic model emphasizes the east-vergent ophiolite emplacement (overriding position) above the Serbo-Macedonian margin/#Dacia terrane" (Schmid et al., 2008, Plate #3, profile 5; Fig. 4). This solution become a widely adopted explanation of the East Vardar ophiolite emplacement in this segment of Neotethyan suture (Schmid et al., 2019; Erak et al., 2016; Maffione & van Hinsbergen, 2018; Fig. 4). Later, Erak et al., (2016) attept to authenticate an eastward-directed obduction by introducing a horizontal emplacement of over 70 km. This concept interprets a Jastrebac phenomenon as an isolated tectonic window of the "Sava Zone" which represents a late Cretaceous–Paleogene suture. Moreover, according to this concept, greenschist-facies rocks of Veliki Jastrebac ("VJG") are interpreted to be of a Western Vardar Zone affinity (not EVZ), suggesting an exposure of the main Vardar slab (Erak et al., 2016; Schmid et al., 2019).

In contrary to the configuration proposed by Erak et al., (2016), the segments of central Veliki Jastrebac Mt. (Fig.5), were, however, interpreted to be overlain by the Serbo-Macedonian Unit (Rakić et al. 1969). The same configuration is imposed for a more southern extension of European foreland, towards Balkanides and Hellenides (*e.g.*, Burchfiel & Nakov, 2015; Menant et al., 2016).

Veliki Jastrebac greenschists: Supragetic-, West Vardar- or East Vardar paleogeographic affinity?

"

The "VJG have a dominant metagabbro body interfingered with epidote-actinolite, albite-chlorite-sericite rocks (Rakić et al., 1969; Aleksić, 1977; Marović et al., 2007; Fig. 5). Given the unknown age of the "VJG", there is neither radiometric dating/geochemistry of orthobasites nor detrital zircon spectra study of local parametamorphic sequences. On the other hand, there is an analogy of the occurrence of calcschists in the Veliki Jastrebac (Fig. 5; lithology #3) and Fruška Gora Mts. (southern Pannonian Basin, Serbia; Fig. 1b). Erak et al. (2016) indicated a similarity of those uncovered in Jastrebac with those documented within the meta-Triassic sequence belonging to the Apulia/Adria microplate. Nevertheless, there is also an analogy with a set of much older calcschists belonging to the Supragetic basement. Marović et al. (2007) indicated a lithological similarity of the Jastrebac late Alpine sequences with certain parts of the Vardar Zone or Vardar–Sava island-arc-back-arc-basin system of northern Bosnia and Croatia (Pamić et al., 1992; Pamić et al. 2000; Pamić, 2002). A more conclusive discriminating marker is the transgressive- to tectonic-type interface between the "JM" and "VJG" (Rakić et al., 1969). The western outskirts of Veliki Jastrebac contain a frontal segment of the west-vergent nappe (partially eroded) which overlies the EVZ ophiolites, mélange and turbidites (Rakić et al., 1969; Fig. 5 and Fig. 6). Marović et al. (2007) furthermore indicated that the recorded ductile folds on the eastern slopes of the Veliki Jastrebac have the west-vergence, implying that the principal stress tensor was from the east (in modern-day reference). Sericite schists, calcschists and marbles appear in the cores of synforms (implying the youngest age, opposite to the oldest Triassic age suggested by Erak et al. (2016). Consequently, epidote-actinolite and albite-chlorite schists develop in the central parts of the local antiforms.

Finite Veliki Jastrebac configuration: Serbo-Macedonian margin over East Vardar ophiolites or vice-versa?

The complex local configuration of the investigated (former) cross-lithosperic plates boundary (western Veliki Jastrebac; Fig. 5) is reconstructed by removing a surrounding Neogene cover (basement map from Rakić et al., 1969; Fig. 6).

(1) The contrasting geological/geotectonic configuration is as follows: (i) There is structural (kinematic) disagreement between the EVZ ophiolites/late-Cretaceous flysch-bearing sediments (western Veliki Jastrebac) and the (ii) formerly down-warped trench analogs exposed in the Veliki Jastrebac itself (Fig. 5). The EVZ ophiolites/late-Cretaceous flysch-bearing sediments of western Veliki Jastrebac are interpreted as the upper plate, and at the same time, these Upper Cretaceous turbidites belonging to a lower plate are exposed within the Veliki jastrebac dome. In contrary to this interpretation, our reconstruction (pre-Neogene configuration map; Fig. 6) illustrates the contact (and kinematics) between the (antithetic, westward directed; probably late D3 phase) Serbo-Macedonian thrust (overriding plate) and the underlying EVZ assemblage (Rakić et al., 1969; Fig. 6). The explanation is as follows: initially, the westernmost Serbo-Macedonian Unit characterized by the elongated NNW–SSE antiforms/synforms and shallow-dipping N-directed b-axes attest the proposed E–W shortening (Figs. 5, 6). Secondly, the Jurassic ophiolites/late-Cretaceous turbidites are exposed within an erosional window be-

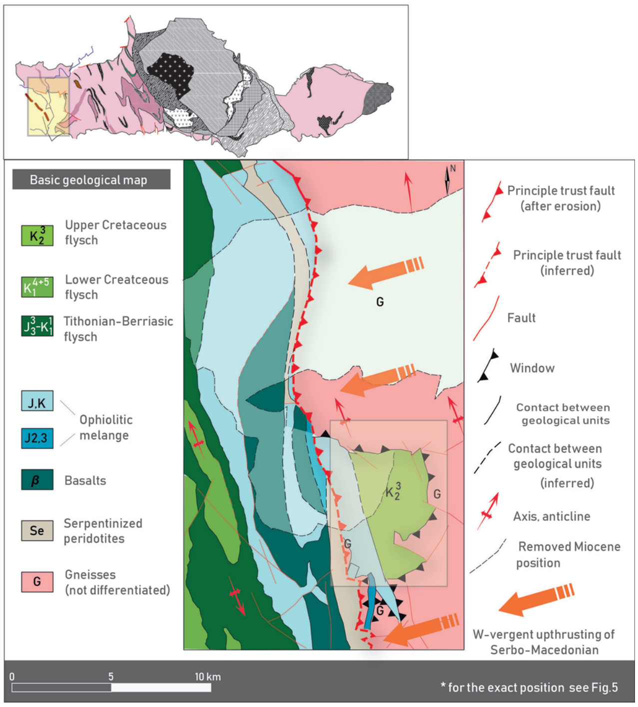

Fig. 6. Reconstruction of the pre-Neogene geological configuration of western Veliki Jastrebac erosional window and its surrounding (inlet from Rakić et al., 1969; position also in Fig. 5). The construction is based upon the geometry of the surface geological boundaries. The map exhibits the configuration of local Paleozoic and Mesozoic formations positioned underneath the Neogene cover (pale shadowed area).

neath crystalline Serbo-Macedonian rocks; (light red rectangle, Fig. 6). The underlying position of the members of the EVZ can be corroborated by the along-margin regional geology. Approximately 50 Km to the north (vicinity of Rekovac) diabase is exposed within the erosional window beneath the westernmost edge of Serbo-Macedonian Unit (Dolić et al., 1980). This mechanism of foreland-directed thrusting of weak continental crust is well-known in fully decoupled collision zones (Faccenda et al., 2009);

(2) Thus, the western Jastrebac and other ophiolite complexes distributed along the contact with the Serbo-Macedonian margin appear almost perfectly "trimmed" along the strike of the EVZ in Serbia (Fig. 3). Such sharp boundary towards the (former) margin outlines rather a westward-directed thrusting placing a Serbo-Macedonian in an overriding position (Fig. 6).

(3) Otherwise, if the EVZ ophiolites were presumably thrusted on top of the western Serbo-Macedonian, whereas the late Cretaceous flysch (K_2^3; Fig. 5 and Fig. 6) has transgressive relationship (Rakić et al., 2016) (in both cases these units should overlie a western Serbo-Macedonian margin), it remains an issue in what manner the adjoining "JG" (metamorphosed oceanic crust assembly) and proximal turbidites ("JM") are exhumed as the Serbo-Macedonian footwall within the Veliki Jastrebac tectonic window;

(4) In general, obducted suprasubduction setting ophiolites can often be characterized by a well preserved, solid-body configuration (*e.g.* Robertson, 2012), unlike those exposed along western Veliki Jastrebac (Fig. 5). These ultramafics distributed in the contact zone with the Serbo-Macedonian gneisses (Fig. 6), including those of the Ždraljica complex (Fig. 3) experienced a substantial syntectonic reworking (*sensu* Dimitrijević & Dimitrijević, 1975; Resimić-Šarić et al., 2005; Boev et al., 2018). As mentioned earlier, there is no metamorphic sole underneath the EVZ ophiolites;

(5) The geophysical 3D model surveyed along this segment of the investigated convergent margin (Petrović et al., 2015) captured the subsurface configuration of the plate boundary. The 3D model illustrated a downwraping configuration of the rock complex positioned underneath the Serbo-Macedonian Unit.

To summarize, the two completely different structural imprints outline the "JM" and "VJG" of the Veliki Jastrebac:

1. **"VJG"** underwent a ductile reworking (presence of the sigma- and delta-clasts, stretching lineation; Spahić, 2006) including the isocline folding and cleavage formation subsequently exposed to the transposition (see pictures with interpretations in Spahić, 2006; Marović et al., 2007); Grubić et al. (1999) indicated at least two phases of folding. Accordingly, the older phase is characterized by the intense folding accompanied by transposition and formation of axial-plane cleavage, therefore the primary sedimentary fabric can only be assumed in hinges of the intrafolial rootles folds (cm-dm, rarely of meter scale). The hinges of these folds plunge top to the NNW, which is in accordance with the observed Alpine deformations in the lower plate (Drina–Ivanjica block; Đoković, 1985). The cleavage planes became the dominant S-surfaces that were subsequently deformed in the course of the reactivated shortening. The emplacement of the Jastrebac granitoid reshaped the folded succession into a symmetrical dome (Grubić et al., 1999; Fig. 5).

2. **"JM"** have only mild, domal bending of the layers produced by the Eocene granodiorite emplacement (Rakić et al., 1969; Spahić, 2006; Marović et al., 2007; Erak et al., 2016; Fig. 5). Black phyllites have the same foliation pattern (Marović et al., 2007; Fig. 5).

Briefly, the main deformation of (former) oceanic crust assembly occurred at least before the late Cretaceous, more likely before Lower Cretaceous "paraflysch" depicting a tentative Jurassic- to earliest Lower Cretaceous age of the VJG.

Assuming the derived Jurassic to early Lower Cretaceous age of the VJG which somewhat fits with the age of the Ždraljica complex (*sensu* Resimić-Šarić et al., 2005), it needs to be answered by what tectonic means an intraoceanic arc sunk together with the late Cretaceous – Paleogene (meta)turbidites (JM). A recent study proposes a subduction zone activity since the Middle Triassic accommodating the closure of the Paleo-Tethys and the back-arc opening of Neo-Tethys (Maffione & van Hinsbergen, 2018). The onset of the EVZ (at least in the investigated region) is dated to the Middle Jurassic (intraoceanic arc) according to the Ždraljica complex (numeric age by Resimić-Šarić et al., 2005). In addition, there is no any documented Triassic record within the central segment EVZ. The onset of the back-arc spreading was followed by the mèlange formation outlining the formation of the EVZ intraoceanic trench. This stage is most probably followed by the formation of, so-called, “Tithonian-Beriassic flysch” (Rakić et al., 1969; Andjelković, 1982; Fig. 6) and/or Lower Cretaceous “paraflysch” of Dimitrijević & Dimitrijević (2009).

Summary and conclusions

Intraoceanic subduction with the retreating collision elements

The retreating collision convergence boundaries or zones of the crustal shortening characterized by the retreating subduction have the gravity as the principal tool for pulling a dense subducting slab (slab pull) ultimately escaping into an oceanic domain (Royden, 1993). This tectonic model was credited to the Carpathians, the Apennines, the Dinarides, and the Hellenicdes (Royden, 1993; Faccenda et al., 2009; Facenna et al., 2014; Burchfiel et al., 2018). Essentially, this convergence model occurs within the regions with the incomplete continent-continent collision (Royden, 1993).

The inference of the continent–continent collision, trench migration and proper discrimination of the retreating plate motions is initially dependent of the proper reference frame (Faccenna et al., 2018) or stable reference points for motion trajectories (Le Breton et al., 2017). Here we use the Serbo-Macedonian (a segment of Apulia/Adria hinterland) as the stable reference point.

The investigated segment of even now active Africa–Europe convergence system has had been controlled by the interaction of several microplates. Essentialy, the investigated area was shaped by the interaction of the (Inner) Dinarides (African promontory, Apulia/Adria indenter or double-vergent orogen, Doglioni et al., 2007) and a leading edge segment of the European foreland; Serbo-Macedonian Unit; Fig. 1b). Importantly, the (micro)plates velocity associated with similar oblique plate junctions (Dimitrijević & Dimitrijević, 1975; Schmid et al., 1991; Riccou et al., 1998; Burchfiel & Nakov, 2015; Prelević et al., 2017) has a slow convergence rate. A slow-paced Vardar Ocean (West Vardar Zone) underplating started beneath (i) short-lived early Middle Jurassic (*ca*. 180 Ma) intraoceanic arc, connecting the “Kopaonik block” (Zelić et al., 2005) of uncertain inheritance with the Serbo-Macedonian margin (Fig. 7a). A marginal/back-arc origin is documented for the Apuseni section (MOR-type affinities slightly enriched in Th and U, and depleted in Nb; *cf.* Gallhofer et al., 2017). The West Vardar oceanic lithosphere or Neotetyhan plate continue with underplating inducing the production and emplacement of the quartz-diorite Ždraljica complex (*ca*. 168 Ma; Fig. 7b). Ongoing shortening and narrowing of the Neotethys led to the obduction of a peripheral East Vardar lithosphere on top of the West Vardar plate (similar to the Peonias zone in northern Greece; Fig. 7b; Michail et al., 2016; see also the position of the interfacing mélange; Fig. 3). The E-directed subduction of the two stacked plates eventually sutured carrying the two clastic Cretaceous sequences: (1) Lower Cretaceous “paraflysch” (distal position) and (2) the posdating late Cretaceous–Paleogene turbidites. During the terminal Alpine convergence, these turbidite sequences were displaced by the thick-skinned thrusting (Fig. 2). The suggested cross-lithospheric configuration (intraoceanic arc) of the two, now thrusted oceanic plates may help in the explanation why the Apuseni ophiolites have no contamination of continental crust as suggested recently (Gallhofer et al., 2017).

A protracted lithospheric warming (at the expense of a slow oblique subduction) sourced from the underlying mantle may cause a weakening slab rheology. The weakened slabs are feeble for the effective stress transfer, however, resistant for a significant down-dip tension (Boutelier & Cruden, 2016). The associated trench retreat (the initial subduction hinge retreat; Fig. 7b) probably started in the course of the ongoing subduction inducing a limited across-strike width obduction of the West Vardar ophiolites on top of the Drina-Ivanjica. Continuous late Mesozoic regional-scale compression at the expense of approaching Apulia/Adria microplate motions (D3, Fig 7), once again slowed down, but on this occasion compensating a trench clogging caused by a buoyant continental segment (Drina-Ivanjica; Inner Dinarides, Fig. 7c). Onset of the retreating crustal motion, followed by the West Vadar slab breakoff (Fig. 7c) caused the already ad-

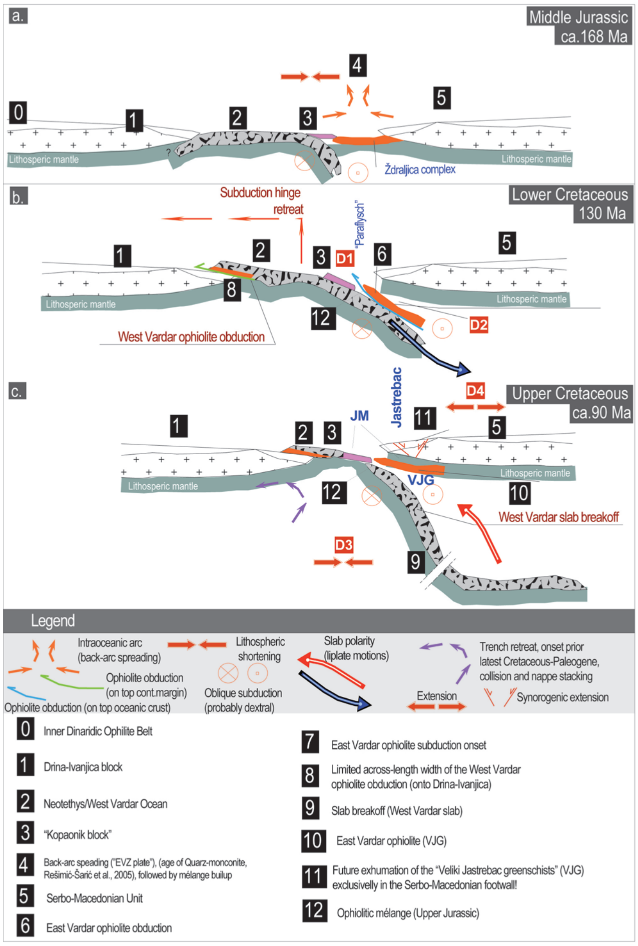

***Fig. 7**. Simplified reconstruction of the Jurassic intraoceanic arc formation. Explanation in the main text. **a)** Intraoceanic-arc setting of the East Vardar ophiolites, very close to the Serbo-Macedonian margin. Black question mark denotes uncertainties associated with the juvenile contact between West Vardar Zone and NE Apulia/Adria margin. Recent authors propose Triassic subduction and the motions of West Vardar plate and its sinking into E-vergent subduction zone drove rollback (Maffione & van Hinsbergen, 2018). **b)** Along with the obducted East Vardar intraoceanic-arc sequence, this system sink. The model emphasizes the intraoceanic obduction with the two terminal slabs. **c)** After the trench retreated, early-subducted crust was metamorphically overprinted reaching the anchizone (JM) to greenschist-facies level (VJG). The ongomning lithospric shortening was accompanied by the delamination and thinining of the Serbo-Macedonian upper plate (Milivojević, 1993) continue into the Miocene.*

vanced segment of the E-directed slab to invert a down going polarity of subducting lithospheric motions so-called eduction (corroborated by the metamorphic changes affecting both, VJG and JM).

In the overriding plate, the process of syn-collisional hanging wall decoupling (*e.g.*, Gürer et al., 2016) led to an efficient rheological weakening and the onset of bimodal stress regime (*sensu* Faccenda et al., 2009). A degree of extension efficiency is high; in particular in a thin crustal wedge likewise Serbo-Macedonian Unit. Density inversion lead the lower-crust extrusion (*sensu* Martinez et al., 2001) triggering the repetitive uplift and core-complex emplacement including those of Jastrebac Mts. The proposed extensional exhumation dynamics of buried Tethyan lithosphere are comparable to those proposed for the Balkan–Aegean region (Jolivet et al., 2013; Menant et al., 2016; Burchfiel et al., 2018). Early pre-continent-continent convergence retreating motions and subsequent lithospheric delamination accommodated the late Cretaceous exhumation of Mali Jastrebac block (*ca*. 90 Ma) and exhumation post-dating Miocene (20 Ma; fission-track numeric age by Erak et al., 2016).

Key developments:

The proposed intraoceanic subduction model, explains a limited time obduction of the East Vardar ophiolites onto the underplating West Vardar oceanic plate. This model is very similar to those of the Vardar-Axios zone in Greece, proposed by Michail et al. (2016) and is in line with observations of Rešimić-Šarić et al. (2005), Boev et al. (2019), Petrović et al. (2015);

The interaction of northern Neotethyan/Vardar Ocean with its bordering basin and antithetic west vergent Eurasian margin can be characterized by a convergence style controlled by the oblique cross-lithosperic thrusting . Oblique motions are in accordance with the NW Apulia/Adria Alpine indentation (overriding plate segment) whereas its NE segment (investigated region) underplate beneath a segment of European margin (Le Breton et al., 2017);

Locally at Jastrebac, the Serbo-Macedonian Unit is in an overriding position overlying the both, 'Jastrebac greenschists' (VJG); and 'Jastrebac Metaturbidites' (JM). The latter two successions were exposed by the extensional exhumation and subsequent erosion;

'VJG'are likely to have a Mezozoic paleogeograhic affinity belonging to the oceanic crust of the East Vardar Zone;

'JM' are proximal sutured turbidite equivalent which entered the foredeep along with the 'VJG'.

The Jastrebac study clearly indicates that further study of the complex regional geology, precise age and paleocontinental affinities of these controversial Neotethyan entities is a must.

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Резиме

Интраокеанска субдукција северозападног Неотетиса (јурски офиолити Западне- и Источне вардарске зоне) и геодинамичка интеракција са Српско-македонском континенталном маргином: Редефинисање односа подинског или повлатног литосферског блока на примеру Јастрепца

У раду је дата кинематска реконструкција и тектонска интерпретација Неотетиског подинског блока на основу анализе регионално-геолошких карактеристика Јастребачког тектонског прозора. Досадашња истраживања указују да се неотетиски афинитет на истраживаном подручију може идентификовати као систем који припада двема тектонским јединицама: Источној- и Западној вардарској зони. Прегледом структурно-тектонских решења предложених за истраживани простор (примена аналогије са деловима Неотетиса и његове маргине у Грчкој), укључујући петролошки састав, палинспастику као и проблематичну палеогеографију и старост наведених литосферних јединица:

Утврђено је да се Српско-македонска једница (СМЈ) налази у западно-вергентно структурном положају, тј. да је навучена преко субдуковане океанске литосфере која највероватније припада Источној вардарској зони (ИВЗ). Предложена конфигурација је у супротности са неким мишљењима који позиционирају офиолите ИВЗ као систем обдукован преко СМЈ са дужином обдукције и од преко 70 km (Erak et al., 2016). Наиме, према ОГК СФРЈ, лист Крушевац (Rakić et al., 1969), аутори указују на западно-вергентно навлачење Српско-македонског кристалина преко Великојастребачког комплекса (зелени шкриљци и горњокредно-палеогени турбидити). Иницијална горњојурска интеракција са СМЈ као континенталном маргином (D1 фаза) се може документовати старошћу меланжа. Међутим, ова конфигурација је прерађена накнадним структурно-тектонским догађајима. Након ове иницијалне интеракције између горњојурско-доњокредне океанске литосфере и формирања залучног басена, Rakić *et al.,* (1969) интерпретирају горњокредне флишеве стављајући их у трансгресивни контакт према СМЈ. Schmid et al. (2008), Erak et al. (2016) истичу супротну или источно-вергентну позицију офиолита ИВЗ према СМЈ, указујући да Јастребачка дома и систем зелених шкриљаца ('VJG') припада главном Вардарском/Неотетиском океану. Међутим, детаљна анализа геолошке конфигурације на потезу западни обронци Великог Јастрепца– централни делови Великог Јастрепца, указује да овај изузетно компликовани неотетиски литосферни океански сегмент се може интерпретирати и као део ИВЗ формиран као (i) последица интраокеанске субдукције са источно-вергентом Западном вардарском зоном (ЗВЗ) која је (ii) касније подвучена под континенталну маргину (СМЈ);

(ii) На основу предложене геолошке конфигурације истраживаног терена (поготову детаљно испитиваног западног дела Великог Јастрепца са широм околином, тј. контакт СМЈ и ИВЗ) као и реконструкције тектонске еволуције ЗВЗ/ИВЗ утврђено је да 'VJG' највероватније припадају

ИВЗ. Реинтерпретација структурно-тектонског склопа искључује дистални афинитет пасивне маргине Апуљско-јадранске микроплоче као ексхумирани део великојастребачке доме. Такође, обдуковање офиолита ИВЗ је западно-вергентно (преко ЗВЗ) и највероватније се одвијало под сличним околностима као што је утврђено нешто јужније, тј. на примеру Пеониас подзоне у Грчкој. Накнадним покретима (наставак сужења Неотетиса и субдукције ЗВЗ/ИВЗ под СМЈ) и терминалним навлачењем (колизија Апуљско-јадранске микроплоче и СМЈ), овај офилитски коплекс је подвучен испод СМЈ. Сходно томе, зелени шкриљци ('VJG') који су покривени СМЈ на Великом Јастрепцу имају палеогеографску припадност која указује на део ИВЗ или средњојурско-горњојурског интраокеанског система у залучној позицији (*back-arc*) сада несталог Неотетиског океана, преко кога су горњокредно-палеогени (мета)турбидити ('JM'). На овакву конфигурацију такође упућује и метаморфни тријас Копаоничке области које се највероватније развијао у *back-arc* или залучним условима, где га наслеђују већ описани литосферни догађаји јурске старости укључујући и „парафлиш“. Доста каснији, повлатни метатурбидити ('JM') Великог Јастрепца су еквивалент горњокредних турбидита који су благо метаморфисани током сутурне фазе (улазак у субдукциони ров). Ексхумација 'JM' је уследила путем екстензије повлатне СМЈ (повлатни литосферни блок) и еоценског гранодиоритског емплејсмента (D4). У касноалпском контексту (мета)турбидити ('JM') потврђују наставак субдукције ЗВЗ (и после обдуковања ИВЗ) у источновергентни субдукциони ров који се налазио испод СМЈ током мезозоика и палеогена.

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