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Oceanic realms in the central part of the Balkan Peninsula during the Mesozoic

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Abstract. During the Mesozoic three oceanic realms existed on the Balkan Peninsula: the **Vardar Ocean** (NW part of the main Tethys) forming the main basin with a marginal basin at the west. Since the Maastrichtian these basins with the intervening units build the Vardar Zone Composite Terrane, embracing the Main ophiolitic belt, the Kopaonik block-and-ridge unit, and the Western ophiolitic belt. The **Dinaridic oceanic tract** (Dinaridic Ophiolite Belt as its present scar) formed the second basin, with a continuation into Mirdita. The **Civcin-Severin oceanic realm** was the third basin at the east. These basins or realms were opened at different times, had different life spans, and were closed during different parts of the Mesozoic. These oceanic realms thus show different general characteristics and display different rock complexes connected with their closing.

Key words: oceanic realms, Mesozoic, Vardar Zone, Main Belt, Western Belt, Dinaridic Ophiolite Belt, Civcin-Severin Zone, Balkan Peninsula.

Introduction

At the beginning of this century two regional ophiolite zones were already noted in the central part of the Balkan Peninsula. These are very well expressed at the Geological map of SFRYu 1:500,000 (Geological Institute of SFRYu, Belgrade, 1970), and numerous papers (especially in the last thirty years) deal with parts or some members of these zones. Only those papers offering new exact data will be quoted here. The real importance of the zones has been understood only with the birth of recent ideas on the development of the Earth, when it became clear that ophiolite belts represent relics of ancient oceanic realms, as remains after the collision of adjacent continental plates and blocks.

The elaboration of the Basic Geological Map of SFRYu (references are given in Dimitrijević, 1997) made it possible to understand specific, essentially different characteristics of these ophiolitic belts. They resulted from differences in geotectonic framework, age of birth and duration of oceanic expanses from which these belts originated, being reflected in presence/absence of specific sedimentary and magmatic members, as well as in their sedimentologic, petrologic and geochemic characteristics. Correlative synthesis of the main belts, based on modern geological approaches was first given by Dimitrijević and Dimitrijević (1973). Recently comparative presentations were given by Karamata, Dimitrijević and Dimitrijević (1998a,b). The present paper is a further elaboration of thoughts developed in these papers.

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General subdivision

Existing data point to the existence of three different ophiolitic belts (Fig.1), resulting from separate oceanic realms and basins, and differing clearly in the features summarized in the Table 1. These ophiolitic belts are:

1. The Vardar Zone, including relics of (at least) two oceanic areas:
   1a. Main ophiolite belt of the Vardar Zone (MVZ) as scar of the main Vardar oceanic realm - the Tethys, and
   1b. Western ophiolitic belt of the Vardar Zone (WB) as scar of the western marginal basin of the Vardar ocean.
2. The Dinaridic Ophiolite Belt (DOB), with the continuation to the south into the Mirdita Zone, as relic of the oceanic tract which ran through the Dinarides and was along its southeastern border locally connected with the Tethys.
3. The Civcin-Severin ophiolite belt at the east.

The Main Ophiolite Belt of the Vardar Ocean (MVZ)

This ophiolite belt represents the suture zone of a vast Mesozoic oceanic realm - the Vardar Ocean i.e. the NW part of the Tethys. This oceanic basin had a long existence as the successor of the Prototethys and later on as the continuation of the Lower Paleozoic (or older?) oceanic realm between the Gondwana and continental blocks at the north, from Permian building one unit the Eurasia (this oceanic realm was formerly named the „Zvornik ocean" by Dimitrijević and Dimitrijević, 1973). This realm was highly complex, with island arcs (terranes docked to the Moesian massif, as well as the Veles series

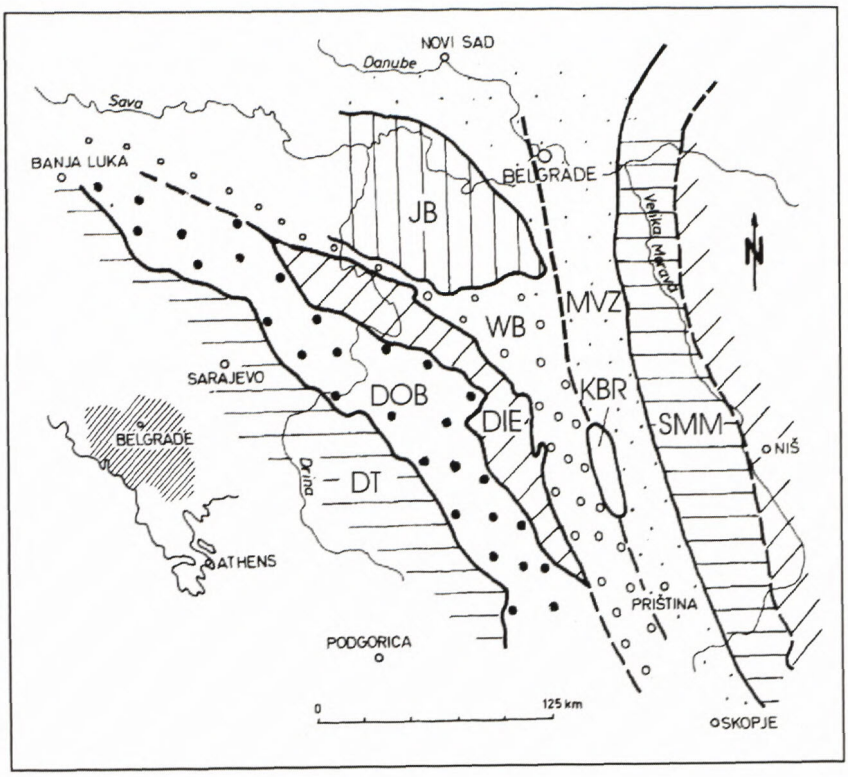

Fig.1. Present position of ophiolite belts, relics of Mesozoic oceanic realms in the central part of the Balkan peninsula. DT - main Dinaridic trunc; DOB - Dinaridic Ophiolite Belt; DIE - Drina-Ivanjica Element; WB - western belt of the Vardar Zone; KBR - Kopaonik block-and-ridge unit; MVZ - main Vardar Zone belt; JB - Jadar Block; SMM - Serbo-Macedonian massif.

units occurring in the belt) and oceanic basins between detached continental blocks. The original position of these terranes and units is presently still impossible to identify, but they were before and during Devonian separated units far at the south. It is assumed that after the Carboniferous the eastern border of this realm was represented by the Serbian-Macedonian Massif, which most probably already docked to the Carpathian units at the east. At the west of this realm lay the Apulian plate and the still unsolved set of Dinaridic microplates. During the Upper Triassic a slice separated from its eastern margin forming the Kopaonik block-and-ridge unit (KBR) and behind it a new back-arc basin or the Western oceanic basin, as the precursor of the Western ophiolite belt of the Vardar Zone (WB) originated.

The Main Vardar Ocean closed before the end of the Jurassic through eastward subduction beneath the Serbian-Macèdonian Massif and the pre-Permian Carpathian-Balkan collage.This closing ensued in a collisional metamorphism, visible less at the north where erosion was lower, and more visible to the south, where (in the area of Valandovo, Macedonia) lowP/highT metamorphic rocks and even S-granites are exposed. In the subduction trough in front of the Serbian-Macedonian massif an olistostrome of regional extension generated. This has blocks and lenses (some of kilometer length) of basalt, gabbro, ultramfites, turbiditic greywackes, dark limestone of unknown origin, red radiolarites, and sparse Tithonian limestone, embeded in a silicious siltstone matrix. This complex is mainly covered by an overstep-sequence of Tithonian reef limestone and Lower Cretaceous paraflysch.

A characteristic member of this ophiolithic complex are kilometer-long lenses of the „Veles series" (Devonian?-Carboniferous, Grubić and Ercegovac, 1975; Stojanović 1997). They probable represent fragments of island arcs existing in the oceanic basin. Some high-grade metamorphic blocks and lenses in the southwestern part of the zone most probably represent late tectonic inclusions.

In the recently studied framework of the Vardar Zone products of this ocean encompass the main, eastern part of the Vardar Zone (the Central Vardar Subzone, Dimitrijević in Mahel, 1973), and are in the figure 1 to the east of the Kopaonik block-and-ridge unit.

Western Ophiolitic Belt of the Vardar Zone Composite Terrane

Along the western border of the Vardar Zone composite terrane, presently between the Kopaonik block-and-ridge unit (KBR) to the east and the Dinaridic Drina-Ivanjica Element (DIE) to the west, an olistostrome zone rich in large basaltic masses runs, representing the relic of a marginal basin of the Vardar (Tethys) ocean. It is mainly covered by Tertiary nappes of peridotite, expelled from the scar east of the Kopaonik block-and-ridge unit and pulled over it to the west as far as the boundary of the DIE (Ibar ultramafites - masses of Troglav, Stolovi, Ra{ka, southern Kopaonik etc.). This zone is thus visible in the deep erosional cuts only (the Studenica gorge, Maglić, Leposavić-Banjska area) only. Toward the north the zone extends over the Jelica Mt. along the Zvornik suture to Majevica and further on to northwestern Bosnia.

According to present data this zone represents the relic of a marginal basin of the Vardar (considered as the main Tethys) ocean, probably opened toward the border of the Dinarides during the Upper Triassic. The basin had to be very wide, with the formation of (probabaly immature) island arcs. The closing of the basin began probably during the early Upper Jurassic (age of the metamorphic rocks in the base of ultramafic slices; Balogh, oral communication), taking a very long time to the final closure. According to Milovanović et al. (1995) Barremian crossite schists at Fruska gora (northern part of the western marginal basin) are also related to this long lasting subduction.

In the subduction trench an olistostrome was formed. In this olistostrome rounded greywacke blocks are common together with pillow-lavas of MORB, as well as of

IAB affinity. Other constituents are blocks of gabbro, metamorphites of various grade from the ophiolite sole from basaltic as well as from sedimentary protoliths, rare ophiolite related albite-granites, abundant Karnian to Kimmeridgian cherts, Triassic limestone lenses and blocks, and fragments of Upper Cretaceous limestones. Fragments of rocks from the „Veles Series", as well as of locally Paleozoic granites, were not found. The matrix is silicious, argillaceous-silty.

The final phases of subduction and the closure of the basin are reflected by relations of the mélange and rudist limestones east of Ivanjica (Brković et al., 1977), by the occurrence of fragments of globotruncana limestones in the mélange of the Jelica Mt. (Vandjel and Marić. 1956; Brković et al., 1978), senonian fragments in the mélange of Sokolska Mt. (D.Ljubović-Obradović, 1985; A.Djurickoviċ and V.Orsolić, 1988, written commun.), and fragments of the Upper Cretaceous limestone in the pillow-lavas near Krupanj (Filipović, oral commun.). To the subduction process can be related the Upper Cretaceous(-Paleogene) magmatic rocks in the Southern Carpathians and in East Serbia, as well as the Upper Senonian volcanics in the Belgrade area, in South Backa and Central Banat (Karamata et al., in print).

The basin existed to the upper Senonian, when it was closed, most probably by the early Maastrichtian. This is also indicated by the Campanian age of metabasalts and interlayered sandy limestones north of Kozara Mt. (Karamata S., Pushkarev Yu., Sladić M., 1999, written commun.).

The Dinaridic Ophiolite Belt

The Dinaridic Ophiolite Belt (DOB) extends between the Sarajevo Sigmoid with the Central Bosnian Schist Mountains Terrane and the East Bosnian-Durmitor block (as parts of the main Dinaridic trunc) to the west and southwest, and the Drina-Ivanjica element/terrane (DIT) to the northeast. Toward the northwest this belt comes into immediate contact with the Western belt of the Vardar Zone, the boundary between may be recognized only due to the differences in age of the mélange. Toward the south the belt continues into the Mirdita Zone, with a conspicuously different character; the relations of this region with the Vardar ocean are still uncertain.

Alongside the main exposed suture zone, olistostromes of a similar composition as those in the main zone occur inside the main Dinaridic trunc, e.g. beneath the front of the Durmitor nappe. They may represent either relics of some smaller oceanic tracts, or parts of the main olistostrome zone separated from it by the emplacement of the East Bosnian-Durmitor terrane. It is highly indicative that this olistostrome lies in a belt characterised by high thermal flux during the Upper Jurassic (*in situ* granitization in the Junik knot), and by extremely complicated relations of the adjoining nappes and terranes.

The Dinaridic Ophiolite Belt is the relic of an oceanic tract which opened during the Middle Triassic between the main Dinaridic trunc and the Drina-Ivanjica element (Dimitrijević and Dimitrijević, 1973). The extensional phase of this ocean probably lasted to the mid-Jurassic, the closure by subduction toward the present northeast lasted up to the end of Jurassic. The beginning of closure is indicated by the Middle Jurassic emplacement of ultramafics. The age of metamorphism of the ophiolie sole is arround 170 Ma for Vijaka and Bistrica (Lanphere et al., 1975), Brezovica (Karamata and Lovrić, 1978), and for Banija (Majer et al.,1979), mostly over already existing trench olistostromes. The final phases of influence of the already subducted oceanic crust or its ridge are shown by the Vallanginian metamorphism in the deeper horizons of the Drina-Ivanjica Paleozoic (Milovanović, 1984). The Pogari series, of Tithonian partly Lower Cretaceous age, was deposited over the ophiolitic mélange. This series contains as constituents in conglomerates and sandstones all members of the olistostrome.

The composition of the ophiolitic olistostrome, exposed in large outcrops, differs from the mélanges of the Vardar Zone. Prevailing are blocks and olistoliths of Triassic limestone and greywackes (turbiditic in places) or silicious siltstones, together with Ladinian (Obradović and Gorican, 1989), Carnian (Gostilje; Gorican 1998, oral commun.), Carnian-Norian (west of Sjenica, Gorican et al., 1999), and Callovian to early Kimmeridgian oceanic cherts (Bistrica; Obradović and Gorican, 1989). Abundant are basalts (pillow-lavas mostly) of MORB character north of the line Peć-Goles and of both MORB and IAB affinity south of this line, some gabbro, enigmatic lenticular bodies of Carboniferous granite of unknown provenience (Karamata et al., 1996), and fragments of metamorphites connected with the emplacement of hot peridotite slabs. An outstanding feature of the belt are kilometer-sized, composite, olistoplakae (large plate shaped olistoliths) of Triassic limestone, gravitationally transported from the Drina-Ivanjica element, less frequently of Triassic to Jurassic limestone from the slope of this element, large bodies of red oceanic silicious globigerina slate („Zlatar chert"), and huge masses of obducted ultramafites which metamorphosed the mélange along their base (Zlatibor, Konjuh, Brezovica etc) or diapirically intruded the oceanic crust (Ozren west of Sjenica; Popević, 1985) with metamorphism of surrounding rocks. Upper levels of these ophiolite complexes are only rarely preserved in continuity (e.g. Visegrad, Brezovica etc).

The Civcin-Severin Ophiolite Belt

This belt is situated at the east of the Serbian-Macedonian massif and the Ranovac-Vlasina-Osogovo terrane. In the lower Alpine nappe of the South Carpathians (Severin Nappe), in Eastern Serbia and southwestern Romania serpentinites are found at several places, together with small amount of other ophiolitic rocks and deep-sea sediments. These rocks, well studied in Romania, are connected with a Jurassic-Cretaceous oceanic basin, the position of which is still highly problematic. The features of this belt and of the former oceanic basin are insufficiently known due to the very complex cover of Alpine nappes, but existing data point to some similarities with the western belts.

Table 1. Correlation of oceanic realms in the present Balkan Peninsula
DBO=Dinaridic Ophiolitic Belt; WB=Western Ophiolitic Belt of the Vardar Zone; MVZ=Main Ophiolitic Belt of the Vardar Zone

AGE				TRENCH ASSEMBLAGES		
	DOB	WB	MVZ	DOB	WB	MVZ
TT		*Ca- alk* FLYSCH rudist limestone				
Mastr.						
Camp.					GRAYWACKE RADIOLARITE T_2, T_3, J_3 basalts of MOR and IA type gabbro ultramafic (harzburgite) limestone (T_2-T_3, K_2) ophiolitic sole metamorphics ≈155 Ma	
K_2		Basalt *mag-* 80 Ma *ma-* (K/Ar) *tism*				
K_1		crossite schist	PARAFLYSCH REEF LIMESTONE			
Tith.	POGARI SERIES					
J_3		emplacement of ophiolite slabs ≈155Ma (K/Ar)		GRAYWACKE RADIOLARITE T_2,T_3,J_3 basalt (MORB) gabbro Ab-granite ultramafic blocks limestone T,J CARBONIFER. GRANITE LIMESTONE T_1,T_2,T_3 OLISTO-PLAKAE ULTRAMAFIC SLABS (Lherzolite) OBDUCTED or INTRUDED with METAMOR-PHIC AUREOLE ≈170 Ma MATRIX ARGILLA-CEOUS -SILTY	MATRIX SILICIOUS AGILLACEOUS-SILTY	BASALT gabbro ultramafics graywacke (turbiditic) radiolarite limestone (dark, white) METAMORFICS OF THE VELES SERIES of low to medium grade MATRIX SILICIOUS SILTSTONE
J_2	emplacement of ophiolite slabs ≈170 Ma (K/Ar)					
J_1						
T_3		← V →				
T_2	← V →					
T_1						
P						
C			ISLAND ARC RELICS – THE „VELES SERIES“ TRANSPORT OF TERRANES towards N-NE			
D						
O						
S						

Time-scale is not linear ← V → opening; → ← closing
Capitals – characteristic members

Conclusions

In the central part of the Balkan Peninsula relics of several Mesozoic oceanic basins are exposed, they differ in their opening and closing times.The main oceanic realm was the Vardar ocean, which existed from the lower Paleozoic (or even earlier), while other basins represented marginal basins or oceanic crust generated between the dispersing continental fragments. The composition of olistostromes, deposited in subduction troughs of these oceanic basins, differs significantly, depending on the width of the oceanic area, geotectonic setting and lithology of the trough margins.

Main characteristics of these oceanic basins are as follows:

The main Vardar basin: long continuous existence as continuation of the lower Paleozoic (or older?) oceanic realm; closing at the end of the Jurassic; presence of Paleozoic island arc relics („Veles Series“); prevalence of

material from the higher parts of the oceanic crust in the olistostrome; absence of limestone olistoplakae;

Western basin of the Vardar Zone: existence from the Late Triassaic to the latest Senonian; prevalence of greywackes and basalts of MORB and IAB affinity in the olistostrome; absence of Paleozoic metamorphites and granites; presence of Upper Cretaceous oceanic-crust basalts with limestone fragment of similar age;

Dinaridic Ophiolite Belt: existence from the Middle Triassic to the end of the Jurassic; prevalence of greywacke and Triassic limestone as olistoliths in the olistostrome; lenticular bodies of Carboniferous granite and kilometer-siyed lenses of deep-sea silicious rocks; olistoliths of Middle Triassic to Upper Jurassic chert; large olistoplakae of Triassic limestone; ultramafic slabs and diapirs with contact-metamorphism in the floor or sides respectively;

Civcin-Severin belt: insufficiently known, but limited existing data point to some similarities with western belt of the Vardar Zone.

These data show that ophiolitic belts of the central Balkan Peninsula represent relics of different Mesozoic basins with oceanic crust. They could not be regarded as products of the one sole oceanic realm, but evolved from a complex area which included more as one oceanic regions during the time of the closure of this large and complex oceanic area.

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