THE INTERNAL DINARIDIC FRAGMENTS INTO THE COLLAGE OF THE SOUTH PANNONIAN BASIN

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Abstract: In the PANCARDI domain, fragments of the following internal Dinaridic units are included: 1) the Bosnian flysch, 2) the Dinaride Ophiolite Zone, and 3) the Sava –Vardar Zone. They occur in the adjoining Tisia-Dinaride segment, however, more commonly into the Alps-Dinarides-West Tisia triple junction area, e.g. the Sava-Bükk-Meliata Zone. Their incorporation into the collage of the South Pannonian Basin (PB) was related to postcollisional Alpine strike slip faulting due to Oligocene Apulian indenting.

Key words: Alpine tectonostratigraphic units, Internal Dinarides, South Pannonian Basin

In the earliest plate tectonic interpretation, the PB was regarded as a back-arc basin relative to the Carpathians (Stegena et al., 1975). Subsequently published papers mainly follow these basic approaches (Royden et al., 1983; Csontos, 1995). Only a few current geodynamic interpretations of the PB were related to the Dinarides (Tari & Pamić, 1998). However, the marginal parts of the South PB, geometrically was strongly controlled by the tectonic contact between the Dinaride Ophiolite Zone and the overlying Sava-Vardar Zone (Pamić, 2002).

Basic geological features of the Internal Dinarides

The largest part of the Dinarides, despite their complex fold-thrust-imbricate structure, is characterized by a regular zoned pattern in the spatial distribution of characteristic Alpine tectonostratigraphic units. From the Adriatic microplate toward the Tisia, e.g. in Central Dinarides, not affected by Apulian and Moesian indenting, the following large tectonostratigraphic units can be distinguished (Pamić et al., 1998): 1) Adriatic-Dinaridic carbonate platform - the External Dinarides; 2) carbonate-clastic formations of the passive continental margin – the Bosnian flysch 3) Mélange of the Dinaride Ophiolite Zone (DOZ) including the Radiolarite Formation, and 4) sedimentary, magmatic and metamorphic formations of the Tethyan active continental formations – the Sava-Vardar Zone. The tectonostratigraphic units 2) to 4) define the Internal Dinarides (see index map in Fig. 1).

The Bosnian flysch (BF), which is about 2000 m thick, includes two units (Aubouin et al., 1970; Olujić, 1978). a) The Vranduk subgroup which is characterized by non-flysch, "paraflysch" and turbidite flysch sequences, in some areas interlayered by radiolarites. Most of the subgroup

belongs to Jurassic up to Berriasian, but its lowermost parts are Liassic in age. b) The Ugar subgroup represents typical carbonate flysch sequence; it is Albian/Cenomanian to Senonian/Early Paleogene in age.

The Dinaride Ophiolite Zone (DOZ) includes several units (Pamić, 1982). a) Radiolarite Formation which is Middle/Late Triassic to Early Cretaceous in age. b) Olistostrome ophiolite mélange with limestone exotics Middle Triassic to Late Jurassic in age. c) Ophiolites included into the mélange are largely represented by peridotite tectonite with subordinate gabbro, diabase-basalt and amphibolite (185-180 Ma). d) Cretaceous clastic-carbonate overstep sequence in which ophiolites are redeposited.

The Sava-Vardar Zone (SVZ) is composed of of the following main units. a) Cretaceous-Early Paleogene "paraflysch" and flysch sequences (Pamić, 2002) in some areas interlayered by coeval subduction-related basalts and rhyolites intruded by comagmatic A-type granites (Rb/Sr isochron 72 Ma). b) Paleogene progressively metamorphosed metaclastic and metacarbonate sequence originated up to medium-grade P-T conditions from the surrounding Cretaceous-Early Paleogene flysch (K/Ar 48-38 Ma). c) Two groups of granitoids : collisional S-type, I-type and A-type granitoids (Rb/Sr 55-48 Ma) and more common Oligocene postcollisional I-type granitoids (K-Ar mainly 32-28 Ma) accompanied by coeval shoshonites and andesites. d) Tectonized (recycled) ophiolite mélange in which are included fragments of ophiolites (K/Ar 110 and 62 Ma) and exotic limestones, the youngest of which are Late Cretaceous/Early Paleogene in age. The mélange also includes in some areas large mappable fragments of Triassic and Jurassic formations.

Internal Dinaridic fragments in the adjoining Tisia-Dinarides segment

Based on field data, analysis of cores from deep wells and refraction seismic data the surface boundary between Dinarides and Tisia coincides with the northern marginal fault of the Sava Depression (Fig. 1).

Surface occurences. Within the northernmost bordering Dinarides, allochthonous SVZ units crop out in the Mts. Prosara, Motajica, Vučjak, Majevica, Cer and Bukulja. In Mt. Požeška Gora (P in Fig. 1), they are represented by fossiliferous Upper Cretaceous sediments interlayered with synsedimentary basalts and rhyolites. Locally, small outcrops of greenschist facies rocks also occur (K-Ar 44 Ma). These rocks as a whole make up an allochthonous klippen-like body, 30 km long, which covers predominant Neogene sediments of the PB, the youngest of which are Pannonian in age. Further eastward, Mt. Fruška Gora (FG in Fig. 1) also represents a "klippen-like" fragment composed of Late Cretaceous flysch intruded by Oligocene shoshonites, and of the tectonized ophiolite mélange (Knežević et al., 1991).

Subsurface SVZ fragments were penetrated by about 100 oil wells in the bordering area of the Dinarides and South Tisia (Kemenci & Čanović, 1975; Pamić, 1997). In the western part of the South PB, the SVZ synkinematic Late Paleogene granites (Rb/Sr 50-50 Ma) and penecontemporaneous metamorphics (K-Ar 48-38 Ma) predominate over the SVZ ophiolite rocks (K-Ar 94-63 Ma) and Late Cretaceous flysch. In basement of the eastern part of the South PB in Vojvodina SVZ ophiolites and Late Cretaceous flysch predominate over contemporaneous volcanics.

Postorogenic interaction between the Dinarides and Tisia. Due to N-dipping subduction of Alpine oceanic crust it is likely that the SVZ during the Eocene collision was overthrust at the low angle by the South Tisia. Dismembered fragments of the subducted SVZ, e.g. Late Cretaceous flysch, Upper Paleogene metamorphic and igneous rocks including ophiolites occurring in the basement of the South PB can be best explained as blocks exhumed during the Oligocene strike slip faulting from the underlying northwestern Dinarides. This conclusion is supported by data of numerous deep wells (Pamić, 1997). After the Oligocene transpressional deformation of the area north of the uplifted Dinarides, geodynamic processes changed fundamentally giving rise to the evolution of the PB (Royden et al., 1983).

In final stages of filling of the South PB, strong tectonic activity occurred at the beginning of the Pliocene (5-4 Ma). Refractory seismic data indicate that in the present structure of the South PB, the SVZ units are thrust under very low angle over the South Tisia (Tari & Pamić, 1998).

The Internal Dinaridic units in the adjoining Dinarides/Alps area

The Internal Dinaridic units wedge out northwestward (index map in Fig. 1) and their consistent zonal pattern gradually disappears, probably due to Tertiary Apulian indenting (Dercourt et al., 1993). In this area the Internal Dinaridic units are mixed with those from the adjacent Alps, forming a mixed Alpine-Dinaridic zone which displays a typical postorogenic collage terrane. Parts of this transitional zone were named by different names in different countries. Based on geographic and tectonic position, we shall call this mixed unit the Sava-Bükk-Meliata Zone (SBMZ) for convenience. It includes the Bükk-Meliata subzone in the northeast and, after a short break, the Sava subzones (Haas et al., 2000) in its southwestern parts continuing to the frontier with Italy and Austria. The SBMZ is bounded by the southeastern margin of the Pelso unit and Periadriatic-Balaton Line in the north and northwest, by the northeastern margin of the External Dinarides and Southern Alps, respectively in the south, and by the Zagreb-Zemplin Line in the southeast (Fig. 1).

The Sava subzone includes the following Internal Dinaridic units.

1) Outcrops of BF occur in the southern marginal parts of the subzone along the frontal parts of the Sava nappe and in tectonic windows within it. The nappe is thrust onto northeastern margin of the Adriatic-Dinaridic carbonate platform. Here in the Sava subzone, the BF is represented by complete Jurassic sequence which is correlative to the Vranduk subgroup of the BF. Overlying Cretaceous-Early Paleogene sequence represents a typical carbonate flysch which fits the Ugar subgroup of the BF from the Central Dinarides.

2) Outcrops of SVZ include tectonized ophiolite mélange; beside predominant peridotite tectonites, fragments of metasomatized ultramafics originating from the upper mantle wedge are also included. Cretaceous flysch sequence is accompanied with tectonized ophiolite mélange.

The Internal Dinaridic units of the Bükk-Meliata subzone represent a single postorogenic collage terrane characterized by ophiolite mélange of the Dinaridic affinity. In this subzone the following tectonostratigraphic units correlative to those from the Internal Dinarides can be distinguished.

1) Middle Triassic to Carnian volcanics represented by metabasalts, metaandesites and metarhyolites (Harangi et al., 1996). The andesites and rhyolites anyhow cannot be included in the ophiolite trinity and based on geochemical data, the basalts from Szarvaskö have signatures of within-plate volcanics. Hence they do not have to do anything with ophiolites.

2) Jurassic Szarvaskö-Meliata ophiolite mélange is composed of sandy-silty-shaley matrix in which are included smaller and larger, frequently mappable fragments of ultramafics, gabbros, diabases, basalts and exotic blocks and olistoliths of Doggerian-Oxfordian radiolarites, in some places accompanied by synsedimentary basalt flows, Triassic limestones, siliceous limestones, cherts, volcanics, dolomites and clastics (Csontos, 1988; Mock et al., 1998). The youngest Oxfordian fragments indicate Late Jurassic age of the ophiolite mélange. This fits with radiometric ages of mafic ophiolite fragments mainly of 166-165 Ma (Dosztaly & Josza, 1992). With all these signatures the Szarvaskö-Meliata ophiolite mélange shows positive correlation with the Dinaride Ophiolite Zone mélange (Pamić et al., 2002).

3) The Mónosbél flysch formation is commonly included within the Szarvaskö-Darno ophiolite complex (Csontos, 1988). However, the Mónosbél Formation is a bed-to-bed sedimentary sequence without any mafic igneous rocks and thus does not have to do anything with ophiolites. This is the flysch sequence which is composed of Liassic to Doggerian graywackes and limestones with graded bedding and olistoliths. However, most of the Mónosbél Formation is composed of Callovian to Oxfordian bioclastics, allodopic limestones with radiolarite intercalations, and common occurrences of Triassic radiolarite and limestone olistoliths (Kovács et al., 1996/97).

The Mónosbél flysch shows positive correlation with lower parts of the Internal Dinaridic Bosnian flysch, e.g. the Vranduk subgroup (Olujić, 1980).

Postorogenic interaction between Alps, Dinarides and Tisia was mainly brought about by postorogenic Tertiary Apulian indenting. It has been generally accepted idea that this strong Tertiary Apulian indenting and accompanied dextral strike slop faulting gave rise to extrusion tectonics (Kázmér and Kovács, 1984).

In such a situation it is hard to come to a definitive geodynamic conclusion. The system of strike slip faulting can partly explain postorogenic collage of the SBMZ. However, the fact that its Sava subzone as a whole includes only the SVZ ophiolite mélange and the Bükk-Meliata subzone as a whole includes the DOZ ophiolite mélange cannot be explained by this mechanism.

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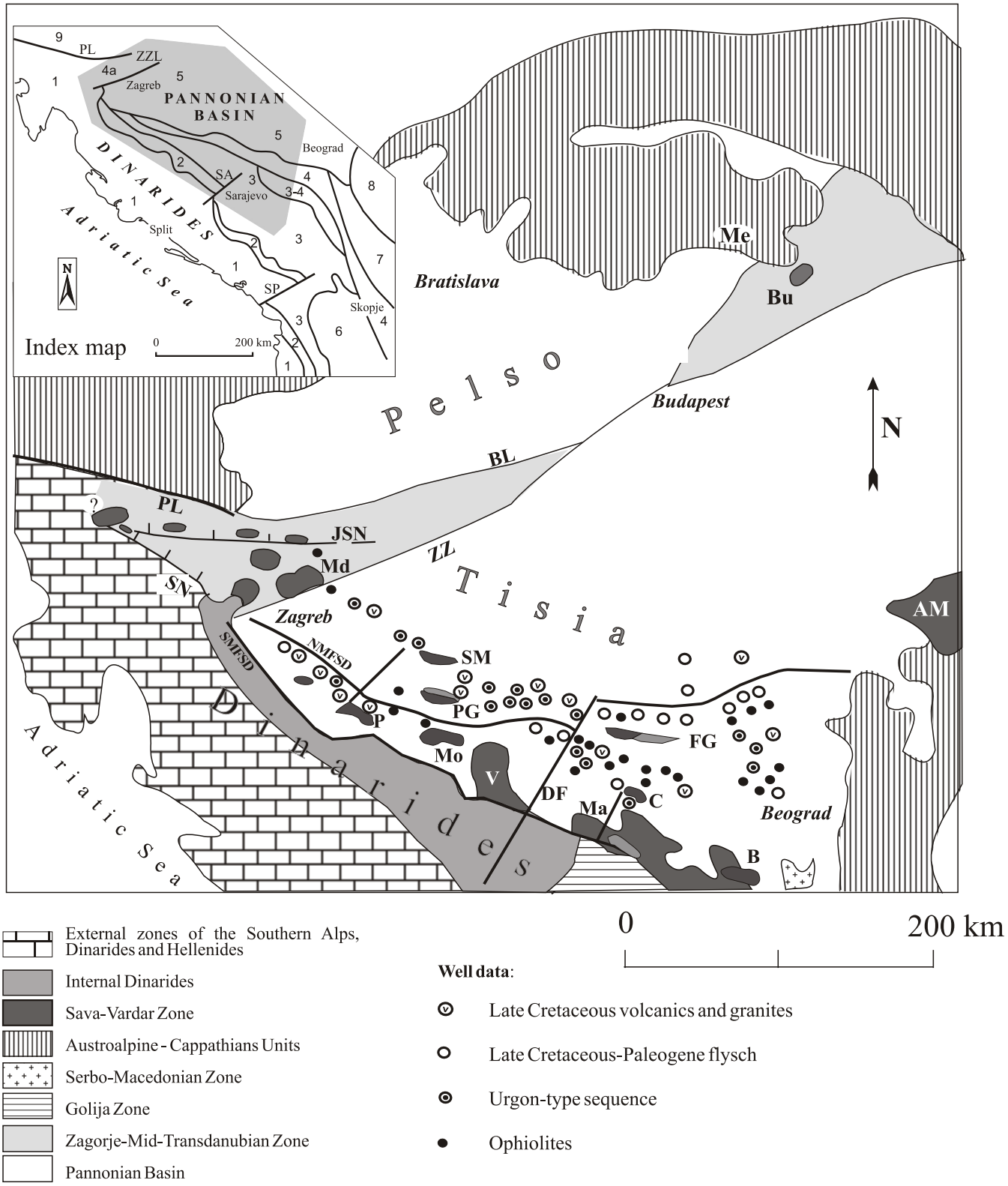

Large faults dividing Apulia and Tisia: PL Periadriatic fault; SF Sava fault; SMFSD southern marginal fault of the Sava Depression; NMFSD northern marginal fault of the Sava Depression
Other larger faults: BL Balaton fault; JSN Julian-avinja Nappe; SD Sarajevo-Drina fault; SN Sava nappe; ZZ Zagreb-Zemplin fault

AM Apuseni, Bu Buekk; B Bukulja; C Cer-Stražbenica; FG Fruška Gora; Me Meliata; Mo Motajica; Ma Majevica; Md Medvednica; P Prosara; PG Požeška Gora; SM Slavonian Mts.; V Vučjak
Index-map: 1 Southern Alps, External Dinarudes and Hellenides; 2 Bosnian flysch; Dionaride Ophiolite and Mirdita zones; 3 Sava-Vardar Zone; 3-4 Golija Nappe; Pannonian Basin; Pelagonides; Serbo-Macedonian Massif; 8 Carpathians; 9 Eastern Alps.

Fig. 1. Tectonic scheme of the NW Alps, central Dinarides and Pannonian Basin (simplified according to Dimitrijević, 1999)