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Principles of the tectonic subdivision of Slovenia

Osnove tektonske razčlenitve Slovenije

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Ključne besede: Severozahodni Dinaridi, Južne Alpe, Vzhodne Alpe, Panonski bazen, Jadransko-Apulijsko predgorje, Jadranska mikroplošča, tektonska razčlenitev

Abstract

New tectonic subdivision of the junction region between Alps and Dinarides which incorporates Eastern Alps, Southern Alps, Dinarides, Pannonian basin and Adriatic-Apulia foreland is described in this article. The course of the boundary between Southern Alps and Dinarides is updated. Dinarides are subdivided into the Internal and External Dinarides. Internal Dinarides comprise only the areas with deep water sedimentary successions and ophiolites. External Dinarides are composed for the most part of the Adriatic-Dinaric carbonate platform and of transitional area to the Internal Dinarides.

Herak's subdivision of the External Dinarides into Adriatic, Epiadriatic and Dinaric is not accepted, because he assumes two separate Mesozoic carbonate platforms (Adriatic and Dinaric). In Slovenia, however, existed only one Mesozoic carbonate platform, so it is justified to use the term Adriatic-Dinaric carbonate platform. It started to disintegrate in the Paleocene.

The position of the Adriatic microplate is also included in this subdivision.

Izvleček

V članku je podana dopolnjena tektonska razčlenitev stičnega ozemlja med Alpami in Dinaridi, ki vključuje Vzhodne Alpe, Južne Alpe, Dinaride, Panonski bazen in Jadransko-Apulijsko predgorje. Dopolnjen je potek meje med Južnimi Alpami in Dinaridi. Dinaridi so razčlenjeni na Notranje in Zunanje Dinaride, pri čemer je k Notranjim prišteto le območje z globokomorskimi sedimenti in ofioliti, k Zunanjim pa pretežni del Jadransko-Dinarske mezozojske karbonatne platforme in prehodno območje nasproti Notranjim Dinaridom.

V razčlenitvi ni sprejeta Herakova delitev Zunanjih Dinaridov na Adriatik, Epiadriatik in Dinarik, ker predpostavlja dve ločeni mezozojski karbonatni platformi, Jadransko in Dinarsko, vendar na območju Slovenije obstaja le ena mezozojska karbonatna platforma, zato je upravičeno uporabljati termin Jadransko-Dinarska karbonatna platforma. Ta se je pričela členiti šele v paleocenu.

V prikazano razčlenitev je vključena tudi lega Jadranske mikroplošče.

Introduction

The present tectonic structure of the Slovenian territory originated during the Tertiary orogeny following the collision of Apulian lithospheric plate (Apulia sensu Schmid et al., 2004) with Eurasian lithospheric plate on which the Apulian plate was overthrust. The presented subdivision of structure is schematic, and it reposes on second and third order terranes that were formed from Apulia and its marginal regions. In this way in the formal structural sense 1. Adriatic-Apulian foreland, 2. Dinarides, 3. Southern Alps, 4. Eastern Alps, and 5. Pannonian basin are distinguished. Boundaries between units in the tectonic sense or in the sense of regional subdivision are presented by important dislocations: the Periadriatic fault, Labot (Lavanttal) fault, Ljutomer fault, Sava fault, South-Alpine thrust border and the external front of External Dinarides thrust area. The Pannonian basin is determined by the depressions filled with Tertiary sediments of Paratethys.

For the presented tectonic division of Slovenia the following references were used: Basic geologic map of Yugoslavia 1 : 100.000 (1967–1986) the last mapped sheet of which was issued as Basic geologic map of Republic Slovenia and Republic Croatia (1998), in short OGK, Structural-tectonic map of Slovenia (Poljak, 2007) that summarizes the structural data of OGK, and Geologic map of Slovenia 1 : 250.000 (Buser, in preparation for print) on which stratigraphic data of all OGK sheets are compiled. The present division reposes on recent (Placer, 1999b; Mioč, 2003; Premru,

2005) and older attempts (Rakovec, 1956) of tectonic division of Slovenia, and on recent publications that contributed to a contemporary view on the matter (e.g. Jelen & Rifelj, 2002).

Subdivision

Figure represents the proposed new tectonic division of Slovenia, as modified after Placer (1999b).

1. The Adriatic-Apulian foreland represents a relatively solid core of the Adria microplate. It comprises the larger part of Istria consisting of rocks of the Adriatic segment of the Adriatic-Dinaric Mesozoic carbonate platform, and the flysch rocks resulting from its degradation. The boundary of the foreland is the external limit of the thrust area of the External Dinarides. Actually it became deformed by later separate underthrusting of Istria, the central structural element of it being the Palmanova thrust fault, named in Slovenia the Črni Kal thrust fault.

The Adriatic-Apulian foreland represents the foreland of Dinarides, Southern Alps and Apennines. The term Dinaric foreland used by Otoničar (2007) is correct, but devoid of the structural unit significance, as it comprises only the northeastern and eastern parts of the Adriatic-Apulian foreland.

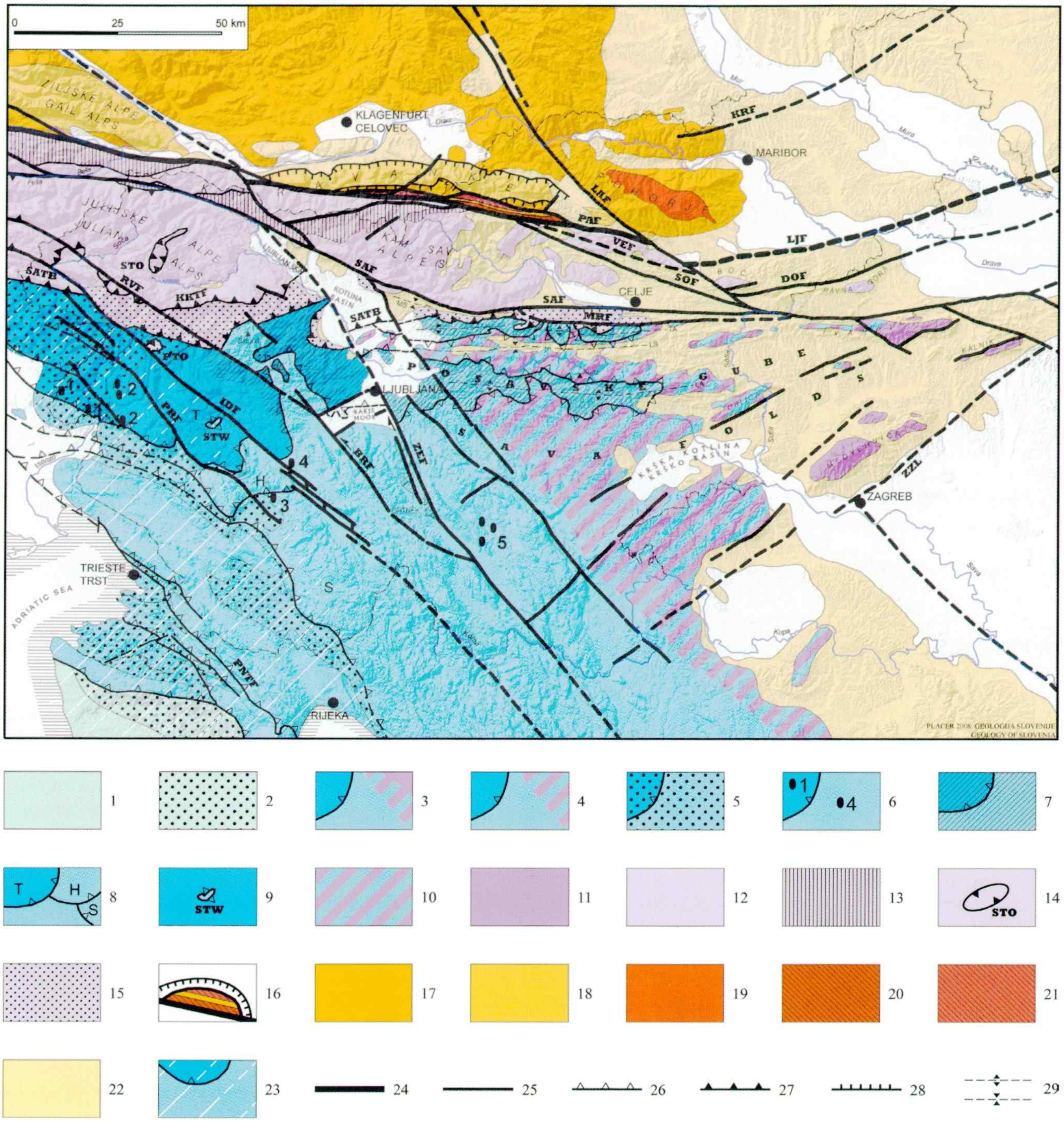
2. The Dinarides consist, following the standard structural-paleogeographic model, of the External and Internal Dinarides, and of the transition region between the two that is attributed in the present text to the External Dinarides. The same subdivision is used e.g. also by Grandić et al. (2004). On Slovenia's territory only the External Dinarides are exposed, comprising also the transition belt. The boundary of Dinarides with Southern Alps is represented by the South-Alpine thrust border which merges further to the east with Marija Reka fault. External Dinarides comprise the prevailing part of Dinaric segment of the Adriatic-Dinaric Mesozoic carbonate platform, and most part of its Adriatic segment. Characteristic for them is the thrust and nappe structure that became accomplished in External Dinarides in the Upper Eocene-Posteocene times, whereas the nappe structure of Dinarides started to take shape with the convergence between Apulia and Dacia with Tisia in the Upper Jurassic time. In the External Dinarides on our territory only the Trnovo and Hrušica nappes and also the Snežnik thrust block can be recognized with more certainty. Premru (2005) subdivided in detail the Dinarides east from there, but we consider, however, that there the level of current research is not sufficient to recognize individual units. On the basis of recent data the Sava folds are attributed to Dinarides, since no clear structural boundary to Southern Alps is visible. With respect to their position within the External Dinarides the Sava folds represent a transition zone to the Slovenian basin in

Figure

1. **Adria-Apulia foreland**; 2. Sediments resulting from disintegration of the Adria-Dinaric carbonate platform: Eocene flysch; 3. **Dinarides**; 4. External Dinarides; 5. Sediments resulting from disintegration of the Adria-Dinaric carbonate platform: Upper Cretaceous carbonatic turbidites, Cretaceouc-Paleocene and Eocene flysch; 6. Cretaceous-Paleocene scaglia: Trnovo nappe (**1** – Goriška Brda, **2** – Banjščice), Hrušica nappe (**3** – Predjama, **4** – Kališče), **5** Kočevje area; 7. Paleozoic (Carboniferous, Permian); 8. **T** – Trnovo nappe, **H** – front of the Hrušica nappe, **S** – front of the Snežnik thrust unit; 9. **STW** – Strug tectonic windov; 10. Transition area betwen External and Internal Dinarides; 11. Internal Dinarides; 12. **Southern Alps**; 13. Paleozoic (Devonian, Carboniferous, Permian); 14. **STO** – Slatna tectonic outlier (»Slatna plate«), **PTO** – Ponikva tectonic outlier; 15. Slovenian basin; 16. **Eastern Alps**; 17. Austroalpine nappes: metamorphic rocks; 17. Austroalpine nappes: Permotrias and sedimentary carbonate overcrop (Gail Alps, Northern Karavanke); 19. Pluton of tonalite/granodiorite (Miocene), Pohorje; 20. Magmatic zone of the Železna Kapla (Eisenkappel): Periadriatic intrusive, tonalite (Oligocene); 21. Magmatic zone of the Železna Kapla (Eisenkappel): granite (Trias); 22. **Pannonian basin and marginal basins**; 23. **Adria microplate**; full lines – Neogene condition, full and interrupted lines – present condition; 24. **Faults**: **PAF** – Periadriatic fault; 25. **KRF** – Kungota – Raab fault; **LAF** – Lavanttal fault; **VEF** – Velenje fault; **SOF** – Šoštanj fault; **LJF** – Ljutomer fault; **DOF** – Donat fault; **SAF** – Sava fault; **MRF** – Marija Reka fault; **ZEF** – Želimlje fault; **IDF** – Idrija fault; **RVF** – Ravne and Sovodenj fault, **BRF** – Borovnica and Ravnik fault, **PRF** – Predjama fault; **ZZL** – Zagreb–Zemplin lineament; 26. Thrust and overthrust faults in the Dinarides: **PNTF** – Palmanova thrust fault; 27. Thrust and overthrust faults in Southern Alps: **SATB** – Southern Alps thrust border; **KKTF** – Krn-Kobla thrust fault; 28. North Karavanke thrust fault in Eastern Alps; 29. **Sava folds**: **MS** – Motnik syncline, **TA** – Trojane anticline, **LS** – Laško syncline, **LA** – Litija anticline

Slika

1. **Jadransko-Apulijsko predgorje**; 2. Sedimenti degradacije Jadransko-Dinarske karbonatne platforme: eocenski fliš; 3. **Dinaridi**; 4. Zunanji Dinaridi; 5. Sedimenti degradacije Jadransko-Dinarske karbonatne platforme: zgornje kredni karbonatni turbiditi, kredno-paleocenski in eocenski fliš; 6. Kredno-paleocenska scaglia: Trnovski pokrov (**1** – Goriška Brda, **2** – Banjščice), Hrušiški pokrov (**3** – Predjama, **4** – Kališče), **5** Kočevsko; 7. Paleozoik (karbon, perm); 8. **T** – Trnovski pokrov, **H** – čelo Hrušiškega pokrova, **S** – čelo Snežniške narivne grude; 9. **STW** – Tektonsko okno Strug; 10. Prehodno območje med Zunanjimi in Notranjimi Dinaridi; 11. Notranji Dinaridi; 12. **Južne Alpe**; 13. Paleozoik (devon, karbon, perm); 14. **STO** – Slatenska tektonska krpa (»Slatenska plošča«), **PTO** – Ponikvanska tektonska krpa; 15. Slovenski bazen; 16. **Vzhodne Alpe**; 17. Avstroalpinski pokrovi: metamorfne kamnine; 18. Avstroalpinski pokrovi: permotrias in karbonatni sedimentni pokrov (Ziljske Alpe in Severne Karavanke); 19. Pluton tonalita/granodiorita (miocen), Pohorje; 20. Železnikapelska magmatska cona: periadriatski intruziv tonalita (oligocen); 21. Železnokapelska magmatska cona: granit (trias); 22. **Panonski bazen in marginalni bazeni**; 23. **Jadranska mikroplošča**: polne črte – neogenska zasnova, polne in prekinjene črte – recentni obseg; 24. **Prelomi**: **PAF** – Periadriatski prelom; 25. **KRF** – Prelom Kungora – Raba, **LAF** – Labotski prelom, **VEF** – Velenjski prelom, **SOF** – Šoštanjski prelom, **LJF** – Ljutomerski prelom, **DOF** – Donački prelom, **SAF** – Savski prelom, **MRF** – Marijareški prelom, **ZEF** – Želimeljski prelom, **IDF** – Idrijski prelom, **RVF** – Ravenski in Sovodenjski prelom, **BRF** – Borovniški in Ravniški prelom, **PRF** – Predjamski prelom, **ZZL** – lineament Zagreb–Zemplin; 26. Narivni in krovni prelomi v Dinaridih: **PNTF** – Palmanovski narivni prelom; 27. Narivni in krovno prelomi v Južnih Alpah: **SATB** – Južnoalpska narivna meja, **KKTF** – Krnsko-Koblanski narivni prelom; 28. Severnokaravanški narivni prelom v Vzhodnih Alpah; 29. **Posavske gube**: **MS** – Motniška sinklinala, **TA** – Trojanska antiklinala, **LS** – Laška sinklinala, **LA** – Litijska antiklinala



the north that occurs prevailingly in the Southern Alps, and to the Bosnian basin in the east.

3. The Southern Alps are paleogeographically a part of Dinarides, but became separated from them in Miocene. Formally they are situated between the Periadriatic fault, Labot (Lavanttal) fault and Ljutomer fault, which are in the broader sense a part of the Balaton fault zone in the north, and South-Alpine thrust border and Sava fault in the south. Mesozoic rocks of the Slovenian basin and Upper Triassic rocks of the Julian carbonate platform are exposed within them. South of the Periadriatic fault in the Carnian Alps and Southern Karavanke also Paleozoic rocks are exposed (Mioč, 1997). Such conditions are associated with the synform structure of Julian and Kamnik-Savinja Alps in west-east direction and with transpressive extrusion along the Periadriatic fault zone. The South-Alpine thrust border is represented by a thrust faults zone that extends eastward to the Sava fault. Its northern edge represents the Krn-Kobla thrust fault. East of Želimlje fault, the South-Alpine thrust border merges with Marija Reka fault, which is an element of the Sava fault zone. In an earlier interpretation (Placer, 1999b), the Krn-Kobla thrust fault was understood on the basis of OGK data (Grad & Ferjančič, 1974, 1976; Buser, 1986, 1987) as the boundary of the Julian nappe. The new concept is based on data supporting the normal position of Upper Triassic carbonates on Middle Triassic clastics in the Julian Alps (Skaberne et al., 2003), and the equivalent conditions in the

Kamnik-Savinja Alps (Celarc, 2003). Therefore the concept of the Julian nappe should be abandoned, and the Julian Alps should be considered as a thrust block. The nature of the South-Alpine fault border also makes unnecessary the introduction of a Tolmin nappe (Krystyn et al., 1994). The Slatna plate is a tectonic outlier (Seidl, 1929; Jurkovšek, 1987a, 1987b; Celarc & Herlec, 2007) that is probably a remnant of the extreme uplift of northern block of the Julian synform during underthrusting of the External Dinarides.

4. The Eastern Alps are a geologic-orographic term comprising the complex of Precambrian and Old Paleozoic high and low grade metamorphic rocks, and of Permian and Mesozoic sedimentary rocks north of the Periadriatic fault that is called Ljutomer fault in the area east of the Labot fault. In structural sense, the Eastern Alps consist of a system of large nappes called the Austroalpine nappes (in short Austroalpine), that represent compressed and elongated remnants of marginal regions of the intermediate sea that existed between the European (Eurasian) and Apulian lithospheric plates. They originated during Cretaceous and Tertiary orogenies, and are, owing to their close connection with the overthrust Apulian plate, attributed to the latter. Tollmann (1977) distinguished in the Austroalpine nappes the Lower, Middle and Upper Austroalpine nappes, and recent researchers, like Schmid et al. (2004), the Lower Austroalpine nappes, Upper Austroalpine basement nappes, and the Upper Austroalpine nappes. In Slovenia, the Kobansko region, Pohorje, Strojna and North Karavanke belong to Eastern Alps. Mioč (2003), using the older terminology, attributed Pohorje and part of Kobansko region to the Upper Austroalpine, and the other part of Kobansko, Strojna and North Karavanke to the Middle Austroalpine. The latter belongs according to the more recent terminology to Upper Austroalpine basement nappes that comprise also Paleozoic and Mesozoic rocks not affected by metamorphism. In Slovenia, the Northern Karavanke form the characteristic transpressive zone along the Periadriatic fault along which were the highest uplifted the Paleozoic phyllitoid schists in the basement of Permotriassic clastites. Northern Karavanke are attributed in the structural sense to the Southern Alps, but they have a similar lithologic development of basement and of sedimentary Mesozoic cover as the Upper Austroalpine basement nappes south of the Northern Calcareous Alps. Therefore it is reasonable to consider them a part of the Eastern Alps.

An important characteristic of Eastern Alps is, in addition to the nappe structure, the tonalite plutonism that consists of the Periadriatic intrusions, in Slovenia the southern belt of Železna kapla (Eisenkappel) magmatic zone, and of the Pohorje tonalite/granodiorite pluton with dacitic sills and dykes. According to data by Trajanova et al. (2008), the Periadriatic intrusion is of Oligocene age, around 32 Ma old, and the Pohorje pluton with dacite is Miocene age, between 19 and 18 Ma old; the age of somewhat younger rhyodacitic and lamprophyric dykes is between 17 and 16 Ma. Owing to the difference in age and in position, the Pohorje tonalite is not considered a part of the Periadriatic intrusions.

5. The Pannonian basin, Pannonian basins system respectively, consists of individual depressions that originated during Paleogene and Neogene. They are filled with sediments of the Paratethys deposited on subsided continuations of the Eastern and Southern Alps and Dinarides. The region of the Pannonian basin started its distinct structural evolution at the beginning of Miocene with the post-collision tectonic escape of the Eastern Alps whose southern border was the Periadriatic fault zone (Ratschbacher et al., 1991). According to surmise of Fodor et al. (2002), we suppose that escape in the starting stage could have taken place along the Ljutomer fault. The lateral extrusion affected also the region of Dinarides north of the Zagreb lineament (Haas & Kovacs, 2001; Jelen et. al., 2001). Development of the basin was polyphase due to the interchanging of extensional and compressional regimes. The result of these processes is the actual structure characterized in northeast Slovenia by subbasins derived from the Lower Miocene Mura-Zala and Styrian basins, e.g. the Haloze-Ljutomer subbasin, and in the western rim the isolated basins in Eastern and Southern Alps and Dinarides. Of more importance are the Smrekovec, Celje, Tunjice-Motnik, Laško, Planina, Senovo and Krško basins. Situated the farthest west is the Bohinj basin (Jelen et al., 2008).

Problems of tectonic division

In updating the scheme of tectonic subdivision of Slovenia, two important questions must be considered, both not appropriately solved yet: firstly, the course of the boundary between Southern Alps and Dinarides, associated with the question of extension of the Trnovo nappe, and secondly, the question of internal subdivision of the Dinarides. The boundary between Southern and Eastern Alps passes formally along the Periadriatic and Balaton fault zones. The question of genesis of the Pannonian basin and of isolated basins along its western rim in Eastern and Southern Alps and Dinarides has been the object of numerous studies in the last two decades.

Boundary between Southern Alps and Dinarides. Data of OGK mapping supported the opinion that Blegoš is a part of External Dinarides (Grad & Ferjančič, 1974, 1976; Premru, 1980). This was confirmed by kinematic analysis of evolution of the Blegoš structure (Placer & Čar, 1997) from which it follows that the Blegoš structure emerged first because of the thrusting in Dinaric direction (from northeast toward southwest), and afterwards, because of underthrusting of External Dinarides under Southern Alps (south-southeast toward north-northwest). Therefore it is possible to determine in the Blegoš area the unequivocal structural boundary, which is a thrust plane, between the External Dinarides and Southern Alps. Its continuation west of Blegoš to the Idrija fault is relatively clear, as on the northern side deeper sea originated rocks of the Slovenian basin crop out, and on the southern side carbonate rocks of the Trnovo nappe are exposed. At the Idrija fault, the boundary is displaced toward northwest for a few kilometers. A special role in defining its character has the Ponikve tectonic klippe, situated east of the Idrija fault, which is an isolated part of the overthrust of the Slovenian basin onto the Trnovo nappe. The considered boundary can be traced east of Blegoš as far as to the Ljubljana depression and along its western rim.

In discussing the passage of boundary between Southern Alps and External Dinarides east of the Ljubljana depression it is useful to compare the development of rocks of the Slovenian basin east of Ljubljana depression in the frame of Southern Alps, with its development east of Ljubljana depression in the western part of the Sava folds, and verify the existence of Dinaric nappe structures in the Sava folds. For the rocks of the Slovenian basin west of Ljubljana depression, Mesozoic deeper sea sediments are characteristic, whereas in the eastern borders of Ljubljana depression the aforementioned sediments exist only in the northern belt of the Sava folds north of Trojane anticline. In central and southern parts of Sava folds, Triassic-Jurassic platform carbonates prevail on which the Upper Cretaceous flysch is deposited (Premru, 1980, 1983a, 1983b, 2005). Such development is found also in certain isolated hills in the Ljubljana field. In association with the nappe structure we recognized that in Sava folds the Mesozoic rocks form one or several large nappe units that became overthrust before the deposition of Middle to Upper Oligocene beds (Placer, 1999a), as deduced from details of mapping the Basic Geologic Map, sheets Celje (Buser, 1978) and Novo mesto (Pleničar & Premru, 1976). The nappe units of Sava folds can be chronologically compared only with the Dinaric nappes of southwest Slovenia; consequently, the cycle of overthrusting was mostly achieved at the end of Eocene or in the beginning of Oligocene time, which allows the conclusion about the Dinaric provenience of the Sava folds nappes. The central and southern part of Sava folds belongs in the facial sense to rocks of the border belt of the Adriatic-Dinaric carbonate platform and the Slovenian basin. The Dinaric provenience is supported also by internal structure of the nappe units. Their boundaries pass east of Ljubljana depression in the west–east direction, which can be formally compared with the Alpine W-E direction. This direction is of multiphase origin under various dynamic conditions.

The Sava folds consist of nappe overthrusts of Dinaric provenience that are folded in the Alpine W-E direction. A part of this system is also the Kum thrust which was considered in the former interpretation (Placer, 1999b) owing to morphological reasons as a continuation of the South-Alpine thrust front east of the Ljubljana depression. The former argument for attribution to the Southern Alps was supported also by similar conditions west of the Julian Alps (Doglioni & Bosellini, 1987; Doglioni & Siorpaes, 1990).

In Sava folds, the structural boundary between the Southern Alps and Dinarides can be positioned only along northern boundary of the Trojane anticline where are, according to the Geological map of Slovenia 1: 250.000 (Buser, in press), deeper water successions of the Slovenian basin thrust toward south. In the macrotectonic subdivision of Slovenia (Placer, 1999b, fig. 8, variant a), this variant was characterized as possible, but considered as less probable due to a different stratigraphical attribution of lithological units. The South-Alpine thrust front merges to the east with Marija Reka fault (Grad, 1969) considered as an element within the Sava fault zone (Vrabec, 2001). Such a solution makes sense, since the Kamnik-Savinja Alps are a cut off part of the Julian Alps displaced along the Sava fault.

The Trnovo nappe sensu Mlakar (1969) and Placer (1998b) is structurally the highest nappe element of the External Dinarides of western Slovenia. The Carboniferous-Permian clastites in the northeastern root part of nappe west of Ljubljana depression undoubtedly lie on Mesozoic carbonate beds of the lower nappe unit. On the contrary, however, the Carboniferous-Permian clastics of the Litija anticline east of Ljubljana depression occur consistently below the Mesozoic beds, and there is no direct or indirect argument to prove the contrary (Placer, 1998b). The Carboniferous-Permian clastites of the Trnovo nappe and Litija anticline come then in contact in the area of Ljubljana depression, although they belong to different structural units. This problem, seen from a different angle, has been solved from various aspects by a number of geologists (Kossmat, 1913; Winkler, 1923; Rakovec, 1956; Buser, 1978, 1979; Mlakar, 1987; Placer, 1999b; Mioč, 1976, 1981, 2003; Premru, 1980, 1983a, 1983b, 2005).

Important for interpretation of continuation of the Trnovo nappe east of Ljubljana depression, and of different development of Mesozoic beds in eastern and western rim of the Ljubljana depression, and in northern and eastern border of the Ljubljana moor, is the existence of the vast Miocene wrenching zone (Tari, 2002) that is supposed to pass from the Ljubljana depression to Imotski in Herzegovina, and farther. Let us call it, for easier communication, the Ljubljana-Imotski fault zone. It has a special position among the longitudinal faults of Dinarides. The most important in the array of faults of this zone is in Slovenia the Želimlje fault that passes over the central part of the External Dinarides along the eastern rim of Ljubljana moor and western rim of Ljubljana depression, where it joins the Sava fault. From the incompatibility of western and eastern rims of Ljubljana depression and of Ljubljana moor, we conclude that the boundary of the Trnovo nappe continues to the Želimlje fault. Its position in the northeastern block must consequently be sought southeast from there. In the Sava folds occur nappe units that lie structurally above the Trnovo nappe. The Carboniferous-Permian beds of Sava folds served as a soft basement for the Dinaric nappe and thrust structure. The importance of the Želimlje fault is indicated also by erosional windows of Permian beds at Ortnek, where they are exposed in the highly uplifted southwestern block of the fault.

The Želimlje fault separates two distinct zones of tectonized rocks on the southern side of the South-Alpine border. In the west, the tectonized zone is narrow and more pronounced and in the east it consists of a broad, multiphase transformed folded zone with subordinate symmetrically arranged thrust faults.

Significant displacement of the Trnovo nappe boundary and insignificant displacement of the South-Alpine thrust boundary are connected with pre-Middle Oligocene age of the Trnovo nappe, which is older than the fault zone Ljubljana-Imotski, and Miocene and post-Miocene underthrusting of the Dinarides under Southern Alps. The last mentioned event is younger than the peak movements along Želimlje fault. According to differences in the tectonic structure of the Ljubljana moor and Ljubljana depression, it is probably still active. Ljubljana moor occupies a transverse position between Želimlje fault and an array of faults on its SW edge. These faults are part of the fault series from Ravne fault to the Sovodenj fault (Mlakar & Placer, 2000) and Borovnica fault to Ravnik fault (Buser, 1976). The latter is connected with the Želimlje fault near Ribnica. On figure, the Ravne and Sovodenj fault are marked RVF, and the Borovnica fault zone and Ravnik fault are marked BRF. These faults, together with the Želimlje fault, form a laterally pushed wedge whose dynamics has not been investigated yet. According to the regional conditions, the wedge could be in the extensional regime, but in the case that Julian Alps prevented its movement and the South Alpine thrust border between aforementioned faults is not active, then the wedge is in the compressional regime.

The question of division of Dinarides is manysided, and several models have been proposed. They are based on the existence of either one, or of two Mesozoic carbonate platforms which influenced the subsequent structural development, and also the division. A single platform is advocated e.g. by Vlahović et al. (2005) (Adriatic carbonate platform), for which certain authors use the term Adriatic-Dinaric carbonate platform (Pamić & Hrvatović, 2003). According to the classical model based on a single Mesozoic carbonate platform the Dinarides consist in the structural sense of Internal and External Dinarides, but the extents of units and concepts of their kinematic evolution have changed in the historical periods. However, the region of Mesozoic carbonate rocks has been attributed to the external part of Dinarides by all, e.g. V. Petković, 1931 and K. Petković, 1957, and by some among them decidedly to the External Dinarides, e.g. B. Ćirić, 1960; J. Aubouin,1974 and M. Anđelković, 1978 (Anđelković, 1978). The Dinarides are built of nappe units that were thrust southwestward, that had a paleogeographic origin, and that were formed in the time from Upper Jurassic to Upper Eocene, and even to Lower Oligocene. External Dinarides comprise the larger part of the Adriatic-Dinaric carbonate platform with the exception of its southwestern part, which belongs to the Adriatic-Apulian foreland and the marginal basins. The Inner Dinarides comprise parts of the oceanic crust. Boundary betwen the External Dinarides and the Adriatic-Apulian foreland is structural, and it passes along the external border of Adriatic islands and across the northeastern part of Istria. The boundary to Internal Dinardes is a wide transition area with marginal deeper water basins.

Based on model of two Mesozoic carbonate platforms, Adriatic and Dinaric, interesting interpretations of the Dinarides were proposed among others by Herak (1986, 1989, 1991, 1999) and Tari (2002). Herak's interpretation assumes large intersequence nappe thrusts. He distinguished the Adriatic comprising the Adriatic carbonate platform, the Epiadriatic encompassing the intermediate basin, the Dinaric comprising the Dinaric carbonate platform, and the Supradinaric consisting of rocks of the transition region. Mioč (2003) used Herak's model in his tectonic division of Slovenia. Tari's interpretation distinguishes Adria in the sense of Adria microplate which comprises Adriatic Mesozoic carbonate platform and Dinarides, with Dinaric Mesozoic carbonate platform as their constitutive part. Dinarides are overthrust on the Adria. Adria consists of a relatively weakly tectonized core in which participate a part of the Adriatic carbonate platform (Istria), Adriatic basin and a part of the Apulian carbonate platform, and the imbricated borderland to which belong in eastern part of Adriatic Sea the islands and the Ravni Kotari area. The Dinarides comprise the entire Dinaric Mesozoic carbonate platform with marginal basins (Western thrust belt) and the overthrust oceanic crust (Eastern thrust belt). The sediments of the Budva basin are covered with the overthrust Dinarides. In Slovenia, the imbricated belt of Čičarija is attributed to the Adria imbricated zone by Tari, and Čičarija itself with the Kras plateau to the Dinarides. Vrabec & Fodor (2006) attributed to the Adria imbricated belt also the belt between Čičarija and Mt. Snežnik thrust. Herak and Tari supposed in Slovenia the existence of large nappe structures.

Drobne & Ogorelec (2008) describe in the northeastern border of Vipava and Brkini flysch syncline elements of deeper water development and Paleocene scaglia, which allowed them to assume the existence of Adriatic in Istria, Čičarija and on Kras plateau, and of Epiadriatic in the northeastern borders of Vipava and Brkini flysch syncline. The Epidinaric unit is believed to be covered by the Dinaric overthrust (sensu Herak, 1999). In this connection they used the model of the structural map of Italy (Bigi et al., 1990–1992), where the Snežnik thrust fault as well as the Hrušica and Trnovo nappe faults are merged into a single nappe thrust plane. By doing so they did not open the question of existence of a Mesozoic basin between the two platforms, which is an essential element of Herak's model.

On the basis of results of structural mapping of southwestern Slovenia (Placer, 2002, 2005, 2007; Placer et al., 2004), investigations in Friuli (Peruzza et al., 2002; Carulli, 2006), the explicit out-of-sequence position of the Snežnik thrust fault, and of Hrušica and Trnovo overthrust fault, sufficiently precise analysis of the Trnovo nappe displacement (Placer, 1973, 1981), and results of drilling within the Trnovo nappe (Placer et al., 2000) it is possible to assume in the northwestern part of Dinarides a deepening between the Adriatic and Dinaric segments of Mesozoic carbonate platform only from the Paleocene on. Therefore it is justified to consider the Adriatic-Dinaric carbonate platform with shallower intraplatform trenches in the sense of Vlahović et al. (2005). Such a conclusion is meaningful also because the Paleocene scaglia occurs also on Sabotin and Banjščice in the Trnovo nappe, on Kalič in the Hrušica nappe, and in the Kočevje region, which all can be interpreted as shallower deepenings. The area of outcropping scaglia on Banjščice is separated from the older basin sedimentary beds of Trnovski gozd by the Predjama fault that covers a stronger thrust fault within the Trnovo nappe. This interpretation of the territory has been proposed by Bigi et al. (1989–2000) and Premru (2005), and is confirmed also by the new geologic map of Friuli-Venezia Giulia (Carulli, 2006). Such a structure confirms the out-of- sequence passage of thrust planes of this part of Dinarides, and with it the justification of a uniform concept of the Adriatic-Dinaric carbonate platform. Conditions in the central and southeast parts of Dinarides are different.

It follows from the partly published fragmentary materials on structure of the border belt between the Adriatic-Apulian foreland and the region in its hinterland - Kras edge (Placer, 2002, 2005, 2007; Placer et al., 2004) that the Trnovo and Hrušica nappe, Snežnik overthrust and the very origin of the Kras edge were formed in the overthrusting phase of the External Dinarides at the end of Eocene and at beginning of Oligocene, whereas the underthrusting of Adria microplate (Tari, 2002) and separately, of Istria, took place in Middle Miocene and later. At that time only developed the actual underthrusting belt in Istria with its central element, the Črni Kal thrust fault, respectively the Palmanova thrust fault. Therefore the formal boundary of the External Dinarides is represented by the border of the external front of the thrust area.

Figure shows also the Adriatic microplate. There is an important question concerning the course of its northeastern border. In the middle and southeastern parts of the External Dinarides it separates the Adriatic and Dinaric segments of the Adriatic-Dinaridic Mesozoic carbonate platform in structural and paleogeographical sense. Relations are more complicated in the northeastern part of the External Dinarides, where both segments of Mesozoic carbonate platform are merged. In the first phase of its forming, in Miocene, the boundary was identical with Snežnik thrust-fault front, and Hrušica and Trnovo nappe thrust-fault front. Recent course of boundary extends from the Snežnik thrust-fault front toward Idrija fault in Upper Soča Valley and along South-Alpine thrust border west of Idrija fault. A similar assumption about recent position of the boundary was proposed already by Carulli et al. (1990).

Osnove tektonske razčlenitve Slovenije

Uvod

Današnja tektonska zgradba ozemlja, na katerem leži Slovenija, je nastala med terciarno orogenezo po koliziji Apulijske litosferske plošče (Apulija sensu Schmid et al., 2004) in Evrazijske litosferske plošče, na katero se je Apulijska narinila. Predstavljena razčlenitev je shematska in sloni na teranih drugega in tretjega reda, ki so se izoblikovali iz Apulije in njenih marginalnih območij. Tako ločimo v formalno-strukturnem smislu: 1. Jadransko-Apulijsko predgorje, 2. Dinaride, 3. Južne Alpe, 4. Vzhodne Alpe in 5. Panonski bazen. Meje med enotami so v tektonskem pomenu ali v smislu rajonizacije pomembni prelomi: Periadriatski prelom, Labotski prelom, Ljutomerski prelom, Savski prelom, Južnoalpska narivna meja in zunanja meja narivnega območja Zunanjih Dinaridov. Panonski bazen določajo depresije, zapolnjene s terciarnimi sedimenti Paratetide.

Za predstavljeno tektonsko razčlenitev Slovenije so bile uporabljene naslednje podlage: Osnovna geološka karta Jugoslavije 1 : 100.000 (1967–1986), katere zadnji list je izšel kot Osnovna geološka karta Republike Slovenije in Republike Hrvaške (1998), skrajšano OGK, Strukturno-tektonska karta Slovenije (Poljak, 2007), ki povzema strukturne podatke iz OGK in Geološka karta Slovenije 1 : 250.000 (Buser, v pripravi za tisk), na kateri so usklajeni stratigrafski podatki z OGK. Sedanja razčlenitev sloni na novejših (Placer,1999b; Mioč, 2003; Premru, 2005) in starejših (Rakovec, 1956) poizkusih tektonske razčlenitve Slovenije ter novejših objavah, ki so prispevale k sodobnem pogledu na to vprašanje (npr. Jelen & Rifelj, 2002).

Razčlenitev

Na sliki je podan predlog nove tektonske razčlenitve Slovenije, ki je dopolnjena po Placerju (1999b).

1. Jadransko-Apulijsko predgorje predstavlja relativno trdno jedro Jadranske mikroplošče. Pripada mu večji del Istre, ki je zgrajena iz kamnin

Jadransko-Dinarske mezozojske karbonatne platforme in flišnih kamnin, nastalih pri njeni degradaciji. Meja predgorja je zunanja meja naluskanega pasu Zunanjih Dinaridov. Danes je deformirana s poznejšim separatnim podrivanjem Istre, katerega osrednji strukturni element je Palmanovski narivni prelom, pri nas imenovan Črnokalski narivni prelom.

Jadransko-Apulijsko predgorje leži v vznožju Dinaridov, Južnih Alp in Apeninov. Zato je termin Dinarsko predgorje, ki ga je uporabil Otoničar (2007) pravilen, vendar nima pomena strukturne enote, saj označuje le severovzhodni in vzhodni del Jadransko-Apulijskega predgorja.

2. Dinaridi so razdeljeni po standardnem strukturno-paleogeografskem modelu na Zunanje in Notranje Dinaride ter prehodno območje med njima, ki ga v prispevku prištevamo k Zunanjim Dinaridom. Enako razčlenitev uporabljajo tudi Grandić in sodelavci (2004). Na našem ozemlju izdanjajo le Zunanji Dinaridi s prehodnim območjem. Meja Dinaridov nasproti Južnim Alpam poteka po Južnoalpski narivni meji, ki se proti vzhodu naslanja na Marijareški prelom. Zunanji Dinaridi zajemajo pretežni del dinarskega segmenta Jadransko-Dinarske mezozojske karbonatne platforme in del njenega Jadranskega segmenta. Značilna zanje je narivna in krovna zgradba, ki se je v Zunanjih Dinaridih zaključila v zgornjeeocenskem-posteocenskem obdobju, medtem ko se je krovna zgradba Dinaridov začela oblikovati s konvergenco med Apulijo ter Dacijo in Tiso na drugi strani v zgornjejurskem obdobju. V Zunanjih Dinaridih našega ozemlja je mogoče natančneje določiti le Trnovski in Hrušiški pokrov ter Snežniško narivno grudo. Premru (2005) je Dinaride vzhodno od tod podrobno razčlenil, vendar menimo, da je stopnja raziskanosti tod premajhna, da bi lahko izločili posamezne enote. Na podlagi novih podatkov prištevamo Posavske gube k Dinaridom, ker v njih ne moremo določiti jasne strukturne meje nasproti Južnim Alpam. Glede na lego znotraj Zunanjih Dinaridov predstavljajo Posavske gube prehodno območje proti Slovenskemu bazenu na severu, ki leži pretežno v Južnih Alpah in Bosanskemu bazenu na vzhodu.

3. Južne Alpe so paleogeografsko del Dinaridov, vendar so se od njih ločile v miocenu. Formalno ležijo med Periadriatskim, Labotskim in Ljutomerskim prelomom, ki je v širšem smislu del Balatonske prelomne cone, na severu ter Južnoalpsko narivno mejo in Savskim prelomom na jugu. V Južnih Alpah izdanjajo kamnine Slovenskega bazena mezozojske starosti in zgornjetriasne kamnine Julijske karbonatne platforme. Južno od Periadriatskega preloma v Karnijskih Alpah in Južnih Karavankah izdanjajo tudi paleozojske kamnine (Mioč, 1997). Taka zgradba je povezana s sinformno strukturo Julijskih in Kamniško-Savinskih Alp v smeri zahod–vzhod in s transpresijskim izrivanjem ob Periadriatski prelomni coni. Južnoalpska narivna meja predstavlja južni rob cone narivnih prelomov, ki segajo na vzhodu do Savskega preloma. Njen severni rob je Krnsko-Koblanski narivni prelom. Vzhodno od Želimeljskega preloma se Južnoalpska narivna meja naslanja na Savski prelom, natančneje na Marijareški prelom, ki je element prelomne cone Savskega preloma. V prejšnji interpretaciji (Placer, 1999b) je bil Krnsko-Koblanski narivni prelom na podlagi podatkov OGK (Grad & Ferjančič 1974, 1976; Buser, 1986, 1987) interpretiran kot meja Julijskega pokrova. Novi sklep izhaja iz podatkov o normalni legi zgornjetriasnih karbonatov na srednjetriasnih klastitih v Julijskih Alpah (Skaberne et al., 2003) in enakih razmerah v Kamniško-Savinjskih Alpah (Celarc, 2003). Zaradi tega moramo opustiti idejo o Julijskem pokrovu in obravnavati Julijske Alpe kot narivno grudo. Iz narave Južnoalpske narivne meje je nepotrebno tudi uvajanje Tolminskega pokrova (Krystyn et al., 1994). Slatenska plošča je tektonska krpa (Seidl, 1929; Jurkovšek, 1987a, 1987b; Celarc & Herlec, 2007), ki je verjetno ostanek ekstremnega dviga severnega krila Julijske sinforme pri podrivanju Zunanjih Dinaridov.

4. Vzhodne Alpe so geološko-orografski termin, ki zajema kompleks predkambrijskih in staropaleozojskih metamorforiziranih kamnin ter permskih in mezozojskih sedimentnih kamnin severno od Periadriatskega preloma, ki se vzhodno od Labotskega preloma imenuje Ljutomerski prelom. V strukturnem smislu so Vzhodne Alpe zgrajene iz sistema obsežnih pokrovov, imenovanih Avstroalpinski pokrovi, skrajšano Avstroalpin, ki predstavljajo stisnjene in razpotegnjene ostanke marginalnih območij vmesnega morja med Evropsko (Evrazijsko) in Apulijsko litosfersko ploščo. Ti pokrovi so nastali v teku kredne in terciarne orogeneze in jih zaradi tesne povezave z narinjeno Apulijsko ploščo prištevamo k slednji. Tollman (1977) je Avstroalpinske pokrove razdelil na spodnji, srednji in zgornji Avstroalpin, mlajši raziskovalci kot Schmid in sodelavci, (2004) pa v spodnji, spodnji del zgornjega Avstroalpina in zgornji Avstroalpin. Pri nas pripadajo Vzhodnim Alpam Kobansko, Pohorje, Strojna in Severne Karavanke. Mioč (2003) je uporabil Tollmanovo razčlenitev ter Pohorje in del Kobanskega uvrstil v zgornji Avstroalpin, del Kobanskega, Strojno in Severne Karavanke pa v srednji Avstroalpin. Ta po novejši terminologiji pripada spodnjemu delu zgornjega Avstroalpina, ki vključuje tudi nemetamorforizirane paleozojske in mezozojske kamenine, pri nas Severne Karavanke. Te tvorijo značilno izrivno transpresijsko strukturo ob Periadriatski prelomni coni, ob kateri so najvišje dvignjeni paleozojski filitoidni skrilavci v podlagi permotriasnih klastitov. Severne Karavanke uvrščajo v strukturnem smislu v Južne Alpe, vendar imajo podobnen litološki razvoj podlage in sedimentnega mezozojskega pokrova kot spodnji del zgornjega Avstroalpina južno od Severnoapneniških Alp. Zato je smiselno, da jih obravnavamo kot del Vzhodnih Alp.

Poleg krovne zgradbe je pomembna značilnost Vzhodnih Alp tonalitni plutonizem, ki ga delimo na periadriatske intruzije (pri nas južni pas Železnokapelske magmatske cone) in na pluton tonalita/granodiorita na Pohorju s sili in dajki dacita. Po podatkih Trajanove et al. (2008) je periadriatska intruzija oligocenska, stara okoli 32 Ma, pohorski pluton skupaj z dacitom pa miocenski, star med 19 in 18 Ma. Nekoliko mlajši so dajki riodacita in lamporfirja, med 17 in 16 Ma. Zaradi razlike v starosti in drugačne lege pohorskega tonalita ne uvrščamo med Periadriatske intruzije.

5. **Panonski bazen**, oziroma sistem bazenov, sestavljajo posamezne depresije, ki so nastajale in se spreminjale tekom paleogena in neogena. Izpolnjene so s sedimenti Paratetide, ki so odloženi na pogreznjenih vzhodnih podaljških Vzhodnih Alp, Južnih Alp in Dinaridov. Prostor Panonskega bazena se je pričel dejavneje strukturno oblikovati s postkolizijskim tektonskim pobegom Vzhodnih Alp proti vzhodu v začetku miocena, katerega južna meja je bila Periadriatska prelomna cona (Ratschbacher et al., 1991). Po podatkih Fodorja in sodelavcev (2002) o vlogi Ljutomerskega preloma, domnevamo, da bi se pobeg v začetnem stadiju lahko dogajal ob Ljutomerskem prelomu. Lateralna ekstruzija je zajela tudi območje Dinaridov severno od Zagrebškega lineamenta (Haas & Kovács, 2001; Jelen et.al., 2001). Razvoj bazena je bil ob menjavanju ekstenzijskih in kompresijskih pogojev večstopenjski. Rezultat teh procesov je današnja zgradba kjer v severovzhodni Sloveniji nastopajo podbazeni, ki so nastali iz spodnjemiocenskega Mura-Zala in Štajerskega bazena, npr. Haloško-Ljutomerski podbazen, na zahodnem obrobju pa izolirani bazeni v Vzhodnih in Južnih Alpah ter Dinaridih. Pomembnejši so Smrekovški, Celjski, Tunjiško-Motniški, Laški, Planinski, Senovški in Krški bazen. Najdlje na zahodu je Bohinjski bazen (Jelen et al., 2008).

Problematika tektonske razčlenitve

Pri posodobitvi sheme tektonske razčlenitve Slovenije je potrebno izpostaviti dve pomembni vprašanji, ki se še vedno intenzivno raziskujeta: Prvič, potek meje med Južnimi Alpami in Dinaridi skupaj z vprašanjem razprostranjenosti Trnovskega pokrova in drugič, vprašanje razčlenitve Dinaridov. Meja med Južnimi in Vzhodnimi Alpami poteka formalno po Periadriatski in Balatonski prelomni coni, vprašanje geneze Panonskega bazena in izoliranih bazenov ob njegovem zahodnem obrobju v Vzhodnih in Južnih Alpah ter Dinaridih je rezultat številnih raziskav zadnjih dveh desetletij.

Meja med Južnimi Alpami in Dinaridi. Podatki kartiranja za OGK so utrdili mnenje, da je Blegoš del Zunanjih Dinaridov (Grad & Ferjančič, 1974,1976; Premru, 1980). To je bilo potrjeno s kinematsko analizo geneze blegoške strukture (Placer & Čar, 1997), iz katere je razvidno, da je zgradba Blegoša nastala najprej zaradi dinarsko usmerjenega narivanja od severovzhoda proti jugozahodu in nato zaradi podrivanja Zunanjih Dinaridov pod Južne Alpe od juga do jugovzhoda proti severu do severozahoda. Na območju Blegoša je zato mogoče nedvoumno določiti strukturno mejo med Zunanjimi Dinaridi in Južnimi Alpami, ki je narivna ploskev. Njen potek zahodno od Blegoša je do Idrijskega preloma sorazmerno jasen, saj se na severni strani nahajajo globljemorske kamnine Slovenskega bazena, na južni strani pa karbonatne kamnine Trnovskega pokrova. Ob Idrijskem prelomu je meja zamaknjena proti severozahodu za nekaj kilometrov. Poseben pomen pri dokazovanju njenega značaja ima vzhodno od Idrijskega preloma ležeča Ponikvanska tektonska krpa, ki predstavlja ostanek nariva kamnin Slovenskega bazena na Trnovski pokrov. Obravnavano mejo je mogoče vzhodno od Blegoša slediti do Ljubljanske kotline in ob njenem zahodnem robu.

Pri razpravi o poteku meje med Južnimi Alpami in Zunanjimi Dinaridi vzhodno od Ljubljanske kotline je pomembno primerjati razvoj kamnin Slovenskega bazena zahodno od Ljubljanske kotline v okviru Južnih Alp z razvojem vzhodno od Ljubljanske kotline v zahodnem delu Posavskih gub in ugotoviti, če obstajajo v Posavskih gubah dinarske krovne strukture. Za kamnine Slovenskega bazena zahodno od Ljubljanske kotline so značilni globljemorski jurski in kredni sedimenti, medtem ko na vzhodnem obrobju Ljubljanske kotline nastopajo ti le v severnem pasu Posavskih gub severno od jedra Trojanske antiklinale. V osrednjem in južnem delu Posavskih gub pa prevladujejo plitvovodne triasno-jurske karbonatne kamnine, na katerih je odložen zgornjekredni fliš (Premru, 1980, 1983a, 1983b, 2005). Tak razvoj najdemo tudi na nekaterih osamelcih Ljubljanskega polja. V zvezi z narivno zgradbo je pomembno, da tvorijo v Posavskih gubah mezozojske kamnine eno ali več obsežnih krovnih enot, ki so bile narinjene pred odložitvijo srednje do zgornjeoligocenskih plasti (Placer, 1999a), kar je razvidno iz detajlov kartiranja za OGK, lista Celje (Buser, 1978) in Novo mesto (Pleničar & Premru, 1976). Krovne enote Posavskih gub lahko časovno vzporejamo le z dinarskimi pokrovi v jugozahodni Sloveniji, torej se je ciklus narivanja zaključil konec eocenske ali na začetku oligocenske dobe, iz česar sklepamo, da so pokrovi Posavskih gub dinarske provenience. Osrednji in južni del Posavskih gub pripada v facialnem smislu kamninam mejnega pasu Jadransko-Dinarske karbonatne platforme in kamninam Slovenskega bazena.

Dinarski izvor potrjuje tudi notranja zgradba krovnih enot. Meje le teh potekajo vzhodno od Ljubljanske kotline v smeri zahod–vzhod, ki jo formalno vzporejamo z alpsko smerjo. Ta je nastala v več fazah pri različnih dinamskih pogojih.

Posavske gube so zgrajene iz krovnih narivov dinarskega izvora, ki so nagubani v alpski smeri. V ta sistem spada tudi Kumski nariv, ki je bil v prejšnji interpretaciji (Placer, 1999b, sl. 8, varianta b) zaradi morfološke izrazitosti obravnavan kot Južnoalpska narivna meja. Tedanjo odločitev za uvrstitev v Južne Alpe so podpirale tudi podobne razmere zahodno od Julijskih Alp (Doglioni & Bosellini, 1987; Doglioni & Siorpaes, 1990).

V Posavskih gubah lahko potegnemo ozko strukturno mejo med Južnimi Alpami in Dinaridi le ob severnem robu Trojanske antiklinale, kjer so po podatkih Geološke karte Slovenije 1 : 250.000 (Buser, v tisku) globljevodne plasti Slovenskega bazena narinjene proti jugu. V makrotektonski razčlenitvi Slovenije (Placer, 1999b, sl. 8, varianta a) je bila ta varianta omenjena kot možna, vendar obravnavana kot manj verjetna zaradi drugačne stratigrafske uvrstitve kamnin tega območja. Južnoalpska narivna meja se proti vzhodu naslanja na Marijareški prelom (Grad, 1969), ki ga obravnavamo kot element znotraj cone Savskega preloma (Vrabec, 2001). Taka rešitev je smiselna, ker so Savinjske Alpe ob Savskem prelomu odrezan in premaknjen del Julijskih Alp.

Trnovski pokrov sensu Mlakar (1969) in Placer (1999b) je najvišja krovna enota Zunanjih Dinaridov zahodne Slovenije. Karbonskopermski klastiti v severovzhodnem korenskem delu pokrova zahodno od Ljubljanske kotline ležijo nedvomno na mezozojskih karbonatih spodnje krovne enote. Nasprotno pa ležijo karbonskopermski klastiti Litijske antiklinale vzhodno od Ljubljanske kotline dosledno pod mezozojskimi kamninami in ni nobenega posrednega ali neposrednega dokaza, da bi bilo kako drugače (Placer, 1999b). Karbonskopermski klastiti Trnovskega pokrova in Litijske antiklinale se torej stikajo na območju Ljubljanske kotline, vendar pripadajo različnima strukturnima enotama. Ta, sicer drugače viden problem, so z različnih gledišč reševali številni geologi (Kossmat, 1913; Winkler, 1923; Rakovec, 1956; Mlakar, 1987; Placer, 1999b; Mioč, 1976, 1981, 2003; Premru, 1980, 1983a, 1983b, 2005).

Za razlago razprostranjenosti Trnovskega pokrova vzhodno od Ljubljanske kotline in različnega razvoja mezozojskih kamnin vzhodnega in zahodnega obrobja Ljubljanske kotline in severnega ter vzhodnega obrobja Ljubljanskega barja je pomemben obstoj velike miocenske strižne cone (Tari, 2002), ki naj bi potekala zvezno od Ljubljanske kotline do Imotskega v Hercegovini in naprej. Zaradi lažje orientacije jo imenujmo prelomna cona Ljubljana-Imotski, ki ima med longitudinalnimi prelomi v Dinaridih posebej pomembno mesto. Najpomembnejši v snopu prelomov te cone je v Sloveniji Želimeljski prelom, ki poteka preko osrednjega dela Zunanjih Dinaridov, ob vzhodnem robu Ljubljanskega barja in zahodnem robu Ljubljanske kotline ter se severno od Radovljice nasloni na Savski prelom. Iz nekompatibilnosti zahodnega in vzhodnega obrobja Ljubljanske kotline ter Ljubljanskega barja sklepamo, da se meja Trnovskega pokrova naslanja na Želimeljski prelom. Njeno izdanjanje v severovzhodnem krilu Želimeljskega preloma moramo potemtakem iskati jugovzhodno od tod. V Posavskih gubah nastopajo krovne enote, ki ležijo strukturno nad Trnovskim pokrovom. Karbonskopermske plasti Posavskih gub tvorijo »mehko posteljico« dinarske krovne in narivne zgradbe. O pomenu Želimeljskega preloma govorijo tudi erozijska okna permskih plasti pri Ortneku, ki izdanjajo v močno dvignjenem jugozahodnem krilu preloma.

Želimeljski prelom razmejuje dva različna tipa prehodne cone ob južni strani Južnoalpske narivne meje. Na zahodu je ta ožja in izrazita, na vzhodu pa široka nagubana cona s podrejenimi simetrično razporejenimi narivnimi prelomi, ki je doživela več transformacij.

Znaten zamik meje Trnovskega pokrova in neznaten premik Južnoalpske narivne meje ob Želimeljskem prelomu je povezan s predsrednjeoligocensko starostjo Trnovskega pokrova, ki je starejši od prelomne cone Ljubljana-Imotski in miocenskim ter postmiocenskim podrivanjem Dinaridov pod Južne Alpe, ki je mlajše od viška premikov ob Želimeljskem prelomu. Glede na razlike v zgradbi Ljubljanskega barja in Ljubljanske kotline pa je verjetno aktiven še danes. Ljubljansko barje je prečno vmeščeno med Želimeljski prelom in snopom prelomov ob njegovem jugozahodnem robu. Ti prelomi so del niza prelomov od Ravenskega preko Sovodenejskega (Mlakar & Placer, 2000), Borovniškega do Ravniškega preloma (Buser, 1976), ki se pri Ribnici naslanja na Želimeljski prelom. Na sliki sta Ravenski in Sovodenjski prelom označena z RVF, cona Borovniškega in Ravniški prelom pa z BRF. Obravnavani niz prelomov tvori z Želimeljskim prelomom bočni izrivni klin katerega dinamika še ni raziskana. Glede na regionalne razmere bi se lahko nahajal v stanju ekstenzije ali kompresije, če Julijske Alpe preprečujejo izrivanje in je Južnoalpska narivna meja med obravnavanima prelomoma neaktivna.

Vprašanje razčlenitve Dinaridov je večplastno, saj se ponuja več modelov, ki izhajajo iz obstoja ene ali dveh mezozojskih karbonatnih platform, iz česar izhaja njihov poznejši strukturni razvoj in zazčlenitev. Eno platformo zagovarjajo npr. Vlahović in sodelavci (2005), ki jo imenujejo Jadranska karbonatna platforma, za katero nekateri uporabljajo termin Jadransko-Dinarska karbonatna platforma (Pamić & Hrvatović, 2003). Po klasičnem modelu, ki izhaja iz ene mezozojske karbonatne platforme, so Dinaridi v strukturnem smislu razdeljeni na Notranje in Zunanje Dinaride, pri čemer pa se je obseg enot in predstava o njihovem kinematskem razvoju v zgodovinskih razdobjih spreminjala. Vendar so območje mezozojskih karbonatnih kamnin vsi uvrščali v zunanji del Dinaridov, npr. V. Petković, 1931 in K. Petković, 1957, nekateri določneje v Zunanje Dinaride, npr. B. Ćirić, 1960; J. Aubouin, 1974 in M. Anđelković, 1978 (Anđelković, 1978). Dinaridi so zgrajeni iz krovnih enot, narinjenih proti jugozahodu, ki so nastajale od zgornje jure do zgornjega eocena in še v spodnjem oligocenu. Zunanji Dinaridi zajemajo večji del Jadransko-Dinarske karbonatne platforme, razen njenega jugozahodnega dela, ki je sestavni del Jadransko-Apulijskega predgorja in marginalne bazene na severovzhodu. Notranji Dinaridi zajemajo dele oceanske skorje. Meja med Zunanjimi Dinaridi in Jadransko-Apulijskim predgorjem je strukturna in poteka po zunanjem robu jadranskih otokov in preko severovzhodnega dela Istre, nasproti Notranjim Dinaridom pa nastopa obsežno prehodno območje z obrobnimi globljevodnimi bazeni.

Po modelu dveh mezozojskih karbonatnih platform, Jadranske in Dinarske, sta med drugimi zanimivi interpretaciji Dinaridov predložila HERAK (1986, 1989, 1991, 1999) in TARIJEVA (2002). HERAK zagovarja velike krovne medsekvenčne narive. Ločil je Adriatik, ki obsega Jadransko karbonatno platformo, nanj narinjeni Epiadriatik, ki zajema vmesni bazen, na Epiadriatik narinjeni Dinarik, ki zajema Dinarsko karbonatno platformo in najvišje v krovni zgradbi Supradinarik iz kamnin prehodnega območja. MIOČ (2003) je v tektonski razčlenitvi Slovenije uporabil Herakov model. TARIJEVA ločuje Adrio v smislu Jadranske mikroplošče, ki zajema Jadransko mezozojsko karbonatno platformo in Dinaride, ki zajemajo Dinarsko mezozojsko karbonatno platformo. Dinaridi so narinjeni na Adrio. Adrio sestavljajo sorazmerno šibko tektonizirano jedro, kamor sodi del Jadranske karbonatne platforme (Istra), Jadranski bazen in del Apulijske karbonatne platforme ter naluskano obrobje, kamor spadajo jadranski otoki in Ravni Kotari. Dinaridi zajemajo celotno Dinarsko karbonatno platformo z marginalnimi bazeni (Zahodni narivni pas) in nanje narinjeno oceansko skorjo (Vzhodni narivni pas). Narinjeni Dinaridi prekrivajo sedimente Budvanskega bazena. V Sloveniji je v naluskani rob Adrie TARIJEVA uvrstila naluskani pas Čičarije, samo Čičarijo in Kraško planoto pa v Dinaride. VRABEC in FODOR (2006) sta v naluskani pas Adrie uvrstila tudi pas med Čičarijo in Snežniškim narivom. HERAK in TARIJEVA predvidevata v Sloveniji veliko krovno strukruro, Herak med Epiadriatikom in Dinarikom, Tarijeva pa med naluskanim robom Adrie in Dinaridi.

DROBNETOVA in OGORELEC (2006, 2008) omenjata na severovzhodnem obrobju Vipavske in Brkinske flišne sinklinale elemente globljevodnega razvoja in paleocensko scaglio, iz česar v smislu Herakovega modela sklepata na obstoj Adriatika v Istri, Čičariji in na Krasu ter na obstoj Epiadriatika na severovzhodnem obrobju Vipavske in Brkinske flišne sinklinale. Epidinarik naj bi bil prekrit z narinjenim Dinarikom (sensu HERAK, 1999). S tem v zvezi uporabita model strukturne karte Italije (BIGI et al., 1990-1992), kjer so Snežniški narivni prelom ter Hrušiški in Trnovski krovni prelom združeni v enotno krovno narivno ploskev. Pri tem se ne dotakneta vprašanja obsega prvotnega bazena med Jadransko in Dinarsko karbonatno platformo, ki je bistveni element Herakovega modela.

Na podlagi podatkov strukturnega kartiranja jugozahodne Slovenije (PLACER, 2002, 2005, 2007; PLACER et al., 2004), raziskav v Furlaniji (PERUZZA et al., 2002; CARULLI, 2006), izrazite izvensekvenčne lege Snežniškega narivnega preloma ter Hrušiškega in Trnovskega krovnega preloma, dovolj natančne analize premika Trnovskega pokrova (PLACER, 1973, 1981) in rezultatov vrtanja znotraj Trnovskega pokrova (PLACER et al., 2000) je mogoče sklepati, da je v severozahodnem delu Dinaridov obstajala poglobitev med Jadranskim in Dinarskim segmentom Jadransko-Dinarske mezozojske karbonatne platforme le od paleocena naprej. Zaradi tega je upravičeno govoriti o enotni Jadransko-Dinarski karbonatni platformi s plitvejšimi intraplatformskimi jarki v smislu VLAHOVIĆA in sodelavcev (2005). Tak zaključek je smiseln tudi zato, ker nastopa paleocenska scaglia tudi na Sabotinu in Banjščicah v Trnovskem pokrovu, na Kaliču v Hrušiškem pokrovu in na Kočevskem, kar vse je mogoče interpretirati kot plitvejše poglobitve. Območje izdankov scaglie na Banjščicah je nasproti starejšim bazenskim sedimentom Trnovskega gozda ločeno s Predjamskim prelomom, ki prekriva močnejši narivni prelom znotraj Trnovskega pokrova. Tako razlagajo zgradbo tega ozemlja BIGI et al. (1989–2000) in PREMRU (2005), potrjuje pa jo tudi nova karta Furlanije Julijske krajine (CARULLI, 2006). Taka struktura potrjuje izvensekvenčni potek narivnih ploskev tega dela Dinaridov in s tem upravičenost enotnega obravnavanja Jadransko-Dinarske karbonatne platforme. Razmere v osrednjem in jugovzhodnem delu Dinaridov so drugačne.

Po sicer delno objavljenih fragmentih o zgradbi mejnega pasu med Jadransko-Apulijskim predgorjem in območjem v njegoven zaledju – Kraški rob (PLACER, 2002, 2005, 2007; PLACER et al., 2004) izhaja, da so Trnovski in Hrušiški pokrov, Snežniška narivna gruda in zasnova Kraškega roba nastali v fazi narivanja Zunanjih Dinaridov konec eocena in v začetku oligocena, medtem ko je podrivanje Jadranske mikroplošče (TARI, 2002) in separatno Istre nastopilo v srednjem miocenu in pozneje. Tedaj se je razvil današnji podrivni pas v Istri, katerega osrednji element je Črnokalski narivni prelom, oziroma Palmanovski narivni prelom. Zato predstavlja formalno mejo Zunanjih Dinaridov meja zunanjega naluskanega pasu.

Na sliki je označena tudi Jadranska mikroplošča. Pomemben problem predstavlja vprašanje poteka njene severovzhodne meje. Ta v srednjem in jugovzhodnem delu Zunanjih Dinaridov ločuje jadranski in dinarski segment Jadransko-Dinarske mezozojske karbonatne platforme v strukturnem in paleogeografskem smislu. V severozahodnem delu Zunanjih Dinaridov v Sloveniji, kjer sta oba segmenta mezozojske karbonatne platforme spojena, pa razmere niso enostavne. V prvi fazi njenega nastajanja v miocenu je bila meja identična s čelom snežniškega narivnega preloma ter čelom Hrušiškega in Trnovskega krovnega narivnega preloma, v recentnem obdobju pa poteka od čela Snežniškega narivnega preloma proti Idrijskemu prelomu v zgornjem Posočju in po Južnoalpski narivni meji zahodno od Idrijskega preloma. Podobno so o tej meji v recentnem obdobju domnevali že CARULLI et al. (1990).

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