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Contribution to the macrotectonic subdivision of the border region between Southern Alps and External Dinarides

Prispevek k makrotektonski rajonizaciji mejnega ozemlja med Južnimi Alpami in Zunanjimi Dinaridi

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Ključne besede: tektonika, Vzhodne Alpe, Južne Alpe, Zunanji Dinaridi, Slovenija

Abstract

In the paper the bases for macrotectonic dismembering of the border region between the Southern Alps and the External Dinarides are given. The gravity point lies on problems of establishing the course of the Southalpine thrust border, or the **Southalpine front** west and east of the Ljubljana basin, and the relationship of the nappe units of the External Dinarides to this border.

North of the Periadriatic lineament lie the **Eastern Alps**. South of the Periadriatic lineament extend the **Dinarides** that are subdivided into **Southern Alps** and **External** and **Internal Dinarides.** The Southern Alps lie between the Periadriatic lineament and the Southalpine front. A special position in the Southern Alps has the Periadriatic tectonic zone between the Periadriatic lineament and the Sava fault. The Southern Alps are thrusted on the **External Dinarides** and the **Adriatic** or **Apulian foreland.** Both units are declined with respect to the Southern Alps for 30-45° **External Dinaric front** is forming the border between the Adriatic or Apulian foreland and External Dinarides, and between the External and Internal Dinarides exists a transitional area that is characterized as the domain of migration of the southwestern border of the pelagic development of the Internal Dinarides during the Mesozoic. The **Pannonian basin** consists of terrains that were formed from parts of the megastructural units of Alps and Dinarides. The Southalpine front passes east of the Ljubljana basin into the Mid-Transdanubian zone.

Kratka vsebina

V članku so podane osnove makrotektonske rajonizacije ozemlja na meji med Južnimi Alpami in Zunanjimi Dinaridi. Težišče članka je razprava o problemih določitve trase Južnoalpske narivne meje ali **Južnoalpske meje** zahodno in vzhodno od Ljubljanske kotline in odnos krovnih enot Zunanjih Dinaridov do te meje.

Severno od Periadriatskega lineamenta so **Vzhodne Alpe.** Južno od Periadriatskega lineamenta so Dinaridi, ki jih delimo na **Južne Alpe** ter **Zunanje** in **Notranje Dinaride. Južne Alpe** ležijo med Periadriatskim lineamentom in Južnoalpsko mejo. Posebno mesto v Južnih Alpah ima Periadriatska tektonska cona med Periadriatskim lineamentom in Savskim prelomom. Južne Alpe so narinjene na Zunanje Dinaride in **Jadransko** ali **Apulijsko predgorje.** Obe enoti sta nasproti Južnim Alpam zamaknjeni za 30o-45o. Mejo med Jadranskim ali Apulijskim predgorjem in Zunanjimi Dinaridi tvori **Zunanjedinarska meja**, med Zunanjimi in Notranjimi Dinaridi pa obstaja prehodno območje, ki označuje predel migracije jugozahodne meje pelagičnega razvoja Notranjih Dinaridov tekom mezozoika. **Panonski bazen** je sestavljen iz terranov, ki so nastali iz delov megastrukturnih enot Alp in Dinaridov. Južnoalpska meja se vzhodno od Ljubljanske kotline nadaljuje v Srednjetransdanubijsko cono.

Introduction

The formal geotectonic subdivision of the territory on the contact of Eastern Alps and Dinarides into the Eastern Alps, Southern Alps, External and Internal Dinarides, Adriatic or Apulian foreland and the Pannonian basin (fig. 1) was built up gradually by generations of geologists starting with the famous Kossmat's (1913) treatise on the folded hinterland of the Adriatic Sea. The boundary between the Eastern and the Southern Alps is not questionable since it passes along the Periadriatic lineament and the Ljutomer fault as the probable extension of the Balaton lineament. Both terms signify the same disjunctive unit that is cut by the Labot (Lavanttal) fault. Also the Pannonian subsidence does not represent an unsolvable problem although its limits cannot be clearly defined. Out of the embarassment helps the distribution of the Tertiary sedimentary beds; therefore the term Pannonian basin is applied. Serious troubles arise, however, when we try to delimit the Southern Alps from the External and Internal Dinarides, and to separate the latter two units. The proposal for tectonic subdivision shown in fig. 1 was made by using the data of the Basic geologic map of Yugoslavia 1:100,000, Buser's Geologic map of Slovenia 1:250,000, in print, Geologic map of Slovenia 1:500,000 (Buser & Draksler, 1993), and the results of recent investigations, as listed in the contents.

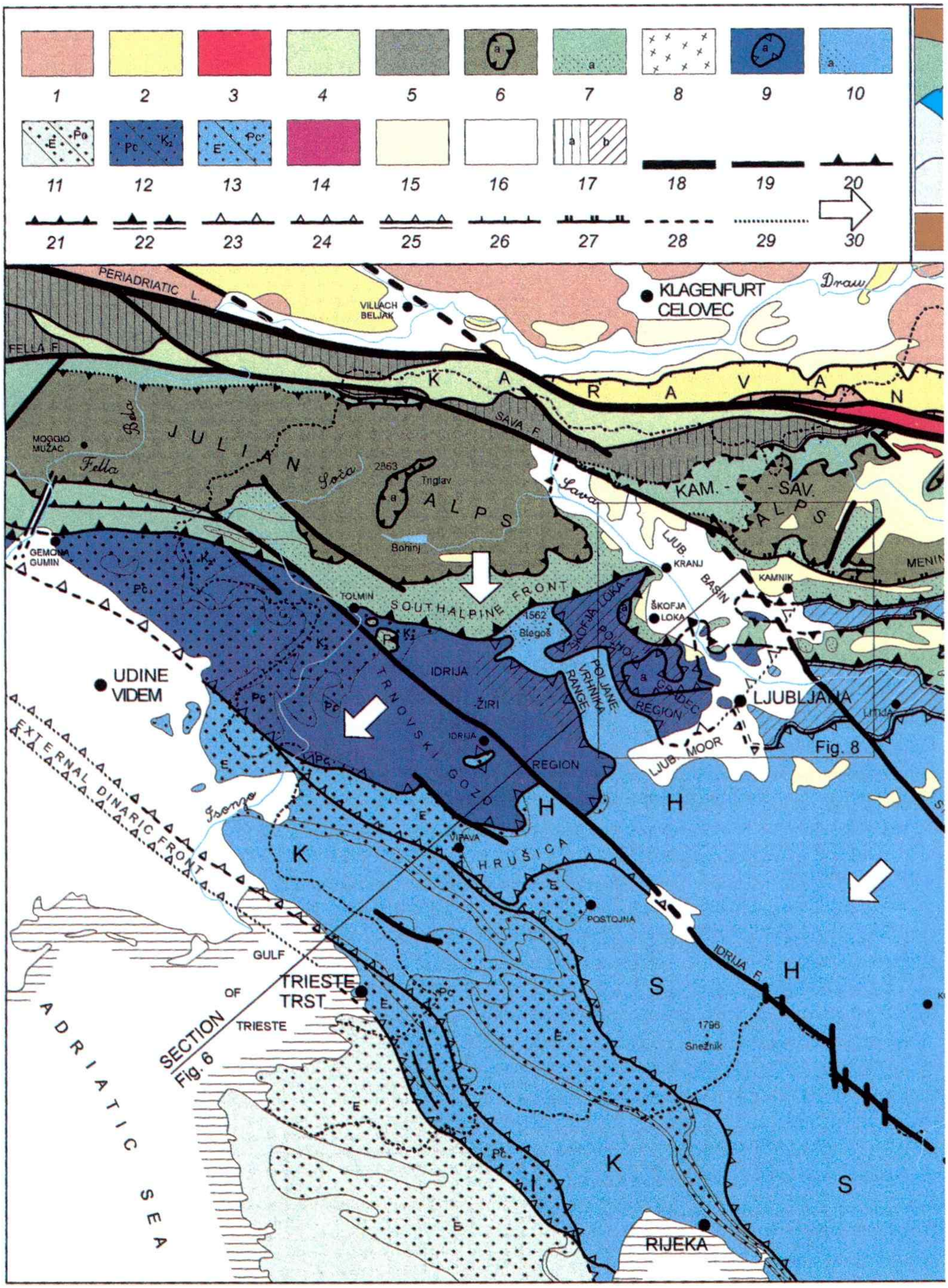
The methodology for the proposed tectonic dismembering is based on the nappe structure of the Southern Alps and External Dinarides, on tectonic elements of various hierarchic levels, and on sedimentologic criteria. The nappe structure of the Southern Alps and External Dinarides is derived from the detachment plane between competent Mesozoic, mostly carbonate rocks, and incompetent Paleozoic clastic rocks. The latter act as a soft bed to the nappe units. The detachment plane was recognized in the Sava folds and in the Upper Savinja valley in the area of Podolševa. A first order tectonic element is considered the Periadriatic lineament that separates the Eastern Alps from the Dinarides and the faults bounding the Tisa unit east of the Zagreb from the Dinarides. A second order tectonic element is the Southalpine thrust border between the Southern Alps and the External Dinarides. This line was formed within the originally unique sedimentation domain. The third order tectonic elements are considered the Sava and Idrija fault and the borders of extended nappe units within the Southern Alps and External Dinarides. The Dinaric directed faults NW-SE, faults of the middlehungarian direction WSW-ENE and the external dinaric border between the External Dinarides and the Adriatic, or Apulian foreland are termed the fourth order tectonic elements. The boundary between the External and the Internal Dinarides is depositional, and such is also the border of the Pannonian basin.

Boundary between the Southern Alps and the External Dinarides

In the present work especially the boundary between the Southern Alps and the External Dinarides will be discussed.

Only with the mapping for the Basic geologic map of Yugoslavia 1:100,000 an undisputed opinion on the attribution of the Blegoš Mountain as part of the Poljane-Vrhnika range to the External Dinarides (Grad & Ferjančič, 1974, 1976; Premru, 1980) could be established. This concept was confirmed also by kinematic analysis of genesis of the Blegoš structure (Placer & Čar, 1997) from which it follows that Blegoš was formed first by overthrusts of dinaric orientation NE-SW, and then by extensive overthrusting of the Southern Alps from north to south. Consequently, in the Blegoš area the structural boundary between the Southern Alps and the External Dinarides can be quite unequivocally defined, since it follows a thrust plane. This boundary is, next to the Periadriatic lineament, the most important dislocation of the considered region. Its course west of Blegoš is relatively clearly defined: in the north of it extend the deeper marine deposits of the Slovenian basin, and on the southern side the carbonate beds of the Trnovo nappe. The lithologic difference of the two units is distinctly visible in the area of Blegoš westwards to Tolmin. West of there the boundary can be followed according to structural criteria, as here are come in contact similar rocks of the two mentioned units. This boundary was defined by Kossmat (1913) already as the line Kobarid-Stol-Cerkno, and more in detail by Buser (1986, 1987) on the sheet Tolmin and Udine (Videm). A special meaning for proving the overthrust character of this boundary have the Ponikve and Senica tectonic klippes at Tolmin. The further westward continuation of the considered thrust plane is resumed from Slejko et al. (1986) who has drawn it to the recent tectonic graben in the Tagliamento valley between Gemona (Gumin) and Moggio Udinese (Mužac), and farther southwestwards. For this boundary they proposed the term Southalpine front. Carulli et al. (1990) proposed the term Periadriatic overthrust. In this paper the older variant is used since it is more distinct.

Eastwards the Southalpine front can be followed to Kranj from where it turns sharply towards south-southwest to east of Škofja Loka, and then eastwards to Medvode along the western rim of the Ljubljana basin. Here start difficulties that need some more extended explanations. To understand the problem properly, the Trnovo nappe which is a part of the External Dinarides, and its relationship to Southern Alps and to the Sava folds should be considered first. The Sava folds extend, according to the new definition (Placer, 1998, this journal), east of the Ljubljana basin only, while west of it they do not exist in the structural sense. The Trnovo nappe comprises the Trnovski gozd with Banjšice, Idrija-Žiri region and Škofja Loka-Polhov Gradec region. It is overthrusted from NE to SW on the Hrušica nappe, whereas from north southwards the Southern Alps are overthrusted on it along the just discussed Southalpine front. It follows from the internal structure of the Trnovo nappe (Mlakar, 1969; Placer, 1973, 1981) that its thrust plane forms an oblique section in the manner that the youngest rocks are developed in the ovethrusting direction in the thrust front above the Vipava valley, where Cretaceous and Paleocene beds occur, and the oldest Carboniferous-Permian clastics in the root of the nappe in the Škofja Loka-Polhov Gradec region. In the latter instance, they are overthrusted on the Triassic rocks of the Poljane-Vrhnika ranges that are in the larger sense a part of the Mesozoic beds of southern Slovenia, and in the narrower sense a part of the Hrušica nappe. In contrast to that lie the Carboniferous-Permian rocks of the Litija anticline


1 2 3 4 5 6 7 8 9 10
11 12 13 14 15 16 17 18 19 20
21 22 23 24 25 26 27 28 29 30
PERIADRIATIC L.
FELLA F.
VILLACH BELJAK
KLAGENFURT CELOVEC
Drau
K A R A V A N
SAVA F.
MOGGIO MUŽAC
Bela
Fella
J U L I A N A L P S
Soča
2863 Triglav
Bohinj
Sava
KAM. - - SAV. A L P S
MENIN
GEMONA GUMIN
LJUB. BASIN
KRANJ
KAMNIK
TOLMIN
SOUTHALPINE FRONT
1562 Blegoš
ŠKOFJA LOKA
ŠKOFJA LOKA POHOLJE
POLJANE-VRHNIKA RANGE
GRADEC REGION
UDINE VIDEM
IDRIJA
ŽIRI
TRNOVSKI GOZD
IDRIJA
REGION
LJUBLJANA
LITIJA
LJUB. MOOR
Fig. 8
EXTERNAL DINARIC FRONT
Isonzo
H
H
K
VIPAVA
HRUŠICA
POSTOJNA
GULF OF TRIESTE
TRIESTE TRST
SECTION Fig. 6
IDRIJA F.
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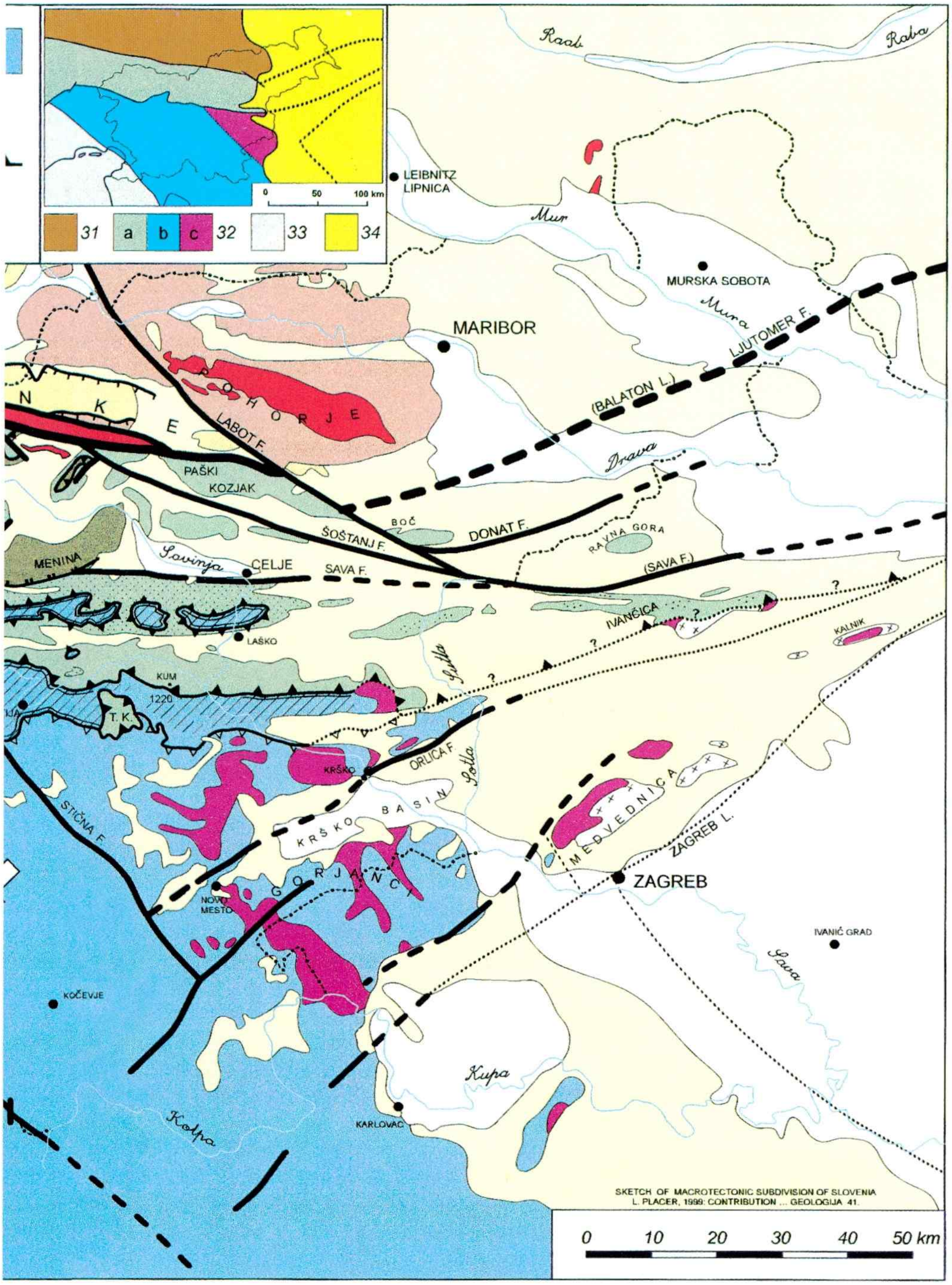
ADRIATIC SEA
K
S
RIJEKA


31
a
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32
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34
0 50 100 km
LEIBNITZ
LIPNICA
Raab
Raba
Mur
MURSKA SOBOTA
Mura
MARIBOR
LJUTOMER F.
(BALATON L.)
POHORJE
LABOT F.
Drava
PAŠKI
KOZJAK
BOČ
ŠOŠTANJ F.
DONAT F.
RAVNA GORA
MENINA
Savinja
CELJE
SAVA F.
(SAVA F.)
IVANČICA
LAŠKO
KALNIK
KUM
1220
T. K.
Sotla
ORLICA F.
KRŠKO
KRŠKO BASIN
STIČNA F.
MEDVEDNICA
ZAGREB L.
GORJANCI
NOVO MESTO
ZAGREB
IVANIĆ GRAD
Sava
KOČEVJE
Kupa
Kolpa
KARLOVAC
SKETCH OF MACROTECTONIC SUBDIVISION OF SLOVENIA
L. PLACER, 1999: CONTRIBUTION ... GEOLOGIJA 41.
0 10 20 30 40 50 km

Fig. 1. Sketch of macrotectonic subdivision the bordering region between Southern Alps and External Dinarides

1 Region of the metamorphic rocks; 2 Northern Karavanke Mountains (Drava range); 3 Regions of the periadriatic igneous rocks; 4 Košuta unit; 5 Javornik unit; 6 Julian nappe, a - Zlatna structure; 7 „Tolmin nappe", a - Supposed Slovenian basin, P - Ponikve tectonic klippe, T.K. - Preveški hrib tectonic klippe; 8 In tectonical sense undefined region; 9 Trnovo nappe, a - Škofja Loka-Polhov Gradec horses; 10 H - Hrušica nappe, S -Snežnik thrust sheet, K - Komen thrust sheet, I - Kras imbricate structure, a - Pseudozilja beds in the Blegoš region; 11 Autochthon - Istria (Adriatic or Apulian foreland), P_c - Paleocene, E - Eocene; 12 Deeper water sedimentary rocks of Dinaric platform in the Trnovo nappe, K_2 - Upper Cretaceous, P_c - Paleocene; 13 Paleogene of External Dinarides, Pc - Paleocene, E - Eocene; 14 Upper Triassic, Jurassic and Cretaceous pelagic sediments of the transitional region between External and Internal Dinarides; 15 Tertiary and Plioquaternary of the Pannonian basin and marginal depressions; 16 Quaternary; 17 Paleozoic, soft bed of the nappe structure of the Dinarides, isostatic and supplantic uplifted region, a - In Southern Alps, b - In External Dinarides; 18 Periadriatic and Balaton lineaments; 19 Important fault; 20 Southalpine front; 21 Overthrust boundary in the Southern Alps region; 22 Detachment plane of the Southalpine overthrust structure; 23 Trnovo nappe boundary; 24 Nappe and overthrust boundary in the External Dinarides region; 25 Detachment plane of the External Dinarides overthrust and nappe structure; 26 Overthrust boundary in the North Karavanke Mountains unit; 27 Thrust boundary of local importance in the Sava compressive wedge; 28 Inaccurately defined or covered fault and thrust line; 29 Hypothetic fault and thrust line or fault and thrust zone; 30 Direction of overthrusting; 31 Eastern Alps; 32 Dinarides, a -Southern Alps, b -External Dinarides, c - Transitional region between External and Internal Dinarides; 33 Adriatic or Apulian foreland; 34 Pannonian basin

Sl. 1. Skica makrotektonske rajonizacije mejnega ozemlja med Južnimi Alpami in Zunanjimi Dinaridi

1 Območje metamorfnih kamnin; 2 Severne Karavanke (Dravski niz); 3 Območja periadriatskih magmatskih kamnin; 4 Košutina enota; 5 Javorniška enota; 6 Julijski pokrov, a - Zlatenska plošča; 7 „Tolminski pokrov", a - Slovenski bazen, P. - Ponikvanska tektonska krpa, T.K. - Preveška tektonska krpa; 8 V narivnem smislu neopredeljeno območje; 9 Trnovski pokrov, a - Škofjeloško-Polhograjske luske; 10 H - Hrušiški pokrov, S - Snežniška narivna gruda, K - Komenska narivna gruda, I - Kraški naluskani prag, a - Psevdoziljske plasti na območju Blegoša; 11 Avtohton - Istra (Jadransko ali Apulijsko predgorje), P_c - paleocen, E - eocen; 12 Globljevodne kamnine Dinarske platforme v Trnovskem pokrovu, K_2 -zgornja kreda, Pc - paleocen; 13 Paleogen Zunanjih Dinaridov, P_c - paleocen, E - eocen; 14 Zgornjetriasni, jurski in kredni pelagični sedimenti prehodnega območja med Zunanjimi in Notranjimi Dinaridi; 15 Terciar in pliokvartar Panonskega bazena in obrobnih depresij; 16 Kvartar; 17 Paleozoik, mehka posteljica krovne zgradbe Dinaridov, izostatično in izrivno dvignjeno območje, a - V Južnih Alpah, b - V Zunanjih Dinaridih; 18 Periadriatski in Balatonski lineament; 19 Pomemben prelom; 20 Južnoalpska meja; 21 Meja pokrova v Južnih Alpah; 22 Ločilna ploskev Južnih Alp; 23 Meja Trnovskega pokrova; 24 Meja pokrova in narivne grude v Zunanjih Dinaridih; 25 Ločilna ploskev Zunanjih Dinaridov; 26 Narivna meja v Severnih Karavankah; 27 Nariv krajevnega pomena znotraj Savskega kompresijskega klina; 28 Nenatančno določena ali prekrita prelomnica in narivnica; 29 Hipotetična prelomnica in narivnica ali prelomna in narivna cona; 30 Smer krovnega narivanja; 31 Vzhodne Alpe; 32 Dinaridi, a - Južne Alpe, b -Zunanji Dinaridi, c - Prehodno območje med Zunanjimi in Notranji Dinaridi; 33 Jadransko ali Apulijsko predgorje; 34 Panonski bazen

south and east of the Ljubljana basin consistently below the Mesozoic rocks of southern Slovenia, and so without a single direct of indirect indication for a different position. This anomaly was noticed by K o s m a t (1913) already, and he solved it by limiting the overthrust of the Škofja Loka-Polhov Gradec region, which he did not compare to the Trnovski gozd nappe, to the domain of Poljane-Vrhnika ranges, Ljubljana Moor and Golovec south of Ljubljana. This concept was adopted from him by W i n k l e r (1923) and R a k o v e c (1956). A new solution was proposed by M i o č (1976, 1981) with his idea of the Sava nappe that should comprise the Idrija-Žiri and Škofja Loka-Polhov Gradec regions and Carboniferous-Permian and Mesozoic beds of the Sava folds, and that should have been thrusted southwards on the Mesozoic beds of southern Slovenia. That the Carboniferous-Permian beds of the Litija anticline were overthrusted southwards was believed also by P r e m r u (1980, 1983a, 1983b) and M l a k a r (1987) as well as by the authors of the Structural model of Italy (B i g i et al., 1990). In contrast did B u s e r (1978, 1979), similarly to Kossmat, Winkler ad Rakovec, consider that the Carboniferous-Permian beds of the Litija anticline underlie the Mesozoic beds of southern Slovenia. With our pilot investigations we came to the same conclusion as Buser.

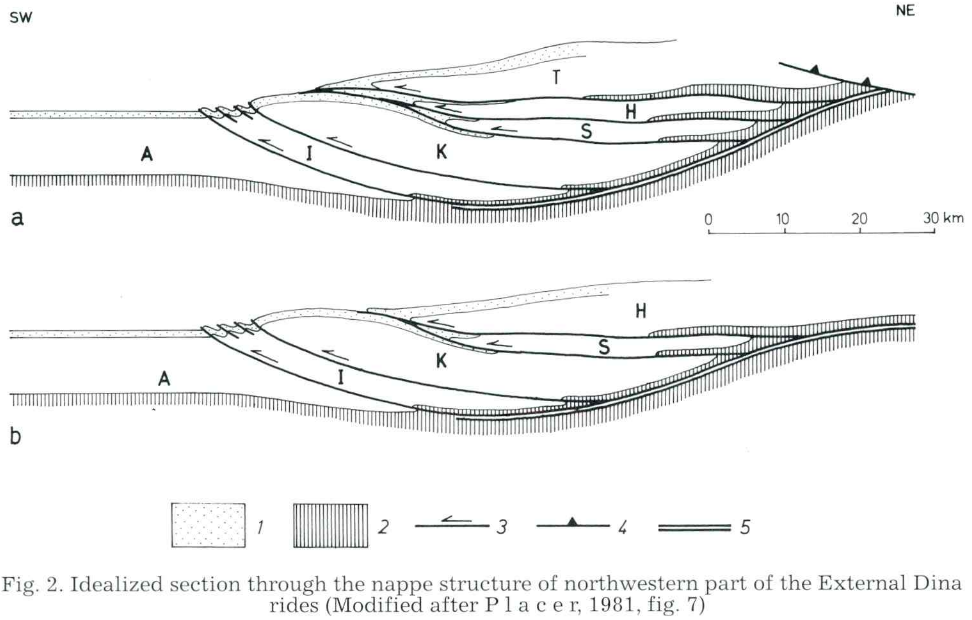

Fig. 2. Idealized section through the nappe structure of northwestern part of the External Dina rides (Modified after P l a c e r, 1981, fig. 7)

1 Eocene flysch; 2 Carborniferous-Permian beds; 3 Thrust plane in External Dinarides; 4 Southalpine front; 5 Detachment plane; **A** Autochthon - Istria (Adriatic or Apulian foreland); **I** Kras imbricate structure, Thrust front of the External Dinarides; **K** Komen thrust sheet; **S** Snežnik thrust sheet; **H** Hrušica nappe; **T** Trnovo nappe

Sl. 2. Idealiziran profil krovne zgradbe severozahodnega dela Zunanjih Dinaridov (Prirejeno po P l a c e r j u, 1981, sl. 7)

1 Eocenski fliš; 2 Karbonskopermske plasti; 3 Narivna ploskev v Zunanjih Dinaridih; 4 Južnoalpska meja; 5 Ločilna ploskev; **A** Avtohton - Istra (Jadransko ali Apulijsko predgorje); **I** Kraški naluskani prag, Narivno čelo Zunanjih Dinaridov; **K** Komenska narivna gruda; **S** Snežniška narivna gruda; **H** Hrušiški pokrov; **T** Trnovski pokrov

It follows from the position of the Carbonoferous-Permian beds west and east of the Ljubljana basin that these beds in central Slovenia take part of two distinct tectonic units. Those in the west belong to the Trnovo nappe, and those in the east lie below the Mesozoic beds of south Slovenia, i.e. below the Hrušica nappe and the thrusted units east of it. In order to understand the problem of structure of central Slovenia in the sense of this concept, we should take a closer look at the nappe structure of southwest Slovenia (P l a c e r, 1981, fig. 7a) that is shown in a simplified version in fig. 2 and 3.

It follows from the relationship between the Trnovo and Hrušica nappes, fig. 2a, that the Carboniferous-Permian beds of the Trnovo nappe in the northeast part of the cross-section overlie analogous beds of the Hrušica nappe. Since the cross-section has been constructed from data on the position, internal sructure, thickness and length of nappe units and overthrust distance, the conclusion can be reached, as in

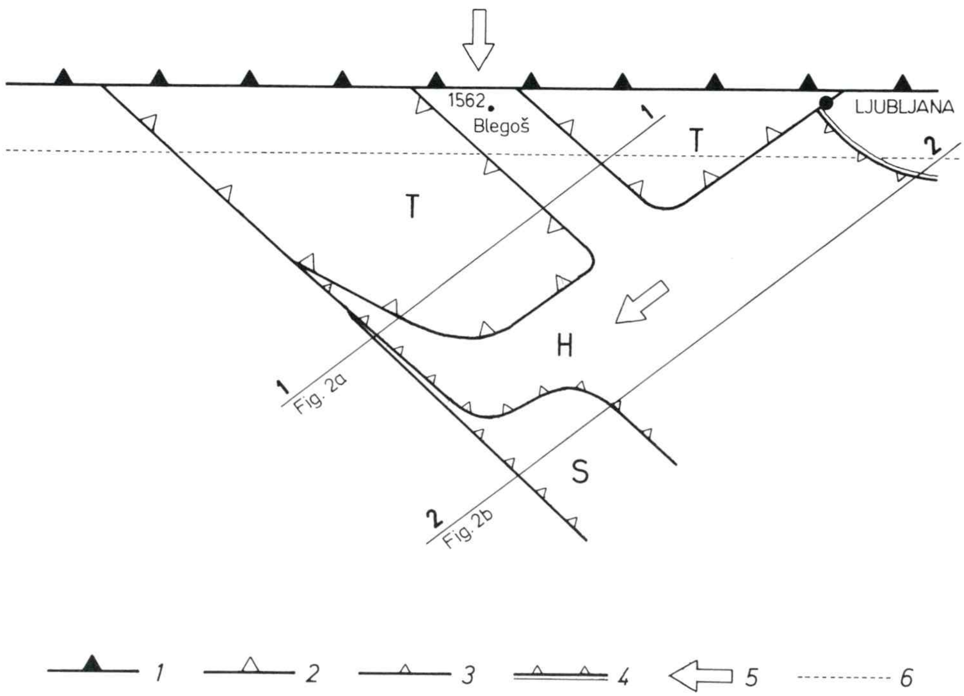

Fig. 3. Relationship between the Trnovo nappe and the Southalpine front

1 Southalpine front; 2 Trnovo nappe boundary; 3 Hrušica nappe and Snežnik thrust sheet boundary; 4 Detachment plane in External Dinarides; 5 Direction of overthrusting; 6 Border of accompanying deformations at the Southalpine front; **T** Trnovo nappe; **H** Hrušica nappe; **S** Snežnik thrust sheet.

Sl. 3. Razmerje med Trnovskim pokrovom in Južnoalpsko mejo

1 Južnoalpska meja; 2 Meja Trnovskega pokrova; 3 Meja Hrušiškega pokrova in Snežniške narivne grude; 4 Ločilna ploskev v Zunanjih Dinaridih; 5 Smer krovnega narivanja; 6 Meja spremljajočih deformacij ob Južnoalpski meji; **T** Trnovski pokrov; **H** Hrušiški pokrov; **S** Snežniška narivna gruda.

the former alinea, that the Carboniferous-Permian beds of the Škofja Loka-Polhov Gradec region overlie the Mesozoic rocks of south Slovenia as well as the Carboniferous-Permian beds of the Litija anticline east of the Ljubljana basin. These lie consistently below the carbonate sedimentary nappe of southern Slovenia. Since we deduce the nappe structure of the External Dinarides from a unique detachment plane, it is possible to conclude the very complicated shape of this plane that forms the boundary between the Carboniferous-Permian of the Litija anticline that in places include also the Val Gardena beds, and east of Kum also the Werfenian and Middle Triassic beds, and the Mesozoic beds. Therefore it is entirely understandable that in the Sava folds the younger beds are overthrusted on older ones, as for the detachment plane the parallel, and not the oblique section is characteristic. This peculiarity has been often used as the basis for an argument against the nappe, or overthrust structure of this part of Slovenia. The detachment plane passes also within the Carboniferous-Permian beds. Therefore its position on the border between the Paleozoic and Mesozoic beds in the Sava folds in fig. 1 is largely formal.

The southeastern border of the Trnovo nappe has a transversal-dinaric direction SW-NE. In the treatise on the structure of southwestern Slovenia (Placer, 1981) this was proved by dip of axes of large overthrust folds in the nappe front towards southwest. However, this fact is not a sufficient reason for the anomalous direction of

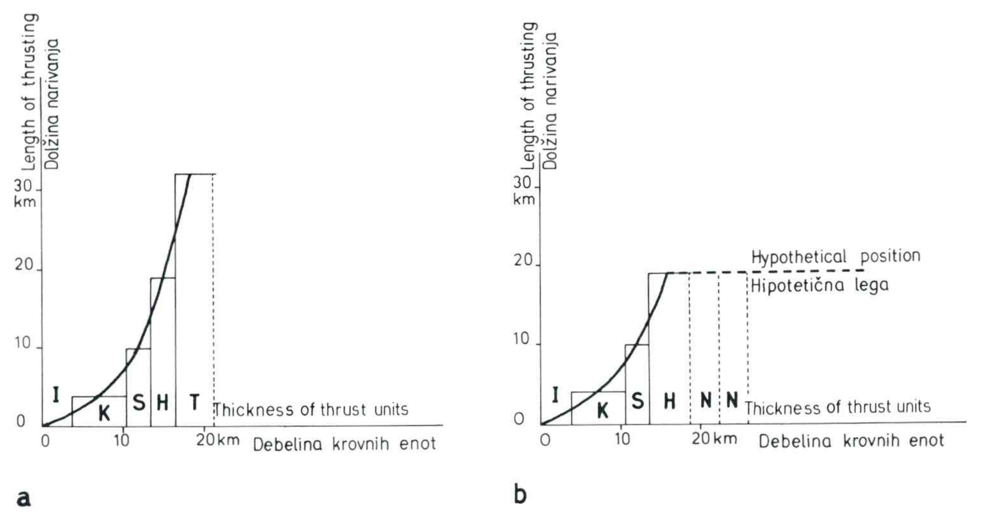

Fig. 4. Two histograms of different types of thrust range in External Dinarides, **a** - exponential thrust range, section in fig. 2a and section 1-1 in fig. 3, **b** - combined thrust range, section in fig. 2b and section 2-2 in the fig. 3

I Karst imbricate threshold; **K** Komen thrust sheet; **S** Snežnik thrust sheet; **H** Hrušica nappe; **T** Trnovo nappe; **N** Thrust unit in hinterland of Hrušica nappe

Sl. 4. Dva histograma različnih tipov narivnega niza v Zunanjih Dinaridih, **a** - eksponencialni narivni niz, profil na sl. 2a in profil 1-1 na sl. 3, **b** - kombiniran narivni niz, profil na sl. 2b in profil 2-2 na sl. 3

I Kraški naluskani prag; **K** Komenska narivna gruda; **S** Snežniška narivna gruda; **H** Hrušiški pokrov; **T** Trnovski pokrov; **N** Narivna enota v zaledju Hrušiškega pokrova

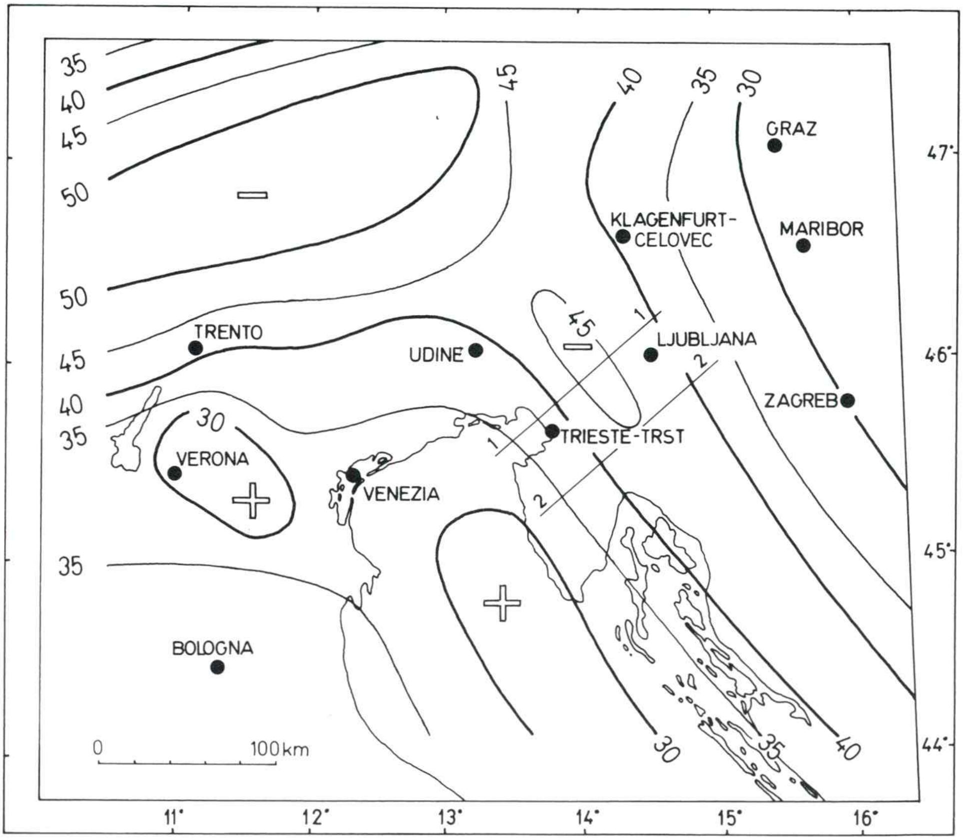

Fig. 5. Map of the Moho isobaths (After C a r u l l i et al., 1990, fig. 3), 1-1 and 2-2 sections in figs. 2 and 3

Sl. 5. Karta Mohorovičićevih izobat (po C a r u l l i j u et al., 1990, sl. 3), 1-1 in 2-2 profila na sl. 2 in 3

the considered border, as in the Poljane-Vrhnika ranges the Trnovo nappe is not inclined towards northwest anymore, but the direction of the border does not change accordingly. It is more likely that the southeast border of the Trnovo nappe represents the lateral border of this large nappe unit the largest part of which is covered by the Southern Alps. The situation is schematically shown in fig. 3 where for easier orientation also the Poljane-Vrhnika ranges and Blegoš are also drawn. The extent of the Trnovo nappe and the extraordinary structure of Blegoš are indications of the importance of the Southalpine front. Along it a large displacement is supposed that could be explained by substantial rotation of the External Dinarides versus the Southern Alps, or by overthrusting without rotation, as believed e.g. by P r e m r u (1980), D o g l i o n i & S i o r p a e s (1990) and P o l i n s k i & E i s b a c h e r (1992).

As the Trnovo nappe is of limited extent, the model in fig. 2 and its kinematic-dynamic derivation with an exponential thrust range (fig. 4a) could be valid only for the cross-section that passes across the Trnovo nappe (cross-section 1-1 in fig. 3), whereas the circumstances in cross-section 2-2 (fig. 3) beyond the Trnovo nappe in

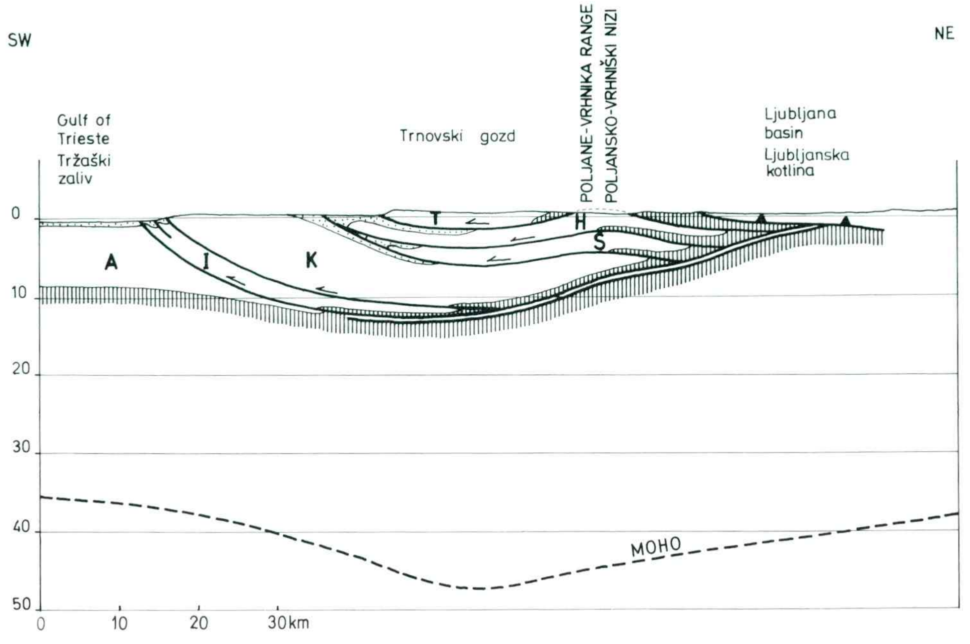

Fig. 6. Crustal cross-section between Gulf of Trieste and Ljubljana basin showing the nappe structure. Legende in fig. 2.

Sl. 6. Profil zemeljske skorje med Tržaškim zalivom in Ljubljansko kotlino z vidika krovne zgradbe. Legenda na sl. 2

fig. 2b and 3 are already different. Although the Trnovo nappe originally extended somewhat farther southeastwards, and was later eroded, we consider its extent in this direction not much different from the present one owing to the absence, throughout south Slovenia, of tectonic klippes that would indicate the contrary. Therefore the structure of the External Dinarides southeast of the Trnovo nappe should be deduced from the cross-section in fig. 2b, namely from the accumulation of nappe units in the southwest, with the Hrušica nappe as the highest member, and in the northeast as the separating thrust imbricated structure as established e.g. from a borehole at Dolenjske Toplice (P r e m r u et al., 1977) where Jurassic beds are thrust over the Cretaceous. We could hypothetically consider a nappe structure derived from the detachment plane with an assumed combined thrust range (P l a c e r, 1982) as shown in fig. 4b.

From cross-section 1-1 in fig. 2 and 3 can further also be hypothesized that the negative anomaly of the Mohorovičić discontinuity at 45 km in fig. 5 (after C a r u l l i et al., 1990, fig. 3) in the relatively narrow space between the Trieste gulf and Ljubljana basin could be the consequence of isostatic subsidence of the territory on which the nappe unit were stacked one above the other. The size of the anomaly in the NW-SE direction corresponds to the position and size of the Trnovo nappe. The map that was published by Carulli et al. was used by us owing to its better resolution with respect to the Structural map of Mohorovičić discontinuity for the territory of Yugoslavia (D r a g a š e v i ć et al., 1989). On the contrast, in the root area of the nappe units the isostatic uplift of the soft bed of incompetent Carboniferous-Permian beds below the Mesozoic strata can be observed. The described relationship between the nappe structure and the Mohorovičić discontinuity is illustrated by cross-section in fig. 6 which is identical with cross-section 1-1, except for the fact that in its construction the real situation from fig. 1 was taken in account but without the Idrija fault, since only the nappe structure is being considered here. The anomaly southeast of the Trnovo nappe is here somewhat smaller (40 km), but it nevertheless clearly expresses the isostatic subsidence of the overthrusted units, and the uplift in the region of the Sava folds. The outcropping of Carboniferous-Permian beds in the Polhov Gradec-Škofja Loka hills and in the area of the Sava folds has consequently a logic explanation. The picture can be supplemented also by the uplift of the Sava folds within the Sava compressive wedge (Placer, 1998, this journal).

From the discussed facts it can be concluded that the Carboniferous-Permian beds of central Slovenia belong in their totality to the External Dinarides. This was believed already by B u s e r (1979).

In looking for the right answer about the course of the Southalpine front east of Medvode, we are faced with a dilemma in spite of the solved question upon the attribution of the Carboniferous-Permian beds to two structural units. This dilemma cannot be adequately solved on the ground of the presently available data. Several questions arise, the first considering the age of overthrusting, and the second one the internal structure of nappe units. The dinaric nappes are connected with the genesis of Eocene flysch beds which would mean that the cycle of this overthrusting terminated most likely at the end of the Eocene times. The southalpine nappes lie on the dinaric nappes, so they could be only younger according to normal logic. In the Sava folds the Mesozoic rocks take part in one or several large overthrust units that were overthrusted before the deposition of the Trbovlje beds (P l a c e r, 1998, this journal; first the Socka beds, and then the Pseudosocka beds - J e l e n et al., 1992) in Middle or Late Oligocene. It would be therefore logical to compare one or several nappe units that comprise the entire Sava folds with the dinaric nappes. However, in the facial sense they are comparable only with rocks of the Slovenian basin and its rim west of Škofja Loka and Kranj.

There is further the question of the age of the Julian nappe, as we named the nappe of the Julian and the Kamnik-Savinja Alps. This nappe was named by G r a d & F e r j a n č i č (1976) the Jelovica nappe, by M i o č (1981) Julian - Savinja nappe, by M i o č (1983) and P r e m r u (1983b) the Savinja overthrust, by J u r k o v š e k (1987b) the nappe of the Julian Alps, by B u s e r (1986) the Krn nappe, and by K r y s t y n et al. (1994) in somewhat modified form the Krn, or the Pokljuka nappe. In the present paper we accepted, regardless of the right of the first author, the name proposed by Mioč, and we modified it to the term Julian nappe. It comprises the Julian and the Kamnik-Savinja Alps. The age of the Julian nappe could be only indirectly ascertained from the relation of the overthrust in the Julian Alps to the Oligocene beds of the Ljubljana basin. These beds are exposed across its entire extent, and, according to data of the Basic geologic map, sheets of Celovec (B u s e r & C a j h e n, 1978) and Kranj (G r a d & F e r j a n č i č, 1974), below the Quaternary alluvial deposits the Ljubljana basin is covered almost completely with them. Therefore we could suppose Oligocene beds overlie also the thrust plane of the Julian nappe, if it sinks below the Oligocene beds of the Ljubljana basin. The situation in the Kamnik-Savinja Alps is at the first look different, however, and the interpretation with nap-

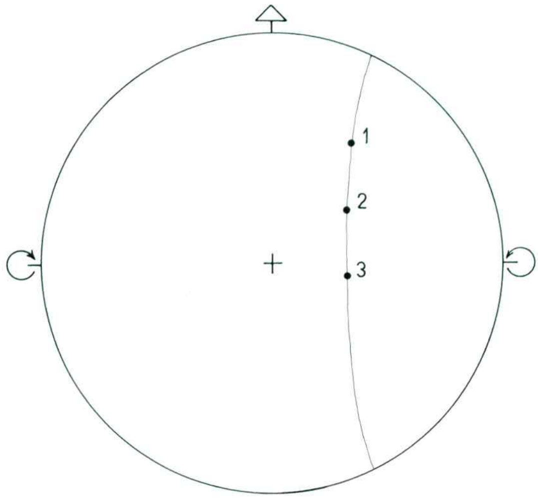

Fig. 7. Position of Upper Triassic beds in western part of the Laško syncline
1 North limb; 2 Hinge; 3 South limb

Sl. 7. Lega zgornjetriasnih plasti v zahodnem delu Laške sinklinale
1 Severno krilo; 2 Sedlo; 3 Južno krilo

pes thrusted on the Oligocene beds in sheet Celovec (B u s e r & C a j h e n, 1978, cross-section C-D) or sheet Ljubljana (P r e m r u, 1983a, cross-section A-B), is not proved. Provable are only small overthrusts of post-Sarmatian, most probably post-Middle Pliocene age that are the result of the compression within the Sava compressive wedge and of the shortening of the area. Based on these data we believe that the Kamnik-Savinja and the Julian Alps could have been overthrusted on the pelagic deposits of the Slovenian basin already before the Middle or Late Oligocene as one, or possibly several nappe units in the Sava folds, and as it is valid also for the central part of the Southern Alps (D o g l i o n i & B o s e l l i n i, 1987). Between the end of Eocene and the Middle to Late Oligocene there could be enough time for formation of the Southalpine nappe structure. On the other side dis B u s e r (1980), P r e m r u (1980) and P o l i n s k i & E i s b a c h e r (1992) attribute the nappes of Juilian and Kamnik-Savinja Alps to Neogene. The question is not simple. It could be solved only by extensive research. The Oligocene beds at Bohinj, on Velika Planina and Kopišče near Kamniška Bistrica river are of special importance for dating of the Julian nappe. It should be noted, however, that separating the genesis of the Julian nappe from the Southalpine front is not logical, and can be only a result of insufficient structural factography on the region of the Julian and the Kamnik-Savinja Alps.

It was already stated with respect to the internal structure of the nappe units and overthrusting directions that west of the Ljubljana basin the separation of the Dinaric and the Southalpine nappe structures can be made on the basis of dinaric (NW-SE) and southalpine (W-E) structural elements. Therefore at the relatively short distance east of the Ljubljana basin equal or at least similar situation could be expected. Yet, the structure there is different. Its dissimilarity is associated with the genesis of the Sava folds within the Sava compressive wedge (P l a c e r, 1998, this journal): the Sava folds were intensely folded with axes in the W-E direction, and in this process the dinaric nappe structures got externally effaced to a large degree. For determining the course of the Southalpine front, the internal structure of the Mesozoic beds in the Sava folds should be analyzed. Since up to the present only the wider area of the Laško syncline was mapped anew, the analysis of of dips of the thick bedded Middle Triassic and Main Dolomite as well as the Dachstein Limestone was done only

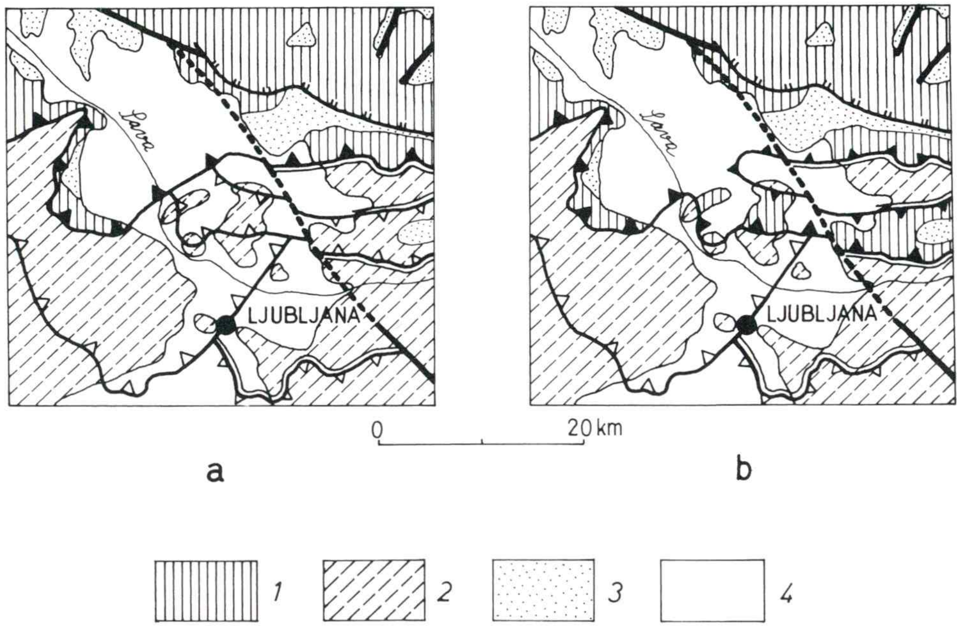

Fig. 8. Course variants of the Southalpine front eastern of the Ljubljana basin
1 Southern Alps; 2 External Dinarides; 3 Tertiary; 4 Ljubljana basin and Ljubljana moor; Explanation of other signs in the legend of fig. 1

Sl. 8. Različici poteka Južnoalpske meje vzhodno od Ljubljanske kotline
1 Južne Alpe; 2 Zunanji Dinaridi; 3 Terciar; 4 Ljubljanska kotlina in Ljubljansko barje; Razlaga ostalih znakov v legendi na sl. 1

in this area. In thick bedded rocks the regional aspects of deformations are preserved relatively independently of the local influences. These rocks occur west of the Kum mountain. In the north limb of the Laško syncline they are found at Reber above Kolovrat northwest of Izlake and in the south limb between Kum and Slemšek above Vače. In the southern limb of the syncline the beds dip generally toward west to west-northwest, and in the northern limb towards southwest to south-southwest. It is possible to determine with a simple rotation around the W-E axis that is parallel to the axis of folding that the poles of the beds of one and the other synclinal limbs lie in the same plane (fig. 7), while the constructed direction of the beds in the apex of the syncline is dinaric (NW-SE). Next to the structural aspect also the facial one is important.

The characteristic condensed cross-section of Val Gardena and Bellerophon beds in the highway cut at Višnja Gora (Skaberne, oral communication) was discovered also in the Borovnik sand pit at Kisovec in the Laško syncline. This could suggest the same depositional region. The position of the Upper Triassic beds and the development of Permian beds could serve as an indication of the appurtenance of Mesozoic rocks in the Sava folds, or at least those south of the Trojane anticline, to the External Dinarides. For confirmation of such conclusion the entire Sava folds must be analyzed. Therefore to this observation no decisive importance could be attributed.

By considering the elements of age of the nappe thrusting and the internal structure of the nappe units the clear answer about the passage of the course of the Southern Alps east of the Ljubljana basin could not be approached. It was established, however, that the nappe structure in the Sava folds is of pre-Middle to pre-Late Oligocene age, that the Julian nappe is of the same, or of post-Sarmatian age, and that the Soutalpine front, along which the rocks of the Slovenian basin was thrusted southwards west of the Ljubljana basin, is a temporal equivalent of the nappe strcuture of the Sava folds; the Oligocene sedimentary beds at Medvode cover the Southalpine front. From the said follow two variants of the passage of the Southalpine front east of the Ljubljana basin. Each of them has its advantages and weaknesses. Both variants are shown in fig. 8.

According to the variant 8a passes the border of the Southern Alps along the northern rim of the Carboniferous-Permian core of the Trojane anticline, and according to variant in fig. 8b along the northern rim of the Carboniferous-Permian core of the Litija anticline whereat also the Preveški hrib tectonic klippe (after the Preveški hrib - hill above Polšnik, 873 m) belongs to the Southern Alps. According to the first variant the Upper Triassic, Jurassic and Cretaceous pelagic deposits of the Slovenian basin would belong to the Southern Alps, while the Triassic beds in the basement and in limbs of the Laško syncline would belong to the highest nappe of the dinaric provenience. This would be indicated also by the position of beds west of Kum. This variant takes into account the strtuctural aspect of the position of beds and similarity in development of condensed Val Gardena and Bellerophon beds at Kisovec and at Višnja Gora, as well as the discordant position of Cretaceous deeper marine beds on Triassic platform carbonate beds which is characteristic of the inner belt of the External Dinarides. It must be borne in mind, however, that the position of beds only in a small part of the Sava folds was analyzed, and that rather a gradual passage from the predominant carbonate facies of Middle to Upper Triassic beds in the south to clastic and pelagic development in the north, and not a radical tectonic discontinuity is indicated by the development of the Mesozoic beds in this area, if the Southalpine front would pass along the northern rim of the Trojane anticline. Therefore we took at the present state of understanding for the working hypothesis the variant 8b which is consistent with K o s s m a t's (1913) and W i n k l e r's (1923) understanding of connection of the considered thrust plane between the western and the eastern borders of the Ljubljana basin, but from different theoretic starting points.

Dilemmas connected with this question are more complex. They concern the formational and structural problems (geometric and kinematic), paleomagnetism, palinspastics, paleogeography and global tectonics. Thereof the need for complex approach to solving these problems in Slovenia is probably the most urgent, and should be directly relied with the universal processing for the mapping of the geologic map 1:50,000. The vagueness is associated not only with the passage of the Southalpine front east of the Ljubljana basin but also with the question of its global meaning.

Owing to insufficient state of investigation at present we cannot decide whether it continues to the Mid-Transdanubian zone, or does it bend towards southeast. On the ground of prevailing global views on the genesis of the Pannonian subsidence (e.g. C s o n t o s et al., 1992; H o r v á t h & T a r i, 1998) in the present treatise the first variant, although it is only hypothetical, was used. We took orientation after the Mesozoic ophiolitic melange of Kalnik and Medvednica that cannot be directly relied to the deeper marine rocks of the Sava and Krško hills and Gorjanci mountain, but we believe they belong in the broader sense to Internal Dinarides.

Here we should call attention to the opinion of P r e m r u (1980), D o g l i o n i & S i o r p a e s (1990) and P o l i n s k i & E i s b a c h e r (1992) on the genesis of declination between the Southern Alps and External Dinarides, and hence follows that in the Southern Alps relics of the dinaric oriented structural elements could be expected. Also therefore the choice of the 8b variant is at present more suitable.

Mentioned should be further the hypothesis by S l e j k o et al. (1986) and C a r u l l i et al. (1990) on the still active character of the Southalpine front west of the Idrija fault. The concept is associated wtih the hereditary effects, and is an indication of the complexity of dating the disjunctive structures in areas in which several tectonic phases occurred.

Discussion

Geotectonic subdivision of the territory of present Slovenia is based upon two megadisjunctive features, the Periadriatic lineament and the Southalpine front as well as on the internally heterogeneous and not very clearly delimited Pannonian subsidence. Therefore it is simpler to talk of the Pannonian basin, although unfortunatelly in the term not only the geometry of the Pannonian subsidence is not reflected, but also of the bordering territories with elements of the hereditary deformations that are not genetically connected with the subsidence.

The aim of the present treatise is not detaiuled genetic subdivision, but moreover a general formal tectonic subdivision of the Slovenian area and determination of the most important tectonic units of regional importance, based upone global principles and on nappe structure resulting from detachment tectonic geometry.

1. The Eastern Alps comprise region of the metamorphic rocks and regions of the Mesozoic carbonate rocks (Drava range and other regions). Drava (Drau) range reaches Slovenian territory as North Karavanke and their eastern relics at Mislinja and Zreče.

2. The Dinarides are delimited from the Eastern Alps by the Periadriatic lineament. They are commonly subdivided into the Southern Alps and the External and Internal Dinarides.

2a. The Southern Alps lie between the Periadriatic lineament and the Southalpine front. Their important structural unit is the Periadriatic tectonic zone (J e l e n et al., 1997; P l a c e r, 1998, this journal) between the Periadriatic lineament and the Sava fault. In the present paper the question of the nappe structure of the Southern Alps is not dealt with in any detail, but several general aspects are discussed that should be the object of attention in the future. In spite of the shift along the Sava fault, let it be 25, 40 or 65 to 70 km (P l a c e r, 1996b), the Julian and the Kamnik-Savinja Alps should be considered as a single tectonic object in which the rocks of the Slovenian basin occupy the central position. They occur, according to K r y s t y n et al. (1994), in the

Tolmin nappe that lies below the Julian nappe. With respect to the extension of the latter it can be stated that it is overthrusted in the south on the rocks of the Slovenian basin (Tolmin area, Baška grapa, Selce valley, Županje Njive near Kamnik, Črna valley near Kamnik), while in the north, on sheet Ravne, it overlies the rocks of Lower to Middle Triassic age, possibly also Upper Triassic (M i o č, 1983; M i o č & Ž n i d a r č i č , 1983). This leads to the idea that the rocks of the northern rim of the Julian nappe form the basement, and in places also the lateral equivalent of the deposits of the Slovenian basin, and that they belong most probably to the Tolmin nappe as well as the rocks of the Slovenian basin. Owing to the hypothetic character of this concept we write the „Tolmin nappe“ of such extent in quotation marks. On sheet Ravne lies the Lower Triassic beds of the „Tolmin nappe“ with tectonic contact on Carboniferous clastics that represent the soft bed of the Southern Alps. This unit comprises next to the Paleozoic beds on the sheets Celovec and Beljak with Pontebba also the Lower and Middle Triassic beds. The thrust plane itself towards the „Tolmin nappe“, however, is most probably hidden within the same formation. The rocks that could be attributed to the Paleozoic basement of the „Tolmin nappe“ occur also south of the Sava fault above Kranjska gora and Rateče (J u r k o v š e k, 1987a). Above them are the Lower and Middle Triassic beds of the „Tolmin nappe“ that exend according to the geologic map of the Structural model of Italy (B i g i et al., 1990) in a narrow belt along the southern side of the Fella (Bela) fault far westward. In the Structural model the boundary of these beds with the Upper Triassic beds is normal. We suppose, however, that here similar situation occurs as on the sheet Beljak with Pontebba (J u r k o v š e k, 1987a, cross-sectioin A-B), and therefore we assume also here the existence of the „Tolmin nappe“, whereas the Paleozoic beds are exposed only in the area of Kranjska gora and Rateče. To the „Tolmin nappe“ belong also the Mesozoic rocks of the Sava folds that were reduced by the decision about the course of the Southalpine front along the northern rim of the Litija anticline to a single nappe unit. This solution must be considered hypothetic, however.

The Paleozoic soft bed rocks of the Southern Karavanke and the Triassic Karawanke belt rocks of the „Tolmin nappe“ betwen Sava fault and Periadriatic lineament did B u s e r (1980), M i o č (1983) and J u r k o v š e k (1987a) attribute to the South Karavanke unit that ought to comprise also the Lower and Middle Triassic beds. Owing to the importance of the Paleozoic basement we propose for it the term Javornik unit after Javorniški Rovt above Jesenice.

With regard to the exposed starting points occur in the Southern Alps the Javornik and the Košuta units, and the „Tolmin“ and the Julian nappe. The Košuta unit is a tectonic lens of Mesozoic rocks between the Periadriatic lineament and several faults within the Periadriatic tectonic zone (B r e n č i č et al., 1995) that played during the development of the latter various dynamic parts. The Javornik unit is the soft bed of the Southern Alps. The „Tolmin nappe“ and the Julian nappe are nappe units overthrusted generally from the north southwards on the External Dinarides. Boskovec, Paški Kozjak, Konjiška gora, Boč and Ravna gora are structurally part of the Julian Alps, and owing to their rock composition we tentatively attribute them to the „Tolmin nappe“. According to rocks the Košuta unit in the Karavanke mountains could be a part od the Julian nappe that was intensely tectonically reworked within the Periadriatic zone. However, this was not taken into account in the dismembering scheme owing to our general starting points.

The Julian and the „Tolmin“ nappes are in the direction W-E dish-like deformed which might be connected with the regional compression. The border between the Javornik unit and the „Tolmin nappe" could be identical with the plane of the Southalpine front. The Southalpine overthrust border is at the same time the southern border of the „Tolmin nappe".

2b. The External Dinarides are declined with regard to the Southern Alps for 30 to 45° and underthrusted below them. They consist of three belts: a - the external para-autochthonous belt with preserved Tertiary sedimentary rocks in cores of synform structures (the Kras imbricate structure, the Komen thrust sheet), b - the central allochthonous part in which the Tertiary sedimentary beds are only exceptionally preserved (Snežnik, Hrušica, Trnovo nappes and the not yet subdivided thrust structure northeast of the Hrušica nappe), and c - of the internal allochthonous belt representing the transition region between the External and the Internal Dinarides, or the so called slope zone (P l e n i č a r & P r e m r u, 1975) that by some authors is considered as the Internal Dinarides. Is characterized by the migration of pelagial through the Upper Triassic, Jurassic and Cretaceous. A special position in the External Dinarides is occupied by the Trnovo nappe which is only the extreme southeast visible part of a larger nappe that is underthrusted below the Southern Alps. Exceptional are its position and structure, since at its northwestern rim the degradation of the Dinaric carbonate platform was started in the Upper Cretaceous already. Since the degradation appeared in the Trnovo nappe first, we believe this observation to be one of the more important data for the study of palinspastics of the Dinarides. In fig. 1 are drawn next to the Trnovo nappe also the thrust borders of the Hrušica nappe, Snežnik and Komen thrust sheets and the Kras imbricated structure, as the Čičarija imbricated structure was more adequately named by us (P l a c e r, 1981). The latter occupies the part of thrust front for the External Dinarides. The boundaries of the overthrust units of the northeastern part of the External Dinarides are not drawn since their courses have not been analytically studied yet.

The Carboniferous-Permian beds in the Sava folds are a part of the External Dinarides.

2c. The transition region between the External and the Internal Dinarides. On the territory of Slovenia, in the megatectonic sense the Internal Dinarides are absent. There remains only the transition region between the External and the Internal Dinarides where the Jurassic and Cretaceous pelagial sediments were deposited discordantly on Triassic and older rocks of the External Dinarides, or where the Upper Triassic shelf gradually passes into the pelagial (O g o r e l e c & D o z e t, 1997) wherefore some authors consider this transitional region as Internal Dinarides. In the region of the Sava folds the transition region between the External and the Internal Dinarides is underthrusted below similar rocks of the Slovenian basin or of the Southern Alps. The question on the appurtenance of the basement of deep sea deposits of Medvednica and Kalnik remains open. It most probably belongs to a distinct structural unit within the Mid-Hungarian tectonic zone, and therefore it was not tectonically considered here. Similar difficulties are connected also with the southern slope of Ivančica, if the hypothetic Southalpine front in this area is correctly placed.

3. The Adriatic or Apulian foreland is an autochthone of the dinaric thrust and nappe structure. It is underthrusted together with the External Dinarides below the Southern Alps.

4. The Pannonian basin is a heterogenous tectonic unit. Its basement consists of the eastern, or better the east-northeastern extensions of the eastern alpine and dinaric geotectonic units that occur subsided under the Tertiary sedimentary beds of Paratethys. After H a a s et al. (1995) these units form extensive central alpine terranes that consist prevailingly of continental crust: the Easternalpine of metamorphic rocks, Transdanubian of rocks of the Drava range or the Northern Karawanke mountains, Mid-Transdanubian of rocks of Southern Alps, and the Tisza terrane consisting of the rocks with European faunistic elements. It follows from the interpretation of the Transdanubian and Mid-Transdanubian terranes that the boundary between them is formed by the Balaton lineament which is a continuation of the Periadriatic lineament east of the Labot (Lavanttal) fault. In the territory of Slovenia the Balaton lineament is marked as the Ljutomer fault. The boundary between the Transdanubian and the Eastern Alpine terrane is represented by the Raba fault (H a a s et al., 1995; H o r v á t h & T a r i, 1998) that should have been also the source structure of the North Karavanke overthrust. On the map in fig. 1 the Raba fault is not drawn because of the uncertainty of its course in the considered teritory on the Basic geologic map (sheets Goričko and Leibnitz, Maribor, Čakovec and Rogatec).

The structure of the Periadriatic tectonic zone is reflected in distinct development of the Tertiary beds north and south of this zone as well as within it (J e l e n et al., 1992, 1997). This diversity is an expression of its tectogenesis that was studied in detail by F o d o r et al. (1998).

Conclusions

The proposed scheme of macrotectonic dismembering has the character of a working hypothesis, and is presented as basis for discussion of tectonic structure of Slovenia. With it we tried to submit those elements of global and the overthrust tectonics of the territory at the crossing of three megastructures that shed light on the proposed scheme. The most important of them are as follows:

1. Paleozoic beds occur in structurally the most uplifted parts for which we supplied kinematic and dynamic explanation: a - in the isostatically strongly uplifted root of the Trnovo nappe, b - in the intensely compressed and extruded Periadriatic tectonic zone, and c - in the isostatically uplifted Sava folds that were, the same as the Periadriatic tectonic zone, in the framework of the Sava compressive wedge uplifted above the neighboring structures.

2. The characteristic structure of the External Dinarides and extension of the Trnovo nappe are confirmed by the negative anomaly of the Mohorovičić discontinuity at the mark of 45 km.

3. The importance of the Southalpine front becomes integrally evident only when being considered in the broader circumadriatic region. Lying at the contact between the Southern Alps and the External Dinarides this front can be traced according to the position of the Trnovo nappe and the peculiar double overthrust structure of Blegoš.

4. Difficulties in determining the course of the Southalpine front east of the Ljubljana basin are connected with deformations within the Sava compressive wedge and with structurally insufficient geologic coverage on the scale of 1:100,000.

The questions that remained open are important for the palinspastic reconstruction of genesis of the Dinarides and the Pannonian basin. Such is for example 1. the question of the course of the Southalpine front east of the Ljubljana basin. It is not unimportant for the palinspastics of this region whether its course is bent at the northern rim of the Litija anticline towards east-northeast, or towards southeast. Depending upon this is, however, the final selection between the variants 8a or 8b (fig.

8), or some other. 2. The question of the course of this border is important also for understanding of the role of Pseudozilja beds in the area of Blegoš in the Poljane-Vrhnika ranges and in the northern flank of the Laško syncline in the Sava folds, which is one of the enigmas of the border territory between the Southern Alps and the External Dinarides.

Finally remains the comparison between several interpretations of the structure of Slovenian territory as they were made on the basis of mapping for the Basic geologic map. Here especially Mioč's idea on the Sava nappe and the structure of the transition teritory between the Eastern and the Southern Alps are meant as well as Premru's interpretation of central Slovenia, although this was already the object of discussion (Placer, 1998, this journal). Since the subdivision scheme presented in this paper has the working character no detailed analysis of differences shall be given. We shall limit ourselves to starting points of individual hypotheses only that are essentially different, as are different also the interpretations. Mioč introduced in his works two novelties, the Sava nappe (Mioč, 1976, 1981) and the idea of a unique overthrust structure of the Southern and Northern Karavanke (Mioč, 1986, 1997). We already said of the Sava nappe that it should include the Paleozoic and Mesozoic beds of the Sava folds and of the Škofja Loka-Polhov Gradec and Žiri regions. It should have been thrusted southwards on the carbonate shelf of the External Dinarides. We also wrote that the Carboniferous-Permian beds of the Škofja Loka-Polhov Gradec region that overlie the Mesozoic beds of Inner and Lower Carniola, or of the so called carbonate shelf, and the same beds that underlie the mentioned Mesozoic beds, cannot be considered equal. Owing to these facts well founded by observations the idea on the Sava nappe has been entirely rejected by us. The concept that the North Karavanke overthrust could be connected with the overthrust of the Paleozoic beds in the Southern Karavanke, the so called Southkaravanke overthrust, moved from south northwards on the Košuta unit, is based on the idea by Frisch (1978) who believed that after the collision of the Adriatic plate with the Eastern Alps the first was overthrusted on the second. This idea was resumed also by the authors of the geologic structure of Austria (Oberhauser, 1980). It would be possible to discuss this subject argumentatively when investigations in the North Karavanke region and the Periadriatic tectonic zone will be acomplished. The obtained results are alreadly partly published by Placer (1996a), by Jelen et al. (1997) and by Fodor et al. (1998).

Premru (1974, 1975, 1980, 1983a, 1983b) treated in his works, and especially in the treatise on the structure of central Slovenia (1980), the most delicate part of the territory east and west of the Ljubljana basin, as it is considered also in the present paper. His kinematic starting point for the structure of the Sava folds is entirely different from ours, and it has been critically discussed in the treatise on the Sava folds (Placer, 1998, this journal). Therefore its analysis will not be repeated here. The major shortcoming of Premru's concept is the negation of hard facts of the structural elements in their essential parts, to which attention was drawn already by Kuščer (1975). Therefore his overthrust interpretation must be rejected. It should be stressed, however, that Premru was the first to study in detail on the basis of the data of the Basic geologic map of Yugoslavia the contact between the Southern Alps and the External Dinarides in the region of central Slovenia, that he in this region as the first applied the structuro-facial analysis, and that he as the first draw attention to the importance of transform faults in interpreting the genesis of paleosedimentation regions in the Dinarides, and their place in the present structure. The transform faults were not considered in the present paper, although they are, also in the light of our studies, an essential element for understanding the structure of the Alpine, Dinaric and Pannonian regions.

Prispevek k makrotektonski rajonizaciji mejnega ozemlja med Južnimi Alpami in Zunanjimi Dinaridi

Uvod

Formalno geotektonsko rajonizacijo ozemlja na stiku Vzhodnih Alp in Dinaridov na Vzhodne Alpe, Južne Alpe, Zunanje in Notranje Dinaride, Jadransko ali Apulijsko predgorje ter Panonski bazen (sl. 1) so postopoma izoblikovale generacije geologov vse od znamenite K o s s m a t o v e (1913) razprave o nagubanem zaledju Jadranskega morja. Meja med Vzhodnimi in Južnimi Alpami ni sporna, ker poteka po Periadriatskem lineamentu in Ljutomerskem prelomu, ki verjetno predstavlja podaljšek Balatonskega lineamenta. Oba termina označujeta isto disjunktivno enoto razmejeno z Labotskim prelomom. Tudi Panonska udorina ne predstavlja nerešljivega problema, čeprav ne moremo jasno določiti njenih meja. Iz zadrege si pomagamo z razprostranjenostjo njenih terciarnih sedimentov, zato govorimo o Panonskem bazenu. Resne težave nastopijo pravzaprav šele pri razmejitvi Južnih Alp od Zunanjih in Notranjih Dinaridov, ter pri ločevanju slednjih dveh enot. Predlog tektonske rajonizacije na sl. 1 je narejen na podlagi podatkov Osnovne geološke karte Jugoslavije 1:100.000, B u s e r j e v e Geološke karte Slovenije 1:250.000 v tisku, Geološke karte Slovenije 1:500.000 (B u s e r & D r a k s l e r, 1993) in rezultatov novejših raziskav, kot je razvidno iz vsebine.

Metodologija predlagane tektonske rajonizacije temelji na krovni zgradbi Južnih Alp in Zunanjih Dinaridov, na tektonskih elementih različnih hierarhičnih stopenj in sedimentoloških kriterijih. Krovna zgradba Južnih Alp in Zunanjih Dinaridov je izpeljana iz ločilne ploskve (detachment) med kompetentnimi mezozojskimi pretežno karbonatnimi kamninami in nekompetentnimi paleozojskimi klastiti, ki igrajo vlogo mehke posteljice krovnih enot. Ločilna ploskev je bila ugotovljena v Posavskih gubah in v Zgornjesavinjski dolini na območju Podolševe. Tektonski elementi prvega reda so Periadriatski lineament, ki razmejuje Vzhodne Alpe od Dinaridov in preloma, ki omejujeta enoto Tisa vzhodno od Zagreba od Dinaridov. Tektonski element drugega reda je Južnoalpska narivna meja med Južnimi Alpami in Zunanjimi Dinaridi. Ta je nastala znotraj prvotno enotnega sedimentacijskega prostora. Tretjega reda so Savski in Idrijski prelom ter meje obsežnih krovnih enot znotraj Južnih Alp in Zunanjih Dinaridov, medtem ko so prelomi dinarske smeri NW-SE in srednjemadžarske smeri WSW-ENE ter Zunanjedinarska meja med Zunanjimi Dinaridi in Jadranskim ali Apulijskim predgorjem četrtega reda. Meja med Zunanjimi in Notranjimi Dinaridi je sedimentacijska, tako kot meja Panonskega bazena.

Meja med Južnimi Alpami in Zunanjimi Dinaridi

V tem prispevku bomo razpravljali predvsem o meji med Južnimi Alpami in Zunanjimi ter Notranjimi Dinaridi.

Šele s kartiranjem za Osnovno geološko karto Jugoslavije 1:100.000 se je izoblikоvalo enotno mnenje, da spada Blegoš kot del Poljansko-Vrhniških nizov k Zunanjim Dinaridom (G r a d & F e r j a n č i č, 1974, 1976; P r e m r u, 1980). To je bilo dokazano tudi s kinematsko analizo geneze blegoške strukture (P l a c e r & Č a r, 1997), iz katere je razvidno, da so Blegoš izoblikovali najprej dinarsko usmerjeni narivi od NE proti SW, nato pa obsežno narivanje Južnih Alp od severa proti jugu. Na območju Blegoša je potemtakem mogoče povsem nedvoumno določiti strukturno mejo med Zunanjimi Dinaridi in Južnimi Alpami, ki je narivna ploskev in poleg Periadriatskega lineamenta najpomembnejša dislokacija obravnavanega prostora. Njen potek zahodno od Blegoša je sorazmerno jasen, saj se na severni strani nahajajo globljemorske kamnine Slovenskega bazena, na južni strani pa karbonatne kamnine Trnovskega pokrova. Litološka raznolikost obeh enot je na območju Blegoša in proti zahodu jasno vidna do Tolmina, zahodno od tod pa je mejo mogoče slediti po strukturnih kriterijih, čeprav se tu stikajo podobne kamnine obeh imenovanih enot. To mejo je definiral že K o s s m a t (1913) kot linijo Kobariški Stol - Cerkno, natančneje pa B u s e r (1986, 1987) na listu Tolmin in Videm. Poseben pomen pri dokazovanju krovnega značaja te meje imata Ponikvanska in Seniška tektonska krpa pri Tolminu. Nadaljnji potek obravnavane narivne ploskve proti zahodu je povzet po S l e j k u et al. (1986), ki jo vlečejo do recentnega tektonskega jarka po dolini Tilmenta med Guminom in Mužacem ter naprej proti jugozahodu. Za opisano mejo predlagajo termin „Southalpine front", ki ga prevajamo kot Južnoalpska meja, oziroma meja Južnih Alp ali Južnoalpska narivna meja. C a r u l l i et al. (1990) pa so predlagali termin „Periadriatic overthrust" oziroma Periadriatski nariv. V tem prispevku smo uporabili starejšo varianto, ker je bolj določna.

Proti vzhodu je Južnoalpsko mejo mogoče slediti do Kranja in nato ostro proti jugo-jugozahodu, vzhodno od Škofje Loke pa ponovno proti vzhodu do Medvod ob zahodnem robu Ljubljanske kotline, nakar se pričenjajo težave, ki zahtevajo obširnejšo razlago. Da bi vprašanje pravilno razumeli, si najprej oglejmo Trnovski pokrov, ki je del Zunanjih Dinaridov in njegov odnos do Južnih Alp in Posavskih gub. Le-te se po novi definiciji (P l a c e r, 1998, ta revija) razprostirajo le vzhodno od Ljubljanske kotline, zahodno od tod pa v strukturnem smislu ne obstojajo. Trnovski pokrov obsega Trnovski gozd z Banjšicami, Idrijsko-Žirovsko ozemlje in Škofjeloško-Polhograjsko ozemlje. Narinjen je od NE proti SW na Hrušiški pokrov, nanj pa so od severa proti jugu narinjene Južne Alpe ob pravkar omenjeni Južnoalpski meji. Iz notranje zgradbe Trnovskega pokrova sledi (M l a k a r, 1969; P l a c e r, 1973, 1981), da tvori njegova narivna ploskev poševni rez tako, da so najmlajše kamnine v smeri narivanja razvite v čelu pokrova nad Vipavsko dolino, kjer nastopajo kredne in paleocenske plasti, najstarejši karbonskopermski klastiti pa v korenu pokrova na Škofjeloško-Polhograjskem ozemlju. Tukaj so le-ti narinjeni na triasne kamnine Poljansko-Vrhniških nizov, ki so v širšem smislu del mezozojskih kamnin južne Slovenije, v ožjem pa del Hrušiškega pokrova. Nasprotno pa ležijo karbonskopermske kamnine Litijske antiklinale južno in vzhodno od Ljubljanske kotline dosledno pod mezozojskimi kamninami južne Slovenije in ni nobenega posrednega ali neposrednega dokaza, da bi bilo kako drugače. Anomalijo je opazil že K o s s m a t (1913) in jo rešil tako, da je nariv Škofjeloško-Polhograjskega ozemlja, ki ga pa ni vzporejal z narivom Trnovskega gozda, omejil na območje Poljansko-Vrhniških nizov, Ljubljanskega barja in Golovca južno od Ljubljane. Enako sta za njim povzela W i n k l e r (1923) in R a k o v e c (1956). Novo rešitev je posredoval M i o č (1976, 1981) z idejo o Savskem pokrovu, ki naj bi zajemal Idrijsko-Žirovsko in Škofjeloško-Polhograjsko ozemlje ter karbonskopermske in mezozojske plasti Posavskih gub in bil porinjen proti jugu na mezozojske plasti južne Slovenije. Da so karbonskopermske plasti Litijske antiklinale narinjene proti jugu sta menila tudi P r e m r u (1980, 1983a, 1983b) in M l a k a r (1987) ter avtorji Strukturnega modela Italije (B i g i et al., 1990). Nasprotno pa je B u s e r (1978, 1979) tako kot Kossmat, Winkler in Rakovec menil, da ležijo karbonskopermske plasti Litijske antiklinale pod mezozojskimi skladi južne Slovenije. S pilotskimi raziskavami smo prišli do enakega sklepa kot Buser.

Iz lege karbonskopermskih skladov zahodno in vzhodno od Ljubljanske kotline torej sledi, da ležijo te plasti v osrednji Sloveniji v dveh različnih tektonskih enotah. Tiste na zahodu pripadajo Trnovskemu pokrovu, tiste na vzhodu pa ležijo pod mezozojskimi skladi južne Slovenije oziroma pod Hrušiškim pokrovom in narivnimi enotami vzhodno od le-tega. Da bi v smislu te ugotovitve razumeli problem zgradbe osrednje Slovenije, si moramo pobliže ogledati krovno zgradbo jugozahodne Slovenije (P l a c e r 1981, sl. 7a), ki jo poenostavljeno podajamo v dveh profilih na sl. 2 in na sl. 3.

Iz odnosa med Trnovskim in Hrušiškim pokrovom na sl. 2a je razvidno, da karbonskopermske plasti Trnovskega pokrova v severovzhodnem delu profila prekrivajo enake plasti Hrušiškega pokrova. Ker je profil narejen po faktografskih podatkih o legi, notranji zgradbi, debelini in dolžini krovnih enot ter dolžini narivanja, zaključujemo tako kot v prejšnjem odstavku, da ležijo karbonskopermske plasti Škofjeloško-Polhograjskega ozemlja hkrati na mezozojskih kamninah južne Slovenije in na karbonskopermskih plasteh Litijske antiklinale vzhodno od Ljubljanske kotline. Te pa ležijo dosledno pod karbonatnim sedimentnim pokrovom južne Slovenije. Glede na to, da izvajamo krovno zgradbo Zunanjih Dinaridov iz enotne ločilne ploskve (decollement, detachment), je mogoče skleniti, da predstavlja meja med karbonskopermskimi skladi Litijske antiklinale, ki ponekod vključujejo tudi grödenske plasti, vzhodno od Kuma pa tudi werfenske in srednjetriasne plasti, nasproti mezozojskim plastem komplicirano zgrajeno ločilno ploskev. Zaradi tega je povsem razumljivo, da imamo v Posavskih gubah mlajše plasti narinjene na starejše, saj je za ločilno ploskev značilen vzporedni ne pa poševni rez. Ta posebnost pogosto predstavlja osnovo za ugovor proti ideji o krovni ali narivni zgradbi tega dela Slovenije. Ločilna ploskev poteka tudi znotraj karbonskopermskih plasti, zato je njena lega na meji med paleolzojskimi in mezozojskimi plastmi v Posavskih gubah na sl. 1 v pretežni meri formalna.

Jugovzhodna meja Trnovskega pokrova ima prečnodinarsko smer SW-NE. V razpravi o zgradbi jugozahodne Slovenije (P l a c e r, 1981) smo to utemeljevali z vpadom osi velikih narivnih gub v čelu pokrova proti severozahodu. Vendar to dejstvo ni zadosten razlog za anomalno smer obravnavane meje, saj na območju Poljansko-Vrhniških nizov Trnovski pokrov ne visi več proti severozahodu, smer te meje pa se zaradi tega ne spremeni. Bolj verjetno je, da predstavlja jugovzhodna meja Trnovskega pokrova bočno mejo te obsežne krovne enote, katere pretežni del je prekrit z Južnimi Alpami. Stanje je shematsko prikazano na sl. 3, na kateri so zaradi lažje orientacije narisani tudi Poljansko-Vrhniški nizi in Blegoš. Obseg Trnovskega pokrova in izjemna struktura Blegoša kažeta na velik pomen Južnoalpske meje. Ob njej domnevamo velik premik, ki bi ga lahko razložili z obsežno rotacijo Zunanjih Dinaridov nasproti Južnim Alpam ali pa s prekrilnim narivanjem brez rotacije kot menijo npr. P r e m r u (1980), D o g l i o n i & S i o r p a e s (1990) ter P o l i n s k i & E i s b a c h e r (1992).

Ker ima Trnovski pokrov omejen obseg, velja model na sl. 2a in njegova kinematsko-dinamska izpeljava z eksponencialnim narivnim nizom (sl. 4a) le za profil, ki poteka preko Trnovskega pokrova (profil 1-1 na sl. 3), medtem ko so razmere v profilu

2-2 (sl. 3) izven Trnovskega pokrova na slikah 2b in 3 nekoliko drugačne. Čeprav je Trnovski pokrov prvotno segal verjetno nekoliko dlje proti jugovzhodu in bil pozneje erodiran, menimo, da njegov obseg v tej smeri ni mogel biti bistveno večji od današnjega, saj nikjer v južni Sloveniji ne najdemo tektonskih krp, ki bi dokazovale nasprotno. Zato je treba zgradbo Zunanjih Dinaridov jugovzhodno od Trnovskega pokrova izvajati iz profila na sl. 2b, in sicer kot kopičenje krovnih enot na jugozahodu katerih najvišji člen je Hrušiški pokrov, na severovzhodu pa kot ločilno narivno luskasto strukturo, ki je bila ugotovljena npr. z vrtino v Dolenjskih Toplicah (Premru et al., 1977), kjer so jurske plasti narinjene na kredne. Lahko bi torej hipotetično govorili o krovni zgradbi izhajajoči iz ločilne ploskve z domnevnim kombiniranim narivnim nizom (Placer, 1982), kot je prikazan na sl. 4b.

Iz profila 1-1 na sl. 2 in 3 je mogoče tudi sklepati, da je negativna anomalija Mohorovičičeve diskontinuitete 45 km na sl. 5 (povzeto po Carulliju et al., 1990, sl. 3) na razmeroma ozkem prostoru med Tržaškim zalivom in Ljubljansko kotlino, nastala zaradi izostatičnega ugrezanja območja, kjer so krovne enote nakopičene ena vrh druge. Obseg anomalije v smeri NW-SE pa ustreza legi in razprostranjenosti Trnovskega pokrova. Karto, ki jo podajajo Carulli et al. smo uporabili zato, ker je bolj graduirana od Strukturne karte Mohorovičićeve diskontinuitete (Dragašević et al., 1989) za območje Jugoslavije. V korenu krovnih enot pa nasprotno opažamo izostatični dvig mehke posteljice iz nekompetentnih karbonskopermskih plasti pod mezozojskimi skladi. Opisani odnos med krovno zgradbo in Mohorovičićevo diskontinuiteto je ponazorjen na profilu na sl. 6, ki je istoveten s profilom 1-1, le da smo pri njegovi konstrukciji uporabili realno stanje s sl. 1, vendar brez Idrijskega preloma, saj obravnavamo le krovno zgradbo. Anomalija jugovzhodno od Trnovskega pokrova je sicer nekoliko blažja (40 km), vendar še vedno poudarjeno izraža izostatični ugrezek narinjenih enot in dvig na območju Posavskih gub. Izdanjanje karbonskopermskih plasti v Polhograjsko-Škofjeloškem hribovju in na območju Posavskih gub ima torej logično razlago. Dopolnimo jo lahko tudi z dvigom Posavskih gub znotraj Savskega kompresijskega klina (Placer, 1998, ta revija).

Iz navedenega moremo sklepati, da pripadajo karbonskopermske plasti osrednje Slovenije v celoti Zunanjim Dinaridom. Tako je menil že Buser (1979).

Pri iskanju pravega odgovora na vprašanje o poteku Južnoalpske meje vzhodno od Medvod, stojimo kljub razrešitvi vprašanja o pripadnosti karbonskopermskih plasti dvema strukturnima enotama pred dilemo, ki je na podlagi danes znanih podatkov še ne moremo zadovoljivo rešiti. Pojavlja se več vprašanj, prvo se dotika starosti krovnega narivanja, drugo pa notranje zgradbe krovnih enot. Dinarski pokrovi so povezani z genezo eocenskih flišnih plasti, torej se je ciklus tega narivanja verjetno zaključil konec eocenske dobe. Južnoalpski pokrovi prekrivajo dinarske in so po normalni logiki lahko le mlajši. V Posavskih gubah tvorijo mezozojske kamnine eno ali več obsežnih krovnih enot, ki so bile narinjene pred odložitvijo trboveljskih plasti (Placer, 1998, ta revija; prvotno soteške plasti, nato psevdosoteške plasti - Jelen et al., 1992) v srednjem ali zgornjem oligocenu. Logično bi torej bilo, da bi eno ali več krovnih enot, ki obsegajo celotne Posavske gube vzporejali z dinarskimi pokrovi, vendar jih v facialnem smislu lahko primerjamo le s kamninami Slovenskega bazena in njegovega obrobja zahodno od Škofje Loke in Kranja.

Nadalje obstaja vprašanje starosti Julijskega pokrova kot smo poimenovali pokrov Julijskih in Kamniško-Savinjskih Alp. Le-tega sta Grad & Ferjančič (1976) imenovala Jelovški pokrov, Mioč (1981) Julijsko-Savinjski pokrov, Mioč (1983) in Premru (1983b) Savinjski nariv, Jurkovšek (1987b) pokrov Julijskih Alp, B u s e r (1986) Krnski pokrov, K r y s t y n et al. (1994) v nekoliko modificirani obliki pa Krnski oziroma Pokljuški pokrov. V tem prispevku smo kljub pravici prvega prevzeli Miočev predlog in ga modificirali v Julijski pokrov, ki obsega Julijske in Kamniško-Savinjske Alpe. Na starost Julijskega pokrova lahko le posredno sklepamo po odnosu krovnega nariva v Julijskih Alpah do oligocenskih plasti Ljubljanske kotline, ki izdanjajo na njenem celotnem območju in jo po podatkih Osnovne geološke karte, listov Celovec (B u s e r & C a j h e n, 1978) in Kranj (G r a d & F e r j a n č i č , 1974) pod kvartarnimi naplavinami prekrivajo skoraj v celoti. Zato bi lahko sklepali, da je z oligocenskimi plastmi prekrita tudi narivna ploskev Julijskega pokrova, če se spusti pod oligocenske plasti Ljubljanske kotline. Razmere v Kamniško-Savinjskih Alpah so na prvi pogled drugačne, vendar interpretacija s krovnimi narivi na oligocenske plasti na listu Celovec (B u s e r & C a j h e n, 1978, profil C-D) ali na listu Ljubljana (P r e m r u 1983a, profil A-B) ni dokazana. Dokazljivi so le manjši narivi postsarmatske, po vsej verjetnosti postsrednjepliocenske starosti, ki so posledica kompresije znotraj Savskega kompresijskega klina in krčenja prostora. Na podlagi teh ugotovitev menimo, da bi se Kamniško-Savinjske in Julijske Alpe lahko narinile na pelagične sedimente Slovenskega bazena že pred srednjim, oziroma zgornjim oligocenom tako kot ena ali več krovnih enot v Posavskih gubah in kot velja tudi za osrednji del Južnih Alp (D o g l i o n i & B o s e l l i n i, 1987). Med koncem eocena in srednjim do zgornjim oligocenom bi bilo lahko dovolj časa za formiranje Južnoalpske krovne zgradbe. Po drugi strani pa B u s e r (1980), P r e m r u (1980) ter P o l i n s k i & E i s b a c h e r (1992) uvrščajo pokrove Julijskih in Kamniško-Savinjskih Alp v neogen. Vprašanje ni preprosto. Rešiti ga bo mogoče le z obsežnimi raziskavami. Vsekakor imajo oligocenske plasti pri Bohinju, na Veliki Planini in na Kopišču ob Kamniški Bistrici za ugotavljanje starosti Julijskega pokrova velik pomen. Pripomniti pa velja, da je ločevanje nastanka Julijskega pokrova od Južnoalpske meje nelogično in izvira iz pomanjkljive strukturne faktografije območja Julijskih in Kamniško-Savinjskih Alp.

Glede notranje zgradbe krovnih enot in smeri narivanja smo že dejali, da je zahodno od Ljubljanske kotline mogoče na podlagi južnoalpskih (W-E) in dinarskih (NW-SE) elementov strukture ločiti dinarsko od južnoalpske krovne zgradbe. Zato bi pričakovali, da so na sorazmerno kratki razdalji vzhodno od Ljubljanske kotline razmere enake ali vsaj podobne. Vendar je struktura drugačna. Njena drugačnost je povezana z genezo Posavskih gub znotraj Savskega kompresijskega klina (P l a c e r, 1998, ta revija), zaradi česar so se le-te močno nagubale v smeri W-E, pri čemer so se dinarske krovne strukture navzven močno zabrisale. Da bi lahko ugotovili potek Južnoalpske meje, bi morali analizirati notranjo strukturo mezozojskih kamnin na območju Posavskih gub. Ker smo na novo skartirali le širše območje Laške sinklinale, smo opravili le analizo vpadov debeloplastnatega srednjetriasnega in glavnega dolomita ter dachsteinskega apnenca na tem območju, saj se v debeloplastnatih kamninah odražajo regionalni vidiki deformiranja razmeroma neodvisno od krajevnih vplivov. Te kamnine nastopajo zahodno od Kuma. V severnem krilu Laške sinklinale jih najdemo na Rebri nad Kolovratom severozahodno od Izlak, v južnem krilu pa med Kumom in Slemškom nad Vačami. V južnem krilu sinklinale vpadajo plasti generalno proti zahodu do zahodu-severozahodu, v severnem krilu pa proti jugozahodu do jugo-jugozahodu. S preprosto rotacijo okoli osi W-E, ki je vzporedna osi gubanja, je mogoče ugotoviti, da ležijo poli plasti enega in drugega krila sinklinale v isti ravnini (sl. 7), smer plasti v temenu sinklinale, ki je konstruirana pa je dinarska (NW-SE). Poleg strukturnega obstoja tudi facialni vidik. Značilni kondenzirani profil grödenskih in belerofonskih plasti v useku avtoceste pri Višnji Gori (Skaberne, ustna izjava) smo odkrili tudi v Borovniškem peskokopu v Kisovcu v Laški sinklinali, kar bi kazalo na isti sedimentacijski prostor. Lega zgornjetriasnih plasti in razvoj permskih plasti bi lahko služila za dokaz, da pripadajo mezozojske kamnine v Posavskih gubah, ali vsaj del južno od Trojanske antiklinale, Zunanjim Dinaridom. Za potrditev takega sklepa pa bi morali analizirati celotne Posavske gube. Zato temu podatku ne moremo pripisovati odločilnega pomena.

Z upoštevanjem elementov starosti krovnega narivanja in notranje zgradbe krovnih enot, se še nismo približali jasnemu odgovoru o poteku meje Južnih Alp vzhodno od Ljubljanske kotline. Ugotovili pa smo, da je krovna zgradba v Posavskih gubah predsrednje do predzgornjeoligocenske starosti, da je Julijski pokrov enake ali pa postsarmatijske starosti in da je Južnoalpska narivna meja ob kateri so se kamnine Slovenskega bazena narinile proti jugu zahodno od Ljubljanske kotline časovni ekvivalent krovne zgradbe Posavskih gub, saj oligocenski sedimenti v okolici Medvod prekrivajo Južnoalpsko mejo. Glede na povedano obstojata o poteku Južnoalpske meje vzhodno od Ljubljanske kotline dve varianti, od katerih ima vsaka nekaj prednosti in nekaj slabosti. Obe sta prikazani na sl. 8.

Po varianti 8a poteka meja Južnih Alp po severnem robu karbonskopermskega jedra Trojanske antiklinale, po varianti na sl. 8b pa po severnem robu karbonskopermskega jedra Litijske antiklinale, pri čemer je v Južne Alpe vključena tudi Preveška tektonska krpa (po Preveškem hribu nad Polšnikom, 873 m). Po prvi varianti bi k Južnim Alpam spadali zgornjetriasni, jurski in kredni pelagični sedimenti Slovenskega bazena, medtem ko naj bi triasne kamnine v podlagi in krilih Laške sinklinale pripadale najvišjemu pokrovu dinarske provenience. Na to bi kazala lega plasti zahodno od Kuma. Ta varianta sicer upošteva strukturni vidik lege plasti in podoben razvoj kondenziranih grödenskih in belerofonskih plasti v Kisovcu in pri Višnji Gori, pa tudi diskordantno lego krednih globljemorskih plasti na triasnih platformnih karbonatih, kar je značilno za notranji pas Zunanjih Dinaridov. Vendar ne smemo zanemariti pomanjkljivosti, da smo analizirali lego plasti na majhnem delu Posavskih gub, in da kaže razvoj mezozojskih plasti na tem območju bolj na postopen prehod od pretežno karbonatnega faciesa srednje in zgornjetriasnih plasti na jugu do klastičnega in pelagičnega razvoja na severu kot pa na obsežno tektonsko prekinitev, če bi Južnoalpska meja potekala po severnem robu Trojanske antiklinale. Zato smo se pri tem stanju raziskanosti odločili za varianto 8b kot delovno hipotezo, ki je sicer skladna s Kossmatovim (1913) in Winklerjevim (1923) razumevanjem povezave obravnavane narivne ploskve med zahodnim in vzhodnim obrobjem Ljubljanske kotline, vendar iz različnih teoretskih izhodišč.

Dileme v zvezi z obravnavanim vprašanjem so širše. Tičejo se formacijskih in strukturnih vprašanj (geometrijskih in kinematskih), paleomagnetizma, palinspastike, paleogeografije in globalne tektonike. Zato je potreba po kompleksnem pristopu k reševanju te problematike na Slovenskem morda najbolj akutna in bi morala biti neposredno povezana z vsestransko obdelavo v okviru geološke karte 1:50.000. Nejasnost ni povezana samo s potekom Južnoalpske meje vzhodno od Ljubljanske kotline, temveč tudi z vprašanjem njenega globalnega pomena. Danes zaradi nezadostne raziskanosti ne moremo ugotoviti ali se nadaljuje v Srednjetransdanubijsko cono ali pa zavije proti jugovzhodu. Na podlagi prevladujočih globalnih pogledov na genezo Panonske udorine (npr. Csontos et al., 1992; Horváth & Tari, 1998), smo v tej razpravi uporabili prvo varianto, ki pa je zgolj hipotetična. Orientirali smo se po mezozojskem ofiolitnem melanžu Kalnika in Medvednice, ki ju sicer ne moremo neposredno povezovati z globljemorskimi kamninami Posavskega in Krškega hribovja ter Gorjancev, menimo pa, da pripadajo v širšem smislu Notranjim Dinaridom.

Ob tej priliki bi opozorili na mnenje Premruja (1980), Doglionija & Siorpaesa (1990) ter Polinskega & Eisbacherja (1992) o genezi zamika med Južnimi Alpami in Zunanjimi Dinaridi iz česar izhaja, da v Južnih Alpah lahko pričakujemo relikte dinarsko usmerjenih elementov strukture. Zaradi tega je izbira variante 8b v tem trenutku primernejša.

Omeniti pa velja še domnevo Slejka et al. (1986) in Carullija et al. (1990), da je Južnoalpska meja zahodno od Idrijskega preloma še aktivna. Misel je povezana z nasledstvenimi učinki in kaže na kompleksnost ugotavljanja starosti disjunktivnih struktur na prostoru, ki je prestal več tektonskih faz.

Diskusija

Geotektonska rajonizacija slovenskega ozemlja temelji na dveh megadisjunktivnih strukturah, Periadriatskem lineamentu in Južnoalpski meji ter na notranje heterogeni in ne povsem jasno zamejeni Panonski udorini. Zaradi tega je enostavneje govoriti o Panonskem bazenu, čeprav se na žalost v njem ne odraža le geometrija Panonske udorine, temveč tudi mejnih ozemelj z elementi nasledstvenih deformacij, ki z udorino niso genetsko povezane.

Cilj pričujoče razprave ni podrobna genetska, temveč generalna formalna tektonska rajonizacija Slovenije in določitev najpomembnejših tektonskih enot regionalnega pomena, ki temeljijo na globalnih principih in na krovni zgradbi izhajajoči iz geometrije ločilne (detachment) tektonike.

1. Vzhodne Alpe obsegajo območje metamorfnih kamnin in območja mezozojskih karbonatnih kamnin (Dravski niz in ostalo). Dravski niz sega na naše ozemlje kot Severne Karavanke in njihovi vzhodni relikti pri Mislinji in Zrečah.

2. Dinaridi so od Vzhodnih Alp razmejeni s Periadriatskim lineamentom. Delimo jih na Južne Alpe ter Zunanje in Notranje Dinaride.

2a. Južne Alpe ležijo med Periadriatskim lineamentom in Južnoalpsko mejo. Njihova pomembna strukturna enota je Periadriatska tektonska cona (Jelen et al., 1997; Placer, 1998, ta revija) med Periadriatskim lineamentom in Savskim prelomom. V tem članku se ne ukvarjamo poglobljeno z vprašanjem krovne zgradbe Južnih Alp, podajamo pa nekaj splošnih izhodišč, ki bi jim morali v bodoče posvetiti vso pozornost. Kljub premiku ob Savskem prelomu najsi je 25, 40 ali 65-70 km (Placer, 1996b), moramo Julijske in Kamniško-Savinjske Alpe obravnavati kot enoten tektonski objekt v katerem zavzemajo osrednje mesto kamnine Slovenskega bazena. Te po Krystynu et al. (1994) nastopajo v Tolminskem pokrovu, ki leži pod Julijskim pokrovom. Glede na razprostranjenost slednjega ugotavljamo, da je ta na jugu narinjen na kamnine Slovenskega bazena (Tolminsko, Baška grapa, Selška dolina, Županje Njive pri Kamniku, dolina Črne pri Kamniku), na severu na območju lista Ravne pa leži na kamninah spodnje do srednjetriasne starosti, morda tudi zgornjetriasne (Mioč, 1983; Mioč & Žnidarčič, 1983). To navaja na misel, da tvorijo kamnine s severnega obrobja Julijskega pokrova podlago, ponekod pa tudi bočni ekvivalent sedimentov Slovenskega bazena in pripadajo verjetno Tolminskemu pokrovu tako kot kamnine Slovenskega bazena. Zaradi hipotetičnosti te domneve navajamo „Tolminski pokrov“ v takem obsegu v narekovajih. Na listu Ravne ležijo na območju Podolševe spodnjetriasne kamnine „Tolminskega pokrova“ tektonsko na karbonskih klastitih, ki predstavljajo mehko posteljico Južnih Alp. Ta enota poleg paleozojskih zajema na listih Celovec ter Beljak in Ponteba tudi spodnje in srednjetriasne plasti, sama narivna ploskev nasproti „Tolminskemu pokrovu“ pa je verjetno skrita znotraj iste formacije. Kamnine, ki bi jih lahko prištevali k paleozojski podlagi „Tolminskega pokrova“, se nahajajo tudi južno od Savskega preloma nad Kranjsko goro in Ratečami (J u r k o v š e k, 1987a) nad njimi pa nastopajo spodnje in srednjetriasne plasti „Tolminskega pokrova“, ki se po geološki karti s Strukturnega modela Italije (B i g i et al., 1990) vlečejo v ozkem pasu ob južni strani Belškega preloma daleč proti zahodu. Na Strukturnem modelu je meja teh plasti nasproti zgornjetriasnim normalna, vendar domnevamo, da obstojajo tu enake razmere kot na listu Beljak in Ponteba (J u r k o v š e k, 1987a, profil A-B), zato tudi tu predvidevamo obstoj „Tolminskega pokrova“, medtem ko se paleozojske plasti pojavljajo le na območju Kranjske gore in Rateč. K „Tolminskemu pokrovu“ spadajo tudi mezozojske kamnine Posavskih gub, ki smo jih z določitvijo poteka Južnoalpske meje po severnem robu Litijske antiklinale reducirali na eno krovno enoto. Vendar moramo tako rešitev obravnavati hipotetično.

Paleozojske kamnine mehke posteljice južnih Karavank in triasne kamnine karavanškega pasu „Tolminskega pokrova“ med Savskim prelomom in Periadriatskim lineamentom so B u s e r (1980), M i o č (1983) in J u r k o v š e k (1987a) uvrstili v Južnokaravanško enoto, ki naj bi zajemala tudi spodnje in srednjetriasne plasti. Glede na pomen paleozojske podlage predlagamo zanjo termin Javorniška enota po Javorniškem Rovtu nad Jesenicami.

Glede na predstavljena izhodišča nastopajo v Južnih Alpah Javorniška in Košutina enota ter „Tolminski“ in Julijski pokrov. Javorniška enota je mehka posteljica Južnih Alp. Košutina enota je tektonska leča iz mezozojskih kamnin med Periadriatskim lineamentom in več prelomi znotraj Periadriatske tektonske cone (B r e n č i č et al., 1995), ki so imeli tekom razvoja slednje različno dinamsko vlogo. „Tolminski“ in Julijski pokrov sta krovni enoti narinjeni generalno od severa proti jugu na Zunanje Dinaride. Boskovec, Paški Kozjak, Konjiška gora, Boč in Ravna gora so strukturno del Južnih Alp, po kamninski sestavi smo jih hipotetično uvrstili v „Tolminski pokrov“. Po kamninski sestavi bi bila Košutina enota v Karavankah lahko del Julijskega pokrova, ki je znotraj Periadriatske tektonske cone močno tektonsko preoblikovana. Vendar tega v shemi rajonizacije zaradi hipotetičnosti nismo upoštevali.

Julijski in „Tolminski“ pokrov sta v smeri W-E skledasto usločena, kar je mogoče povezati z regionalno komprimacijo. Meja med Javorniško enoto in „Tolminskim pokrovom“ bi lahko bila istovetna z narivno ploskvijo Južnoalpske meje. Južnoalpska narivna meja je hkrati tudi južna meja „Tolminskega pokrova“.

2b. Zunanji Dinaridi so nasproti južnim Alpam zamaknjeni za 30° do 45° in pod slednje podrinjeni. Sestavljeni so iz treh pasov: a - iz zunanjega paravtohtonega z ohranjenimi terciarnimi sedimenti v jedrih sinformnih struktur (Kraški naluskani prag, Komenska narivna gruda), b - iz osrednjega alohtonega dela, kjer so terciarni sedimenti le izjemoma ohranjeni (Snežniški, Hrušiški, Trnovski pokrov ter nerazčlenjena narivna zgradba severovzhodno od Hrušiškega pokrova), in c - iz notranjega alohtonega pasu, ki predstavlja prehodno območje med Zunanjimi in Notranjimi Dinaridi oziroma t.i. pregibno zono (P l e n i č a r & P r e m r u, 1975), ki jo nekateri avtorji uvrščajo v Notranje Dinaride. Zanjo je značilna migracija pelagiala skozi zgornji trias, juro in kredo. Posebno lego v Zunanjih Dinaridih ima Trnovski pokrov, ki je le skrajni jugovzhodni vidni del večjega pokrova, podrinjenega pod Južne Alpe. Izjemna je njegova lega in zgradba, saj se na njegovem severozahodnem robu prične degradacija dinarske karbonatne platforme že v zgornji kredi. Ker se degradacija pojavlja najprej v Trnovskem pokrovu sodimo, da je ta podatek eden pomembnejših za študij palinspastike Dinaridov. Na sl. 1 so poleg Trnovskega pokrova izrisane tudi narivne meje Hrušiškega pokrova, Snežniške in Komenske narivne grude ter Kraškega naluskanega praga, kot smo ustrezneje preimenovali Čičarijsko naluskano zgradbo (P l a c e r, 1981). Slednja ima vlogo narivnega čela Zunanjih Dinaridov. Meje narivnih enot severovzhodnega dela Zunanjih Dinaridov niso izrisane, ker njihov potek še ni analitično proučen.

Karbonskopermske plasti v Posavskih gubah so del Zunanjih Dinaridov.

2c. Prehodno območje med Zunanjimi in Notranjimi Dinaridi. Na območju Slovenije v megatektonskem smislu ni Notranjih Dinaridov. Obstaja le prehodno območje med Zunanjimi in Notranjimi Dinridi, kjer so jurski in kredni pelagični sedimenti odloženi diskordantno na triasnih in starejših kamninah Zunanjih Dinaridov ali pa zgornjetriasni šelf polagoma prehaja v pelagial (O g o r e l e c & D o z e t, 1997), zaradi česar nekateri prehodno območje uvrščajo v Notranje Dinaride. Na območju Posavskih gub je prehodno območje med Notranjimi in Zunanjimi Dinaridi podrinjeno pod podobne kamnine Slovenskega bazena oziroma Južnih Alp. Odprto ostaja vprašanje pripadnosti podlage globokomorskih sedimentov Medvednice in Kalnika, saj po vsej verjetnosti pripada posebni strukturni enoti znotraj Srednjemadžarske tektonske cone, zato ju v tektonskem smislu nismo uvrstili. Podobne težave povzroča južno pobočje Ivančice, če je hipotetična Južnoalpska meja na tem mestu postavljena pravilno.

Južnoalpska narivna meja loči podobne ali enake kamnine Trnovskega pokrova in prehodnega območja med Notranjimi in Zunanjimi Dinaridi od Slovenskega bazena. V času nastajanja so bile te kamnine bolj ali manj daleč narazen. Razdaljo med paleogeografskimi enotami v času sedimentacije bo mogoče oceniti po palinspastični rekonstrukciji tektogeneze Dinaridov, po detajlni kinematski in dinamski analizi megastrukturnih enot in po detajlni analizi faciesov.

3. Jadransko ali Apulijsko predgorje je avtohton dinarske narivne in krovne zgradbe. Skupaj z Zunanjimi Dinaridi je podrejeno pod Južne Alpe.

4. Panonski bazen je heterogena tektonska enota. Njegovo podlago sestavljajo vzhodni oziroma vzhodno-severovzhodni podaljški vzhodnoalpskih in dinarskih geotektonskih enot, ki so pogreznjene pod terciarne sedimente Paratetide. Po H a a s u et al. (1995) sestavljajo te enote obsežne srednjealpske terrane, sestavljene pretežno iz kontinentalne skorje; Vzhodnoalpskega iz metamorfnih kamnin, Transdanubijskega iz kamnin Dravskega niza oziroma Severnih Karavank, Srednjetransdanubijskega iz kamnin Južnih Alp in Tisinega iz kamnin z evropskimi favnističnimi elementi. Iz interpretacije Transdanubijskega in Srednjetransdanubijskega terrana sledi, da tvori mejo med njima Balatonski lineament, ki je podaljšek Periadriatskega lineamenta vzhodno od Labotskega preloma. Na ozemlju Slovenije je Balatonski lineament označen kot Ljutomerski prelom. Mejo med Transdanubijskim in Vzhodnoalpskim terranom tvori Rabski prelom (H a a s et al., 1995; H o r v á t h & T a r i, 1998), ki naj bi bil tudi izvorna struktura Severnokaravanškega nariva. Na karti na sl. 1 Rabski prelom ni narisan, ker njegov potek na obravnavanem ozemlju na Osnovni geološki karti (listi Goričko in Leibnitz, Maribor, Čakovec in Rogatec) ni določen.

Zgradba Periadriatske tektonske cone se odraža v različnem razvoju terciarnih plasti severno in južno od te cone in znotraj nje (J e l e n et al., 1992, 1997). Ta raznolikost je odsev njene tektogeneze, ki so jo natančneje obdelali F o d o r et al. (1998).

Sklep

Predlagana shema makrotektonske rajonizacije je delovna in je predstavljena kot osnova za razpravo o tektonski zgradbi Slovenije. V njej smo skušali podati tiste elemente globalne in krovne tektonike ozemlja na stičišču treh megastruktur, ki predlagano shemo osvetljujejo. Od teh so najpomembnejši:

1. Paleozojske plasti nastopajo v strukturno najbolj dvignjenih delih, za kar podajamo kinematsko in dinamsko razlago: a - v izostatsko močno dvignjenem korenu Trnovskega pokrova, b - v močno stisnjeni in iztisnjeni Periadriatski tektonski coni in c - v izostatsko dvignjenih Posavskih gubah, ki so bile poleg tega, tako kot Periadriatska tektonska cona, v okviru Savskega kompresijskega klina dvignjene nad okolne strukture.

2. Značilno zgradbo Zunanjih Dinaridov in razprostranjenost Trnovskega pokrova potrjuje negativna anomalija Mohorovičićeve diskontinuitete na koti 45 km.

3. Pomen Južnoalpske meje je v celoti razviden šele tedaj, ko jo obravnavamo v širšem cirkumadriatskem prostoru. Na stiku med Južnimi Alpami in Zunanjimi Dinaridi jo je mogoče oceniti po legi Trnovskega pokrova in nenavadni dvojni narivni strukturi Blegoša.

4. Težave pri določitvi poteka Južnoalpske meje vzhodno od Ljubljanske kotline so povezane z deformacijami znotraj Savskega kompresijskega klina in strukturno pomanjkljivo geološko osnovo v merilu 1:100.000.

Vprašanja, ki so ostala odprta so pomembna za palinspastično rekonstrukcijo geneze Dinaridov in Panonskega bazena. Táko je npr. 1. vprašanje poteka Južnoalpske meje vzhodno od Ljubljanske kotline, saj za palinspastiko tega prostora ni vseeno ali zavija le-ta ob severnem robu Litijske antiklinale proti vzhodu-severovzhodu ali proti jugovzhodu. Od tega je odvisna končna izbira variante 8a ali 8b (sl. 8) ali pa katere druge. 2. Vprašanje poteka te meje je pomembno tudi za razlago vloge psevdoziljskih plasti na območju Blegoša v Poljansko-Vrhniških nizih in v severnem krilu Laške sinklinale v Posavskih gubah, kar je ena od zagonetk mejnega ozemlja med Južnimi Alpami in Zunanjimi Dinaridi.

Nazadnje nam ostane še primerjava z nekaterimi interpretacijami zgradbe Slovenskega ozemlja, ki so nastale na podlagi kartiranja za Osnovno geološko karto. Mislimo predvsem na Miočevo idejo o Savskem pokrovu in zgradbi prehodnega ozemlja med Vzhodnimi in Južnimi Alpami ter na Premrujevo interpretacijo osrednje Slovenije, čeprav smo o tem že razpravljali (Placer, 1998, ta revija). Ker je v tem prispevku predstavljena rajonizacija delovna, se ne bomo spuščali v detajlno analizo razlik. Omejili se bomo le na izhodišča posameznih hipotez, ki so bistveno različna, kot se razlikujejo tudi interpretacije. Mioč v svojih delih uvaja dve novosti, Savski pokrov (Mioč, 1976, 1981) in idejo o enoviti narivni zgradbi Južnih in Severnih Karavank (Mioč, 1986, 1997). O Savskem pokrovu smo že dejali, da naj bi zajemal paleozojske in mezozojske plasti Posavskih gub ter Škofjeloško-Polhograjskega in Žirovskega ozemlja. Porinjen naj bi bil proti jugu na karbonatni šelf Zunanjih Dinaridov. Zapisali smo tudi, da ne moremo enačiti karbonskopermskih skladov Škofjeloško-Polhograjskega ozemlja, ki ležijo na, in enakih skladov v Posavskih gubah pod mezozojskimi plastmi južne Slovenije, oziroma takoimenovanim karbonatnim šelfom. Poleg tega paleozojske plasti pri Ortneku ne predstavljajo tektonskih krp, temveč erozijska okna pod mezozojskimi plastmi. Zaradi teh dejstev, ki imajo faktografsko težo, idejo o Savskem pokrovu v celoti zavračamo. Zamisel, da je Severnokaravanški nariv povezan z narivom paleozojskih plasti v Južnih Karavankah, takoimenovanim

Južnokaravanškim narivom, porinjenim od juga proti severu na Košutino enoto sloni na ideji F r i s c h a (1978), ki je menil, da se je po koliziji Jadranske plošče z Vzhodnimi Alpami prva na slednje narinila. To idejo so povzeli tudi pisci geološke zgradbe Avstrije (O b e r h a u s e r, 1980). O tej ideji bo moboče argumentirano razpravljati, ko bodo končane sedanje raziskave Severnih Karavank in Periadriatske tektonske cone, katerih delne rezultate so objavili P l a c e r (1996a), J e l e n et al. (1997) in F o d o r et al. (1998).

P r e m r u (1974, 1975, 1980, 1983a, 1983b) je v svojih delih, posebej pa v razpravi o zgradbi osrednje Slovenije (1980), obdelal najbolj občutljivi del v tem prispevku obravnavanega ozemlja zahodno in vzhodno od Ljubljanske kotline. Njegovo kinematsko izhodišče o zgradbi Posavskih gub je povsem drugačno od našega in smo ga kritično že obdelali v razpravi o Posavskih gubah (P l a c e r, 1998, ta revija), zaradi česar analize tukaj ne bomo ponavljali. Glavna pomanjkljivost njegove ideje je, da v bistvenih delih zanika faktografijo elementov strukture, na kar je K u š č e r (1975) že opozoril. Zaradi tega moramo njegovo narivno interpretacijo zavrniti. Poudariti pa je treba, da je na podlagi podatkov Osnovne geološke karte Jugoslavije prvi podrobneje obdelal stik med Južnimi Alpami in Zunanjimi Dinaridi na območju osrednje Slovenije, da je v tem prostoru prvi uporabil strukturno-facialno analizo in da je prvi opozoril na pomen transformnih prelomov pri interpretaciji geneze paleosedimentacijskih prostorov v Dinaridih in njihovega mesta v sedanji zgradbi. Transformnih prelomov v tem prispevku nismo obravnavali, pomenijo pa tudi po naših raziskavah enega bistvenih elementov razumevanja zgradbe alpsko-dinarsko-panonskega prostora.

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