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Tectonic Structures Along the Periadriatic Lineament in Slovenia

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Key words: Periadriatic lineament, Karavanke, Tectonic structure, Zone of Periadriatic lineament, Northern Karavanke thrust, Velunja thrust, Olševa-Košuta thrust, Southern Karavanke thrust.

Ključne riječi: Periadrijatski lineament, tektonska struktura, Zona periadrijatskog lineamenta, navlaka sjevernih Karavanka, Velunja navlaka, navlaka Olševa-Košuta, navlaka južnih Karavanka.

Abstract

The Periadriatic lineament extends from the Sesia zone in Italy across southern Austria into Slovenia, in the area of the Karavanke mountains. It continues eastwards into the Pannonian basin in Hungary as the Balaton line. The Karavanke mountain range runs from Slovenia in the east westwards into the Carnian Alps of Austria. Further east they extend beneath the Tertiary sediments of the Pannonian basin into Hungary. The Karavanke mountains represent a boundary zone between the Eastern Alps to the north and the Julian and Savinja-Kamnik Alps or Southern Alps to the south. The Periadriatic lineament intersects the eastern part of the Karavanke mountains from Austria, trending eastwards, dividing this unit into the Northern and Southern Karavanke.

Geologically, the Karavanke mountains consist of Palaeozoic, Mesozoic (mostly Triassic) rocks and Tertiary sediments. In the eastern part of the Karavanke mountains, along the Periadriatic lineament, there is a belt of magmatic rocks, granite in the north and tonalite in the south, with a narrow belt of metamorphic rocks in between.

The tectonic structure of the aforementioned boundary zone is especially interesting. New research results show that both the overall structure and individual tectonic units respectively of this zone steeply deep towards the south beneath the Julian and Savinja (Kamnik) Alps. The Karavanke mountains are on the north thrusted over Eastern Alps by horizontal movements along single faults. Among these faults, the Periadriatic lineament, along which the mentioned magmatic (granite - tonalite) zone appears, is especially interesting.

This paper attempts to define the sequence of tectonic movements which took place at the end of the Alpine geotectonic cycle, and the tectonic structure of the Karavanke Mt. zone.

Sažetak

Periadriatski lineament koji se pruža od Sesia zone u Italiji, preko južnoga dijela Austrije seže u Sloveniju na području Karavanki. Prema istoku se nastavlja na područje Panonskog bazena u Madžarsku kao Balaton linija. Karavanke se protežu iz pravca istoka u Sloveniji i u pravcu zapada se nastavljaju u Karnijske Alpe u Austriji. Na istok sežu pod tercijarne sedimente Panonskog bazena i prelaze u Madžarsku. Uzduž svog pružanja Karavanke predstavljaju graničnu zonu između istočnih Alpa na sjeveru i Julijskih te Savinjsko-Kamniških Alpa odnosno Južnih Alpa na jugu. U istočni dio Karavanki prelazi iz Austrije na istok Periadriatski lineament, koji razdvaja tu jedinicu na Sjeverne i Južne Karavanke.

U geološkoj građi Karavanki nastupaju paleozojske i mezozojske, pretežno trijaske naslage te tercijarni sedimenti. U istočnom dijelu Karavanki javlja se uzduž Periadrijatskog lineamenta pojas magmatskih stijena, granit u sjevernom i tonalit u južnom dijelu pojasa, a između njih se proteže uzak pojas metamorfnih stijena.

U geotektonskom smislu Karavanke predstavljaju graničnu zonu između Istočnih Alpa i Južnih Alpa. Posebno je zanimljiva tektonska građa spomenute granične zone. Noviji rezultati istraživanja ukazuju da strukture odnosno pojedine tektonske jedinice te zone padaju strmo prema jugu pod Julijske i Savinjske (Kamniške) Alpe. Prema sjeveru su Karavanke navučene na Istočne Alpe. Pri tom su zanimljiva relativna horizontalna kretanja uzduž pojedinih rasjeda. Među rasjedima je posebno značajan spomenuti Periadrijatski lineament, uzduž kojega se pojavljuje prije spomenuta magmatska (granitno - tonalitna) zona.

Analizom spomenutih rezultata novijih istraživanja, prikazat ćemo redoslijed tektonskih kretanja krajem alpidskog geotektonskog ciklusa i tektonsku građu ove zone.

1. INTRODUCTION

The Periadriatic lineament represents an important tectonic line. It extends from the Sesia zone in Italy across Austria into Slovenia and across the north-western part of Croatia into Hungary in the direction of the Balaton line (Fig. 1). Its total length exceeds 700 km. The geotectonic position, significance and length of the lineament attracted the attention of numerous researchers, whereby it has been given different names e.g. the "Alpine-Dinaric suture" SUESS (1909), the "Alpine-Dinaric boundary" TOLLMAN (1963), and the "Periadriatic lineament" of ANGENHEISTER & BÜGEL (1972).

The Periadriatic lineament extends in Slovenia from the Austrian border along the eastern part of the Karavanke mountains which it divides into the Northern and Southern Karavanke. The Eastern Karavanke form a

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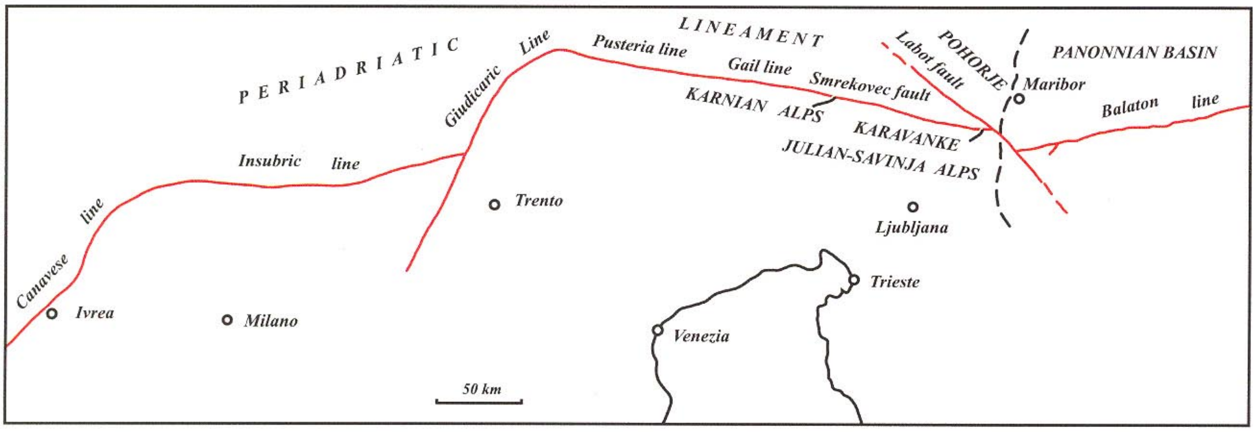

Fig. 1 The geographic position of the Periadriatic Lineament from Iverea zone in Italy to the Panonnian basin in Hungary.

belt 10 to 15 km wide, and approximately 60 km long from the boundary of the Pannonian basin to the east. The total length of the western and eastern part of the Karavanke mountains from Jesenice in the west to the Boč mountain and Pannonian basin respectively in the east exceeds 150 km (Fig. 2).

The Karavanke mountain range represents orogenetically, a very impressive mountain range which continues westwards into the Carnian Alps of Austria. It extends as a narrow belt along the Slovenian/Austrian border from west of Jesenice, eastwards via Košuta, Olševa and Boč, before passing into the basement of the Pannonian Basin.

The northern boundary of the Karavanke mountain range is defined, from the west to the east, by the Mežica-Vitanje tectonic ditch, and the southern part of Pohorje. At the southern side of the western part they are divided from the Julian Alps by the Sava fault, and are also surrounded by the Savinja Alps and the Velenje-Dobrna basin. The most eastern part of the southern Karavanke mountains extends into the area of Haloze.

The interesting geological composition of the Karavanke mountains has attracted the attention of many researchers. TELLER (1899) wrote about the geological structure of single parts of the Karavanke mountains, and produced maps for each of those parts. DIENER (1903), collectively named the Karavanke Mts., Carnian and Zilja Alps as the Drava belt (Drauzug).

RAKOVEC (1956) published an overview of the tectonic structure of Slovenia, including the Karavanke mountain area. ANDERLE (1970) wrote about the tectonic structure of the western part of the Karavanke mountains and BEMMELEN (1970) about the tectonics of the eastern part of the Southern Alps. In the same year, ŠTRUCL (1970) produced an overview of the geological structure of the northern part of the eastern Karavanke mountains in the area around Mežica.

Lately, the Karavanke area was studied for production purposes for the basic geological map, scale 1:100,000. The western part was studied by BUSER (1980) for the Celovec sheet. The eastern part was stud-

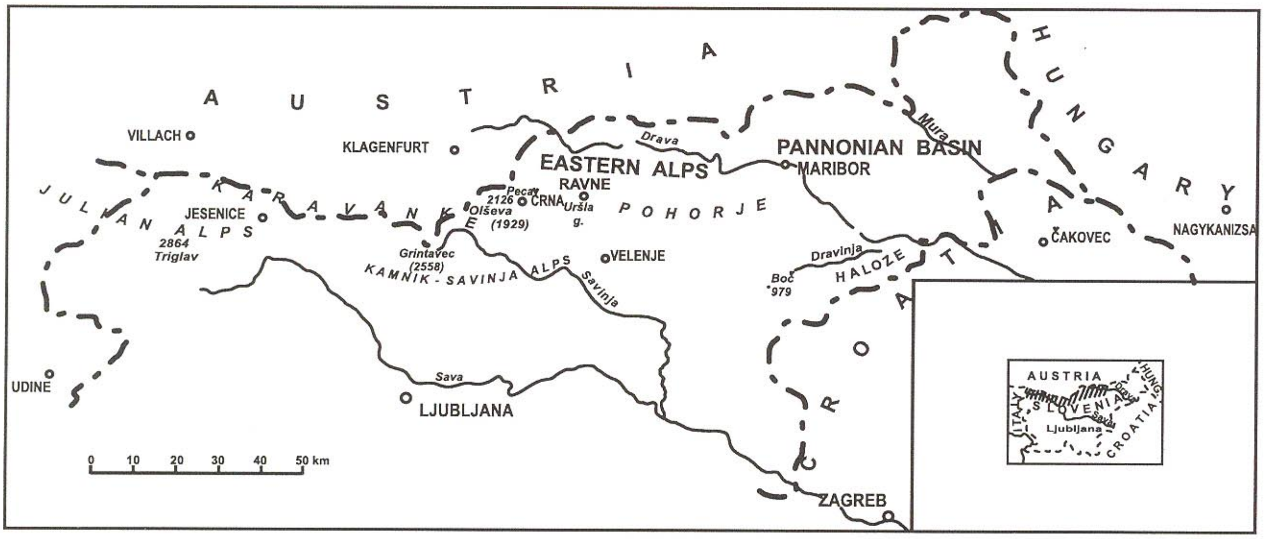

Fig. 2 The geographic position of the Karavanke Mountains.

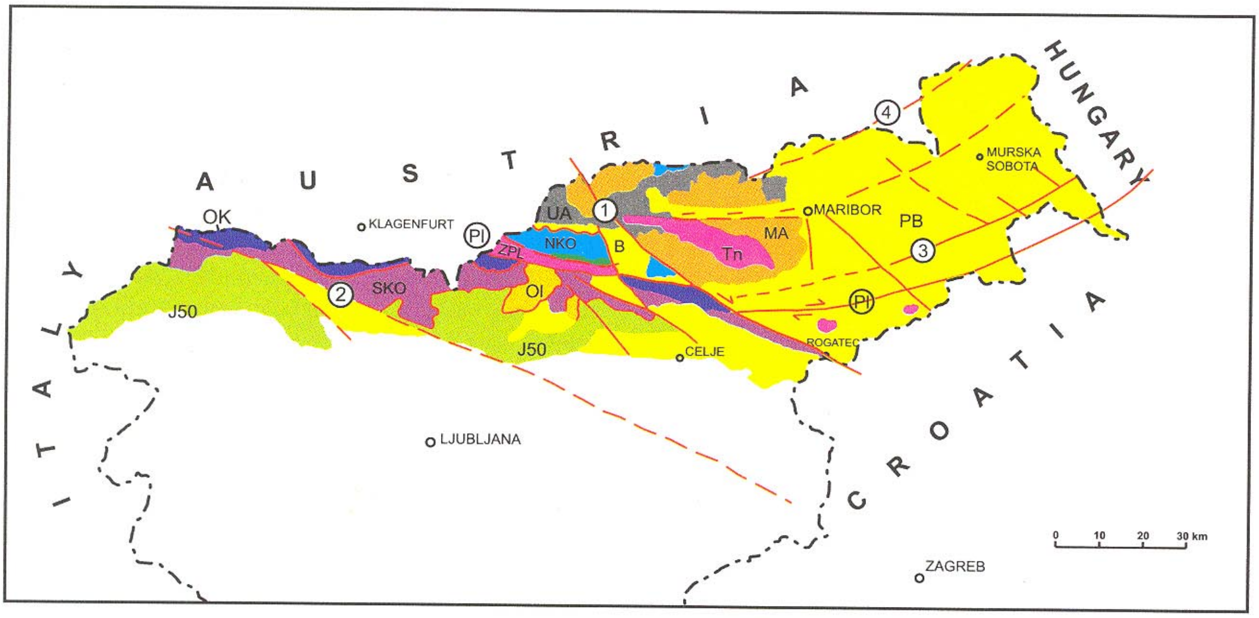

Fig. 3 A generalised tectonic map of the Karavanke Mts. with the boundary tectonic units of the Eastern Alps, Julian-Savinja Alps and Panonnian basin. Legend: JSO) Julian-Savinja units; SKO) South Karavanke overthrust; OK) Olševa-Košuta overthrust; PL) Periadriatic lineament; ZPL) Zone of Periadriatic lineament; NKO) North Karavanke overthrust; MA) Middle Austroalpine; UA) Upper Austroalpine; T) Tonalite of Pohorje; B) Neogene basins; PB) Pannonian basin; 1) Lavantal fault; 2) Sava fault; 3) Ljutomer fault; 4) Raba fault.

ied by MIOČ (1978, 1983) and MIOČ & ŽNIDARČIČ (1983) for the Slovenj Gradec and Ravne sheets. The most eastern extension of the Karavanke mountains, reaching into the Haloze area, was studied by ANIČIĆ & JURIŠA (1985) for the Rogatec sheet. These authors prepared geological maps and reviews of the geological structure of the studied areas.

The Periadriatic lineament runs along the Karavanke mountains and divides them into the Northern and Southern Karavanke. Near the system of faults, running along the lineament, there is an uplifted part of the metamorphic basement with granite and tonalite. Recently these rocks represent a zone dividing the Karavanke mountains into three parts. From north - south, these are: the Northern Karavanke, the Periadriatic lineament (ANGENHEISTER & BÖGEL, 1972) or zone of the Periadriatic seam (MIOČ, 1983, 1984, 1986) and the Southern Karavanke. In the western part of the Slovenian Karavanke mountains, between Jesenice to the west and Olševa to the east, only the Southern Karavanke Mts. occur reaching into Slovenia. From Olševa to the south to Peca to the north all the parts of the Karavanke mountains extend into Slovenia (Figs. 2 & 3).

2. STRATIGRAPHY

Subdivision of the Karavanke mountains into three parts was made according to lithological and stratigraphic characteristics as well as the tectonic structure of the single units. To facilitate correlation of the geological development with the neighbouring areas of the Karavanke mountains, we represent accretionary diagrams for the complete Eastern and Southern Alps (Fig. 4).

The Northern Karavanke are formed from Siluro-Devonian, Permo-Triassic and Jurassic rocks. The Siluro-Devonian beds are composed of phyllitoidic slates with single plates of diabase in between. These beds are known as the Magdalensberg Series (RIEHL-HERWIRSCH, 1970).

The Permo-Triassic clastic sedimentary rocks unconformably overlie the Lower Palaeozoic slates and phyllites of the consolidated pre-Alpine basement. These sediments are represented by reddish sandstones and conglomerates of the "Veruccano"-type, which originated from weathering of the surrounding metamorphic rocks, and to a lesser extent acid volcanic rocks. They are conformably overlain by the Lower Triassic clastic carbonate rocks.

In the Triassic (Scithian) Series there are sandstone, shale and bedded limestone. Dolomite as well as thin bedded limestone of the Anisian follow. The Ladinian is represented by clayey marl beds in the lower part (Partnas beds) with crystalline limestone and dolomite known as the Wetterstein beds on top of them. Marls and limestones occur in the Carnian sequence and are followed by the Norian-Rhaetian beds - Main Dolomite (Hauptdolomit) and Dachstein limestone. Bedded limestones with cherts and clayey marl sediments belong to the Jurassic, although these Mesozoic rocks extend from the Lias to the Lower Cretaceous.

The Jurassic sediments in the lower parts of lithologically heterogeneous sequences are formed from limestone breccias, which are overlain by reddish to greenish platy micritic limestones, which contain clayey mixtures and grade into calcite shales (RAMOVŠ

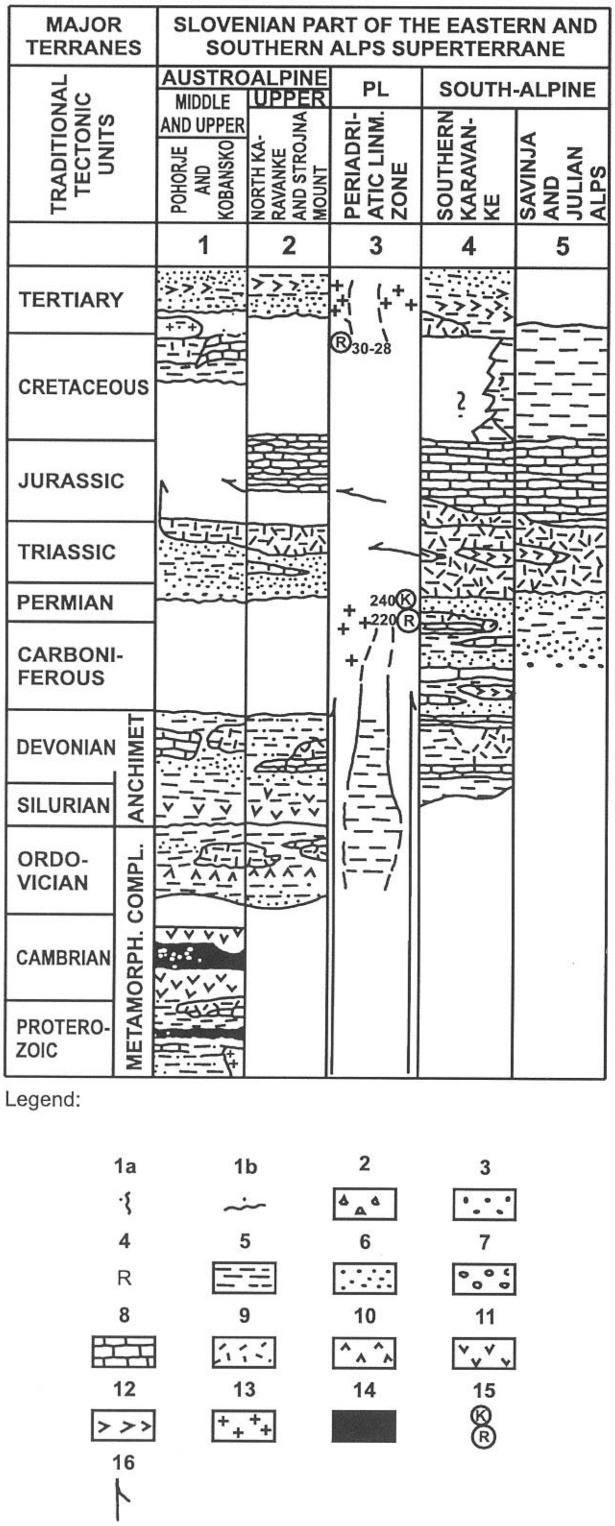

Fig. 4 Accretionary diagrams of the Eastern and Southern Alps in Slovenia. Legend: 1a) facies change; 1b) uncorformity; 2) tillites; 3) continental clastics; 4) red beds. Marine enviroments: 5) pelites; 6) arenites; 7) conglomerates; 8) pelagic carbonates; 9) shallow water carbonates. Volcanic rocks: 10) felsic; 11) mafic; 12) intermediate; 13) plutonic rocks; 14) ophiolitic sequence; 15) ages: K = K-Ar; R = Rb-Sr; 16) post-accretionary thrust.

& REBEK, 1970). These sediments are interlayered with radiolarian cherts. This basinal sequence was deposited during the Lias, Dogger, Malm and Berriasian-Valanginian as indicated by characteristic fossils (MIOČ & ŠRIBAR, 1975). The limestone radiolarite sequence was also thrusted from the south over the lithological units of the Northern Karavanke. Based on lithological correlation, it can be assumed that this sequence was deposited in the northern, distal parts of Tethys.

The Zone of Periadriatic lineament runs along the northern contact of the Periadriatic lineament and extends from Austria into Slovenia near Črna eastwards, and wedges out along the faults, north-east from Velenje, continuing as a fault into the Pannonian basin. The mentioned zone is up to 43 km in length in Slovenia and up to 3.5 km wide (ŠTRUCL, 1970).

The zone consists of a granite belt in the north, a metamorphic belt in the central part and a tonalite belt in the south. The granite belt on the northern side is in tectonic contact with rocks of the Magdalensberg Series, and on the southern side in primary contact with the metamorphic belt. Along this primary contact, the neighbouring rocks were incorporated into a granitic magma thus forming intrusive magmatites, (agmatites and venites), in the boundary part of the granite and cordierite schists (slates) and appear near the contact in the metamorphic belt (Fig. 5). However, many varieties of granite exist in the granite belt, ranging from fine grained, medium grained to porphyritic granite. In some parts, e.g. Čofati hill, the granite grades into granitoid, and in some places to diorite.

The beginning of the Alpine Orogeny was characterized by intense rifting, which resulted in strong magmatic activity. In the initial phase there was a granite intrusion. Relics of granite, formed at that time, are today found along the Periadriatic lineament. Numerous authors have published papers on the granite, including EXNER (1973, 1976), FANINGER & ŠTRUCL (1970), MIOČ (1983, 1984) and others. Isotope analysis of the granite gave the following results: K-Ar = 245-210 Ma, U-Pb = 230 Ma and Rb-Sr = 224-216 Ma (CLIFF et al., 1974; SCHARBERT, 1975), according which the granite and the granite intrusion, respectively, are of Upper Permian - Triassic age.

In the metamorphic belt there are phyllites (Ordovician-Silurian), amphibolites and gneisses, which are considerably older. In the Upper Oligocene the tonalite massif originated (K-Ar and Rb-Sr 30-28 Ma, SCHARBERT, 1975).

The Southern Karavanke consists of the Devonian, Carboniferous, Permian, Triassic, Jurassic and Tertiary sediments. In the Lower Devonian there is bedded limestone, overlain in part by reddish breccia. The Middle Devonian reef limestone with corals and hydrozoa follows and in the Upper Devonian there are bedded limestones and shales.

The Lower Carboniferous developed as a flysch sequence. This includes shales, graywacke, olistostrome breccia, quartz conglomerates and single beds of dark limestone. Appearances of quartz porphyry and tuff are also characteristic. The molasse sedimentation began in the Upper Carboniferous, and is represented

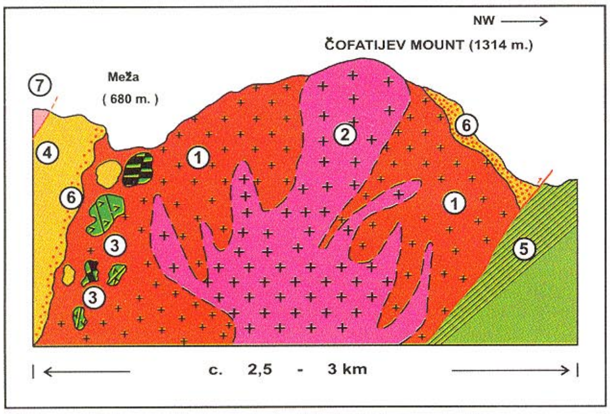

Fig. 5 Schematic cross-section of the Karavanke-granite zone by Črna. Legend: 1) granite; 2) porphyroid-granite; 3) enclaves of the gneiss, amphibolite and diabase; 4) gneiss and phyllites; 5) Magdalensberg series (greenish slates intruded by diabase sills); 6) kornites; 7) tonalite.

by quartz sandstones and conglomerates as well as shales with single beds of limestone containing micro and macro faunal remains.

In the Lower Permian there are Trogkofel organogenic limestones, shales, sandstones and conglomerates. Trbiž breccia and Gröden clastic layers lie above these beds. The Neoschwagerina limestone is a stratigraphic equivalent of the mentioned Gröden layers. In the Upper Permian there are grey limestones with fossil fauna and dolomite.

The age of the Palaeozoic, Carboniferous and Permian sediments has been proven with numerous fossils studied by Ramovš and partly Kochansky-Devidé. The fossil fauna has been cited by BUSER (1980) and MIOČ (1978, 1983, 1984).

The Triassic begins with yellowish dolomite lying on the Upper Permian beds. It is followed by shales, shaly marls, sandstones and single horizons of bedded limestones. In the Middle Triassic (Anisian) there is bedded dolomite, single horizons of bedded limestones which continue into the Ladinian. Beds of marl and volcanic rocks (keratophyres and tuff) appear in the Ladinian, as well as bedded limestones and dolomites. The Upper Triassic - Carnian is represented by limestones, dolomites and marls, while for the Norian-Rhaetian Main Dolomite and Dachstein limestone are most characteristic.

The Jurassic is represented by bedded limestones with cherts and reddish marl. The lithological development of these beds is similar to that in the Northern Karavanke, and it is assumed that they originate from the same marine basin.

The Eocene limestones are the oldest Tertiary sediments of the Karavanke mountains. They appear as erosional remnants on the Upper Triassic deposits. Some of the clastites (marls), which overlie these limestones and are included into the Oligocene, are in fact of Eocene age.

In the Upper Oligocene there are breccias, sandstones and marls and characteristic andesite tuff. The tuff is most abundant in the eastern part of the Southern Karavanke. Beside the tuff there are also volcanic breccias and "outflows" or single beds of andesite. The mentioned vulcanites are also known as the Smrekovec Series (MIOČ, 1983). These sediments continue towards the east into the area of Hrvatsko Zagorje (ŠIMUNIĆ & PAMIĆ, 1993) and further into the Pannonian basin.

The Neogene sediments surround the Northern Karavanke and the eastern parts of the Southern Karavanke. They are represented by clastic sediments which stratigraphically range from the Ottnangian to Pliocene.

The Quarternary sediments infill river valleys and cover the slopes of the Alps. The most interesting are the glacial sediments, especially moraines being preserved at three different altitudes.

3. TECTONICS

The geotectonic position and corresponding geological and tectonic composition of the Karavanke mountains have intrigued many researchers. Numerous authors (WINKLER, 1924; KAHLER, 1953), have discussed the tectonics of the Karavanke Mountains, including RAKOVEC (1956) who assumed that the Košuta thrust was shifted northwards. The same thrust was mentioned by BUSER (1980) who interprets it to be shifted southwards. ANDERLE (1970) discovered, while researching the Austrian part of the Western Karavanke, that the tectonic units in this part were thrust towards the north. ŠTRUCL (1970) wrote about the tectonics of the Northern Karavanke in Slovenia and also mentioned the thrust of the Northern Karavanke.

SIKOŠEK (1971) defined the Karavanke mountains geotectonically as the Alpine-Dinaride boundary zone. HERAK (1986) included the Karavanke mountains together with the Julian and Savinja Alps into the Supradinaricum.

According to the results of the latest geological investigations, the Northern and Southern Karavanke were each divided into two tectonic units, between which lies the Periadriatic zone and Periadriatic lineament, respectively. In the Northern Karavanke these are the Northern Karavanke thrust and the Velunja thrust (MIOČ, 1978, 1983, 1984). They are followed by the Periadriatic lineament and after that the Olševa-Košuta thrust and the Southern Karavanke thrust.

The Northern Karavanke thrust (Fig. 6) consists of the Middle and Upper Triassic deposits with the Jurassic layers caught between them. This unit is thrusted northwards over the Tertiary sediments of the Mežica-Vitanje tectonic ditch. A single tectonic klippen of this thrust has been preserved on metamorphic rocks in the area of Strojna, and on Oštri vrh (Sveti Duh) of Kobansko. The tectonic klippen shows the former size of this thrust which later disintegrated and was to a large extent eroded.

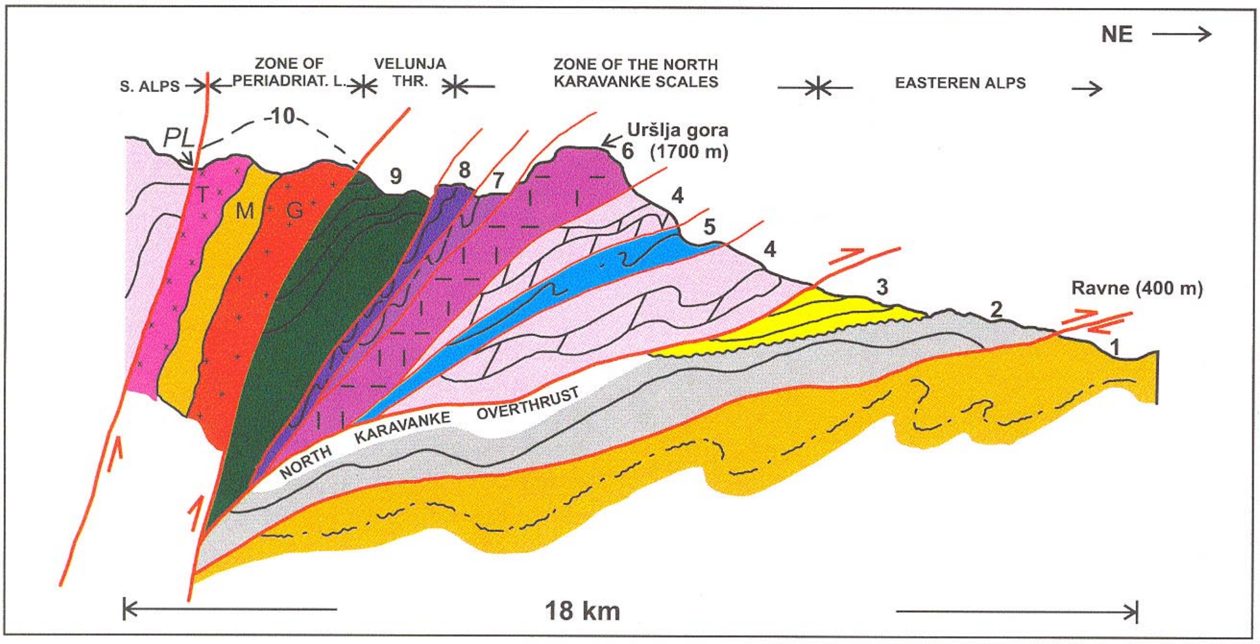

Fig. 6 Schematic cross-section of the Northern Karavanke, from the Periadriatic zone of the south to the Eastern Alps of the north. Legend: 1) gneiss; 2) phyllites; 3) Miocene deposits; 4) Upper Triassic dolomite; 5) Jurassic deposits; 6) Middle Triassic-Wetterstein limestones and dolomites; 7) Karnian layers; 8) Lower Triassic deposits; 9) Magdalensberg series; 10) granites (G), metamorphic rocks (M), tonalites (T).

Single parts of the thrust were stacked over each other along reverse faults during later tectonic activity. These stacks represent an entire thrust of Triassic beds and Jurassic pelagic sediments which were all thrusted over the metamorphic basement of the Eastern Alps. Five single stacks were estimated within the frame of the Northern Karavanke thrust. Thrusting over the crystalline rocks north of the present Karavanke mountain area had already taken place in the Upper Cretaceous. Later thrusting over the Neogene sediments occurred somewhere at the end of the Neogene at the time when the Alps were uplifting, indicating a gravitational component to this thrusting.

The Velunja thrust (named after the river Velunja) was thrusted northwards on to the Triassic deposits of the Northern Karavanke thrust. From the southern side, the granite of the Periadriatic zone has been thrusted over the Velunja thrust along a reverse fault. The composition of this tectonic unit includes old Palaeozoic slates of the Magdalensberg Series which dip southwards under the granite.

The Periadriatic lineament extends from Austria into Slovenia as the Periadriatic zone. The zone is bounded by two reverse faults and it plunges southwards. The reverse faults are the Cofatia fault on the north and the Periadriatic lineament, locally named Smrekovec fault, on the south (Figs. 5-7). The zone extends eastwards to Paški Kozjak where it wedges out and runs as a lineament towards the south-eastern Pohorje. The eastern extension of the Periadriatic lineament is cut by the Labot fault, which runs in a NW-SE direction along the south-western Pohorje, where the extension of the Lineament is shifted towards south-east. The eastern and north-eastern extension continues along the Dravinja river, then along the Drava valley, south from Ormož, and further towards Čakovec, extends into the Panonnian Basin and runs towards Balaton in Hungary.

The geological composition of the Periadriatic zone includes a granite belt, metamorphic and tonalite belts. This zone represents a part of the continental crust, which was cut along a fault and after horizontal-vertical movement reached the surface. Structural elements, including foliation and lineation in the metamorphic belt, are parallel to the Lineament, and the foliation dips steeply (70 - 90°) towards the south. The parallel lineation dips towards the west and south-west (60 - 80°), which proves horizontal-vertical movements along the Lineament.

Generally, the Periadriatic lineament represents the tectonic boundary between the Eastern Alps in the north and the Southern Alps (Julian Alps and Karavanke mountains in Slovenia). Single parts of the lineament have local names, e.g. the Canavese line, Insubric line, Guidicaric line, Pususteria line, Gail line, Smrekovec line, and in Hungary the Balaton line (Fig. 1).

The Olševa-Košuta overthrust extends from the Austrian border in the west, via Košuta, Olševa, Boč and Haloze, respectively, towards the east into the basement of the Pannonian basin. It consists mostly of the Upper Triassic deposits and to a lesser extent, of the Jurassic deep marine sediments. In the eastern part, in the area of Olševa, this unit bounds to the north to the Periadriatic lineament and dips towards the south (reverse fault), under the Southern Karavanke thrust. The contacts of these two units are clearly visible especially on the southern slopes of Olševa (Fig. 7), where the Upper Carboniferous beds of the Southern Kara-

Fig. 7 The tectonic contact of the Olševa-Košuta unit with the Southern Karavanke unit on the southern slopes of Olševa. Legend: CP) Upper Carboniferous - Permian beds (of the Southern Karavanke thrust); T) the Upper Triassic dolomites (milonitised) of the Olševa-Košuta unit.

vanke thrust overthrust the Upper Triassic sediments (Main Dolomite) of the Olševa-Košuta unit. The Jurassic sediments are usually trapped between the Triassic sediments.

The Southern Karavanke overthrust (Fig. 8) consists of the Devonian, Carboniferous, Permian and Triassic beds. The structural elements have, in general, southern vergence. In isolated places, the beds are folded and single parts of the unit disintegrated into numerous smaller parts. The general position of this tectonic unit as a whole also verges towards the south. In the western part of the Southern Karavanke it dips under the Julian Alps and in the eastern part of the Southern Karavanke under the Savinja Alps.

4. DISCUSSION

The state of the single tectonic units, in the area directly adjacent to the Periadriatic lineament, is considerably different from the structural state of the tectonic units regionally, e.g. in the Slovenian part of the Eastern Alps and in the Julian and Savinje Alps. Tectonic klippen of the Northern Karavanke, thrust on the

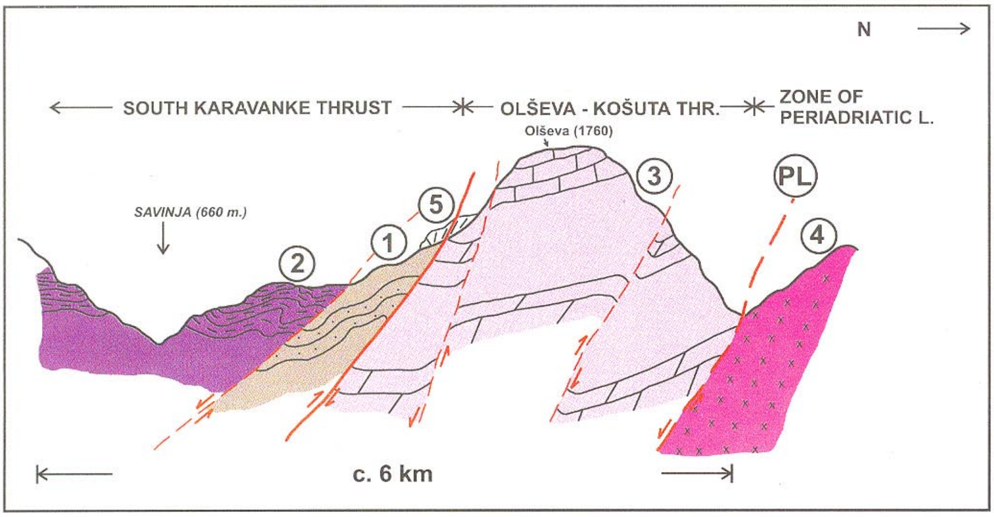

Fig. 8 Schematic cross-section of the Southern Karavanke Mts. from the Periadriatic lineament to the Savinja river. Legend: 1) Permo-Carboniferous layers; 2) Triassic sediments; 3) Upper Triassic dolomites (Main Dolomite) and Dachstein limestones; 4) tonalite; 5) Quaternary rock-fall breccia; PL) Periadriatic lineament.

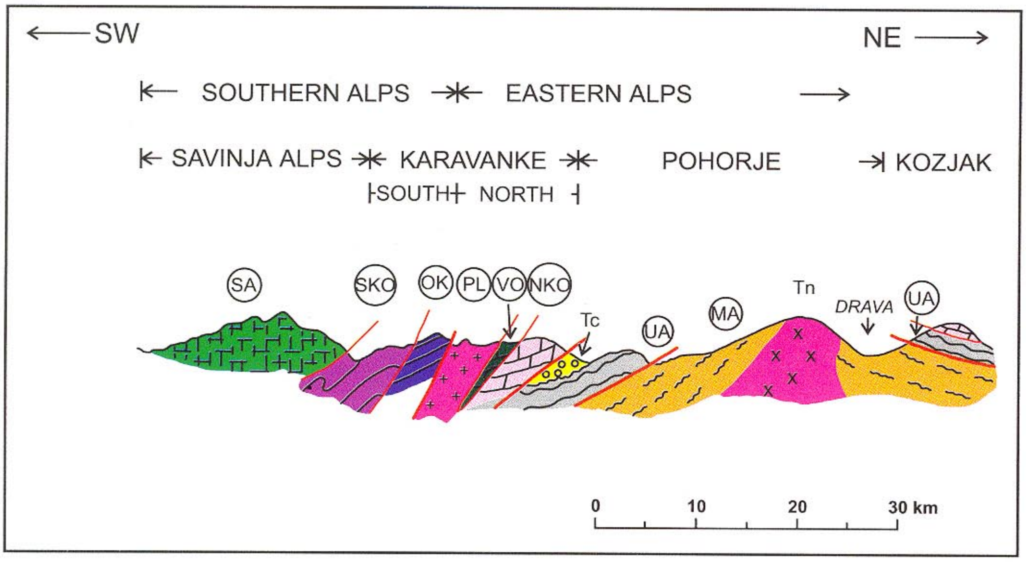

Fig. 9 Schematic cross-section between Kozjak and the Savinja Alps. Legend: SA) Savinja Alps (overthrust); SKO) Southern Karavanke thrust; OK) Olševa-Košuta thrust; PL) Zone of the Periadriatic lineament; VO) Velunja thrust; NKO) North Karavanke thrust; Tc) Tertiary deposits; MA) Middle Austroalpine; UA) Upper Austroalpine; Tn) tonalite.

metamorphic complex has a subhorizontal position, while tectonic units near the Periadriatic lineament are subvertical (Fig. 9).

The force producing these thrusts, as far as we know, was provided by the movement and collision of two "microplates" - the Adriatic (Apulian) and the Eastern Alps (Austroalpinic) microplate in the Upper Cretaceous and the Tertiary. Due to the movement of the Adriatic plate towards north, the thrust of the Southern Alps appeared in the same direction (FRISCH, 1978), and their thrust over the Eastern Alps (Ostalpinum) in the Upper Cretaceous. At that time, single thrusts consisting of the Lower Palaeozoic slates, (e.g. the Strojna and Remšnik thrust) were shifted in the Slovenian part of the Eastern Alps, as well as the Northern Karavanke thrust (of the Triassic-Jurassic sediments) which was thrusted over the Lower Palaeozoic rocks.

Collision of the microplates also caused disintegration of the southern margin of the Eastern Alps plate. Classical thrusting stopped, but the continental crust was dislocated and the horizontal-vertical (transcurrent) movements of the single blocks appeared along the mentioned faults. Single blocks from the basement disintegrated the above laying sediment complexes and some parts, like the Periadriatic zone, came to the surface (Fig. 10).

The horizontal movements are especially distinctive along the Periadriatic lineament, where large facies differences of the same stratigraphic units, recently lying north and south of the Periadriatic lineament can be seen. For example, the Permo-Triassic was deposited in the area of the Eastern Alps in a form of continental clastic formations, whereas South of the Periadriatic lineament the Permian and Triassic form a marine development. In Lombardia similar Permo-Triassic sediments lie south of the Periadriatic lineament and have the same mineralogical composition as those in Austria and Slovenia. On the basis of this, we can conclude that these sediments formed a cohesive regional sedimentary unit. The Triassic and Jurassic sediments on Košuta, included into Košuta-Olševa tectonic unit, were once the same tectonic unit with the corresponding layers of the Northern Karavanke thrust.

It can be concluded that the Periadriatic lineament was active after overthrusting of the Northern Karavanke thrust. The Periadriatic zone reached the surface during or after the Miocene, as shown by the inclusions of tonalite from the Karavanke mountains in the granites of the Ottnangian - Karpathian sediments (MIOČ, 1978).

With continuing approach of the Adriatic and Austroalpinic micro-plates, subduction of the Eastern Alps micro-plate and anatexa of its active southern margin occurred. A granitoidic magma was produced as a consequence of these processes. It seems that mafic magma was partially contaminated by continental crust in the southern part of the subduction and anatexic zones, respectively. The result of this mixing was the Karavanke tonalite enriched with hornblende. The same magma gave rise to the intense andesitic volcanism. In the Upper Oligocene, a sialic island ridge with a system of volcanoes, which can be traced through the whole of Slovenia from Jesenice to Rogaška Slatina, where it crosses to Croatia, was formed along the northern margin of the Southern Karavanke. South of this ridge, a basin was formed in which sedimentary-volcanogenic material was deposited (MIOČ et al., 1986). Deposition proceeded from the northern margin area into the basin by mudflows, as reflected in the sedimentary textures developed. In the northern part of the basin there are coarse to fine grained sediments (from breccia to pelite) with graded bedding, while in the southern part there are mostly laminated layers of turbiditic character. This complex of volcanogenic sediments is called the Smrekovec Series and reaches a thickness of approximately 1,000 m (MIOČ, 1983).

Northwards, in the area of Pohorje, granitoidic magma having textural characteristics of tonalite contains mostly biotite instead of hornblende as a characteristic mineral. Dacite appears as its effusive equivalent. It

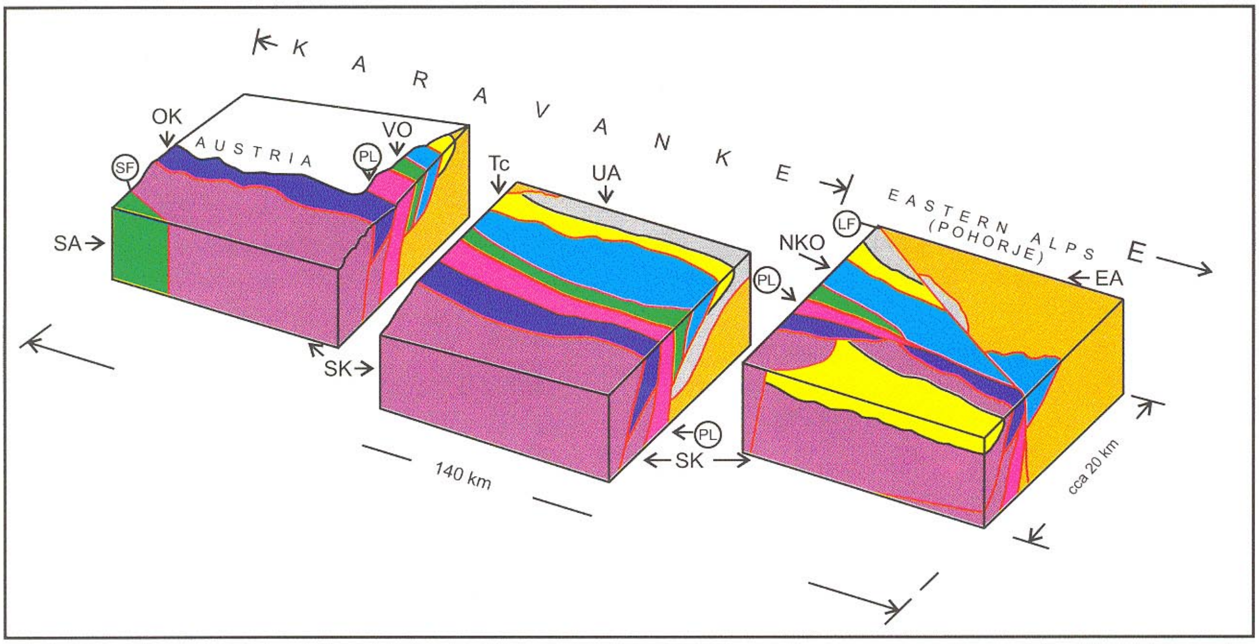

Fig. 10 Schematic block-diagrams of the Karavanke Mts. on the border with Eastern Alps. Legend: SA) Julian and Savinja Alps unit; SF) Sava fault; SK) Southern Karavanke overthrust; OK) Olševa-Košuta overthrust; PL) Zone of Periadriatic lineament; VO) Velunja ovethrust; NKO) North Karavanke overthrust; Tc) Tertiary; EA) Eastern Alps metamorphic complex.

seems that this intrusion occurred a little later, when the Miocene dacite volcanism took place in the Carpathian. It seems like this part of the intrusive zone was less contaminated with mafic admixtures. In the Miocene (Ottnangian-Carpathian), sedimentation expanded, and a transgression appeared from the southern part towards the north from the Lineament.

Uplifting of the Alps during the Plio-Quaternary caused gravitational overthrusting; from the uplifted parts of the area, over the younger Neogene sediments along the margin of the Northern Karavanke.

The Potočka zijalka palaeolithic station is the most conclusive proof of the intense uplifting in the Quaternary. There, the remains of plants and animals, the food sources of palaeolithic man occur covered by fluvial deposits.

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