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GEOTECTONIC MODEL OF THE ALPINE DEVELOPMENT OF LAKAVICA GRABEN IN THE EASTERN PART OF THE VARDAR ZONE IN THE REPUBLIC OF MACEDONIA

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Abstract: Lakavica graben is located in the eastern subzone of the Vardar zone, which during the Alpine orogenesis was covered with very complex processes of tectogenesis. On the area of about 200 km², in the Lakavica graben, are present geological units from the oldest geological periods (Precambrian) to the youngest (Neogene and Quaternary). Tectonic structure, or rupture tectonic, is very intense developed and gives possibility for analysis of the geotectonic processes in the Alpine orogen phase. This paper presents the possible model for geotectonic processes in the Lakavica graben, according to which can be generalized geotectonic processes in the Vardar zone during the Alpine orogeny.

Key words: Lakavica graben; geotectonic model; Alpine orogeny; Vardar zone

INTRODUCTION

Vardar zone as a tectonic unit, for the first time, is separated and showed on the "Geological-tectonic map of Dinarides and a part of Karpato-Balkanides" from F. Kossmat (1924). Later, the zone is studied by several investigators: Dimitrijević M. (1974), Karamata S. (1974), Arsovski et al. (1984), Ivanov T. et al. (1987), Dumurdžanov et al. (1990), which, from aspect of global tectonic, gave plate – tectonic models according to which Vardar zone is determined as rift zone, subduction zone, faulting zone, peeling and overlapping and zone of tectonic melange. Today, Vardar zone is determined as ophiolite structure (rift), or geotectonic unit that separates Dinarides on west from Serbian–Macedonian massif, Rodopian and Karpato–Balkanides on east. With length of above 1000 km, it is assumed that Vardar zone starts north from Belgrade, than stretches toward south along Serbia and central Macedonia, with width of 60–80 km, and goes toward south to the Thessalo-

niki Gulf (Greece), than bent eastward and crosses the ophiolite zone Izmir–Ankara (Turkey).

Vardar zone is old structure (Arsovski et al., 1984) which was formed with crushing of the Grenville earth's crust in Riphean Cambrian. Until Triassic, Vardar zone is characterized with geosynclinals development, tended to thinning the earth's crust. With rifting processes in the mediterranean part of Tethys, in Jurassic was formed narrow ocean, and in the Vardar zone was created ocean type of crust.

In the Vardar zone, based on the determined differences in the lithological composition and structure, three subzones with orientation NNW–SSE are separated: eastern Vardar subzone, central Vardar subzone and western Vardar subzone (Fig. 1).

In the eastern Vardar subzone, in their middle part (south-southeast from Štip) is situated Lakavica graben.

TECTONIC CHARACTERISTICS OF THE LAKAVICA GRABEN AND WIDER VICINITY

The territory of the Republic of Macedonia enters into the composition of Mediterranean oro-

gen area, where geosyncline conditions of development and riftogenesis finished in the end of Pa-

leogene and early Neogene, when started continental development. The first phase of continental development, during the Miocene, there was penetration of the structures created by Pyrenean and Savian orogeny stage. Relics of plateaus

formed in this period can now be found on Mountains ridges of different heights. In some places these plateaus are covered by Pliocene and Quaternary sediments.

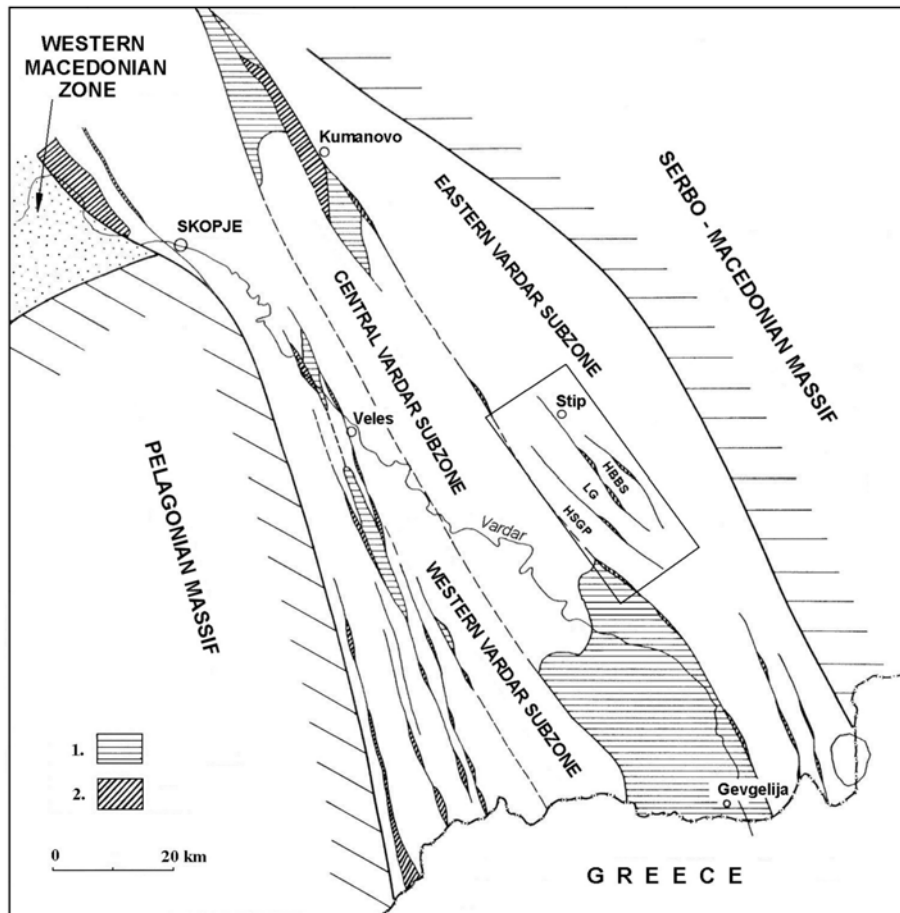


Fig. 1. Tectonic zoning of the Vardar zone on the territory of the Republic of Macedonia (Dumurdžanov N. et al., 1990)

1. Relics of Vardar oceanic crust, 2. Main parts of tectonic ultramafites,

LG – Lakavica graben, HBBS – horst Bučim block–Smrdeš, HSGP – horst Serta–Gradeški Mountains

At the beginning of Neogene, or in the middle of Miocene, the first depressions were formed, such as Skopje and Kumanovo depression.

During Pliocene were activated tectonic processes and were formed structures of rising and sinking, which today can be seen in the contemporary relief. The process of differential movements between depressions and horsts over the time increased, leading to activation of old and formation of new faults, which are edge faults of the created morpho-structures.

Lakavica graben is located in the Vardar zone. It is long about 40 km with average width of around 5 km. It is relatively sinked block with ori-

entation NW-SE, between the horst Serta–Grdeški Mountains and the horst Bučim block–Smrdeš (Fig. 1). From the southwest, Lakavica graben is limited with the horst Serta–Smrdeški Mountains along the contrast normal (gravitational) fault. The horst Bučim block–Smrdeš which is characterized with very complex morphological structure limits the Lakavica graben on the northeast.

General conclusion is that all morphostructures on the area of the Lakavica graben have regular position that results from the tectonic processes which took place in Alpine period of the geological development on the territory of the Republic of Macedonia.

GEOLOGICAL COMPOSITION OF LAKAVICA RIDGE

In the wider vicinity of the Lakavica graben are present rocks from Precambrian, Palaeozoic, Mesozoic, Tertiary and Quaternary (Fig. 2).

Precambrian complex is presented with high metamorphic rocks (different types of gneisses, micaschists, graphitic schists, amphibolites, quartzites, marbles and cipollino marbles).

Lower Paleozoic complex occurred in the horst Serta–Gradeški Mountains. In this complex are separated: series of amphibole schists and marbles and schistose-carbonate series composed of

carbonate schists, cipollino marbles, marbles and chlorite-amphibolite schists. Igneous rocks are presented with gabbros.

Mesozoic is presented with Jurassic acid igneous rocks (Štip granites) with granite, quartz-monconite to granodiorite composition.

Cretaceous sediments occurred in the horst Bučim block–Smrdešh (near the locality Močarnik), where transgressively lied over the Štip granites. They are presented with basal conglomerates, marls, sandstones and slates.

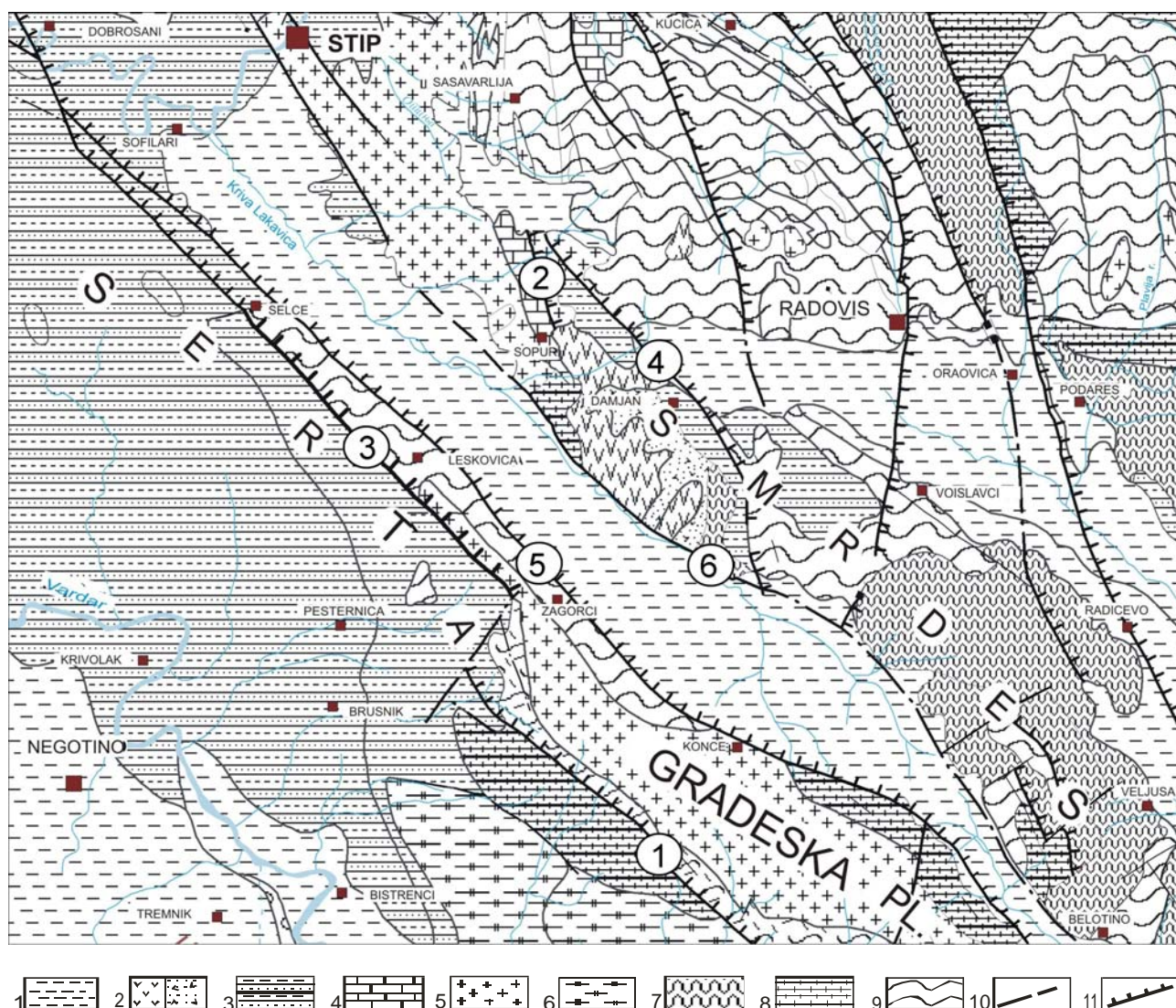


Fig. 2. Geological map of the wider vicinity of Lakavica graben

- 1 – Quaternary and Neogene sediments, 2 – Tertiary volcanic rocks, 3 – Upper Eocene flysch sediments, 4 – Cretaceous sediments,
- 5 – Jurassic (and older) granitoides, 6 – Jurassic gabbro-diabases, 7 – Lower Paleozoic complex, 8 – Riphean Cambrian complex,
- 9 – Precambrian complex, 10 – faults, 11 – peels

Tertiary is presented with Upper Eocene terrigenous sediments in which, according to the lithological composition are separated: basal lithozone, lower flysch lithozone, lithozone of yellow sandstones and upper flysch lithozone.

Tertiary volcanism is presented with: andesites, latites, quartz–latites, trachytes and pyroclastic rocks (mainly on the contact with Serbian–Macedonian massif).

Pliocene sediments occurred in Lakavica graben with gravels, sands, clays and sandy clays with thickness over 200 m.

RESULTS AND DISCUSSION

Vardar zone since its formation, in Riphean Cambrian–Lower Paleozoic (before Lower Jurassic) had geosyncline development, with a tendency to thinning of the Earth's crust. In Lower Jurassic in the central parts of paleo-Vardar structure led to the opening of the Earth's crust and the formation of oceanic type of crust (Fig. 3). Rift development in the Vardar zone lasted from Lower Jurassic to Upper Jurassic, when it came to creating thick ophiolite masses. In the Tetonian came to closure of the rift with the one sided subduction eastward. The result was the creation of a long strip of granitoides (Štip granites, Serta, Gradeški Mountains etc.).

In the upper Jurassic–lower Cretaceous with subduction, generally eastward, under the continental crust of the Serbian–Macedonian massif, in the further development of the Vardar zone and beyond, have changed several times the compression mode with mode of extension, with orientation east–west. Such a direction of compression and extension conditioned orientation of Paleozoic, Mesozoic and Paleogene rocky complexes, faults and fault blocks and axes of the folding structures in direction NNW–SSE with N–S.

The first phase of compression took place in the period of uppermost Jurassic–lowermost Cretaceous (young Cimmeric orogeny phase). As a result of this compression, in the wider vicinity of the Lakavica graben were formed several reversed faults (peels) with overlapping toward west–southwest.

In Albian–Cenomanian–Turonian–Senonian, in conditions of extension, were formed graben structures filled with flysch and flyschoidal sediments (presented with conglomerates, marls, sandstones and slates).

Along the flow of the river Kriva Lakavica are developed Quaternary gravels and sands with thickness to 100 m.

In the wider vicinity of the Lakavica graben are confirmed many rupture structures (faults and peels). These are longitudinal structures with orientation NW–SE. They are old ruptures that several times over the geological history were reactivated and have important role in the formation of Lakavica graben and surrounding horsts.

The second compression phase started in Paleocene (Laramide orogeny phase). As a result of this compression, from northeast toward southeast, on the terrain of Lakavica graben comes to formation of several reversal faults (peels). Along the Vučjačka peel (Fig. 2,1) granites from the Gradeški Mountains are overlapped along the ophiolite complex Demir Kapija–Gevgelija, and along the Koševo peel (Fig. 2,2) Štip granites are overlapped over the Albian–Cenomanian sediments (near the locality Močarnik).

In the Upper Eocene again started mode of extension, when there were formed more graben structures. In this period there was a sinking of the space of Lakavica graben along SW Lakavica fault (Fig. 2,5) and NE Lakavica fault (Fig. 2,6). These faults were reactivated in the Pliocene, when it was formed Lakavica graben.

After Upper Eocene maximum transgression, when much of the region of Lakavica graben was covered with Upper Eocene epicontinental, continental and flysch sediments in the Upper Oligocene–Lower Miocene (Pyreneic and Savian orogeny phase) the space of Lakavica ridge was subjected to intense compression of the northeast side as a result of repeated compression of the Serbo–Macedonian massif on the Vardar zone. With this compression upper Eocene sediments were folded, and the folds were formed which were mostly slope and inverse southwest. It also led to the formation of reversal faults and peels, along which there was a tectonic diapire intrusion of tectonic ophiolites. Along Serta peel (Fig. 2,3) and Damjan peel (Fig. 2,4) occurred overlapping from NE to the SW on the Paleozoic schists and Jurassic granitoides through Upper Eocene sediments (Fig. 4).

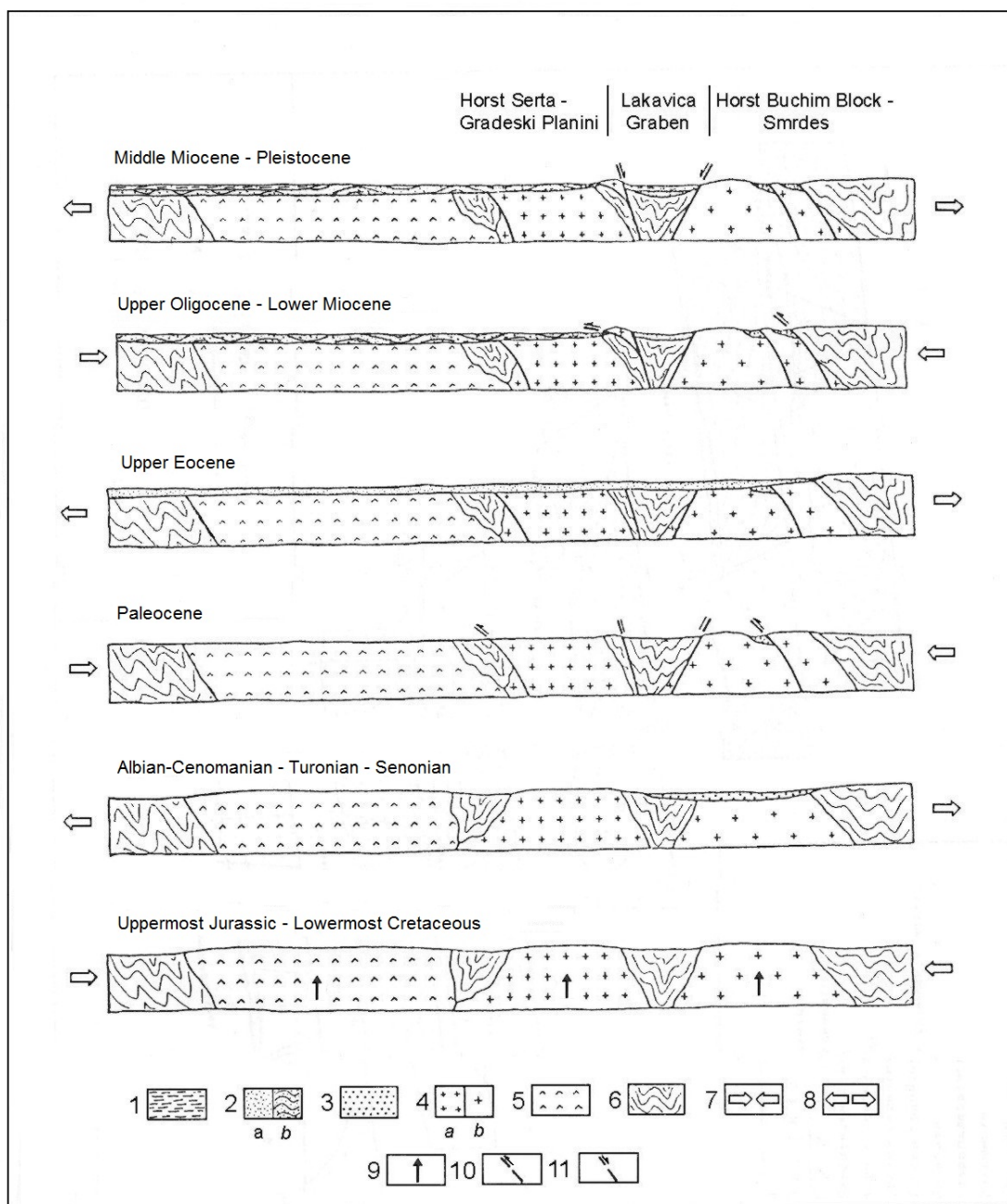


Fig. 3. Geotectonic model of Lakavica ridge in Alpine orogeny cycle

1 – Pliocene sediments, 2 – upper Eocene sediments, 3 – Cretaceous sediments, 4 – Jurassic granitoides, 5 – gabbro – diabases, 6 – Paleozoic and Precambrian metamorphic rocks, 7 – compression, 8 – extension, 9 – vertical rising through the compression, 10 – overlapping, 11 – gravitational sinking

At the end of Oligocene and the beginning of Miocene in the Vardar zone starts the period of extension. In the period of middle Miocene to Pleistocene were formed numerous neotectonic continental grabens filled with lake sediments.

In this period on the territory of the Lakavica graben comes to penepplanation of the before formed morpho-structural forms and formation of denudation plateaus. Relics of these plateaus today

are found on different heights (400–600 m in horst Serta–Gradeški Mountains, or 600–800 m in horst Bučim block–Smrdeš).

In the Miocene–Pliocene proceeded intense volcanic activity of andesite–latite–quartzlatite composition, and in Pliocene–Pleistocene basalt and alkali basalt composition.

Definitive Lakavica graben formation began in the Pliocene with reactivation of older faults

with NW-SE orientation (SW Lakavica fault and NE Lakavica fault), as a result of the extension strain in the Vardar zone. With the departure of the horst Serta–Gradeški Mountains from the horst Bučim block–Smrdeš and gravitational descent of the block between the two horsts was formed Lakavica graben.

Especially important in this area is SW Lakavica fault, which is a regional fault that cuts deep crust in this part of the Vardar zone. This is an old fault, along which during on Jurassic, on more places occurred diapire intrusion on tectonic ultrabasites and later was reactivated several times.

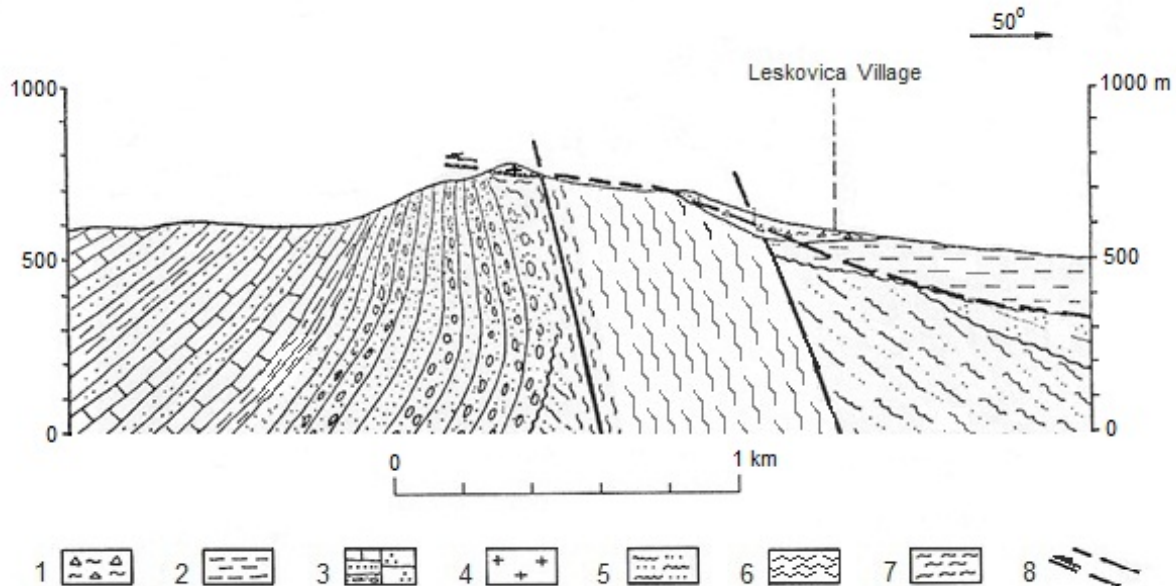


Fig. 4. Geological profile near the village of Leskovica

1 – deluvium, 2 – Pliocene sediments, 3 – Upper Eocene sediments, 4 – Jurassic granites, 5 – biotite gneisses, 6 – crushed zone, 7 – mylonitization, 8 – faults and peels

CONCLUSION

Although Lakavica graben is a relatively small structure, which together with the wider environment covers an area of about 200 km², can serve for quite accurately reconstruction of geotectonic processes in Alpine orogeny. The same can be generalized on entire area on the Vardar zone on the territory of the Republic of Macedonia. Namely, before creating of the Lakavica graben (in the Pliocene), the resulting strain extension in Alpine orogeny epoch, continental collision was fol-

lowed by three periods of compression that existed between periods of extension. The first compression period is related to the young Cimeric orogeny stage, the second compression period is associated with the Laramide orogeny stage and the third with Pyreneic–Savian orogeny phase. The result of these tectonic processes and refolding and folding, faulting, peeling and overlapping toward west-southwest to all newly created and older formations.

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Резиме

ГЕОТЕКТОНСКИ МОДЕЛ НА АЛПСКИОТ РАЗВОЈ ЛАКАВИЧКИОТ ГРЕБЕН ВО ИСТОЧНИОТ ДЕЛ НА ВАРДАРСКАТА ЗОНА ВО РЕПУБЛИКА МАКЕДОНИЈА

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Клучни зборови: Лакавички грaben; геотектонски модел; Алпска орогенеза; Вардарска зона

Лакавичкиот грaben се наоѓа во источната субзона на Вардарската зона, која за време на Алпскиот ороген циклус била зафатена со многу сложени процеси на тектогенеза. На површина од околу 200 km², во Лакавичкиот грaben се застапени геолошки единици од најстарите геолошки периоди (прекамбриум) до најмладите (неоген и квартер). Тектонската градба, особено руптурната текто-

ника, е интензивно развиена, што дава можност за расчленување на геотектонските случувања во Алписката орогена фаза.

Во овој труд е презентираан веројатен модел на геотектонските процеси во Лакавичкиот грaben, преку кој може да се генерализираат геотектонските процеси во Вардарската зона за време на Алписката орогенеза.