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TECTONICS EVOLUTION OF THE PALEOGENE BASINS IN THE REPUBLIC OF MACEDONIA

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A b s t r a c t: Paleogene sediments on the territory of the Republic of Macedonia are widespread, especially in its central and eastern parts, i.e. in the Vardar zone and Serbo–Macedonian massif (Kraisthide zone). After Laramide orogeny compression, in expansion conditions, along the gravitational faults, continental trenches were created on these spaces, with general direction NW–SE, in which paleogene molassa sediments were accumulated. In the Vardar zone, continental trenches are extended to the north to Skopska Crna Gora mountain (north of Skopje), which includes the Skopje–Kumanovo basin, Ovče Pole basin, Tikveš basin, Gevgelija–Strumica basin and Valandovo basin. In Kraisthide zone continental trenches stretches along the border with Bulgaria and it includes Deve Bair basin and Delčevo basin. Bearing in mind the different thickness of the allocated Paleogene lithozones in the separate basins, and the fact that in some basins lithozones absent, it can be assumed that their spreading along trenches were segmented by cross faults with NE–SW direction. Cross faults are mainly contemporaneous faults.

Key words: Paleogene; molassa sediments; continental trench; contemporaneous fault

INTRODUCTION

After the final closure of the Vardar Ocean and finishing processes of collision with Laramide orogeny phase (Latest Cretaceous–Paleocene), the southern parts of the Balkan Peninsula (the territory of Macedonia, southern Bulgaria, northern Greece and eastern Albania), in the Eocene–Oligocene period, became in the conditions of expansion in the south Balkan extension region (SBER) (Dumurdžanov et al. 2005). This extension system belongs to a much wider area, separated as Aegean extension region (Sengor et al. 2004) (Fig. 1).

Besides the intensive tectonics of Paleogene sediments with Pyrenian orogeny and Savian orogeny compression (folding, faulting and shelling), lithostratigraphy of these sediments is relatively simple. Along the edge parts of the basin, sediments are represented by coarse conglomerates and sandstones, while internal parts are represented by finegranular sediments, marlstone, clay and others. They are transgressive through the older formations, from Precambrian to Mesozoic.

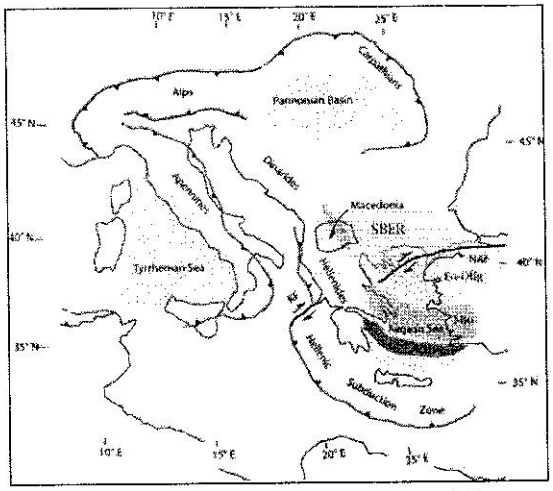

Fig. 1. Simplified tectonic map of the Eastern Mediterranean region showning Southern Balkan Extensional Region (SBER – horizontal lines) in relation to selected tectonic features. In Balkan region, position of the volcanic arcs of Eocene–Oligocene age (Eo-Olig); Miocene (Mio), and Pliocene to Recent (Active); are shown. The location of Macedonia is outlined. KF – Kefalonia fault zone; NAF – North Anadolska fault zone (taken from Dumurdžanov et al. 2005)

In all these basins, Paleogene sediments have been identified as Upper Eocene–Priabonian and Lower Oligocene (Pavlović 1926; Темкова 1958, 1967; Mitrović et al. 1990; Džuranov et al. 1999: Туцева 2000). The total thickness of Paleogene sediments (Upper Eocene–Lower Oligocene) is evaluate at about 3 000–3 500 m.

STRATIGRAPHY OF PALEOGEN IN THE R. MACEDONIA

According to the spatial expansion, Paleogene in R. Macedonia can be divided into 4 main (larger) basins and a few isolated blocks, usually located along the shells with NW-SE orientation. These are: Tikveš, Ovče Pole, Skopje–Kumanovo and Delčevo basin as the main basins and Deve Bair, Dedeli–Rabrovo (near Valandovo) and Ilovica–Štuka in Strumica valley, as isolated blocks (Fig. 2).

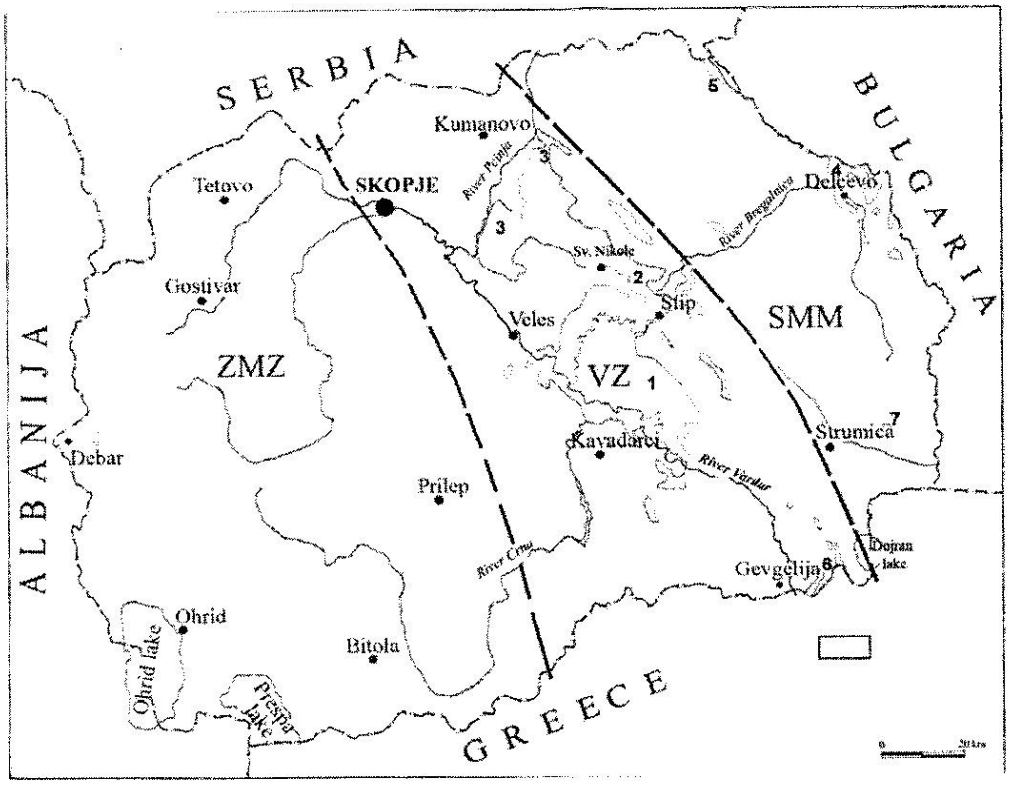

Fig. 2. Distribution of Paleogene sediments in Macedonia
1– Tikveš basin, 2 – Ovče Pole basin, 3 – Skopje–Kumanovo basin, 4 – Delčevo basin, 5 – Valandovo–Gevgelia basin, 6 – Strumica basin, 7– Deve Bair basin

With lithostratigraphical studies to Paleogene sediments in the basins of R. Macedonia, five superpositional lithostratigraphical units (litozones) were separated: basal lithozone, low flysch lithozone, lithozone of yellow sandstones, upper flysch lithozone and Oligocene lithozone (Fig. 3).

Basal lithozone ($^1E_3$) starts with basal conglomerates and sandstones, clay stone and kalkarenits (all in red and purple color) lay above. This zone is presented in all Paleogene basins on the territory of the R. Macedonia. Thickness of this lithozone varies from 350–700 m. Paleontological is documented in the Tikveš basin, with large macrofauna, represented by Molusca and Anthozoa (Maksimović et al. 1954).

Lower flysch lithozone ($^2E_3$) is a thick about 1100 m. It is developed in Tikveš, Ovče Pole and Deve – Bair basin with rhythmically replacement of red and gray conglomerates, sandstones, claystones and marlstone and alevrolites. In Deve Bair basin, in the rhythms of the zone volcanogenetic sediments appear. In the upper stratigraphic levels Priabonian snails, shells, coral and macroforaminifer fauna are determined (Темкова 1958).

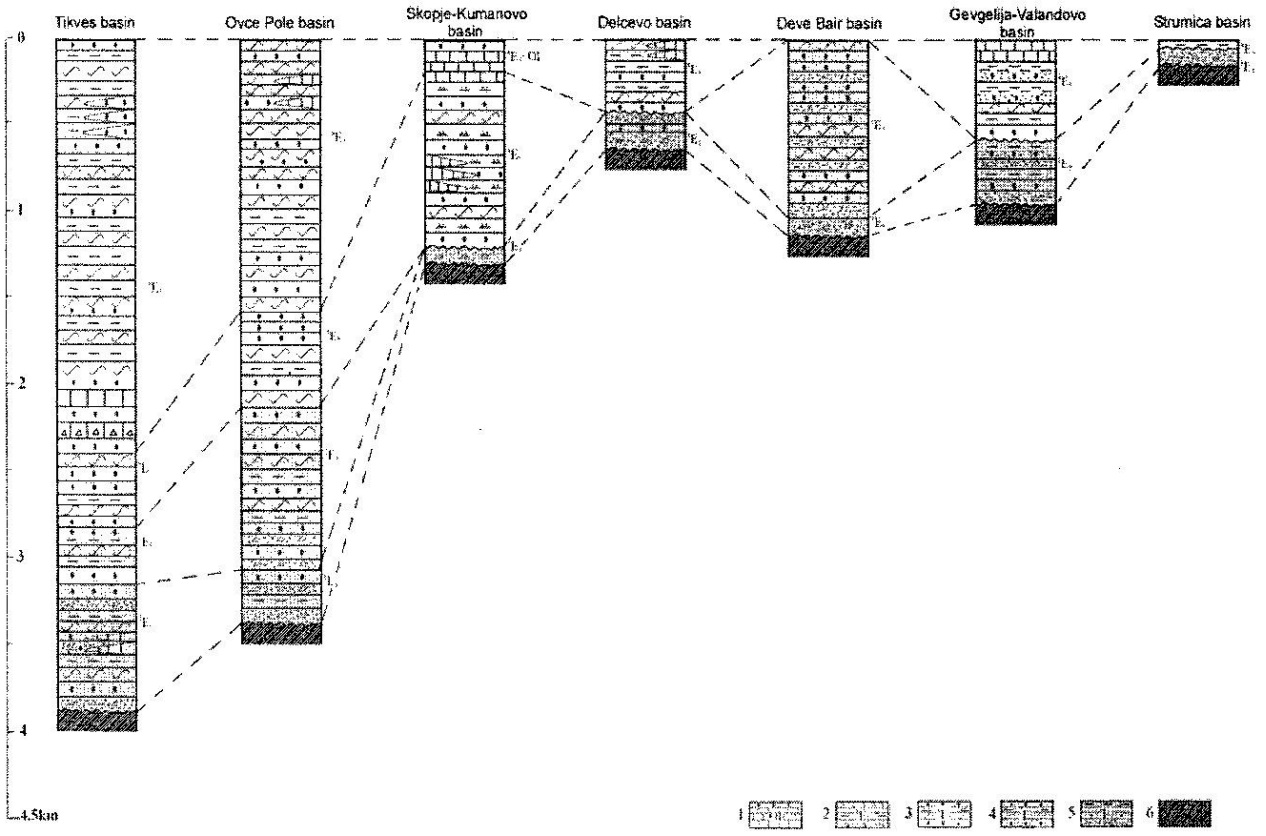

Fig. 3. Correlation of Paleogene basins in the Republic of Macedonia
1 – lower oligocene sediments, 2 – upper flysch lithozone, 3 – lithozone of yellow sandstones, 4 – lower flysch lithozone, 5 – basal lithozone, 6 – paleorelief

Lithozone of yellow sandstones ($^3E_3$) is thick from 600 to 1000 m. It is present in Tikveš and Ovče Pole basin, where vertical and lateral passes in the top flysch lithozone, while in Skopje–Kumanovo basin sediments that belong to this lithozone were moved out into the sediments with Oligocene age. Lithozone of yellow sandstones is determined as Priabonian with large foraminifer fauna, snails, corals, shells and more (Темкова 1967).

Upper flysch lithozone ($^4E_3$) is thick from 1000 – 2000 m. The greatest thickness (about 2000 m) is presented in Tikveš basin (based on data from drilling). Characteristic for this lithozone is its gray color. In the upper flysch lithozone gray sandstone, marls and claystones are present and on the top are limestones, with obvious gradation, convolution and lamination.

All levels of the lithozone are rich in snails, shels and foraminifer fauna, while in the upper limestone layers are determined: *Nummulites fabiani, Nummulites incrassatus, Nummulites budensis, Operculina alpina, Discocyclina angastae* (Maksimović et al. 1954, Ракичевиќ et al. 1976) and microforaminifer fauna of Priabonian age (Džuranov et al. 1999).

Oligocene sediments are preserved with thickness from 200–300 m in some parts of Ovče Pole basin (in the vicinity of Kočani) and in Skopje –Kumanovo basin. This lithozone begins with ridge gray limestones, with typical marine fauna the sandstones are above them and on the top ends with clay stones.

Limestones have typical shallow character. In the lower part they are in breccious, and in the upper part move into corale limestone. The age of limestone is problematic, because despite Oligocene types of Nummulti (*Nummulites intermedius* – typical oligocene kind), Anthozoa, Gasteropoda, Bivalvia and Echinodermata (Karajovanović et al. 1975), in fossil association occur species from Eocene to Oligocene. But according to stratigraphy position, lithologic composition and discovered fauna, the age of these sediments is determined as the lower Oligocene.

TECTONICS EVOLUTION OF PALEOGEN AND DEVELOPMENT OF ACUMULATION BASIN IN THE R. MACEDONIA

In terms of expansion and a general trend of segmentation in the wider region of the Balkan Peninsula, wide areas of the territory of the Republic Macedonia, primarily the area of the Vardar zone and Serbo-Macedonian massif (Kraisthide zone) and border areas with Albania (near Debar), during Upper Eocene were covered with differential vertical movements. Such processes of extension and vertical tectonics conditioned the formation of trenches, along which gradually entering marine waters from the south and southeast to the north and northwest. Today preserved Eocene–Oligocene masses with its geological position, extension and orientation suggest that the formation of trenches was controlled by the gravitational faults with a dominant direction NW–SE. Faults in this direction, often represent reactivated older faults, located in the border, very mobile, parts of the Vardar zone with Pelagonian massif (from west), Serbo-Macedonian massif (eastern side) and the newly formed fault lines in the Vardar zone and Serbo-Macedonian massif of the same orientation (NW–SE).

With the intensive transgression, because of the spreading of the sedimentation basin, sedimentation from the trenches expanded and spread to most of the Vardar zone. Towards north reach the terrains northeast of Skopje, and to the east covered the entire central and eastern Vardar subzone, and most of the Serbo – Macedonian massif (and Kraisthide zone). In that way, very wide sedimentary basin that existed in the Upper Eocene was formed.

The accumulation of Upper Eocene sediments began with continental terrigenous sediments, with red and red–violet color, presented by coarse conglomerates, sandstones and clay stones and thin layers of gray kalkarenites. With the gradual deepening of the area, sedimentation become sea type. Vertical sinking of the terrains was the most expressive in Tikveš basin, where sediments are formed by mass with thickness 3 000–3 500 m and in Ovče Pole basin to 3 000 m (Fig. 3).

Paleogene sedimentary masses from Tikveš, Ovče Pole and Skopje–Kumanovo basin presented, more or less, a whole, in places covered by Neogene or Quarter deposit or divided by a narrow neotectonics horst. The general orientation of this mass is NW–SE, conditioned by postlaramie faults segmentation of the area, with which trenches were formed and after which entering Eocene transgression with accumulation of sediments. Most of these fault structures were renewed in posteocene period, and because of that mass maintaining the same orientation. Small deviations in the extension of mass in the WNW–ESE direction are caused by faults of neotectonic stage.

After the forming of Late Eocene–Oligocene sediment mass, in the Lower Oligocene, it was covered with Pyrenian compression, and at the end of Oligocene and Lower Miocene with Savian compression. During these orogeny phases, intensive folding, faulting and sheathing was made towards the west. As a result, widespread Paleogene mass was segmented in a large number of partially or completely isolated blocks. Compression oriented east–west, conditioned folding of Paleogene sediments in discrete anticline and syncline form, often with an orientation NW–SE to N–S. With this compression, parallel with folding, creation of numerous faults and shells with NW–SE to N–S orientation starts.

RESULTS AND DISCUSSION

More conclusions can be done if analyzing the horizontal distribution of Upper Eocene–Lower Oligocene sediments (separated in 5 superpositional lithozone) in individual sedimentary basins, and analysis of the thickness of individual lithozone. Namely, it was mentioned that basal lithozone ($^1E_3$) is present in all Paleogene basins, suggesting that in this period sedimentation took place in relatively calm tectonic conditions. The thickness of the basal lithozone is the largest in Tikveš and Gevgelija–Valandovo basin, which means that in such a relatively calm tectonic conditions southern part of Paleogene sedimentary basin in the territory of the R. Macedonia sinking faster.

During the deposition of the lower flysch lithozone ($^2E_3$), differentiated vertical movements

in sedimentary basin took place. This lithozone is absent in Skopje–Kumanovo, Delčevo, Gevgelija–Valandovo and Strumica basin, which means that these regions were land in that time. This suggests that in addition to faults with spreading NW–SE (after formation of Paleogene trenches) existed transverse fault lines in NE–SW direction (Fig. 4), after which becomes differentiated vertical rising (or sinking).

In the Vardar zone, lower flysch lithozone has larger thickness in the Ovče Pole basin than in Tikveš basin, and it can be concluded that along the transverse contemporaneous fault, Ovče Pole basin is sinking faster. In border areas of Bulgaria (in Kraisthide zone) in the northern trench (Deve Bair basin) sinking was more intense compared to the southern part (Delčevo basin).

Lithozone of yellow sandstones ($^3E_3$), as the lower flysch lithozone is not continuous in all Paleogene basins. It is absent in Delčevo basin, Gevgelija–Valandovo basin and in Strumica basin. The trench in the Vardar zone has the greatest thickness in the Skopje–Kumanovo basin, and along the transverse fault sinked relatively faster compared to Ovče Pole and Tikveš basins. In the Serbo–Macedonian basin lithozone of yellow sendstones is not present, meaning that these areas were land.

In the final phase of Paleogene sedimentation, at the time of deposition of upper flysch lithozone ($^4E_3$), the Vardar zone and Serbo–Macedonian massif (Kraisthide zone) were under water. The southern parts of Vardar zone (Tikveš and Ovče Pole basin) sinking more intense compared to the northern parts (Skopje–Kumanovo basin). In Kraisthide zone southern of the trench (Delčevo basin) sinking more intense compared to the north, where the upper flysch lithozone is eroded.

In the Lower Oligocene (Ol) sedimentation took place mainly in the northern parts of continental trench along the Vardar zone. In Skopje–Kumanovo basin sinking was most intense, and in the SE terrains relative rising was present.

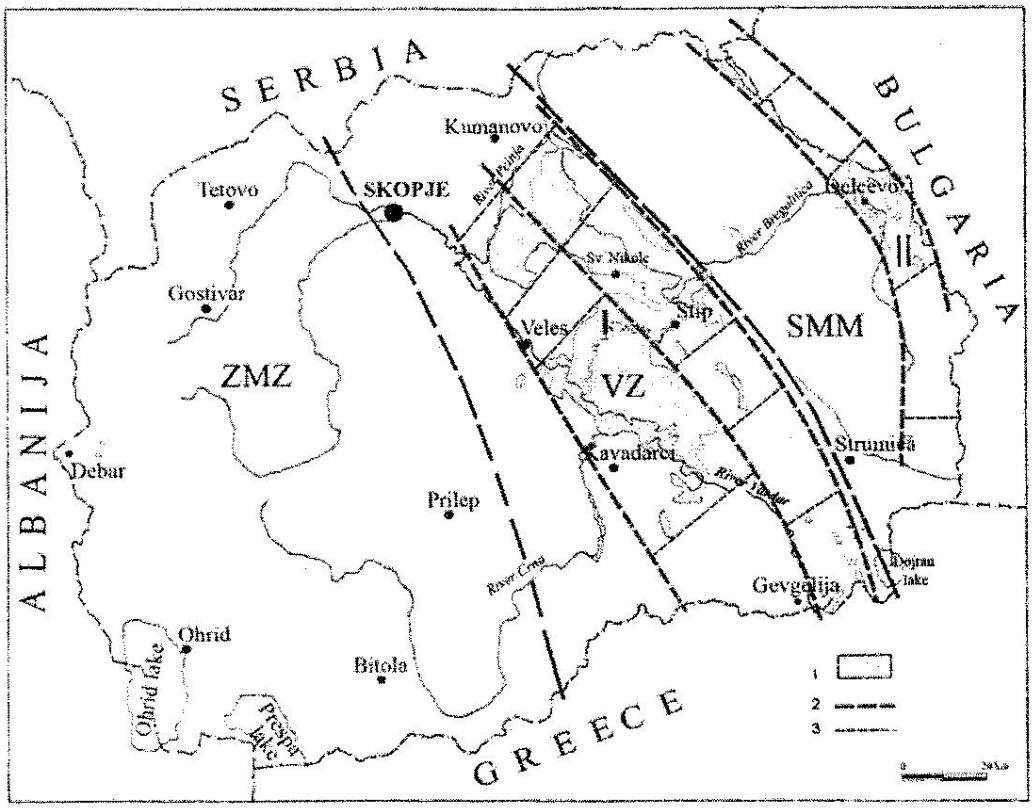

Fig. 4. Simplified tectonic map of the Paleogene in the Republic of Macedonia
Paleogene continental trenches: I – in Vardar zone, II – in Serbo–Macedonian massif (Kraisthide zone); 1 – paleogene sediments, 2 – longitudinal faults, 3 – cross (transverse) faults

CONCLUSION

On the territory of the Republic of Macedonia Paleogene sedimentary basins are present in two continental trenches formed in extension conditions along the gravitational fault lines with direction NW–SE. Continental trench that was formed in Vardar zone, starts north of Skopje–Kumanovo basin. Towards SE structure expands and includes the Ovče Pole basin, Tikveš basin, Gelgelija–Valandovo basin and Strumica basin. In the border belt with Bulgaria, in the Kraisthide zone, relatively narrower continental trench that covered Deve Bair basin and Delčevo basin was formed.

Besides gravitational edge faults, along which the continental trenches were formed, great significance for the course and character of the individual Paleogene sedimentation basins have cross–faults with NE–SW direction. Along these, mainly contemporaneous fault, during the Upper Eocene – Lower Oligocene differentiated vertical movements took place. As a result of such sinking or rising, big differences in thickness of individual lithozone (Fig. 3) appeared. In Tikveš basin and Ovče Pole basin the Paleogene lithostratigraphic columns are complete, while in other Paleogene basins one or two lithozones are missing (lower fhysch lithozone and the lithozone of yellow sandstone)

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Резиме

ТЕКТОНСКА ЕВОЛУЦИЈА НА ПАЛЕОГЕНИТЕ БАСЕНИ ВО РЕПУБЛИКА МАКЕДОНИЈА

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Клучни зборови: палеоген; моласни седименти; континентален трог; контемпорарен расед.

Палеогените седименти на територијата на Република Македонија се широко распространети, особено во нејзиниот централен и источен дел, односно во Вардарската зона и Српско-Македонскиот масив (Краиштидната зона). По Ларамиската орогена компресија, во услови на екстензија, на овие простори биле создадени континентални трогови, долж гравитациони раседи со генерален правец на протегање СЗ–ЈИ, во кои се таложеле палеогени моласни седименти.

Во Вардарската зона континенталниот трог на север се простирал до Скопска Црна Гора (северно од Скопје), во кој влегуваат Скопско-Кумановскиот басен, Овчеполскиот басен, Тиквешкиот басен, Гевгелиско-Валандовскиот басен и Струмичкиот басен. Во Краиштидната зона континенталниот трог се протега долж границата со Бугарија и во него влегуваат Девебаирскиот басен и Делчевскиот басен.

Имајќи ја предвид различната дебелина на издвоените палеогени литозони во поедините басени, и фактот што во некои басени некои литозони отсуствуваат, може да се претпостави дека троговите долж нивното протегање биле сегментирани со напречни раседи со протегање СИ–ЈЗ. Напречните раседи главно претставуваат контемпорарни раседи.

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