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LITHOSTRATIGRAPHIC CHARACTERISTICS OF PALEOGENE BASINS IN THE REPUBLIC OF MACEDONIA

Violeta Stojanova, Goše Petrov

Faculty of Natural and Technical Sciences, "Goce Delčev" University,
P.O. Box 201, MK 2001 Štip, Republic of Macedonia
violeta.stojanova@ugd.edu.mk//gose.petrov@ugd.edu.mk

A b s t r a c t: In this paper is given the lithostratigraphy of the Paleogene sediments in the basins on the territory of the Vardar zone and Serbian-Macedonian massif in the Republic of Macedonia. Within this research are separated lithostratigraphic units (lithozones) in Upper Eocene – Lower Oligocene sediments, we analyzed the thickness of lithozones and made a correlation between lithostratigraphic profiles of the Paleogene basins on the territory of the Republic of Macedonia.

Key words: lithostratigraphy; Paleogene basins; molassa sediments

INTRODUCTION

The Paleogene is one of the most intriguing intervals in the Earth history, marked by significant changes in paleodynamic, palaeoclimate and in marine productivity.

Paleogene sediments are widespread in the Republic of Macedonia and preserved with considerably thick masses on the Vardar zone, and in smaller relict masses on the Serbian-Macedonian massif. During the Upper Cretaceous-Paleocene, after closure of the Vardar Ocean and collision processes (Laramie orogeny phase), on the territory of the Vardar zone and Serbian-Macedonian massif, in conditions of extension, were formed continental trenches where Paleogene molassa sediments are deposited. Early accumulation of Paleogene sediments began with continental terrigenous sediments and, with gradual deepening of the environment, sedimentation was transformed into marine sedimentation. After the formation of the Eocene-Oligocene sediment mass, during the Upper Miocene-Oligocene, it was subjected to Pirinei-Sava compression, where Paleogene mass was dislocated, raised, faulted and exposed to intensive erosion.

Lithostratigraphical structure of Paleogene sediments in the basins can be analyzed on numerous open cross sections. Deep drilling was performed in the Tikveš and Ovče Pole basin (to 2703 m). Paleogene sediments have been identified as Upper Eocene – Priabonian and Lower Oligocene (Maksimovič et al., 1954; Dzuranov et al., 1999; Stojanova, 2008) with a maximum thickness of 3000 – 4000 m.

LITHOSTRATIGRAPHY OF THE PALEOGENE BASINS IN MACEDONIA

The territory of Macedonia sediments of Paleogeneage are widespread and show certain lithofaces diversity as a result of different conditions of sedimentation in sedimentation basins.

A general characteristic of Paleogene deposits is that they all lie transgressively through all older formations from Precambrian to Mesozoic that along the edges of the basins are represented by conglomerates and sandstones, while in the internal parts there are fine-grained sediments, marls and clays.

Paleogene in Republic of Macedonia is represented in 4 larger basins: Tikveš, Ovče Pole, Skopje-Kumanovo and Delčevo basins and a few isolated masses: Deve Bair, Valandovo-Gevgelia and Strumica, located along the shells and covers with NW-SE orientation (Fig. 1).

With lithostratigraphical studies of the Paleogene sediments in the basins of Republic of Macedonia, 5 superpositionally disposed lithostratigraphical units (lithozones) have been determined: basal lithozone ($^1E_3$), lower flysch lithozone ($^2E_3$), lithozone of yellow sandstones ($^3E_3$), upper flysch lithozone ($^4E_3$), carbonate-sandy lithozone (Ol_1).

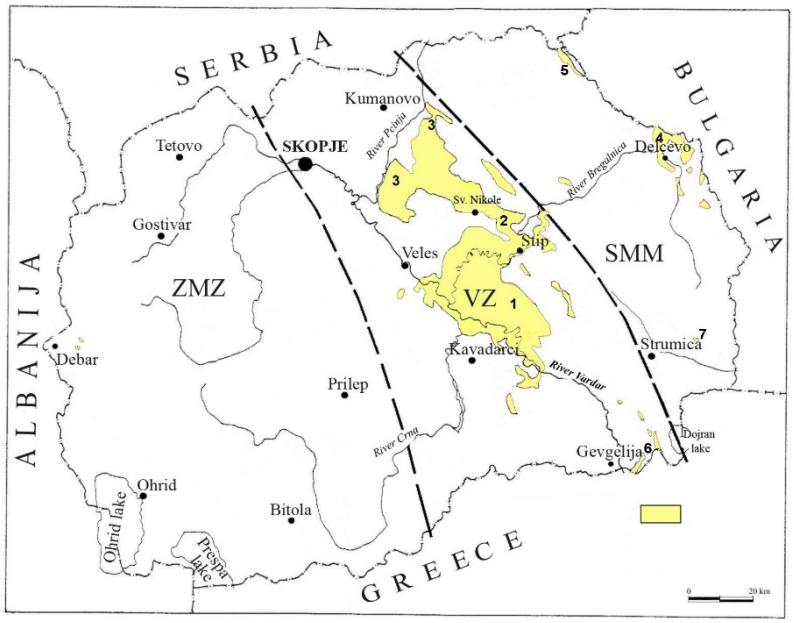

Fig. 1. Sketch of the locations of the Palaeogene basins in the Republic of Macedonia
Paleogene basins: 1 – Tikveš; 2 – Ovče Pole; 3 – Skopje-Kumanovo; 4 – Delčevo; 5 – Deve Bair; 6 – Valandovo-Gevgelia; 7 – Strumica, *Other abbreviations used*: Serbian-Macedonian Massif (SMM), Vardar Zone (VZ), Western Macedonian Zone (ZMZ).

LITHOSTRATIGRAPHICAL UNITS IN THE PALEOGENE BASINS IN THE REPUBLIC OF MACEDONIA

Tikveš basin

Tikveš basin is located in the SW part of the territory of Macedonia and belongs to the central part of the Vardar zone.

Paleogene sediments developed in the Tikveš basin, extending in the direction of NW-SE, occupy more than 20% of the area and have a great thickness that reaches 3000–3500 m. Most of these are found in edge parts of the Tikveš basin while the central parts of the basin are covered by Neogene and Quaternary deposits. Paleogene in the Tikveš basin is developed in flyschoid and flysch facies. Depending on the lithological composition of flysch in Paleogene sediments there are four lithostratigraphic units:basal lithozone, lower flysch lithozone, lithozone of yellow sandstones and upper flysch lithozone (Fig. 2)

The basal zone of the Tikveš basin is represented by conglomerates and sandstones which alternately change into clayey soil and sandy marls, and pelitomorphic limestone. The lower border of the basal lithozone is transgressive, and the upper border is concordant, and continuously passes into the lower flysch lithozone. The thickness varies from 350–700 m, and it is paleontologically documented with the large microfauna of Bivalvia and Anthozoa.

The lower flysch lithozone differs from other units by rhythmic occurrence and prevalence of sandstones over conglomerates, and by rare inner layers of clayey soil, marls, and aleurolites. The lower border is concordant and it represents a gradational transition of basal lithozone into lower flysch lithozone. The upper border is concordant and sharp, and it stands out because of the characteristic yellow-brown color of the sandstones covering the lower flysch lithozone. The thickness of the lower flysch lithozone is 300 m. Rich macrofauna represented with Gastropods, Bivalvia, Anthozoa and macroforaminifers is found in the sandy-clay member of this lithozone. The age of

the lower flysch lithozone is determined as belonging to Upper Eocene- Preabonian (Maksimovič et al., 1954; Temkova, 1958).

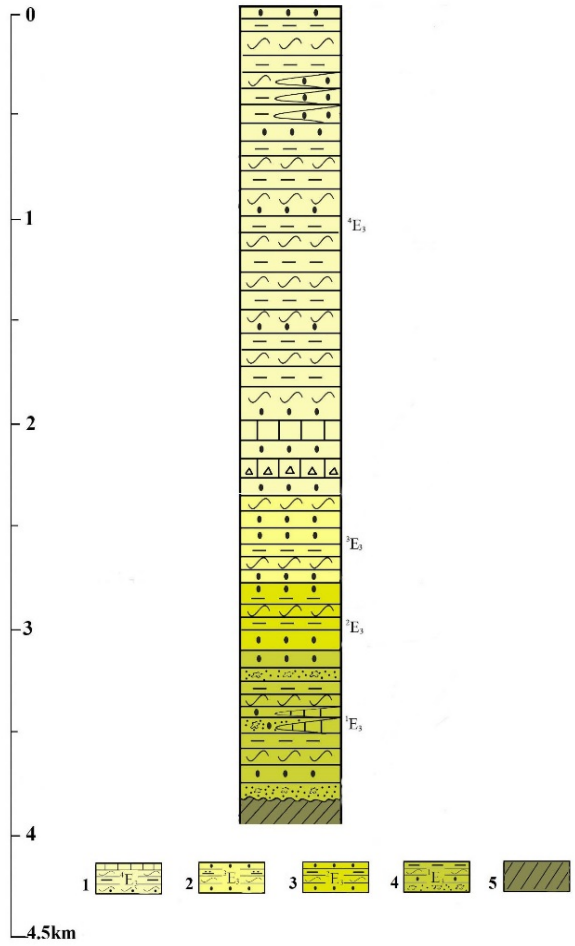

Fig. 2. Geological column of the Tikveš basin
1 – basal lithozone, 2 – lower flysch lithozone, 3 – lithozone of yellow sandstones, 4 – upper flysch lithozone, 5 – paleorelief

The lithological composition of the lithozone of yellow sandstones is represented with yellow sandstones with layers and inner layers of clayey soil and marls. The lower and upper borders of the lithozone of yellow sandstones are continuous and clear, which separates this unit from the lower and upper flysch lithozone. The thickness of this lithozone ranges from 100 to 400 m. The age of the lithozone of yellow sandstones is determined as Preabonian with macroforaminifera, Gastropods, Bivalvia and Anthozoa.

The upper flysch lithozone is isolated as being a separate lithostratigraphic unit because of the rhythmic occurrence and prevalence of clayey soil and sandstones with the presence of thin inner layers of marls, aleurolites and limestones. The lower border of the upper flysch lithozone is continuous, clear, outlined and separated from the yellow sandstones lithozone. The upper border of this lithozone is mostly covered in effusive rocks and younger sediment deposits, parts of which are uncovered and decomposed. The thickness of the upper flysch lithozone ranges from 2000 to 2500 m. The discovered and determined faunal material of Gastropods, Bivalvia, Anthozoa, Foraminifers and nannofossils confirms the Upper Eocene–Preabonian age of these sedimentary layers (Maksimovič et al., 1954; Temkova, 1958; Stojanova, 2008, 2012).

Ovče Pole basin

Ovče Pole basin is located in eastern and central part of the Vardar subzone. To the south and southwest are associated with Tikveš basin. There are four lithostratigraphic units: basal lithozone, lower flysch lithozone, lithozone of yellow sandstones and upper flysch lithozone in the Paleogene sediment mass of the basin (Fig. 3).

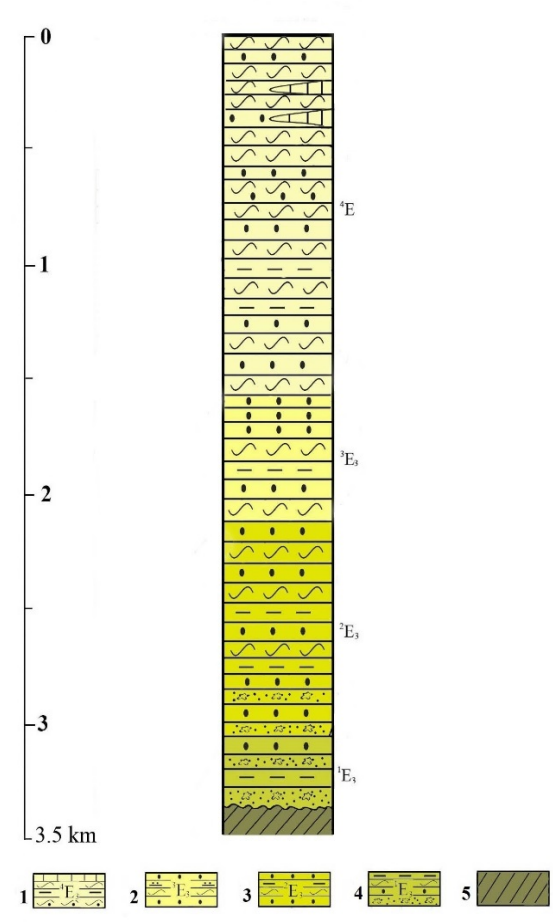

Fig. 3. Geological column of the Ovče Pole basin
1 – basal lithozone, 2 – lower flysch lithozone, 3 – lithozone of yellow sandstones, 4 – upper flysch lithozone, 5 – paleorelief

The basal lithozone of the Ovče Pole basin is represented with conglomerates and sandstones that alternate with clayey soil, limestones, and marls. The lower border of the basal lithozone is transgressive, and the upper border is concordant, and it continuously passes into the lower flysch lithozone. The thickness of the basal lithozone is about 350 m. Based on the lithological composition and the super positioning order the age of this lithozone is calculated as being Upper Eocene–Preabonian (Maksimovič et al.,1954; Rakićević, 1976).

The lithological composition of the lower flysch lithozone is different and represented with: sandstones, conglomerates, clayey soil, marls, and aleurolites. Because of the different lithological features in this lithozone, two lithostratigraphic units (members) can be distinguished as follows: terrigenous-clay and sandstone-clay member. The lower border is concordant and it represents a gradational transition of basal lithozone into lower flysch lithozone. The upper border is concordant and sharp, and it stands out because of the characteristic yellow-brown color of the sandstones covering the lower flysch lithozone. The thickness of the lower flysch lithozone is 900 m.

On the basis of the found and particular fauna, the age of the lower flysch lithozone is determined as Upper Eocene–Preabonian (Maksimovič et al.,1954; Rakićević, 1976).

The lithological composition of the lithozone of yellow sandstones is represented with sandstones having yellow-brown color and thin inner layers of clayey soil. The lower and upper border of the yellow sandstones lithozone is continuous and clear, which separates this unit from the lower and upper flysch lithozone. The thickness of this lithozone ranges between 500 and 600 m. The age of the yellow sandstones lithozone is determined on the basis of the found fauna (Temkova, 1967) as being Upper Eocene–Preabonian.

The lithological composition of the upper flysch lithozone is represented with straight flysch sediment mass in which clayey soil, sandstones, aleurolites, marls, and limestones rhythmically alternate. The lower border of the upper flysch lithozone is continuous, clear, outlined and separated from the yellow sandstone lithozone. The upper border of this lithozone is mostly covered with effusive rocks and younger sediment deposits, parts of which are uncovered and decomposed. The thickness of the upper flysch lithozone ranges from 1500 to 2000 m. The found and determined faunal material from Gastropods, Bivalvia, Anthozoa, Foraminifers and nannofossils confirms the Upper Eocene–Preabonian age of these sedimentary layers (Maksimovič et al., 1954; Temkova, 1958, 1967; Stojanova, 2008, 2012).

Skopje-Kumanovo basin

Skopje-Kumanovo basin is mainly spread in the central region of Vardar zone. To the south and southeast is associated with Ovče Pole basin. Based on the fauna and lithological construction, there are three lithostratigraphic units: basal lithozone, lithozone of yellow sandstones, carbonate-sandy lithozone (Fig. 4).

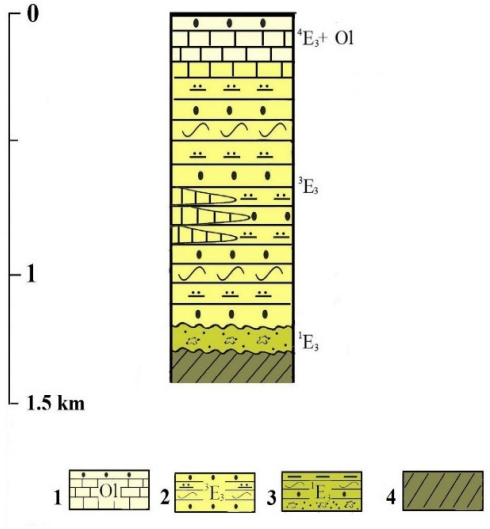

Fig. 4. Geological column of the Skopje-Kumanovo basin
1 – basal lithozone, 2 – lithozone of yellow sandstones, 3 – carbonate-sandy lithozone,4 – paleorelief

Basal lithozone is represented by conglomerates and sandstone, and thin layers of clayey soil within. The lower border of the basal lithozone is transgressive, and sediments of the yellow sandstone lithozone lie over this transgression. The thickness of the basal lithozone is about 100 m. In the basal lithozone the presence of basal fauna has not been found. Based on the lithological composition and the super positioning order, the age of this lithozone is determined as belonging to Upper Eocene–Preabonian (Pendžerkovski et al., 1975).

The lithozone of yellow sandstones stands out because of the yellow color of sandstones that have the identical development as the highest horizons of the Ovče Pole Upper Eocene flysch – of the upper yellow sandstones. The lithological composi-

tion of this unit is represented with conglomerates, sandstones, and clayey soil, and in some places with inner layers of carbonate sandstones, clayey and carbonate aleurolites, marly limestones and limestones. The lower border is transgressive, and the upper border is concordant and continuously passes into the flysch lithozone. The thickness of this lithozone is about 1000 m. The age of this lithozone is determined as being Upper Eocene, based on the found fauna: Anthozoa, Bivalvia and macroforaminifers, and on the faunal association and regional connection with Upper Eocene sediments from the Ovče Pole basin. Another evidence of age is discovered in microforaminifer lithozone (Stojanova, 2008, 2013).

The lithological composition of the carbonate-sandy lithozone is represented with dominant participation of limestones as related to sandstones and clayey. The lower and upper borders of the carbonate-sandy lithozone are continuous and clear, and they separate this unit from the lithozone of yellow sandstones and Upper Oligocene sediments. The thickness of this lithozone is about 200 m. On the basis of the found and determined fossil fauna the lithological composition and the super positioning order the age is determined as being Upper Eocene–Lower–Oligocene (Karajovanovič et al., 1972; Valchev et al. 2013).

Delčevo basin

The Delčevo basin is located in the NE part of the Republic of Macedonia, and belongs to the Serbo-Macedonian massif. To the norhteast, the basin extends locally to the area of Crna Skala (close to the Macedonian/Bulgarian border), and continues on the territory of Bulgaria. According to the lithological composition and the super positioning order there are two lithostratigraphic units: basal lithozone and upper flysch lithozone in Paleogene sediments (Fig. 5).

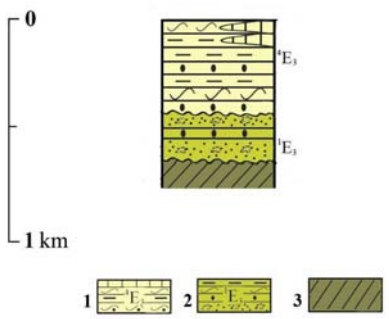

Fig. 5. Geological column of the Delčevo basin
1 – basal lithozone, 2 – upper flysch lithozone, 3 – paleorelief

The basal lithozone is represented with conglomerates and breccias that alternate with thinner layers of sandstones, clayey soil, and marls. The lower border of the basal lithozone is transgressive, and the sediments of the upper flysch litozone trasgressively lie over this lithozone. The thickness of the basal lithozone is about 100 m. This age is confirmed by the team of the Geological Institute (1973) based on the lithological composition. Based on the lithological composition and the super positioning order the age of this lithozone is determined as being Upper Eocene–Preabonian (Gjuzelkovski, 1959; Kovačevič et al.,1973).

The lithological composition of the upper flysch lithozone is represented with straight sediments of clayey soil, sandstones, aleurolites, marls, and limestones. The lower border of the upper flysch lithozone is transgressive, outlined and separated from the basal lithozone. The upper border of this lithozone is in some parts covered in nummulitic limestones, and its greatest part is covered in effusive rocks and younger sediment layers, parts of which are uncovered and decomposed. The thickness of the flysch lithozone is 400–600 m. The age of the upper flysch lithozone, based on the found faunal material of Gastropods, Bivalvia, Echinoidea and macroforaminifers, is determined as Upper Eocene–Preabonian (Temkova, 1960). In recent years micropaleontological research was done of Foraminifer fauna and nannofossil flora and, based on characteristic species, the age of sediments – Lower Oligocene was obtained (Stojanova, 2008; Valchev et al., 2013).

Valandovo–Gevgelia basin

Valandovo–Gevgelija basin appears in most suthern areas of Republic of Macedonia, up until Macedonian-Greek border. There are two lithostratigraphic units: basal lithozone and upper flysch lithozone in the basin Paleogene mass (Fig. 6).

The basal lithozone is represented by conglomerates and sandstones. Characteristic of the lithozone is the indicative gray-red color, which comes from iron-silicic cement, and also the color represented clasts of gneiss, granite, gabbro, diabase, etc. The basal lithozone lays transgressively and discordantly over Paleozoic phyllites where it can be seen clearly along their west border, while on the east side they are covered in flake phyllites. The thickness of the basal lithozone is about 350 m. Based on its lithological composition its age is determined as belonging to Upper Eocene (Ivanovski et al., 1966).

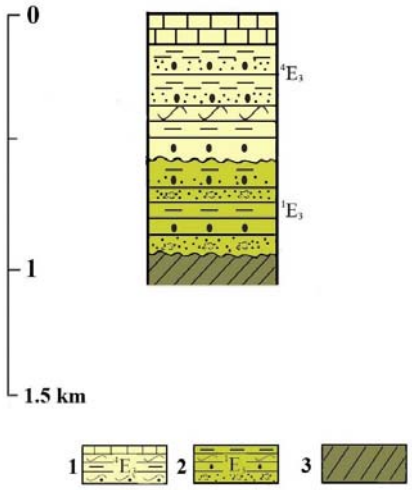

Fig. 6. Geological column
of the Valandovo-Gevgelija basin
1 – basal lithozone, 2 – upper flysch lithozone,
3 – paleorelief

The lithological composition of the upper flysch lithozone is represented with straight flysch sediments: conglomerates, sandstones, clayey soil, aleurolites, marls and limestones. The sediments from flysch lithozone are characterized by colorful look, with dominant reddish-purple shade. The lower border of the flysch lithozone is continuous, clear and separated from the basal lithozone. The upper border of this lithozone is mostly covered by younger sedimentary deposits, some of them are uncovered and decomposed, and in some places they are covered with older Paleozoic rocks. The thickness of the upper flysch lithozone is about 600 m. Based on the found fauna material represented with gastropods, Bivalvia, and corals, the Upper Eocene–Preabonian age of these sediment layers is determined (Kühn, 1951; Temkova, 1967; Karajovanović et al., 1972). With micropaleontological analysis of Foraminifer fauna and nonnofossil flora the geological age of the sediments in the lower Oligocene is obtained (Stojanova et al., 2013, 2014).

Strumica basin

Strumica basin is located in the SE part of the territory of Republic of Macedonia. Paleogene sediments in the region of Strumica valley are discovered with less weight than the flysch sediments in NNE–SSW direction. According to the lithological composition and the super positioning order, the sediments are divided into two lithostratigraphic lithozones: basal lithozone and upper flysch lithozone (Fig. 7).

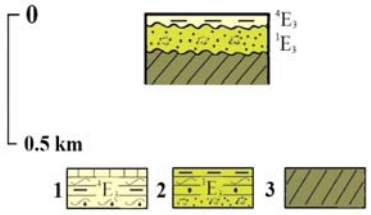

Fig. 7. Geological column of the Strumica basin
1 – basal lithozone, 2 – upper flysch lithozone, 3 –paleorelief

Basal lithozone is represented by sandstones in which layers of thin marls, microconglomerates and lumpy limestones alternate. The lower border of the basal lithozone is transgressive and it lies over Ogražden granites. The upper border is also transgressive towards the upper flysch lithozone. The discovered thickness of the basal lithozone ranges from 20–50 m. The age of the lithozonae is determined as belonging to Upper-Eocene (Rakićević et al., 1973).

The upper flysch lithozone is manifested as being a volcanogenic-sediment mass represented with: conglomerates, sandstones, sandy limestones and tuffs. The lower border of the flysch lithozone is transgressive, clear, outlined and separated from the basal lithozone. The upper border is mostly covered with effusive rocks and younger sediment layers. The thickness of the flysch lithozone is 100 m. According to the position of the volcanogenic sediments in the flysch lithozone, the presence of macrofauna of urchins, mussels, microfauna and micro-Foraminifer, the age of these sediments is Upper Eocene–Lower Oligocene (Rakićević et al., 1973; Stojanova, 2008; Stojanova et al., 2013).

Deve Bair basin

Deve Bair basin is located in Osogovo Mountains along the border with Bulgaria. The Paleogene in the basin is developed into a volcanogenic sediment formation. Based on the fauna and the lithological construction two separate lithostratigraphic units: basal lithozone and lower flysch lithozone can be distinguished in the Paleogene mass (Fig. 8).

The basal lithozone is represented with breccias and conglomerates, with inner layers of sandstones, aleurolites, clayey soil, and tuffaceous sandstones.

The characteristic of the whole lithozone is a noticeable shift of purple, red and gray color of layers, by which the lithozone looks disintegrated, inhomogeneous, and colorful. The lower border of

the lithozone is transgressive, its members lie over older rocks of various age. The upper border is concordant and it continuously passes into the lower flysch lithozone. The thickness of the basal lithozone is about 100 m. Based on the lithological composition, the lithozone is separated on basal parts of the Upper Eocene (Hristov, 1969).

The lithological composition of the lower flysch lithozone is various and it is represented with: sandstones, conglomerates, clayey soil and volcanogenic sediments represented with tuffites, tuffs and tuffaceous clayey soil. The lower border is concordant and represents a gradational transition of the basal lithozone into the lower flysch lithozone. The upper border is discordant and most part of it is covered in younger sediment deposits and effusive rocks, and a small part is uncovered and decomposed. The thickness of the lower flysch lithozone is about 1100 m. Based on the discovered flora and fauna the age is determined as belonging to Upper Eocene (Hristov, 1969).

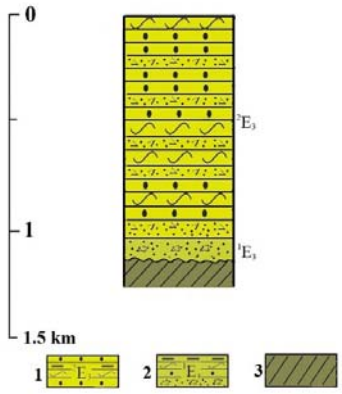

Fig. 8. Geological column of the Deve Bair basin
1 – basal lithozone, 2 – upper flysch lithozone,
3 – paleorelief

RESULTS AND DISCUSSION

Analyzing the horizontal distribution of Upper Eocene and Lower Oligocene sediments, as well as analysis of the thickness of lithozones, correlation is made between the lithostratigraphic profiles of the Paleogene basins on the territory of the Republic of Macedonia (Fig. 9).

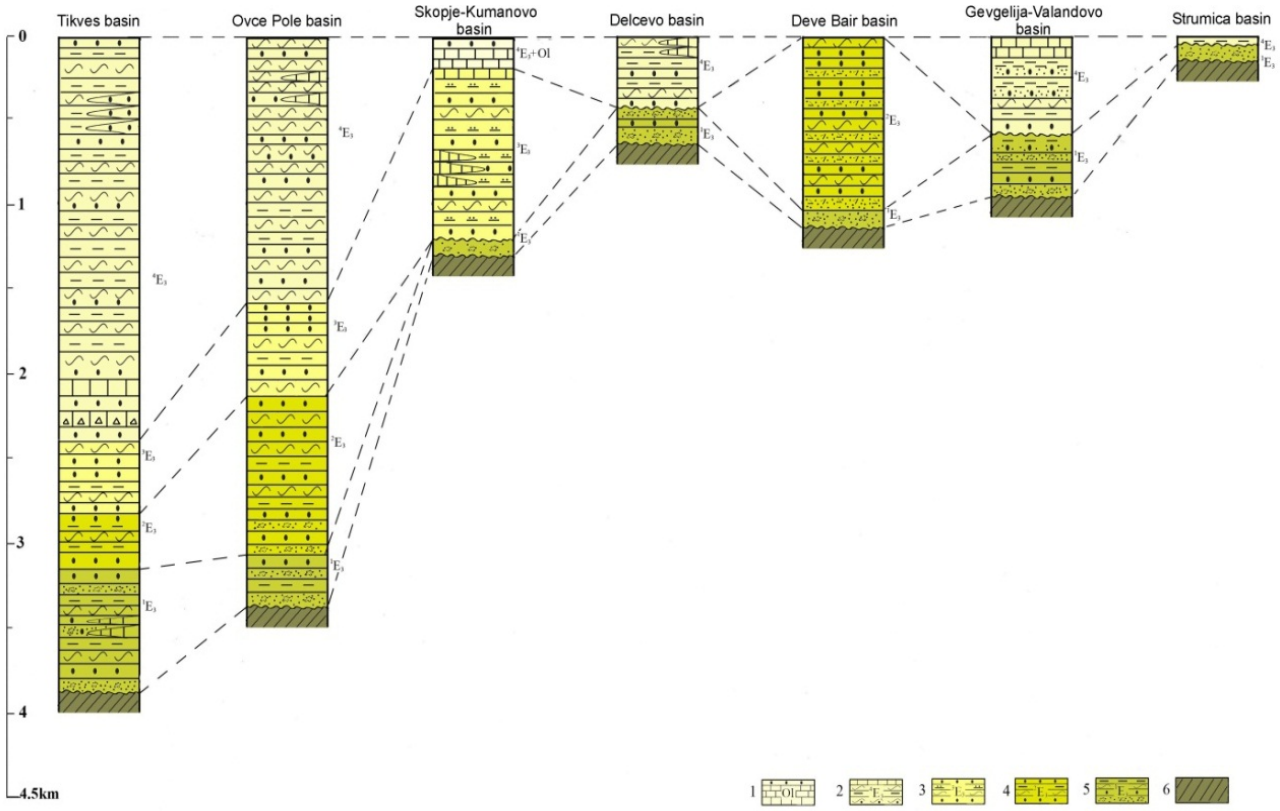

Fig. 9. Correlation of Paleogene basins in the Republic of Macedonia
1 – **c**arbonate-sandy lithozone; 2 – upper flysch lithozone; 3 – lithozone of yellow sandstones; 4 – lower flysch lithozone; 5 – basal lithozone; 6 – paleorelief

CONCLUSION

The differences in lithostratigraphic profiles, related to presence in the lithozones and their thickness, on Upper Eocene and Lower Oligocene in Paleogene basins on the territory of the Republic of Macedonia are evident. Probably, they are result of differential vertical tectonic movements in Vardar zone and Serbian-Macedonian massif during the Pyrenean-Savian orogeny phase.

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Р е з и м е

ЛИТОСТРАТИГРАФСКИ КАРАКТЕРИСТИКИ НА ПАЛЕОГЕНИТЕ БАСЕНИ ВО РЕПУБЛИКА МАКЕДОНИЈА

Виолета Стојанова, Гоше Петров

Универзитет "Гоце Делчев", Факултет за природни и технички науки,
Гоце Делчев 89, МК 2000 Штип, Република Македонија
violeta.stojanova@ugd.edu.mk//gose.petrov@ugd.edu.mk

Клучни зборови: литостратиграфија; палеогени басени; мекотелни седименти

Палеогените седименти се широко распространети на територијата на Република Македонија и се зачувани во значително дебели маси на просторот на вардарската зона, и во помали реликтни маси на просторот на српско–македонскиот масив. Во Република Македонија палеогенот е застапен во 4 покрупни басени: тиквешкиот, овче-

полскиот, скопско-кумановскиот и делчевскиот, и во неколку изолирани маси: девебаирска, валандово-гевгелиска и струмичка, сместени надолж лушпи и навлаки со ориентација СЗ-ЈИ.

Геолошката старост на седиментите во сите басени е одредена како горноеоценска до долноолигоценска, врз основа на досегашните истражувања на база на многубројни фосилни остатоци од макро- и микрофосилни групи.

Со литостратиграфски проучувања на палеогените седименти во басените на Република Македонија се издвоени 5 суперпозициони литостратиграфски единици (литозони): базална литозона ($^1E_3$), долна флишна литозона ($^2E_3$), литозона на жолти песочници ($^3E_3$), горна флишна литозона ($^4E_3$) и карбонатно-песоклива литозона (Ol_1).

Со анализа на хоризонталната распространетост на горноеоценско-долноолигоценските седименти, како и со анализа на дебелината на литозоните, направена е корелација помеѓу литостратиграфските профили на палеогените басени на територијата на Република Македонија.

Разликите во литостратиграфските профили, во однос на застапеноста на литозоните и нивната дебелина, на горноеоценско-долноолигоценските седименти во палеогените басени на територијата на Република Македонија се евидентни. Тие најверојатно се резултат на диференцијалните вертикални тектонски движења во вардарската зона и српско-македонскиот масив за време на пиринејско-савската орогена фаза.