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FORAMINIFERS AND NANNOFOSSILS FROM UPPER FLYSCH LITHOZONE IN THE TIKVEŠ PALEOGENE BASIN, REPUBLIC OF MACEDONIA

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A b s t r a c t: In this paper, the results of micropaleontological research of foraminifer fauna and calcareous nannofossils for upper flysch lithozone in Tikveš basins, stratigraphically important for determining geological age Paleogene complex in the basin, is presented. Rich and diverse nannofossil flora and microforaminifer fauna found in sediments above flyschlithozone of Krivolak section from Tikveš Paleogene basin, gives an option to identify a bio-stratographic zone according to benthic foraminifera and nannofossil zone.

Key words: foraminifera; nannofossils; biozones; Paleogene; Tikveš basin

INTRODUCTION

Tikveš Paleogene basin is large Eocene sediment mass located in the central part of Vardar zone, and is located in the central part of the territory of the Republic of Macedonia. Paleogene sediment of Tikveš basin stretches in the direction NW–SE, occupying more than 20 % of the entire surface and a great thickness which reaches 3 000–3500 m. Most are detected in edgy parts of Tikveš basin while the central parts of the basin are covered by Neogene and Quaternary deposits.

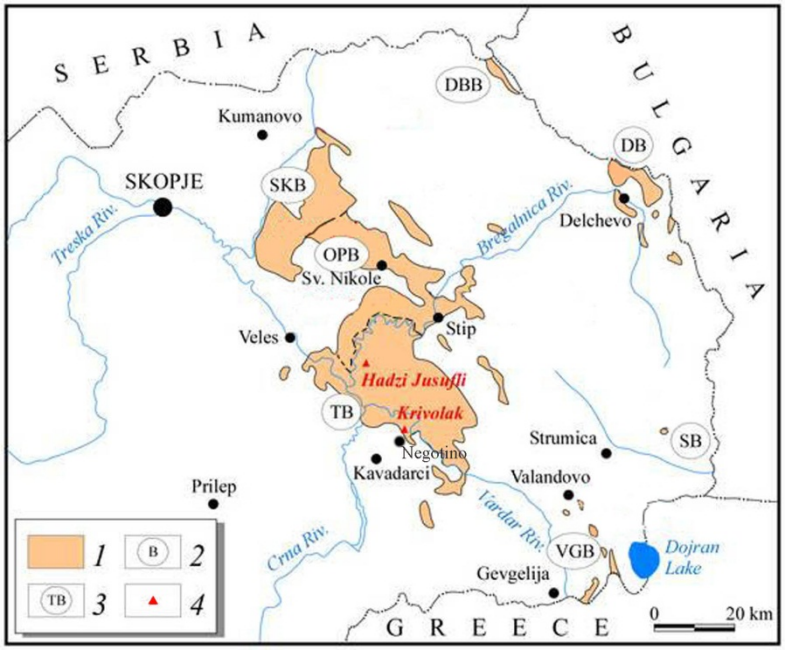

Fig. 1. Distribution of Paleogene sediments in the Republic of Macedonia
1 – Paleogene sediments, 2 – Tikveš basin, Ovče Pole basin, Skopje–Kumanovo basin, Delčevo basin, Valandovo-Gevgelia basin, Strumica basin, Deve Bair basin, 3 – Investigation basin, 4 – Paleogene cross-section

Paleogene sediments of Tikveš basin are rich in fossil and have been studied by several authors. First and most important paleontological research of Tikveš Paleogene basin has been carried out by a group of authors from the Geological Institute of the SAN, Belgrade (1954). The Upper Eocene (Priabonian) age of the Paleogene mass is being determined according numerous fossil gastropods remaining, lamellibranchiate and corals.

Important data in determining the thickness and lithostratigraphy of Paleogene in Tikveš basin have been derived from deep structural drilling performed by oil exploration carried by NAFTA-GAS – Novi Sad, done in the 60s and 70s of the last century (drill KR-1).

Through the development of OGK sheet Kavadarci 1:100 000 by Hristov S. et al. (1973), the Paleogene in Tikveš basin has been solidly paleontologically processed and documented, and determined as Priabonian. In order to gain new insights for geological age, the Paleogene sediments in Tikveš basin micropaleontological studies of foraminifer fauna and calcareous nannofossils were made.

MATERIAL AND METHODOLOGY

Micropaleontological research of Paleogene sediments in Tikveš basin was carried out with modern paleontological methods, in accordance with contemporary standards of research in paleontological science. As methods for determining the geological age of Paleocene sediments the following methods have been applied: method of foraminifer fauna and method of nannofossils.

Examination and testing of foraminifer fauna and nannofossil flora covered sediments in the upper flysch lithozone of two discovered Paleogene cross-section in Tikveš basin. The technical processing of the material of the samples was performed by classical methods of micropaleontological analysis (decomposition, washing, drying, selecting and determination). The taxonomic determinations were performed with a Zeiss microscope binocular 50 to 80 magnification, while allocated foraminifer tests were further examined with a SEM.

While for the method of nannofossils, the overall procedure for allocating nannofossils was performed with standard processing methods, which include making microscopic preparations with Canada balsam. Paleontological determinations were made under JENAPOL – d light microscope with magnificationx 2000.

LITHOSTRATIGRAPHY OF PALEOGEN IN TIKVEŠ BASIN

The Paleogene in the Tikveš basin is developed in flyscheet and flysch series. Based on the rich fauna that occurs in all levels the Paleogene mass is defined as Upper Eocene–Priabonian.

According to recent research, the mass of about 3.5 km thick (obtained according the drilling KR-1) is constructed from 4 lithostratigraphic units: basal lithozone, lower flysch lithozone, lithozone of yellow sandstones and upper flysch lithozone.

Micropaleontological research covered two characteristic discovered Paleogene cross-sections in Tikveš basin: Krivolak and Hadži Jusufli where 14 samples has been taken and obtained positive results regarding foraminifer fauna and nannofossil flora (Fig. 1).

The examined cross-sections are located in the upper sediments of flysch lithozone. The litho composition above flysch lithozone is presented by making flysch sediments such as: clayey, sandstones, siltstones, marly and limestones.

The sandstones are the most abundant members of this lithozone. Color-gray to yellow, they occur in the form of layers with a thickness of 5–30 cm, however much rarely in the form of a thick bungee over 100 cm.

The marly are frequent members of lithozone and they represent upper sequence of the roughly grinded material. Color-gray to gray-white, they occur in a community with siltstones and marly limestones. Clayey products are most common members in the upper parts of the upper flysch lithozone. Color-gray to gray-green, they occur in very thin tiles often in a form of leaf. Siltstones appear as thin semi-layers in clay layers. Limestones microcrystals, color-white to white-yellow, in flysch lithozone are in the form of plate semi-layers, with a thickness of 20 – 30 cm.

The thickness of the upper flysch lithozone in Tikveš Paleogene basin ranges from 2000–2500 m.

KRIVOLAK SECTION

Krivolak site is located 5 km north-east of the city of Negotino. The profile where samples are taken and micro-paleontological trials performed on foraminifer fauna and nannofossils is located on the right side of the Vardar river on the road facing village of Krivolak. The section that is being researched is located in the upper flysch lithozone with thickness of 7 m. The section is built from marly clayey sediments, marly, clayey, products that shift in grain sandstones and limestones (Fig. 2).

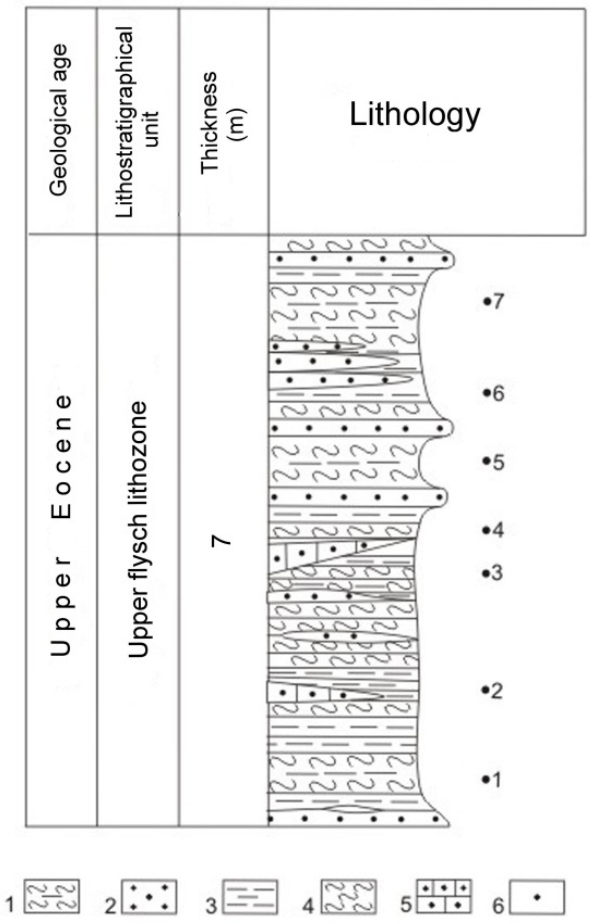

Fig. 2. Geological cross-section – Krivolak
1 – marly-clayey sediments, 2 – sandstones, 3 – marly, 4 – clayey, 5 – sandy-limestones, 6 – samples

As for the section seven samples have been taken, and the testing was made about 90 cm between samples in marly – clay layers. The faunal material from benthic and plankton foraminifera has been found into the section (Fig. 3).

UPPER EOCENE							GEOLOGICAL AGE
Upper flysch lithozone							Lithostratigraphic unit
1	2	3	4	5	6	7	Samples / Foraminifera
*	*		*				*Quinqueloculina juleana*
*	*						*Bathysiphon* sp.
*		*					*Cibicidoides lectus*
	*	*	*				*Textularia minuta*
*	*		*				*Robulus* sp.
	*	*	*		*		*Triloculina gibba*
*		*	*				*Triloculina angularis*
			*	*			*Pyrgo bulloides*
	*	*		*	*		*Gyroidina soldani*
	*		*	*			*Guttulina irregularis*
*		*		*	*		*Spiroplectamina carinata carinata*
		*	*	*			*Bolivina dilatata*
		*		*			*Anomalinoides welleri*
*	*		*		*		*Bolivina gracilis*
		*	*	*			*Bulimina sculptilis*
				*	*	*	*Globigerina officinalis*
*		*	*		*		*Pleurostomella ex. gr. bellardi*
	*		*		*		*Cibicides tallahatensis*
		*			*	*	*Globigerina ouachitaensis*
*			*		*	*	*Bolivina cf. antegressa*
	*		*			*	*Cibicides lobatulus*
Bolivina antegressa Subzone							Benthic foraminiferal zone

Fig. 3. Distribution of the foraminifera in the Paleogene cross-section – Krivolak

By analyzing the stratigraphic position of certain taxa of foraminifer fauna, in Krivolak, as of age perspective classifies two groups of foraminifera:

The first group consists of species belonging to lower levels that are distributed as far as Upper Eocene (E_3) including *Textularia minuta* Terquem, *Triloculina angularis* d'Orbigny, *Triloculina gibba* d'Orbigny, *Cibicides tallahatensis* Bandy, *Cibicides lobatulus* (Walker and Jakob). Foraminifera

species *Bolivina gracilis* Cushman and Applin, *Bolivina* cf. *antegressa* Subbotina, *Spiroplectamina carinata carinata* (d'Orbigny), *Guttulina irregularis* (d'Orbigny), *Pleurostomella ex. gr. bellardi* Hantken are distinctive for the Upper Eocene.

The second group consists of transitional species for the Eocene (E) – Oligocene (Ol) boundary consisting of the following: *Quinqueloculina juleana* (d'Orbigny), *Bolivina dilatata* Reuss, *Gyroidina soldani* d'Orbigny, *Globigerina officinalis* Subbotina and *Globigerina ouachitaensis* Howe and Wallace.

Based on stratigraphic position of foraminifera species regarding the age as of the Krivolak section, the following can be concluded: section sediments are determined with geological age – Upper Eocene. The age is confirmed by the presence of species: *Bolivina gracilis* Cushman and Applin, *Bolivina* cf. *Antegressa* Subbotina, *Spiroplectamina carinata carinata* (d'Orbigny), *Guttulina irregularis* (d'Orbigny), *Pleurostomella ex. gr. bellardi* Hantken, characteristic only for the Upper Eocene. These appear in the interval between samples 1 – 7, i.e. from the bottom to the upper parts of the section that defines the highest levels of E_3.

As of the research of nannofossil sediments, all testing of section yielded positive results.

The discovered nannofossil flora in the section is well preserved, diverse and quantitatively presented and represented with the following species: *Reticulofenestraumbilica, Reticulofenestrahillae, Reticulofenestra oamaruensis, Reticulofenestra samodurovi, Cyclicargolithusfloridanus, Coccolithus eopelagicus, Coccolithus pelagicus, Transversopontis fibula, Zygrhablitus bijugatus, Pontosphaera* sp., *Lanternithus simplex, Reticulofenestra bisecta, Reticulofenestra scrippsae, Sphenolithus moriformis, Discoasternodifer, Pontosphaera multipora, Ericsonia subdisticha, Braarudosphaera bigelowii, Cyclicargolithus abisectus, Transversoponites pulcheroides* (Fig. 4). By analyzing the stratigraphic position of individual species of nannofossil association, the section sediments belong to the Upper Eocene further on to the lowest levels of lower Oligocene. Age confirms the presence of the species: *Reticulofenestra oamaruensis, Cyclicargolithus floridanus* and *Ericsonia subdisticha* represented in the interval between samples from 1 to 7, and stratigraphic coverage of NP 19 – 21 (Martini, 1971).

UPPER EOCENE							GEOLOGICAL AGE
Upper flysch lithozone							Lithostratigraphic unit
1	2	3	4	5	6	7	Samples / Nannofossils
*	*	*	*	*	*	*	*Reticulofenestra umbilica*
*					*	*	*Reticulofenestra hillae*
*					*	*	*Reticulofenestra oamaruensis*
*							*Reticulofenestra samodurovi*
*	*	*	*	*	*	*	*Cyclicargolithus floridanus*
*						*	*Coccolithus eopelagicus*
*			*	*	*		*Coccolithus pelagicus*
*							*Transversopontis fibula*
*			*	*			*Zygrhablitus bijugatus*
*	*				*	*	*Pontosphaera* sp.
	*	*					*Lanternithus simplex*
	*	*	*	*	*	*	*Reticulofenestra bisecta*
	*	*					*Reticulofenestra scrippsae*
	*	*					*Sphenolithus moriformis*
	*	*					*Discoasternodifer*
	*	*					*Pontosphaera multipora*
		*					*Ericsonia subdisticha*
		*	*	*			*Braarudosphaera bigelowii*
				*			*Cyclicargolithus abisectus*
				*	*	*	*Transversoponites pulcheroides*
		*			*	*	*Quadrum trifidum**
		*			*	*	*Quadrum sissinghi**
					*	*	*Micula decussata**
		*				*	*Prediscosphaera cretacea**
						*	*Eiffellithus turriseifellii**
					*	*	*Cretarhabdus crenulatus**
						*	*Cribrosphaera ehrenbergii**
NP 19 – 21							Nannofossil zone

*depositednannofossils

Fig. 4. Distribution of the nannofossils in the Paleogene cross-section – Krivolak

In the samples 3, 6 and 7 of the Krivolak section, the nannofossils from the Upper Cretaceous are found. Those nannofossils representatives are presented with the following exponents: *Quadrum trifidum, Quadrum sissinghi, Micula decussata, Prediscosphaera cretacea, Eiffellithus turriseifel-*

lii, Cretarhabdus crenulatus, Cribrosphaera ehrenbergii.

The present cretaceous nannofossilhat are located in the Paleogene sediments are most probably resedimented from the surrounding cretaceous cliffs, during the process of erosion and deposition of the Paleogene sediments.

HADŽI JUSUFLI SECTION

Hadži Jusufli site is located about 23 km north-west of town of Kavadarci. The section in which the samples have been taken and where micro paleontological samples of foraminifer fauna and nannofossil flora have been performed, is located on the left side of the Bregalnica river about 7 km before the Vardar river flow.

The section that was the subject of research is located in the upper flysch lithozone with thickness of 9 m.

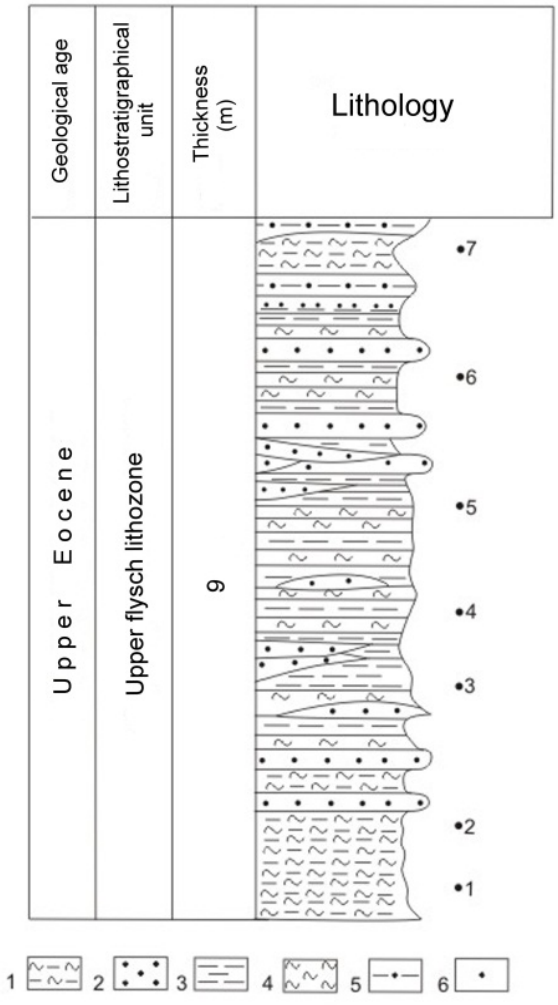

Fig. 5. Geological cross-section – Hadži Jusufli
1 – marly-clayey sediments, 2 – sandstones, 3 – marly, 4 – clayey, 5 – sandy-carbonates, 6 – samples

The section is built from marly-clayey sediments, marly, clayey and siltstones with transitions in thin layers and sublayers of sandstones and sandy, marly (Fig. 5).

As for the section, seven samples have been taken, and the testing was done about one meter between the samples in marly-clayey layers (samples 1, 2, 6 and 7), in clayey and marly (samples 3, 4 and 5).

The faunal material from benthic and plankton foraminifera has been found into the section (Fig. 6)

UPPER EOCENE							GEOLOGICAL AGE
Upper flysch lithozone							Lithostratigraphic unit
1	2	3	4	5	6	7	Samples / Foraminifera
*							*Saccamina placenta*
*	*						*Hyperammina* sp.
*	*		*	*			*Quinqueloculina juleana*
		*	*				*Pyrgo bulloides*
*	*		*		*		*Triloculina gibba*
*		*			*		*Spiroplectamina dentata*
	*		*	*		*	*Gyroidina soldani*
					*	*	*Textularia broniana*
		*		*	*		*Bolivina gracilis*
	*					*	*Bulimina sculptulis*
		*			*	*	*Globigerina officinalis*
*			*	*		*	*Cibicides tallahatensis*
		*	*		*	*	*Cibicides lobatulus*

Fig. 6. Distribution of the foraminifera in the Paleogene cross-section – Hadži Jusufli

The analysis of the stratigraphic location of certain taxa made it possible to infer that, in terms of age, three groups of foraminifera can be defined. The following genres belong here:

The first group consists of species belonging to lower levels that are distributed as far as Upper Eocene (E_3) including *Triloculina gibba* Bandy,

Cibicides tallahatensis Bandy, *Cibicides lobatulus* (Walker and Jakob). Foraminifera species *Bolivina gracilis* Cushman and Apllin, *Pyrgo bulloides* (d'Orbigny) and *Bulimina sculptulis* Cushmanare distinctive for the Upper Eocene.

The second group consists of transitional species for the Eocene (E) – Oligocene (Ol) boundary consisting of the following: *Quinqueloculina juleana* (d'Orbigny), *Gyroidina soldani* d'Orbigny and *Globigerina officinalis* Subbotina.

The third group consists of species that lived later than the Eocene. This group belongs to the species *Textularia broniana* d'Orbignythat occurs in samples 6 and 7.

Paleogene sediments Hadži Jusufli section are from geological age of Upper Eocene. The age is confirmed by the presence of *Bolivinagracilis* Cushman and Apllin, *Pyrgo bulloides* (d'Orbigny) and *Buliminas culptulis* Cushman which is spread only in the Upper Eocene and occurs in the interval between samples from 2 to 7.

By nannofossil research of sediments, all samples of the section yielded positive results, while the nannofossil flora that is found in the section is quantitatively represented, diverse and relatively well preserved. The nannofossil association is represented by the following species: *Reticulofenestra umbilica*, *Cyclycargolithus floridanus, Coccolithus eopelagicus, Zygrhablitus bijugatus, Reticulofenestra bisecta, Reticulofenestra scripsae, Lanternithus simplex, Discoaster* sp., *Pontosphaera multipora, Pontosphaera* sp., *Braarudospaera bigelowii, Transversopontis pulcheroides* (Fig. 7).

In Hadži Jusufli section samples 2, 3 and 7 contain older, i.e. redeposited nannofossil species which probably originated from the surrounding cretaceous rocks, during the process of sedimentation of the Paleogene sediments.

By analyzing the stratigraphic position of species *Cyclicargolithusfloridanus, Reticulofenestraumbilica* from nannofossil association, the sediments of the Hadži Jusufli–section belong to nannofossil zone NP19 – NP 21 (Martini, 1971). The nannofossil zone NP 19 – NP 21 represents Paleogene sediments in the section that are interpreted as upper parts of the Upper Eocene and lower parts of Lower Oligocene.

UPPER EOCENE							GEOLOGICAL AGE
Upper flysch lithozone							Lithostratigraphic unit
1	2	3	4	5	6	7	Samples / Nannofossils
	*	*	*	*	*	*	*Reticulofenestra umbilica*
				*	*	*	*Cyclycargolithus floridanus*
*		*			*	*	*Coccolithus eopelagicus*
*	*		*	*	*	*	*Zygrhablitus bijugatus*
					*	*	*Reticulofenestra bisecta*
			*		*	*	*Reticulofenestra scripsae*
	*	*					*Lanternithus simplex*
	*	*					*Discoaster* sp.
				*	*	*	*Pontosphaera multipora*
*	*				*	*	*Pontosphaera* sp.
	*	*	*		*	*	*Braarudospaera bigelowii*
					*	*	*Transversopontis pulcheroides*
	*	*					*Watznaueria barnesae**
						*	*Eiffellithus turriseifellii**
						*	*Cretarhabdus ehrenbergii**
						*	*Cretarhabdus elliptica**
						*	*Cribrosphaera surrirelus**
NP 19 – 21							Nannofossil zone

*depositednannofossils

Fig. 7. Distribution of the nannofossils in the Paleogene cross-section Hadži Jusufli

RESULTS

Analyzing micropaleontological research of foraminifer fauna and nannofossil flora in the upper flyschlithozone of Tikveš Paleogene basin, many conclusions could be made.

Positive results were obtained for the middle and upper levels above flysch lithozone which were also determined as rich in foraminifer fauna and nannofossils.

Systematic classification of foraminifer fauna in the Krivolak and Hadži Jusufli cross-sections was carried out according to Loeblich and Tappan (1988).

By analyzing the stratigraphic position of individual species of foraminifer fauna, sediments of the upper flysch lithozone in the Krivolak and Hadži Jusufli sections belong to the Upper Eo-