

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 Tikvesh 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 flysch lithozone of Krivolak section from Tikvesh Paleogene basin, gives an option to identify a biostratigraphic zone according to benthic foraminifera and nannofossil zone.

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

INTRODUCTION

Tikvesh Paleogene basin is large Eocene sediment mass located in the central part of Vardar zone, and is located in the SW part of the territory of the Republic of Macedonia. Paleogene sediment of Tikvesh basin stretches in the direction NW - SE, occupying more than 20% of the entire surface and a great thickness which reaches 3 000-3 500 m. Most are detected in edgy parts of Tikvesh basin while the central parts of the basin are covered by Neogene and quaternary deposits.

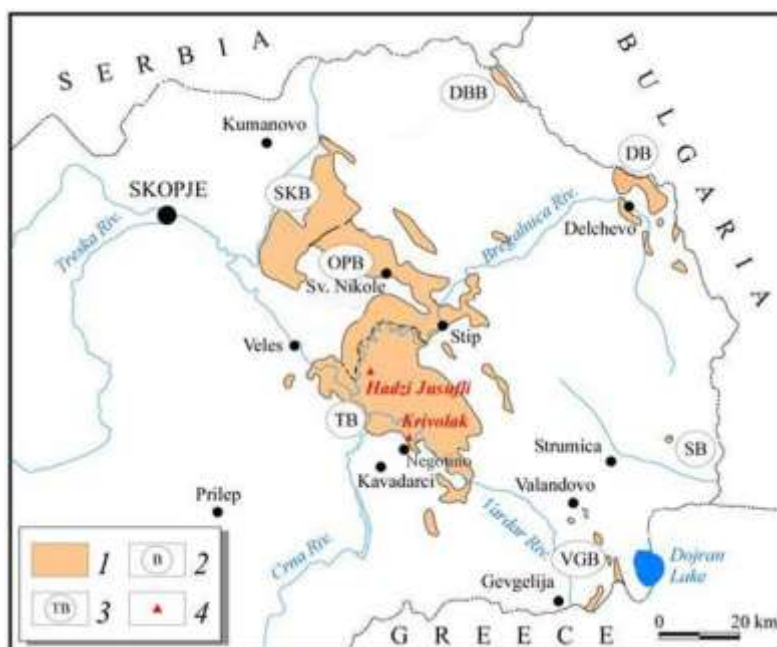


Fig. 1. Distribution of Paleogene sediments in the Republic of Macedonia
1- Paleogene sediments, 2 – Tikveš basin, Ovče Pole basin, Skopje-Kumanovo basin, Delčevo basin, Valandovo-Gevgelija basin, Strumica basin, Deve Bair basin,
3 – Investigation basin, 4 – Paleogene cross-section

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 Tikvesh basin have been derived from deep structural drilling performed by oil exploration carried by NAFTAGAS - 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 C., etc. (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, selectig 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 determination were made under JENAPOL - d light microscope with magnification x 2000.

LITHOSTRATIGRAPHY OF PALEOGEN IN TIKVESH BASIN

The Paleogene in the Tikveš basin is developed in flyshoid 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 Tikvesh basin: Krivolak and Hadzi 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, sandsones, 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.

SECTION – KRIVOLAK

Krivolak site is located 5 km northeast 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 river Vardar on the road facing village Krivolak. The section that is being researched is located in the upper flysch lithozone with thickness of 7 meters. The section is built from marly clayey sediments, marly, clayey, products that shift in grain sandstones and limestones (Fig. 2).

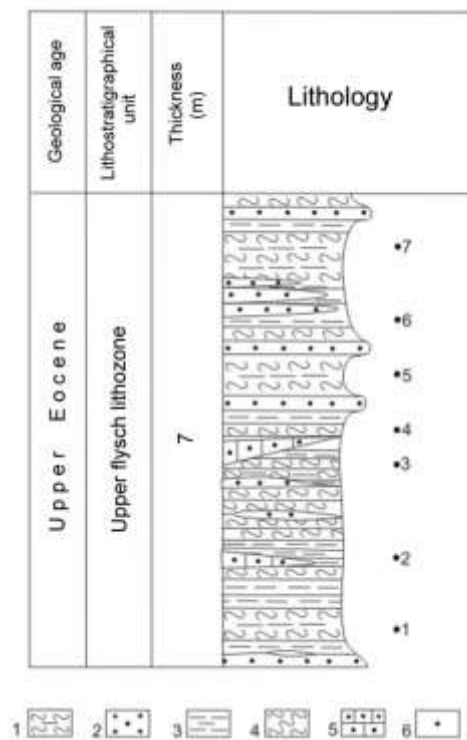


Fig. 2. Geological cross-section – Krivolak

- 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 - clayey layers. Faunal material from benthic and plankton

foraminifera has been found into the section. Benthic foraminifer is represented by: Plankton foraminifera is poorly represented in quantity and is represented by *Globigerina officinalis* and *Globigerina ouachitaensis* (Fig. 3).

UPPER EOCENE							GEOLOGICAL AGE
Upper flysch lithozone							Lithostratigraphic unit
1	2	3	4	5	6	7	Samples Foraminifera
*	*		*				<i>Quinqueloculina juleana</i>
*	*						<i>Bathysiphon sp.</i>
*		*					<i>Cibicidoides lectus</i>
	*	*	*				<i>Textularia minuta</i>
*	*		*				<i>Robulus sp.</i>
	*	*	*		*		<i>Triloculina gibba</i>
*		*	*				<i>Triloculina angularis</i>
			*	*			<i>Pyrgo bulloides</i>
	*	*		*	*		<i>Gyroidina soldani</i>
	*		*	*			<i>Guttulina irregularis</i>
*		*		*	*		<i>Spiroplectamina carinata carinata</i>
		*	*	*			<i>Bolivina dilatata</i>
		*		*			<i>Anomalinoidea welleri</i>
*	*		*		*		<i>Bolivina gracilis</i>
		*	*	*			<i>Bulimina sculptilis</i>
				*	*	*	<i>Globigerina officinalis</i>
*		*	*		*		<i>Pleurostomella ex.gr. bellardi</i>
	*		*		*		<i>Cibicides tallahatensis</i>
		*			*	*	<i>Globigerina ouachitaensis</i>
*			*		*	*	<i>Bolivina cf. antegressa</i>
	*		*			*	<i>Cibicides lobatulus</i>
<i>Bolivina antegressa</i> 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 section-Krivolak, as of age perspective classifies two groups of foraminifers:

The first group consists of species belonging to lower levels that are distributed as far as Upper Eocene (E₃) including *Textularia minuta*, *Triloculina angularis*, *Triloculina gibba*, *Cibicides tallahatensis*, *Cibicides lobatulus*. Foraminifer species *Bolivina gracilis*, *Bolivina cf. antegressa*, *Spiroplectamina carinata carinata*, *Guttulina irregularis*, *Pleurostomella ex.gr. bellardi* 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*, *Bolivina dilatata*, *Gyroidina soldani*, *Globigerina officinalis* and *Globigerina ouachitaensis*.

Based of stratigraphic position of foraminifer species regarding the age as of the section – Krivolak, 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*, *Bolivina cf. antegressa*, *Spiroplectamina carinata carinata*, *Guttulina irregularis*, *Pleurostomella ex.gr. bellardi*, 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 E₃.

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

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

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

The discovered nannofossil flora in the section is well preserved, diverse and quantitatively presented and represented with the following species: *Reticulofenestra hillae*, *Reticulofenestra hillae*, *Reticulofenestra oamaruensis*, *Reticulofenestra samodurovi*, *Cyclicargolithus floridans*, *Coccolithus eopelagicus*, *Coccolithus pelagicus*, *Transversopontis fibula*, *Zygrhablitis bijugatus*, *Pontosphaera sp.*, *Lanternithus simplex*, *Reticulofenestra bisecta*, *Reticulofenestra scrippsae*, *Sphenolithus moriformis*, *Discoaster sp.*, *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 u *Ericsonia subdisticha* represented in the interval between samples from 1 to 7, and stratigraphic coverage of NP 19 - 21 (Martini, 1971).

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 turriseifellii*, *Cretarhabdus crenulatus*, *Cribrosphaera ehrenbergii*.

The present cretaceous nannofossil hat are located in the Paleogene sediments are most probably re-sedimented from the the surrounding cretaceous cliffs, during the process of erosion and deposition of the Paleogene sediments.

SECTION – HADZI JUSUFLI

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

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

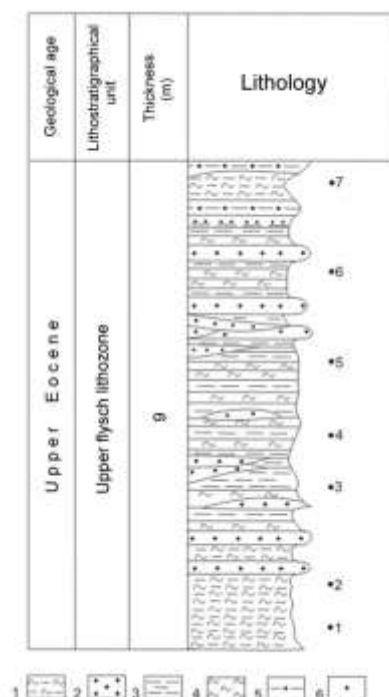


Fig. 5. Geological cross-section – Hadzi Jusufli

- 1- marly-clayey sediments, 2 - sandstones, 3 - marly, 4 - clayey, 5 – sandy-carbonates,
6 - samples

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).

Faunal material from benthic foraminifera has been found into the section: *Textularia broniana*, *Saccamina placenta*., *Spiroplectamina dentata*, *Bolivina gracilis*, *Triloculina gibba*, *Hyperammina sp.*, *Cibicides lobatulus*, *Cibicides tallahatensis*, *Quinqueloculina juleana*, *Triloculina gibba*, *Gyroidina soldani*, *Pyrgo bulloides*, *Bolivina gracilis*, *Bulimina sculptulis*, *Cibicides tallahatensis*, *Cibicides lobatulus* and one species of plankton foraminifer *Globigerina officinalis* (Fig. 6).

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

The first group consists of species belonging to lower levels that are distributed as far as Upper Eocene (E₃) including *Textularia minuta*, *Triloculina angularis*, *Triloculina gibba*, *Cibicides tallahatensis*, *Cibicides lobatulus*. Foraminifer species *Bolivina gracilis*, *Pyrgo bulloides* and *Bulimina sculptulis* 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*, *Gyroidina soldani* and *Globigerina officinalis*.

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

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

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

Paleogene sediments Hadzi Jusufli section are from geological age of Upper Eocene. The age is confirmed by the presence of *Bolivina gracilis*, *Pyrgo bulloides* and *Bulimina sculptulis* 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*, *Cyrcargolithus floridans*, *Coccolithus eopelagicus*, *Zygrhablitus bijugatus*, *Reticulofenestra bisecta*, *Reticulofenestra scripsae*, *Lanternithus simplex*, *Discoaster sp.*, *Pontosphaera multipora*, *Pontosphaera sp.*, *Braarudosphaera bigelowii*, *Transversopontis pulcheroides* (Fig.7).

In Hadzi–Jusuflı section samples 2, 3, and 7 contain older, i.e. re-deposited nannofossil species which probably originated from the surrounding cretaceous rocks, during the process of sedimentation of the Paleogene sediments.

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

Fig. 7. Distribution of the nannofossils in the Paleogene cross-section - Hadzi Jusuflı

By analyzing the stratigraphic position of species *Cyclicargolithus floridanus* *Reticulofenestra umbilica* from nannofossil association, the sediments of the section - Hadzi Jusuflı 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.

RESULTS

Analysing micropaleontological research of foraminifer fauna and nannofossil flora in the upper flysch lithozone of Tikvesh 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 cross-sections Krivolak and Hadzi Jusuflı 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 sections - Krivolak and Haji Jusuflı belong to the Upper Eocene - Priabonian geological age. As for Tikvesh basin only section - Krivolak (appearing with a geological age of Upper Eocene) is a stratigraphic section that can set aside biozone *Bolivina antegressa*. The criterion for distinguishing of biozone *Bolivina antegressa*, is the appearance and disappearance of taxa of the *Bolivina* group representats with *Bolivina*

antegressa Subb., and Bolivina nobilis (Hantk). The biozone Bolivina antegressa distinguished and the benthic species belongs to the upper portion of the Planulina costata (Bugrova, 1988) belonging to the Upper Eocene - Priabonian geological age.

The nannofossil association that was found in sediments above flišna litozona sections Krivolak and Hadzi Jusufli from the Tikvesh paleogene basin, is well preserved and the solidly represented in quantity, is as well represented by taxonomic species: *Reticulofenestra umbilica* *Sphenolithus pseudoradians*, *Ericsonia subdisticha*, *Coccolithus pelagicus*, *Zygrhablitus bijugatus* having biostratigraphic meaning.

Based on the data obtained from nannofossil analysis the nannofossil zone with stratigraphic coverage of NP 19 - NP 21 (Martini, 1971) is outlined. Allocated nannofossil zone NP 19 - NP 21 refers to the Upper Eocene to lower levels of Lower Oligocene geological age.

In both methods, as the basic criterion for separating biozones, as well as setting the boundary between them, the combinations of matching (FOs) and extinction (LOs) of foraminifer and nannofossil species have been used.

If we correlate the zones allocated according the nannofossil NP 19 - NP 21 (Martini, 1971), by the benthic foraminifer zone Planulina costata (Bugrova, 1988) for Krivolak section, it can be concluded that the results according nannofossil zoning and zoning of benthic foraminifer, is seen that they match.

P E R I O D	E P O C H	S T A G E		T I K V E Š P A L E O G E N E B A S I N	
				S e c t i o n K r i v o l a k	
				N P	B
P A L E O G E N E	O L I G O C E N E	L O W E R	R U P E L I A N	NP 23	
				NP 22	
				NP 21	
	E O C E N E	U P P E R	P R I A B O N I A N	NP 20	P l a n u l i n a c o s t a t a B o l i v i n a a n t e g r e s s a S u b z o n e
				NP 19	
				NP 18	
				NP 17	
	M I D D L E	B A R T O N I A N	NP 16		

Fig. 8. Correlation of the benthic foraminiferal zones (B) with calcareous nannofossils (NP) zones in the Upper flysch lithozone of Tikvesh Paleogene basin

Sediments of Krivolak section according nannofossil zoning NP 19 - NP 21 (Martini, 1971) belong to the middle parts of Priabonian to the lowest parts of the Lower Oligocene - Rupelian, and according zoning of benthic foraminifer Planulina costata

(Bugrova, 1988) these sediments belong to the highest parts of the Upper Eocene – Priabonian (Fig. 8).

CONCLUSION

The association of benthic foraminifers and nannofossils found in the upper flysch lithozone of Tikvesh Paleogene basin gives an opportunity to identify a biostratigraphic subzone - *Bolivina antegressa*, which belongs to the zone *Planulina costata* (Bugrova, 1988) and nannofossil zone NP19 - NP 21 for the Krivolak section.

By analyzing the correlation between these biostratigraphic zones, it also confirms the geological age of the upper flysch lithozone in Tikvesh paleogene basin, which belongs to the Upper Eocene - Priabonian geological age.

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Резиме

ФОРАМИНИФЕРИ И НАНОФОСИЛИ ОД ГОРНАТА ФЛИШНА ЛИТОЗОНА НА ТИКВЕШКИОТ ПАЛЕОГЕНСКИ БАСЕН, Р. МАКЕДОНИЈА

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Тиквешкиот палеогенски басен претставува голема еоценска седиментна маса сместена во централниот дел на Вардарската зона, и се наоѓа во ЈЗ дел на територијата на Република Македонија.

Палеогените седименти во Тиквешкиот басен се богато фосилоносни и биле предмет на проучување од повеќе автори. Врз основа на бројни фосилни остатоци на гастроподи, ламелибранхиати и корали е одредена горно еоценска (приабонска) старост на палеогената маса.

Според досегашните истражувања, масата дебела околу 3.5 km (добиена врз основа на дупчотината КР-1) е изградена од 4 литостратиграфски единици: базална литозона, долна флишна литозона, литозона на жолти песочници и горна флишна литозона.

Во трудот ги презентираме резултатите од микропалеонтолошките истражувања на фораминиферна фауна и нанофосилна флора, пронајдени во седиментите на горната флишна литозона на Тиквешкиот палеогенски басен.

Асоцијацијата на бентосни фораминифери и нанофосили пронајдени во горната флишна литозона на палеогенските откриени профили Криволак и Хаџи Јусуфли од Тиквешкиот басен, овозможи да се идентифицира една биостратиграфска подзона *Bolivina antegressa*, која припаѓа на зоната *Planulina costata* (Бугрова, 1988) и нанофосилна зона со стратиграфско опфаќање од NP 19- NP 21 (Martini, 1971) за профилот- Криволак.

Со анализа на корелацијата помеѓу овие биостратиграфски зони, а воедно ја потврдува и геолошката старост на горната флишна литозона на Тиквешкиот басен, која припаѓа на горен еоцен- приабонски кат.

Клучни зборови: фораминифера, нанофосили, биозони, Палеоген, Тиквешки басен.