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MACRO AND MICROFAUNA IN UPPER-EOCENE SEDIMENTS AT THE SITE CRNA SKALA, REPUBLIC OF MACEDONIA

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A b s t r a c t: This paper presents the results of macro and microfauna of the upper flysch lithozone of the Paleogene sediments from the site Crna Skala in the Delčevo basin. The macrofauna material is represented by a number of small and large forms of bivalves, gastropods, echinoides, corals and the microfaunal material is presented with benthic and planktonic foraminiferal fauna, represented by 16 species belonging to 14 genera and 11 families.

Key words: macrofauna**;** benthos and planktonic foraminifera; Paleogene sediments; Delčevo basin

INTRODUCTION

The site Crna Skala belongs to the basin of Delčevo, the Republic of Macedonia. The Delčevo basin is located in the NE part of the Republic of Macedonia. 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 (Fig. 1).

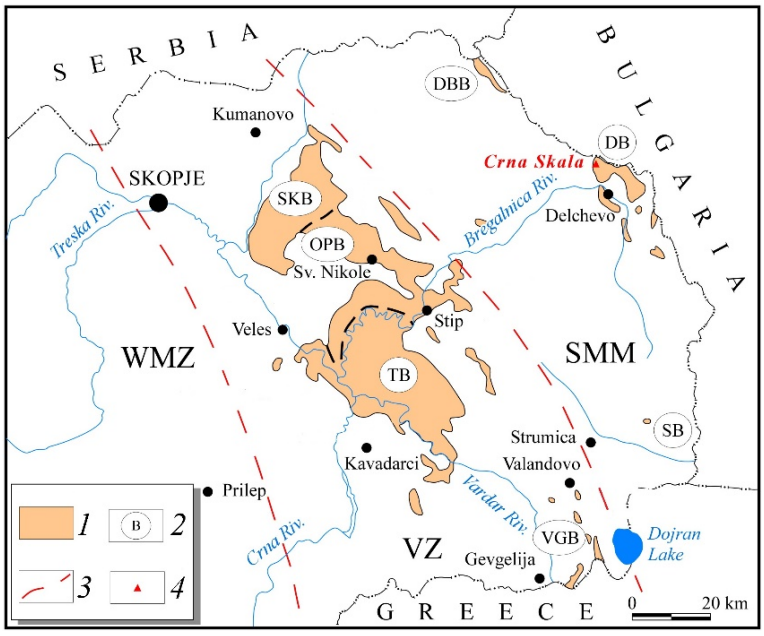

Fig. 1. Sketch of the location of the Paleogene basins in the Republic of Macedonia
1) Distribution of Paleogene sediments; 2) Paleogene basins: Tikveš basin (TB), Ovče Pole basin (OPB), Skopje-Kumanovo basin (SKB), Delčevo basin (DB), Valandovo-Gevgelia basin (VGB), Strumica basin (SB), Deve Bair basin (DBB); 3) Tectonic boundary; 4) Studied sections. Other abbreviations used: Serbian-Macedonian massif (SMM), Vardar zone (VZ), western Macedonian zone (WMZ)

The Paleogene sediments of the Delčevo basin are developed in several outcrops with NNW-SSE trends, usually lying transgressively upon the high-grade metamorphic and magmatic rocks of the Serbo-Macedonian massif, and mostly covered by Neogene effusive and sedimentary rocks. At some places the Paleogene sediments were found to be disrupted. The first evidence for the presence of Paleogene in the Delčevo Basin was provided by Belmustakov (1948), who dated these sediments as Oligocene. Based on the study of gastropods, bivalves and other fossil groups, Temkova (1957) and Gjuzelkovski (1959) determined the overal age of the Paleogene rocks in the Delčevo basin as Late Eocene, and Kovačević et al. (1973) referred them to the Priabonian. The first foraminiferal taxonomical investigations of the Paleogene sediments from the Republic of Macedonia was published at the end of the 20th century when Džuranov et al. (1999), and later Stojanova (2008), Stojanova et al. (2011, 2012, 2013, 2014) and Valchev et al. (2013) presented foraminifers from Paleogene basins from the Republic of Macedonia.

MATERIALS AND METHODS

According to the current knowledge, the Paleogene sediments of the Delčevo basin are nearly 700 m thick. In terms of their lithology, these rocks are developed in flysch succession that can be subdivided into two units: basal and upper flysch lithozone. Our work was focused on the upper flysch lithozone, which is 400–600 m thick. For the purposes of this study, the Crna Skala section, was sampled. A total of 26 samples were collected from approximately 75 m thick sequence of rhythmic clay-marl-sandstone alternation, and positive results for foraminifer fauna were obtained from all stratigraphic levels. Technical work was carried out by using classical methods for the micropaleontological analysis (chemical break up, washing, drying, selection and determination). Selected foraminiferal specimens were photographed with an electron microscope JMS - 5510 – JEOL.

LITHOSTRATIGRAPHY OF PALEOGENE IN DELČEVO BASIN

Delčevo basin is a tectonic graben structure with NW-SE orientation, situated between Mt. Vlaina in the east and Osogovo mountains in the west. In the south and southeast it connects with Berovo valley and Maleševo mountains, in the north it extends to Crna Skala (Bulgarian border) and continues to the northeast on Bulgarian territory.

The areas of the broader environment of Delčevo basin are part of the Serbian–Macedonian massif and are characterized by very heterogeneous lithological structure, with a predominance of tectonic elements in SMM direction. The heterogeneous lithological structure is represented with different rocky types of Precambrian complex, rocks from Paleozoic complex, Mesozoic rocks, sediments from Upper Eocene and Neogene-Quarter sediments and volcanics (Fig. 2).

The Paleogene sediments in the basin are developed in several localities, which lie transgressively over crystal masses of the Serbian-Macedonian massif, and are mostly covered with effusive rocks and Neogene sedimentary deposits, of which some are uncovered and decomposed. According to the current knowledge, the Paleogene sediments of the Delčevo basin are nearly 700 m thick.

The Paleogene in the Delčevo basin is developed in flysch facies. Based on the fauna that occurs at all levels of the Paleogene mass, it is defined as belonging to Upper-Eocene. According to the lithologic composition and the super-positioning, Upper-Eocene sediments are separated into two lithostratigraphic units: basal lithozone and upper flysch lithozone.

Basal lithozone was discovered in the vicinity of the Dramče and Pančarevo villages and in the area between the villages of Gabrovo and Zvegor. Because of the different color in the lithological unit, in this lithozone two lithostratigraphic units (members) are distinguished: violet-reddish and gray-greenish basal member. Both litostratigraphic members have the same lithological composition, so the first basal member is characterized by red to purple color, and the second by gray-greenish color. They are represented with large conglomerates, sandbox and marlyshales. The entire lithozone is characterized by noticeable red to violet color. The thickness of the basal lithozone is approximately 100 m.

The upper flysch lithozone was discovered southwest of the city of Delčevo, southeast of the village of Virče, east of the Vetren and Ostrec vil-

lages, and the very border at Crna Skala. It has been allocated as a separate lithostratigraphic unit because of the participation and rhythmic switching of various lithological members, represented by sandstones, clay and microconglomerates with the presence of thin layers of aleurolites, marls, and limestones. Sandstones are the most abundant members of this lithozone. Sandstones are gray-white, greenish to yellowish in color and contain a rather large proportion of mica. They are characterized by fine-grained to middle-grained composition, mostly with silicon-iron matter. In them there are poorly preserved prints of flora. Small-grained to fine-grained sandstones contain more clay, and a poorly expressed horizontal lamination is present with alternating switching of dark and bright laminas, where the thickness varies from 2 to 5 mm.

Microconglomerates together with sandstones in the lithozone occur in its middle and final part, and are distinguished by their purple color. They lie directly and concordantly through the flysch lithozone. They are built from various fragments, mostly of quartzite, sandstone pebbles and granodiorite rocks, shale etc., and are unevenly distributed. The cement substance is a carbonate.

Marls are in the form of thin leaves and occur in clay layers. They are dark green in color, but iron substance is often present that gives them a reddish color. In some places the clay substance prevails within the composition of marls and they are turned into marly clays that are characterized by dark gray to black color. Aleurolite clays are quite thin and leafy with much mica-muscovite. Limestones are compact, usually dark gray and they occur in thin layers. The thickness of the upper flysch lithozone is about 400–600 m.

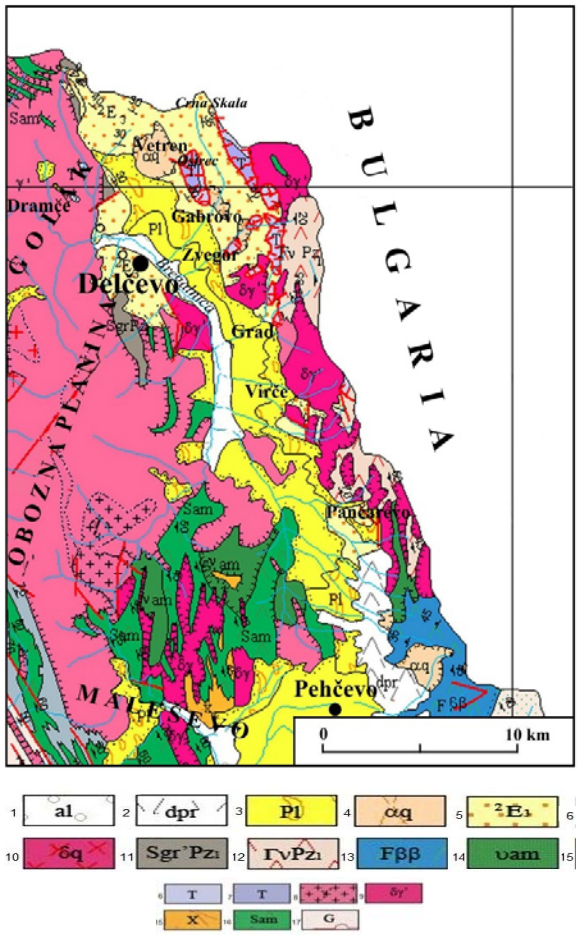

Fig. 2. Geological map of Delčevo basin
1) Aluvium, 2) Deluvium–proluvium, 3) Marl-clays, sands and gravels, 4) Quartzlatites, 5) Conglomerates, flysch lithozone, limestones, 6) Limestones, 7) Gray-red clays and stones, 8) Granitporphyre, 9) Granodiorite, 10) Quartzdiorite, 11) Graphitic-quartz schists, 12) Metaklastits with small bodies of granodiorite, 13) Metasediments, 14) Amphibolgabbro, 15) Metamorphosed rhyolite, 16) Amphibole schists, 17) Gneisses

CRNA SKALA SECTION

The explored Crna Skala section is located 3 km NE of the village Vetren, on the very border with the Republic Bulgaria, located in the upper flysch lithozone (Fig. 2).

The thickness of the section is approximately 75 meters. The section is represented by the following lithological characteristics: clay-sandy layers that gradually turn into each other, which rhythmically alternate with sandstones, claystone with marly clays and thin interlayers of limestone (Fig. 3).

Specific macrofauna is represented by a number of small and large forms of bivalves, gastropods, echinoides and corals, Temkova (1957) (Table 1).

Macroforaminifera in the section is represented by nummulite fauna, including *Nummulites fabiani* Prever, Temkova (1957).

Micropaleontological research of the for aminiferal fauna has been made in the sediments of the upper flysch lithozone. The base of the profile starts with sandstones that alternate with sandy clay, with a thickness of 50–80 cm, rich with nummulites. Sampling was performed in marly-clay layers and 26 samples were taken. Sampling was performed on every 1.5 to 2 meters in the clay-marl layer, with the exception of samples 1, 3, 8, and 14 that were taken in the gray-greenish clay-sandy layers (Fig. 4).

Fig. 3. Section at the site Crna Skala

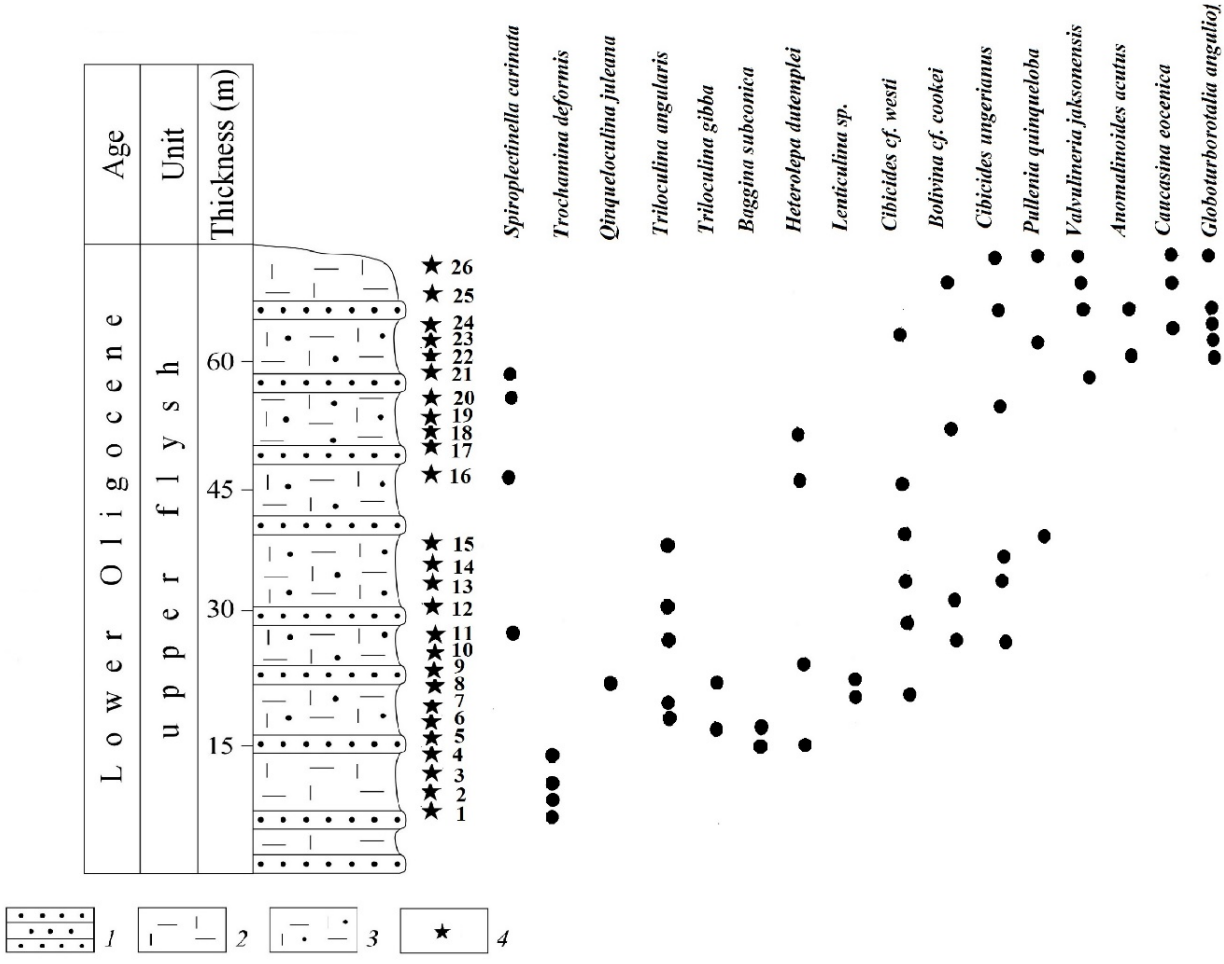

Fig. 4. Stratigraphical distribution of the foraminifer fauna in the Crna Skala section
1) sandstones; 2) clayey-carbonate sediments; 3) clayey-carbonate-sandy sediments; 4) samples

The faunal material from benthic and planktonic foraminifer fauna has been found into the section.

From micropaleontological analysis positive results were obtained for samples 1–26 for foraminifer fauna. Benthic foraminifers are represented by the gender representatives: *Spiroplectinella carinata* (d'Orbigny), *Trochamina deformis* Grzybowski, *Quinqueloculina juleana* d'Orbigny, *Triloculina angularis* d'Orbigny, *Triloculina gibba* d'Orbigny, *Baggina subconica* (Terquem), *Heterolepa dutemplei* (d'Orbigny), *Lenticulina* sp, *Pullenia quinqueloba* (Reuss), *Bolivina* cf. *cookei* Cushman, *Cibicides* cf. *westi, Cibicides ungerianus* (d'Orbigny), *Anomalinoides acutus* (Plummer), *Caucasina eocenica* Chalilov, and *Valvulineria jaksoensis* Cushman. In contrast, the planktonic foraminifers yielded only specimens of *Globoturborotalia angulioficinalis* (Blow).

RESULTS AND DISCUSSION

From previous macrofauna research of Paleogene sediments (Temkova, 1957) at the site Crna Skala 44 species were determined belonging to the classes: Gastropoda, Bivalvia, Echinoidea and Anthozoa (Kühn, 1951). Specific fauna is characterized with multitudinousness and diversity. Of the total fauna collected from the site, a prominent place belongs to the nummulite fauna represented by *Nummulites fabiani* Prever, which is the managing fossil for Upper and Eocene-Priabon (Table 1).

Stratigraphic horizontal positioning of the Paleogene lithozone on this site based on paleontological data of the macrofauna was quite difficult. The macrofauna discovered in the flysch lithozone is a set of forms from Upper Eocene-Priabon. Among them there are those that also go into the Lower Oligocene and Middle Oligocene. These are the species that occur quite early and have great vertical spreading while in the macrofauna collection of the Crna Skala section typical Oligocene forms have not been found. The age of the flysch lithozone of the sediments at Crna Skala section based on the species *Nummulites fabiani* Prever has been designated as Upper-Eocene.

After a careful examination of the samples collected from the Crna Skala section, abundant benthic and less common planktonic foraminifers were found: 16 species from 14 genera that belong to 11 families: *Spiroplectamminidae* Cushman 1927, *Trochamminidae* Schwager 1877, *Cibicididae* Cushman 1927, *Nonionidae* Schultze 1854, *Bagginidae* Cushman 1927, *Caucasinidae* Bykova 1959, *Bolivinidae* Glaessner 1937, *Hauerindae* Schwager 1876, *Heterolepidae* Gonzáles-Donoso 1969, *Nodosariidae* Ehrenberg 1838, *Globigerinidae* Car., Park. and Jones, 1862.

The systematic classification of the foraminiferal fauna follows that of Loeblich and Tappan (1988).

Thus, the species composition of the benthic foraminifers from the studied section includes: 2 species of agglutinated foraminifera: *Spiroplectinella carinata* (d'Orbigny, 1846), *Trochaminadeformis* Grzybowski, 3 porcelaneous: *Quinqueloculina juleana* d'Orbigny, *Triloculina gibba* d'Orbigny, *Triloculina angularis* d'Orbigny, and 10 hyaline ones: *Baggina subconica* (Terquem), *Heterolepa duteplempei* (d'Orbigny), *Lenticulina* sp., *Pullenia quinqueloba* (Reuss), *Bolivina* cf. *cookei* Cushman, *Cibicides* cf. *westi, Cibicides ungerianus* (d'Orbigny), *Anomalinoides acutus* (Plummer), *Caucasina eocenica* Chalilov, and *Valvulineria jaksoensis* Cushman.

Benthic species occur throughout the section (samples 1–26).

By analyzing the stratigraphic position of certain taxa of the foraminifer fauna at Crna Skala section it is concluded that:

Benthos hyaline foraminifer of the Crna Skala section *Baggina subconica* (Terquem), *Heterolepa dutemplei* (d'Orbigny), *Lenticulina* sp, *Pullenia quinqueloba* (Reuss), *Bolivina* cf. *cookei* Cushman, *Cibicides* cf. *westi*, *Cibicides ungerianus* (d'Orbigny), *Anomalinoides acutus* (Plummer), *Caucasina eocenica* Chalilov, and *Valvulineria jaksoensis* Cushman, have broad stratigraphic extension (Upper Cretaceous to Paleocene or Miocene) and cannot determine the exact geological age. Agglutinated and porcelaneous foraminifers do not represent determination of the geological age. Planktonic species *Globoturborotalia angulioficinalis* (Blow) is found in the upper levels of the section (samples 13 to 26). Generally from stratigraphic distribution of planktonic foraminifera *Globoturborotalia angulioficinalis* (Blow) occurs together from the Upper Eocene (Zone P 16) to the end of the Oligocene (Zone P 22). The chronostratigraphic framework (Lower Oligocene) of our investigation is based on planktonic foraminiferal data Stojanova et al. (2013).

T a b l e 1

Correlation of macrofauna at the site Crna Skala with other basins

	Name of species	Crna Skala	Tikveš basin	Ovče Pole basin	Bulgaria	Northern Italy
1.	*Nummulites fabiani* Prever	•			•	•
2.	*Baryphyllia italica* D'Ach.	•				•
3.	*Colpophyllia flexuosa* D'Ach.	•				•
4.	*Dendrogyra italica* D'Ach.	•				•
5.	*Echinolampas* cf. *anceps* Lambert et Ch.	•				
6.	*Pectunculus striatissimus* Bellardi Bouss.	•				•
7.	*Chlamus subdiscors* D'Ach. Boussac	•		•		•
8.	*Crassatella bertrandi* Boussac	•				•
9.	*Crassatella semicostata* Bolardi	•	•			•
10.	*Crassatella* sp.	•				
11.	*Meretrix villannovae* Desch. Boussac	•	•	•		•
12.	*Meretrix incrassata* Boussas	•		•		•
13.	*Meretrix bonetensis* Boussas	•		•		
14.	*Lucina pullensis* Opp.	•				
15.	*Lucina* sp.	•				
16.	*Amussium corncum sow.* sp. Doussak.	•	•	•		•
17.	*Pecten robianae* Mgh.	•				•
18.	*Pecten* sp.	•				
19.	*Ostrea gigantica* Solander in Brander	•		•		
20	*Cytherea heberti* Desh.	•				•
21.	*Cyprina brevis* Fuchs	•				•
22.	*Cyrena sarena* Brongniart	•		•		
23.	*Corbis* cf. *escheri* Mayer Eymar	•				
24.	*Corbis aglaurac* A. Br.	•				
25.	*Cardium polyptictum* Bayan	•				
26.	*Cardium* sp.	•				
27.	*Corbula bernencis* Boussac	•	•			
28.	*Corbula semicostata* Bellardi	•	•	•		•
29.	*Corbula nicensis* Bellardi	•				
30	*Spondylus bifrons* Munster en Coldfuss.	•	•	•		
31.	*Cypraea marginata* Fuch.	•				•
32.	*Cerithium vivari* Oppenh. var. *alpinum* Tour.	•		•		
33.	*Diastoma costellatum* Lamarck var. *alp*. Tour.	•	•		•	•
34.	*Nicula elongata* Vinassa de Bagny	•				
35.	*Nerita namnetica* Vassseur	•				
36.	*Melongana pyruloides grat.* var. *bonnot*, Bouss.	•		•		
37.	*Conus* cf. *diversiformis* Deshayes	•				•
38.	*Turritella imbricataria* Lamarck et var. *Carinifera*.	•			•	
39.	*Turritella hortensis* Vinassa	•				•
40.	*Natica vapincana* d'Orbigny	•		•		•
41.	*Natica crassatina* Lamk.	•		•	•	
42.	*Natica vulcaniformis* Oppenhein	•		•		•
43.	*Natica patula* Desh.	•				•
44	*Natica depressa* Lamarck	•		•		•

From the given table it can be seen that a number of specific forms are common with the forms from other areas. The macrofauna of the site Crna Skala has noticeable resemblance with the forms in Northern Italy (Vicentino). It also has great similarity with the forms in Bulgaria, both in facial relationships and in the presence of common fossils. The fauna on the site Crna Skala also contains common forms with the fauna of the Tikveš basin and the Ovče Pole basin, which confirms similar bionomic conditions and common links between these basins during the deposition of sediments.

CONCLUSION

From previous macrofaunal studies of the Paleogene sediments on the site Crna Skala, based on the species *Nummulites fabiani* Prever, the age of the sediments in the upper flysch lithozone has been determined as Upper Eocene.

The stratigraphic distribution of this valuable species within the foraminiferal association from section Crna Skala is accepted age as Lower Oligocene. Age Lower Oligocene is accepted because of the presence of *Globoturborotalia angulioffici-nalis* (Blow) in other sections together with typical Oligocene species.

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Р е з и м е

МАКРО- И МИКРОФАУНА ВО ГОРНОЕОЦЕНСКИТЕ СЕДИМЕНТИ ОД ЛОКАЛИТЕТОТ ЦРНА СКАЛА, РЕПУБЛИКА МАКЕДОНИЈА

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Клучни зборови: макрофауна; бентосна и планктонска фораминифера; палеогени седименти; делчевски басен

Локалитетот Црна Скала му припаѓа на делчевскиот басен, Р. Македонија. Делчевскиот басен се наоѓа во СИ дел на територијата на Република Македонија, и во геотектонска смисла припаѓа на српско-македонскиот масив.

Според досегашните истражувања, палеогените седименти во делчевскиот басен се со дебелина од околу 700 m и се издвоени две литостратиграфски единици: базална и горна флишна литозона.

Истражуваниот локалитетот Црна Скала се наоѓа околу 8 km северно од градот Делчево, на самата граница со Р. Бугарија. Лоциран е во седиментите од горната флишна литозона, во кои се пронајдени богата и разновидна макрофауна и мошне интересен микропалеонтолошки материјал.

Макрофауната е претставена од голем број бивалвии, гастроподи, корали, нумулити и др., а микрофаунистичкиот материјал е претставен од бентосна и планктонска фораминиферна фауна, од која се одредени 16 видови кои припаѓаат на 14 рода и 11 фамилии.

Според резултатите од претходните истражувања на макрофауната седиментите од горната флишна литозона во профилот Црна Скала се со горноеоценска старост. Меѓутоа, врз основа на стратиграфската распространетост на видовите во рамките на фораминиферната асоцијација во профилот Црна Скала може да се прифати дека геолошката старост на седиментите од горната флишна литозона е долноолигоценска. Оваа старост е прифатена поради стратиграфската распространетост на видот *Globoturborotalia anguli officinalis* (Blow) (зона P16 до зона P22), бидејќи овој вид во другите палеогенски профили во Македонија се среќава заедно со типични олигоценски видови.

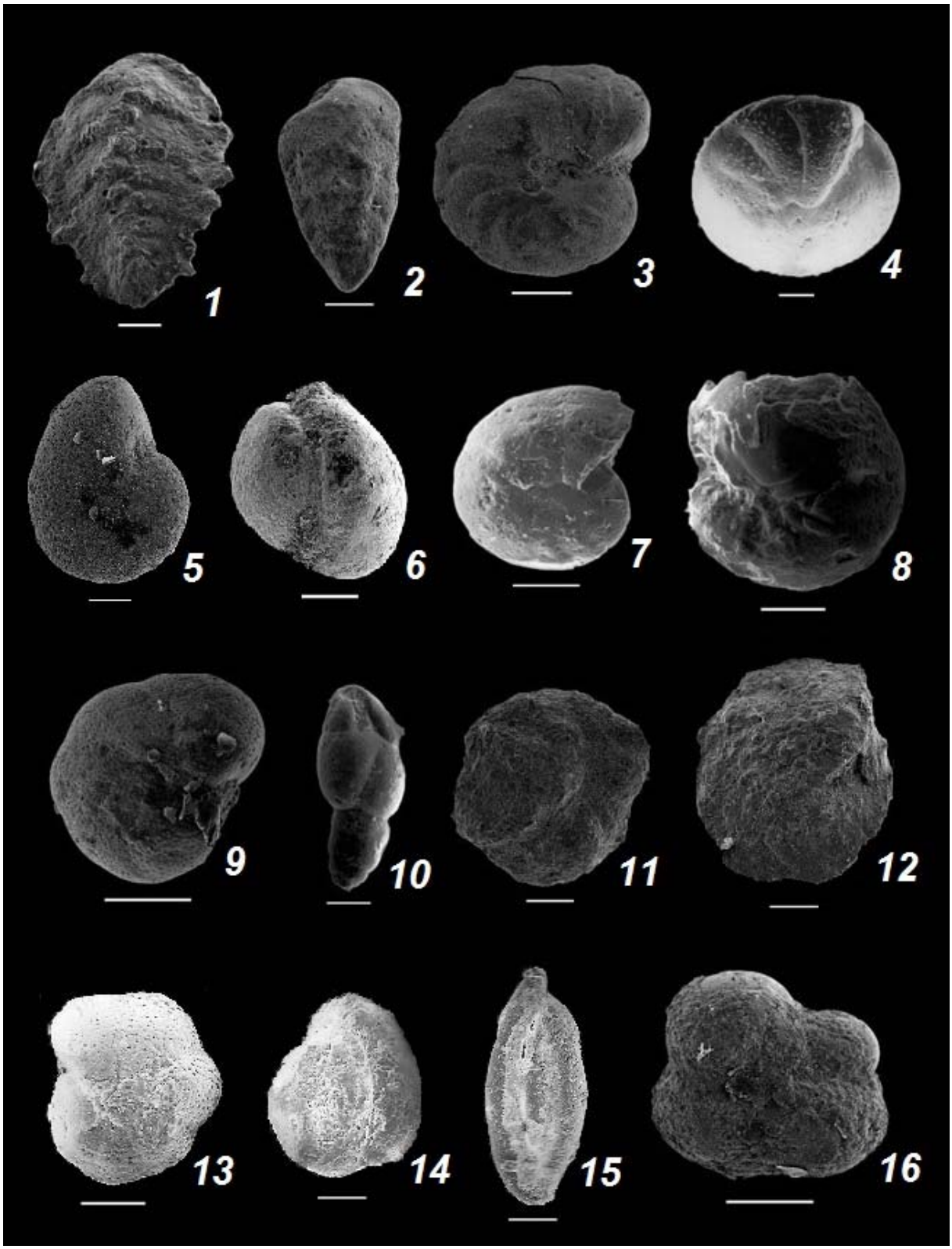

PLATE I

1. *Spiroplectinella carinata* SEM×120, **2.** *Bolivina cookei* SEM×130, **3.** *Anomalinoides acutus* SEM×180, **4.** *Heterolepa dutemplei* SEM×120, **5.** *Pullenia quinqueloba* (Reuss) SEM×140, **6.** *Triloculina angularis* d'Orbigny SEM×180, **7.** *Cibicides ungerianus* SEM×160, **8.** *Baggina subconica* SEM×150, **9.** *Valvulineria jacksoensis* SEM×250, **10.** *Caucasina eocenica* SEM×240, **11.** *Trochammina deformis* SEM×150, **12.** *Lenticulina* sp. SEM×180, **13.** *Cibicides* cf. *westi* Howe SEM×150, **14.** *Triloculina gibba* d'Orbigny SEM×137, **15.** *Quinqueloculina juleana* d'Orbigny SEM×137, **16.** *Globoturborotalia anguli of icinalis* SEM×220, Scale bar = 100 μm

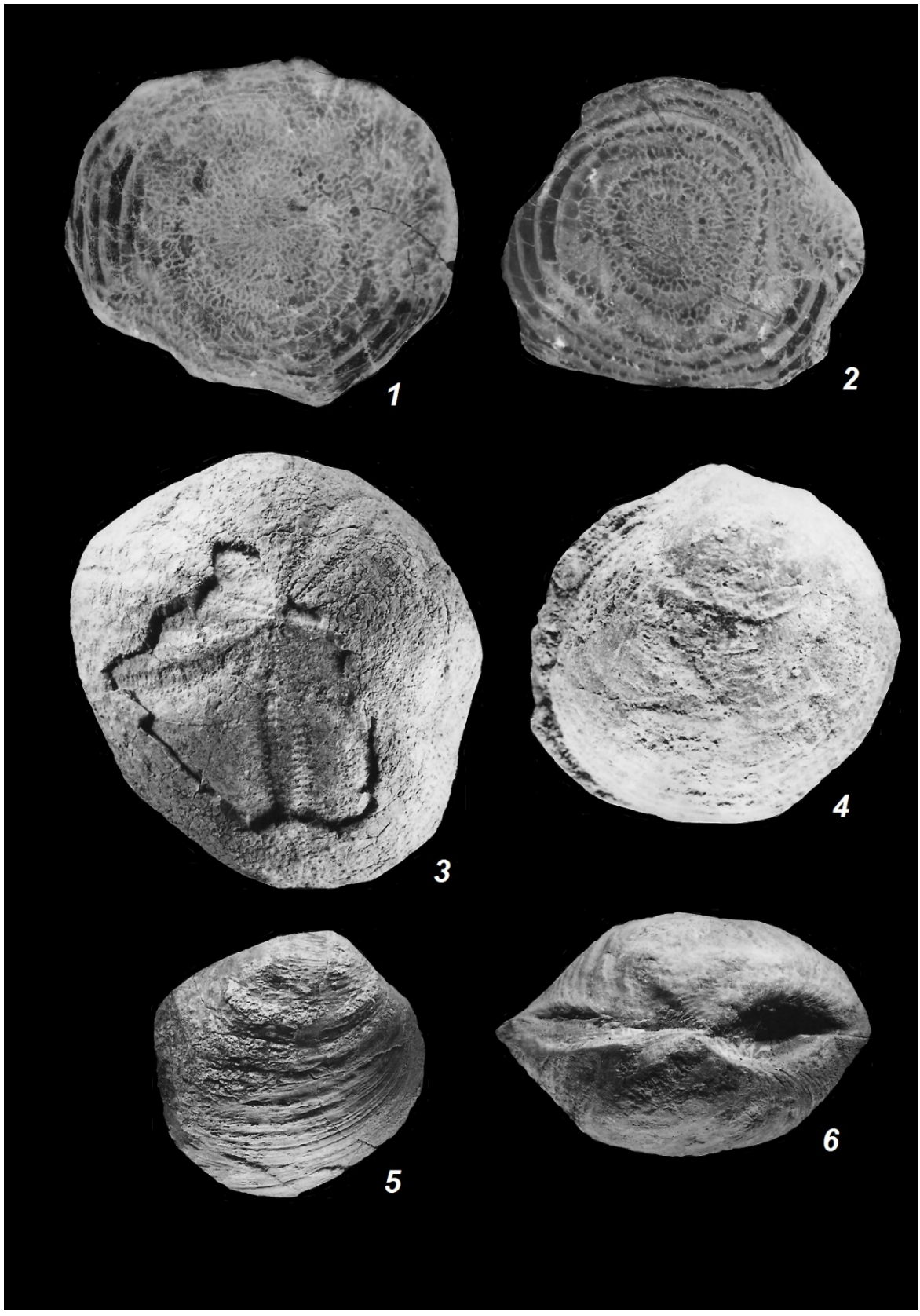

PLATE II
1–2. *Nummulites fabiani* Prever, **3**. *Echinolampas* cf. *anceps* Lambert et Chsutard, **4.** *Pectunculus triatissimus* Bellardi Boussac, **5–6.** *Crassatella semicostata* Bellardi (after V. Temkova)

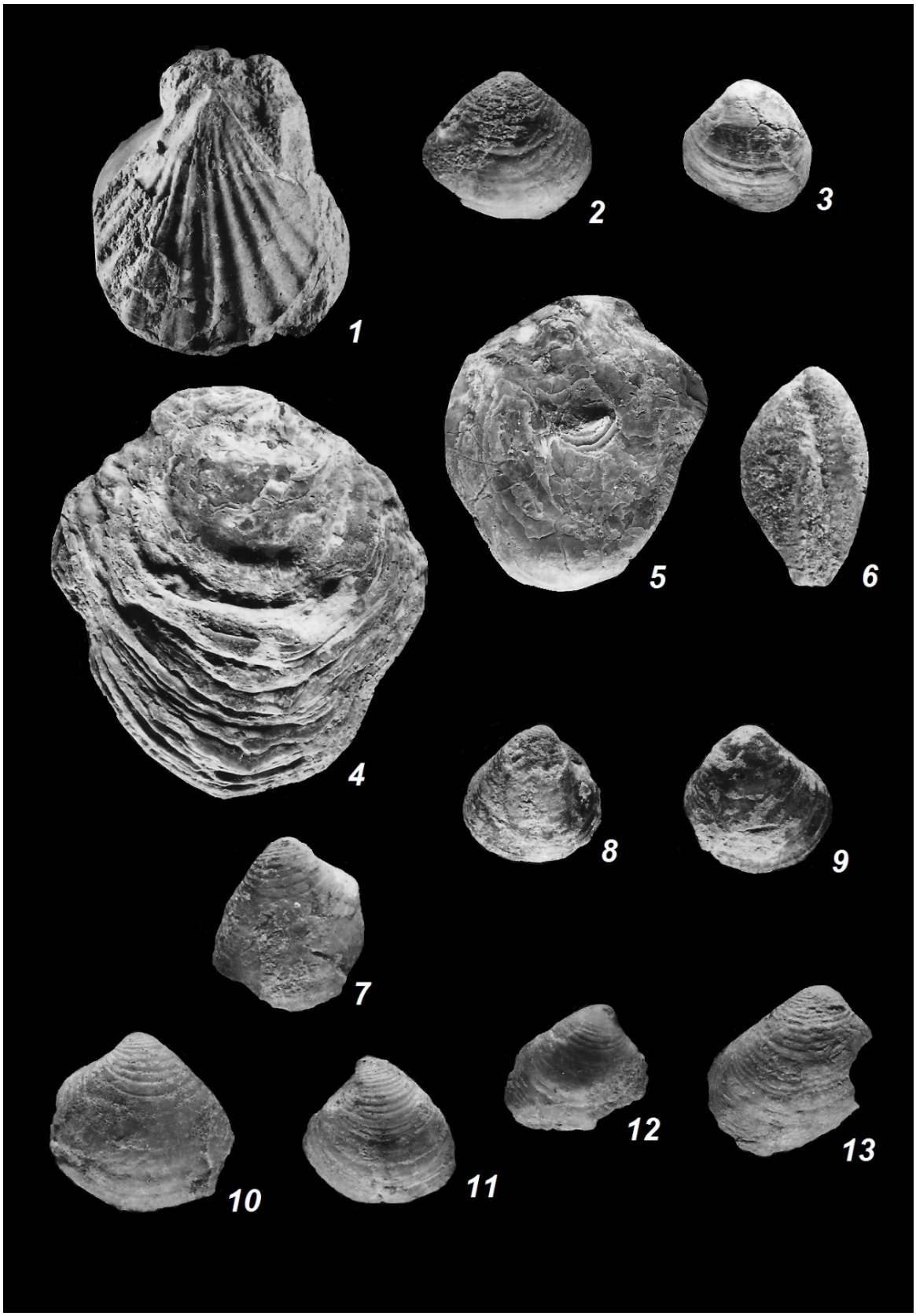

PLATE III
1. *Pecten* sp., **2**. *Meretrix villanovae* Desch sp. Boussac**, 3**. *Meretrix incrassate* Sowely et Boussac,
4–5. *Ostrea gigantica* Solander in Brander**, 6.** *Cyprina marginata* Fuchs, **7, 10, 11**. *Cyprina brevis* Fuchs,
8–9. *Cytherea* cf. *incrassate* Sow, **12–13**. *Cyrena sarena* Brongniart
(after V. Temkova)

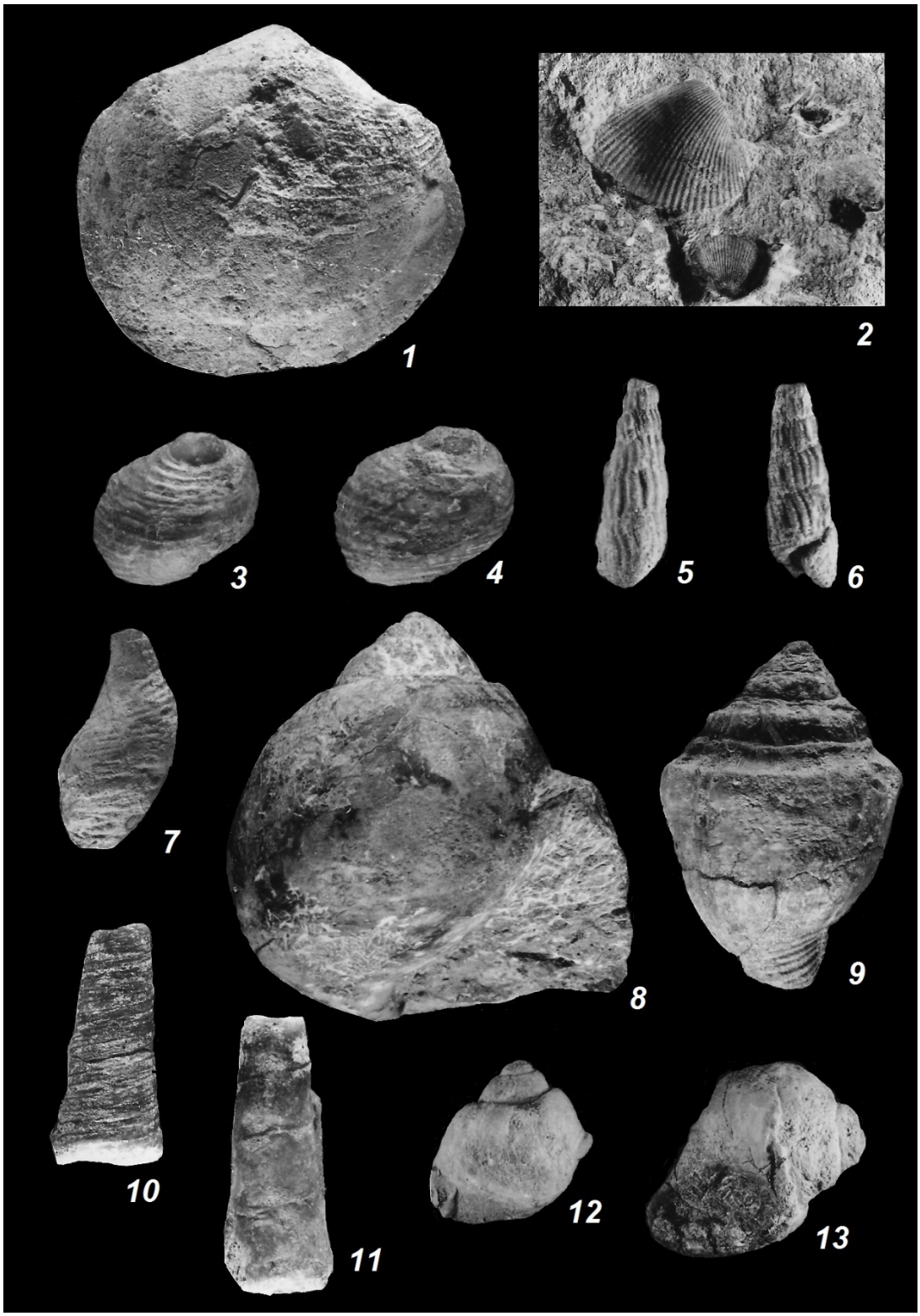

PLATE IV

1. *Corbis aglaurac* Br., **2.** *Cardium polyptuctum* Bayan, **3–4.** *Nerita namnetica* Vasseur, **5–6**. *Diastoma costellatum* Lamarck sp. mut. *alpinum*, **7.** *Ficulae longate* Vinassa de Regny, **8.** *Natica vapincana* d'Orbigny**. 9.** *Melongena pyruloides* sp. mut. *bonetensis* Boussac, **10.** *Turritella inbricataria* Lemn. var. *carinifera* Dec., **11**. *Turritella hortensis* Vinass., **12–13**. *Natica vulcani* Brongniart
(after V. Temkova)