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New Data on the Planktonic Foraminifers from the Yunusdag Formation (Coniacian–Santonian) in the Kelevudag Section, Northeastern Azerbaijan

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Abstract—An assemblage of planktonic foraminifers is recognized for the first time from the Yunusdag Formation (Kelevudag Section, northeastern Azerbaijan) The analysis of foraminifers from the studied sample suggests that it may belong to the upper part of the Marginotruncana coronata Zone, embracing the interval from the upper Turonian to the lower Coniacian inclusive. The taxonomic composition of the assemblage allows the Kelevudag section to be assigned to an intermediate province separating the Boreal and Tethyan realms and including the Late Cretaceous carbonates of Dagestan.

Keywords: Caucasus, stratigraphy, Coniacian, Santonian, planktonic foraminifers.

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INTRODUCTION

This paper continues a series of publications on Cretaceous foraminifers and radiolarians in the Kelevudag Section. The studied region is located on the northeastern slope of the Greater Caucasus (northeastern Azerbaijan, Gubinsk District, Fig. 1a). Cretaceous deposits are widespread in the Azerbaijan zone of the Greater Caucasus, which has a complex geological structure. The biostratigraphic subdivision of the Cretaceous deposits was mainly substantiated by D.M. Khalilov on foraminifers and by A.G. Khalilov on rare occurrences of macrofauna (Aliev, 1965; *Geologiya*..., 1972). It is noted in a book (Melovaya..., 1988): "In the Khizinskaya Zone, the Coniacian deposits in the section of Kelevudag Mountain are represented by light gray clay, marl, and microconglomerate. Up the section the deposits are represented by a frequent alternation of gray clay, sandstone, and limestone containing *Gyroidinoides depressus* (Alth.), *Osangularia whitei* (Brotz.), *Gavelinella infrasantonica* (Balakhm.), *Schackoina multispinata* (Cushm. et Wick.), *Globotruncana coronata* Bolli, *Gl. lapparenti* Brotz., *Striataella striata* (Ehrenb.), and *Pseudotextularia plummerae* (Loett.). Thickness 60 m." The Santonian Stage in the section of Kelevudag Mountain is represented by an alternation of gray bedded arenaceous limestone, light gray bedded arenaceous marl, and variegated (greenish and reddish) bedded calcareous, arenaceous clay. The clay contains *Bulumina brevis* (d'Orb.), *Ataxophragmium compactum* Brotz., *Cibicides eriksdalensis* Brotz., *Globotruncana fornicata* (Plumm.), *Gl. verrucosa* Vasil., *Heterohelix globulosa* (Ehrenb.), *Striataella striata* (Ehrenb.), *S. santonica* (Agal.), *Globorotalites michelinianus* (d'Orb.), and *Eponides biconvexus* Marie. Thickness is 10 m. Unfortunately, no modern publications exist on this region. Many data that were considered to be of acceptable standard in the 1960s–1970s are now outdated, as the taxonomy of the orthostratigraphic taxa has changed, as has knowledge on the stratigraphic ranges of many index taxa.

The Kelevudag Section is located on the south slope of Kelevudag Mountain to the northeast of the village of Konakhkend (Fig. 1b). Radiolarians from the Berriasian–Valanginian, Albian, and Cenomanian of this section were previously studied by Aliev (1961, 1965, 1967, 1968, 1976). Later, a new detailed study of the Albian–upper Turonian radiolarians was conducted here (Bragina and Bragin, 2015). Unfortunately, in the Coniacian and Santonian of the Kelevudag Section, radiolarians are poorly preserved and are unidentifiable. In recent years, the planktonic foraminifers from the lower Cenomanian–lower Turonian of the Kelevudag section have been studied (Kopaevich et al., 2015). This paper presents new materials on foraminifers of the Coniacian–Santonian part of the section.

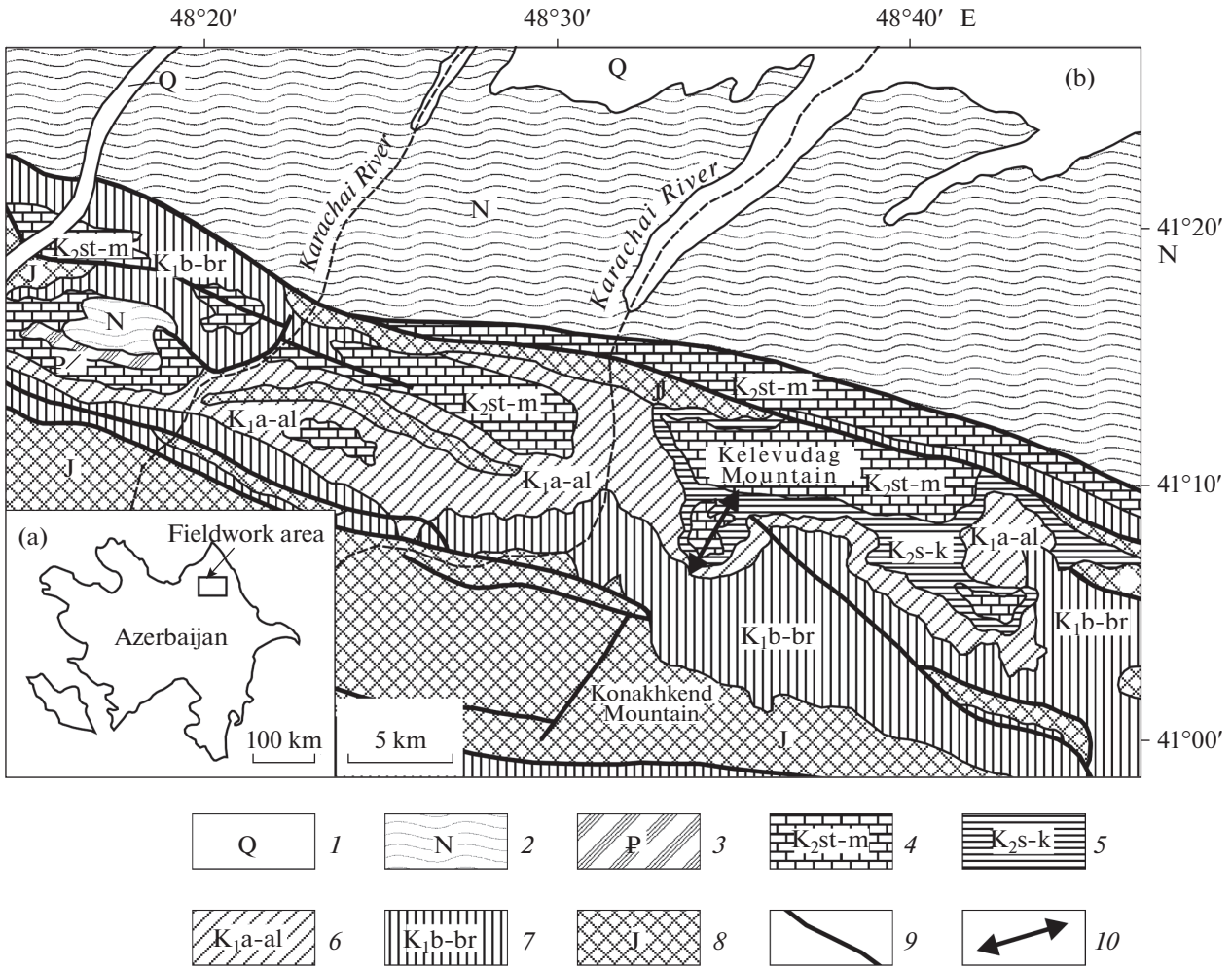

Fig. 1. (a) Location of fieldwork in Azerbaijan and (b) scheme of geological structure of the studied region showing the Kelevudag Section (*Geologicheskaya*..., 1976). (b): (*1*) Quaternary deposits; (*2*) Neogene deposits; (*3*) Paleogene deposits; (*4*) Santonian–Maastrichtian deposits; (*5*) Cenomanian–Coniacian deposits; (*6*) Aptian–Albian deposits; (*7*) Berriasian–Barremian deposits; (*8*) Jurassic deposits; (*9*) faults; (*10*) position of the section of Kelevudag Mountain (after Bragina and Bragin, 2015).

MATERIALS AND METHODS

N.Yu. Bragin, during fieldwork in 2005, collected samples from the clay, carbonate, and cherty lithological rock types in the Kelevudag Section. Cherty beds disintegrated using hydrofluoric acid and micritic limestones disintegrated by formic acid using standard methods both produced good results (Pessagno and Newport, 1972). The preparation of material from one sample from the Coniacian–Santonian part of the section yielded a representative assemblage of planktonic foraminifers. The recognized microfossils were photographed using a Tescan 2300 SEM equipped with a BSE detector (Plates I–IV).

STRATIGRAPHY

Bragina and Bragin (2015) provided a detailed description of the Albian–Coniacian part of the Kelevudag Section, and the same member numbering system is retained in this paper. A lithological description of the Coniacian–Lower Campanian part of the section sampled for foraminifers and radiolarians is given below (Fig. 2).

Member 6. Kemchi Formation. Alternation of opoka-like, light gray, white, black, and greenish gray, platy cherts; cherty, yellowish gray and light gray marls; gray, small and medium-grained sandstones; light gray, cherty argillites. Thickness 15 m.

Member 7. Yunusdag Formation. Calcareous conglomerates, gravelites and calcarenites, massive, light yellowish gray, with layers of gray micritic limestone and gray cherty marl (in the lower part of the bed). Up the section, the conglomerate contains rare beds of greenish gray calcareous clay and gray arenaceous limestone. Thickness 40 m. The formation is assigned to the Santonian, although in (*Geologiya*..., 1997) there was a suggestion of the Coniacian age of the lower part of the conglomerate series in the Kelevudag

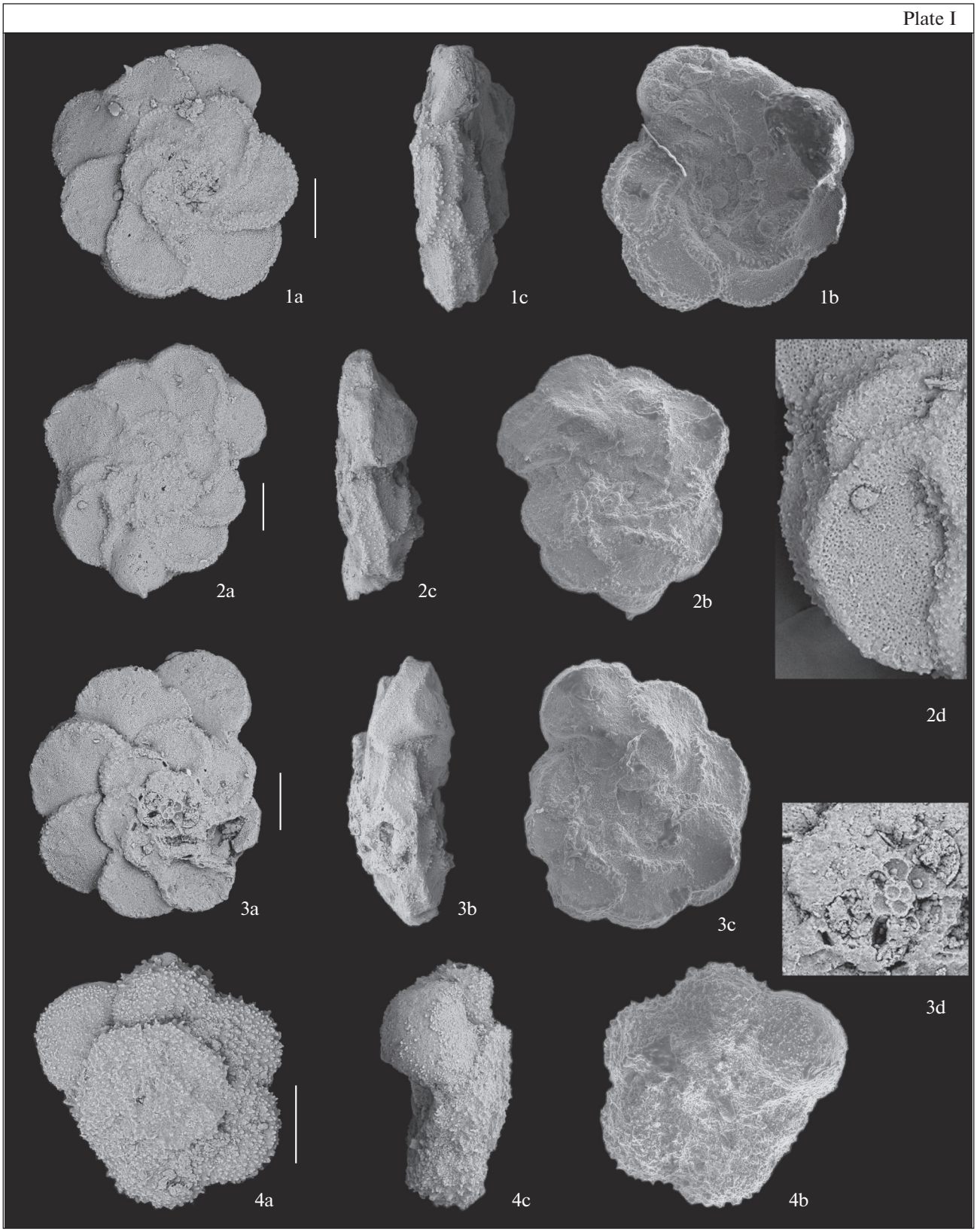

Plate I. Planktonic foraminifers from the Coniacian–Santonian of Kelevudag Mountain (Azerbaijan). (1, 2a–2d, 3a–3d) *Marginotruncana coronata* (Bolli), (2d) enlarged fragment of the dorsal side; (3d) enlarged fragment of the dorsal side showing the inner structure and the initial whorl; (4) *Archaeoglobigerina cretacea* (d'Orbigny). All photographs here and in Plates II–IV are of specimens from Sample 05-7-58. All scale bars are 200 μm. Here and in Plates II–IV: (a) dorsal view, (b) umbilical view, (c) peripheral view.

Section. In the middle of the member (Sample 05-7-58), we found planktonic foraminifers, which belong to the following taxa: *Marginotruncana pseudolinneiana* Pessagno (Plate II, fig. 3; Plate III, figs. 1–4), *Marginotruncana renzi* (Gandolfi) (Plate II, fig. 2), *Marginotruncana coronata* (Bolli) (Plate I, figs. 1–3; Plate II, fig. 1), *Marginotruncana marginata* (Reuss) (Plate IV, figs. 2, 3), *Whiteinella paradubia* (Sigal) (Plate IV, fig. 1), *Archaeoglobigerina cretacea* (d'Orbigny) (Plate I, fig. 4; Plate IV, fig. 4).

Member 8. Gray and yellowish gray calcarenite, with layers of greenish gray clay, white marl, and white micritic limestone. Up the section, marl and clay become more frequent, whereas calcarenite is replaced by calcareous small-grained sandstone. Thickness 40 m. These deposits belong to the upper part of the Yunusdag Formation or the lower part of the Akburun Formation (*Geologiya*..., 1972; *Geologiya*..., 1997); they contain the Campanian foraminifers *Guembelina striata* (Ehrenb.), *Plectina convergens* (Keller), *Neoflabellina jarvisi* Cushm., and *Ataxophragmium crassum* d'Orb. (*Geologiya*..., 1972).

ANALYSIS OF THE FORAMINIFERAL ASSEMBLAGE

An assemblage from one test sample 05-7-58 (Member 7) is analyzed. Previously, the following foraminiferal taxa were recognized in the sections of the Yunusdag Formation in the Shakhdag-Khizi Zone: *Guembelina santonica* Agal., *Schackoina multispinata* (Cushm. et Wick.), *Arenobulimina presli* Reuss, *Bulimina brevis* (Schwag.), and *Globotruncana morozovae* Vasil., whereas the same formation in the Dibrar Zone also contained *Inoceramus inconstans* Woods, *I. lobatus* Goldf., and *I. regularis* Orb. (*Geologiya*..., 1972). The assemblage of the above taxa does not allow dating of the host rocks more precisely than Turonian–Maastrichtian. There are several reasons for this. Firstly the, Yunusdag Formation is thicker (over 100 m); therefore, it is necessary to know which part of the formation contained previously identified fossils. Secondly, at present, the taxonomy of planktonic foraminifers and inoceramids has been considerably revised. For example, the generic name *Guembelina*, according to the taxonomy of Loeblich and Tappan (1987), was replaced by a new generic name *Heterohelix*. Its stratigraphic range is limited to the Upper Cretaceous. The late Campanian and Maastrichtian age is determined by the presence of *Globigerina morozovae* Vasil., which is at present assigned to the genus *Contusotruncana* (Vasilenko, 1961; Maslakova, 1978; Kopaevich, 2010). Species of the genus *Schackoina* dominate at stratigraphic levels marked by episodes of anoxia, including the OAE 2 event at the Cenomanian–Turonian boundary (Coccioni et al., 2006; Kopaevich and Kuzmicheva, 2002; Gorbachik and Kopaevich, 2011; Kopaevich and Gorbachik, 2017). This interval of sections of southwestern Crimea contain *Schackoina multispinata* (Cushm. et Wick.). This species has strongly elongated chambers of the last whorl and two tubulospines on the last chamber, which facilitated its floating in the upper water layers, which were not contaminated by H_2S (Venturati, 2006; Kopaevich and Gorbachik, 2017). Other foraminiferal taxa belong to benthic morphotypes, the stratigraphic position of which does not allow precise dating of the host rocks; it is only possible to tell that this is Upper Cretaceous. Thirdly, inocerams cited from the Dibrar Zone have a different stratigraphic distribution. *Inoceramus inconstans* Woods is currently cited as *Cremnoceramus crassus inconstans* (Woods) and occurs in the lower Coniacian deposits (Walaszczyk and Peryt, 1998; Walaszczyk et al., 2010). The species *Inoceramus lobatus* Goldf. belongs to the genus *Sphenoceramus*, but it is impossible to identify it to species in the absence of a good illustration. At the same time, it is known that the genus *Sphenoceramus* Boehm occurs from the late Coniacian to the early Campanian inclusive. *Inoceramus regularis* Orb. belongs to the genus *Cataceramus* Cox, which is characteristic of the Campanian and lower Maastrichtian deposits (Walaszczyk and Peryt, 1998; Walaszczyk et al., 2010; Walaszczyk, pers. comm.). It is possible that the occurrences of this species belong to the uppermost horizons of the Yunusdag Formation.

The assemblage of planktonic foraminifers studied comes from a bed of arenaceous clay lying between calcarenites, gravelites, and conglomerates in the middle part of the Yunusdag Formation (Coniacian–Santonian) Kelevudag Section.

The sample contains well-preserved planktonic foraminifers. The assemblage includes the following species: *Whiteinella paradubia* (Sigal), *Archaeoglobigerina cretacea* (d'Orbigny), *Marginotruncana pseudolinneiana* Pessagno, *M. renzi* (Gandolfi), *M. coronata* (Bolli), *M. marginata* (Reuss). Although the Turonian–Coniacian interval was quite favorable for planktonic foraminifers, it is difficult to establish their stratigraphic position in this section. For example, members of the group of flat marginotruncanids *Marginotruncana pseudolinneiana* Pess. and *M.* coronata (Bolli) appear here later than in the Western Paratethys and classical Gubbio Section, Central Italy (Robaszynski and Caron, 1995; Coccioni and Premoli Silva, 2015). The sample lacks representatives of single-keeled marginotruncanids, which would permit a positive correlation with these regions (Robaszynski et al., 1990; Robaszynski and Caron, 1995; Coccioni and Premoli Silva, 2015). In the Crimean-Caucasian region, the appearance of *Marginotruncana coronata* (Bolli) is typical of the middle–upper Turonian, and therefore the Marginotruncana coronata Zone was established at this level (Tur et al., 2001; Kopaevich, 2010; Kopaevich and Vishnevskaya, 2016). It is noteworthy that specimens of *Marginotruncana coronata* (Bolli) clearly dominate the assemblages, while the higher diversification is characteristic of the early

Plate II

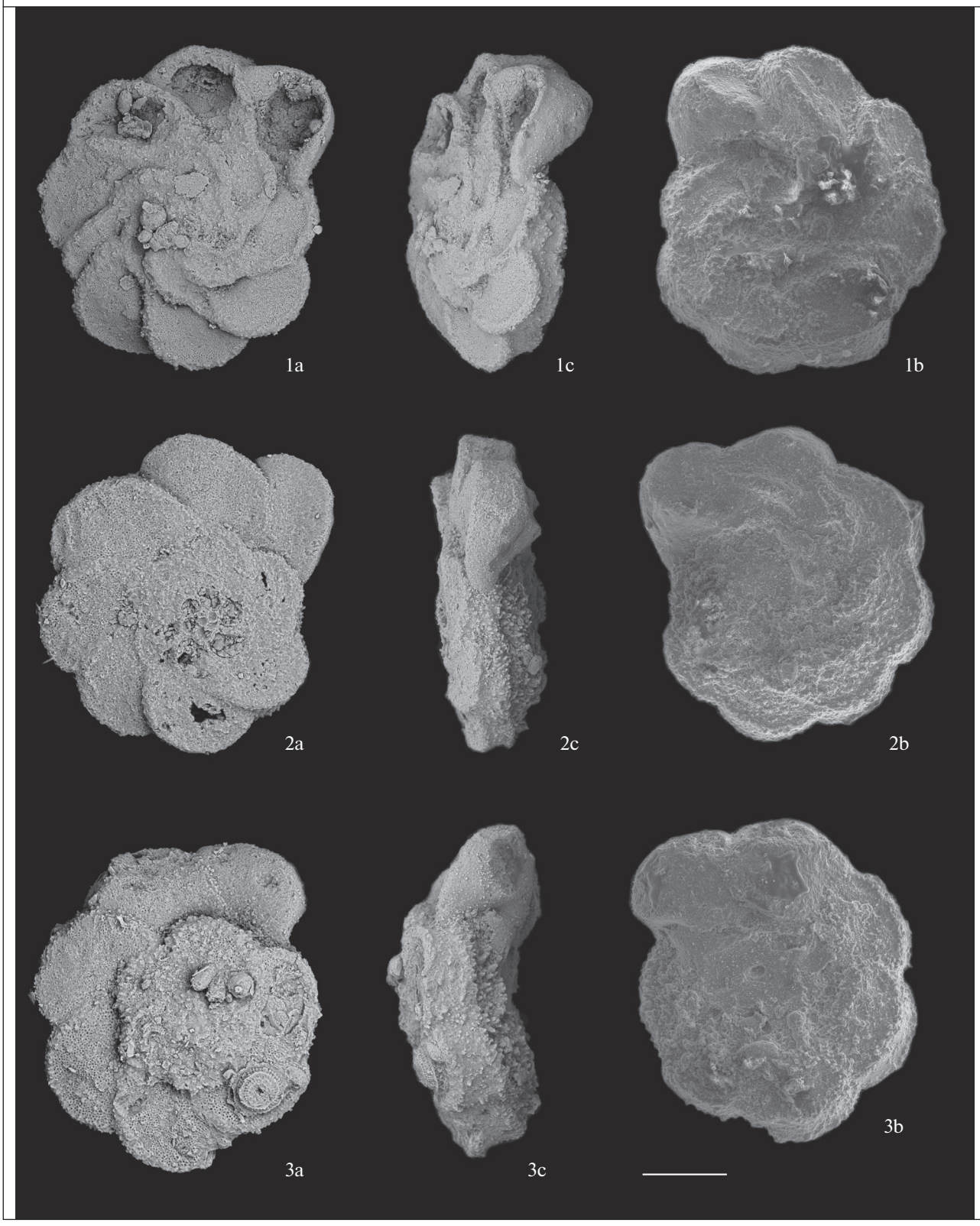

Plate II. Planktonic foraminifers from the Coniacian–Santonian of Kelevudag Mountain (Azerbaijan). (1) *Marginotruncana coronata* (Bolli); (2) *Marginotruncana renzi* (Gandolfi); (3) *Marginotruncana pseudolinneiana* Pessagno. Scale bar is 200 μm.

Plate III

Plate III. Planktonic foraminifers Coniacian–Santonian of Kelevudag Mountain (Azerbaijan). (1–4) *Marginotruncana pseudolinneiana* Pessagno. All scale bars are 200 μm.

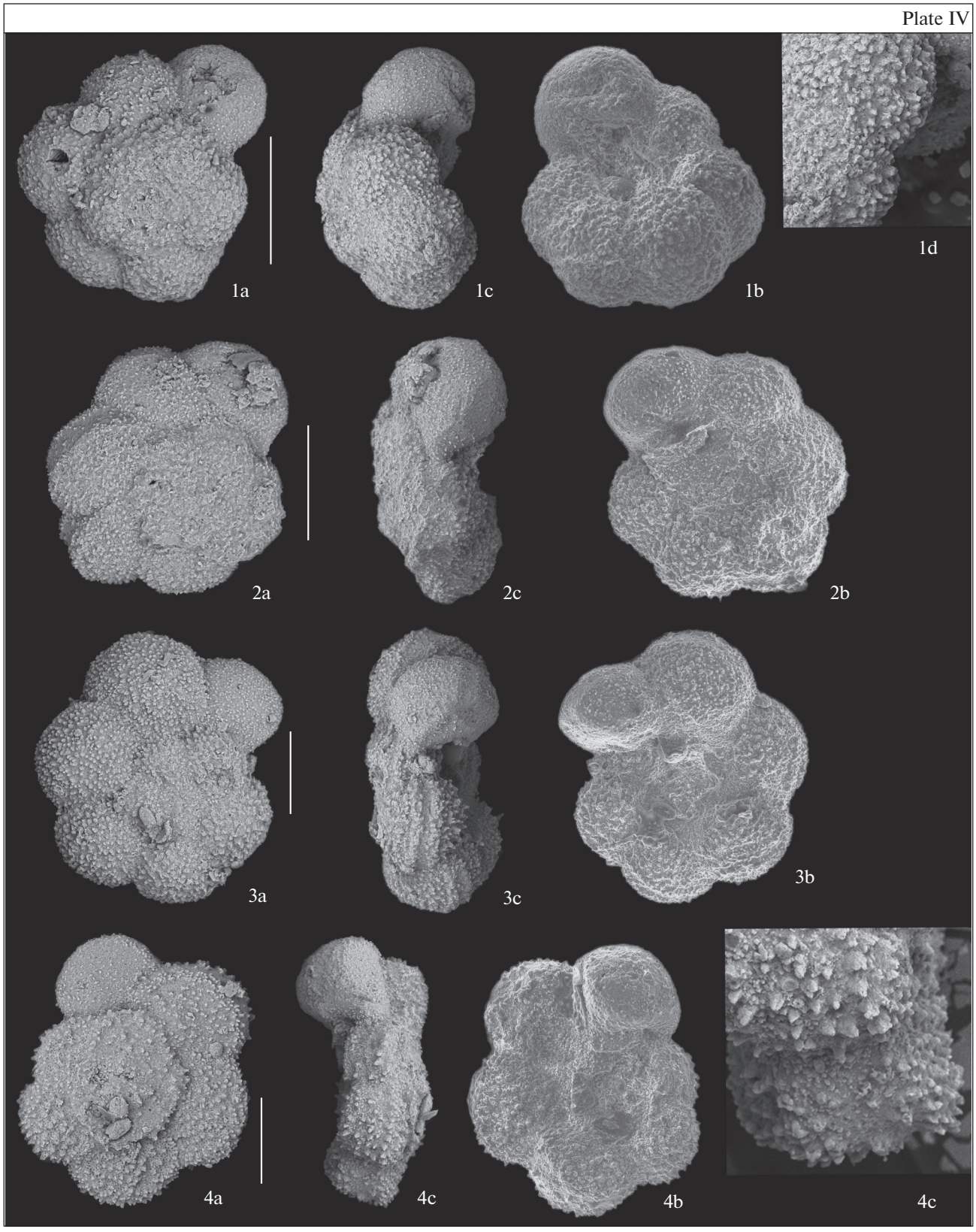

Plate IV. Planktonic foraminifers Coniaciana–Santoniana of Kelevudag Mountain (Azerbaijan). (1) *Whiteinella paradubia* (Sigal), (1d) enlarged fragment of the peripheral view; (2, 3) *Marginotruncana marginata* (Reuss); (4) *Archaeoglobigerina cretacea* (d'Orbigny), (4d) enlarged fragment of the peripheral view demonstrating the double keel and spinous shell. All scale bars are 200 μm.

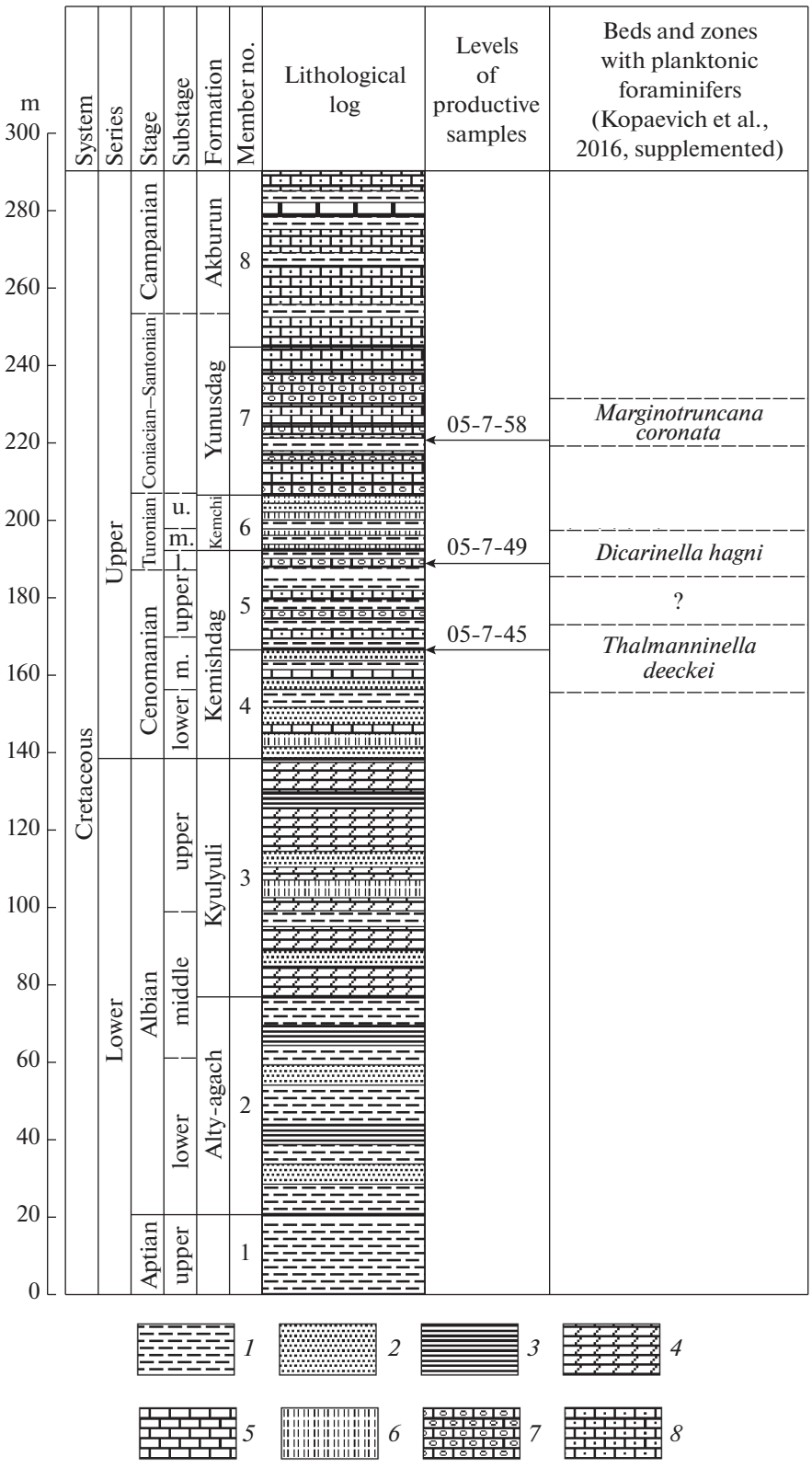

Fig. 2. Lithological log and stratigraphic distribution of the planktonic, benthic foraminifers, and characteristic radiolarians in the Kelevudag Section. (*1*) Clay and argillites; (*2*) sandstones; (*3*) oil shales; (*4*) marls; (*5*) micritic limestone; (*6*) cherty rocks; (*7*) calcareous conglomerates; (*8*) gravelites and calcarenites.

Coniacian interval (Walaszczyk et al., 2010; Kopaevich, 2010). Therefore, the sample described can be dated to the late Turonian–early Coniacian, possibly only to the early Coniacian.

It is unlikely that the studied assemblage of planktonic foraminifers can belong to higher stratigraphic levels, e.g., to the late Coniacian–early Santonian beds. At present, the Dicarinella primitiva–Marginotruncana sigali Zone (upper part of the Turonian), Dicarinella primitiva Zone (upper parts of the Turonian–Coniacian), and the Dicarinella concavata Zone (upper Coniacian–lower Santonian) are successively recognized in the Gubbio Section at the level of the upper Turonian–Coniacian and Santonian (Coccioni and Premoli Silva, 2015). However, in the Crimean-Caucasian region, the appearance of the umbilical-convex dicarinellids such as *Dicarinella primitiva–Dicarinella concavata* is observed at higher stratigraphic levels (it should be noted that in our publications these taxa are assigned to the genus *Concavatotruncana*; see Korchagin B., 1982; Korchagin O., 2003; Loeblich and Tappan, 1987). In Crimea, *Concavatotruncana primitiva* and *Concavatotruncana concavata* were originally associated with the upper Coniacian–lower Santonian deposits (Maslakova, 1978). At present, the stratigraphic range of *C. concavata* can be expanded up to the middle–upper part of the Coniacian Stage (Tur et al., 2001; Kopaevich, 2010). The assemblage studied does not include representatives of the umbilical-convex morphotypes. This suggests its earlier age, which is discussed above.

PALEOBIOGEOGRAPHIC ASPECT

The number of specimens of planktonic foraminifers in the studied sample is relatively high, but their taxonomic diversity is low. The sample is dominated by representatives of so-called "large flat marginotruncanids" (Walaszczyk et al., 2010, p. 460), assigned to four species. In addition, the assemblage contains keel-less taxa belonging to the genus *Whiteinella* (1 species) and also morphotypes with weakly developed keels and convex, almost globular shape of the chambers of *Archaeoglobigerina* (1 species).

A low taxonomic diversity of planktonic foraminifers in the higher latitudes compared to the Tethyan Realm has been known for a long time (Caron, 1985; Hay, 2008; Petrizzo, 2002; Spezzaferri and Spiegler, 2005; and many others). While it is suggested that in the Late Cretaceous the distribution of planktonic foraminifers in the seawater was controlled by the same factors as in the present (temperature, salinity, stability/instability of the environment, and nutrition), the following features of the spatial distribution of these microfossils can be noted. (1) Their diversity decreases toward the higher latitudes. (2) The Tethyan assemblage contained large, ornamented shells, with one or two keels. (3) The transitional assemblages of temperate latitudes contained assemblages of planktonic foraminifers composed of mixed morphotypes. The number of ornamented taxa usually increased nearer the Tethyan Realm. The presence of morphologically derived taxa toward temperate regions and higher latitudes suggests an expansion of the Tethyan waters northward.

The following should be mentioned for the section studied. The composition of the studied assemblage of planktonic foraminifers indicates that the section belongs to the northern periphery of the Tethyan Paleogeographic Realm (Walaszczyk and Peryt, 1998; Walaszczyk et al., 2010; Kopaevich and Vishnevskaya, 2016) or the so-called intermediate province (Tur, 1994). This is indicated, on one hand, by the presence in the assemblages of large two-keeled representatives of marginotruncanids and a low number of primitive, weakly ornamented taxa (*Whiteinella, Archaeoglobigerina*). On the other hand, assemblages of planktonic foraminifers do not contain shells of the genera *Sigalitruncana* and *Concavatotruncana* typical of the Tethyan Realm. At the same time, the studied assemblages of the Kelevudag Section are considerably richer both taxonomically and in the number of specimens compared to the assemblages of the southern regions of the East European Platform, e.g., from the sections of the Voronezh Anteclise (Walaszczyk et al., 2004; Olferiev et al., 2005). Hence, it is possible to suggest that this section belongs to a province intermediate between the Temperate and Tethyan realms (Tur, 1994; Walaszczyk and Peryt, 1998; Walaszczyk et al., 2010).

CONCLUSIONS

1. The sample from the middle part of the Yunusdag Formation does not contain radiolarians, but is characterized by an assemblage of planktonic foraminifers typical of the upper Turonian–lower Coniacian deposits of the Crimean-Caucasian region.

2. The absence in the foraminiferal assemblage of species of the genus *Sigalitruncana* or umbilical-convex specimens of the genus *Dicarinella* (*Concavatotruncana*) suggests that the Kelevudag Section belongs to an intermediate province separating the Temperate Realm from the Tethyan Realm.

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