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Lower Miocene stratigraphy of the Eastern Paratethys: problems and state of the art

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Key words:
Lower Miocene, Eastern Paratethys, Ciscaucasia, Kartli Depression of Georgia, Mollusks, Foraminifera, Calcareous Nannofossils, Dinocysts, Correlation.

Abstract. The Lower Miocene regional stages of the Eastern Paratethys, the Caucasian, Sakaraulian, and Kozakhurian, have been recognized in different structural facies zones of the basin and have no reliable universal stratigraphic basis for defining their boundaries and volume. Mollusks, benthic and planktonic foraminifers, calcareous nannoplankton, and dinocysts have been studied in a number of Lower Miocene sections in stratotype areas of the Central Ciscaucasia and Kartli Depression in Georgia. The fossil biota groups of the Caucasian, Sakaraulian, and Kozakhurian sediments are briefly characterized. The available new data on the phytoplankton of these regional stratigraphic units as well as the records of the benthos composition in the marginal facies of the Ciscaucasian Basin allow a comparison between the stratotype regions and show possibilities for a more detailed correlation among them.

Кључне речи:
доњи миоцен, источни Паратетис, Северни Кавказ, депресија Картли у Грузији, молуске, фораминифере, кречњачки нанопланктон, диноцисте, корелација.

Апстракт. Регионални катови доњег миоцена источног Паратетиса: кавкаски, сакараулски и коцахурски, откривени су у различитим структурно-фацијалним зонама басена и не пружају поуздану универзалну стратиграфску основу за дефинисање његових граница. Мекушци, бентоски и планктонски фораминифери, кречњачки нанопланктон и диноцисте проучавани су у бројним деловима доњег миоцена у стратотипским областима централног Северног Кавказа и Картли депресије у Грузији. Укратко су описане групе фосилних организама у кавкаским, сакараулским и коцахурским седиментима. Нови подаци о фитопланктону и бентоској фауни у маргиналним фацијама Севернокавкаског басена омогућавају поређење између стратотипских области и детаљнију корелацију међу њима.

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Introduction

The Neogene regional stratigraphic scheme of the Eastern Paratethys was developed based on material from the sections in southern Ukraine, the Kerch and Taman Peninsulas, in the Ciscaucasian and Transcaspian regions (Neogenovaya Sistema, 1986). However, the Lower Miocene in these sections is composed of a uniform upper Maikopian clayey facies and very few fossils were accumulated under the hydrogen sulfide contamination of waters (Popov et al., 2009). In this regard, the sediments remained hard to subdivide and were often mapped as the undivided middle–upper Maikopian.

The Lower Miocene regional stage subdivisions, Caucasian, Sakaraulian, and Kozakhurian, were distinguished in different structural facies zones of the basin, they do not have contiguous boundaries (except Sakaraulian/Kozakhurian) and do not have a reliable universal stratigraphic basis for their identification in most areas of the Eastern Paratethys. Due to the lack of benthic organisms and the low probability of preservation of calcareous plankton, the ability to recognize and trace Lower Miocene stratigraphic units is sharply limited.

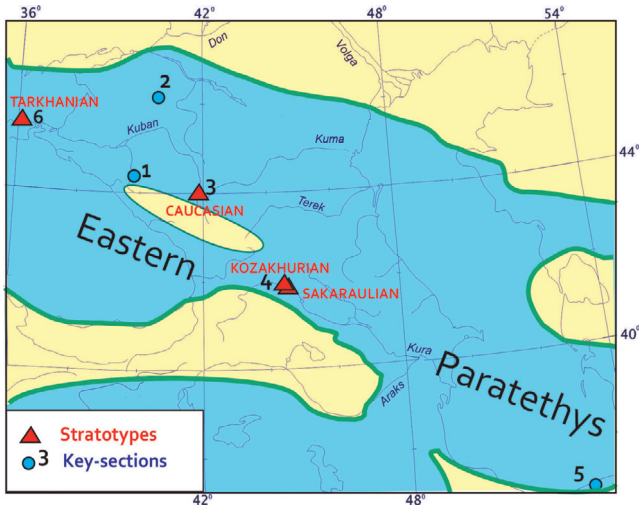

Fig. 1. *Location of the Lower Miocene stratotype and reference sections of the Eastern Paratethys. The numbers indicate sections:* ***1,*** *Belaya River;* ***2,*** *Novopokrovskaya-4 Borehole;* ***3,*** *Kuban River near Cherkessk city;* ***4,*** *Nadarbazevi Gully, Kartli, Georgia;* ***5,*** *Babol River, North Iran;* ***6,*** *Malyi Kamyshlak, Kerch Peninsula. Blue color shows the area covered by the waters of the Early Miocene basin during the Sakaraulian time. Yellow color indicates land areas.*

The lower unit, Caucasian Regional Stage, was distinguished in deep-water facies within the upper part of the Maikopian Group in Ciscaucasia, whereas the Sakaraulian and Kozakhurian regional stages were recognized in the shallower sandy facies of the Kartli Depression in Georgia. In most other areas of the Eastern Paratethys, the equivalents of Sakaraulian and Kozakhurian deposits are represented by clayey or argillaceous, usually anoxic upper Maikopian facies without fossils or with strongly impoverished assemblages, not correlated with stratotypical ones. The maximum thickness of the Miocene part of the middle–upper Maikopian is observed in the central parts of the West Kuban Trough and in the Taman Peninsula area and according to Bogdanowicz and Buryak (Neogenovaya Sistema, 1986), is 500–800 m, up to 1000 m.

Lower Miocene regional stages of the Eastern Paratethys

Caucasian Regional Stage

The Caucasian regional stage was first proposed by Bogdanowicz, Muratov, Nosovskii, and Ter-Grigor'yants (Bogdanowicz et al. in Nevesskaya et al., 1975) and was initially recognized as the lowermost Miocene regional stage and understood as the analog of Aquitanian (Nevesskaya et al., 1975; Nosovskii & Bogdanowicz, 1980), although at that time no possibilities for such correlations existed. The foraminifer evidence reported in these works according to Bogdanowicz and Ter-Grigor'yants (Nevesskaya et al., 1975), was mainly derived from the wells drilled significantly northward from the stratotype region, in the Novopokrovskaya and Derbetovskaya areas, and included only species with a wide stratigraphic range (Chattian–Aquitanian).

The Caucasian stratotype is located on the Kuban River, downstream of the city of Cherkessk (Fig. 1), and the Caucasian regional stage there comprises the Alkun, Septarian, and Zelenchuk formations and the lower part of the Karadzhalga Formation (Nosovskii & Bogdanowicz, 1980). When identifying

these formations, Prokopov (1937) did not indicate their stratotypes. This was done later, for the first time only in the Stratigraficheskii slovar (1982), according to which the stratotypes of the Batalpashinsk, Karadzhalga, and Zelenchuk (including the Septarian Beds) formations are represented in the section along the Kuban River near the Cherkessk city.

The Caucasian stratotype along the Kuban River is currently exposed only in places (Fig. 2). It was described very long ago and was rather poorly characterized by general lists of microfossils from the surrounding sediments (Prokopov, 1937; Nosovskii & Bogdanowicz, 1980). Prokopov did not distinguish the Alkunian Horizon in his stratigraphic scheme of the Central Ciscaucasia; however, he noted an analogy of the section along the Kuban River with the Assa River section, where he identified the Alkunian Horizon on Alkunka Creek.

Subsequently, this stratum of calcareous clays and concretions beneath the Septarian Beds and Zelenchuk sands in the Kuban section near the city of Cherkessk was described (Dmitrieva et al., 1959) as the Alkun Formation, 35–40 m thick, bearing foraminifers *Bolivina* ex gr. *plicatella*, *Discorbis* sp., *Ammodiscus tenuiculus*, and *Uvigerinella* sp. The lower boundary of the Caucasian regional stage in the stratotype is placed at the top of the Batalpashinsk Formation and is defined by the appearance of bedded concretions, as well as by the carbonate content of clays and finds of foraminifers mentioned above. In the underlying and overlying beds microfauna is missing.

The detailed description of the section of the Caucasian regional stage was published earlier (Popov et al., 2022, 2023). The studies of planktonic groups, nannofossils and dinocysts, in the Lower–Middle Miocene section of the Kuban River revealed two nannofossil beds and the succession of dinocyst biostratigraphic assemblages described below (see Fig. 2), which enabled the correlation of the section with the International Chronostratigraphic Chart (ICC).

The reference section of the Caucasian regional stage is the Novopokrovskaya-4 Borehole (Fig. 1) (Nevesskaya et al., 1975; Nosovskii & Bogdanowicz, 1980; Popov et al., 2023). This section occurs in a more shallow-water platform part of the northern Ciscaucasia and is characterized by the benthic fauna that inhabited the Caucasian basin.

In the Transcaucasian part of the basin, the Caucasian is correlated with the Upper Uplistsikhe Subformation, which is characterized by mollusks and nannofossils in its lower part (Popov et al., 1993, 2022; Ananiashvili & Minashvili, 2000).

Sakaraulian Regional Stage

The Sakaraulian regional stage was proposed as a horizon by Davitashvili (1933). The stratotype was not designated and consequently the section along the Nadarbazevi Gully near the Metekhi Station was proposed as a hypostratotype, based on the description by Kvaliashvili (1970) and Voronina et al. (1991). In the stratotype area in the middle course of the Mtkvari River (=Kura), the Sakaraulian is represented by massive coarse-grained sandstones with cross-bedded gravelstones in the lower part and clayey sandstones and siltstones in the upper part, about 200 m thick (Voronina et al., 1991; Popov et al., 2022). Based on the similarity of the mollusk composition of the Sakaraulian regional stage of Georgia and Eggenburgian regional stage in the Western Paratethys (1/3 of species in common according to Popov et al., 1993), these assemblages are considered as stratigraphic equivalents, although their boundaries may not coincide. The Sakaraulian regional stage is correlated with the lower part of the Burdigalian through the Eggenburgian.

Some authors compare the Sakaraulian in the Ciscaucasia with the upper part of the Karadzhalga and with Olginskaya formations relying on similar benthic foraminiferal assemblages (Nosovskii & Bogdanowicz, 1980). The benthic foraminifer and mollusk assemblages known in the platform part of the Ciscaucasian basin are not comparable with that from the Transcaucasian area owing to facial difference of the sediments. The stratotype of the Olginskaya Formation is located on the left bank of the Kuban River on the southern outskirts of the village of Kochubeevskaya (former village of Olginskaya), where neither the lower nor the upper boundaries of the formation are exposed. Therefore, such a comparison remains unproved.

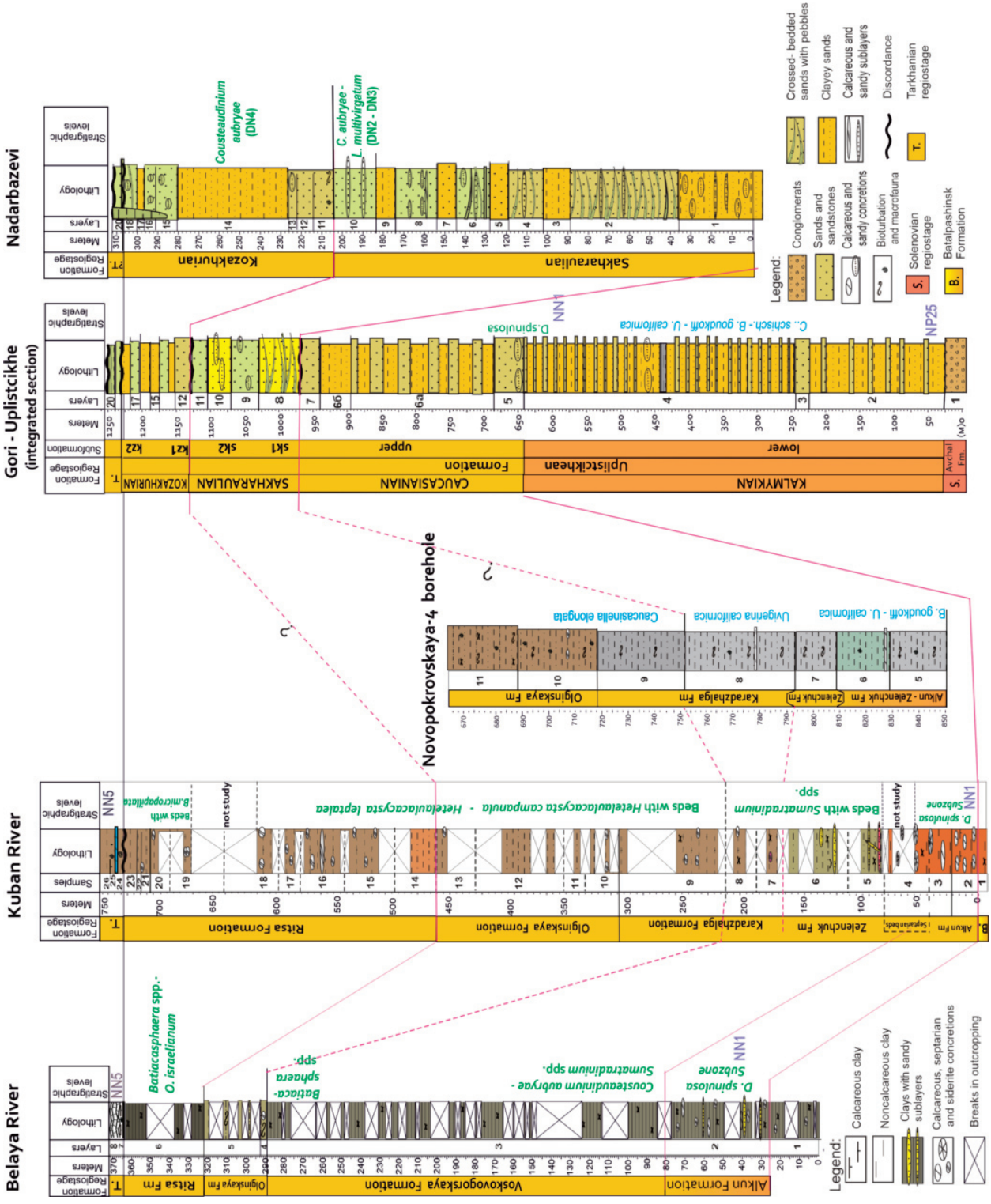

Fig. 2. *Scheme of correlation of the Lower Miocene stratotype and reference sections of the Eastern Paratethys. Purple font shows nannofossil zones; green – dinocyst beds and zones; blue – benthic foraminiferal beds.*

Kozakhurian Regional Stage

The Kozakhurian was also recognized as a horison by Davitashvili (1933). The section on the left bank of the Mtkvari (=Kura) River was chosen as a lectostratotype. It is situated on the western outskirts of the town of Kaspi on the slope of the Kozakhuri Ridge, and was described by Kvaliashvili (1962). The continuation of the section along the Nadarbazevi Gully near the Metekhi Station, which was chosen as a hypostratotype of the Sakaraulian regional stage, was proposed as the hypostratotype of the Kozakhurian (Popov & Voronina, 1983). In the stratotype area of the Kartli Depression, the Kozakhurian regional stage is represented by massive sandstones with concretions in the lower part and by clayey siltstones with concretions and sandstone interbeds in the upper part (Fig. 2), and contains a peculiar assemblage of endemic brackish-water mollusks including species of *Rzehakia* (=*Oncophora*), *Eoprosodacna, Lymnopappia, Congeria, Melanopsis*, and other genera.

The Kozakhurian lower boundary in the stratotype area is marked by an appearance of the brackish-water mollusk assemblage with *Rzehakia dubiosa*. In shallower sections, including the stratotype area, there is a hiatus at the top of the Kozakhurian.

In the Central Ciscaucasia the Ritsa Formation is assigned to the Kozakhurian regional stage. In the marginal facies it is characterized by saccammins among benthic foraminifers and *Rzehakia* in mollusk assemblages, which indicates a disruption of the salt regime of the basin. The upper boundary in deep-water facies is defined by the replacement of dark anoxic facies of Ritsa Formation, characteristic of the Maikopian Group, by lighter carbonate facies, and by the appearance of rich foraminifer and mollusk assemblages of the Tarkhanian regional stage in both the Ciscaucasian and Transcaucasian regions.

The stratotype of the Ritsa Formation occurs on the right bank of the Kuban River on the Ritsa Hill near the city of Nevinnomyssk, where an approximately 70-80 m thick sequence of brown non-carbonate clays with numerous interbeds of siderite concretions is exposed. The lower boundary with the Olginskaya Formation is not exposed there and the upper contact with the Tarkhanian is only outlined in the poorly exposed upper part of the western slope of the hill. For this reason, the section along the Kuban River downstream of the city of Cherkessk (described in Popov et al., 2022; Popov et al. 2023), where the entire sequence of Lower–early Middle Miocene sediments, including the lowermost Tarkhanian regional stage, is exposed in a monoclinal occurrence, is also proposed as a reference section for these formations (Fig. 2).

Goals and objectives of the studies

As can be seen from the above, sharp facies, bathymetric and biogeographical differences between the two stratotype areas of the Lower Miocene of the Eastern Paratethys, i.e. Western and Central Ciscaucasia and the Kartli Depression in Transcaucasia, make their comparison a difficult task. The available new data on the phytoplankton in the sequences discussed and the consideration of the benthic composition in the marginal facies of the Ciscaucasian basin makes it possible, often only tentatively, to compare these areas and to offer an approximate correlation for them, as well as to determine possible ways to achieve this goal in the future.

Material and methods

The material for the present research included both long-standing investigation of the Ciscaucasian and Georgian sections and their mollusk fauna (S.V. Popov) and foraminifera (T.N. Pinchuk), as well as special field work with comprehensive sampling for paleomagnetic analysis, microfauna and phytoplankton carried out in 2014–2018 on the Belaya River, and in 2019, 2020 on the Kuban River and sections of the Kartli Depression.

Studies of nannoplankton were carried out by L.A. Golovina, both in smear-slides prepared from unprocessed samples, and in preparations from samples processed according to a standard procedure (Bown & Young, 1998). Chemical and analytical processing of palynological samples was carried out according to the methodology adopted in the Laboratory of Paleofloristics in the Geological Institute,

Russian Academy of Sciences (Aleksandrova et al., 2012). Benthic foraminifers were studied by T.N. Pinchuk and K.P. Koiava; planktonic foraminifers, by M.E. Bylinskaya. The results were partially published for Georgian sections (Popov et al., 2022), or prepared for publication for the Kuban stratotype (Aleksandrova et al., 2024, in press), but these papers and monograph (Popov et al., 2023) do not include the comparison between the two stratotype regions.

The results of paleomagnetic analysis for these sections carried out by D.V. Palcu still remain uninterpretable owing to fragmentary exposure of the Lower Miocene sediments in the Ciscaucasia and too coarse sandy material in the sections of the Kartli Depression, where the paleomagnetic signal is often not preserved.

Fossil biota groups

Calcareous nannofossils

Caucasian regional stage. In the Central Ciscaucasia, in the stratotype of the Caucasian regional stage, namely, in the Alkun Formation carbonate sediments, a nannofossil assemblage of the ***Cyclicargolithus floridanus*** **Beds** including *Coccolithus pelagicus, Coronocyclus nitescens,* common *Cyclicargolithus floridanus,* scarce *Cyclicargolithus abisectus, Helicosphaera* sp., *Pontosphaera multipora, Pontosphaera* sp., *Reticulofenestra* sp., *Thoracosphaera* sp., and *Triquetrorhabdulus* sp., was recognized (Plate I). The occurrence of the NN1 *Triquetrorhabdulus carinatus* Zone index species remains questionable. However, the section of the Alkun formation 70 km downstream of the stratotype, on the Kuban River near Karamurzinski settlement, the nannofossil assemblage of the *Cyclicargolithus floridanus* Beds includes the index species of the **NN1 *Triquetrorhabdulus carinatus* Zone** together with *T. milowii*, suggesting the attribution of the assemblage to the lowermost Miocene (Filippova et al., 2015; Beluzhenko et al., 2018) and its correlation with the Lower Aquitanian.

The *Cyclicargolithus floridanus* Beds are also recorded in the Alkunian sediments at the Belaya River, in the northern Ossetia sections (Filippova et al., 2010, 2015; Beluzhenko et al., 2018), and in the stratotype section of the Alkun Formation at the Alkunka River (Golovina et al., 2024, in press).

In the northern Black Sea region a similar nannofossil assemblage including *Triquetrorhabdulus carinatus, Helicosphaera kamptneri, Sphenolithus belemnos, Cyclicargolithus floridanus,* and *Discoaster druggi,* marks the Oligocene–Miocene boundary and was recorded in the lower part of the Chernobaevka Formation (Andreeva-Grigorovich & Gruzman, 1989).

In Georgia, in low-carbonate facies of the Upper Uplistsikhe Subformation of the Maikopian Group, nannofossil records made it possible to reveal the transitional Upper Oligocene–Lower Miocene beds corresponding to the NP25 *Sphenolithus ciperoensis* - NN1 *Triquetrorhabdulus carinatus* zones of the Martini scale (Minashvili & Ananiashvili, 2017). According to the calcareous nannofossil composition, i.e. according to the findings of *Triquetrorhabdulus carinatus* in the absence of *Sphenolithus ciperoensis*, the base of the Upper Uplistsikhe Subformation of the Kartli Depression of Georgia is correlated (Fig. 3) with the Alkun level of the Caucasian regional stage in Ciscaucasia (for details, see Popov et al., 2022, 2023).

Sakaraulian regional stage. No significant and representative nannofossil assemblages were identified in the sediments of the Sakaraulian regional stage.

Kozakhurian regional stage. Nannofossils were not found in the sediments of the Kozakhurian regional stage. The upper boundary of the unit is defined by the occurrence of nannofossils of the ***Sphenolithus heteromorphus*** **Beds.** According to the composition of the assemblage and to the presence of *Sphenolithus heteromorphus,* the nannofossil complex is correlated with the lower part of the NN5 Zone of the Martini (1971) scale. The lower boundary of the *Sphenolithus heteromorphus* Beds corresponds to the base of the Tarkhanian regional stage and can be traced throughout the Eastern Paratethys (Popov et al., 2022, 2023).

Dinoflagellate cysts

Caucasian regional stage. According to the dinocyst records, the ***Deflandrea spinulosa*** **Subzone** (Zaporozhets, 1999; Zaporozhets & Akhmetiev, 2017) was identified in the section along the Kuban River

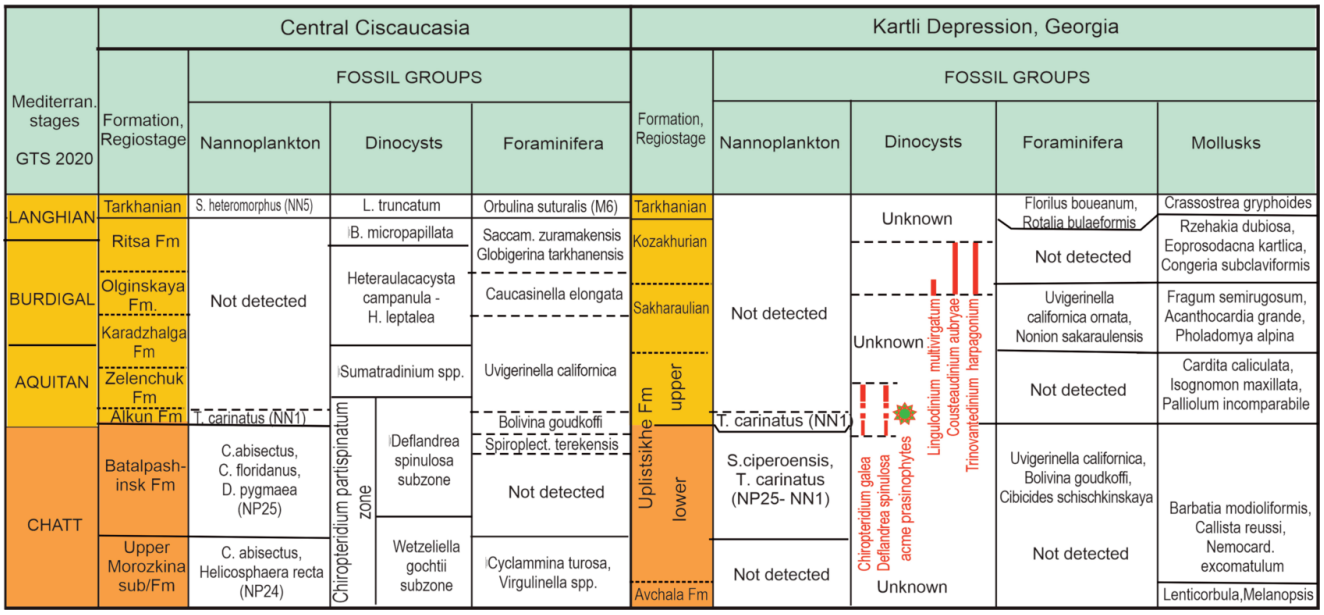

Fig. 3. *Scheme of correlation of the zones and faunal beds in the Lower Miocene stratotype and reference sections in the Eastern Paratethys.*

at the level of the Alkun Formation and in the Septarian Beds of the Zelenchuk Formation (Aleksandrova et al., 2024, in press). The lower boundary was defined by the *Rhombodinium draco* LO and characterized by abundant *Deflandrea spinulosa*; the upper, by the appearance of *Sumatradinium* spp. and *Trinovantedinium* spp. (Plate II). Within the Subzone, the last common occurrence (LCO) of *Apteodinium australiense*, and *Apteodinium maculatum* was recognized; at the top, the LCO of *Deflandrea spinulosa*. The dinocyst assemblage of the *Deflandrea spinulosa* Subzone is characterized by a high taxonomic diversity and includes over 60 taxa. On the whole, the taxonomic composition of the assemblage is close to that recorded in the section along the Belaya River in the *Deflandrea spinulosa* (non *typica*) Subzone of the ***Chiropteridium partispinatum* Zone** (Zaporozhets & Akhmetiev, 2017) identified at the level of the NP24-25 zones by calcareous nannofossils.

The *Deflandrea spinulosa* Subzone exposed in the section along the Kuban River, corresponds to the *Chiropteridium galea* Zone (DN1) of the North Atlantic (De Verteuil & Norris, 1996; De Verteuil, 1997), the *Deflandrea* spp. Subzone (Def) of the *Ectosphaeropsis burdigalensis* Zone (Ebu) of the Mediterranean (Zevenboom, 1995), DM1 Zone and D16b Subzone of northwestern Europe (Powell & Brinkhuis, 2004; King, 2016), and to the *Chiropteridium galea* and *Deflandrea phosphoritica* zones of the Danish basin (Dybkjær & Piasecki, 2010), which cover the chronostratigraphic range of the terminal Chattian–lower Aquitanian based on the latest occurrence of *Chiropteridium galea* and abundance of *Deflandrea* spp.

The ***Sumatradinium* spp. Beds** are recognized in the overlying Zelenchuk Formation and the lower part of the Karadzhalga Formation (Aleksandrova et al., 2024, in press). The lower boundary is defined by the first occurrence (FO) of *Sumatradinium* spp., and *Trinovantedinium* spp.; the upper, by the last common occurrence (LCO) of *Homotryblium* spp., and *Dapsilidinium pseudocolligerum,* and the last occurrence (LO) of *Deflandrea spinulosa.* The cooccurrence of *Cousteaudinium aubryae* and *Sumatradinium soucouyantiae* makes it possible to correlate the strata containing *Sumatradinium* spp. Beds with the *Cousteaudinium aubryae* (DN2) Zone of the De Verteuil & Norris (1996) scale, to correlate them with a part of the nannofossil NN2 Zone, and to date the beds to the upper part of the Aquitanian –?lower part of the Burdigalian (~22.2–19.1 Ma). The occurrence

of *Sumatradinium hamulatum* identified in the middle part of the *Sumatradinium* spp. Beds, in the Danish sector of the North Sea was recorded in the *Sumatradinium hamulatum* Zone that corresponds to the middle part of the nannofossil NN2 Zone of the Early Burdigalian (Dybkjær & Piasecki, 2010).

Sakaraulian regional stage. Dinocysts were studied only from the upper part of the Sakaraulian regional stage in the Nadarbazevi reference section (data by N.I. Zaporozhets and Aleksandrova in Popov et al., 2023). Based on the cooccurrence of *Cousteaudinium aubryae* and *Lingulodinium multivirgatum*, this assemblage can be correlated with the *Sumatradinium soucouyantiae* (DN2) – *Cousteaudinium aubryae* (DN3) zones of the dinocyst scale (De Verteuil & Norris, 1996), which correspond to the NN2 (upper part)–NN4 (lower part) zones of the upper Aquitanian–lower Burdigalian, according to the nannofossil Martini (1971) scale. The presence of *Trinovantedinium harpagonium* (known from higher beds) in these samples makes it more probable to correlate the upper part of the Sakaraulian regional stage only with the Burdigalian.

In the section on the Kuban River the upper Karadzhalga – Olginskaya – lower Ritsa sediments are characterized by the ***Heteraulacacysta campanula – Hetelaulacacysta leptalea*** **Beds** (see Fig. 2). Dinocysts are represented by taxonomically and quantitatively impoverished assemblage, mainly by the taxa of wide stratigraphic range. Within the unit, in Bed 13 (see Fig. 2) the last occurrence of *Cordosphaeridium cantharellus* was recorded, which is dated in the equatorial latitudes at 17.8 Ma (Williams et al., 2004) and in middle latitudes of the Northern Hemisphere, at 19.2 Ma. In the sections of the Atlantic coast of the USA the *C. cantharellus* LO defines the top of the DN2b Subzone of the scale by De Verteuil & Norris (1996). The subzone is correlated with the lower part of the Burdigalian (~20.0–19.4 Ma) and with a part of the nannofossil NN2 Zone (De Verteuil, 1997). The dinocyst assemblage of the *H. campanula–H. leptalea* Beds can be partially comparable to that from the Burdigalian stratotype (Londeix & Jan Du Chêne, 1998), the dinocyst zones GOS2 and GOS3 recognized in the Gulf of Suez area and correlated with nannofossil zones NN2 (upper part)–NN4 (lower part) (Soliman et al., 2012), and to the *Exochosphaeridum insigne* (Ein) Zone of the Central Paratethys (Jimenez-Moreno et al., 2006). Based on correlations, the upper part of the Karadzhalga and the Olginskaya formations in the Kuban River section are limited to the Burdigalian and are correlated with the *H. campanula–H. leptalea* Beds characterizing the Sakaraulian and lower Kozakhurian regional stages.

Kozakhurian regional stage. Relatively representative palynological data were obtained only in the Kozakhurian middle part in Bed 14 of the Nadarbazevi section. Although dinocysts were few, judging from the presence of *Cousteaudinium aubryae*, the studied interval can be limited to the *Distatodinium paradoxum* (DN4) dinocyst zone of the Atlantic coast of the USA (De Verteuil & Norris, 1996) and to the *Cribroperidinium tenuitabulatum* (Cte) Zone of the Central Paratethys (Jimenez-Moreno et al., 2006; Bakrač et al., 2012). These zones correspond to the NN4–lowermost NN5 zones of Martini (1971). The available data are consistent with the palynological results obtained for the Miocene of the North Sea, where *Cousteaudinium aubryae* disappeared within the *Labyrinthodinium truncatum* Zone correlated with the upper NN4 – lowermost NN5 zones of Martini (1971) in the Langhian (Dybkjær & Piasecki, 2010; Dybkjær et al., 2020).

In the Kuban River section, the lower part of the Ritsa Formation is characterized by the upper part of the *Heteraulacacysta campanula–Hetelaulacacysta leptalea* Beds. In the middle-upper parts of the Ritsa Formation on the Kuban River and in the stratotype section on the Ritsa Mountain the ***Batiacasphaera micropapillata*** **Beds** are distinguished. The lower boundary of the beds is defined by *Heteraulacacysta campanula* LO; the upper, by the FO of *Labyrinthodinium truncatum.* The dinocyst assemblage is dominated by *Batiacasphaera* representatives, namely, *B. micropapillata, B. sphaerica,* and *B. baculata.* The upper strata are characterized by common taxa ex gr. *Bigantedinium* spp.*, Selenopemphix nephroides, Operculodinium centrocarpum, Spiniferites* spp., and small-sized *Echidinium*-type cysts. A similar complex of dinocysts was found in the uppermost Maikopian Group in the sections of northern Azerbaijan (data by Zaporozhets in Popov et al., 2008). Based on the position in the section and paleontological data from the

overlying deposits, the most of the Kozakhurian regional stage is dated to the upper Burdigalian–lower Langhian.

The lower part of the **Tarkhanian regional stage** in the Kuban River section, on the grounds of the *Labyrithodinium truncatum* occurrence, can be correlated with a part of the DN4 dinocyst Zone (De Verteuil & Norris, 1996; Köthe, 2012), Subzone D17b of the Powell & Brinkhuis (2004) scale, the *Labyrithodinium truncatum* Zone of the Dybkjær & Piasecki (2010) scale, and with the Zone DM4 of the King (2016) scale, which are dated to the terminal Burdigalian–lower Langhian.

Planktonic foraminifers

Caucasian regional stage. Planktonic foraminifers were previously mentioned as rare findings in the basal part of the Caucasian sediments in Ciscaucasia (Bogdanowicz, 1986; Nosovsky & Bogdanowicz, 1979; Pinchuk, 2006, 2018).

Biserial planktonic foraminifers *Streptochilus pristinum* (Plate I, fig. 14) were found in the Alkun Formation, in the section of Fyuntv Creek, a tributary of the Belaya River (Popov et al., 2023), and subsequently were recorded in a number of sections of the Alkun Formation in Ciscaucasia, within the nannofossil *Cyclicargolithus floridanus* Beds (Golovina et al., 2024, in press). *Streptochilus pristinum* ranges from the mid-Late Oligocene through the Middle Miocene and was also reported in the Upper Oligocene of Syria (Smart & Thomas, 2018). During its stratigraphic range it is characterized by intermittent distribution, so the strata with its occurrence can serve as marker beds, e.g. those in the Transylvanian basin in the uppermost Lower Miocene (Beldean et al., 2010). A narrow interval bearing biserial planktonic foraminifers *Streptochilus pristinum* enabled the distinction of an additional stratigraphic marker, the ***Streptochilus pristinum* Beds,** in the Alkun Formation.

Sakaraulian regional stage. Planktonic foraminifers were not found in the sediments of the Sakaraulian and Kozakhurian regional stages in the stratotype area of Georgia. Pinchuk (Popov et al., 2022) in places noted the occurrence of *Globigerina* in the analogous to the Sakaraulian sediments in Ciscaucasia.

In the northern Black Sea region, planktonic foraminifers of the genus *Trilobatus* (*T. primordius, T. trilobus,* etc.) were reported at the base of the Chernobaevka Formation (Andreeva-Grigorovich & Gruzman, 1989).

Kozakhurian regional stage. Extremely rare finds of planktonic *Globigerina* sp. and *G. tarchanensis* were recorded in the sections of Borehole SG-12000 and in the Priyutninskaya area (middle Manych) in the lower part of the Ritsa Formation.

Representative planktonic foraminiferal assemblages occur only in the overlying sediments of the **Tarkhanian regional stage.** In the Ciscaucasia, in the Pshekha River section, the Tarkhanian sediments contain a specific planktonic foraminiferal assemblage that includes, among other taxa, single *Orbulina suturalis, Globorotalia (Fohsella) peripheroronda* and *G. scitula* (data by Bylinskaya in Popov et al., 2023). The assemblage composition indicates that it likely belongs to the *Orbulina suturalis* M6 Zone of the Wade et al. (2011) scale and its age is no older than mid-Langhian, from 15.1 to ~14 Ma.

Benthic foraminifers

Caucasian regional stage. The Early Caucasian basin was characterized by a relatively rich benthic foraminiferal assemblage, widespread in the Crimean–Caucasian region. The typical strata for the Middle Maikopian are the ***Uvigerinella californica–Bolivina goudkoffi* Beds** (Bogdanowicz, 1971, 1986).

Maikopian sediments of Western and Central Ciscaucasia differ facially. The basal strata of the Caucasian regional stage in the stratotype area are represented by calcareous clays bearing planktonic and benthic fauna of the Alkun Formation, and contain assemblages characteristic of the ***Virgulinella* Beds** (Bogdanowicz, 1986) or the ***Fursenkoina schreibersiana–Caucasina* sp. Beds** (Pinchuk, 2006, 2018). In the northern Black Sea region, the lower part of the Arabat Formation developed along the Parpach Ridge on the Kerch Peninsula, and the Alagol Formation in the eastern Kerch Peninsula, are represented by sediments

containing the foraminiferal assemblage *Haplophragmoides periferoexcavatus* (Vernyhorova & Ryabokon, 2018).

In the reference section along the Belaya River, the Voskovogorsk Formation contains an assemblage of the ***Bolivina goudkoffi caucasica* Beds** (Bogdanowicz, 1971, 1986), and is also characterized by core material from deep borehole sections on the southern edge of the West Kuban Trough. These Beds are widespread in Ciscaucasia, Ukraine, Transcaucasia, and the Black Sea region in the middle part of the Maikopian Group. The ***Uvigerinella californica* Beds** (Bogdanowicz, 1986) are recorded in sections of Ciscaucasia, the Black Sea region, the Crimea and Transcaucasia. The beds correspond to the upper part of the Caucasian regional stage (Nosovskii & Bogdanowicz, 1980) and to the upper part of the Middle Maikopian.

The southern Stavropol region is characterized by relatively deep-water and transitional facies with foraminiferal assemblages containing planktonic and benthic microfauna. The northern Stavropol region is characterized by a shallow-water facies with benthic microfauna. In the northeastern Stavropol region, rich microfauna with *Virgulinella* and *Bolivina goudkoffi* was found in Well Derbetovskaya-37 (a reference borehole for the Caucasian regional stage) in analogs of the Alkun Formation. Two microfaunal units were recognized, the ***Trochamminoides concentricus* Beds** in the sediments of the Zelenchuk Formation (Ter-Grigor'yants, 1964) and the ***Haplophragmoides kjurendagensis* Beds** (Ter-Grigor'yants, 1964) in the Karadzhalga Formation sediments.

Benthic foraminiferal assemblages of the reference section of the Caucasian regional stage, derived from the Borehole Novopokrovskaya-4 are recognized as ***Bolivina goudkoffi caucasica* Beds** or ***Haplophragmoides kjurendagensis* Beds**. Upward from the base of the section Bogdanowicz defined the ***Uvigerinella californica* Beds** (Nosovskii & Bogdanowicz, 1980).

In the northern Black Sea region, the lowermost Lower Miocene (Gornostaevka Formation) is dominated by the benthic species *Porosononion dendriticus, Elphidium onerosum,* and *Heterolepa ornata,* whereas *Spiroplectammina caucasica*, *Bolivina goudkoffi*, and *Sphaeroidina variabilis* are common in the sandy facies (Nosovskii and Semenenko in Neogenovaya Sistema, 1986).

In the Upper Kerleut Subformation of southern Ukraine and in Kerch Peninsula, the ***Bolivina goudkoffi caucasica* Beds** and the ***Uvigerinella californica* Beds** are dated to the Late Oligocene (Chattian), according to dinocysts (Vernyhorova & Ryabokon, 2018, 2020).

Sakaraulian regional stage. The communication between the Eastern Paratethys and the normal marine basins during the Sakaraulian provided formation of an abundant and diversed benthic foraminiferal assemblage in Georgia and Abkhazia (up to 38 genera and 100 species) and in northern Ciscaucasia (up to 40 genera, 50 species). The basin was dominated by the representatives of *Caucasinella*, *Bulimina*, *Bolivina*, *Porosononion*, and other genera. Agglutinated forms included specimens of *Saccammina*, *Haplophragmoides*, and *Cyclammina.* The migrant species included *Caucasinella* aff. *elongata* (now accepted as *Bulimina elongata*), *Bolivina* ex gr. *floridana*, neoautochthonous taxa were represented by *Cibicides stavropolensis*, *Caucasinella elongata leninabadensis*, *Bulimina tumidula*. Species that passed from the preceding Caucasian basin, namely *Porosononion dendriculus*, *Hyperammina caucasica*, *Elphidium onerosum*, and other, should be noted.

Lower Miocene deposits in the Uplistsikhe and Nadarbazevi sections are characterized by the absence of foraminifera. In the southern zone of the Kartli Depression, one of the most complete sections bearing foraminifers is exposed in the gorge of the Cheradkhevi River, 40–50 km upstream along the Mtkvari River valley. The Nabatkhevian sandstones contain a rich foraminiferal fauna. The species identified in this area, namely, *Elphidium mariae*, *E. kvesanensis*, *Nonion umbilicatulum*, *Porosononion* ex gr. *granosum*, *Bolivina floridana*, *Uvigerinella californica*, *Caucasina schischkinskayae*, and *Asterigerinata bracteata,* made it possible to date the enclosing deposits to the Early Miocene (Sakaraulian) (Chubinishvili & Archvadze, 1958). A similar foraminifer assemblage can be found in the Sakaraulian sections near the Skra settlement. In western Georgia and Abkhazia two microfaunal assemblages were identified within the Sakaraulian

Regional Stage: sediments in the lower part include the "*Uvigerinella* zone" and in the upper part, the *Caucasinella* (=*Neobulimina*) *abchasiensis* "zone" (Dzhanelidze, 1970).

The lower part of the Upper Maikopian presumably correlated with the Sakaraulian, in the northern Ciscaucasia is recognized as ***Caucasinella elongata* Beds** (Bogdanowicz, 1986; Pinchuk, 2006). In the Olginskaya Formation *Haplophragmoides periferoexcavata*, *H. inaequilateralis*, *Hyperammina* sp., *Ammodiscus granatus*, *Trochammina depressa*, *Trochammi-noides* sp., *Cyclammina* (?) sp., *Bulimina* cf. *ovata* (now accepted as *Globobulimina ovata*), *Bolivina* sp., and *Globigerina* sp. were recorded in the Kuban River section (Bogdanowicz, 1986). In the central Ciscaucasia, the *Caucasinella elongata* Beds contain an assemblage of agglutinated and calcareous forms.

In Azerbaijan the ***Caucasinella elongata leninabadensis* Beds** are attributed to the Sakaraulian and are considered to be analogous to *Caucasinella elongata* Beds (Khalilov & Kuznetsova, 1964).

The foraminifer species common for the entire Eastern Paratethys in the Sakaraulian are *Hyperammina caucasica*, *Bolivina* ex gr. *floridana*, *Bulimina tumidula*, *Caucasinella* aff. *elongata* (now accepted as *Bulimina elongata*), *Cibicides stavropolensis*, *Astrononion ergenicus*, *Ammomarginulina depressa*, *Porosononion dendriculus*, and *Elphidium onerosum* (Bogdanowicz, 1986).

Kozakhurian regional stage. The upper part of the upper Maikopian is characterized by an impoverished assemblage of foraminifers, which was recognized as the "Thurammina Zone" by Subbotina (1936) or as ***Saccammina zuramakensis* Beds** (Bogdanowicz, 1971; 1986). Their characteristic features are the confinement of *Saccammina* to the upper part of the Maikopian (Ritsa Formation) and their wide distribution in Ciscaucasian sections. However, in the sections of Borehole SG-12000 and in the Priyutninskaya area faunal beds alternate with barren strata in the lower part of the Ritsa section, which is accompanied by a gradual disappearance of Maikopian calcareous species and in places by rare occurrence of planktonic *Globigerina* sp. and *G. tarchanensis*, indicating intermittent connection with the open basins.

In the Kerch Peninsula sediments, only few specimens of *Saccammina zuramakensis* were recorded in the Korolevo Formation, according to Kozyreva (Astakhova et al., 1984). Despite the rare finds of *Saccammina* and other foraminifer species in the upper part of Maikopian sediments, it is possible to correlate certain formations across the Crimean–Caucasian region. In the southern Stavropol Region, the *Saccammina* assemblage is confined to the Ritsa Formation; in the northern areas, the Upper Maikopian sediments were eroded or were not accumulated.

Mollusks

Caucasian regional stage. In the deep Ciscaucasian basin, mollusks were missing because of hydrogen sulfide contamination of bottom water (Popov et al., 2009). They were found only in its northern shelf part, namely, in boreholes of the platform area, on the Stavropol Arch and in the Manych region, from where rare finds of *Plagiocardium abundans, Palliolum incomparabile, Nucula* sp., *Parvicardium*, and *Cerastoderma prigorovskii* are known.

A more diverse mollusk assemblage was recorded in the stratotype section of the Uplistsikhe Formation in Georgia. At the base of the Upper Uplistsikhe Subformation, mollusks were found in the gravelstone interlayer in Member 5 and in overlying sandstone concretions (see Fig. 2); their composition is similar to that of the underlying assemblage, but differs in the additional presence of several warm-water forms of the Tethys origin, such as *Palliolum incomparabile*, *Ctena squamosa*, *Cardita calyculata*, *Cerithium* sp., *Nassarius* sp., and *Oliva flammulata* (Popov et al., 1993, Table 10).

The **Sakaraulian regional stage** of the stratotype area is characterized by mollusks that occasionally occur in the middle and upper parts of the section and are represented by a warm-water, shallow-water assemblage, including large species *Acanthocardia kuebeckii, Glossus major, Pholadomya alpina, Aequipecten csepreghymezhericsae* etc. (Kharatishvili, 1952; Popov et al., 1993). Among the species of wide geographical distribution, there are fairly a lot of

taxa common with the Eggenburgian assemblages of Central Europe (over 35%); however, there are almost no species in common with the Burdigalian fauna of the Mediterranean and Aquitaine and, at the same time, unknown in the Eggenburgian assemblages. The degree of continuity of this fauna from the Oligocene one is approximately the same as that in the Eggenburgian fauna – about 40%.

Kozakhurian regional stage. The representative associations of the brackish water malacofauna of the Kartli Depression are known only from Georgia (Kvaliashvili, 1962; Popov, 1983; Popov et al., 1993). The assemblage includes 18 bivalve taxa bearing endemic in the Paratethys genera, namely, *Eoprosodacna* (4 species), *Limnopappia caucasica*, *Rzehakia dubiosa*, *Cerastoderma ivericum* and *C. lacustre*, extremely euryhaline *Corbula (Lenticorbula)* sp., *Polymesoda convexa brongniarti*, *Congeria* (2 species), and *Siliqua* (3 species). Among gastropods, the most common are Melanopsidae (e.g. *Melanopsis impressa*) and fresh- or brackishwater genera as *Theodoxus*, *Anisus*, *Viviparus*, *Lymnea*, and *Radix*. All the genera and many of the species were common with the late Ottnangian assemblages of the Central Paratethys (Popov & Voronina, 1983).

In the Ciscaucasia, mollusks are rare and were found only in a shallow water facies in the Stavropol Arch (*Rzehakia dubiosa* and *Hydrobia* sp.) (Volkova, 1962) and in the Manych area (Priyutnensky region) (*Rzehakia dubiosa* and upward from the base together with *Nucula* sp. and *Parvicardium* sp.). The upper boundary of the Kozakhurian regional stage is defined by the unconformity at its top or by the lithology in full sections (the appearance of carbonate content) and by the occurrence of pteropods, foraminifers, or marine mollusks characteristic of the Tarkhanian regional stage.

Discussion

The identification and correlation of the base of the Caucasian regional stage became much more reliable and substantiated after the available data on the composition of calcareous nannofossils and dinocysts in the Alkun Formation (Akhmetiev et al., 1995; Filippova et al., 2010, 2015; Beluzhenko et al., 2018), and on the data by Golovina and Aleksandrova reported in this paper, which confirmed that this level was really regionally traceable and that it occupied a position close to the Oligocene–Miocene boundary in the Mediterranean stratotype region, according to phytoplankton (Fig. 4).

In general, the correlation of the stratotype areas of the Central Ciscaucasia and the Kartli Depression in Georgia is still rather complicated. The facies, bathymetric, and biogeographical difference between the two stratotype regions of the Eastern Paratethys greatly hampers their correlation, especially when using benthic foraminifers and mollusks, whose composition is more facially strictly determined.

The correlation of the Caucasian in the Kuban and Belaya river sections with the Upper Uplistsikhe Subformation (Figs. 3, 4) in the Kartli Depression in Georgia, is based on the inferred attribution of the nannofossil assemblage of the *Triquetrorhabdulus carinatus* NN1 Zone (Minashvili & Ananiashvili, 2017) to the base of the subformation and to the dinocyst complex from its lower part, which corresponds to the *Deflandrea spinulosa* Beds, the same as in the Alkun Formation and the lower part of the Septarian Beds of the lowermost Caucasian. However, the upper half of the Upper Uplistsikhe Subformation and the lower half of the Sakaraulian stratotype have not yet been correlated with the Ciscaucasian sections.

The current notion on the correlation of the Sakaraulian with the uppermost Karadzhalga and Olginskaya formations (Nosovskii & Bogdanowicz, 1980) is based only on the presumed Sakaraulian age of the *Caucasinella elongata* Beds of the platform part of Ciscaucasia, which has not yet been substantiated in stratotype sections. Cooccurrence of *Cousteaudinium aubryae* and *Lingulodinium multivirgatum* in the upper part of Sakaraulian makes it possible to correlate this assemblage with the *Sumatradinium soucouyantiae* (DN2) – *Cousteaudinium aubryae* (DN3) zones of the dinocyst scale (De Verteuil & Norris, 1996) and with the Burdigalian but does not provide reliable data on its correlation with the Ciscaucasian formations.

The correlation between the Kozakhurian of Georgia and the Ritsa Formation of Ciscaucasia, inferred from the evidence of disrupted normal hydrological regime in the basin, seems to be more

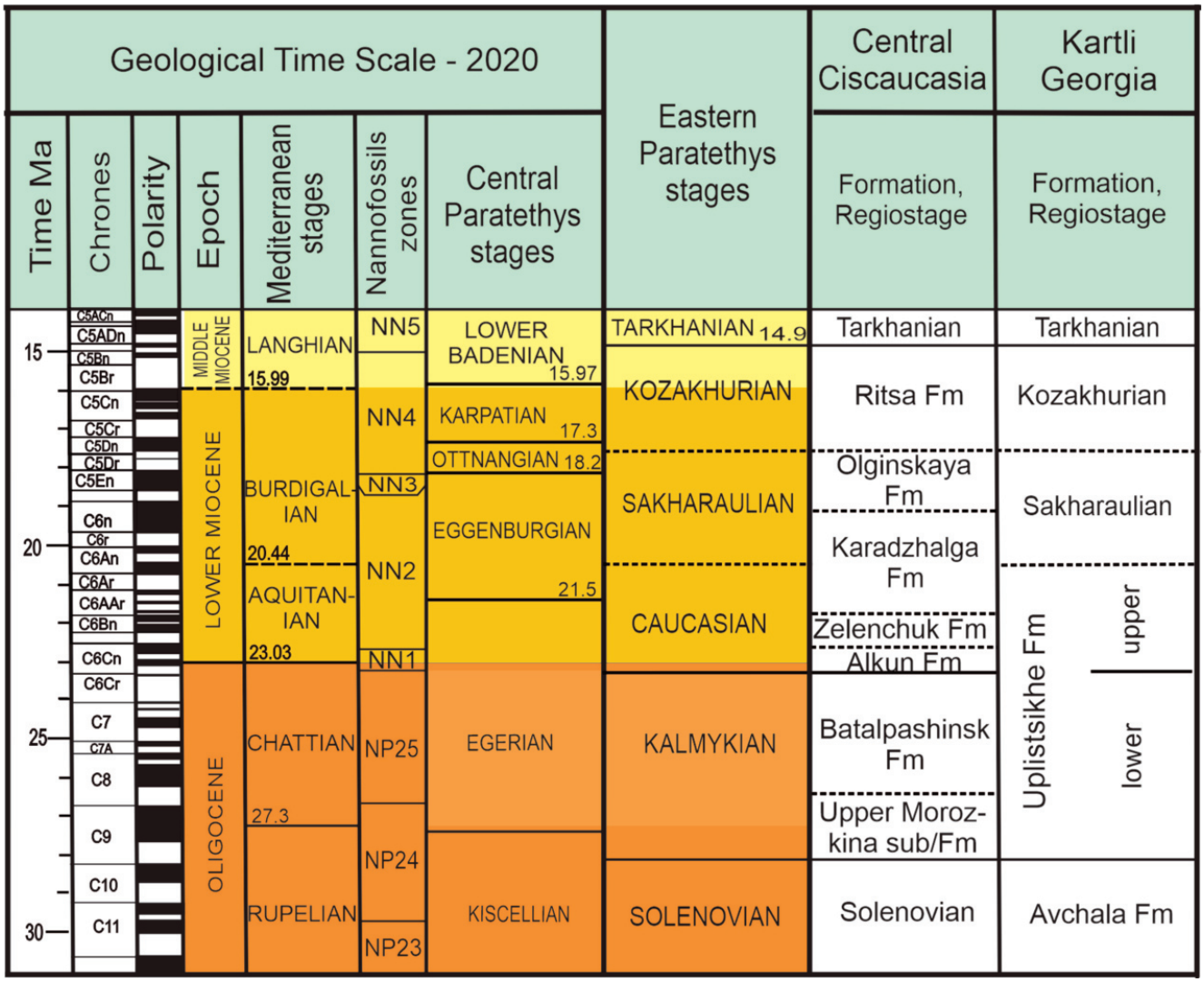

Fig. 4. *Correlation of the Oligocene–Lower Miocene stratigraphic subdivisions of Central Ciscaucasia and Georgia with that of the Central Paratethys and Geological Time Scale (2020).*

substantiated. At the same time, the cooccurrence of sharply impoverished, down to brackish-water, mollusk and benthic foraminiferal assemblages with marine zonal dinocyst associations in the Kozakhurian, Georgia, suggests a sharp differentiation of the water mass by salinity.

Conclusions

(1) We accept the Caucasian regional stage in its original volume, which includes in the stratotype region of the Central Ciscaucasia the Alkun Formation, Zelenchuk Formation with Septarian Beds at the base, and the lower part of the Karadzhalga Formation.

(2) The lower boundary of the regional stage in the Caucasian stratotype is placed at the top of the Batalpashinsk Formation, Chattian in age, and is defined in the sections by the appearance of bedded limestone concretions, carbonate clays, and occurrence of foraminifers *Bolivina* ex gr. *plicatella, Discorbis* sp., *Ammodiscus tenuiculus*, and *Uvigerinella* sp. characteristic of the Alkun Formation.

(3) The Early Miocene age of the Alkuni Formation is confirmed by the recognized nannoplankton assemblage of *Cyclicargolithus floridanus* Beds, bearing in the section at the Kuban River the index species of the **NN1 *Triquetrorhabdulus carinatus* Zone** along with *T. milowii,* which indicates its

assignment to the lowermost Miocene and the correlation with the Lower Aquitanian. At the same time it is not improbable that the lowermost Alkun Formation beds correspond to the terminal Chattian.

(4) The studies of dinoflagellate cysts from the Lower Miocene of the Central Ciscaucasia (Kuban River), mainly composed of noncarbonate sediments and poor in other fossils, enabled the biostratigraphic estimation of the age of these rocks. It was shown that the dinocyst complexes are comparable to the Lower Miocene zonal assemblages of northwestern Europe, North Sea, and the eastern coast of the USA. It was determined that the sediments of the lower part of the Caucasian regional stage (Alkun Formation and lowermost Zelenchuk Formation) were accumulated in the Late Chattian–initial Aquitanian, whereas the upper parts of the Caucasian (Zelenchuk and lower part of Karadzhalga formations), in the Aquitanian. The upper part of the Karadzhalga, the Olginskaya, and lower part of the Ritsa formations are correlated with the Sakaraulian and lower part of the Kozakhurian regional stages and are dated as Early Burdigalian. The upper part of the Ritsa Formation corresponds to the upper part of the Kozakhurian regional stage and is correlated with the late Burdigalian–early Langhian (Fig. 4).

(5) The mollusk assemblages of the Upper Uplistsikhe Subformation of Georgia contain predominantly species passing from the Oligocene, with a small proportion of new warm-water migrants of Tethys origin. The Sakaraulian mollusk composition sharply differs from the Uplistsikhe assemblages and includes a lot of thermophilic subtropical taxa, a third of which are shared with the Eggenburgian mollusks of the Central Paratethys.

(6) The dinocyst assemblage of the upper part of the Sakaraulian of Georgia is comparable to the dinocyst zones DN2-DN3 of the North Atlantic scale (De Verteuil & Norris, 1996), which are correlated with the zones NN3–lower NN4 by nannofossils and are dated to the Burdigalian.

(7) The lower member of Kozakhurian in Georgia is correlated by dinocysts with the zones DN4–DN5 of the De Verteuil & Norris (1996) scale. Finds of *Glaphyrocysta* in the middle Kozakhurian of the Nadarbazevi section also indicate its assignment to the Burdigalian.

(8) The Kozakhurian mollusk assemblage consists of euryhaline genera and species and brackish-water endemics of the Paratethys, some of which are known from low-saline basins of the late Ottnangian of the Central Paratethys.

(9) The nannoplankton assemblage bearing *Sphenolithus heteromorphus* at the base of the Tarkhanian regional stage is correlated with the lower part of the NN5 Zone of the Martini (1971) scale and the planktonic foraminifer assemblage indicates the correlation of the Tarkhanian with the M6 *Orbulina suturalis* Zone of the Wade et al. (2011) scale, and the age no older than mid-Langhian, from 15.1 to ~14 Ma.

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Резиме

Стратиграфија доњег миоцена источног Паратетиса: проблеми и тренутно стање

Регионална стратиграфска скала неогена источног Паратетиса утврђена је углавном у деловима јужне Украјине, на Керчком и Таманском полуострву, Северном Кавказу и Транскаспијским областима. Међутим, доњи миоцен у овим областима представљен је уједначеним горњомајкопским глиновитим фацијама са врло мало фосила, таложених у условима контаминације водене средине водоник-сулфидом. У тим условима, наслаге су слабо стратификоване и често су издвајане као средњи-горњи мајкопијан. Магнетостратиграфска анализа референтних профила доњег миоцена Северног Кавказа и Грузије није дала резултате високог квалитета због великих празнина, ниског палеомагнетног сигнала, (бар делимичне) ремагнетизације и недостатка поузданих биостратиграфских маркера.

Поред тога, регионални катови доњег миоцена источног Паратетиса: кавкаски, сакараулски и коцахурски, откривени су у различитим структурно-фацијалним зонама басена и не пружају поуздану универзалну стратиграфску основу за дефинисање његових граница. Сви ови фактори спречавају поуздану корелацију стратиграфских јединица доњег миоцена унутар источног Паратетиса.

Циљ овог рада је да пружи нове податке о налазима фитопланктона у седиментима доњег миоцена Централног Предкавказја Русије и Картли депресије Грузије, узимајући у обзир састав бентоске фауне у маргиналним фацијама севернокавкаског басена (Fig. 1). Детаљни описи фосилних група приказани су у серији претходних публикација (Popov et al., 2021, 2022, 2023). У раду је дат кратак опис фосилних група (мекушаца, бентоских и планктонских фораминифера, кречњачких нанофосила и диноцисти) кавкаског, сакараулског и коцахурског ката са фотографијама карактеристичних таксона диноциста, кречњачког нанопланктона и планктонских фораминифера (Plates I и II).

Нови подаци омогућавају поређење стратотипа доњег миоцена и референтних профила у целом источном Паратетису (Fig. 2). Корелација седимената кавкаског ката на профилима у долинама река Кубан и Белаја са формацијом Горње Уплистсикхе у Грузији заснива се на сличности нанопланктонске заједнице Зоне NN1 (*Triquetrorhabdulus carinatus* Zone) (Minashvili & Ananiachvili, 2017) и диноцисти у слојевима са *Deflandrea spinulosa.* Слична заједница кречњачког нанопланктона и диноцисти откривена је и у најстаријим деловима кавкаског ката, односно у алкунском хоризонту и доњем делу септаријских слојева, у стратотипу кавкаског ката на реци Кубан. Међутим, највиши делови подформације Горње Уплистсикхе и доње партије стратотипа сакараулског ката у Картли депресији још увек нису корелисани са профилима Северног Кавказа.

Досадашња корелација сакараулског ката са највишим деловима формација Караџалга и Олгинскаја (Nosovsky, Bogdanovich, 1980) заснива се само на претпостављеној сакараулској старости слојева са *Caucasinella elongata* платформског дела Северног Кавказа, без издвојеног стратотипа. Упоредни наласци *Cousteaudinium aubryae* и *Lingulodinium multivirgatum* у горњем делу сакараулског ката омогућавају корелацију ове фосилне заједнице са зонама диноцисти *Sumatradinium soucouyantiae* (DN2)–*Cousteaudinium aubryae* (DN3) (de Verteuil and Norris, 1996) и бурдигалским катом, али још увек не омогућавају корелацију са формацијама Северног Кавказа.

Корелација седимената коцахурског ката развијеног у Грузији са ритском формацијом Северног Кавказа на основу доказа о нарушавању нормалног хидролошког режима у басену, чини се разумнијом. У исто време, коегзистенција осиромашених, бракичних бентоских мекушаца и фораминифера и диноцисти у седиментима коцакурског ката Грузије, сугерише оштру диференцијацију водене масе према салинитету.

Шема корелационих зона у стратотипу доњег миоцена и референтним профилима источног Паратетиса (Fig. 3), може послужити као основа за даља истраживања.

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Plate I

Lower Miocene calcareous nannoplankton and planktonic foraminifers of the Central Ciscaucasia.

Figs. 1–3. *Cyclicargolithus floridanus* (Roth et Hay, in Hay et al., 1967) Bukry, 1971:
1, 2. Alkunka River;
3. Kuban River;

Fig. 4. *Reticulofenestra dictyoda* (Deflandre in Deflandre et Fert, 1954) Stradner in Straner et Edwards, 1968, Alkunka River;

Fig. 5. *Triquetrorhabdulus carinatus* Martini, 1965, Karamurzinskii section, Kuban River;

Fig. 6. *Sphenolithus moriformis* (Brönnimann et Stradner, 1960) Bramlette et Wilcoxon, 1967, Alkunka River;

Fig. 7. *Sphenolithus conicus* Bukry, 1971, Alkunka River;

Figs. 8–9. *Pontosphaera multipora* (Kamptner, 1948 ex Deflandre in Deflandre et Fert, 1954) Roth, 1970:
8. Fyuntv Creek,
9. Kuban River;

Fig. 10. *Coronocyclus nitescens* (Kamptner, 1963) Bramlette and Wilcoxon, 1967, Alkunka River;

Figs. 11–12. *Discoaster deflandrei* Bramlette et Riedel, 1954:
11. Alkunka River,
12. Kuban River;

Fig. 13. *Helicosphaera carteri* (Wallich 1877) Kamptner, 1954, Karamurzinskii section, Kuban River;

Fig. 14. *Streptochilus pristinum* Brönnimann et Resig, 1971, Fyuntv Creek.

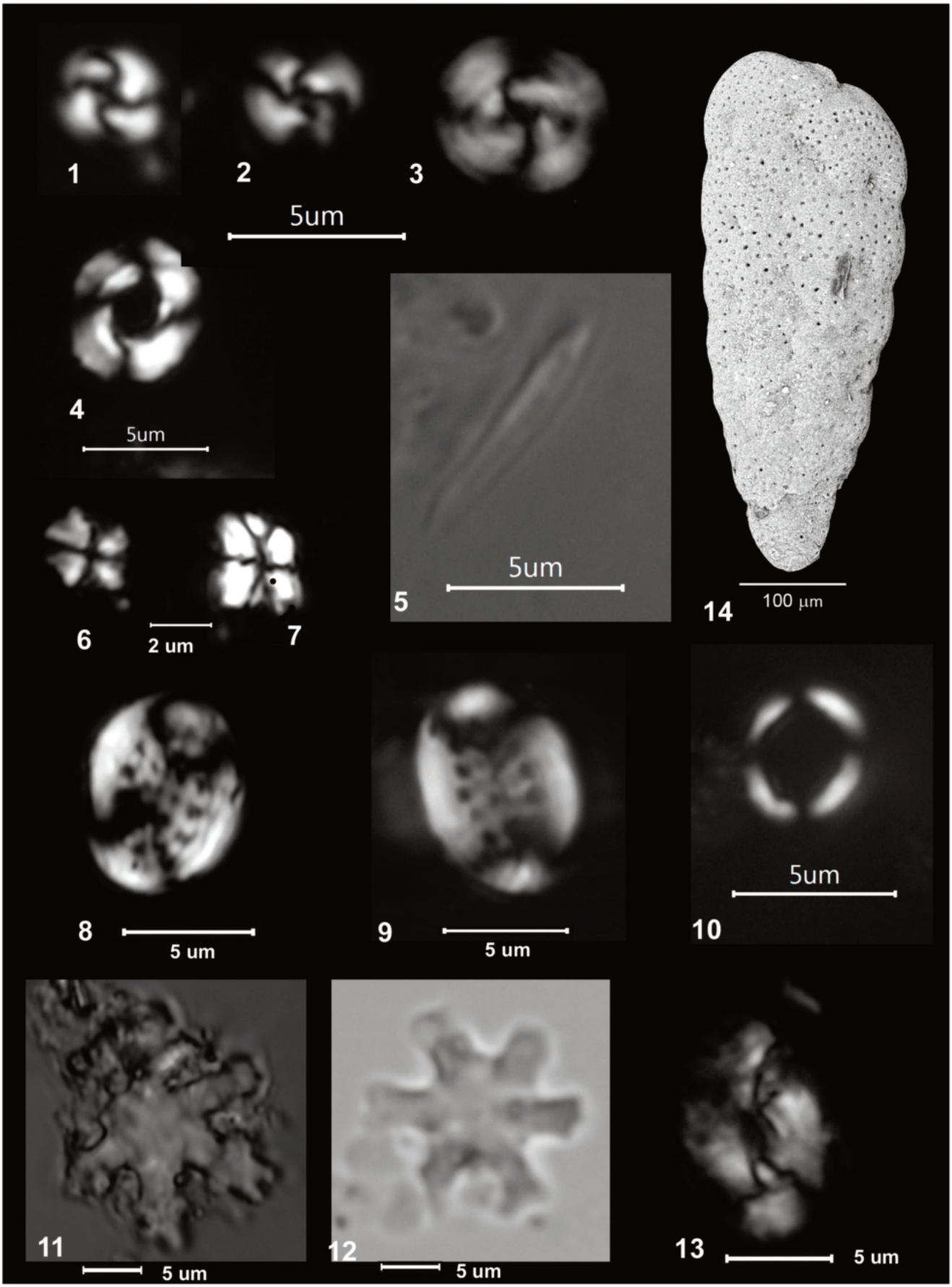
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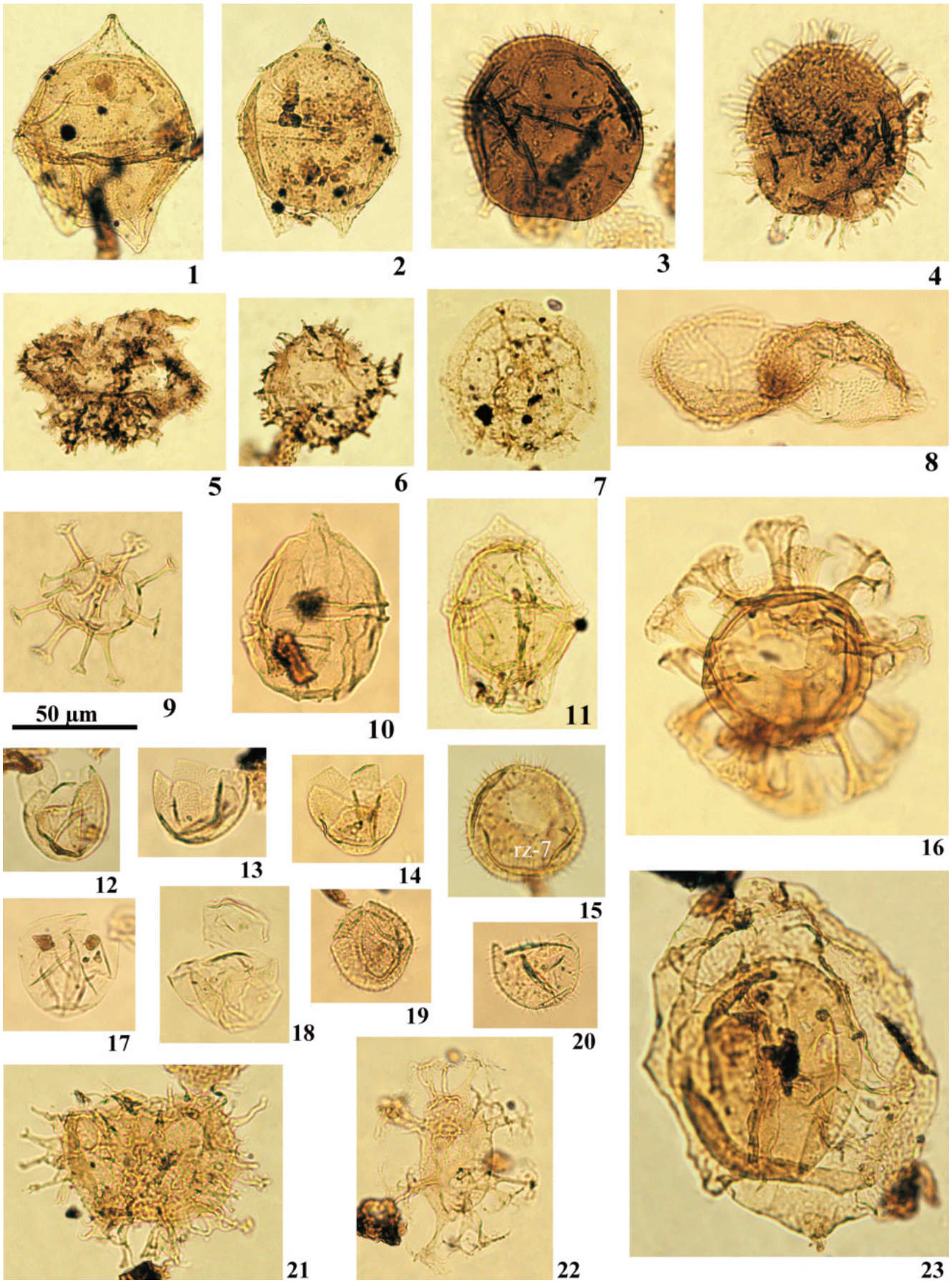
Plate II

Lower Miocene dinocysts of the Central Ciscaucasia (the Kuban River section).
All images are at one magnification.

Figs. 1–2. *Deflandrea spinulosa* Alberti, 1959b: Alkunian Horizon;
Fig. 3. *Sumatradinium soucouyantiae* de Verteuil et Norris, 1992: Zelenchuk Formation;
Fig. 4. *Sumatradinium druggii* Lentin et al., 1994: Zelenchuk Formation;
Fig. 5. *Gerlachidium aechmophorum* (Benedek, 1972) Benedek et Sarjeant, 1981: Septarian Beds;
Fig. 6. *Trinovantedinium harpagonium* de Verteuil et Norris, 1992: Zelenchuk Formation;
Fig. 7. *Heteraulacacysta leptalea* Eaton, 1976: Karadzhalga Formation;
Fig. 8. *Heteraulacacysta campanula* Drugg et Loeblich Jr., 1967: Karadzhalga Formation;
Fig. 9. *Homotryblium tenuispinosum* Davey et Williams, 1966: Zelenchuk Formation;
Fig. 10. *Cribroperidinium tenuitabulatum* (Gerlach, 1961) Helenes, 1984: Ritsa Formation;
Fig. 11. *Hystrichosphaeropsis ovum* Deflandre, 1935: Olginskaya Formation;
Figs. 12–14. *Batiacasphaera micropapillata* Stover, 1977: Ritsa Formation;
Fig. 15. *Operculodinium centrocarpum* (Deflandre et Cookson, 1955) Wall, 1967: Ritsa Formation;
Fig. 16. *Cordosphaeridium cantharellus* (Brosius, 1963) Sarjeant, 1981: Olginskaya Formation;
Figs. 17–18. *Batiacasphaera* sp.: Ritsa Formation;
Figs. 19–20. *Echinidinium*-type: Ritsa Formation;
Fig. 21. *Chiropteridium galea* (Maier, 1959) Sarjeant, 1983: Alkun Formation;
Fig. 22. *Distatodinium paradoxum* (Brosius, 1963) Eaton, 1976: Zelenchuk Formation;
Fig. 23. *Cousteaudinium aubryae* de Verteuil et Norris, 1996: Zelenchuk Formation.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