

Lectostratotype of the Maikopian Group in the Belaya River Section Upstream of the Town of Maikop (Western Ciscaucasia) in the Oligocene Part

S. V. Popov^{a, *}, I. P. Tabachnikova^b, A. F. Bannikov^a, E. K. Sytchevskaya^a, T. N. Pinchuk^c,
M. A. Akhmet'ev^d, N. I. Zaporozhets^d, A. van der Boon^e, W. Krijgsman^e,
A. S. Stolyarov^{f, †}, and J. Krhovsky^g

^a*Borissiak Paleontological Institute, Russian Academy of Sciences, Moscow, 117647 Russia*

^b*All-Russia Geological Institute (VSEGEI), St. Petersburg, 199106 Russia*

^c*Kuban State University, Krasnodar, 350040 Russia*

^d*Geological Institute, Russian Academy of Sciences, Moscow, 119017 Russia*

^e*Paleomagnetic Laboratory of Utrecht University, Utrecht, 3584 CD The Netherlands*

^f*Fedorovsky All-Russian Scientific Research Institute of Mineral Resources (VIMS), Moscow, 119017 Russia*

^g*Ministry of the Environment of the Czech Republic, 100 Prague 10, Czech Republic*

*e-mail: serg.pop@mail.ru

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Abstract—The section of Maikop deposits on the Belaya River upstream of the town of Maikop is characteristic of Western and Central Ciscaucasia; it is well exposed and well-studied and can be considered as the type section of the Maikop Group. The section shows a continuous transition from the underlying white marl of the Belaya Gлина Formation to dark clay lying at the base of the Maikop Group. The lower Oligocene part of the section exposes an almost uninterrupted outcrop of the Pshekha Formation and shows unconformities at the base and top of the Polbian Bed. These are overlain by the lower non-carbonate and upper carbonate subformations of the Morozkina Balka Formation and the Batalpashinsk and undivided Upper Oligocene Septarian + Zelenchuk formations. This paper contains a detailed lithological description of the section with a summary of its fossils. The composition of the studied microphytoplankton and animal remains, including nannoplankton, planktonic and benthic foraminifers, mollusks, and ichthyofauna is described and paleomagnetic study results are presented. The study of palynology and dinocysts from the same series of samples was previously completed. The history of the study of the Maikop Group and its subdivision into formations are discussed. This paper discusses the possibility of using the data for correlation and reconstruction of the depositional environment.

Keywords: Upper Paleogene, nannoplankton, dinocysts, foraminifers, mollusks, ichthyofauna, paleomagnetism, stratigraphy, depositional settings

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INTRODUCTION

The term “Maikop Formation” began to be applied at the end of the 19th century by a group of geologists who worked under the leadership of K.I. Bogdanovich and was first published by Prokopov (1910, quoted in Prokopov, 1937b, p. 32). The Maikop mollusks were described by Korobkov (1937, 1939), Liverovskaya (1938), and Volkova (1962), whereas a microfaunistic substantiation for the stratigraphy of the Maikop Formation was provided by Bogdanovich (1960), Ter-Grigoryants (1961), and many others (see Grossheim,

1960). The ichthyofauna was studied by Danilchenko (1960) and others.

We studied the Maikop part of this section in the 1980s and then in 1994–1996, while working on Projects MPGK nos. 174 and 326, when, along with the traditional fossil groups (foraminifers, mollusks, ichthyofauna), the phytoplankton was studied for the first time, and a guidebook for an international excursion was compiled (Akhmetiev et al., 1995). For the Belaya River Section, nannoplankton data were obtained by Krhovsky et al. (1995) and others, while Akhmetiev et al. (1995) and Zaporozhets (1999) studied dinocysts and spore-pollen assemblages, and E.K. Sytchevskaya (in Akhmetiev et al., 1995; Popov et al., 2009; etc.)

[†] Deceased.

reviewed the ichthyofauna; fishes were described by Prokofiev (2005, 2006; 2013) and were also collected and studied by Bannikov (see Bannikov, 2010; Bannikov and Parin, 1997; etc.). In 2014–2018, the section was studied by Russian geologists in collaboration with an international group, which included specialists from Utrecht University (Netherlands), who conducted paleomagnetic and cyclostratigraphic studies, and also colleagues from the Montanuniversität Leoben (Austria), who obtained and prepared for publication geochemical and isotopic data (Sachsenhofer et al., 2017). To ensure a correct stratigraphic and event interpretation of these data and biotic control of the conclusions, we continue a comprehensive paleontological and lithological study of the section aiming to obtain a considerably more detailed biotic and sedimentological characterization of the recognized formations, to allow more precise definitions of their boundaries and thickness, and to interpret depositional settings. At present dinocysts and spore-pollen assemblages are most comprehensively studied (Zaporozhets and Akhmetiev, 2017) from samples collected in 2014. Nannoplankton and foraminifers are studied from the series of samples collected for paleomagnetic study in 2015 and 2016. Both groups of samples are reliably correlated (Fig. 1). Nannoplankton was studied by I.P. Tabachnikova. In addition, data obtained by J. Krhovsky as a result of studies of 1995, which were previously cited only in the excursion guidebook (Akhmetiev et al., 1995) and in summaries of reports (Krhovsky et al., 1995; etc.), were used. Foraminifers were studied by T.N. Pinchuk.

FORMATIONS OF THE MAIKOP SECTION

The formation stratigraphy of the Maikop Group of Ciscaucasia was proposed by Prokopov (1937a, 1937b) and Korotkov (1935). Prokopov subdivided the Maikop series from bottom to top into the Khadum, Batalpashinsk, Septarian, Zelenchuk, Karadzhalga, Olginskaya, and “Ritsa” horizons on the basis of sections of the Central Ciscaucasia, primarily on the section on the Kuban River near the town of Cherkessk. Originally, the “Ritsa” Horizon was spelled “Ritsevsky Horizon” by Prokopov and later by Grossheim (1960), and later major reviews and reference books began citing it as the “Ritsa Formation” (*Neogenovaya...*, 1986; *Paleogenovaya...*, 1975; *Stratigraficheskii...*, 1982), probably mainly from Ritsev (Ritsa) Mountain in the southern vicinity of Nevinnomyssk.

Korotkov (1935), while conducting research in the Khadyzhensk and Neftegorsk districts, subdivided the Khadum Horizon into three subhorizons: Pshekha,

Polba, and Morozkina Balka. The early authors did not include the Khadum Horizon in the Maikop Group, and it was considered as a transitional series from the carbonate “foraminiferal beds” to non-carbonate clay of the Maikop Group (Prokopov, 1937a, p. 17); later, the Khadum Horizon was included in the Maikop Group (Grossheim, 1960). Korotkov (1940, unpublished) described the main sections and boreholes from the Kuban River to the Pshekha River and in the middle Maikop recognized the Abadzekhskaya and Voskovogorskaya formations. However, the manuscript remained unpublished, and short descriptions of these formations were later published by Grossheim and Gladkova (1953).

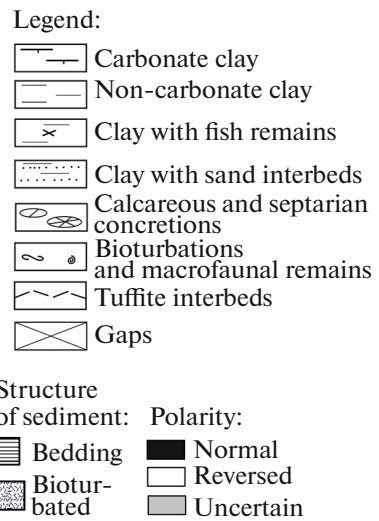
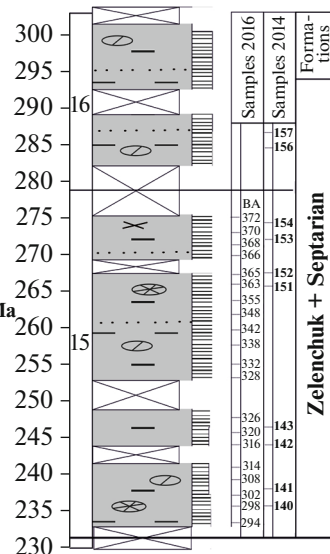
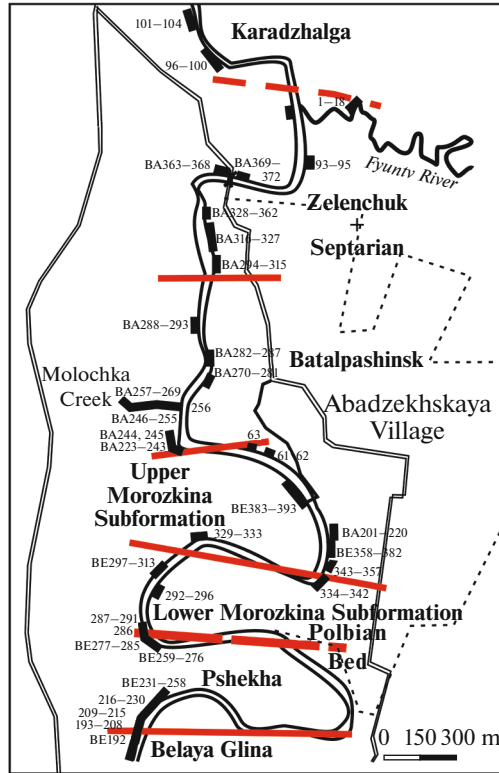
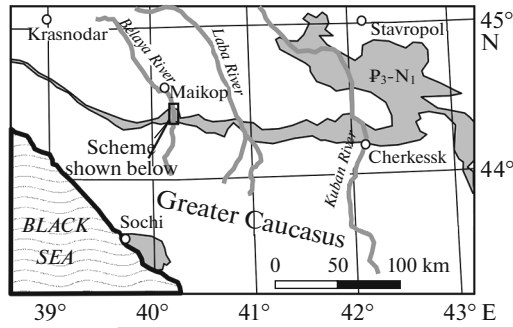
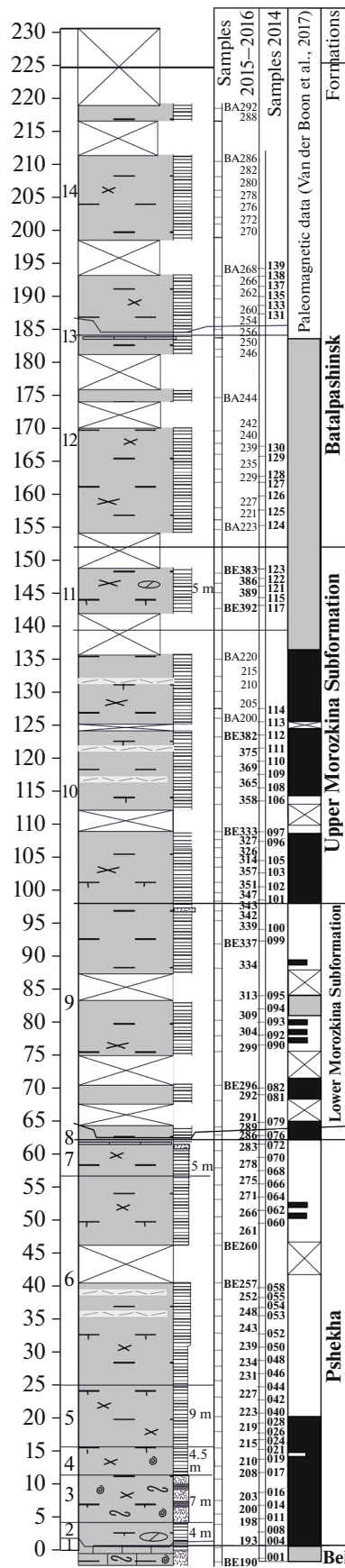
Two competing stratigraphic schemes are used for the Maikop Group in modern publications on the section of the Belaya River. Geologists conducting the geological mapping of the western Caucasus of 1 : 50000 scale in the 1950–1980s and 1995–2008 used stratigraphic nomenclature close to Korotkov’s scheme (Beluzhenko, 2010; Beluzhenko and Kovalenko, 2006), considerably differing from Prokopov’s scheme of Central Ciscaucasia (Fig. 2). The reason for the proposal of various schemes was an inability to directly trace the stratigraphic units of Central Ciscaucasia because of the presence of the delta facies in the section of the Laba River above the Batalpashinsk level.

At the same time, geologists and lithologists of the Koltsov Expedition who were particularly involved in studying potentially productive facies in the Maikop sediments showed that such tracking is quite possible if data from boreholes nearer the trough axis are used.

Therefore, they used Prokopov’s scheme, with a refined Khadum part as proposed by Korotkov, and extended its subdivisions along the whole of Western and Central Ciscaucasia (Semenov and Stolyarov, 1970; Stolyarov and Ivleva, 2004). We also use these more widely traceable formations for the upper part of the Maikop Group.

A.S. Stolyarov, an expert on the Maikop deposits of Ciscaucasia, Mangyshlak, and Kopetdag, compiled in 1985 a full lithological description of the section on the Belaya River. Stolyarov’s correlation of the upper part of the Maikop Group (Semenov and Stolyarov, 1970; Stolyarov and Ivleva, 2004) used the tracing of “fish facies” associated with anoxia: the Batalpashinsk Formation in the Upper Oligocene and the Karadzhalga Formation in the Lower Miocene, separated by a bed with sandy interlayers and septarian concretions. In this work, as well as in the guidebook of the excursion along the Belaya River (Akhmetiev et al.,

Fig. 1. Location of samples collected from the Oligocene formations in the valley of the Belaya River near the village of Abadzekhskaya (from a satellite image) and a lithological log showing the position of samples. Numbers of the beds (1–16) are on the left of the column; structure of the sediment is on the right.



Series	Scale, m	Beds	Lithology	Thickness, m	Formations, subformations after Beluzhenko, 2010; Beluzhenko et al., 2014	Formations, subformations in this paper
Lower Miocene	230	17			Voskovogorskaya	Karadzhalga
	220					
Upper Oligocene	210					
	300	16		25	Alkun	Alkunian Horizon
	290					
	280					
	270	15		40	Batalpashinsk	Septarian + Zelenchuk
	260					
	250					
	240					
	230	14		40	Batalpashinsk	Batalpashinsk
	220					
	210	13		0.7	Batalpashinsk	Batalpashinsk
	200					
	190	12		36	Batalpashinsk	Batalpashinsk
	180					
	170	11		5	Batalpashinsk	Batalpashinsk
	160					
	150	10		35	Morozkina Balka Subformation	Upper Morozkina Subformation
140						
130	9		36	Morozkina Balka Subformation	Lower Morozkina Subformation	
120						
110	8		0.5	Polb	Polb	
100						
Lower Oligocene	90	7		5	Khadum	Khadum
	80					
	70	6		32	Pshekha Subformation	Pshekha
	60					
	50	5		9	Pshekha Subformation	Pshekha
	40					
	30	4		4.5	Pshekha Subformation	Pshekha
20						
10	3		7	Pshekha Subformation	Pshekha	
0						
Eocene	1-2		4		Belaya Glina	Belaya Glina

Fig. 2. Correlation of the subdivision of the Oligocene part of the Belaya River section (Beluzhenko, 2010; Beluzhenko et al., 2014) and accepted in this paper. Polb.—Polbian Bed.

1995), we accept this division of the section, using Stolyarov's field book notes for a lithological description and stratigraphy. Comparison of these two main competing schemes (Fig. 2) shows that, in the lower part, they are almost identical, differing only in the rank of units. The outcrop is excellently exposed and the boundaries of the Pshekha, Polba, and Morozkina Balka formations are readily recognizable.

At the same time, we consider it important to separate the lower subsystem of the latter from the upper one, since the boundary between them corresponds to the transition from the brackish water Solenovian basin to a normal marine basin (Popov et al., 1993; Sachsenhofer et al., 2017; Zaporozhets and Akhmetiev, 2017).

The boundary at the base of the Batalpashinsk Formation in these two schemes is not unequivocally interpreted. This part of the section contains a thin bed (Bed 11, about 5 m thick cropping out near the suspension bridge in the village of Abadzekhskaya), containing small carbonate nodules. The bed is assigned by Beluzhenko et al. (2014) to the Batalpashinsk Formation on the grounds that the nodules are included in non-calcareous clay.

Now, with low water, the beds are well exposed, showing that the host clay beds are calcareous, and therefore we assign them to the uppermost part of the upper member of the Morozkina Balka Formation. It was not possible to observe the boundary with the non-carbonate Batalpashinsk Formation, but it is certain that it is in a very thin (about 5 m) covered interval (Fig. 1). The greatest differences in the allocation of formations and the position of their boundaries begin with the top of the Batalpashinsk Formation as we currently interpret it.

Our opponents do not recognize the Septarian and Zelenchuk formations on the Belaya River (Pismennaya et al., 2009; Beluzhenko, 2010; Beluzhenko et al., 2014), considering the level of the appearance of the septarian nodules and sands in the sections to be non-isochronous, and they assign the non-carbonate part of the sequence with nodules and sand beds to the top of the Batalpashinsk Formation.

Prokopov, in the original description of the "Septarian Horizon" (Prokopov, 1937b, pp. 34–35), emphasized the tentative nature of the boundary between the Septarian and Zelenchuk formations: "examining the section from bottom to top and finding septarian concretions, we can expect the appearance of sandstone higher up, and vice-versa" Infrequent septarian concretions occur on the Belaya River along a considerable distance (40 m thickness near the road bridge in the northern vicinity of the village of Abadzekhskaya), immediately above the Batalpashinsk Formation, as in the sections of Central Ciscaucasia. The main beds of fine-grained sand, as in the Kuban section, appear on the Belaya River above the level with septarian nodules. However, the lowermost

level of the appearance of sandy interbeds is indeed not consistent: thin sand beds already appear in the upper part of the Batalpashinsk Formation; higher up, they alternate with clay with nodules. It is this gradual increase in arenaceous content that Stolyarov considered regionally consistent and considered it to be of stratigraphic importance, emphasizing that the content of the arenaceous material here remains very low, from a few tenths of one percent to a few percent (Stolyarov and Ivleva, 2004, p. 268). Therefore we consider it important to separate this regionally well-defined level from the Batalpashinsk level and accept it as an undivided Septarian + Zelenchuk Formation, beginning from the level of the first Septarian concretions, approximately coinciding with the appearance of noticeable sandy interbeds (Figs. 1, 2).

In his main study on the stratigraphy of the Maikop Group, Prokopov (1937b, p. 35) noted the similarity of the section on the Kuban River to the section on the Assa River: both sections contain the level of the first appearance of fine sands, underlined by a horizon with septarian nodules, in turn underlined by a “horizon of platy marl—arenaceous or dolomitic (Alkunian Horizon).” Stolyarov considered the Alkun beds traceable only in eastern Ciscaucasia (Stolyarov and Ivleva, 2004, p. 267). The westward wedging out of the Alkun Formation was also shown by Kovalenko et al. (1977, unpublished, text-figs. 2, 3).

In the section of the Belaya River, the Alkun level is traditionally recognized on the weakly carbonate clay with nodules at the top of the septarian-sandy series (i.e., Septarian-Zelenchuk Formation in our interpretation), exposed in the lower reaches of the Fyuntv River (Figs. 1, 2) (Beluzhenko and Kovalenko, 2006; Beluzhenko et al., 2014; Dmitrieva et al., 1959; etc.). This carbonate level with foraminifers, nannoplankton of the NP25–NN1 Zone, and a characteristic dinocyst assemblage, containing the first Miocene taxa, is currently traced in the sections of the Kuban River near the village of Karamurzinsky and in North Ossetia (Beluzhenko, 2010; Filippova et al., 2010, 2015). Our opponents refer to this level as to the Alkun Formation and assign its lower, larger, non-carbonate portion with septarian concretions and sandy interbeds to the Batalpashinsk Formation (Fig. 2). We agree with the importance of tracing this stratigraphic level as a regional subdivision—marker beds with a distinct faunal assemblage—and propose, following Dmitrieva et al. (1959), to assign it to the Alkunian Regional Stage, which has a significant stratigraphic importance according to the Stratigraphic Code (*Stratigraficheskii kodeks*, 2006, Article IV.4). In the paper by Dmitrieva et al. (1959, p. 98, Fig. 3) the Alkunian Regional Stage, rather than the formation, is shown in a separate column at the level of the upper part of the Batalpashinsk and Septarian formations. We are also prepared to agree with Beluzhenko and

Kovalenko (2006; Beluzhenko, 2010, p. 42) that septarian concretions and possibly sands are frequently present below and above the Alkunian level. In fact, on the Belaya River, there is a probable erosional horizon above the upper level of concretions: the dinocyst assemblage is here characterized by a pronounced redeposition with the presence of redeposited Paleogene and Cretaceous taxa, according to Zaporozhets and Akhmetiev (2017).

The Upper Maikop deposits are more uniform and difficult to subdivide stratigraphically, so they will be dealt with in a separate paper when the results of biotic and paleomagnetic studies become available.

SECTION DESCRIPTION

The outcrop of the Maikop part of the section begins south of the village of Abadzekhskaya, 1.5 km below the highway and railway bridges, along the left bank of the Belaya River (Fig. 1), and directly continues from the Eocene section (Cherkessk, Kerestinsk, Kuma, and Belaya Glina formations; Popov et al., 2018).

For the first time for this formation, remains of benthic fauna appear in the marl clays near the top of the Belaya Glina Formation (top 0.5 m). These are the bivalves *Propeamussium fallax* and *Nucula* sp., remains of echinoids, imprints of bryozoans, and small bioturbations. The beds contain evidence of massive redeposition of phytoplankton, indicating regression and erosion.

Dinocysts show a high species diversity, dominated by marine to open ocean chorate forms, including *Impagidinium spiniferites*, while *Charlesdownia clathrata angulosa*, a zonal index species characteristic of the Priabonian, continues.

Pshekha Formation

(1) Clay greenish gray, overlying a distinct boundary, thinly bedded because of alternation of gray calcareous clay with brownish fossils and barren greenish non-calcareous clay. The bed contains infrequent fish remains: “*Sardinella*” *rata*, *Thunnus* sp. Thickness 0.4–0.5 m.

(2) Clay dark gray, weakly calcareous, micro- and thin-bedded, with shells of planktonic pteropods of the genera *Vaginella* and *Limacina* (identified by I.A. Gontsharova) on the bedding planes, with numerous fish remains, including boreal taxa. The assemblage is dominated by the Clupeidae “*Sardinella*” *rata*, Perciformes *Anachelum angustum* and *Palimphyes chadumicus*, and Gadiformes *Palaeogadus* (five species) and *Eophycis pshekhiensis*; less common are isolated skeleton imprints and teeth of lamnoid sharks (according to P.G. Danilchenko, E.K. Sytchevskaya, V.F. Fedotov, and A.F. Bannikov). The leaf

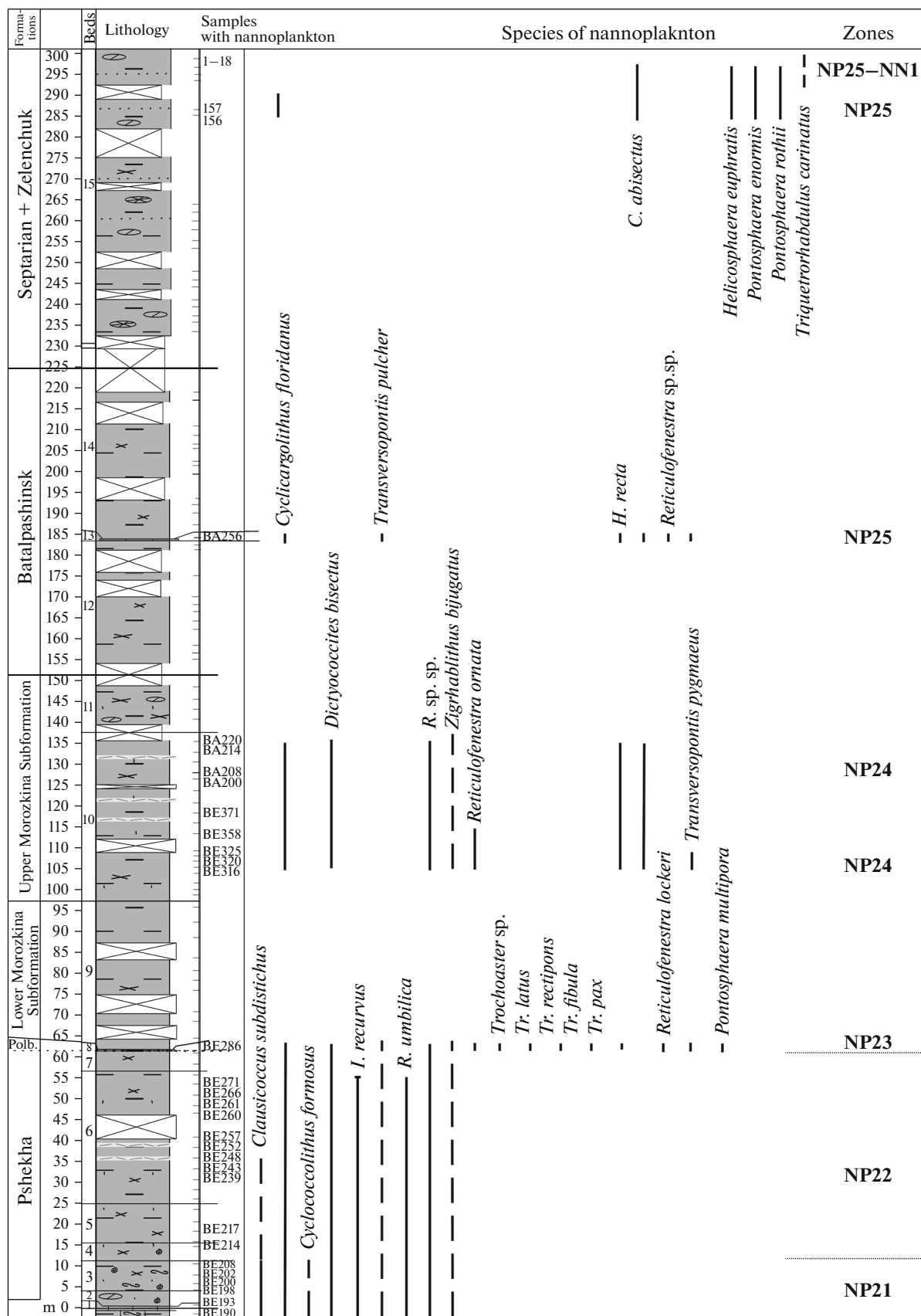


Fig. 3. Stratigraphic distribution of nannoplankton species in the Belaya River Section and zonations of Oligocene–Lower Miocene deposits. Polb.—Polbian Bed.

flora is represented by *Cryptomeria* sp., *Taxodium dubium*, *Castanopsis* sp., *Cinnamomophyllum* sp., and *Myrica* sp. (identification by M.A. Akhmetiev). The bed contains nannoplankton of the NP20–21 Zone and small foraminifers *Globigerina officinalis* and *G. bulloides*. The dinocyst assemblage of the *Phtanoperidinium amoenum* Zone (D13) includes *Deflandrea phosphoritica*, *Homotryblium floripes*, and *Areosphaeridium pectiniforme*. Thickness 3.5 m.

(3) Similar dark gray clay with limacids, but in places bioturbated, containing diverse benthic fossils: bivalves *Pterolucina batalpaschinica* (Korob.), *Yoldiella chadumica* (Korob.), *Thyasira nysti* (Phil.); gastropods *Aporrhais speciosa* Sch.; scaphopods *Dentalium (Antalis) acutum parvum* (Gonch.) (identified by I.A. Gontsharova); and tubes of the tube worm *Spirorbis*, i.e., a typical assemblage for the basal Oligocene. The ichthyofauna is similar to that of the underlying bed. The nannoplankton assemblage is also similar to that of the underlying bed, but does not contain *Discoaster saipanensis* or *D. barbadiensis*, whereas *Sphenolithus pseudoradians* is very uncommon (NP21 Zone). Thickness 7 m.

(4) Alternation of gray laminated calcareous clay with *Limacina* and darker, less carbonate clay. Benthos is absent. The basal part of the bed contains nannoplankton of the NP21 Zone, while in the overlying part *Clausicoccus subdistichus*, *C. fenestratus*, and *Cyclococcolithus formosus* disappear, and the assemblage belongs to the NP22 Zone, according to J. Krhovsky (Akhmetiev et al., 1995). The fish association is similar to that of the underlying beds. The palynoassemblage is diverse, dominated by Taxodiaceae over Pinaceae, and contains *Rhus*, *Carpinus*, *Carya*, Fagaceae, *Corylopsis*, Myricaceae, and *Aralia*. The dinocysts indicate the *Phtanoperidinium amoenum* D13 Zone (Zaporozhets, 1999). Thickness 4.5 m.

(5) Clay dark gray and gray, thin-bedded, in places calcareous, without *Limacina*. Nannoplankton belongs to the NP22 Zone. The ichthyofauna contains both coastal (*Aeoliscus heinrichi*) and numerous deep-water taxa with photophores: *Eovinciguerrria obscura*, *Scopeloides glarisanus*, and *Archaeolicus strictus* (*Aeoliscus* assemblage with thermophilic tropical and subtropical taxa, such as *Bregmaceros*, *Aeoliscus*, and *Fistularia* (Sytchevskaya in Akhmetiev et al., 1995; Bannikov, 2010)). The deep-water assemblage indicates depths to 1000 m. Thickness 9 m.

(6) Clay dark gray, thin-bedded, along bedding planes calcareous owing to the carbonate inclusions (zooplankton coprolites with nannoplankton). The fish association is similar to that of Bed 5. Nannoplankton belongs to the NP22 Zone, and *Wetzeliella gochtii* appears in the dinocyst assemblage, which is characteristic of the second half of the Early Oligocene. The middle part contains several thin layers of tuffites. Thickness 31–32 m.

The upper part of Bed 6 and Beds 7–9 are exposed in the next bend of the river, in the cliff of the left bank opposite the village of Abadzekhskaya (Fig. 1, Sample BE259–291):

(7) Clay dark, non-carbonate, in places and in lenses silty and micaceous, on the surface indistinctly bedded, strongly jarositized, with rare fish remains. The appearance of *Batiacasphaera baculata* and *B. sphaerica* in the dinocyst assemblage suggests the beginning of a decrease in salinity. The top (upper 0.5 m) contains clay with interbeds of sand and bioturbation traces. Thickness 5 m.

Polbian Bed

(8) Marl light gray, with lenticular and cross-bedding, inconsistent in thickness (0.1–0.5 m), with ferruginous bed at the base, with lenses of sandy, glauconite, bony, and tuff material. The bed contains infrequent mollusks of a brackish-water endemic association of *Janschinella*, *Lenticorbula*, and Cardiidae, characteristic of the Solenovian Regional Stage, and ostracodes of the *Disopontocipris oligocaenica* (Zal.) association. The nannoplankton association belongs to the NP23 Zone: *Reticulofenestra ornata*, *Transversopontis fibula*, *T. latus*, and *T. pax*. The dinocysts belonging to the *Wetzeliella gochtii* Zone include *Batiacasphaera sphaerica*, thin-walled *Hystrichokolpoma* and *Glaphyrocysta*, and acritarchs (*Horologinella*), indicating a significant freshening of the basin. Toward the top, marls become greenish marly clay with bioturbation traces and lenses of quartz-glauconite sand. Thickness 0.2–0.6 m.

Morozkina Balka Formation, Lower Morozkina Subformation

(9) Bed of dark gray, thin-bedded, non-carbonate clay, with fish detritus and scales, jarosite on the weathered surfaces, overlying a distinct boundary. Dinocyst species indicating brackish-water basin (thin-walled *Hystrichokolpoma*, *Batiacasphaera sphaerica*) continue to occur. However, in the middle part of the member, taxa of the brackish-water basins almost disappear, while the assemblage is dominated by cysts of open marine species: *Lejeunecysta* spp., *Wetzeliella gochtii* (index species of a regional zone), *Selenopemphix nephroides*, and *Operculodinium*. This suggests the influx of marine water in the basin, which was previously suggested by E.K. Sytchevskaya (Popov et al., 2009, p. 69). The ichthyofauna includes sharks of the family Charcharinidae, bony fishes of the families Clupeidae, Osmeridae, Gadidae, Reproccidae, Priacanthidae, Caproidae, Scombridae gen. indet., and coastal Syngnathidae (Prokofiev, 2013; Sytchevskaya and Prokofiev, 2013). The types of cysts that appear above indicate a reinstatement of the desalination

regime. At the top, the clay becomes bioturbated in places. Thickness 35–37 m.

The upper part of Bed 9 and Bed 10 crop out in the high slope of the right bank above the suspension bridge in the village of Abadzekhskaya (Fig. 1):

*Morozkina Balka Section,
Upper Morozkina Subformation*

(10) Rhythmic alternation of gray and dark gray carbonate clay, in places with non-carbonate clay in the lower part and with carbonate material (coprolites of zooplankton above). The nannoplankton belongs to the NP24 Zone (Nagymarosy and Voronina, 1993; data from Tabachnikova, this paper). The bed contains a dinocyst assemblage with *Wetzeliella gochtii* and *Chiropteridium partispinatum*, characteristic of the transition from the Lower to Upper Oligocene. The ichthyofauna contains marine pelagic Clupeidae, Palaeorhynchidae, Gempylidae, and Scombridae. The middle part has several thin profiles of tuffite. Thickness 30–35 m.

The left and right bank downstream of the suspension bridge shows an outcrop of Bed 11 (Samples BE383–393, 61–63).

(11) Clay thin-bedded, carbonate, silty, with rare carbonate nodules (up to 0.35 cm in diameter). The fish association is similar to that of the preceding bed. The dinocysts are taxonomically diverse and represent inhabitants of an open sea shelf. The appearance of *Rhombodinium draco* suggests that the assemblage belongs to the Upper Oligocene. The bedding is almost horizontal or upturned. Visible thickness around 5 m.

Bed 12 crops out in a high slope of the left bank, 1 km downstream of the suspension bridge (Fig. 1, Samples BA223–245):

Batalpashinsk Formation

(12) Clay dark gray, silty, non-carbonate, microlaminated, with rare fish remains. The dinocyst assemblage belongs to the *Chiropteridium partispinatum* Zone. The palynoassemblage is dominated by the gymnosperms *Pinus* and *Picea*, indicating a cooling episode. Thickness 35–37 m.

The mouth of Molochka Creek has an outcrop of the upper part of Bed 12 and Bed 13; upstream in the river channel and on the right slope, clay of Bed 14 is exposed (Fig. 1):

(13) Clay thin-bedded, light, carbonate, silty, down and up the section gradually becoming dark non-carbonate clay, with white mottles on the bedding planes. The latter contains abundant nannoplankton dominated by *Cyclicargolithus abisectus* and *C. floridanus*. The absence of *Dictyococcites bisectus*

and *Zygrhablithus bijugatus* suggests that this assemblage belongs to the NP25 Zone. Thickness 0.7–0.8 m.

(14) Clay gray and dark gray, non-carbonate, thin-bedded and with fine cross-hatching, with fish remains. The middle part of the bed shows the appearance of thin interbeds of tuffite, fine-grained quartz micaceous sand, calcareous sandstone, and carbonate material (described by Stolyarov in the channel of Molochka Creek). Thickness about 40 m.

The cliff of the right and then left bank in the northern vicinity of the village of Abadzekhskaya also shows clay of Bed 14 (Samples BA270–293), replaced (over a gap of 15 m) by Series 15 with nodules (Samples BA294–262):

Septarian + Zelenchuk Formation

(15) Similar non-carbonate dark gray non-calcareous clay frequently with interlayers of brownish organics, with fish remains (in “fish facies”) shows the appearance of horizons with small calcareous and septarian concretions (up to 0.7×0.3 over 4–5 m), with septa composed of well-crystallized calcite (as in the section on the Kuban River). The succession at the level of nodules sometimes contains interbeds of calcareous clay (up to 0.15 m). There are several interbeds of fine-grained glauconite-quartz (0.1–0.3, to 0.5 m) and a sandy dike of the same sand. Thickness about 40 m.

The same series continues to be exposed above and below the road bridge in the northern vicinity of the village of Abadzekhskaya up to the Fyuntv River (Samples BA363–372, 93–95).

The carbonate interbeds in the middle part of the series contains nannoplankton: *Cyclicargolithus floridanus*, large *Helicosphaera euphratis*, *Pontosphaera enormis*, *P. rothii*, *Cyclicargolithus abisectus*, *Dictyococcites bisectus* (NP25 Zone, data from J. Krhovsky); there is a dinocyst assemblage with *Chiropteridium partispinatum* and *Deflandrea spinulosa* (epibole) in the upper part of the *Chiropteridium partispinatum* Zone. In the palynoassemblage, Taxodiaceae are more abundant than *Pinus*, while angiosperms constitute approximately 25% and include subtropical taxa: *Engelhardtia*, *Castanopsis*, and *Quercus* ex gr. *graciliformis*.

On the Fyuntv River, the upper part of the series contains nannoplankton: *Coccolithus pelagicus*, rare *Pontosphaera enormis*, *Cyclicargolithus floridanus*, one specimen of *Triquetrorhabdulus carinatus?*, frequent *Cyclicargolithus abisectus* (NP25–NN1 Zone, according to J. Krhovsky). The ichthyofauna is represented by a relatively poor thermophilic association with *Aeoliscus* sp., *Capros longispinatus*, *Repropca* sp., and “*Sardinella*” sp., whereas the dinocyst assemblage includes *Labirintodinium truncatum*, *Cleistrosphaeridium thalassiphora*, *Paleocystodinium golzowense*, *Bitectodinium* sp., and *Selenopemphix nephroides*. The palynoassemblage is characterized by the Angiosper-

mae/Gymnospermae ratio = 3.5, by the greater abundance of Taxodiaceae over Pinaceae, and by the dominance of Betulaceae over Fagaceae + Juglandaceae. This suggests a humid, moderately warm climate.

These beds are followed by outcrops of the right and left banks downstream of the Fyuntv River, where the Miocene part of the Maikop Group about 300 m thick crops out, in outcrops that are somewhat less completely exposed. These beds are to be described in a separate paper.

MAJOR FOSSIL GROUPS

Nannoplankton

Diverse nannoplankton assemblages of the Belaya Glina Formation in its upper part become less diverse, containing *Coccolithus eopelagicus*, *Cyclococcolithus formosus*, *Chiasmolithus oamaruensis*, *Corannulus germanicus*, and *Discoaster tani*; the amount of *Discoaster* sharply decreases. *Sphenolithus pseudoradians* (Martini, 1971), the index species of the NP20 Zone (=CP15 *Discoaster barbadiensis*, 15b *Istmolithus recurvus* Subzone according to Bukry, 1975), is still present.

The uppermost horizons of the Belaya Glina Formation (Sample BE190) and the base of the Pshekha Formation (Fig. 3, Beds 1, 2, Samples BE193, 196) contain abundant *Clausicoccus subdistichus*, the explosion of abundance of which is in the Eocene–Oligocene boundary beds within the NP21 Zone or CP16 Zone (Gradstein et al., 2012).

Pshekha Formation. The basal horizons of the Pshekha Formation (Beds 1, 2, Samples BE193, 196) are still dominated by species continuing from the Eocene (*Coccolithus eopelagicus*, *Dictyococcites bisectus*, and *Reticulofenestra umbilica*). We also found *Discoaster barbadiensis* and *D. saipanensis*, one specimen each; the disappearance of these taxa defines the upper boundary of the NP20 Zone (or CP15 *Discoaster barbadiensis* Zone). However, this level shows mass redeposition of the microbiota (Zaporozhets, 1999); hence, isolated occurrences probably should not be considered as very important.

Up the section (Bed 3, Samples BE202–208), *Discoaster saipanensis* and *D. barbadiensis* completely disappear, but the assemblages are still dominated by *Istmolithus recurvus*, *R. umbilica*, and *Clausicoccus subdistichus*. *Cyclococcolithus formosus*, a species disappearing at the upper boundary of the NP21 Zone, is represented by only a few specimens, so the association corresponds to the upper part of the NP21 Zone.

In Bed 4, the precise position of the NP21/22 boundary cannot at present be established above the Beds with *Limacina* because of the almost constant, although rare, presence of *Cyclococcolithus formosus* and also of redeposited specimens of *Discoaster*. In the upper part of Bed 4 and in Bed 5 (Samples BE214 and

217), carbonate interbeds contain a nannoplankton assemblage in which *C. formosus* is absent, *Istmolithus recurvus* is dominant, and large specimens of *Reticulofenestra umbilica* are found only occasionally, which is characteristic of the NP22 Zone.

In most of the Pshekha Formation (Fig. 3, Bed 6, Samples BE239–271), nannoplankton assemblages are composed of small *Reticulofenestra* and *Istmolithus recurvus* and occasional *Reticulofenestra umbilica*, *R. hillae*, and *Dictyococcites dictyodus*, and very rare *Cyclococcolithus formosus* and correspond to the NP22 Zone. It needs to be said that Sample BE250 contains a few representatives of the genus *Transversopontis* (*T. fibula*, *T. pulcher*, *T. sp.*). Usually, the presence of such endemic markers as *T. fibula* is characteristic of the Polba Formation and its equivalents (NP22–23) in many localities of the Eastern Paratethys.

Polba Formation. The nannoplankton assemblage from the Polba marl is very distinct (Bed 8, Sample BE286). This assemblage is dominated by small *Reticulofenestra ornata* and contains numerous *Transversopontis fibula*, *T. pax*, and *T. latus* and occasional *Trochoaster* sp. J. Krhovský assigned this peculiar assemblage to the NP23 Zone (Akhmetiev et al., 1995), whereas Tabachnikova assigned it to the NP22–23 zones (Muzylev and Tabachnikova, 1987).

Morozkina Balka Formation. The overlying non-carbonate thinly laminated clay of the Lower Morozkina Subformation does not contain nannoplankton. The alternating carbonate and non-carbonate clay beds at the base of the Upper Morozkina Subformation contain *Reticulofenestra lockeri*, *Cyclicargolithus floridanus*, *Dictyococcites bisectus*, *Coccolithus pelagicus*, *Pontosphaera multipora*, and *Transversopontis pygmaeus* and belong to the NP24 Zone, indicated by the last occurrence of *T. pygmaeus* and the first appearances of *Helicosphaera recta* and *Cyclicargolithus abisectus*. Up the section (Bed 10, Samples BE316–325), abundant nannoplankton is represented by numerous small *Reticulofenestra* spp., *Cyclicargolithus floridanus*, *Dictyococcites bisectus*, and *Pontosphaera multipora*, and also by occasional (6–7 specimens) *Helicosphaera recta*, the index species of the NP24 Zone. This zone was also indicated for this locality by A. Nagymarosy (Nagymarosy and Voronina, 1993).

In the middle part of the Upper Morozkina Subformation (Samples BE358–373), the nannoplankton is similar to that of the previous assemblage, but contains more *Cyclicargolithus abisectus* and includes *Helicosphaera recta*. Both of these species are characteristic of the NP24–25 zones. Samples BA200–214 from the upper part of the Morozkina Balka Formation contain abundant nannoplankton with numerous *Dictyococcites bisectus*, *Cyclicargolithus floridanus*, and *C. abisectus* and with index species *Helicosphaera recta*, which is also characteristic of the NP24–25 interval.

Deposits of the **Batalpashinsk Formation** contain one carbonate bed (Fig. 3, Bed 13, Sample BA256), with abundant *Reticulofenestra* and dominated by *Cyclicargolithus abisectus*, and *C. floridanus*. The occasional presence of *Discolithina pygmaea* and the absence of *Dictyococcites bisectus* and *Zygrhablithus bijugatus* suggest that this assemblage belongs to the NP25 Zone. The assemblage is very similar to the association described by Baldi-Beke (1984) from Hungary in the upper part of the Kiscellian Regional Stage to Egerian Regional Stage in Borehole 33, which she assigned to the NP24–25 zones, also dominated by *C. abisectus* and *C. floridanus* and with a noticeable presence of *Transversopontis cf. pulcher*.

Predominantly non-carbonate clays of the overlying **Septarian + Zelenchuk Formation** lack nannoplankton. It is found only in isolated weakly carbonated interbeds with concretions in the upper part of the formation and is represented, according to J. Krhovsky, by *Cyclicargolithus floridanus*, large *Helicosphaera euphratis*, *Pontosphaera enormis*, *P. rothii*, *Cyclicargolithus abisectus*, and *Dictyococcites bisectus*, assigned to the NP25 Zone.

The uppermost beds of the Septarian + Zelenchuk Formation (in the Alkunian Horizon) in an outcrop of the Fyuntv River show a rhythmic alternation of non-carbonate clay in places with carbonates and marl nodules. Here the composition of nannoplankton is similar to that described above (*Coccolithus pelagicus*, rare *Pontosphaera enormis*, *Cyclicargolithus floridanus*, and *C. abisectus*), but the assemblage contains one specimen of *Triquetrorhabdulus carinatus?*, which provisionally dates this assemblage as the NP25–NN1 Zone (Krhovsky in Akhmetiev et al., 1995). The overlying non-carbonate clay and silt of the Karadzhalga Formation do not contain nannoplankton.

Foraminifers

In the upper part of the Belaya Glina Formation, the foraminiferal assemblage is replaced by an impoverished association with *Globigerina officinalis*, characteristic of the Oligocene, and this change occurs below the lithological boundary between the Belaya Glina facies and dark clay of the Pshekha Formation (with Sample BE191), from the level of Beds with *Propeamussium fallax*, where nodosariids of the genera *Nodosaria*, *Lenticulina*, *Robulus*, and *Marginulina* begin to dominate, and representatives of *Cibicidoides* appear. The planktonic assemblage is not diverse (species of three to four genera), is represented by smaller tests compared to earlier Eocene plankton, and includes the index species *Globigerina officinalis*. Thus, the foraminiferal assemblage is strikingly different from the typical Late Eocene Belaya Glina assemblage with large tests, but is genetically connected with the Pshekha assemblage of small plankton and diverse

benthic taxa. The distribution of foraminifers along the section of the Belaya River is shown in Fig. 4.

Pshekha Formation. Foraminifers are found in most studied samples and are mostly represented by benthic species, often as pyritized casts; tests are small and thin-walled. The lower part of the section (Fig. 4, Samples BE193, 200b, 210, 220, 235, 252) contains an alternation of interbeds with a small amount of benthic fauna and predominance of planktonic microfauna of the genera *Globigerina*, *Chiloguembelina*, and *Pseudohastigerina* and without microfauna, which was apparently connected with the presence of carbon dioxide and hydrogen sulfide of bottom waters and dissolution of thinner shelled tests in the muddy waters of the upper layers of sediments.

The upper part of the Pshekha Formation (Samples BE240, 265, 279) is dominated by benthos, especially frequently with *Haplophragmoides aff. stavropoliensis* Ter-Grig., *H. fidelis* Ter-Grig., *H. sp.*, *Trochammina aff. complecta* Ter-Grig., *Asterigerina lucida* (Min.), *Cibicidina amphisyliensis* (Andreae), and *Cibicidoides oligocenicus* (Samoilova), but planktonic assemblages continue to be present. According to Ter-Grigoryants (1964), who in the stratigraphic scheme of the Maikop Group in the lower Khadum Horizon at the level of the Pshekha Formation established biostratigraphic units in the rank of local zones with *Haplophragmoides fidelis* and *Asterigerina lucida* as index species, characteristic of the assemblage of Beds with *Globigerina officinalis*, the assemblage of benthic foraminifers from the Belaya River is similar in composition to the assemblage from the Southern Stavropol Region.

The Polba Formation in the section of the Belaya River does not contain foraminifers, but Sample BE284 (0.2 m below the Polbian Bed) contains fragments of *Spirorbis* tubes, occasional *Haplophragmoides fidelis* Ter-Grig., *Trochammina sp.*, and *Cibicidoides oligocenicus* (Samoilov). Sample BE288 (0.5 m above the Bed) contains pyrite and siderite as rounded, fragmented, and not identifiable algal ossicles, test fragments, and casts of foraminifers.

The Lower Morozkina Subformation (Samples BE295, 328, 334, 340, 343), composed of noncalcareous clay, includes benthic and planktonic species of foraminifers, occurring in the underlying deposits of the Pshekha Formation, and the species *Pseudoparella caucasica* Bogd., appearing at that level. The foraminiferal assemblage of this subformation contains *Rhabdammina cylindrica* Glaessner, *Saccammina variabilis* Bogd., *Reophax sp.*, *Ammodiscus aff. perlucidus* Andreae, *A. tenuiculus* Subb., *Haplophragmoides sp.*, *H. aff. periferioexcavatus* Subb., *Cyclammina turosa* Ter-Grig., *C. aff. clivosa* Subb., *C. aff. kubanica* Ter-Grig., *Ammomarginulina aff. lobsanense* (Andr.), *Baggina aff. iphigenia* (Sam.), *Pseudoparella caucasica* Bogd., *Cibicidina amphisyliensis* (Andreae), *Globigerina officinalis* Subb., *G. bulloides* Orb., *G. praebulloides* Blow,

Series	Formations, subformations	Scale, m	Beds	Lithology	Thickness, m	Samples with foraminifers	Beds with foraminifers	Species of foraminifers																																																																
									Upper Oligocene	Lower Oligocene																																																														
L. Miocene	Karadzhalga	230-210	17	Lithology	25	18-1	Bolivina goudkoffi	<i>Globigerina officinalis</i> <i>Globigerina bulloides</i> <i>Globigerina praebulloides</i> <i>Chiloguembelina gracillima</i> <i>Spiroplectamina aff. terekensis</i> <i>Trochammina complexa</i>																																																																
									Septarian + Zelenchuk	280-230	16	BA370, BA364, BA332, BA328, 9/07, BA314, BA309																																																												
Upper Oligocene	Batalpashinsk	220-150	14	Lithology	40	BA256	Spiroplectamina terekensis	<i>Globigerina officinalis</i> <i>Globigerina bulloides</i> <i>Globigerina praebulloides</i> <i>Globigerina parva</i> <i>Globigerina pseudoedita</i> <i>Saccamina variabilis</i> <i>Ammodiscus perlucidus</i> <i>Ammodiscus tenuiculus</i> <i>Haplophragmoides periferexcavatus</i> <i>Trochammina complexa</i> <i>Trochammina caucasica</i> <i>Trochammina parva</i> <i>Trochamminoides concentricus</i> <i>Cyclamina tyrosa</i> <i>Cyclamina clivosa</i> <i>Cyclamina kubanica</i> <i>Glomospirella sp.</i> <i>Bagina iphigenia</i> <i>Bolivina mississippiensis</i> <i>Bolivina dilatata</i> <i>Cibicides sp.</i> <i>Cibicoides expertus</i> <i>Virgulina californica</i> <i>Fursenkoina schreibersiana</i> <i>Virgulina ex gr. pertusa</i> <i>Virgulina neobulminiformis</i>																																																																
									Upper Morozkina Subformation	140-100	11	Lithology	36	BA220, BA200	Cyclamina turosa, Virgulina	<i>Globigerina officinalis</i> <i>Globigerina bulloides</i> <i>Globigerina praebulloides</i> <i>Globigerina parva</i> <i>Globigerina pseudoedita</i> <i>Saccamina variabilis</i> <i>Ammodiscus perlucidus</i> <i>Ammodiscus tenuiculus</i> <i>Haplophragmoides periferexcavatus</i> <i>Trochammina complexa</i> <i>Trochammina caucasica</i> <i>Trochammina parva</i> <i>Trochamminoides concentricus</i> <i>Cyclamina tyrosa</i> <i>Cyclamina clivosa</i> <i>Cyclamina kubanica</i> <i>Glomospirella sp.</i> <i>Bagina iphigenia</i> <i>Bolivina mississippiensis</i> <i>Bolivina dilatata</i> <i>Cibicides sp.</i> <i>Cibicoides expertus</i> <i>Virgulina californica</i> <i>Fursenkoina schreibersiana</i> <i>Virgulina ex gr. pertusa</i> <i>Virgulina neobulminiformis</i>																																																								
																	Lower Morozkina Subformation	90-70	9	Lithology	35	BE347	Cyclamina turosa, Virgulina	<i>Globigerina officinalis</i> <i>Globigerina bulloides</i> <i>Globigerina praebulloides</i> <i>Globigerina parva</i> <i>Globigerina pseudoedita</i> <i>Saccamina variabilis</i> <i>Ammodiscus perlucidus</i> <i>Ammodiscus tenuiculus</i> <i>Haplophragmoides periferexcavatus</i> <i>Trochammina complexa</i> <i>Trochammina caucasica</i> <i>Trochammina parva</i> <i>Trochamminoides concentricus</i> <i>Cyclamina tyrosa</i> <i>Cyclamina clivosa</i> <i>Cyclamina kubanica</i> <i>Glomospirella sp.</i> <i>Bagina iphigenia</i> <i>Bolivina mississippiensis</i> <i>Bolivina dilatata</i> <i>Cibicides sp.</i> <i>Cibicoides expertus</i> <i>Virgulina californica</i> <i>Fursenkoina schreibersiana</i> <i>Virgulina ex gr. pertusa</i> <i>Virgulina neobulminiformis</i>																																																
																									Polb.	60-30	7	Lithology	32	BE284, BE279	Cyclamina turosa, Virgulina	<i>Globigerina officinalis</i> <i>Globigerina bulloides</i> <i>Globigerina praebulloides</i> <i>Globigerina parva</i> <i>Globigerina pseudoedita</i> <i>Saccamina variabilis</i> <i>Ammodiscus perlucidus</i> <i>Ammodiscus tenuiculus</i> <i>Haplophragmoides periferexcavatus</i> <i>Trochammina complexa</i> <i>Trochammina caucasica</i> <i>Trochammina parva</i> <i>Trochamminoides concentricus</i> <i>Cyclamina tyrosa</i> <i>Cyclamina clivosa</i> <i>Cyclamina kubanica</i> <i>Glomospirella sp.</i> <i>Bagina iphigenia</i> <i>Bolivina mississippiensis</i> <i>Bolivina dilatata</i> <i>Cibicides sp.</i> <i>Cibicoides expertus</i> <i>Virgulina californica</i> <i>Fursenkoina schreibersiana</i> <i>Virgulina ex gr. pertusa</i> <i>Virgulina neobulminiformis</i>																																								
																																	Pshekha	20-10	6	Lithology	9	BE265, BE240, BE235	Cyclamina turosa, Virgulina	<i>Globigerina officinalis</i> <i>Globigerina bulloides</i> <i>Globigerina praebulloides</i> <i>Globigerina parva</i> <i>Globigerina pseudoedita</i> <i>Saccamina variabilis</i> <i>Ammodiscus perlucidus</i> <i>Ammodiscus tenuiculus</i> <i>Haplophragmoides periferexcavatus</i> <i>Trochammina complexa</i> <i>Trochammina caucasica</i> <i>Trochammina parva</i> <i>Trochamminoides concentricus</i> <i>Cyclamina tyrosa</i> <i>Cyclamina clivosa</i> <i>Cyclamina kubanica</i> <i>Glomospirella sp.</i> <i>Bagina iphigenia</i> <i>Bolivina mississippiensis</i> <i>Bolivina dilatata</i> <i>Cibicides sp.</i> <i>Cibicoides expertus</i> <i>Virgulina californica</i> <i>Fursenkoina schreibersiana</i> <i>Virgulina ex gr. pertusa</i> <i>Virgulina neobulminiformis</i>																																
																																									Eocene	0-4	5	Lithology	4.5	BE220, BE216, BE210, BE200, BE193	Cyclamina turosa, Virgulina	<i>Globigerina officinalis</i> <i>Globigerina bulloides</i> <i>Globigerina praebulloides</i> <i>Globigerina parva</i> <i>Globigerina pseudoedita</i> <i>Saccamina variabilis</i> <i>Ammodiscus perlucidus</i> <i>Ammodiscus tenuiculus</i> <i>Haplophragmoides periferexcavatus</i> <i>Trochammina complexa</i> <i>Trochammina caucasica</i> <i>Trochammina parva</i> <i>Trochamminoides concentricus</i> <i>Cyclamina tyrosa</i> <i>Cyclamina clivosa</i> <i>Cyclamina kubanica</i> <i>Glomospirella sp.</i> <i>Bagina iphigenia</i> <i>Bolivina mississippiensis</i> <i>Bolivina dilatata</i> <i>Cibicides sp.</i> <i>Cibicoides expertus</i> <i>Virgulina californica</i> <i>Fursenkoina schreibersiana</i> <i>Virgulina ex gr. pertusa</i> <i>Virgulina neobulminiformis</i>																								
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																																																																	Eocene	0-4	4	Lithology	4	BE191	Cyclamina turosa, Virgulina	<i>Globigerina officinalis</i> <i>Globigerina bulloides</i> <i>Globigerina praebulloides</i> <i>Globigerina parva</i> <i>Globigerina pseudoedita</i> <i>Saccamina variabilis</i> <i>Ammodiscus perlucidus</i> <i>Ammodiscus tenuiculus</i> <i>Haplophragmoides periferexcavatus</i> <i>Trochammina complexa</i> <i>Trochammina caucasica</i> <i>Trochammina parva</i> <i>Trochamminoides concentricus</i> <i>Cyclamina tyrosa</i> <i>Cyclamina clivosa</i> <i>Cyclamina kubanica</i> <i>Glomospirella sp.</i> <i>Bagina iphigenia</i> <i>Bolivina mississippiensis</i> <i>Bolivina dilatata</i> <i>Cibicides sp.</i> <i>Cibicoides expertus</i> <i>Virgulina californica</i> <i>Fursenkoina schreibersiana</i> <i>Virgulina ex gr. pertusa</i> <i>Virgulina neobulminiformis</i>

Fig. 4. Stratigraphic distribution of foraminifers in the Belaya River Section and zonations of Oligocene–Lower Miocene deposits. Polb.—Polbian Bed.

G. yeguaensis Wienz. et Applin, *G. aff. ouachitaensis*, *ouachitaensis* Howe et Wallace, *G. parva* Bolli, *G. pseudoedita* Subb., and *G. sp.*

The Upper Morozkina Subformation (Samples BE347, BA200, 209, 214, 220), composed of calcareous clay,

is characterized by a relatively diverse benthic assemblage dominated by representatives of *Cibicoides*, *Virgulina*, and *Bolivina* and low number of planktonic species. The foraminiferal assemblage contains *Ammodiscus sp.*, *Ammodiscus aff. perlucidus* Andreae,

A. aff. tenuiculus Subb., *Saccamina* sp., *Trochamminoides aff. concentricus* Subb., *Trochamina* sp., *T. compressa* Ter-Grig., *T. caucasica* Ter-Grig., *T. parva* Cushman et Laiming, *T. aff. khadumica* Ter-Grig., *Baggina iphigenia* (Samoilova), *Pseudoparella aff. caucasica* Bogd., *Cibicidina amphisyliensis* (Andreae), *Cibicoides oligocenicus* (Samoilova), *C. expertus* (Schutzkaya), *C. almaensis* (Samoilova), *C. aff. pseudoungerianus* (Cushman), *Fursenkoina schreibersiana* (Czjzek), *Virgulinea* ex gr. *pertusa* (Reuss), *V. aff. neobuliminiformis* Kuznezova, *Angulogerina gracilis* (Reuss) *oligocenica* Andreae, *Bolivina* sp., *B. dilatata* Reuss, *B. mississippiensis* Cushman, *B. aff. anglica* Cushman, *Globigerina praebulloides* Leroyi, Blow et Banner, *G. yeguaensis praedovenezuelana* Blow et Banner, and *G. officinalis* Subb. The assemblage contains the common Oligocene species *Ammodiscus aff. perlucidus* Andreae and *Cibicoides pseudoungerianus* (Cushman), indicating a normal marine basin. The assemblage contains index species of beds with foraminifers (*Cyclamina turosa* Ter-Grig. and *Virgulinea* ex gr. *pertusa* (Reuss)); the latter species first appears at that level. *Trochamminoides concentricus* is an index species of the assemblage of the foraminiferal beds of the Stavropol Region, overlying the deposits with abundant ostracodes (Ter-Grigoryants, 1964). In the section of the Belaya River, deposits with *T. concentricus* also lie above beds with ostracodes *Disopontocypris oligocenica*, which allows their correlation with biostratigraphic units of the Stavropol Region.

The **Batalpashinsk Formation** is represented by non-calcareous clay without remains of foraminifers. The latter are found in only one calcareous interbed (Fig. 4, Sample BA256), which contains rare *Ammodiscus aff. perlucidus* Andreae and *Cibicides* sp.

The **Septarian + Zelenchuk Formation** is mostly represented by non-calcareous clay lacking foraminifers. Only the presently covered sandstones of Lysaya Hill (Sample 9/07 of N.Yu. Filippova) contained sponge spicules, radiolarians, and small tests of foraminifers *Spiroplectamina aff. terekensis* Bogd., *Trochamina depressa* Subb., *Baggina* sp., *Cibicides aff. pseudoungerianus* Cushman, *C. almaensis* Samoilova, *Caucasina aff. buliminoides* Bogd., *Globigerina praebulloides* Leroyi, Blow et Bannet, *G. yeguaensis yeguaensis* Winz., *Globorotalia* sp., and *Guembelina gracillima* (Andreae). This assemblage suggests an environment of the outer shelf of a normally saline marine basin. This assemblage is of Oligocene–Lower Miocene (middle–upper Maikop).

Clay deposits in the lower reaches of the Fyuntv River contain carbonate interbeds with microfauna. Dmitrieva et al. (1959) characterize these interbeds as Alkunanian and trace them to Eastern Ciscaucasia. This is a stable, accepted regional marker level, the age of which is indicated by nannoplankton and dinocysts as Early Miocene (Filippova et al., 2010, 2015). We stud-

ied samples from this outcrop collected by N.Yu. Filippova (in 2004) and T.N. Pinchuk (in 2016). This locality contained a foraminiferal assemblage of a relatively deep-water normally saline basin with calcareous benthic taxa: cf. *Lenticulina*, *Caucasina schischinskajae* (Sam.), *C. aff. magna* Bugrova, *C. aff. buliminoides* Bogd., *Buliminella aff. pulcha* Subb., *Virgulinea* ex gr. *pertusa* (Reuss), *Uvigerinella aff. hybridica* Subb., *U. californica* Cushman, *Bolivina aenariensisiformis* Mjatl., *B. carnata complanata* Subb., *B. mississippiensis* Cush., *B. aff. goudkoffi caucasica* Bogd., *B. dilatata* Reuss, *Asterigerina* sp., and *A. aff. bracteata* Cush. Plankton is represented by *Globigerina aff. bulloides* (Orb.), *G. aff. officinalis* Subb., etc.

In his early papers, Bogdanovich (1960) noted that the co-occurring species *Uvigerinella* ex gr. *californica* and *Spiroplectamina carinata* are index species of the second zone in the foraminiferal biostratigraphic scheme of the Maikop Group of the Kuban Lowland, Stavropol Region, and Trans-Terek Plain and assigned them to the Oligocene. The species *Uvigerinella californica* Cushm. was described as a characteristic species of the foraminiferal assemblage of the Kalmyk Formation of the Chattian Stage of the Volga-Don region (Kurgalimova in Voronina et al., 1988). However, in the section on the Fyuntv River, these taxa are found alongside nannoplankton of the NP25–NN1 zones and Miocene dinocyst species (Beluzhenko et al., 2014). Occurrences of index species *Bolivina goudkoffi caucasica* and *Uvigerinella californica*, characteristic of the Caucasus Regional Stage (Bogdanovich, 1965), in Bogdanovich's opinion, indicated the beginning of the Neogene and the transgressive depositional stage in a normally saline marine basin.

Mollusks

Mollusks are rare in the deep-water Maikop sections of Ciscaucasia. They are associated with short-term stages of restoration of the gas regime, favorable for large benthic fauna. Mollusks (*Propeamussium fallax*, *Nucula* sp., nautiloids *Aturia ziczac*) are found at the top of the Belaya Gлина Formation together with remains of echinoids and imprints of bryozoans. This benthic assemblage is found far beyond Ciscaucasia: in Crimea, in the Southern Aral Region, and in Kyzylkum (Korobkov, 1939; Merklin, 1974; Popov et al., 1993).

The lower part of the Pshekha Formation (Beds 2–4) is characterized by planktonic pteropods of the genus *Limacina* (= *Planorbella*, *Spiratella*). These mollusks were very widely distributed in the outer shelf of Paratethys at the base of the Oligocene—from the Central Carpathian Paleogene basin of Hungary to Transcaucasia and the Pre-Kopetdag Depression. Baldi (1986) suggested that such a wide distribution of these mollusks was connected with Boreal influence, i.e., the influx of North Sea waters. However, modern species

of *Limacina* are more widely distributed in warm-water basins, where they are buried at moderate depths in non-bioturbated sediment (Berger, 1978). Apparently, it would be more correct to explain the occurrence of pteropod facies at the base of Oligocene by the favorable conditions of their burial: moderate depth prevented their dissolution, whereas a constrained gas regime limited the existence of benthic fauna.

In Bed 3, interbeds with *Limacina* alternate with somewhat bioturbated beds with burials in the living position of the bivalves *Pterolucina batalpaschinica* (Korob.), *Yoldiella chadumica* (Korob.), and *Thyasira nysti* (Phil.); there are occurrences of the gastropod *Aporrhais speciosa* Sch. and scaphopod *Dentalium (Antalis) acutum parvum* (Gonch.) (identified by I.A. Gontsharova), which is a typical member of the assemblage of the basal Oligocene, also traceable very widely from the Crimea, Volga-Don Interfluve, and Georgia to Mangyshlak and the Pre-Kopetdag Depression, and characteristic of the outer shelf (Korobkov, 1937, 1939; Merklin and Gontsharova, 1967; Popov et al., 1993). Up the section, in Bed 4, benthic mollusks disappear, but *Limacina* continues to be present. The disappearance of large benthos, including mollusks, was directly connected with reinstatement of an unfavorable gas regime, indicated by results of geochemical studies (Sachsenhofer et al., 2017) and study of dinocysts (Zaporozhets and Akhmetiev, 2017). Up the section (Bed 5), *Limacina* also disappears, which could have been caused by continuous deepening of the basin. In modern basins, the depth of aragonitic compensation where pteropods are completely dissolved varies considerably, reaching 1.5 km in low latitudes. In the Aegean Sea, which in its climatic and bathymetric characteristics could have been near the conditions of the early Maikop basin, samples from depths of 500–800 m contained pteropods, whereas at greater depths and in sapropel, their abundance sharply decreased (Aksu et al., 1995). This suggests that the depth of the Maikop Basin in the Adygea Region by the mid-Pshekha time could have been close to critical values and later reached 1 km. Similar estimates are obtained using seismic profile methods (Antipov and Kurina in Popov et al., 2010) and ichthyological studies.

Rare imprints of benthic mollusks were found in the bed of Polba marl. These imprints are only identifiable to genus: *Janschinella*, *Lenticorbula*, and cardiid costae. Despite their poor state of preservation, they clearly belong to the brackish-water endemic association characteristic of the lower Solenovian Regional Substage. A more diverse assemblage was collected on the Fars River, right tributary of the Belaya River, in dark carbonate clay. These beds contain *Urbnisia lata*, *Janshinella vinogradski*, *Korobkoviella* sp., and *Cerastoderma* cf. *chersonense*. This is a typical early Solenovian association.

Up the section, mollusks are absent in the Maikop deposits and appear only in the beds immediately overlying the Maikop group.

Ichthyofauna

In the Belaya Glina Formation, the ichthyofauna is represented by rare full skeletal remains and large scales of *Lyrolepis caucasica* and also by accumulation of small bones and scales of other bony fishes. The rarity of the full skeletal remains suggests unfavorable conditions for burial of bony fishes in the Priabonian basin owing to intensive bioturbation.

Pshekha Formation. The Pshekha Formation is generally widely characterized by a diverse fauna of marine fishes, sharply dominated by bony fishes (more than 70 species; Bannikov, 2010 and this paper), with rare skeletal imprints and isolated teeth of sharks *Carcharias acutissima*, *C. cuspidata*, *Alopias* cf. *exigua*, *Echinorhinus* sp., *Isurolamna (Lethenia) vandenbroeckani*, and *Physogaleus latus* (identified by T.P. Malyskina); the assemblage also contains gill rakers of the whale shark *Keasius parvus*.

The Pre-Planorbella Bed (Bed 1) contains pelagic taxa: Clupeidae and fragments of Thunnini.

The lower part of the Pshekha Formation (Planorbella Bed according to Danilchenko, 1960; Beds 2–4 in this paper) characteristically contains numerous “*Sardinella*” *rata*, *Anenchelum angustum*, *Palimphytes chadumicus*, *Auxides cernegurae*, *Protobrotula sobijevi*, *Eophycis pshekhiensis*, and *Palaeogadus* (five species); pelagic *Pomolobus curtus*, *Palaeorhynchus zitteli*, *Homorhynchus colei*, *Pavlovichthys mariae*, and *Oligobalistes robustus*; pelagic hatchings of *Caprovesposus parvus*; and coastal *Doryrhamphus squalidus*, *Pshekhagnathus polypterus*, *Oliganodon comparabilis*, *Priacanthus spinosus*, *Caranx daniltshenkoi*, and *Champsonodon grossheimi*.

Less common bathypelagic taxa lacking photophores (*Proargentina inclinata*, *Glossanodon confusus*, and *Gephyroberix robustus*) are sporadically found in the overlying beds (Beds 3–4 of the Planorbella level).

With the disappearance of pteropods (Bed 5 of the Pshekha Formation; the Amphisytle Bed according to Danilchenko, 1960) in the second half of the Pshekha time, assemblages of coastal marine and pelagic fishes were replaced by subtropical ones as a result of a warming episode. At the same time, the deepening of the Paratethys in the area of the Caucasus resulted in the development of diverse very deep-water fish assemblages (including taxa with luminescent organs, which included the genera *Eovinciquerria*, *Scopeloides*, *Argyropelecus*, and *Eomyctophum*). The abundance of deep-water taxa in the late Pshekha assemblage, which was dominated by Myctophidae, suggests the presence of very deep zones in the basin, probably up to 1000 m. The entire generic range of the deep-water Caucasian

ichthyofauna of the late Pshekha time was also represented in the Carpathian Basin, where the generic diversity of a synchronous deep-water ichthyofauna was twice the Caucasian one. The assemblage under consideration lacks some early Pshekha species; *Aeoliscus heinrichi* (subdominant) appears; and mesopelagic taxa with photophores (*Eovinciquerria obscura*, *Eomyctophum koraense*, and *Scopeloides glarisanus*) are present. The assemblage contains *Sparus priscus*, *Leiognathoides altapinna*, *Rybapina caucasica*, and rare *Bregmaceros filamentosus*, *Doryrhamphus squalidus*, and *Syngnathus incertus*. This assemblage corresponds to the *Aeoliscus* assemblage with warm-water tropical and subtropical taxa (*Bregmaceros*, *Aeoliscus*, and *Fistularia*) (Sytchevskaya in Akhmetiev et al., 1995; Prokofiev, 2005, 2006a, 2006b, 2007; Bannikov, 2010, et al.).

Some fish species in common have been recorded in various regions of the Paratethys at various geochronological intervals. For instance, the Rauenberg locality in the Upper Rhine Graben dated as the NP23 Zone (Maxwell et al., 2016), most distant from the Maikop Basin, is characterized by several species found on the Belaya River in older and younger beds: *Pinichthys pulcher* (NP21), *Aeoliscus heinrichi* and *Leiognathoides altapinna* (NP22), and *Abadzekhia marinae* (NP24). The ichthyofauna of the outer Carpathian basins (Poland, Romania) is not recorded from the basal Oligocene ichthyofauna (NP21 Zone) (Cioabanu, 1977; Kotlarczyk and Jerzmańska, 1988; Sytchevskaya in Akhmetiev et al., 1995; Kotlarczyk et al., 2006), although the earliest of the Carpathian ichthyofaunas (from the bituminous marl of Romania and ichthyofaunal IPM1 Zone of Poland) includes species occurring in the NP21 Zone on the Belaya River.

Morozkina Balka Formation. The lower part of the Lower Morozkina Subformation contains a marine fish assemblage (Sytchevskaya in Popov et al., 2009, p. 69; Sytchevskaya and Prokofiev, 2013; Prokofiev, 2013), indicating the restoration of normal salinity after the early Solenovian salinity decrease. Beds at this stratigraphic level on the right bank of the Belaya River yielded imprints of sharks of the family Charcharinidae: *Physogaleus* cf. *latus* (Storms, 1894); remains of the bony fishes of the families Clupeidae: “*Sardinella*” sp. nov., Osmeridae: *Austromallotus musceli* (Paučá, 1929), Syngnathidae: *Hypposyngnathus* sp., Gadidae: *Palaeogadus simionescui* Daniltschenko, 1950; Repropcidae: *Repropca surcula* Prok.; Priacanthidae: *Pristigenys geminus* Prok.; Caproidae: *Proantigonia radobojana* (Kramberger, 1882); and Scombridae gen. indet. The assemblage is dominated by neritic-pelagic taxa of a moderately warm normally saline marine basin 100 to 600 m deep.

Deposits of the Upper Morozkina Subformation (Bed 10) contain an ichthyofauna with mesopelagic *Palaeogadus latebrosus* and *P. simionescui*; numerous normally marine pelagic Clupeidae, Palaeorhynchi-

dae, *Abadzekhia marinae*, and *Sarda remota*; and coastal Carangidae, *Oliganodon budensis*, *Cooceolus artus*, and Scorpaenidae (Sytchevskaya in Akhmetiev et al., 1995 and this paper).

Batalpashinsk and Septarian + Zelenchuk Formations. In the deposits of these formations, fish occurrences are relatively rare and are mostly represented by incomplete or fragmented specimens. A locality in the lower reaches of the Fyuntv River yielded *Aeoliscus* sp., *Holosteus* sp., *Repropca* sp., *Capros longispinatus*, and *Pseudotetrapturus luteus*.

PALEOMAGNETIC STUDY OF THE SECTION

The paleomagnetic study of the Belaya River section was conducted during the fieldwork in 2015, in collaboration with colleagues from the Paleomagnetic Laboratory of Utrecht University, Netherlands. Samples were collected with an interval of 0.4–0.8 m; the cases where the interval exceeded 2 m are shown in Fig. 1 as discontinuities in the outcrop. The sampling method and preparation of samples for the analysis is described by van der Boon et al. (2017). For the Maikop part of the section, about 400 samples were analyzed from the Pshekha Formation, Polbian Bed, and Morozkina Balka Formation. Up the section, samples were collected during the fieldwork of 2016–2017, but these results have not been completed.

Changes in the polarity in the section are shown in Fig. 1. The lower ~20 m of the Pshekha Formation mainly show normal polarity, and up the section, reversed polarity becomes dominant up to the Polbian Bed. In this interval, radiometric argon dating of 33.20 ± 0.34 Ma was obtained from a tuffite interbed (Fig. 1).

The Polbian Bed (61 m above the base of the Maikop deposits) is characterized by normal polarity.

The following brief intervals of normal polarity were recorded in the lower part of the Lower Morozkina Subformation (62–64 and 68–70 m), an interval of alternating polarity was recorded in its middle part (75–80 m), and an interval of reversed polarity was recorded in its upper part (87–97 m). The Upper Morozkina Subformation, except for its uppermost part for which no data have yet been obtained (97–135 m), has mostly normal polarity, except for the interval 108–113 m, part of which is in a covered interval.

The interpretation of these data is discussed the next section.

CHANGES IN BIOTIC ASSEMBLAGES, FACIES, AND PALEOMAGNETISM OF THE SECTION AND THEIR POTENTIAL USE FOR CORRELATION AND RESTORATION OF DEPOSITIONAL SETTINGS

Despite an extreme impoverishment of the malacofauna in deep water facies of the Ciscaucasian Oli-

Age, Ma	Series		Paleomagnetic chrons	Planktonic foraminifers	Calcareous nanoplankton	Dinocysts	Biotic data from the Belaya River			Paleomagnetic chrons	Ciscaucasian formations
							Calcareous nanno- plankton	Dinocysts	Foraminifers, ostracodes		
25	Aquitanian 23.03	C6B	N4	NN1	CN1	D16b	NP25–NN1	Labyrinthinium truncatum	Bolivina goudkoffi	C6B	Karadzhalga
	C7A	P21	NP24	D15c	NP24	Rhombodinium draco	Cyclamma turosa Virgulinea	C9	Batalpashinsk		
										C6B	P20
	C9	P19	CP19	D15a	NP22	W. symmetrica	Disoponocypris oligocaenica	C11	Lower Morozkina Subformation		
										C10	P18
	C11	P17	NP21	D14a	NP19–20	Charlesdownia clathrata angulosa/ Rh. perforatum D12	Brotzenella taurica, Bolivina antegressa	C12n	Pshekha		
										C12	P16/
	C13	P15	NP19–20	D12c	NP21	P. amoenum D13	Asterigerigerina lucida Globigerina officinalis	C13n	Pshekha		
										C15	P15
C16	P15	NP19–20	D12b	NP19–20	Charlesdownia clathrata angulosa/ Rh. perforatum D12	Brotzenella taurica, Bolivina antegressa	C13n	Pshekha			

Fig. 5. Correlation of the zonal division of the Belaya River section with the International Scale (after Gradstein et al., 2012; *International...*, 2017) using nanoplankton, dinocysts, and paleomagnetic data.

gocene, this was the group from which the faunistic dating of the Maikop deposits began in the 1930s (Korobkov, 1937, 1939; Liverovskaya, 1938). Using mollusks, I.A. Korobkov determined the position of the “Lower/Middle Oligocene boundary” interpreted as the Latdorfian–Rupelian boundary: between molluscan assemblages with *Propeamussium fallax* and association with *Pterolucina batalpashinica*. Later, the same position of the boundary (but interpreted as the Priabonian–Rupelian boundary or the Eocene–Oligocene boundary) was supported by planktonic groups (planktonic foraminifers and nanoplankton) (Krashennikov and Muzylev, 1975; Krhovsky et al., 1995; Muzylev, 1980) and later by dinocysts (Akhmetiev et al., 1995; Andreeva-Grigorieva, 1980; Zaporozhets, 1999; Zaporozhets and Akhmetiev, 2017).

In the uppermost part of the Belaya Glina Formation and at the base of the Pshekha Formation, Beds

with *Clausicoccus subdistichus* are important for correlation (Fig. 5); a sharp increase in abundance of the index species in these beds is within the Eocene–Oligocene boundary beds, within the NP21 Zone or CP16 Zone (Gradstein et al., 2012). Therefore, despite the presence of occasional specimens of *Discoaster barbadiensis* and *D. saipanensis*, the disappearance of which determines the upper boundary of the NP20 Zone (or CP15 *Discoaster barbadiensis*), we assign the upper part of the Belaya Glina Formation to Zone NP21 or CP16, considering the mass redeposition of microbiota at this level (Zaporozhets, 1999). The paleomagnetic data (normal polarity in the deposits from the very base of the Maikop Group) suggest the possible position of the Eocene–Oligocene boundary in the uppermost horizons of the Belaya Glina Formation, because in the international scale it is drawn within the reversed Chron C13r (Berggren et al., 1995; *International...*, 2017).

Pshekha Formation. The assignment of the lower part of the Pshekha Formation to the nannoplankton NP21 (CP16) Zone and to the Phthanoperidinium amoenum (D13) Zone by dinocysts and the presence of a large zone of normal polarity characterizing the lower third of the Pshekha Formation and interpreted as Chron C13r allow this formation to be confidently dated to the beginning of the Rupelian (Fig. 5). A change in lithology from light-colored marly bioturbated facies to dark laminated weakly carbonate clay with abundant pyrite, the change in the molluscan assemblage of the Beds with *Propeamusium fallax* to the assemblage with *Pterolucina batalpaschinica*, and the appearance of assemblages of benthic foraminifers with *Asterigerina lucida* and *Haplophragmoides fidelis* have a regional correlative value for the bathymetric zone of the outer shelf of the entire Paratethys. In addition, Beds with *Limacina* recognized from Hungary to Kopetdag are well traceable in this sea zone.

A number of shared species connect the Rupelian ichthyofaunas of the Caucasus, Carpathians, Switzerland, and the Rhine Basin: *Aeoliscus heinrichi*, *Priacanthus spinosus*, *Leiognathoides altapinna*, and *Capros rhenanus*; *Homorhynchus colei* so far has not been recorded from the Rhine graben. Some other species of genera in common allopatrically replace one another in the Paratethys (Bannikov, 2010). For instance, *Anenichelum glarisianum* is recorded from the Rhine basin, Switzerland, Carpathians, and Abkhazia, whereas *A. angustum* is recorded from the Northern Caucasus and Azerbaijan; *Palaeorhynchus zitteli* is known from the Caucasus and the Carpathians, and *P. glarisianus* is recorded from the Rhine basin, Switzerland, and Slovenia. The genus *Eophycis* is represented in the Rupelian of the Paratethys by three species (*E. pshekhiensis* from the Caucasus, *E. jamnensis* from the Carpathians and *E. froidefontainensis* from the Rhine basin), and *Trachinus* is represented by two species (*T. minutus* from the Carpathians and Rhine basin and *T. rusticus* from Ciscaucasia). The deep zones of the Rhine basin and some of the intra-Carpathian basins were insufficiently deep for the mesopelagic luminescent fishes. In the sufficiently deep areas, *Scopeloides glarisianus* (Switzerland, Carpathians, and Caucasus), *Eovinciguerrria obscura*, *Oligophus moravicus*, and *Eomyctophum koraense* (Carpathians and Caucasus) are recorded. An almost entire generic range of the deep-water Caucasian ichthyofauna is also represented in the Carpathian basin, deep-water ichthyofauna of which was twice as diverse in the number of genera compared to the Caucasian fauna (Prokofiev, 2006, 2007).

Polbian Bed. The accumulation of a carbonate bed corresponding to the beginning of the Solenovian decrease in salinity is the most important marker level for the entire Paratethys. This level, corresponding in the Western and Central Ciscaucasia to the Polbian

Bed and the Lower Morozkina Subformation, can be confidently traced from the foothills of the Alps and Carpathians and intra-Carpathian depressions using endemic brackish-water mollusks, ostracodes, specific composition and morphs of dinocysts of the lower subzone of the Wetzeliella gochtii Zone, and nannoplankton of the NP23 Zone (Popov and Studencka, 2015; Voronina and Popov, 1984; Zaporozhets and Akhmetiev, 2015), across southern Ukraine and the Volga-Don interfluvium, Ciscaucasia, and Transcaucasia to Ustyurt and Kopetdag (Merklin, 1974; Popov et al., 1993).

It is possible to observe on the Belaya River discernible unconformities at the base and top of the Polbian Bed sharply changing in thickness from 0.2 to 0.6 m. In the more complete sections (Kuban River, Keu River), it is known that the Polbian Bed has normal polarity, which is interpreted as the next positive Chron C12n (Bogachkin, 2004), although in the even more complete sections of the Volga-Don interfluvium and Kalmykia, the transition to the Solenov Formation occurs at the top of the previous Chron C12r, whereas interval C12n of normal polarity is determined 25–27 m above (Bogachkin, 2004; Zastrozhnov et al., in press).

Morozkina Balka Formation, lower subformation. These beds contain species of dinocysts indicating a brackish water depositional environment for the lower subzone of the Wetzeliella gochtii Zone (thin-shelled *Hystrichokolpoma*, *Batiacasphaera sphaerica*). However, the middle part of the member is dominated by cysts of taxa inhabiting marine environments: *Lejeunecysta* spp., *Wetzeliella gochtii*, *Selenopemphix nephroides*, and *Operculodinium*. This suggests the influx of marine waters in the basin, which was suggested earlier by E.K. Sytchevskaya (Popov et al., 2009, p. 69). The ichthyofauna of this interval includes sharks of the family Charcharinidae and bony fishes of the families Clupeidae, Osmeridae, Gadidae, Reproptidae, Priacanthidae, Caproidae, Scombridae gen. indet., and coastal Syngnathidae (Sytchevskaya and Prokofiev, 2013). Higher beds are again characterized by dinocysts, which indicate decreased salinity and restoration of brackish-water conditions.

A positive chron in the lower part of the subformation we tentatively correlate with Chron C11n, and the overlying part of the subformation with reversed polarity we correlate with Chron C10r.

Morozkina Balka Formation, upper subformation. The restoration of marine conditions in the Paratethys and the beginning of carbonate sedimentation is the next regional marker event. As in the deposits of the Pshekha Formation, carbonate material accumulated mainly as light-colored pellets on the bedding planes of non-bioturbated sediment. These pellets are composed of nannoplankton and apparently represent feces of planktonic copepods. Such facies were also

widespread in the Oligocene of the Carpathian basin (Ciurej and Pilarz, 2016; Krhovsky's unpublished data). According to nannoplankton data, the upper subformation belongs to the NP24 Zone (Nagymarosy and Voronina, 1993; Tabachnikova's data in this paper), although Krhovsky et al. (1995) correlated the lower part of the subformation with the NP23 Zone. The dinocyst assemblage with *Wetzeliella gochtii*–*Chiropteridium partispinatum* established for this subformation is characteristic of the transitional beds from the Early to Late Oligocene. The ichthyofauna contains marine pelagic Clupeidae, Palaeorhynchidae, Gempylidae, Scombridae. Owing to detailed data on dinocysts and geochemistry, it has become possible to precisely reconstruct changes in the hydrology and gas regime of this basin throughout time (Sachsenhofer et al., 2017; Zaporozhets and Akhmetiev, 2017). The fluctuations in the oceanic water influx during restoration of marine conditions have been documented.

Along with nannoplankton and dinocysts, benthic foraminifers of the families Fursenkoinidae Loeblich et Tappan, 1961 and Virgulinelidae Loeblich et Tappan, 1984 have a significant correlative importance at this level in the Paratethys (Semenov and Stolyarov, 1970). Stolyarov considered “Virgulinelidae Beds” “as second (after the ostracode) marker horizon of the Maikop Group” (Stolyarov, 2001, p. 164). In the section on the Belaya River, virgulinelids become numerous in the upper part of the Upper Morozkina Subformation, where they are represented by three species: *Fursenkoina (Virgulina) schreibersiana* (Czjzek), *Virgulinella ex gr. Pertusa*, and *V. neobuliminiformis* Kuznetzova.

According to the published data, these species are not confined to any certain stratigraphic level. For instance, the species *Fursenkoina (Virgulina) schreibersiana* was recorded in the Upper Khadum of the southwestern regions of the Black Sea Region (Pechenkina, 1964) and Northern Stavropol Region (Ter-Grigoryants, 1964), but at the same time, it is found in the upper part of the Lower Chegan Subformation of the Northern Aral Region (Chernyshev Bay; Bondareva, 1964) currently dated as Barthonian, in the upper part of the Middle Maikop Group (Zeiva Formation of Azerbaijan) (Khalilov and Kuznetsova, 1964), and in the middle part of the Lower Maikop series of the Akhaltsikh Depression in Georgia (Kacharava, 1964). This species was also found in the Lower and Middle Oligocene of the Khiva Depression of the Central Karakum Dome (Balakhmatova, 1964); in the Upper Oligocene of the Salo–Manych interfluvium and Ergenei (Bugrova, 2005); in the Lower Miocene, in Beds with *Bolivina goudkofi caucasica* of the Caucasian Stage; and higher up in the section, in the Olginskaya Formation of Western Ciscaucasia (Bogdanovich, 1965). *Virgulinella ex gr. pertusa* is encountered in the Upper Khadum of Western and Central

Ciscaucasia and also in the upper part of the Batalpashinsk and Abadzekh formations (Ter-Grigoryants, 1964), above the Solenovian level in Mangyshlak (Stolyarov, 2001), in sections of the Salo–Manych interfluvium and Ergenei (Bugrova, 2005; Stolyarov, 2001), and in the Lower Miocene (Sakaraulian) of Abkhazia (Dzhanelidze, 1964). *Virgulinella neobuliminiformis* Kuznetzova is also known from the Lower Miocene deposits of Azerbaijan and Eastern Ciscaucasia (Ter-Grigoryants, 1964).

In the Belaya River Section, *Virgulinella ex gr. pertusa* and *V. neobuliminiformis* are found not only in the upper part of the Upper Morozkina Subformation but also considerably higher in the section, at the level of the Upper Oligocene Septarian + Zelenchuk Formation (Fig. 4). Apparently, these taxa, like *Fursenkoina (Virgulina) schreibersiana*, are not confined to any narrow stratigraphic level, but rather reflect certain conditions in a basin. According to Stolyarov's data, *Virgulinella* occurrences are restricted to anoxic facies, in the zone from a transition from deep-water to shallower water sediments with rich benthos associations and with no indications of anoxia. In deeper water facies, *Virgulinella* assemblages are replaced by purely planktonic ones with *Globigerina* and nannoplankton. According to Krashenninikov (pers. comm.), *Virgulinella* consume sulfate-reducing bacteria and are therefore assigned to the upper boundary of the sulfate reduction zone.

The interval of normal polarity at the base of the Upper Morozkina Subformation with the nannoplankton NP24 Zone is interpreted here as Chron C10n, the overlying interval of the subformation with reversed polarity is interpreted as Chron C9r, and the upper interval of normal polarity also with the nannoplankton NP24 Zone is correlated to Chron C9n.

Batalpashinsk Formation. The overlying deposits of the Batalpashinsk Formation correspond to the time of the maximum Late Oligocene anoxia in the basin also characterizing the entire Paratethys. Therefore benthic fauna is absent here and above this level. The lower third of the formation contains a thin bed of banded marl (0.7 m), also composed of pellets with the nannoplankton NP25 Zone.

The dinocyst assemblages below this marl constantly contain *Deflandrea spinulosa f. majkopica* and *Rhombodinium draco* and also *Wetzeliella*, *Chiropteridium* (*Ch. partispinatum* and *Ch. mespilanum*) and *Batiacasphaera hirsuta* (Zaporozhets and Akhmetiev, 2017). Up the section of the marl, cavate cysts of *Wetzeliella* and *Rhombodinium* completely disappear, whereas the diversity of *Chiropteridium* is reduced (only *Ch. partispinatum* remains). In the zonal scale of the Upper Oligocene, these changes are reflected as a transition from the dinocyst *Chiropteridium mespilanum*–*Ch. partispinatum* Subzone to the *Deflandrea spinulosa f. majkopica* Subzone. The former subzone

encompasses a significant interval of the section of the first half of the Late Oligocene: Bed 11 of the Upper Morozkina Subformation and also Bed 12 of the lower part of the Batalpashinsk Formation. *Ch. mespilanum* dominates in the Upper Morozkina Subformation, and *Ch. partispinatum* dominates in the Batalpashinsk Formation.

The clay sediments of the formation accumulated in a basin with a slightly reduced salinity with a distinctly pronounced anoxia of bottom waters, which is inferred from the mass occurrences of acritarchs and prasinophytes (*Leiosphaeridia*, small *Pterospermella*, and also *Horologinella*), with cyanobacterial accumulations.

Septarian + Zelenchuk Formation. Anoxic conditions were preserved later, when septarian concretions were formed, followed by calcareous nodules. Interbeds of fine-grained sand are characteristic of the Septarian and Zelenchuk formations. This is suggested by the presence of prasinophytes and acritarchs *Pterospermella* sp. and *Leiosphaeridia* in palynoassemblages, but their role was considerably less important.

Up the section, in the main part of the Septarian + Zelenchuk Formation, dinocyst species diversity considerably decreases; the considerable dominance of the amount of spores and pollen over organic-walled phytoplankton indicates a lower coefficient of marine conditions (less than 5%) and suggests the formation of sediments in the high-energy environment in a normally marine basin (Zaporozhets and Akhmetiev, 2017). Apparently, the impoverishment of marine phytoplankton resulted from a considerable influx of fresh water of the Laba paleodelta. This is indicated by the composition of palynomorphs including redeposited taxa not only from Paleogene but also from Mesozoic series.

Importantly, this formation contains occasional representatives of *Labyrinthodinium truncatum*, zonal species of the basal Miocene, together with *Rhombodinium*, *Chiropteridium*, and *Thalassiphora*. Representatives of these genera hardly continue to the Miocene; therefore, we date this formation, probably except for the terminal beds, as Late Oligocene.

Carbonate nodules and host clay in the upper part of the Formation sometimes contain the nannoplankton NP25 Zone and the top horizons of the NP25–NN1 Zone, according to J. Krhovsky (Fig. 5).

Up the section, there is a transition to anoxic “fish facies” of the Karadzhalga Formation, which has an important correlative potential and is traced, apart from Ciscaucasia, in Mangyshlak and depressions of Ustyurt (Semenov and Stolyarov, 1970; Stolyarov and Ivleva, 2004).

CONCLUSIONS

(1) The lithological transition from the light marl of the Belaya Glina Formation to the dark clay of the

Pshekha Formation at the base of the Maikop Group coincides with a replacement of the assemblage of the dinocyst *Charlesdownia clathrata angulosa* Zone (D12), characteristic of the Priabonian, by the assemblage of the *Phthanoperidinium amoenum* Zone (D13) of the lower Rupelian, and also with a change in the assemblage of mollusks of Beds with *Propeamussium fallax* by the assemblage with *Pterolucina batalpaschinnica*. However, according to the paleomagnetic data, the interval of normal polarity (Chron C13n) begins from the very base of the Pshekha Formation. The Eocene–Oligocene boundary is probably in the upper part of the Belaya Glina Formation, since in the international scale it is drawn within the previous Chron C13r.

(2) A replacement of a diverse planktonic foraminiferal assemblage with *Turborotalia centralis* and *Globigerinatheka tropicalis* by an impoverished association with *Globigerina officinalis* and small tests characteristic of the Oligocene occurs at the upper part of the Belaya Glina Formation, in Beds with *Propeamussium fallax*. These beds are overlain by beds with a sudden increase in *Clausicoccus subdistichus* in the NP21 Zone, characteristic of the Eocene–Oligocene boundary.

(3) The Pshekha Formation corresponds to the nannoplankton NP21 Zone, dinocyst *Phthanoperidinium amoenum* (D13) Zone in its lower part and nannoplankton NP22 Zone, dinocyst *Wetzeliella symmetrica* Zone and *Wetzeliella gochtii* Zone in the middle terminal parts, and also several assemblages of ichthyofauna and paleomagnetic Chrons C13n and C12r (Fig. 5). The disappearance of first benthic mollusks and later planktonic mollusks and the abundance of deep-water luminescent taxa in the late Pshekha ichthyofauna suggest a considerable deepening (up to about 1000 m).

(4) The Polba marl, containing brackish-water Early Solenovian mollusks, ostracodes of the *Disopontocipris oligocaenica* association, nannoplankton of the NP23 Zone, dinocysts of the *Wetzeliella gochtii* Zone, and incomplete fish remains, overlies the Pshekha Formation with a gap and unconformity overlain by the Morozkina Balka Formation.

(5) The lower subformation of the Morozkina Balka Formation contains foraminifers, marine fishes, and dinocysts of the *Wetzeliella gochtii* Zone, indicating a considerably changing hydrology of the basin from brackish water to normal marine. Chrons C11n and C10r are recognized by paleomagnetic data.

(6) The upper carbonate subformation of the Morozkina Balka Formation at the base shows a fluctuating character of marine water influx during episodes of salinity restoration, contains nannoplankton of the NP24 Zone, dinocysts of the *Chiropteridium partispinatum* Zone, *Rhombodinium draco* Subzone, and is dated by paleomagnetic Chrons C10n, C9r and C9n (Fig. 5).

(7) The Batalpashinsk Formation corresponds to the episode of the maximum anoxia in the Late Oligocene and corresponds to the dinocyst *Chiropteridium partispinatum* Zone, *Rhombodinium draco* Subzone in the lower part and *Deflandrea spinulosa* (non typical) Subzone above the interbed of laminated marl of the nannoplankton NP25 Zone.

(8) The undivided Septarian + Zelenchuk Formation is composed of clay with concretions, septarian in the lower part, and in places subdominant sands. The carbonate interbeds of the upper part of the formation contain nannoplankton of the NP25 Zone and dinocysts of the *Deflandrea spinulosa* Subzone, and the top part of the formation contains nannoplankton of the NP25–NN1 Zone.

(9) The basal part of the overlying clayish-silty non-carbonate Karadzhalga Formation, composed mainly of “fish lithofacies” characteristic of anoxic conditions, contains dinocysts of the Lower Miocene *Labyrinthodinium truncatum* Zone.

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