

# To the Problem of the Oligocene–Miocene Boundary Position in the Northern Caucasus (in Support of the Caucasian Regional Stage)

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**Abstract**—Stratigraphic position of the Oligocene–Miocene (Paleogene–Neogene) boundary in the northern Caucasus and, in this connection, of the Alkun Formation and the Caucasian regional stage in geological sections of Maikop deposits, primarily in those of the Belaya and Kuban rivers, is considered. Arguments in support of the Caucasian regional stage are presented and necessity of distinguishing the Karadzhalganian regional stage is called in question. Stratigraphic implications of the Alkun Formation, the regional reference horizon traceable in many sections of the northern Caucasus, are discussed. It is substantiated based on nannoplankton, dinocysts, foraminifers, and distinctive lithological features of deposits that the Oligocene–Miocene boundary is confined to the Alkun Formation at the Belaya River.

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*Key words:* Oligocene–Miocene boundary, Caucasian regional stage, Maikop deposits, Alkun Formation, northern Caucasus, nannoplankton, dinocysts, foraminifers.

## INTRODUCTION

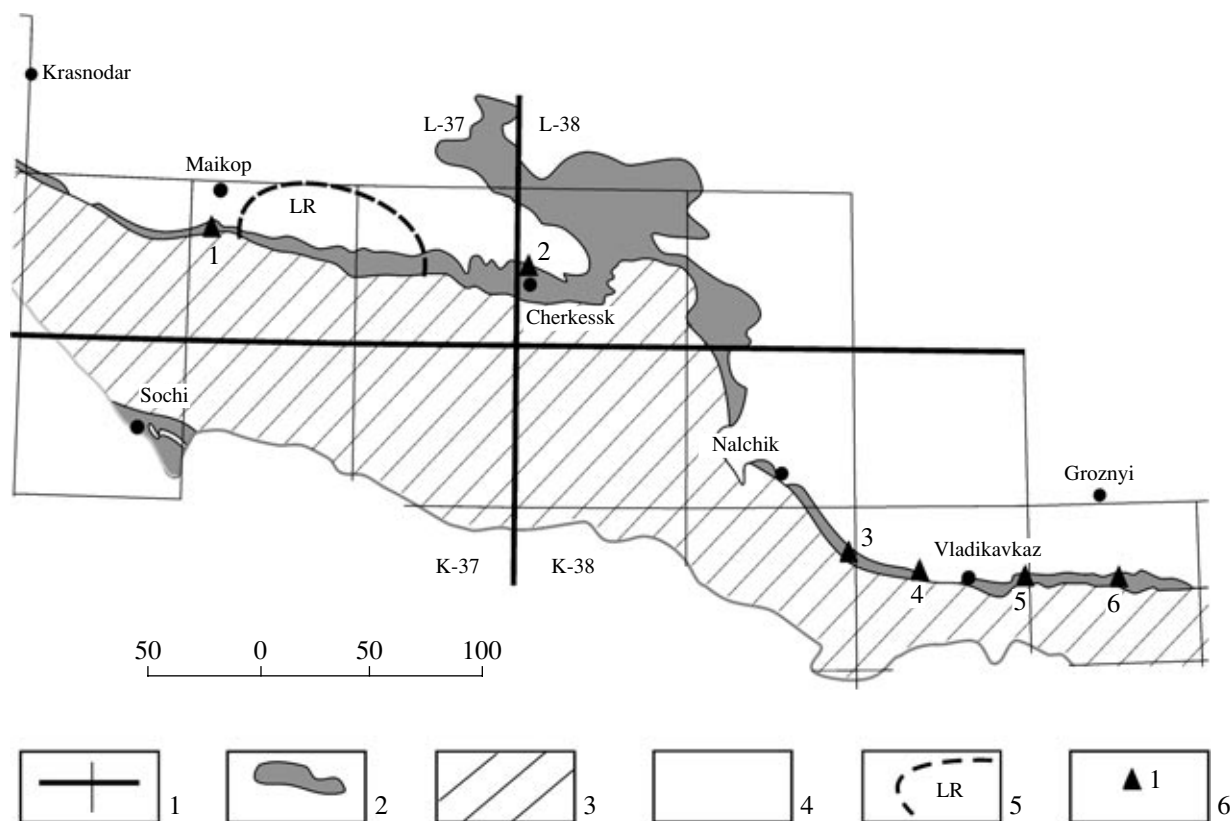
Establishing the boundary between the Paleogene and Neogene always was one of the most complex and ambiguously solvable problems of Cenozoic stratigraphy in the northern Caucasus. The boundary position changed repeatedly with time (*Stratigraphy of the USSR...*, 1975; 1986). In recent years, positioning of this boundary in sections of the Northern Caucasus has become more definite owing to study of the organic-walled phytoplankton (dinocysts) first of all (Akhmetiev et al., 1995; Zaporozhets, 1998; Akhmetiev and Ben'yamovski, 2003; Nevesskaya et al., 2003, 2004).

In the explanatory note to the “Unified Regional Stratigraphic Scheme of Neogene Deposits in Southern Regions of the European Russia,” which is approved by the Bureau of the Interdepartmental Stratigraphic Committee (ISC) of Russia, April 12, 2002, the Caucasian regional stage (horizon) corresponds to the basal Miocene, and the Alkun Formation is placed at the base of this regional stage (Nevesskaya et al., 2003, 2004). On the other hand, the lower part of the Caucasian regional stage may belong to the Oligocene as is assumed in the Explanatory Note. In the “Regional Stratigraphic Scheme of Paleogene Deposits of the Scythian Plate and the Russian Sector of the Greater Caucasus,” which was approved by the Russian ISC Bureau in 2000 (Akhmetiev and Beniamovski, 2003), the Batalpashinsk Formation or its equivalents under-

lying the Alkun Formation are distinguished in the upper part of the Oligocene. Thus, in both approved schemes, the Oligocene–Miocene boundary is placed, though conditionally, at the base of the Alkun Formation or its analogs known in the northern Caucasus.

In the explanatory note (Nevesskaya et al., 2004), there is a separate opinion of Moscow geologists, the well-known specialists on stratigraphy of the Oligocene–Lower Miocene deposits (M.A. Akhmetiev, N.I. Zaporozhets, S.V. Popov, A.S. Stolyarov). They call in question the affiliation of deposits of the Caucasian regional stage in the stratotype section at the Kuban River (and in a series of other sections) with the Miocene and argue for the necessity of replacing the Caucasian regional stage by the Karadzhalganian one. In their opinion, “...the Caucasian regional stage in its range suggested by the authors ...does not correspond to any appreciable stage in the evolution of the Eastern Paratethys: its analogs are difficult to distinguish and trace even within the stratotype area of Ciscaucasia. Moreover, it was distinguished as an analog of the Aquitanian, although arguments in favor of such an inference are extremely weak. Further studies show that its lower part, at least, is of the Oligocene age” (Nevesskaya et al., 2004, pp. 67–68).

The proposal of distinguishing the Karadzhalganian Horizon (regional stage) was first put forward in an earlier work (Popov et al., 1993) by authors of the special



**Fig. 1.** Distribution area of Oligocene–Lower Miocene (Maikop) deposits in the northern Ciscaucasia: (1) boundaries of geological map sheets, Caucasus series, scale 1 : 200 000 (thin lines) and 1 : 1 000 000 (thick lines; L-37, L-38, K-37, K-38, sheet nomenclature); (2) Oligocene–Lower Miocene (Maikop) deposits exposed, (3) area barren of these deposits, (4) areas of the deposits overlain by younger sediments; (5) boundaries of the Laba Region; (6) sites of the Alkun Formation sections studied at the Belaya R. (1), Kuban R. (2), Uruk R. (3), Fiagdon R. (4), Assa R. (Alkun R.) (5), and Argun R. (6).

opinion. In that work, they refer a lower part of the Caucasian regional stage (the Alkun and Zelenchuk formations) to the Oligocene (the Kalmykian regional stage) and consider the Karadzhalga Formation only as belonging to the Miocene in the rank of separate regional stage. As Neveeskaya et al. (2003, p. 6) have rightly noted, “a denial of the Caucasian regional stage by authors of the Kalmykian and Karadzhalgian regional stages in the mentioned work is not substantiated, and even the name Caucasian regional stage is even not mentioned. This seems strange and not quite correct especially because the Egerian regional stage of the Western Paratethys correlated with the Caucasian regional stage is of the same debatable position: its basal interval belongs to the Upper Oligocene, whereas the upper parts, to the Lower Miocene...”

Criticism of the Caucasian regional stage is based on theses expounded in the special opinion (Neveeskaya et al., 2004, pp. 67–68). Since our arguments in the stage support have not been included in that note, we adduce them in this work, substantiating our concept by the facts available, analyzing and criticizing arguments of our opponents.

#### CAUCASIAN REGIONAL STAGE (ARGUMENTS IN SUPPORT)

The Caucasian regional stage was discriminated by A.K. Bogdanovich, M.V. Muratov, M.F. Nosovskii, and L.S. Ter-Grigoryan (Neveeskaya et al., 1975). The stratotype section of the regional stage was described by M.F. Nosovskii and A.K. Bogdanovich at the Kuban River downstream of Cherkessk (Fig. 1), where the Alkun Formation, the Zelenchuk Formation with septarian beds at the base, and the lower half of the Karadzhalga Formation were included into the stage. The formations composed mainly of noncalcareous clays correspond to the middle part of the Maikop Group. The reference section of the regional stage is that of shallower-water deposits penetrated by Borehole Novopokrovskaya-4 in the northern slope of the Stavropol arch (Nosovskii and Bogdanovich, 1980). Some claims to the Caucasian regional stage advanced in the special opinion are hard to dispute. In particular, it is difficult to trace the stage upper boundary in real sections. On the other hand, the same is typical of other regional stages (Sakaraulian and Kotsakhurian) of the middle Miocene. It is also difficult to trace these regional stages in sections of the northern Caucasus and

Ciscaucasia because of rare microfauna (foraminifers), inadequate study of nannoplankton and organic-walled phytoplankton, and almost total lack of macrofauna finds. The same statement would be correct, even to a greater extent, with respect to the Karadzhalgian regional stage proposed.

Authors of the special opinion distinguished the Karadzhalgian regional stage based on a horizon described by Prokopov (1937b) who named it first the Clay–Siderite Horizon and attributed later on to the Karadzhalga Formation. He described the horizon stratotype section along the Kuban River downstream of Cherkessk and named the formation after the Karadzhalga River, a left tributary of the Kuban River. It should be noted also that Prokopov did not imply a regional significance to that horizon. Moreover, distinguishing horizons in the Kuban and Malyi Zelenchuk river valleys he surmised that "...characteristics of individual horizons, their properties, thickness and rocks, they are composed of, may surely change along the strike, and we will undoubtedly observe these during further studies" (Prokopov, 1937b, p. 19). All the horizons he had distinguished were regarded later as local units or formations distinguishable in a particular region—the central Ciscaucasia (*Stratigraphy of the USSR...*, 1986). The Karadzhalga Formation can hardly be distinguished in terms of lithology from the overlying Ol'ginskaya Formation (the same noncalcareous clays without siderite concretions). This distinction is often lacking in sections of neighboring regions. Buryak (1965, p. 352) also pointed to this aspect: "Lithological evidence, the basis for distinguishing individual formations in the upper Maikop succession, is very indistinct and not persistent throughout the area." The Karadzhalga Formation is poorly characterized by fauna in the stratotype section of the Kuban River. Only a depleted foraminiferal assemblage was found there (Buryak, 1965). As authors of the special opinion reported, dinocysts, "...the only group promising for this section and interval..." remain to be studied at the Kuban River (Neveeskaya, 2004, p. 67). Hence, the Karadzhalgian regional stage, which is proposed in the special opinion to be at the base of the Neogene in the northern Caucasus, has no characteristic lithological or faunal features and distinct boundaries in the stratotype region (the Kuban River basin).

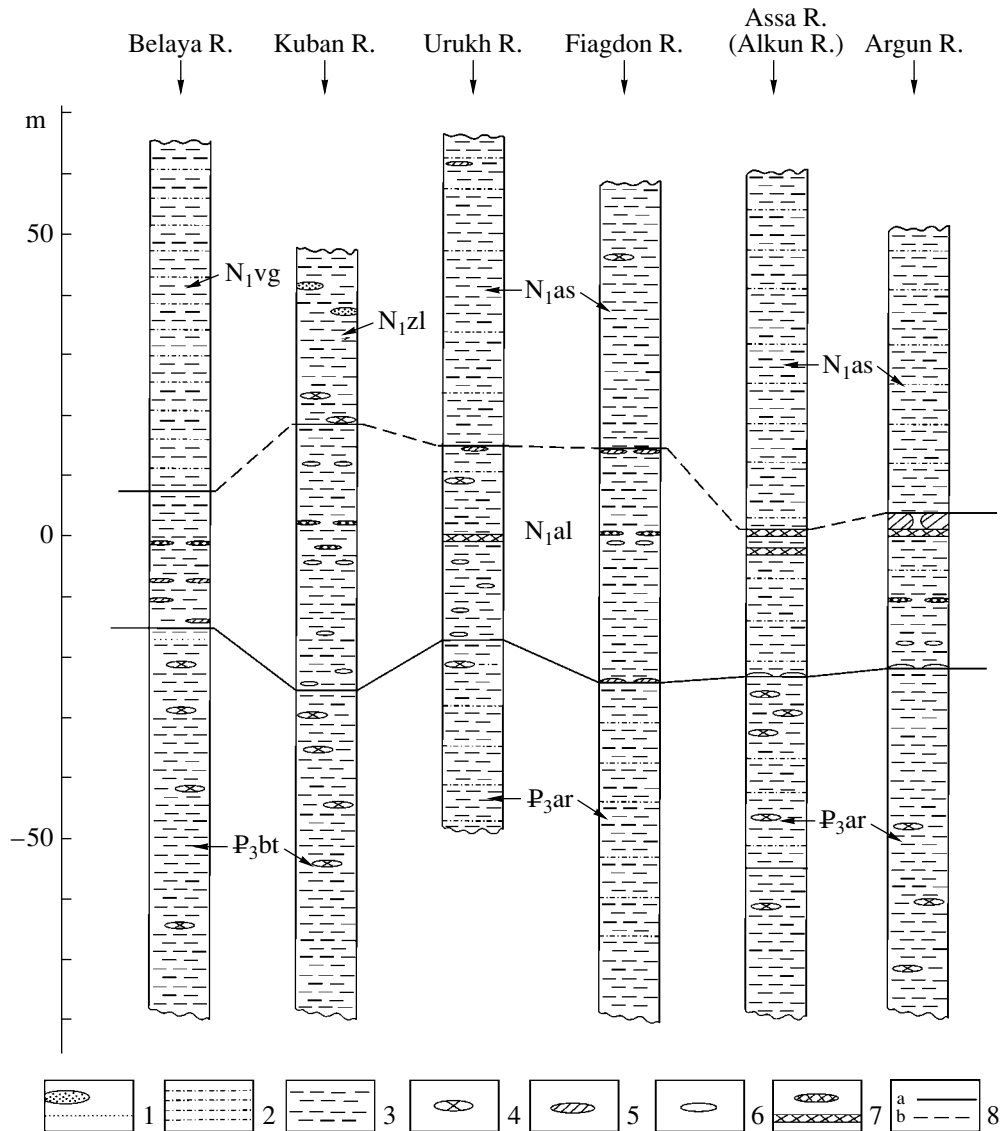
At the base of the Caucasian regional stage, there is a regional reference horizon, reliable and well characterized in terms of lithology and fauna. This is the Alkun Formation traceable in many sections of Maikop deposits of the northern Caucasus for hundreds kilometers from the Belaya River in the west to the Argun River in the east (Figs. 1, 2). Moreover, it is traced easterly at the Sulak River (Dmitrieva et al., 1959). In the west near Anapa, it is correlated with coeval clay strata (Neveeskaya et al., 2004). The stratotype section of the Alkun Formation (formerly horizon) was described by Prokopov at the Alkun River, a left tributary of the Assa River (Prokopov, 1937a). Stratigraphic significance of

the Alkun Formation (horizon) is considered in detail by Caucasian geologists (Dmitrieva et al., 1959), and we reproduce here Fig. 2 from their work with necessary additions. The Alkun Formation is represented in all the sections by intercalated noncalcareous and calcareous clays containing flat concretions of marls and dolomitic limestones (up to 0.3 m thick), the latter with impressions of brown algae *Cystoseira* (Dmitrieva et al., 1959). Subsequent works confirmed presence of the Alkun Horizon (Formation) in many sections of western and central Ciscaucasia, which is therefore a reliable regional datum in Maikop deposits (Buryak, 1965; Nosovskii and Bogdanovich, 1980; *Stratigraphy of the USSR...*, 1975, 1986). One of these sections of the Maikop deposits is that exposed at the Belaya River (Figs. 2, 3).

#### SECTION OF THE MAIKOP DEPOSITS AT THE BELAYA RIVER

The international geological excursion to Maikop deposits was carried out in the Belaya River valley in 1995 (Akhmetiev et al., 1995). The composite section adduced in the excursion guidebook was based on materials of A.S. Stolyarov who investigated the region in the 1970s (Zaporozhets, 1998). Unfortunately, authors of the guidebook (Akhmetiev et al., 1995) missed from consideration some published works on stratigraphy of Maikop deposits in this region (Korotkov, 1936; Dmitrieva, 1959; *Stratigraphy of the USSR...*, 1975; Bogdanovich and Buryak, 1986) and materials of geological survey, scale 1 : 50000, carried out in the region by the Central Geological Expedition (Essentuki) in 1980–1984 (data of 1984 by E.I. Kovalenko, Yu.V. Mel'nikov, and their colleagues). That is why our interpretation of the Maikop section (above the Khadum Formation) at the Belaya River, which is based on works of Caucasian geologists and our field observations, does not coincide in many aspects with that adduced in the excursion guidebook (Akhmetiev et al., 1995) and in work by Zaporozhets (1998).

First of all, we disagree with our opponents that the Neogene part of the Maikop section at the Belaya River is divided into the Septarian, Zelenchuk, Karadzhalga, Ol'ginskaya, and Ritsa formations, i.e., into local stratigraphic units of the Central Ciscaucasian zone, which correspond to formations (horizons) discriminated by Prokopov (1937b) in stratotype sections at the Kuban River. As early as in the mid-20th century, S.T. Korotkov and V.A. Grossgeim distinguished the Abadzekhs-kaya, Alkun, Voskovaya, and "Clay–Siderite" formations at the Belaya River (*Stratigraphy of the USSR...*, 1975; Bogdanovich and Buryak, 1986). Later it was established that the Abadzekhs-kaya Formation, the stratotype section of which was described at the Belaya River near the eponymous village, is in lithology and stratigraphic range an analog of the Batalpashinsk Formation that is therefore shown in the stratigraphic scheme of the region (Neveeskaya et al., 2004). Hence,



**Fig. 2.** Correlation scheme of the Alkun Formation sections in the Northern Caucasus (after Dmitrieva et al., 1959; with modifications): (1) sand lenses and interlayers; (2) silt; (3) clay; (4) septarian, (5) marly, and (6) siderite concretions; (7) lenses and beds of dolomitic limestone; (8) boundaries of the Alkun Formation lower (a) and upper (b). Geological indices of formations: ( $P_3$ bt) Batalpashinsk; ( $P_3$ ar) Argun; ( $N_1$ vg) Voskovaya; ( $N_1$ zl) Zelenchuk; ( $N_1$ as) Assa.

the Batalpashinsk Formation is traceable from the central Ciscaucasia (Kuban River). The Khadum and Alkun formations in sections of the western Caucasus are traced from the eastern Caucasus.

In the Belaya River section, overlying formations of the Miocene are traced from the west, not from the east. These are the Voskovaya and "Clay-Siderite" formations with their stratotypes described Korotkov (1936) in the Mt. Voskovaya area, the Pshish-Pshekha interfluvium 30 to 40 km west of the Belaya River. Exactly this subdivision scheme of Maikop deposits is accepted in recent monographs on the issue (*Stratigraphy of the USSR...*, 1975; Bogdanovich and Buryak, 1986). The attempts to subdivide the lower Miocene part of the

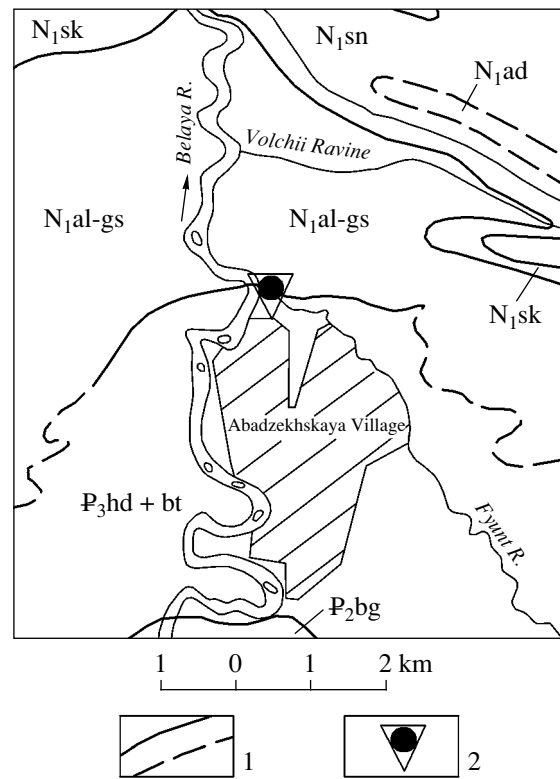
Maikop Group into formations of the central Ciscaucasia are artificial and unconvincing for the Belaya River section, as we believe. Moreover, even placing the boundary between the Voskovaya and "Clay-Siderite" formations at the Belaya River by lithological evidence is difficult because of a monotonous nature of the poorly exposed section. When preparing to publication the State Geological Map-200, Sheet L-37-XXXV (the second edition), we were forced to show these formations in the map as undivided (Fig. 3) (Korsakov et al., in press). In our opinion, it is unjustified to extend five Miocene formations from the Kuban River area to this site for more than 100 km away of their stratotype sections via the region of Laba manganese deposit, a pecu-

liar one in terms of lithology and genesis (Fig. 1). We discussed in detail this issue in our recent paper (Beluzhenko and Kovalenko, 2005).

It should be mentioned also that we doubt the lack of an upper part in succession of Maikop deposits at the Belaya River (the Ritsa Formation), which was argued for by Zaporozhets (1998). According to our observations, the Tarkhanian regional stage overlies anyway the upper Maikop deposits without visible signs of a hiatus in the Belaya River section near the Semikolennaya River mouth. Moreover, single foraminifers *Saccammina zuramakensis* Bogd. (Bogdanovich and Buryak, 1986), which are characteristic of the upper Maikop deposits, were found at the top of the “Clay–Siderite” Formation at the Belaya River.

The main contradiction of our opponents is that they missed the Alkun Formation from the Belaya River section. Based on data from the excursion guidebook, Zaporozhets distinguishes in her work of 1998 the “Septarian” Formation above the Batalpashinsk Formation of the Belaya River section and correlates it with the Alkun and Zelenchuk formations of the central Ciscaucasia. The Alkun Formation proper is not distinguished however despite the available evidence. At the same time, the above correlation implies presence of the Alkun Formation in the lower part of the “Septarian” Formation in understanding of our opponents. It is apparent that authors of the special opinion took the so-called “Septarian Beds” and “Zelenchuk Sands” for the reference horizons in their interpretation of the Belaya River section. Dmitrieva et al. (1959) showed earnestly that septarian concretions occur not in the lower part of the Voskovaya Formation (an interval correlative by age with the Zelenchuk Formation of the Kuban section), but in the upper part of the Abadzekhskaya (now Batalpashinsk) Formation in the Maikop sedimentary succession at the Belaya River. It is also shown in the same work that septarian concretions occur above and below the Alkun Formation (more frequently below) in exposures of Maikop deposits along rivers of the northern Caucasus (Fig. 2). Hence, septarian concretions have no particular stratigraphic significance in sections of the Maikop deposits. The “Septarian Beds” distinguished above the Alkun Formation (*Stratigraphy of the USSR...*, 1986) have never been ranked as formation, but their restricted occurrence is emphasized instead. These beds are not mentioned in the concrete description of the Belaya River section (Bogdanovich and Buryak, 1986).

As for the mentioned Zelenchuk Sands of the Belaya River, they actually correspond to a thin (up to 1 m) interlayer of fine-grained sand exposed on the Belaya River left bank (the Mt. Lysaya site) near a bridge in the Abadzekhskaya Village (Zaporozhets, 1998). Accordingly, they occur stratigraphically lower than the Alkun Formation (Dmitrieva et al., 1959). In our opinion, the small sand bodies (lens-like interlayers) represent remnants of the Yakun’ka Formation that



**Fig. 3.** Distribution area of Oligocene–Lower Miocene (Maikop) deposits at the Belaya River (a fragment of Geological Map, Sheet L-37-XXXV; after Korsakov et al., in press): (1) geological boundaries (proved and inferred); (2) locality of the Alkun Formation reference section. Geological indices: ( $P_2$ bg) Belaya Glina Formation; ( $P_3$ hd + bt) Khadum and Batalpashinsk formations undivided; ( $N_{1al-gs}$ , Alkun, Voskovaya, and Clay–Siderite formations, undivided; ( $N_{1sk}$ ) Semikolennaya, ( $N_{1sn}$ ) Shuntuk and ( $N_{1ad}$ ) Adygeya formations.

pinches out west of its distribution area along the Fars and Yakun’ka rivers, 30 to 40 km east of the Belaya River. The Yakun’ka Formation distinguished in the Laba region (Fig. 1) represents sandy to silty deposits of ancient delta incised into upper strata of the Batalpashinsk Formation. These deposits with manganese showings confined to them are known for a long time, and the formation is likely the late Oligocene in age (Beluzhenko and Kovalenko, 2005). It seems more logical to compare sections of Maikop deposits at the neighboring Belaya and Fars rivers instead of extending the Zelenchuk Formation from the Kuban to Belaya River via the distance of tens kilometers based on such unreliable datum as the sand interlayer less than 1 m thick.

We are of opinion based on data of many Caucasian geologists and our own investigations that the Alkun Formation of the Belaya River succession is exposed in right-hand scarps of the Fyunt River near its mouth, from where it is traceable upstream for about 250–300 m (Fig. 3). Strata of the Maikop Group are dipping

northward and northwestward at the angle of 5 to 10°. Hence, the Alkun Formation occurs stratigraphically above the “Septarian Beds” and sand interlayer of the Mt. Lysaya site, which belong to the Batalpashinsk Formation, and therefore above the “Septarian” Formation of our opponents (they define its top at the level of uppermost septarian bed). No septaria were found in deposits of the Alkun Formation and above it in sediments of the Voskovaya Formation (Fig. 2). The apparent thickness of the Alkun Formation is 22–23 m, and its sediments are represented by noncalcareous and highly calcareous clays (not less than three interlayers, each up to 1 m thick) alternating with interlayers of flat concretions and dolomitic limestones. The latter contain impressions of *Cystoseira*. Abundant foraminifers *Bolivina ex gr. plicatella* Cushm., *Uvigerinella ex gr. californica* Cushm., *Virgulinella* sp. and others associated with single pteropods were found in the clays (Dmitrieva et al., 1959). Exposed below the Alkun Formation is the Batalpashinsk Formation, the upper part of which comprises interlayers of septarian nodules up to 1 m in diameter and up to 0.3 m thick, as well as the sand interlayer exposed at the Mt. Lysaya site. Septaria are found in exposures of the upper part of the Batalpashinsk Formation at the Fyunt and Belaya rivers, upstream of the Fyunt mouth, being traceable along the riverbeds. Our field observations of 1999–2000 once again confirmed the adequacy of this viewpoint on the Belaya River section of Maikop deposits.

We completely agree with authors of the special opinion regarding the geographic position of the Paleogene–Neogene boundary at the Belaya River: “...for the Belaya River section,... unambiguous data on the position of the Oligocene–Miocene boundary are obtained near the lower outskirts of the Abadzekhskaya Village upstream of the Fyunt Creek mouth (Akhmetiev et al., 1995); these are data on distribution of two plankton groups—dinocysts (Zaporozhets, 1998) and nannoplankton (data of Ya. Krhovskii)” (Nevevskaya et al., 2004, pp. 67–68). As is said further however: “The boundary is lithologically confined to upper strata with carbonate concretions above the sandy member correlated with the Zelenchuk Sands. Resting above are pure fine-laminated noncalcareous clays attributed to lower parts of the Karadzhalka Formation.” We decidedly oppose such a correlation that is incorrect in our opinion, confusing stratigraphy of the region. Authors of the special opinion point to the same place in the section and locality, but interpret it in terms of formations of the Kuban River section.

Hence, we disagree with nomenclature of formations suggested for the Belaya River section by authors of the special opinion who do not distinguish here the Alkun Formation. We believe that stratigraphic schemes without the Alkun Formation are devoid of a reliable basis. Different interpretation of the Belaya River section by regional geologists and by authors of the special opinion is a common case in geological practice. We would not respond to disagreements if

they were not the arguments for substantiating the special opinion against the Caucasian regional stage and position of system boundaries in the northern Caucasus as a whole.

#### AGE OF FOSSILS AND LITHOLOGY OF THE ALKUN FORMATION

Let us consider now age of fossils from sediments of the Alkun Formation. Andreeva-Grigorovich (1977) referred the nannoplankton assemblage from the lower part of the Caucasian regional stage (Alkun Formation) of the stratotype section (at the Kuban River) to the uppermost Oligocene (Zone NP25). Authors of the regional stage state however that the nannoplankton assemblage identified by Andreeva-Grigorovich is lacking representative zonal species of either the late Oligocene or Miocene. At the same time, they note: “...being acquainted with composition of nannoplankton from the Alkun Formation, E. Martini supported the assemblage indexing by the NP25–NN1 transition zone” (Nosovskii and Bogdanovich, 1980, pp. 6–8). As to the borehole section Novopokrovskaya 4, the reference one for the Caucasian regional stage, it was of incomplete core recovery, and deposits of the Alkun Formation had not been reliably established here. The Caucasian regional stage was distinguished in this section based on characteristic foraminifers and mollusks. These are species *Bolivina goudkoffi* Rankin and euryhaline mollusks from the stage lower part, and foraminifers *Uvigerinella californica* Cushm. and mollusks *Cerastoderma helmersenii* Iljina from the upper part (Nosovskii and Bogdanovich, 1980). Proponents of the Caucasian regional stage rightly note: “In the type sections, deposits of the Caucasian regional stage yield some species (*Bolivina goudkoffi* Rankin, *Uvigerinella californica* Cushm.) and even one genus (*Virgulinella*), which appeared and became abundant in the lower Miocene exactly” (Nosovskii and Bogdanovich, 1980, p. 6). It should be noted that L.S. Ter-Grigoryants distinguished the Miocene basal beds with *Bolivina goudkoffi* Rankin in all borehole sections of the Stavropol region (*Stratigraphy of the USSR...*, 1986). The Oligocene dinocysts (species of the genus *Chiropteridium*, *Ch. partispinatum* included) occurring in the lower part of this regional stage undoubtedly call for an explanation, as authors of the special opinion mention (Nevevskaya et al., 2004). Their presence is however established in one section only, and this fact necessitating a close inspection cannot disprove validity of the Caucasian regional stage.

The nannoplankton assemblage of the NP25–NN1 transitional zone was identified in the Belaya River section near northern outskirts of the Abadzekhskaya Village upstream of the Fyunt River mouth (Akhmetiev et al., 1995). The Oligocene–Miocene boundary was established based on dinocyst assemblages at the same site (Zaporozhets, 1998). Data on both fossil groups from the Belaya River section appear to be unambigu-

ous, and boundary between the series is confined to the Alkun Formation, as we believe, most likely to its lower part (Figs. 2, 3). As far as we know, there are no other data on this boundary position in the northern Caucasus.

The transitional character of fauna can be commented in a few words. Changes in habitat environments also change species of living organisms. If life conditions change gradually, they do not lead to mass extinction of certain species and prompt appearance of the others. Consequently, it would be more reasonable to speak about the mixed but not transitional character of the nannoplankton assemblage in question. Of critical importance is the appearance of new species rather than disappearance of older ones. The case is formulated in *Addenda to the Stratigraphic Code* (2000, p. 16) as follows: "If a primary marker is a particular species, then its first occurrence level is more reliable as a rule than the extinction event". Thus, we can consider the nannoplankton assemblage of NP25–NN1 transition zone as a mixed one assuming that the Miocene base corresponds to the first occurrence level of new species, i.e., to the assemblage lower boundary, or is inside the transition zone at least.

As for lithologic peculiarities of the Alkun Formation, its interval is marked by intercalations of highly calcareous clay, interlayers and lenses of marls and limestones, which appear for the first time above the Khadum strata among noncalcareous sediments of the Maikop Group. The Alkun Formation is traced for a great distance from the eastern Ciscaucasia to the Belaya River (Figs. 1, 2) and even westerly, to the Mt. Voskovaya (Korotkov, 1936; *Stratigraphy of the USSR...*, 1986). In our opinion, the Karadzhalgan Formation is obviously less remarkable than the Alkun Formation in terms of lithologic and paleontologic distinctions. In any case, it is more logical, efficient, and understandable for field geologists to use the Alkun Formation as a reference stratigraphic horizon indicative of the regional stage boundary during the geological survey.

We believe that geological events of the Paleocene–Neogene boundary time are lithologically manifested in sections of the northern Caucasus by appearance of interlayers of highly calcareous rocks (clay, marl, and dolomitic limestone) amidst noncalcareous deposits. Clays of the Maikop Group above the Alkun Formation are not calcareous throughout the region. Hence, the Alkun Formation marks the last occurrence of calcareous sediments in the Maikop deposits. To some extent, it is analogous in lithologic composition to the Khadum Formation.

## CONCLUSIONS

1. Criticism of the Caucasian regional stage by authors of the "Special Opinion" cited in the *Explanatory Note to the Unified Regional Stratigraphic Scheme for Neogene Deposits of Southern Regions of the Euro-*

*pean Russia* seems to be unjustified. They misinterpret the Belaya River section disregarding data of Caucasian geologists on stratigraphic subdivision of the Maikop deposits, presence and position of the Alkun Formation.

2. The Alkun Formation represents a reliable regional datum recognizable in many sections of the northern Caucasus, the Belaya and Kuban rivers included. Taking into consideration data on nannoplankton, dinocysts, foraminifers, and lithology of deposits, the boundary between the Oligocene and Miocene is confined in the Belaya River section to the Alkun Formation (most likely to its lower part).

3. The Caucasian regional stage should not be abandoned at present. Even if it will be proved in future that the stage lowermost part belongs to the Oligocene, there are no sufficient grounds to replace this subdivision by the Karadzhalganian regional stage. At present, the Caucasian regional stage is the only one amidst Neogene regional stages of Eastern Paratethys, the stratotype of which is located in Russia being accessible for studying by Russian geologists. A possibility of replacing the Caucasian regional stage by the Karadzhalganian one should be checked and verified by studying relevant sections at the Kuban River near Cherkessk, along that river tributaries, and in other river valleys of the northern Caucasus. The problem can be solved only after obtaining unambiguous and verified data on all the fossil assemblages with due consideration of paleomagnetic data.

Reviewer M.A. Akhmet'ev

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