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Geological Structure of the Ubinka River Valley (Northwestern Caucasus)

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Abstract—A thick olistostrome strata of late Paleocene–early Eocene age is outlined in the northern flank of the Northwestern Caucasus folded structure in the Ubinka river valley, which shows the significant role of earlier Cenozoic tectonic movements in forming the alpine structure of the region. The largest part of the strata is composed of dark weakly calcareous clays, which were earlier recognized as Lower Cretaceous deposits. Olistoliths and large olistoplaques are mostly of light calcareous rocks in which microfauna of Cenomanian and Maastrichtian ages were discovered in dark clays. A poor series of foraminifers was recognized in the dark clays hosting these olistoliths; this series do not enable one to determine with certainty the age of the strata (of approximately the late Paleocene–early Eocene). Small structural forms were recognized in olistoliths and olistoplaques, which are not traced in the matrix, this indicates that a series of folded and fissured structures were formed before these olistoliths and olistoplaques appeared in the olistostrome strata.

Keywords: Olistolith, olistostrome, Paleocene, Eocene, North-Western Caucasus, folding.

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A narrow band of Upper Cretaceous and Palaeogenic sediments exposure runs along the northern flank of the folded structure of the Northwestern Caucasus. The overall thickness and stratigraphical volume of the Upper Cretaceous deposits are considerably smaller here comparing to the southern flank of the folded structure. In this region a carbonate strata of Companian and Maastrichtian ages with overall thicknesses of 200–400 m occurs. In the Paleocene–Eocene part of the stratigraphical section many scientists have reported structural unconformities and avalanche sedimentation related to the beginning of later alpine folding. Large massifs of Upper Cretaceous and Lower Cretaceous rocks in sediments of the Ilskaya series (of Lower Eocene age according to the recent assumptions) were described [Grossgeim, 1960, 1961]. Dispersed rounded debris of Upper Cretaceous marlstones in sandy clays of Ilskaya series have been described [Zemchenko, 1978]. Later, I.G. Shcherba wrote of submarine slides (of gravitational olistostromes) in terrigenous flysch of the Ilskaya series. According to results described in her paper, sliding horizons are composed of "rounded and subrounded debris and large massifs of Cretaceous limestone delivered from the northern flank of the flysch trough" [Shcherba, 1993]. The occurrence of Eocene olistostrome massifs was recognized, both in the northern slope in the Psebeps river valley and in the southern slope near the Agoi village of the Tuapce region [Borkuraev et al., 1981; Rastsvetaev, Marinin, 2001]. The results of our studies in the Ubinka river [Marinin, Kopaevich, 2010] show the occurrence of thick (above 1200 m) Upper Paleocene–Lower Eocene olistostrome strata, whose structure shows the rather significant role of movements in the formation of the alpine structure of the region that occurred earlier (late Paleocene–early Eocene).

The studied region is located in the northern flank of the folded structure of the Northwestern Caucasus in the valley of the Ubinka river between the Ubinskay stanitsa in the south and the Azovskaya stanitsa in the north. Here a 6-km long rapidly dipping northwards structure (from the Lower Cretaceous near Ubinskaya stanitsa to Neogene near Azovskaya stanitsa) is typical. Southwards of the Ubinskaya stanitsa the Maloubinskaya syncline, which is composed of Lower Cretaceous deposits of west–north–western strike with a flat southern flank and a steep (up to overtilt) flank in the north, is located. The syncline is composed of Aptian deposits in the core and Barremien deposits in the northern flank [Zemchenko, 1978]. To the north of this fold, the contact was apparently not recognized, a thick strata of Palaeogene sediments composed mainly of limestone, marlstones, and clays

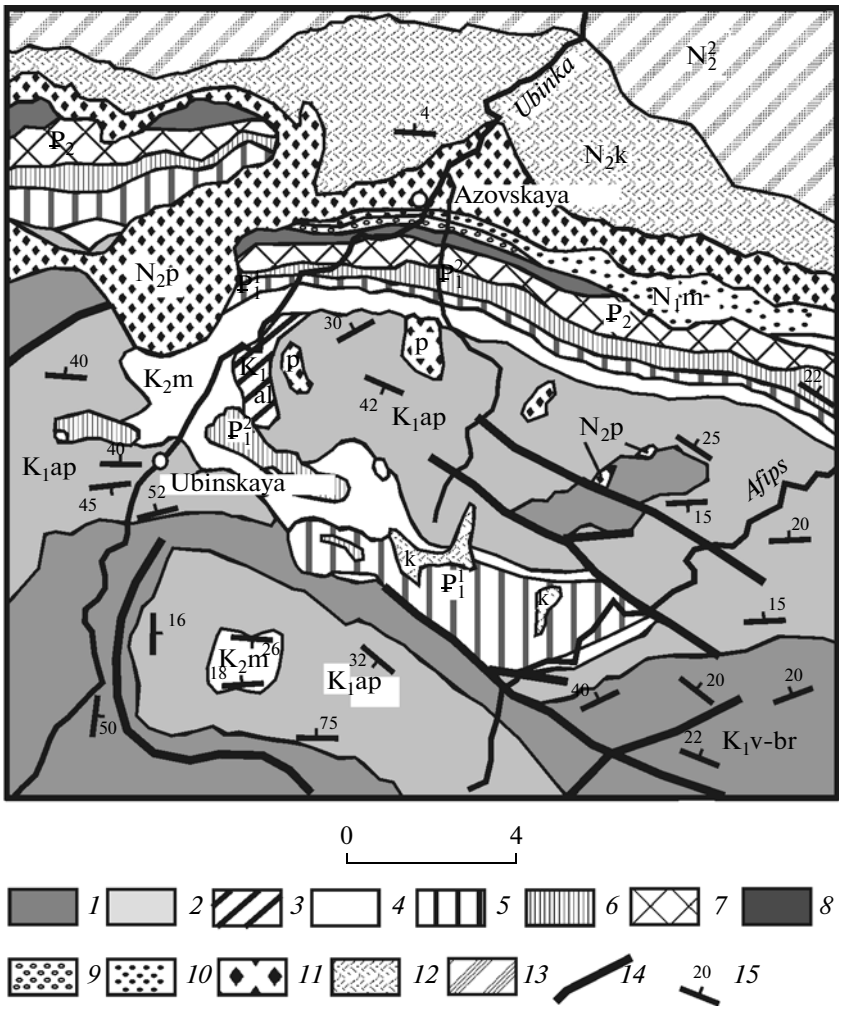

Fig. 1. A section of the geological map [Zemchenko, 1978]: *1–7* is the area of sediments: Valanginian–Borremian (*1*), Aptian (*2*), Albian (*3*), Maastricht (*4*), Lower (*5*) and Upper (*6*) Poleocene, Eocene (*7*), Maikop series (*8*), Sarmatian (*9*), Maeotian (*10*), Pontian (*11*), Kimmerian (*12*), and Upper Pliocene (*13*); ruptures (*14*); dip and strike characteristics of the layers (*15*).

occurs sharply transgressively. First the strata was referred to the Maastrichtian sediments based on external lithological features (white limestone and marlstones outlined in the section). In geological maps, the regions of its occurrence were shown as an area of Maastrichtian sediments. Thus, according to the map by A.F. Zemchenko (Fig. 1) Maastrichtian sediments lie transgressively at different horizons of the Lower Cretaceous deposits [Zemchenko, 1978]. Palaeogene deposits in this area of the Ubinka river valley in geological maps were not outlined and are shown only eastwards and westwards of the Urbinskay stanitsa, where they transgressively lie at Lower and Upper Cretaceous (Maastrichtian) deposits. Eastwards of the Azovskaya stanitsa the section of the Solenaya ravine, which has been described in many papers, is located [Grossgeim, 1960; Leonov, Alimarina, 1964]. Here sediments in Tsitse, Goryachii Klyuch, Il'skaya, and Zybzinskaya series are described. According to S.G. Korsakov, in the course of recent field studies Palaeogene sediments were mapped in the northern periphery of the Ubinskaya stanitsa (Kutaisskaya and Kaluzhskaya series) and in the southern periphery of the Azovskaya stanitsa (El'burganskaya, Goryachii Klyuch, Il'skaya, and Zybzynskaya series) and between them an area of Lower Cretaceous deposits is thought to occur. However, Palaeogene foraminifers and Upper Cretaceous olistoliths have been found recently, which suggests that the strata located between Ubinskaya and Azovskaya stanitsas are Paleocene–Eocene sediments.

MATERIALS AND METHODS

Materials were collected in the process of studies in 1999, 2001, 2005, and 2009. These are data of routing studies, diagrams, photographs, and samples. The layout of the observation and sampling points for laboratory and micro-paleontological studies are shown in Figure 2. The samples were collected at different inter-

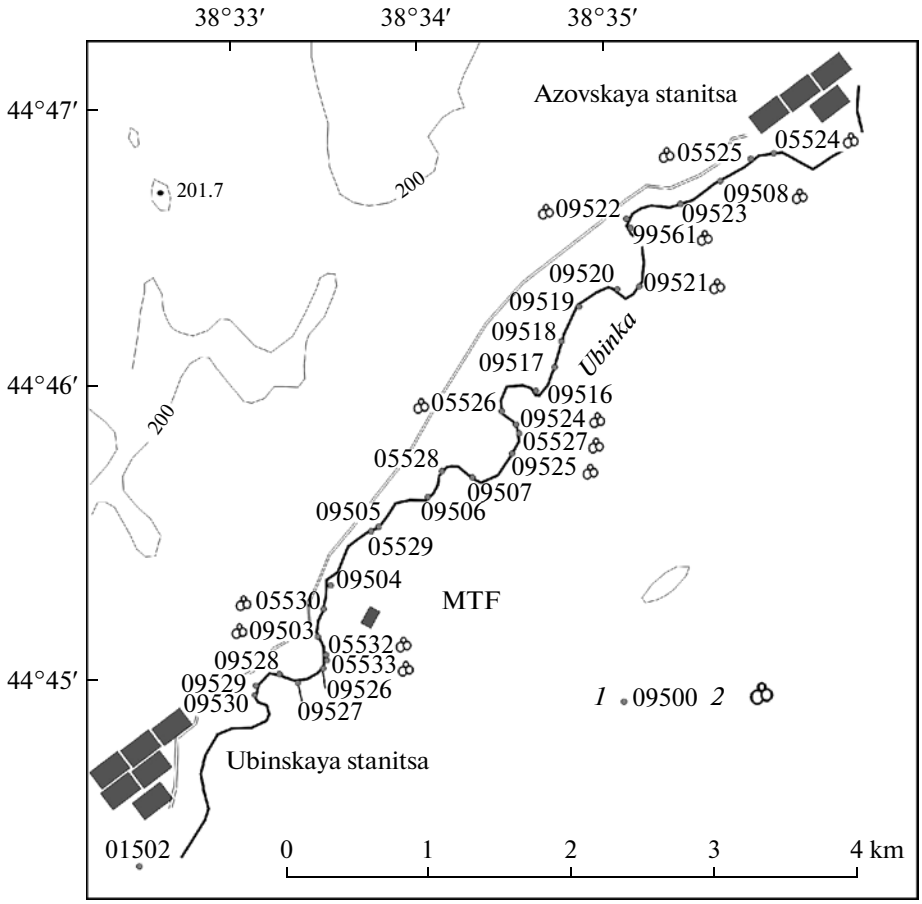

Fig. 2. Layout of points of observation and sampling: *1*, observation points; *2*, areas of sampling and microfauna definition.

vals (depending on the purpose of the studies and testing opportunities) from 5 to 200 m. In total, 16 samples were collected. The mass of the samples generally was 150–200 g. As typical "horizons with inclusions" were found in this region the samples for micro-paleontological studies were selected both from the hosting rock matrix and inclusions (olistoliths). Detailed samples from the most important intervals were collected: from the boundaries of stratigraphical structures, rocks with anomalous substantial composition and large and small olistoliths. In field studies, these olistoliths stood out in both lithological and structural characteristics. Some samples were selected from the lower edge of the studied "strata with inclusions" and its upper edge. The microfauna was selected and defined in 12 samples.

Shells of foraminifers were selected in samples by mechanical disintegration until receive fragments of 0.1–0.5 cm size and further were soaked in water with further levigation of the clayey part. Clayey differences of rocks were boiled with technical soda ($NaHCO_3$). To process the hardest rocks hydrogen peroxide, icy acetic acid (99.5%), and blue copper ($Cu_2SO_2 \cdot 5H_2O$) were used. After washing, the powder was run through a bolter with a cell size of 40 to 250 μm and larger. Selection and determination of foraminifers were undertaken using a LEIKA MZ12 binocular microscope with 20–50 enlargement. The lists of types allowed one to make a conclusion on the age of the hosting rocks.

The geological map scheme (Fig. 3), detailed structural section (Fig. 4), and stratigraphical column of the studied region (Fig. 7) were drawn based on the data of routing observations.

DESCRIPTION OF THE GEOLOGICAL STRUCTURE OF THE REGION

Geological section of the described region from the south-east to north-west from Ubinskaya stanitsa to Azovskaya stanitsa has the following structure:

(1) In the southern periphery of the Ubinskaya stanitsa observation point (OP) (OP 01502. 44°44.024′ north latitude, 38°32.187′ east longitude) Lower Cretaceous sediments (alternation of clays and sandstones) with a northwest dip of 30°C (southern flank of the Maloubinskaya syncline) occur. Northwards in the stanitsa, Lower Cretaceous sediments of subvertical occurrence are exposed (the dip azimuth is 170, ∠80 °0,

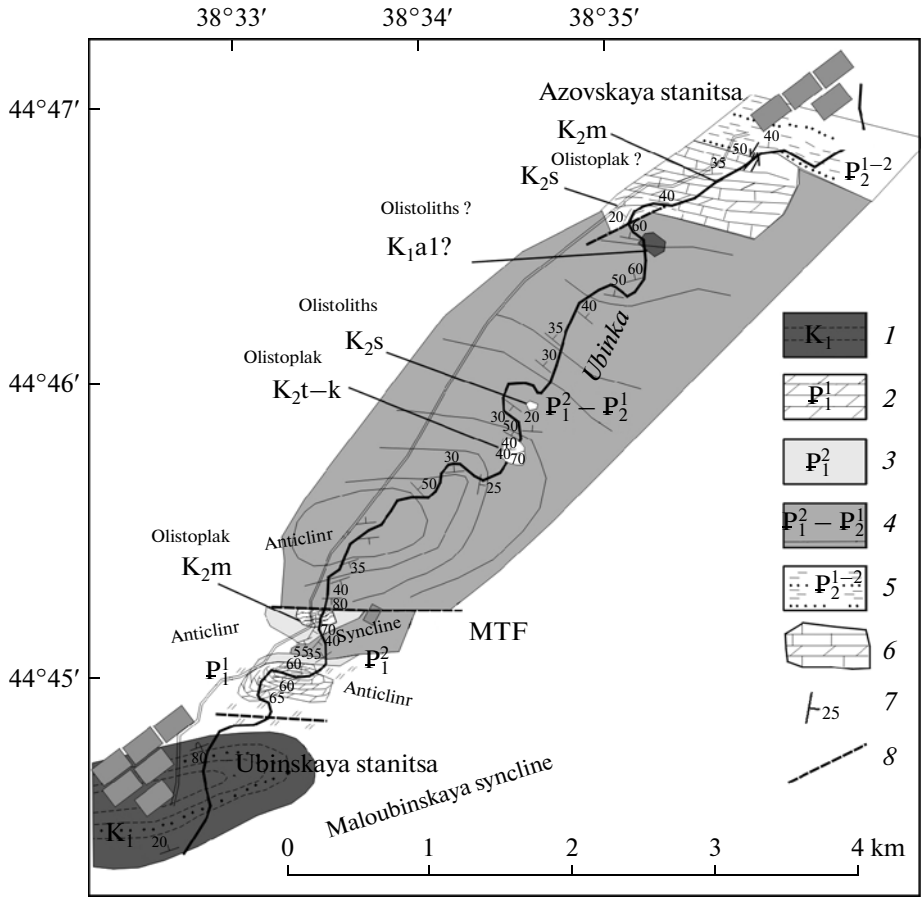

Fig. 3. Geological layout of the Ubinka river valley: *1–5* are areas of sediments: *1*, Lower Cretaceous; *2*, Lower Paleocene; *3*, Upper Paleocene; *4*, Paleocene–Eocene; *5*, Lower- and Middle Eocene; *6*, Olistoplak of Upper Cretaceous age; *7*, dip and strike characteristics of the bedding; *8*, rupturing.

overtilt); this is the northern flank of the Maloubinskaya syncline;

(2) Exposures of green marlstones occurring at normal dip in the southern rhumbs extend from the northern periphery of the Ubinskaya stanitsa (OP 09530, 44°44.955′ north latitude, 38°33.227′ east longitude) to OP 09527 (44°045.012′ north latitude, 38°33.419′ east longitude). These green marlstones we compare with Lower Paleocene sediments of the Tsetse series, which are mainly composed of green marlstones with total thicknesses of 200–250 m in the valley of the Ubinka river and above 500 m in the southern flank of the Western-Kuban trough [Geologiya SSSR, 1968; Zemchenko, 1978]. Unfortunately we could not observe the contact between closely located Lower Cretaceous and Lower Paleocene rocks due to its closed area 200 m length. Here, one may assume both sharply transgressive occurrence of Lower Paleocene sediments on Lower Cretaceous and faulting structure with an uplifted southern flank.

Lower Paleocene sediments form an anticline fold of sublatitudinal (to the east–northeast) strike with flank dip angles of 60°. At OP 09528 (44°45.021′ north latitude, 38°33.37′ east longitude) a periclinal of the fold with a westward dipping hinge (the dip azimuth is 270, ∠15°) is found; in the southern flank the dip azimuth is 190, ∠60° (normal) and in the northern flank the dip azimuth is 0, ∠60° (normal). In marlstones we recognized one horizon with a thickness of 1 m composed of sandstones and gravelites. Debris with sizes of 8 mm are mostly angular and non-rounded in gravelites. According to our data the thickness of the sequence composed of green marlstones is 170 m (in the area of the Ubinka river valley available for observations);

(3) The closed area from OP 09527 (44°45.012′ north latitude, 38°33.419′ east longitude) to OP 09526 (44°45.062′ north latitude, 38°33.562′ east longitude);

(4) Exposures of the interbedded gray limestone, blue-gray marlstones, and clays with a northwest dip azimuth of 320, ∠30–35° (OP 05533, 44°45.097′ north latitude, 38°33.566′ east longitude) are located between OP 09526 (44°45.062′ north latitude, 38°33.526′ east longitude) and OP 05532 (44°45.154′ north latitude, 38°33.563′ east longitude). A block with sizes of 1.5 m composed of interbedded sand-

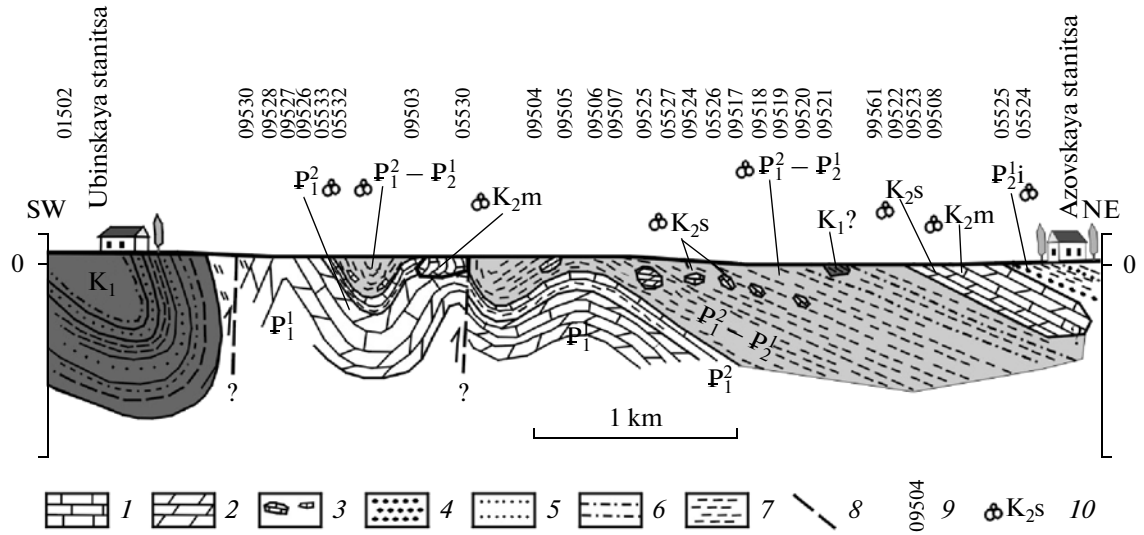

Fig. 4. Schematic geological section along the Ubinka river valley: *1*, limestones; *2*, marlstones; *3*, blocks and olistoplaques; *4*, gravelites; *5*, sandstones; *6*, siltstones; *7*, clays; *8*, ruptures (suggested); *9*, observation points; *10*, areas of defining microfauna (with age index).

stone, micrograin limestone, and marlstone is outlined in these deposits. The hosting clays of the strata (sample no. 62/2) include Radiolaria and Benthic agglutinating foraminifers *Ammodiscus* sp., *Cyclammina* sp., *Repmanina charoides* (Jones and Parker) characterizing the upper part of the Upper Paleocene (definitions by V.N. Ben'yamovkii). The thickness is approximately 100 m;

(5) Dark-gray soft clays with limestone blocks of 0.5 × 1.5 m occur higher along the section from OP 05532 (44°45.154′ north latitude, 38°33.563′ east longitude) to OP 09503 (44°45.203′ north latitude, 38°33.531′ east longitude), surfaces of hard-ground type were recognized at blocks. In dark-gray clays (sample no.9) agglutinating benthic was outlined with a complex similar to that described [Lavrishchev et al. 1999] for the sediments of the Upper Paleocene–Lower Eocene in the Northwestern Caucasus (Il'skaya and Zybzinskaya series): *Bathysiphon nodosariaformis* Subbotina, *Haplophragmoides tenuis* Cushman, *Bigeneriana plana* Subbotina, *Bolivinopsis rosula* Ehrenberg, *Textularia agglutinans* d' Orb. The thickness is above 50 m;

(6) A southern flank of the anticline is located northwards from OP 09503 (44°45.203′ north latitude 38°33.531′ east longitude) to OP 05530 (44°45.261′ north latitude, 38°33.548′ east longitude) at which interbedded limestone, marlstones, and clays similar to the sequence 4 are exposed. This interbedded sequence includes blocks of Upper Cretaceous rocks

Fig. 5. Zone of contact between olistoplaque (Maastricht marlstones) and Paleocene–Eocene clays at OP 05530.

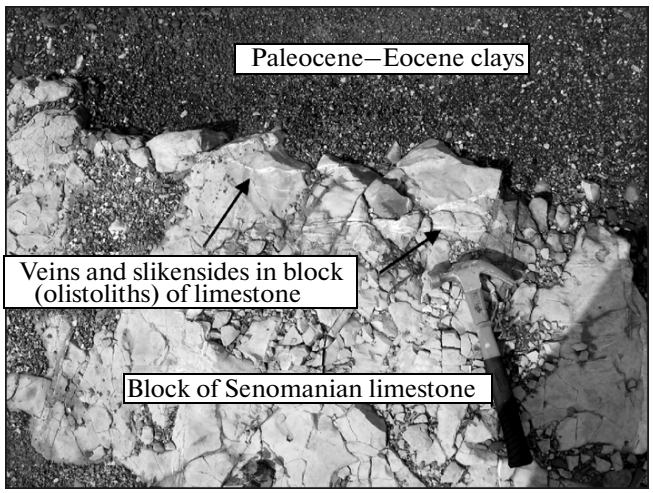

Fig. 6. Blocks of Upper Cretaceous (Senomanian) marlstones in Paleocene–Eocene clays.

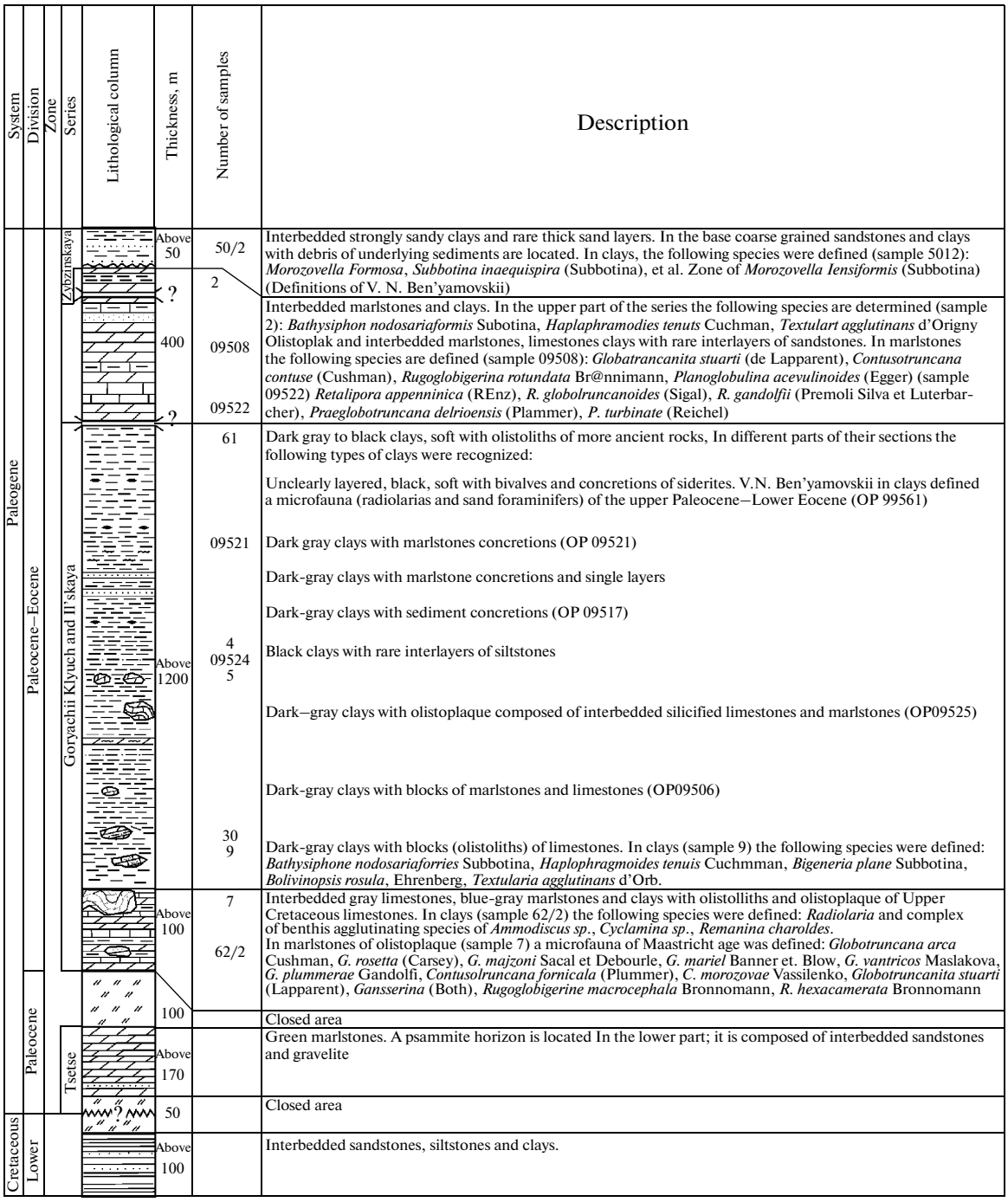

Fig. 7. Stratigraphical column of Ubinka river area.

and in the upper part large olistoplaque composed of strongly fissured limestone and brecciated layered limestones of Maastrichtian (the age is determined according to microfauna definitions, see below) is located. Within limits of the olistoplaque Maastrichtian limestones are wrinkled in small folders.

Sizes of the olistoplaque is above 200 m in the lateral section and dip characteristics of Maastrichtian limestones in the olistoplaque differ from those of the persistent occurrence of the hosting rocks (dip azimuth 120–160, ∠55–70°). In limestone of the olistoplaque (sample no.7) a Maastrichtian microfauna was determined: *Globotruncana arca* Cushman, *G. roseetta* (Carsey), *G. majzoni* Sacal et Debourle, *G. mariel* Banner et Below, *G. ventrcos* Maslakova, *G. plummerae* Gandolfi, *Contusotruncana fornicate* (Plummer), *C. morozovae* Vassilenko, *Globotruncanita stuarti* (Lapparent), *Gansserina gansseri* (Both), *Rugoglobigerina macrocephala* Bronnomann,

R. hexacamerata Bronnomann (a complex of plankton foraminifers typical of Lower Maastrichtian according to data [Botvinnik, 1973, 1982; Maslakova, 1978]). The thickness of the series is above 50 m (not taking the thickness of the olistoplaque into consideration);

(7) Northwards of OP 05530 (44°45.261′ north latitude and 38°33.548′ east longitude) continuous exposures of uniform dark-grey (up to black) clays series proceed up to OP 99561 (44°46.516′ north latitude, 38°34.976′ east longitude). The relationship between sediments in this strata and sequences 5 and 6 is not clear yet as the contact at OP 05530 is disturbed by tectonic deformation (fault) with relatively small in thickness (up to 10 cm) area of contact and rock variation, which is indirectly indicates the small amplitude of displacement (Fig. 5). This fault has a subvertical plane (dip azimuth is 180, ∠70°) and had a throw-and-thrust nature of fault traces in the slipping plane. We assume that along this sublatitudinal fault the southern flank was lifted relative to the northern. This way sequence 7 builds up sequence 5 upwards in the section and sequence 6 is an analogue of sequence 4 (Figs. 4 and 7).

The uniform nature of the thick clay strata (sequence 7) allows one to describe only some of its peculiarities that are recognized at the observation points.

In OP 09504 (44°45.346′ north latitude, 38°33.600′ east longitude) dark-grey clays include blocks (up to 2 m) of marlstones and interbedded marlstones and siltstones (dip azimuth 160, ∠40°).

Near the fort in OP 09505 (44°45.522′ north latitude, 38°33.761′ east longitude) the core of the anticline fold clearly is outlined in stable subhorizontal occurrence of dark-grey clays. Further northwards Paleocene–Eocene deposits of the strata form a monocline with dips in northern rhumbs.

In the right flank of the river (44°45.584′ north latitude, 38°33.870′ east longitude) dark-gray clays include series of blocks composed of interbedded marlstones and siltstones with cross section of 1.5 to 3 mm.

Dark-gray clays are recognized in OP 09506 (44°45.634′ north latitude, 38°34.041′ east longitude), dip azimuth 50, ∠50°. In dark-gray clays 50 m downstream rounded blocks of marlstones and limestones with cross sections from 1 to 4 m were outlined.

In OP 09507 (44°45.698′ north latitude, 36°34.297′ east longitude) dark gray clays with a layer of white fragmental (debris?) marlstones, dip azimuth is 100, ∠25°.

In OP 09525 (44°45.789′ north latitude, 36°34.452′ east longitude) the olistoplaque of the Upper Cretaceous (Cenomanian) age was outlined, It is composed of interbedded silicified limestones and marlstones (with a cross-sectional size not less than 50 m). Rocks in the olistoplaque have tectonic disturbances and different dip-and-strike characteristics (110, ∠40°; 0, ∠40°; 110, ∠40°; 160, ∠40–70°, etc.). A complex of plankton foramonifers was determined in rocks of the olistoplaque (sample 09525), it includes: *Rotalipora appernninica* (Renz), *R. globotruncanoides* (Sigal), *R. gandolfi* (Premoli Silva et Luterbancher), *R. cushmani* Mornod, *Praeglobotruncana delrioensis* (Plummer), *P. turbinata* (Reichel), *Hedbergella planispira* (Tappan), *H. caspia* (Vasiilenko), *H. simplicissima* (Magne et Sigal), this enables one to determine the age of sediments as Cenomanian (more probably middle of the Cenomanian age).

In OP 05527 (44°45.813′ north latitude, 38°34.471′ east longitude) exposures of dark-gray clays with marlstones blocks intersected with numerous veins of calcite (Fig. 6) are located. The age of the microfauna in the marlstone bloke was determined as Upper Cenomanian, it includes: *Rotalipora globotruncanoides* (Sigal), *R. appenninica* (Renz), *R. greenhornensis* (Morrow), *R. deechei* (Fraiike), *Hedbergella olanispira* (Tappan), *H. simplicissima* (Hang et Zeit), *H. delrioensis* (Carsey). The strike and dip characteristics of the deposits vary from 90, ∠40° (normal?) to 30, ∠50° (normal?)

Near the ford of the Ubinka river (OP 09524, 44°45.856′ north latitude, 38°34.467′ east longitude) dark-gray siltstone uniform clays are described (dip-and-strike characteristics are 10, ∠20°). Further to the northwest (to the OP 05526, 44°45.922′ north latitude, 38°34.388′ east longitude) continuous exposures of black clays with rare interlayers of aleurolites and fucoid limestones are recognized. In clays that were extracted in this area (sample no. 4) the following species of microfauna were determined: *Pyrulina cylindroides* (Roemer), *P. fus* (Roemer).

Dark-gray clays with concretions of siderites were found from OP 09517 (44°46.058′ north latitude, 38°34.614′ east longitude) to OP 09518 (44°46.149′ north latitude, 38°34.665′ east longitude) with dip characteristics of 40, ∠35°.

In OP 09520 (44°46.305 north latitude, 38°928′ east longitude) layers of dark-gray ashy-color dry-state clays occur with thickness of 15–20 cm and siderite interlayer of 3–7 cm thickness, total thickness is approximately 5 m, dip characteristics are 10, ∠50°.

In OP 09521 (44°46.320′ north latitude, 38°35.020′ east longitude) dark-gray clays with massive marlstone concretions occur with dip azimuth of 345, ∠60°.

Exposures of soft black smudge clays with bivalves and concretions of siderites were outlined in OP 99561 (44°46.516′ north latitude, 38°34.976′ east longitude). Clays with unclearly defined layers presumably dipping in northern rhumbs (from 0 ∠25–30° to 10, ∠70°). In clays (sample no. 61) V.N. Ben'yamovskii microfauna (radiolarias and sandstone foramonifers) of late Paleocene-early Eocene was determined. The role of Lower Cretaceous sediments in the structure of the area must be taken into consideration as according to the data of A.F. Zemchenko [Zemchenko,1978] and S.G. Korsakov (oral report) there is an area of Lower Cretaceous sediments (Aptian-Alpine) with early Cretaceous microfauna located. A detailed analysis of

the micro- and macrofauna allows one to refer these exposures to primary Lower Cretaceous deposits or to formations proceeding the olistostrome association of blocks and olistoplaques located in the Eocene (Ypresian) matrix. Northeastwards in the section of the Solenaya ravine inclusions of Albian ammonites and Apt–Albian pelecipods were previously determined [Grossgeim, 1960].

The total thickness of the strata composed of dark-gray clays with olistoplaques is more than 1200 m. The inner structure of the strata is characterized by the occurrence of ancient olistoplaques from the Paleocene to Cenomanian from the lower edge to the upper edge.

(8) A very large olistoplaque is located above (which we assume is most probable) or a block composed of Upper Cretaceous rocks is pinched out along the fracture system. In the description and in the schemes we will suppose that a large olistoplaque (up to 1 km in cross section) is located here, which is composed of interbedded light limestones (marlstones) and green clays with rare interlayers of green sandstones. Occurrence within the olistoplaque is persistent, with normal dips in northern rhumbs. The northern part of the olistoplaque with angular unconformity is overlapped with clays of the Lower Eocene. In the southern part of the olistoplaque in the lowest part of the section in OP 09522 (44°46.545′ north latitude, 38°34.967′ east longitude) a complex of plankton foramonifers (singular benthic forms are also recognized) was determined in white limestones (sample 09522), it includes: *Rotalipora appenninica* (Renz), *R. globotruncanoides* (Sigal), *R. gandolfii* (Premoli Silva et Luterbancher), *Praeglobotruncana delrioensis* (Plummer), *P. Turbinate* (Reichel) and can be dated as Senomaniam age. Northwards, solid exposures of Upper Cretaceous rocks with a dip azimuth of 300, ∠30° up to the OP 09523 (44°46.576′ north latitude, 38°35.200′ east longitude), where the dip azimuth is 0–10, ∠40–45°.

Near a new bridge over the Ubinka river (OP 09508, 44°46.681′ north latitude, 38°35.420′ east longitude) exposures of white marlstones are located. In marlstones (sample 09508) a vast complex of plankton foramonifers was determined, it includes: *Globotruncanita stuarti* (de Lapparent), *Contusotruncana contusa* (Cushman), *Rugoglobigerina rotundata* Bronnimann, and *Planoglobulina acervulinoides* (Egger); it is considered as being of Maastricht age. The absence of *Abathomphalus mayaroensis* (Bolli) species, i.e., the zonal form of the late Maastricht in the complex, indicates of Early Maasticht age of the deposits.

Interbedded layers of light-gray marlstones, white limestones and limestone clays with dip characteristics of 0, ∠35° (normal) proceed above. Rare interlayers of green sandstones with numerous trace fossils in the upper boundary and thick interlayers with thickness of up to 1.5 m are found. Marlstones and limestones are intersected with a clastic dike of sandstone with a thickness of 2 cm. Dip characteristics are 110, ∠85°; for interbedded marlstones, limestones, and clays they are 0, ∠35°.

In the upper part of the described series (OP 05525, 44°46.736′ north latitude, 38°35.565′ east longitude) dip characteristics are 20, ∠50° (normal). The section is composed of interbedded tight green marlstones (10–30 cm) and green clays (from 10 to 25–30 cm). In green clays (sample no. 2 extracted from clays 1 m below the contact with overlying sequence) the following microfauna were determined: *Bathysiphon nodosariaformis* (Subbotina), *Haplophragmoides tenuis* Cuchman, and *Textularia; agglutinans* d'Orbigny (agglutinating benthis most probably of Paleocene–Eocene period). It is not yet clear if this part of sequence 8 can be referred to the olistoplaque (it also may be "contamination" with young forms of microfauna in sample no. 2) or it belongs to hosting rocks. The total thickness of the section within the olistoplaque is approximately 400 m;

(9) In the southern periphery of the Azovskaya stanitsa (OP 05525, 44°46.736′ north latitude, 28°35.565′ east longitude) an alternation (10, ∠40°) of light-gray at the surface and light-brown clays, gingery at the surface and black in the shear strongly sandy clays, which, when washed out, occur on the surface of the underlying sequence. In the base, a basalt horizon of loose large-grained (up to 2 mm) sandstone is outlined and clays include unrounded and half-rounded debris of green marlstones. The layer of basalt loose sandstone becomes thinner (2–3 cm) in the eastern direction and below in the section dark-gray clays occur on green marlstones with a small angular unconformity. In alternating clays (sample no. 50/2) a microfauna was determined, it includes: *Morozovella formosa* (Boli), *Subbotina inaequispira* (Subbotina) et al. and it characterizes the second half of the Middle Ipr; here the *Morozovella lensiformis* zone is referred to the Zybzinskaya series (by the definition of V.N. Ben'yamovskii). Above the deposit, series are generally composed of dark-gray clays, including thick (above 1 m) layers of loose sandstones and siltstone clays and interlayers of green clays as well. The thickness of the series is above 50 m.

The total stratigraphic column of the described deposits is shown in Figure 7. Northwards (in the Azovskaya stanitsa) younger horizons occur, which are dipped to the north over the Western-Kuban trough. Northwards of the Azovskaya stanitsa (under a thick cover of flat Neogene deposits) the dipping Paleocene strata is deformed with a series of folds of the Azovskaya anticline zone (belt).

CONCLUSIONS

Based on field studies and analysis of microfauna we suggest that the strata located between the Ubinskaya and Azovskaya stanitsas are Upper Paleocene–Lower Eocene deposits that form several folds and gradually dip in the direction of the Western-Kuban

fore deep. The larger part of this strata is composed of dark carbonate free or poor carbonate clays and is characterized by a complex of foraminifers with agglutinating forms dominating. G.P. Leonov and V.P. Alimarina [Leonov, Almarina, 1964] described the peculiarities of the Paleocene deposits of the Western-Kuban area as containing inconsiderable amount of foraminifer shells remains and sporadic assemblies of "sandy" foraminifers and radiolarias.

Many researchers have noted vast occurrence of redeposited Upper Cretaceous forms in the described deposits. Description of such deposits has been recently undertaken by S.I. Stupin, who united them under the one name "facies of the Goryachii Klyuch." Dark color, carbonate free content and specific complex of foraminifers with agglutinating forms dominating are typical of deposits of these facies. Upon sediments of Goryachii Klyuch series a similar nature of deposits is typical of the overlying Ilskaya series of the Lower Eocene, which are different in the presence of interlayers of sandstones and debris of Cretaceous rocks. The facies were formed in a shelf environment (the depth apparently was less than 300–350 m) with faulted hydrogeological and geochemical modes [Stupin, 2004].

In our opinion, the described strata belongs to the Goryachii Klyuch series and Il'skaya and Zybzinskaya series. The strata includes blocks and olistoplaques of chalk rocks of Cenomanian and Maastrichtian age. Upper Cretaceous rocks have tectonic features (small faults, slip planes, and veins) that are not traced in the host matrix. Thus, we can make the conclusion that significant tectonic movements took place in Pre-Eocene or Ypresian time, most probably within the northern part of the modern folded structure of Northwestern Caucasus or near the northern border (the Ahtyrskii section).

This assumption is confirmed by the fact that olistoliths have angular shapes and are large. Olistoliths could be of a southern origin connected to growing submarine uplifts. Thus, in the surrounding areas the Soberbash and Papai Upper Cretaceous deposits are almost denuded and occur only in the form of outliers on the tops of crusts, where they are composed of carbonate deposits with sharply decreased thickness (compared to the axial part of the Novorossiisk–Lazarevskii trough). The studies by V.A. Grossgeim on the orientation of the tilts of oblique laminas in Palaeogene sections of the Western Kuban showed that the material was spread in the northern direction.

The eroded swell was composed mostly of chalk rocks [Grossgeim,1961]. Sedimentation apparently took place at a shelf depth (probably up to 300–350 m) and the shelf was strongly dissected.

Southwards to Azovskaya stanitsa a monocline occurrence of Paleocene-Eocene deposits was characterized with tectonic disturbances, which are represented in a form of system of left shifts with a northeastern strike azimuth (20–30°) and amplitude of dislocation from 0.4 to 5 m. Another system of shifts has a strike azimuth of 70° NE (dip azimuth is from 140–150, ∠55–75°) and is also characterized by left-slip dislocations. The systems are composed of calcite (up to 4 cm) and are often half-opened (they have a faulting component). Studies of tectonic fissility showed slip planes with a slip nature of creasing, outlining an area of subhorizontal compression with a slipping tectonic mode that is characterized by submeridional orientation of maximal compressing stresses. The time interval of this tectonic mode rather certainly can be determined from the late Eocene (i.e., after this strata was accumulated) and to the Paleocene inclusively, as overlying quaternary deposits did not acquire the characteristics of tectonic deformation.

The development of folding and rupture movements is more clearly seen in the structure of the overlying sedimentary strata of the region. Sediments of Kutaisskaya and Kaluzhskaya series (Middle Eocene) overlying Zybzinskaya series are characterized by decreasing thickness in the anticlines and increasing thickness in adjusting synclines; moreover, in the arches of anticline structures the erosion of underlying deposits is recognized [Geology SSSR, 1968]. Based on the data on the geological structure of the territory and analyses of angular unconformities of adjusting parts of the northwestern Caucasus in the Palaeogene one may recognize at least two significant stages of the tectogenesis of the region: (1) from the end of the late Maastrichtian to Ipr, when folding and rupture deformations appeared, which resulted, apparently, in tectonic erosion with the formation of olistoliths and a large olistoplaque; (2) from the late Eocene to the beginning of the Oligocene, when folding and rapture deformations (including Paleocene–Eocene formations) were filled with Oligocene sediments (the Maikop series).

In our opinion, further paleontological studies on the age of the series of green marlstones (sequence 2) and definition of the nature of their occurrence on the Lower Cretaceous deposits are required, as well as desectioning and defining the age of sequence 7, whose uniform nature did not allow us outline and trace separate typical horizons (the absence of defined foraminifers in samples did not allow us to dissect this strata basing on microfauna data). For detailed studies on the structure of this strata it is necessary to apply other methods, viz., studies on nanoplankton and radiolarias, and detailed lithological studies. Moreover, there is a need to define the structural position of the large olistoplaque (a block composed of Upper Cretaceous rocks), i.e., sequence 8 should also be investigated via microfauna studies on the rocks that compose it (there are definitions of Senomanian and Maastricht complexes of foramonifers).

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