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Palaeogeography

Genesis and Sedimentation of the Lacustrine Layers in the Caucasus Mountains

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ABSTRACT. As a result of complex studies it became known that the most lakes of the Quaternary period of the Caucasus Mountains were formed due to blocking of river gorges that was caused by different phenomena (lava flows, glacier moraines, tectonic faults, collapse of rocks, filling up of karst channels and etc.). The studies of the samples from the sections in the Tsebelda Gorge made it clear that the fossil spectra are similar to the spectra taken from the soil layer characteristic of the vegetation cover of the foothill line in West Georgia. As to the existence of the aliens (Sequoia, Cedrus) in the lacustrine sediments of the Main Ridge of the Caucasus Mountains, it refers to the oldness of the sediments and sedimentation conditions, namely the warmer climate compared to the modern one. On the basis of the existing material we may conclude that the genesis of the most lakes of the Main Ridge of the Caucasus Mountains are linked to the last glaciation (late Pleistocene) period and the conditions for sedimentation were not much different from the modern conditions (damp subtropical warm period). *© 2019 Bull. Georg. Natl. Acad. Sci.*

Key words: lakes, Caucasus, fossil, sediments, glaciation

The genesis of lacustrine sediments of the Caucasus Mountains is linked to various phenomena from the Quaternary period (the lower Pliocene) to Holocene. Precise ages of many lacustrine formations are not known so far due to lack of related material. The most lakes of the Quaternary period in the Caucasus Mountains were formed as a result of blocking river gorges by lava flows or glaciers (Kazbegi Municipality), tectonic faults (Racha Ridge), collapse of rocks (Abkhazia), glacier exaration, filling up karst channels, which supplied closed valleys (Shaori, Turchu).

In the western part of the Caucasus Mountains the lacustrine sediments are spread over the gorge of the river Gega (the right tributary of the river Bzipi) at the confluence of the river Iupshara. Here the lake was formed after a mountain collapse, which caused damming of the river Gega, where grey clay layers were deposited.

Lacustrine sediments are also observed in the basin of the river Kodori, in the gorges of the rivers Sakeni, Bramba and Chkhalta. Above the river Sakeni, lacustrine sediments fill up the valley bottom, formed by the Wurm glacier at 1950 m above sea level. The Sakeni Wurm glacier at its maximum spread reached 1500 m above sea level and left the valley below. As far as the Sakeni glacier ends

approximately at 2550 m above sea level, we may suppose that in the valley the lake was formed in the middle of Holocene, not earlier than 10-12 thousand years ago after the glacier left this part of the valley.

The lacustrine sediments in the Chkhalta Gorge (1400 above sea level) are linked to blocking the river by the branch ridges of the main ridge of the Caucasus Mountains. The Chkhalta lacustrine sediments are characterized with alternation of fine and medium size materials, the sedimentation age of which must date back to the period not earlier than the upper Quaternary. The friable material also contains the sediments of the clay deposited by the river Amtkeli and also well processed granite rocks, which were brought from so called "Tsebeldi Moraine". The clay was periodically deposited into the closed reservoir, when the brachi-anticline reached its maximum height and the river was dammed. According to the description by E. Velikovskaya, V. Kozhevnikova and V. Fomin [1] there is a section on the left bank of the river Amtkeli, where lacustrine sedimentary rows are observed, which are built of sand and aleurite and their thickness is 5-7 m at some places.

The palynological studies of the samples taken from three sections of the friable sediments [2,3] enabled us to offer our opinion on the conditions for the deposition of the friable sediments. In all the three sections the fossil spectra resemble the spectra taken from the soil layer that is characteristic of the vegetation cover of the foothill line in West Georgia [4]. As to the aliens (Sequoia, Cedrus) in the fossil spectrum, they make us think of oldness of the age of the sediments and the conditions for their sedimentation, namely, the climate, which was warmer than the one at present. It is also proved by the fact that these sediments are covered with 1 meter thick alluvium layer, where, according to the above mentioned data, the clay was deposited in the lakes of the Tsebeldi area in the climate conditions that were similar to those we have today.

According to D. Tsereteli [5] lacustrine sediments are observed in the gorge of the river Mulkhra below village Mulakhi and at the Ughviri Pass. The Mulakhi lacustrine sediments are located among moraines, which were left by the Wurm glacier in the formed lake after its recession. Additionally, the sediments are interesting for the observed imprints of fossilized leaves in them. At the same time, at the Ughviri Pass, among the moraines there are lacustrine sediments, which, according to D. Tsereteli [5], were left after the fore-Wurm early- glaciations.

According to S. Kuznetsov, S.Maksimovich and G. Kharatishvili [6] lacustrine-fluvial sediments are found on the territory of Mulakhi Community, in the areas of village Cholashi. In their opinion, the sediments were accumulated here due to damming of the river Mulkhura by the stage moraine of an old glacier developed in the Mestiachala Gorge, probably in Holocene.

In the Askha limestone massif, between the gorges of the rivers Tekhura and Tskhenistskhali, lacustrine sediments are observed on the Turchu valley and at the lower reach of the river Okatse below village Rondishi, which is built of 10-12 high well-defined fine-granular sand layer. Probably, the lake was formed due to the damming of the gorge that was caused by tectonic faulting.

Fig. 1. The Lacustrine Sediments of Gorda.

The lacustrine sediments (Fig. 1) survived in Gorda area are especially noteworthy. They were discovered in 1943 in the Okatse basin of the right tributary of the river Tskhenistskali and were studied in the south-eastern part of the Askha limestone massif, near village Gorda, in the Okatse Canyon, the

width of which reaches nearly 4 m. Exactly in this part, a fault transversely crosses the Okatse Gorge, which caused formation of the old lake as far as fauna and cultural layers are not revealed in the lacustrine sediments of Gorda. There is only analysis of the palynological material left for determining the sediment age. The Gorda lacustrine sediments are built of thin-layer clay with aleurite particles and alternation of sand layers. We took 16 samples from the above mentioned sediments, the visible thickness of which is 20 m. The palynological studies of the samples made it clear that the fossil vegetation spectrum is basically not different from the modern vegetation in Colchis. Only in the lower part of the section Taxodium (2-24%) and Engelhardia (1%) are decreased to minimum quantity.

Among the vegetation cover of Gorda there are no plants (Cedrus, Sequoia) characteristic of the older (lower Pleistocene) in the Caucasus. However, coniferous, broadleaf vegetation characteristic of sub-alpine forests, are widely distributed. On the basis of the above said we may suppose that the fossil spectrum expresses the modern vegetation spectrum of the south-east slope of the Askha Massif, the line at 300-2500 m above sea level. Here, especially noteworthy is the great quantity (44%) of the granules of birch dust in the lower layers of the lacustrine sediments. It means that birch forests were spread over a wide area at the beginning of the middle Pleistocene in the upper part of the Askha Massif.

According to the fossil vegetation spectrum the Gorda lacustrine sediments cannot date back to a period earlier than the middle Pleistocene, and the Okatse Canyon may belong to the upper Pleistocene as far as it is formed in the old ravine. Generally, it is important to study the Gorda lacustrine sediments by means of additional methods in order to obtain the material on the fauna and cultural remains, which will enable us to determine their absolute age [7].

The Shaori Valley on the northern slope of the Racha Ridge, is a closed valley, the floor of which is built of lacustrine sediments. As it is known the Shaori Valley has always been filled up with water. Like the karst channels were filled with water in the Turchu Valley, it was usually filled up as a result of snow melting and torrential rains. Generally, taking into consideration wide distribution of lacustrine sediments, we should suppose that permanent existence of the Shaori Lake must have been linked to the initiation of the process of formation of the valley, when the river Shaori formed an underground channel for the river Shareula. The lacustrine sediments of the Shaori Valley are presented as clay with sand and rarely gravel in the middle. The average thickness of the lacustrine sediments is 4-5 m, though it reaches 15-20 m at some places. The age of the Shaori Valley coincides with the age of the young fault crossing the northern slope of the Racha Ridge [8], dating back to the end of the upper Pleistocene. As to the permanent lake, it must have existed at the end of Pliocene (middle Quaternary).

According to the data by Z. Tintilozov [9], at the upper reach of the river Kvirila, lacustrine sediments are presented at the floors of the valleys of Tsona and Ertso. Nowadays, there is absolute lack of water in the Tsona Valley, and a reservoir in the form of the Ertso Lake has survived on the territory of Ertso. Here the lacustrine sediments are observed at the height of 70-80 m from the floor. Formation of the lake at this place is linked to the strike of an avalanche on the northern slope of the mountain Sirj-Liberta, as a result of which the river Jejora occupied the source of the river Kvirila.

Lacustrine sediments are widely spread at the sources of the river Tergi, above the Dariali Gorge, from Stepantsminda to the villages of Sioni and Karkuchi. The beds of the river Tergi and its tributaries (the Snostskali) are filled up with layers of lacustrine sediments, which are covered with a modern fluvial alluvium. The sediments here are presented as solid clay with sand and rocks. At the borough Kazbegi the thickness of the sediments reaches 80-100 m. As a matter of fact, formation of the lake is linked to blocking of the Tergi Gorge in Stepantsminda. Some researchers [10] consider that the blocking of the gorge was linked to the stage moraines of the last (Wurm) glaciation. However, it seems doubtful to us as far as the detailed studies prove that on the territory of Kazbegi Municipality, below the Truso Gorge, the glaciers did not reach the Tergi Gorge. We suppose it is more credible that the

gorge was blocked with the material (lava flow) erupted from a volcano. The precise age of the lacustrine sediments on the territory of Kazbegi Municipality is not known. However, as a matter of fact, they must date back to a period not earlier than the upper Quaternary. The Truso Gorge lacustrine sediments above the Kasriskhevi Straits were accumulated as a result of damming the river Tergi by the lava flowing from the mountain Khorisa. Here, as well, the lacustrine sediments are met below the modern and Holocene alluvium of the river Tergi. There is a similar situation in the gorge of the Khda, the right tributary of the river Tergi, where lacustrine sediments fill up the hollows formed by the Wurm glacier and their age is supposed to belong to the afterpglation period.

Table. Results of Palynological Analysis of the Highway Section (near Icon) in the Tergi Gorge

Sample №	1	2	3	4	5	6	7
General number of spores and arboreal plants	10	417	33	25	27	206	70
Arboreal dust	10	167	11	13	18	80	34
Herbaceous dust	-	221	20	8	4	115	20
Spores	-	29	2	4	5	11	16
ARBOREAL AND HERBACEOUS DUST							
Abier	-	-	-	-	-	-	2
Tsuga canadonsis	-	1	-	-	-	-	2
Pinus	2	39	4	4	8	31	7
Juniporus	-	-	-	-	-	-	1
Salix	-	3	-	2	-	4	-
Juglans	-	2	-	-	-	-	-
Carpinus caucasica	-	22	1	-	1	4	-
Corylus	1	28	-	4	1	20	6
Botula	1	8	-	-	-	-	-
Alnus	1	10	-	-	3	5	6
Quercus	-	4	-	-	-	2	-
Fagus	-	23	3	-	1	10	4
Ulmacoae	-	2	-	1	-	-	-
Ulmus	-	3	-	-	-	-	2
Acer	-	2	-	-	-	-	-
Tilia	-	2	1	-	1	-	-
Rhododendron	-	-	-	-	2	-	-
Indefinable	5	18	2	1	2	4	4
HERBACEOUS DUST							
Gramineae	-	47	-	1	1	12	3
Polygonum	-	-	-	1	1	2	-
Chenopodiaceae	-	-	-	-	-	7	4
Caryophyllaceae	-	-	1	-	-	-	-
Talictrum	-	-	1	-	-	3	-
Cruciferae	-	5	-	-	-	-	-
Umbolliforae	-	8	-	1	-	3	-
Bifora	-	3	-	-	-	11	-
Labiatae	-	5	1	-	-	1	-
Compositae	-	38	10	-	-	29	7
Artemisia	-	78	2	1	-	20	1
Campanula rapunculoides	-	1	-	1	-	-	1
Indefinable	-	36	5	3	2	27	5
SPORES							
Polipodiacoae	-	22	2	2	4	10	10
Woodsia	-	-	-	-	-	-	1
Dryoptoris	-	1	-	-	-	-	-
Ptoris	-	-	-	1	-	-	-
Polypodium	-	-	-	-	1	1	4
Osmunda	-	1	-	-	-	-	-
Indefinable	-	5	-	1	-	-	1

On the basis of palynological studies of the samples (Table) taken from the section of the lacustrine sediments above village Gveleti, in the Tergi Gorge, on the left bank of the river, at the height of 150-180 m from the gorge bottom (near Icon), it became clear that together with herbaceous plants, we can observe here almost all taxa of broadleaf forests. Especially noteworthy are the unique granules of relicts (Tsuga, Cedrus), which are characteristic of moderate and damp climate conditions. It is obvious that the sedimentation of the "Icon" lacustrine sediments was the result of the invasion of the glacial mudflow from the gorge of the river Amala to the Tergi Gorge that caused long-term damming of the river Tergi and formation of the lacustrine regime.

While considering the lacustrine sediments of the Caucasus Ridge we should note the volcanic plateau of Keli at 3000 m above sea level, where there are many lakes nowadays. Among them the most distinguished are the lakes Keli and Kelitsali, which are the sources of the Ksani and Tetri Aragvi, the left tributaries of the river Mtkvari. Taking into account the location of the Keli Plateau from the sea level, we should consider the lakes here have mainly glacial-volcanic genesis as far as the Keli Plateau itself is built of lava flows, the ages of which date back to a period not earlier than the middle of Pleistocene and the most of them belong to the Holocene period. The surfaces of the lavas were levelled by glaciers. The trog gorge forms survived morphologically in good state. As to lacustrine sediments on the Keli Plateau, here only smashed material of andesite and andesite-dacite are mainly met; particles of clay and sand layers are rare.

The lacustrine sediments were revealed by G. Dzotsenidze and V. Krestnikov [11] in the Aragvi Gorge in Pshavi, near village Barisakho.

The palynological analysis of the upper part (5.75 m) of the section of the lacustrine sediments of the Ertso Cavity carried out by I. Tumajanov and N.Margalitadze [12] prove the Holocene age of the sediments.

Taking into consideration the material obtained by us, the gneiss of the most lakes of the Main Ridge of the Caucasus are linked to the last glaciation period (late Pleistocene) as far as the lakes survived to nowadays are located in the cirques, kars and stage moraines freed from glaciers. There are few cases, when reservoirs are formed in the main gorge, as a result of invasion of a lava flow, glacier or massive mudflow from the tributary gorge and damming the river.

As to the sedimentation conditions for the lacustrine sediments of the Main Ridge of the Caucasus Mountains, taking into account the results of the palynological studies of some sections (Gorda, Tsebelda, the place near the Icon in the Tergi Gorge), it becomes obvious that the environmental conditions during the sedimentation were not much different from the modern conditions (damp subtropical warm period). Moreover, we should suppose that there was rather warmer period at the places the relicts (Sequoia, Cedrus) are revealed.

პალეოგეოგრაფია

კავკასიონის ტბიური ნაფენების გენეზისი და სედიმენტაციის პირობები

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(წარმოდგენილია აკადემიის წევრის რ. გაჩეჩილაძის მიერ)

კომპლექსური კვლევითი სამუშაოების ჩატარების შედეგად ირკვევა, რომ კავკასიონის მეოთხეული პერიოდის ტბების უმეტესი ნაწილი დაკავშირებულია მდინარეთა ხეობების გადაკეტვასთან, რაც გამოწვეული იყო სხვადასხვა მოვლენებთან (ლავური ნაკადებით, მყინვარული მორენებით, ტექტონიკური რღვევებით, კლდეების ჩამოწგრევით, კარსტული არხების გადავსებით და სხვა). წებელდის ხეობაში არსებული ჭრილებიდან აღებული ნიმუშების დამუშავების შედეგად ირკვევა, რომ განამარხებული ფოსილური სპექტრები მსგავსებას ახდენს ნიადაგის ფენიდან აღებულ სპექტრებთან, რომელიც დამახასიათებელია დასავლეთ საქართველოს მთისწინა ზოლის მცენარეული საფარისათვის. რაც შეეხება კავკასიონის მთავარი ქედის ტბიურ ნაფენებში ეგზოტების (სექვოია, ცედრუსი) არსებობას, ისინი მიუთითებენ ნაფენების სიძველესა და დალექვის პირობებზე, კერძოდ, თანამედროვესთან შედარებით თბილ პერიოდზე. არსებული მასალის საფუძველზე კავკასიონის მთავარი ქედის ტბების უმეტესი ნაწილის გენეზისი დაკავშირებულია უკანასკნელი გამყინვარების (გვიან პლეისტოცენის) პერიოდთან, ხოლო ნაფენების სედიმენტაციის პირობები დიდად არ განსხვავდება თანამედროვესთან შედარებით (ნოტიო სუბტროპიკული თბილი პერიოდი).

REFERENCES

1. Velikovskaya E.M., Kozhevnikov A.V. and Fomin V.I. (1960) Eshche raz o ″morene″ u Tsebel'dy. *Vestnik Moskovskogo Universiteta*: seriia *Geologiia*, **IV**, 4:14-20 (in Russian).
2. Mamatsashvili N.S. (1975) Palinologicheskaia kharakteristika chetvertichnykh kontinental′nykh otlozhenii Kolkhidy, p. 114. Tbilisi (in Russian).
3. Khazadarze R., Mamatsashvili N. (1979) The genesis and accumulation conditions of friable sediments in the Tsebelda area (left bank of the river Amtkeli). The nature of Georgia and nature management, pp. 32-42 (in Georgian).
4. Grossheim A. A. (1948) Rastitel'nyi pokrov Kavkaza, p. 264. M. (in Russian).
5. Tsereteli D.V. (1959) Chetvertichnye otlozheniia v basseinakh rek Inguri i Rioni, **XX**: 89-101, Tbilisi, (in Russian).
6. Kuznetsov S.S., Maksimov S.E. Kharatishvili, G.D. (1940) O geomorfologii Verkhnei Svanetii i prilegaiushchei chasti Abkhazii. Sbornik: Verkhniaia Svanetiia i prilegaiushchaia chast' Abkhazii. **2**: 60 – 70. M.–L., USSR (in Russian).
7. Maruashvili L.I., etc. (1988) Iavlenie Gorda, pp. 85-99. Tbilisi, (in Russian).
8. Janelidze. A. I., (1941) Geologicheskii kompleks gory askhi. *Izvestiia akademii nauk Gruzinskoi SSR*, **2**, 1-2: 87-98 (in Russian).
9. Tintilozov Z.K. **(**1958) On the problem of Kvirila bed river and geomorphology of Ertso and Tsona basin, v.III. Trudy geografich. ob-va Gruz. CCR (in Georgian).
10. Skhirtladze N.I. (1958) Postpaleogenovyi effuzivnyi vulkanizm Gruzii, p. 368, Tbilisi (in Russian).
11. Dzotsenidze G.S., Krestnikov V.N. (1943) Geologo-petrograficheskii ocherk iuzhnogo sklona Glavnogo Kavkazskogo khrebta v predelakh Khevsureti, vol. V, Trudy Gruzinskogo gosudarstvennogo Geologicheskogo Upravleniia, Tbilisi (in Russian).
12. Tumajanov I.I., Margalitadze N.L., (1961) K istorii lesov Kartliiskogo i Kakhetinskogo khrebtov v golotsene. *Izvestiia akademii nauk Gruzinskoi SSR,* **27**: 451–458 (in Russian).

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