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ORIGINAL ARTICLE

Reconstruction of past plant associations in the Altai mountains based on the results of the study of fossil flora

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The conditions of burial of vegetation in past geological epochs are considered and their species diversity in the Altai mountains is established. Authors assert that during the Quaternary period, the low-mountainous areas of the Altai Mountains with their specific physiographic feature were the area in which plants migrated from the highlands to the foothills during the climate cooling, or the promotion of thermophilic forms to the mountains during warming. At the same time, the number of relics from the beginning of the Quaternary period to the present has been reduced by species diversity.
Keywords: absolute age of sediments; Altai; paleocarpology; Quaternary sediments; relict plants; spore-pollen analysis; transition zone

The dynamics of erosion processes in the past and the accumulation of rocks freed from destruction and denudation on the territory of the Altai mountains were distributed extremely unevenly. In many ways, this depended on the natural conditions that were capable of changing natural landscapes in a short period of time at different stages in the formation of this mountainous country. Such events include break of the preglacial-pond lakes, the formation of landslides and topplings, the manifestation of earthquakes and other extreme phenomena occurred in the mountains constantly. These factors and, undoubtedly, planetary climatic changes, led to the destruction of vegetation existing in this or that historical period, which was especially demonstrated in the highlands and middle mountains.

Many years of experience in studying the quaternary deposits of the Altai mountains and the fossil plant remains contained in them enable us to assert that the probability of finding such plants is much higher in alluvial and lacustrine-bog sediments of river valleys located along the periphery of the mountain structure than in its central parts. Paleogeographic reconstructions of the natural conditions of this territory and features of the geomorphological structure allowed us to single out such a morphostructural relief subdivision as the relief of the “transition zone” (Baryshnikov, 1992).

The territory of this zone, occupying the lowlands, partly the middle mountains and the adjacent foothill plain, on which the egress to the day surface of individual blocks of foundation rocks is fixed, are characterized by special climatic features with increased moisture content in comparison with the steppe regions of the Altai Krai and the central parts of the Altai Mountains, a certain wind transfer of precipitation from the southwest to the northeast and their fallout in the region of the foremost mountain ranges, the richness and diversity of modern plant associations in the black taiga, which apparently caused the preservation of relict plants, often found today in this territory.

At the end of the XIX century, P. N. Krylov noted this fact in his work when he described the existence of a relict lime grove north of Teletskoye lake (Krylov, 1891). When examining the valley of the river Lebed (the right tributary of the Biya River), near Turochak village we discovered thickets of *Alnus glutinosa* Gaerth., also a relic of the Tertiary period. It is also known about the existence of relict species in the Manzherok lake located on a high terrace of Katun river near the Manzherok village – *Trapa natans* L. There are other examples.

Methods

To establish the species diversity of plant associations of past epochs, we widely used paleocarpological and spore-pollen methods for determining the species composition, and radiocarbon dating of organic matter, optical-luminescence determination of the age of host rocks and microfauna analysis of freshwater inhabitants for establishing the age range of plants existence. For studying geological sections in outcrops and boreholes we also used stratigraphic and petrographic methods.

Together, these methods made it possible to establish that the age of these alluvial deposits was no older than 30 thousand years, which corresponds to the time of maximum cooling. Nevertheless, in many spore-pollen spectra and paleocarpological complexes of this time, we often found plant species that are not found in modern plant associations and which should not have been preserved in the global climate change towards cooling.

All this indirectly indicates that in the past geological times the climatic conditions in the Altai were such that even in the time of the maximum Upper Neo-Pleistocene glaciation, the influence of the glaciation on the vegetation of low-mountain areas or transition zones was insignificant. The advance of glaciers along the river valleys from the central part of the mountainous country was limited to the territory of high mountains and partly middle mountains. Thus, for example, the lower boundary of the glacier spreading along the graben of the Teletskoye lake is established by moraine deposits in the very upper reaches of the Biya river, and in the Katun river valley – apparently, in the middle and upper reaches of Chuya river.

Materials

In the preglacial period, in the latitudinal part the Teletskoye lake was filled with clayey lake sediments with a thickness of over 60 m. This is indicated by a section along a borehole drilled 2.7 km below the village Artybash (Bublichenko, 1939, 1946). The section has the following structure (from top, m):

1. Rubbles with poorly rounded pebbles and sand 2.27
2. Rubbles with pebbles, cemented with yellow loam 3.18
3. Rubbles with pebbles and a small amount of slightly drained gravel and sand, with participation of gray and yellow loam 2.32
4. A layer of fine, well-rounded gray sand with a slight presence of weak rounded gravel 0.20
5. Rubbles with pebbles and gravel, cemented with gray sandy loam 1.95
6. Pebbles with gravel and sand of medium degree of roundness........ 1.98
7. Half-rounded pebbles with a small amount of gray loam and sand 2.87
8. Fine-grained sand of medium degree of roundness, slightly clayey........ 1,38
9. Fine evenly grained sand, with individual grains of coarse sand........ 4,60
10. Grayish loam with sand, with fragments of charred wood........ 32,83
11. Gray clay........ 9.12
12. Gravel and pebbles with sand of medium degree of roundness 0.90
13. Gray clay with individual grains of coarse sand 0.85
14. Gray clay with individual grains of coarse sand and with a small amount of pebbles 1.75
15. Large pebbles poorly rounded 2.62

Below the bedrock lies. The total thickness of loose sediments is about 69 m.

Analysis of the geological structure of the deposits studied by the well indicates that the upper part of the section to a depth of 10 m is represented by glacial formations, and the lower large part – by products of water treatment and sedimentation.

As the latitudinal segment of the lake was filled with detritus, dammed conditions for its inflows were created, in particular, for Iogach river, flowing into the lake at the source of Biya river, where in the wellhead part of this river in front of the lateral moraine sorted sand and gravel material accumulated (Fig. 1). At the base of this section, we selected a sample of a sandy substrate for an optic-luminescent analysis, the age of which corresponded to 82.6 ± 7.0 thousand years (GdTL-1715). At the top of the outcrop, the age of the sediments showed 50.2 ± 3.3 thousand years (GdTL-1716) (Baryshnikov et al., 2015). Thus, about 90–100 thousand years ago, perhaps earlier, the glacier blocked the flow of the Iogach river, what was contributed to the accumulation of horizontally layered sand and pebble deposits opened by a quarry (Baryshnikov et al., 2018).

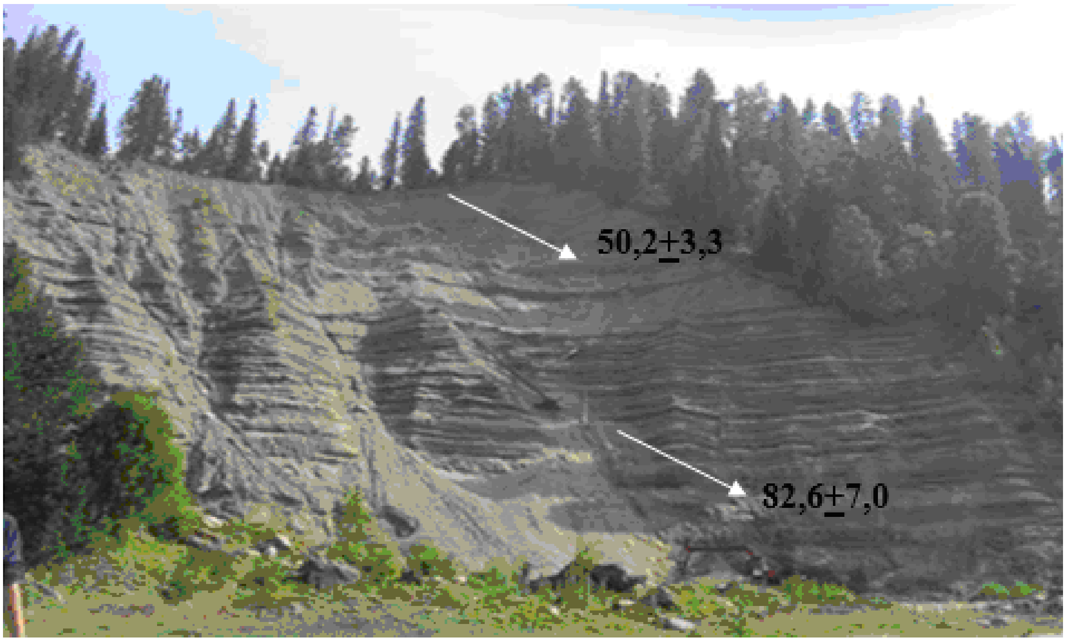

Figure1. Lake glacial-pond sediments along the Iogach river

In fact, from this time period, we should count paleogeographic events in the basins of Biya and Katun rivers, alluvial deposits of which have preserved plant remains and on which it is possible to restore the plant associations of past epochs and the time of their existence.

Thus, in the alluvial deposits of terraces at different levels these river valleys and their inflows, steppe vegetation (*Aegopodium* sp., *Aster sp.*, *Alnus glutinosa* Gaerth., *Centaurea sp.*, *Ceratophyllum demersum* L., *Dryopteris* Adans., *Echinops* L., *Ephedra* L., Euphorbiaceae, *Onoclea* sp., *Potamogeton perfoliatus* L., *P. natans* L., *Polypodium australe* L., *Sparganium simplex* Huds.), as well as representatives of the highland flora – *Aquilegia* sp., *Betula nana* L., *B. humilis* Schrank., *Larix sibirica* L., *Papaver nudicaule* L., *Potamogeton alpinus* Balb., *Selaginella selaginoides* Link. was often found.

In the reservoirs of the upper reaches of Isha river, the right tributary of the Katun river and the Ayskoe lake, located in the left bank of the Katun river, *Najas marina* L. and *Chara* sp. were recorded, as well as representatives of broad-leaved forests in the Lebed river valley and in the Isha upper reaches – *Yuglans*, *Tsuga* and *Vitis*. Such a combination of species different in the growth conditions indicates the interpenetration of plants different in ecology, typical for the black taiga, which is a relict itself located on the boundary between different landscape formations, which is characteristic of the transition zones.

From this point of view, the data obtained by drilling a well in the inter-river space of two different river basins of Biya and Katun are very interesting. The absolute mark of the surface on which this well is drilled is 382 m above sea level (Baryshnikov, 1992). Well No. 8 is located in the Isha upper reaches (Katun basin), on the one hand, and the upper reaches of the river Choyka (Biya river basin), on the other one (Fig. 2).

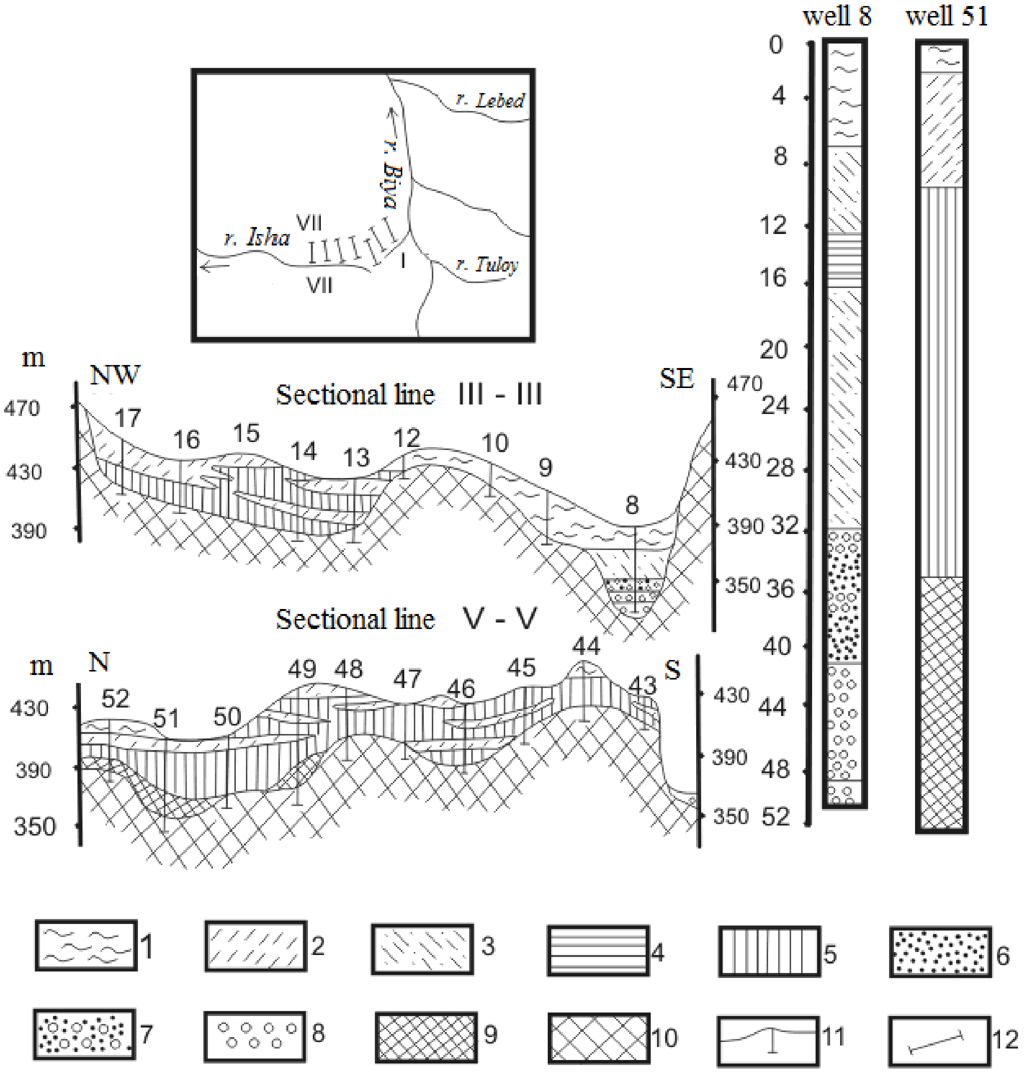

Figure 2. Geological section of Quaternary sediments on the watershed of Biya and Katun rivers (the upper reaches of the Isha and Choyka rivers).

1 – loams, 2 – sandy loam, 3 – silty sandy loam, 4 – silt, 5 – clay, 6 – fine-grained sand, 7 – sand with pebbles, 8 – pebbles, 9 – residual soil, 10 – bedrock, 11 – well and its number, 12 – boreholes profile.

In the relief, this watershed is almost not expressed. The section of the well is represented by the following geological formations (from the top, m):

1. Brown loam, dense.. 7.0
2. Mud dense, dirty-greenish-gray, acquiring a bluish-greenish color with depth. At the break, a plaque

of iron hydroxides.. 5.5

3. Sandy loam silty, dense, dark gray with a lot of organic remains. At a depth of 24.3–14.5 m, at the end of the interval, a large number of debris of mollusk shells... 3.5
4. Silt dense, bluish-gray. In some intervals with rare inclusions of organic remains 16.0
5. Sand fine-grained, bluish-gray. At the beginning of the interval there are well-rounded pebbles up to 3 cm in size represented by sandstones, quartz, quartz porphyrites, and fine-crystalline granites among the sands. In the interval 38.0–38.5 m, gravel with pebbles of quartz-epidote rocks and fine-crystalline granites predominates over sand material.. 9.0
6. Sand and gravel material of gray color, consisting of igneous and metamorphic rock debris. The size of a well-rounded pebblestone reaches 3 cm 8.0
7. Pebble-sandy material of tawny color. Pebbles of sedimentary and igneous rocks 1–2 cm and smaller in size. Roundness good 2.0

The total thickness of the opened deposits is 51 m.

In the interval 12–16 m from the surface we exposed a thick stratum of silt-sandy-pebble material with a large number of organic residues in a layer of silty sandy loam. From the total mass of organics we isolated the following seed complexes: Bryales, *Picea obovata, Picea* sp., Pinaceae gen. indet., *Sparganium sp., Potamogeton alpinus* Balb., *P. filiformis* Pers., *P. hyperboreus* Rottb., *P. lucens* L., *P. perfoliatus* L., *P. praelongus* Wulf., *P. trichoides* Cham. et Schlecht., *P. zosterifolius* Schum. et Schlecht., *Potamogeton sp., Batrachium sp., Carex* ex gr. A, *Carex sp., Ceratophyllum demersum* L., *C. sp.*, Chenopodiaceae gen. indet., *Chenopodium rubrum* L., *C. sp.*, Asteraceae gen. indet., Poaceae (Gramineae) gen. indet., *Matricaria sp.*, *Myriophyllum spicatum* L., *M. verticullatum* L., *Najas marina* L., *Najas sp., Ranunculus acer* L., *R. sceleratus* L., *Roripa palustris* (DC) Bess., *Thalictrum sp.*

Of the isolated complexes, two species are relict forms: *Potamogeton alpinus*, a representative of high mountain plant associations and currently growing in the Chuya steppe and Chuya peaks regions, and the thermophilic *Najas marina* not found in Altai at all.

By the composition, the complexes restore the existence of a large pond and suggest that in the early stages of the development of the hydrographic network of the region in the rivers upper reaches, there was an intermontane depression filled with water, indicating a unified water system in the past. It means that plant seeds easily moved from one river system (the Biya river) to another (the Katun river). On the shores of this reservoir was a forest-steppe landscape with pine-spruce forests among wormwood-orach-herbaceous steppes, as evidenced by the spore-pollen spectra of the following species: spore – Bryales, *Sphagnum, Botrychium, Lycopodium, L. clavatum* L., Polypodiaceae; woody – *Abies sibirica* Ledeb., *Picea obovata* Ledeb., *Pinus sylvestris* L., *P. sibirica* Du Tour*., Betula* sect. *Albae, Betula.* sect. *Nanae, Hippophae rhamnoides* L., *Alnus, Salix;* herbaceous – *Alisma, Sparganium, Gramineae, Cyperaceae*, *Carex, Polygonum, P. bistorta* L., *P. amphybium* L., *Fagopyrum tataricum* L., Liliaceae, *Chenopodium*, Caryophyllaceae, *Thalictrum, Ranunculus,* Brassicaceae (Cruciferae), Rosaceae, Euphorbiaceae, Apiaceae (Umbelliferae), *Geranium, Campanula,* Fabaceae (Leguminosae), Rubiaceae, *Artemisia, Echinops, Achillea, Aster, Centaurea,* Compositae, Angiospermae, *Ephedra.*

Among the represented spore-pollen spectrum, we have also distinguished relict forms. On a number of characters we dated the sediments with the plant remains to middle-upper Neoplestocene. The same age is confirmed by the results of a microfauna analysis. We found following freshwater ostracods: *Cyclocypris bradyi* Sars., *Cyclocypris gibla* Ramb., *Cyclocypris laevis* O.F.Muller, *Cypria tambovensis* Mandel st., *Candona arcina* Liepin, *C. candida* O.F.Muller, *C. rostrata* Br. et Norm., *C. rectangulata* Alm., *C. falaeform* Fischer, *Cryptocandona* sp., *Lymnocythere inopinata* Baird., *L. relicta* Lillg., *L. falcata* Diebel., *L. manitschensis* Neg., *Cypridopsis vebua* O.F.Muller, *Eucypris crassa* O.F.Muller, as well as debris of mollusk shells, seeds, vertebrae of fish.

The spore-pollen complexes isolated from alluvial deposits of the terraces of the large rivers of Altai are interesting too. So, in the Biya river valley the fourth floodplain terrace of the main river is broken by a small stream, flowing into the main river on the right side near Kebezen village. The terrace contains in its thickness a six-meter stack of clay-sludge accumulations with residues of plant dust, among which, in addition to the usual representatives of plant associations, often found in the fossil state and similar with described from the well, are *Ephedra* and *Dryopteris*.

Pure alpine plants, for example, *Larix* sp. and *Aquilegia* sp. are presented here. But most surprisingly, with the ordinary thermophilic and psychrophilic forms there is also a relic of the Turgai flora – *Tsuga*, whose fossil remains are known from the Eocene deposits (about 50 million years ago). Currently, it is found in the natural plant communities of Japan and China. The absolute age of the terrace complex deposits with *Tsuga*, determined by radiocarbon analysis of ^{14}C, corresponds to 14980 $\pm$ 70 non-calibrated years (SOAN-1863).

At the same time, in the seed complexes found in the Pyzha river valley (left inflow of Biya) in the outcrop of the terrace near vil. Novotroitskoye, deposits are revealed that contain organic matter. Here, at the base of the nine-meter terrace, thin-layered clays are exposed with a thickness of individual layers up to 2–3 cm. After thin-layered clays there are small horizontal-layered pebbles with intercalations of clays up to one centimeter in thickness. Above the section there is an interlayering of pebbles, fine-grained sands and clays. The section is overlapped by a meter layer of dark gray loam.

From thin-layered clays, we isolated the seed flora indicating the cold conditions of enclosing sediments deposition. *Betula nana* L. is met among *Carex* ex gr. A, *Carex* ex gr. B, *Scirpus sylvestris* L., *Betula* sp., *Rumex* sp., *Polygonum lapatifolium* L., *Rubus idaeus* L., *Viola* sp., Lamiaceae (Labiatae) gen. indet (*Ballota*) sp.

L. I. Efimova studied spores and pollen from this section. In the complexes isolated by her, a change in plant groups is observed upwards along the section. Thus, at the base of the section, Bryales, *Botrychium*, Polypodiaceae are distinguished among the spore plants and *Picea obovata* Ledeb., *Pinus sibirica* (Rupr.) Mayr., *P. sylvestris* L., *Betula*, *Salix* – among the woody plants. The herbaceous plants – Poaceae, Cyperaceae, *Carex*, Chenopodiaceae, *Ranunculus*, Brassicaceae, Euphorbiaceae, Lamiaceae, *Artemisia*, *Achillea*, *Crepis*, Asteraceae, Angiospermae are much more widely represented. Fungi are also marked.

A different composition of the spores and pollen is isolated in the middle part of the section. Here, spore plants are represented by *Lycopodium*, *Botrychium*, *Equisetum*, Polypodiaceae, *Dryopteris*, woody – by Pinaceae and *Salix*. The herbaceous representatives are more poorly too – Cyperaceae, Caryophyllaceae, Apiaceae, *Aegopodium*, Lamiaceae, *Crepis*, Asteraceae.

Perhaps the sediments of the uppermost part of the section are the most representative. Besides spore plants (Bryales, *Botrychium, Lycopodium,* Polypodiaceae, *Dryopteris*), woody forms (Pinaceae, *Abies sibirica* Ledeb., *Picea obovata* Ledeb., *Pinus sylvestris* L., *Pinus sibirica* Du Tour., *Betula* sect. Albae, *Betula* sp.) are presented here significantly wider. The spectrum of herbaceous plants – Poaceae, Cyperaceae, *Carex*, Chenopodiaceae, Rosaceae, Brassicaceae, Euphorbiaceae, *Aegopodium*, Apiaceae, Lamiaceae, *Artemisia*, *Achillea*, Compositae, Angiospermae – is also rich. The absolute age of the wood taken from the lowest part of the section is 16120 $\pm$ 80 non-calibrated years (SOAN-1864). This is the time of the beginning of the climate warming after the last glaciation, which is confirmed by the diversity of vegetation in the younger (upper part of the section) sediments, and also by the appearance of thermophilic forms – *Dryopteris*, *Aegopodium* and *Ephedra*.

Some other conditions of sedimentation existed in the dammed third over-floodplain terrace of Biya river –Lebed river (Baryshnikov, 1996). On the left bank of this river, near with Turachak village at a brick factory, 12 km from the mouth, in a 17-meter outcrop, we described the following geological section (from the top, m):

1. Soil and vegetation layer 0.6
2. Loam light gray with a pale shade, structureless 0.3
3. Soil buried on brownish, sandy loam 0.1
4. Loam grayish-yellow, sandy 1.2
5. Sand yellowish-gray, fine-grained 0.5
6. Sand gray, medium-grained, horizontally layered 0.6
7. Sand yellowish-gray, fine-grained. In the upper part of the layer, thin layers of larger sand. There is spotted ferrugination, especially intense at the base of the layer 1.9
8. Clay brown, in the upper part of the layer light gray, with ferruginous interlayers, the amount of which increases to the base of the layer. There is a layer of fine-grained sand with a thickness of 1–3 cm in the upper part of the layer with a small amount of well-rounded pebble material. In the lower part, the Liesegang rings are marked 3.5
9. Sand grayish-yellow, medium-grained 0.2
10. Clay light gray 0.1
11. Sand gray and yellowish-gray, crossbedded, coarse-grained with small pebbles of the size from 0.5 to 2.0 cm 2.1
12. Clay light gray 0.2
13. Sand gray-brown, coarse-grained with fine-grained well-rounded pebbles. The layer base ferruginized 1.2
14. Clay light gray. At the base a layer with a thickness of 1 cm with remains of woody vegetation 0.4
15. Sand yellowish-gray, medium-grained, in the upper part cemented with iron hydroxides 0.2
16. Clay light gray with a clear stratification 0.3
17. Sand gray, medium-grained, ferruginous, in the lower part with a clear stratification 0.3
18. Sand gray, coarse-grained, in the middle part of the layer with the inclusion of fine-grained well-rounded pebbles 0.3
19. Clay light gray. A clear horizontal stratification at the base of the layer 0.1
20. Sand coarse-grained, crossbedded, with small pebbles. To the base of the layer, the size of the pebble increases to 10 cm in diameter 1.0
21. Sand yellowish-gray, medium-grained 0.4
22. Sand coarse-grained with small and large well-rounded pebbles 0.5

The above section shows that its middle part is composed of typically lake sediments, in which plant remains are preserved. From a sample of light gray clays (200 grams) of layer 14 we determined a seed flora of the following composition: *Chara* (many oogonies), *Sphagnum* (10 branchlets), *Bryales* (36 branchlets), *Picea obovata* (400 needles), *P*. sp. (17 nuts), *Pinus sibirica* (5 nut fragments), *P. sylvestris* (3 nuts), Pinaceae gen. (cones, scales), *Selaginella selaginoides* (2 macrospores), *Sparganium simplex* (2 stones), *Potamogeton perfoliatus* (2 endocarps), *P*. sp. (4 endocarps), Poaceae gen. (6 tegmen), *Carex* ex gr. A (10 nuts), *C.* ex gr. B (11 nuts), *Alnus glutinosa* (7 nuts), *Juncus gerardii* Loise (13 seeds), *Betula nana* L. (5 scales), *Betula* sp. (6 scales, 20 nuts), *Salix* sp. (2 bolls), *Rumex* sp. (3 nuts), *Papaver nudicaule* L. (1 seed), *Rorippa palustris* (DC) Bess. (2 seeds), *Allium* L. sp. (2 seeds), *Cerastium* sp. (2 seeds), Caryophyllaceae gen. (*Stellaria* sp.) (1 seed), *Ranunculus acer* L. (2 nuts), *R.* sp. (2 nuts), Brassicaceae gen. (4 seeds, pod), *Linum* sp. (4 seeds), *Viola* sp. (2 bolls), *Euphorbia* sp. (17 seeds), *Matricaria* sp. (2 seeds), Apiaceae gen. (1 seed), *Nepeta* sp. (3 seeds).

This complex shows that the *Chara* alga, inhabiting the temperate water bodies of Europe and Central Asia, is adjacent to the *Selaginella selaginoides*, which grows high in the mountains. Steppe species *Sparganium simplex* and *Alnus glutinosa* grew earlier together with dwarf birch. There is also *Juglans*, established by spore-pollen spectra. The age of the deposits by radiocarbon dating corresponds to 13750 ± 70 non-calibrated years (SOAN-576).

Results and discussion

What is the reason for the joint finding of plant remains of different ecology in the same deposits of alluvial terraces? The question is still open. By now, there are two points of view on this problem. P. N. Krylov (1891) allowed the preservation of individual *Tilia* specimens in the basin of the Lebed river from the Neogene and connected it with the existence of favorable conditions of relief and climate. O. V. Matveeva (1960) also did not exclude the fact that the *Tilia* could be preserved in small shelters due to the fenced off parts of the mountain-hilly foothills with small absolute elevations from the northern winds and the influence of glaciers in the highlands. But such exceptional local physical and geographical conditions could not be extended to the entire south of Western Siberia.

V. V. Reverdatto (1940) suggested a second point of view. He believed that *Tilia* and relics of broad-leaved forests came to Siberia quite recently. We think that the first point of view is closer to the truth, since to the finds of relics in modern plant associations, as noted above, the facts of finding them in the fossil state are added. It indicates a peculiar transition of some plant species from one geological epoch to another. In addition, with pollen of the Quaternary appearance there is a significant amount of pollen of *Ulmus* and *Tilia*, as well as pollen of exotic species – *Carya*, *Pterocarya*, *Nissa*, *Tsuga* etc. in spore-pollen spectra extracted from the Lower Neoplestocene sediments (Matveyeva, 1960).

The same sediments consist of representative of the mountain flora – *Selaginella selaginoides*. In similar combinations of flora, O. M. Adamenko (1974) described the "doris" forms of plants (*Potamogeton alpinus* Balb.) in the sediments of the krasnodubrov suite of the Lower-Middle Neo-Pleistocene in the foothills of the Altai. He also noted that along the river valleys during the monastery times (Middle Neopleistocene) dark coniferous taiga dominated with abundance of spruce, fir, larch with an admixture of small-leaved species – birch, alder. The herbaceous forms are variously represented by the families of *Potamogetonaceae, Ranunculaceae, Cyperaceae* and others. Macrospores of small aquatic ferns *Azolla interglacialica* Nikit. and *Selaginella selaginoides* are occasionally found. The polar-arctic species, among which *Betula nana* L., *Alnus fruticosa*, *Oxyria dygina* (L.) Hill, *Papaver nudicaule* L., *P. alpinus* L., *Linaria alpine* L., *Adoxa moschatelliana* L., *Ranunculus hyperboreum*, *R. flammula*, *R. pedafidus*, *Leonurus latanus*, *Potamogeton vaginatus*, etc., are very characteristic in the complexes. The seeds of psychrophilic plants are no different in their degree of fossilization from other seeds, do not carry traces of transportation and are buried, undoubtedly, *in situ*.

The remains of vegetation, represented by *Chara*, *Juglans*, *Najas marina*, *Alnus glutinosa*, *Betula nana*, *Papaver nudicaule* and others, do not carry traces of processing in the unified location of Upper Neo-Pleistocene sediments along the Lebed river, described by us. All this shows that during the Quaternary period the transitional zone of Altai, with its specific physiographic feature, was the area in which migrations of plants from high mountains to the foothills occurred during the climate cooling, or the promotion of thermophilic forms to the mountains during warming. At the same time, the number of relics from the beginning of the Quaternary period to the present has been reduced by species diversity.

Consequently, the territory of the transitional zone of the Altai Mountains was never covered by ice of mountain-valley glaciers and was not deprived of vegetation in the half-coated glaciation, the scale of its manifestation was, apparently, even less than in the mountain-valley one.

References

Adamenko, O.M. (1974). Mesozoic and Cenozoic of the Steppe Altai. Novosibirsk: Nauka Publishers, 1–168 (in Russian).

Baryshnikov, G.Y. (1992). The development of the relief of the transition zones of mountainous countries in the Cenozoic (on the example of Gorny Altai). Tomsk: Tomsk State University Press, 1–182 (in Russian).

Baryshnikov, G.Y. (1996). Fossil vegetation in Terraceal complex of the Mountail Altai. In: *Flora and vegetation of Altai*. Barnaul: Publishers Altai State University, 129–135 (in Russian).

Baryshnikov, G., Panin, A., Adamiec, G. (2015). Geochronology of the late Pleistocene catastrophic Biya debris flow and the Lake Teletskoye formation, Altai Region, Southern Siberia. *International Geology Review*, 1–15.

Baryshnikov, G.Y., Panin A.V., Moska P. (2018). New data on the age of glacial deposits in the Teletskoye lake region, Russian Altai. *Geomorphology - the science of the 21st century*. Barnaul: Publishers Altai State University, 49-53 (in Russian).

Bublichenko, N.L. (1939). Origin of the Teletskoye Lake. *Bulletin of the West Siberian Geological Administration*, 3, 42–58.

Bublichenko, N.L. (1946). To the question of the origin of the Teletskoye Lake. *Izvestiya Vsesoyuznogo Geographical Society of the USSR*, 78(4), 443–448 (in Russian).

Krylov, P.N. 1891. Lime in the foothills of the Kuznetsk Alatau. Tomsk University Press, 1–40 (in Russian).

Matveyeva, O.V. (1960). Spore-pollen spectra of Quaternary sediments of the Altai foothills, mountain areas of the Eastern Altai and Western Tuva. *Proceedings of the Geological Institute of the USSR Academy of Sciences*. Moscow, 31, 85–112.

Reverdatto, V.V. 1940. The main moments of the development of the post-Tertiary flora of Central Siberia. *Sovetskaya botanika*, 2, 48-64 (in Russian).

Citation:

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