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GEOGRAPHY

Radiocarbon Dates of Evolution Cycles of Thermokarst Lakes on the Kolyma Lowland

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Lacustrine thermokarst plays an exclusively important role in the evolution of periglacial lithogenesis and relief formation on the Kolyma Lowland, which is located along the East Siberian Sea and the western Yana–Indigirka Lowland [1]. The multicomponent process of heat exchange upsets thermodynamic equilibrium, development of the deep-seated thermokarst, and migration of lakes on the lowland surface [2]. The migration of lakes results in restoration of thermodynamic equilibrium on areas previously occupied by the lakes and revival of underground ice formation. Polycyclic evolution of lakes is related to their migration. Lacustrine–thermokarst erosion of the high surface of the lowland (edoma), which is irregular in terms of duration in different areas, leads to the formation of alasses (depressions in pergelisoil) of several levels.

The polycyclic evolution of a thermokarst lake and its migration are reflected in alass deposits exposed on the bank of the Stadukhina Creek flowing near 68°40′ N 7–15 km north of the latitudinal segment of the Kolyma River channel on the left bank of its lower course. An exposure 5 m high and 250 m long is located on the left bank of the creek at a distance of 22 km from its confluence with the Kolyma River. The exposure shows the following beds: Bed 1 (0–15 cm) modern soil; Bed 2 (15–45 cm) lacustrine, fine-grained, brownish gray sandy loam with thin horizontal lamination; Bed 3 (45–60 cm) black, peaty, buried soil with shrub and grass remains; Bed 4 (60–100 cm) lacustrine, brownish gray, horizontally laminated sandy loam; Bed 5 (100–139 cm) brown, horizontally laminated sandy loam with abundant rewashed crumble peat; Bed 6 (139–275 cm) brown, coarse-fibrous, moss–sedge peat with massive cryotexture and remains of *Larix dahurica* trunks; Bed 7 (275–370 cm) lacustrine, fine-grained, gray sandy loam with abundant inclusions of *Betula* sp. and *Salix* sp. branches (the bed top with fine- and medium-grained sand is characterized by an imperfect reticulate cryogenic texture and the predominance of ice 1- to 2-mm-thick schlieren); Bed 8 (370–404 cm) lacustrine, fine-grained, horizontally laminated, gray sandy loam with small (2–3 mm) mollusk shells; and Bed 9 (405–425 cm) fine-grained, gray sand.

In the eastern part of the exposure (lower course of the Stadukhina Creek), lacustrine sediments exhibit features of coastal facies that account for the proximity of the edoma, which formerly made up the lake shore. Lacustrine sandy loam (Beds 2, 4, 7, 8) is characterized there by alternation of numerous horizontal interlayers of fine sand (1–4 cm) and fine inwash peat (1–3 cm). Fragments of trunks and roots of trees and shrubs are more abundant. The peat bog (Bed 6) near the edoma is rich in fine sand, which forms interlayers and comprises numerous branches of shrubs.

The figure shows that the alass spore-and-pollen diagram can be subdivided into five zones based on variations in the ratio of key taxons. The figure demonstrates the share of each pollen taxon in the sum total of all pollen grains. The content of spores is given separately for each spore taxon in the total amount of pollen grains.

Each zone includes *Larix* pollen indicating the growth of larch during the whole period of sedimentation in the alass. Zone S1 (birch zone) is characteristic of pollen lacustrine records for northeastern Siberia. The zone shows that mosaic grass tundra predominating during the Last Glaciation was replaced by *Betula middendorffii* communities due to climate warming about 12 ka B.P., which in turn were replaced in the Boreal time by communities with predominating alder forests [3]. The spectra and the position of the zone in the pollen record of alass sediments indicate that the zone predated the Boreal time of the Holocene. The vegetation cover was represented by larch forests with high birch.

Zone S2 corresponds to the Boreal time characterized in northeastern Siberia by the expansion of com-

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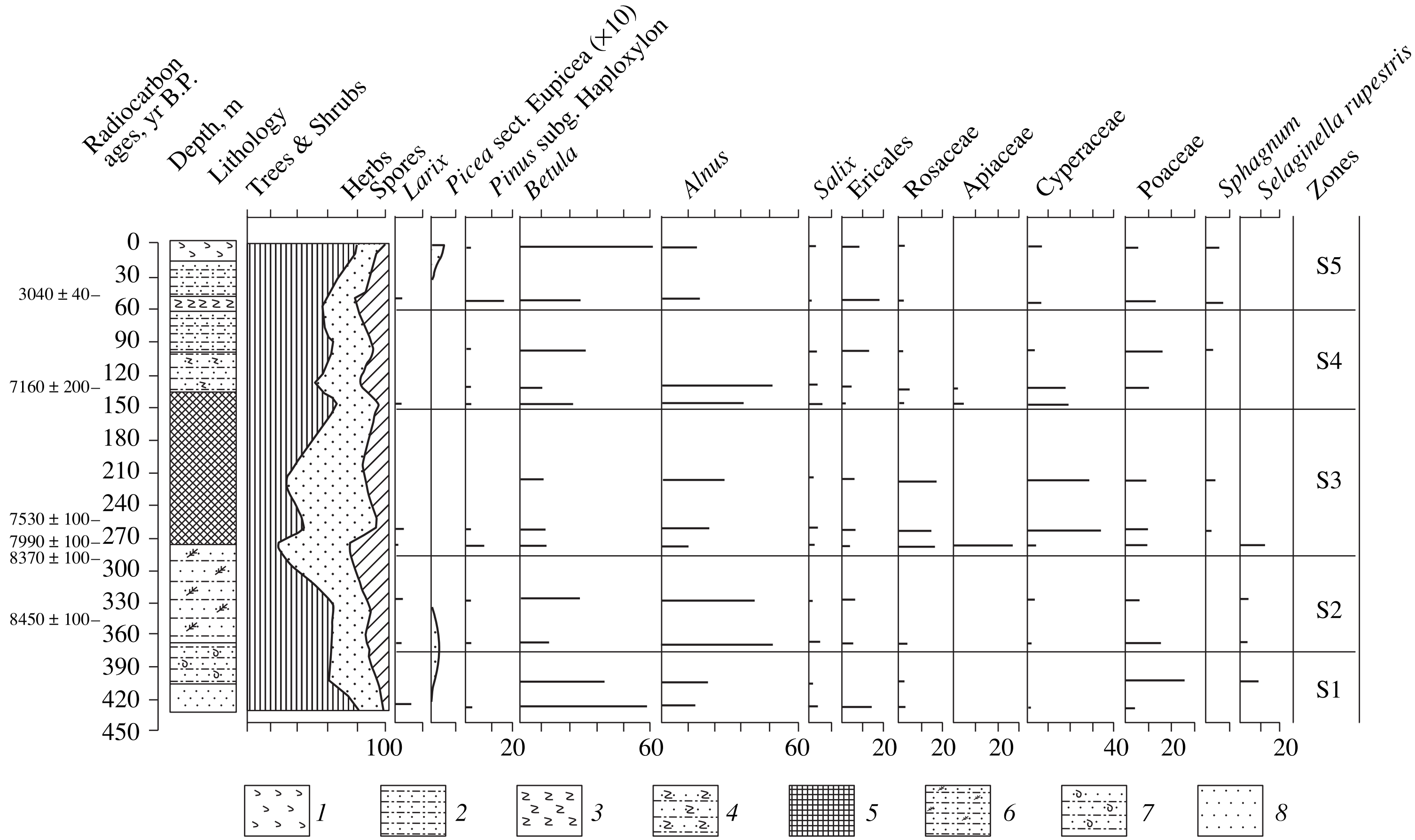

Spore-and-pollen diagram of alass sediments of Stadukhina Creek. Lithology: (*1*) present-day soil; (*2*) lacustrine sandy loam with thin horizontal lamination; (*3*) buried soil; (*4*) sandy loam with peat; (*5*) peat; (*6*) sandy loam with fragments of shrubs (*Betula, Salix*); (*7*) sandy loam with small shells of mollusks; (*8*) sand.

mon birch and alder forests to areas of the present-day Arctic tundra [4]. The radiocarbon date of 8450 ± 100 yr B.P. (MAG-472) established for willow branches at the depth of 345 cm belongs to this zone reflecting larch–birch forests with alder undergrowth. Shrub and peat near the top of Bed 7 in the eastern part of the exposure formed 8370 ± 100 yr B.P. (MAG-479). Another radiocarbon date 7990 ± 100 yr B.P. (MAG-473) was established for a larch stem found at the depth of 275 cm at the contact of Bed 7 with the peat bog (Bed 6). This date corresponds to the boundary of the Boreal and Atlantic times of the Holocene and shows that the peat bog accumulated at the beginning of the Atlantic period. Peat from a depth of 250 cm was dated at 7530 ± 100 yr B.P. (MAG-474). Based on the dating of a sample from the depth of 140 cm, peat formation ended 7160 ± 200 yr B.P. (MAG-475).

A high content of different herbs in the spectra of Zone S3 is likely to reflect both local and regional features of the vegetation cover. Variations in the landscape due to evolution of the forest tundra and a wide development of herb communities is one of the first (in northeastern Siberia) indications of climatic cooling in the earliest Atlantic period.

Spectra of Zone S4 corresponding to the second half of the Atlantic and Subboreal periods reflect larch forests with an admixture of common birch and *Betula middendorffii, Duschekia fruticosa,* and *Salix* sp. undergrowth.

Zone 5 exhibits a regional distribution of *Pinus pumila*, which is dated at 3040 ± 40 yr B.P. (MAG-476) based on plant remains from the buried soil (Bed 3), as well as the development of forest tundra communities with *Betula middendorffii* thickets.

The above-mentioned vegetation variations related to climatic fluctuations during the postglacial thermal maximum and a series of radiocarbon ages indicate that the thermokarst lake formed at the beginning of the Holocene. Sediments represented by Beds 9–7 were deposited in the lake in the pre-Boreal and Boreal periods.

The lake migrated about 8 ka B.P. The subsequent peat bog formation fostered the activation of thermokarst processes and the origin of a new lake 7160 ± 200 yr B.P. The beginning of this cycle of lake formation is reflected in Bed 5, which is composed of brown sandy loam with abundant rewashed peat. Sedimentation in the lake during a new cycle in the second half of the Atlantic and Subboreal periods (Beds 2, 4, 5) was accompanied by one more, though insignificant in scale, migration of the lake about 3 ka B.P. The migration was developed only in its eastern part (Bed 3), but the lake expanded again as the result of thermokarst processes in this area at the terminal Subboreal time.

The lake migration and the hydrological system development resulted in the lake capture by a river. Water from the lake was drained into the creek. The creek incision and the alass exposure in the sub-Atlantic time are confirmed by dates obtained for lenslike peat deposits in the floodplain 200 cm high on the right bank of the creek. A peat sample from the depth of 95–105 cm was dated at 1300 ± 50 yr B.P. (MAG-489); a sample from 117–125 cm, at 1350 ± 50 yr B.P. (MAG-490). At present, one can see activation of the next cycle of the thermokarst lake evolution on the alass surface north of the creek.

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