New results of a palynological study of the Lake Doroninskoe sediments (Eastern Siberia, Transbaikalia)

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Abstract. This article presents the results of the study of the bottom sediments of the meromictic Lake Doroninskoe. For the study, the method of spore-pollen analysis was used. The record showed that during the accumulation of 65 cm of the sediment layer in the Chita-Ingodinskaya depression, pine and larch predominated along the ridges, with steppe and meadow associations in the lower parts of the depression. According to regional correlations, the distribution of light-coniferous-taiga vegetation in Transbaikalia occurred as early as the Middle Holocene, and it did not undergo cardinal changes until modern times. According to these data, sediments may have accumulated during this time period.

1. Introduction
It is generally known that the bottom sediments of lakes with an undisturbed sequence of layers are chronicles in which detailed paleoecological information at different scales is preserved. Meromictic lakes, in which the bottom layers of water are isolated from the turbulent and convective processes occurring in the surface layers, are ideal objects for this kind of research. Constant anaerobiosis and high concentrations of hydrogen sulphide in the bottom waters impede the activity of benthic invertebrates, and, as a consequence, bioturbation is absent [1], while the original chronological sequence of sedimentary deposits is maintained [2]. This makes it possible to carry out reconstructions of environmental changes in the past without traces of obvious anthropogenic impacts. In the territory of Zabaikalsky Krai, there is the only meromictic lake Doroninskoe, which belongs to reservoirs with stable meromixia [3]. This article presents the results of studying the bottom sediments of the lake using the palynological method.

2. Materials and methods
The lake is located in the Ingoda river basin in the central part of the Chita-Ingodinskaya depression, 150 km south-west of Chita [4]. The height above sea level is 780.4 m, and the average depth of the lake is 4 m. The lake is closed and has high salinity and high mineralization. Basically, it contains carbonate, chloride, and sulphate sodium salts. From 1912 to the mid-1950s, soda was extracted on the lake by simply pumping water onto the ice surface and removing salt impurities by storing gudzhir its surface [5]; therefore, it is assumed that the bottom layers have an undisturbed structure and reflect the natural process of sedimentation. The silts of the lake have an average thickness of 4–5 m, are finely dispersed organogenic deposits, and belong to the sulphide mud class [6].
From a landscape-geographical perspective, the basin of Lake Doroninskoe is part of the Chita-Ingoda steppe-depression district of the Ingoda-Onon depression-mid-mountain province of the South Siberian mountain region [7]. According to dendrological zoning [8], the lake is located on the border of the Chita and Ingoda districts of the mountain-forest zone. The landscape complex of the territory under consideration includes mountain taiga, steppes, and meadow-steppes, as well as the shrub-meadow-bog types of vegetation. The predominant part of the mountain taiga is confined to the ridges and is occupied by light coniferous pine-larch Pinus sylvestris L., Larix gmelinii (Rupr.) Kuzen, Larix sibirica Ledeb. with an admixture of Betula platyphylla Sukaczev birch and Populus tremula L. aspen. The steppe occupies a lowered area of depression in which the lake is located. About 800 m south-west of the lake is the Ablatui pine forest. A spotted meadow steppe is observed on the north-eastern slopes of the coastal part of the lake. On the northern slope of the lake basin, there are thickets of the elm Ulmus pumila L., and on the southern shore, there is a birch grove. In the floodplain of the stream, meadow-bog vegetation is widespread; it mainly consists of grasses.

The climate in the region is sharply continental, with long, cold winters and short, relatively warm summers. The average annual air temperatures are negative. The average January temperature in the study area is −25.7 °C, and in July, it is 18.1 °C. The average annual amount of atmospheric precipitation is 250–300 mm [7]. The wind direction in the area under consideration is north in the winter and south-west in the summer. The maximum average monthly wind speed occurs from April–May, and the minimum occurs in the winter months [9].

In 2018, a core sample Dor-2018 with a thickness of 65 cm was taken in the middle part of the lake using a piston tube. The sediments consisted of dark organogenic silts without pronounced bedding, with a soda lens in the bottom hole. Every third cm was analysed. The weighed portion for studying dusting of dark coniferous representatives, and their ability to achieve long-distance airborne transport.
[11, 12] it is most likely that their pollen is brought in from the ridges of the Ingoda Okrug district [8], located to the south-west and covering the course of the Ingoda River.

The small amount of Larix pollen grains (2%), given its poor burial capacity [13], reflects its significant participation in the composition of vegetation. Ulmus pollen from thickets on the northern slope was not found in surface samples.

Thus, the soil spore-pollen spectra of the lake coast reflect the development of modern light-coniferous-taiga forests, which developed on the ridges, the upper reaches of the ridges, and in the valley of the depression, with areas of meadow and steppe vegetation.

The results of the spore-pollen analysis of the bottom sediment column showed that the pollen of Pinus sylvestris dominates in all spore-pollen spectra 60% on average (figure 1).

Figure 1. Pollen diagram of the sediments lake Doroninskoe Dor-2018.

The abundance of Larix pollen does not exceed 2% on average. The pollen of Abies and Picea is found in rare specimens. The amount of grass pollen is insignificant and does not exceed an average of 6%; it is represented by the taxa of the pollen of meadow-steppe forbs, largely from those found in the modern soils of the coast. The quantitative and taxonomic similarity of the spore-pollen spectra of the section and modern soils indicates that during the accumulation of 65 cm of the bottom sediment layer, there was vegetation similar in composition to modern vegetation, with the predominance of light-coniferous-taiga vegetation. It was possible for pine in Transbaikalia to experience wide dispersal in the Middle Holocene according to the scale of Wolker et al. [14], and it dominated throughout the Late Holocene, which is recorded in the palynological records of lakes and peat deposits [15,16,17,18,19,20]. Therefore, the bottom sediments of Lake Doroninskoe with a thickness of 65 cm could well have accumulated during this period of time.

In addition to pollen, the spore-pollen spectra contained charcoal microparticles of various sizes (figure 1). They were present in each sample, which indicates regular fire events in the depression and its mountainous surroundings. Their maximum abundance was found in the lower part of the section in the interval 63–40 cm. Samples 19, 23, and 53 contained microparticles of bulk sizes larger than 50 μm, which may indicate fires that occurred in the immediate vicinity of the lake coast.

4. Conclusions
As a result of studies of the bottom sediments of the meromictic Lake Doroninskoe, the palynological method was used to reconstruct the vegetation of the Chita-Ingodinskaya depression. The
reconstructions showed that light coniferous vegetation consisting of pine and larch trees prevailed in the mountainous surroundings of the depression. Spruce and fir trees grew on the ridges. The intermontane depressions of the depression were occupied by meadow-steppe associations. The reconstructed vegetation is close to the modern vegetation, the composition of which is reflected in the subrecent spectra of the lake coast soils.

A new, more detailed record of the bottom sediments of Lake Doroninskoie Dor-2018 confirmed the results of studies of an 85 cm core obtained earlier in 2006 (unpublished data), which was briefly examined at intervals of 5 cm. Regional correlations of palynological records make it possible to correlate the time of accumulation of sediments to a depth of 85 cm with the period of the Middle-Late Holocene. In the record of core Dor-2018, an increase in the amount of Pinus sibirica pollen is observed in the 35-15 cm interval, which may indicate the expansion of its areas in the mountain frame of the depression during the accumulation of a 20 cm layer of precipitation and indicate a change in climatic conditions towards relative cooling and moisture. A similar trend was recorded in the palynological record of Lake Arakhlei in the Bekemishevskaya depression in the period from 3500 to 2500 years ago. To carry out detailed correlations of the obtained regional natural events of the Beklemishevskaya and Chita-Ingodinskaya depressions, it is necessary to carry out radiocarbon dating of the sediments of Lake Doroninskoe, which will help to correct their geochronological boundaries.

The analysis of the content of coal particles in the obtained record showed that fire events in the depression and its surroundings occurred constantly. Their maxima are noted for the lower part of the section. The presence of the largest particles indicates fires that took place in the immediate vicinity of the lake.

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