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The dynamics of vegetation and environmental conditions in the southern Yamal Peninsula during the Holocene inferred from the palynological analysis of lake sediments

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ABSTRACT. Based on the palynological analysis of the bottom sediment column of the arctic lake with the code name 21-Ya-01A of the Erkuta River basin from the southeastern part of the Yamal Peninsula, we received preliminary information on climatic changes, as well as on changes in vegetation character in the area around the water body. According to the results of the palynological analysis, the area around lake 21-Ya-01A was occupied during the Holocene by tree species (dwarf birch, spruce, larch) and characterized by a much warmer climate than today. It has been determined that the lower part of the column from 122 cm to 95 cm formed when dwarf vegetation and light birch-spruce forests covered the territory at that time. The middle part of the column from 95 cm to 15 cm laid under more favorable conditions - the climate was warmer and wetter than in the previous phase. It can be assumed from the spectra from 15 cm to 0 cm of the column that the climate was characterized by even colder temperatures and that the territory turned into a dwarf shrub–yernik tundra.

Keywords: pollen, spores, flora, bottom sediments, climate, north of Western Siberia

1. Introduction

Lake sediments are important environmental archives that document the history of ecosystems, especially of those located at high latitudes (Subetto, 2009). Here we performed a spore-pollen analysis of the sediment core from lake 21-Ya-01A (68°11´ N, 68°57 E) in the Erkuta River basin to reconstruct the palaeovegetation dynamics in the southeastern part of the Yamal Peninsula. The region under study has a rigorous climate: low temperatures and high humidity, strong winds, permafrost (Shabanova, 2013). The mean annual temperature is -9°C. The annual precipitation rate is estimated at 295 mm/yr. The frost-free season lasts 68 days. The snow cover becomes stable in September and does not melt away until early June, i.e., for about 247 days. July is the warmest month of the year, with the mean temperature increasing to +5 – +13°C, and February is the coldest, with the mean temperature dropping to -22 – -27°C (Czernyadjeva, 2001). The entire territory lies within the southern subarctic tundra subzone where bushes (alder, willow, dwarf birch thickets called yerniks) are natural and floodplains are occupied by larch and spruce-larch light forests, as well as grass-moss fens, polygonal and palsa bogs. Areas with typical bog plants alternate with tundra vegetation. Hence, tundra-bog and bog-tundra complexes are common (Yurtsev, 1978; Morozova and Magomedova, 2004). Lake 21-Ya-01A is surrounded by plant communities typical of the shrub-moss tundra and dominated by dwarf birch, willow, cottongrass, cloudberry, horsetail, and mosses.

2. Materials and methods

A 124-cm-long core of bottom sediments was recovered from the central part of lake 21-Ya-01A (68°11.272´ N, 68°57.099´ E) during the summer expedition in 2021. For palynological analysis, a total of 62 samples taken at 2-cm intervals were used. Prior chemical treatment of the samples was carried out with the help of the Faegri–Iversen method, but without the acetolysis stage (Faegri and Iversen, 1989). Microscopic examinations were made at x400 magnification under a light microscope Axio Imager A2 (Carl Zeiss, Germany). Identification of pollen and spores was performed using special keys (Kupriyanova and Aleshina, 1972; 1978). Each sample was spiked with a tablet of *Lycopodium clavatum* spores (Lund University, Batch 1031) to determine the concentration of pollen grains in the bottom sediments (Stokmarr, 1972). At least 310 palynomorphs per sample were found. Percentages of

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all taxa were calculated from the total pollen sum taken as 100% (spores and non-pollen palynomorphs were not considered). A spore-pollen diagram was created with the Tilia/TiliaGraph software (Grimm, 2004). The boundaries of pollen zones were defined with the CONISS software (Grimm, 1987).

3. Results and discussion

The bottom sediments of lake 21-Ya-01A are made by loose aleuritic silt of gray and light brown colors. The palynological analysis revealed 37 palynomorphs (9 tree, 23 grass, and 5 spore palynomorphs).

All the fossil spectra obtained were characterized by high percentages of arboreal pollen, such as *Betula sect. Nanae*, *Betula sect. Albae*, and *Alnus spp.* Among the non-boreal taxa, Cyperaceae pollen prevailed. Spores mostly belonged to *Sphagnum* spp.

Three palynozones were distinguished in the spore-pollen diagram. The spectra of palynozone I (PZ I, 122–95 cm) are clearly dominated by the pollen of dwarf shrubs: the percentage of *Betula sect. Nanae* and *Alnus spp.* in the bottom sediments is up to 56 and 15%, respectively. *Betula sect. Albae* pollen presented (up to 10%). The pollen record of this zone is also marked by the significant proportion of pine species: *Pinus s/g Haploxylon* (up to 10%), *Picea* sp. (up to 5%); Pinaceae and *Picea s/g Diploxylon* pollen is registered. Non-boreal pollen is largely ascribed to Cyperaceae (up to 17%), Poaceae (up to 11%), and Ericaceae. The content of *Sphagnum* spp. spores reaches 15% (maximum); Lycopodiaceae and Polypodiophyta spores are present as well. The pollen density increases toward the end of the zone ($3\text{-}8 \times 10^4$ grains/g). The analysis of the pollen spectra shows that dwarf vegetation and light birch-spruce forests covered the territory at that time.

Palynozone II (PZ II, 95–15 cm) has higher pollen levels. The maximum pollen density (14×10^4 grains/g) is observed at the depth of 82–78 cm. The pollen spectra indicate an increase in the concentration of motley grass pollen and the high levels of pollen grains identified as *Alnus* spp. (30%), Cyperaceae (15%), and Ericaceae (up to 10%). *Larix* sp. and *Picea* sp. pollen was noticed. The vegetation cover of this period was still dominated by dwarf shrubs, birch forests with spruce and larch trees were present. The spectra suggest that the climate was warmer and wetter than in the previous phase.

In palynozone III (PZ III, 15–0 cm), dwarf birch pollen becomes the most widespread (up to 60%). *Betula sect. Albae* pollen was not detected in the spectra. The content of Cyperaceae pollen is quite high. The pollen density is $5\text{–}11 \times 10^4$ grains/g. It can be assumed from the spectra that the climate was characterized by even colder temperatures and that the territory turned into a dwarf shrub–yernik tundra.

4. Conclusions

According to the results of the palynological analysis discussed above, the area around lake 21-Ya-01A was occupied during the Holocene by tree species (dwarf birch, spruce, larch) and characterized by a much warmer climate than today. The pollen grains of pine and cedar were probably alien to this region and might have got there from other locations (Vasil'chuk et al., 1983; Panova et al., 2008).

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Conflict of interest

The authors declare no conflict of interest.

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