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Holocene environmental history recorded in Lake Lyadhej-To sediments, Polar Urals, Russia

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Abstract

An 1180-cm long core recovered from Lake Lyadhej-To (68°15′ N, 65°45′ E, 150 m a.s.l.) at the NW rim of the Polar Urals Mountains reflects the Holocene environmental history from ca. 11,000 cal. yr BP. Pollen assemblages from the diamicton (ca. 11,000–10,700 cal. yr BP) are dominated by Pre-Quaternary spores and redeposited Pinaceae pollen, pointing to a high terrestrial input. Turbid and nutrient-poor conditions existed in the lake ca. 10,700–10,550 cal. yr BP. The chironomid-inferred reconstructions suggest that mean July temperature increased rapidly from 10.0 to 11.8 °C during this period. Sparse, treeless vegetation dominated on the disturbed and denuded soils in the catchment area. A distinct dominance of planktonic diatoms ca. 10,500–8800 cal. yr BP points to the lowest lake-ice coverage, the longest growing season and the highest bioproductivity during the lake history. Birch forest with some shrub alder grew around the lake reflecting the warmest climate conditions during the Holocene. Mean July temperature was likely 11–13 °C and annual precipitation—400–500 mm. The period ca. 8800–5500 cal. yr BP is characterized by a gradual deterioration of environmental conditions in the lake and lake catchment. The pollen- and chironomid-inferred temperatures reflect a warm period (ca. 6500–6000 cal. BP) with a mean July temperature at least 1–2 °C higher than today. Birch forests disappeared from the lake vicinity after 6000 cal. yr BP. The vegetation in the Lyadhej-To region became similar to the modern one. Shrub (*Betula nana, Salix*) and herb tundra have dominated the lake catchment since ca. 5500 cal. yr BP. All proxies suggest rather harsh environmental conditions. Diatom assemblages reflect relatively short growing seasons and a longer persistence of lake-ice ca. 5500–2500 cal. yr BP. Pollen-based climate reconstructions suggest significant cooling between ca. 5500 and 3500 cal. yr BP with a mean July temperature 8–10 °C and annual precipitation—300–400 mm. The bioproductivity in the lake remained low after 2500 cal. yr BP, but biogeochemical proxies reflect a higher terrestrial influx. Changes in the diatom content may indicate warmer water temperatures and a reduced

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ice cover on the lake. However, chironomid-based reconstructions reflect a period with minimal temperatures during the lake history.

Keywords: Polar Urals; Holocene; pollen; diatoms; chironomids; biogeochemical records; climate reconstructions

1. Introduction

Despite increased palaeoenvironmental studies in the northeast part of the European Arctic over the last decade, relatively little is known about the Holocene environmental changes at the NW rim of the Polar Urals (Fig. 1). Only a few poorly radiocarbon-dated pollen records from nearby regions were published before 1995 (Surova, 1967; Surova et al., 1975; Nikiforova, 1980, 1982; Bolikhovskaya et al., 1988; Veinbergs et al., 1995). Although several new and partly well ^{14}C dated pollen, diatom, macrofossils and insects records from the adjacent regions were published during the last years (Andreev et al., 1998, 2001; Serebryanny et al., 1998; Koshkarova et al., 1999; Andreev and Klimanov, 2000; Kaakinen and Eronen, 2000; Panova and Jankovska, 2000; Oksanen et al., 2001; Väliranta et al., 2001; Kultti et al., 2003; Panova et al., 2003; Paus et al., 2003; Sarmaja-Korjonen et al., 2003), the environmental history of the NW rim of the Polar Urals is still poorly known.

The southward extent of the Barents-Kara Ice Sheet during the Late Pleistocene has been a matter of discussion for a long time. Detailed studies of terrestrial sections recovered in the areas west of the Ural Mountains showed that maximum ice-sheet extension occurred during the Early and Middle Weichselian and that the region was ice-free during the Late Weichselian (e.g., Mangerud et al., 2001). The most recent studies suggest a continental shelf position of the ice-sheet margin during the Last Glacial Maximum (LGM) and, consequently, an ice-free northern mainland including the NW rim of the Polar Urals (e.g., Mangerud et al., 2002; Hubberten et al., 2004 and references therein).

An ESF funded project "Eurasian Ice Sheets" focusing on the Late Pleistocene glacial and climatic history of the Eurasian Arctic was initiated in order to establish a regional chronology of palaeoenvironmental fluctuations since the LGM. A lake-sediment coring was conducted on the Lake Lyadhej-To within this project. The lake is situated at the hypothetical margin of the Middle Weichselian Barents-Kara Ice Sheet (the so-called Halmer Moraine, Mangerud et al., 2001) and was suggested as an excellent long-term archive of environmental changes in the region since the Middle Weichselian. However, the first investigations of the lake cores (Wischer et al., 2001) demonstrated that lake sediments recorded only the Holocene environmental changes. Diatom and preliminary pollen records were published by Cremer et al. (2004). This paper focuses on new environmental and quantitative climatic reconstructions based on radiocarbon-dated pollen, chironomid, diatom and biogeochemical records from Lake Lyadhej-To. The applied palaeoecological approaches and quantitative climate reconstruction techniques have not been previously combined into a multiproxy study of an anthropogenically not-disturbed lake in the northeast part of the European Arctic.

2. Study area

Lake Lyadhej-To is situated at the NW rim of the Polar Urals (68°15′ N, 65°45′ E, 150 m a.s.l., Fig. 1a). Numerous small and shallow thermokarst/glaciokarst lakes surround the lake, which is ca. 2.5 km long and 1.5 km wide with a maximum depth of 26 m (Fig. 1b). A hummocky landscape around the lake was probably formed during the disintegration of the ice sheet. Laminated fine sands in kame sediments nearby the lake were OSL dated to 90 ka (Henriksen et al., 2003). Potentially, the lake is well situated for archiving continuous sedimentary records since the last glaciation. Geomorphological evidence for a presumably Early- to Middle Weichselian Barents-Kara Ice Sheet margin was found ca. 25 km to the south of the studied lake (Astakhov et al., 1999).