Late Pleistocene-Holocene paleolimnology of three northwestern Russian lakes

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Abstract

The vegetation history and development of three different types of lakes, lakes Valday, Kubenskoye and Vishnevskoye (northwest of the East European Plain) were reconstructed using paleolimnological techniques. Watershed vegetation demonstrates a close connection with climate fluctuations: gradual expansion of the southern broad-leaved trees to the north during the Holocene with the maximum extent during the climate optimum (8000–5000 BP); and their subsequent retreat afterwards; followed by the extension of spruce during the cold and dry Subboreal time; and dominance of pine-spruce-birch forests in the Subatlantic time. The Late Pleistocene and Holocene climate changes resulted in lake-level fluctuations and other ecosystem changes. Valday Lake was formed ca. 12,500 BP as an oligotrophic, deep water basin. The lake level decreased during the dry Boreal, then increased again during the humid Atlantic period. The large shallow Kubenskoye Lake was formerly a part of an ice margin lake, which was then separated (ca. 13,000 BP) and developed into the Sukhona Basin with an outflow to the northwest. During the Atlantic, the outflow direction changed to the east. As a result, the ancient Sukhona Lake disappeared and Kubenskoye Lake formed in its modern size and shape. Vishnevskoye Lake, on the Karelian Isthmus, was formed at the beginning of the Preboreal after the disappearance of the Baltic Ice Lake. It was flooded by waters of the Boreal Ancylus transgression of the Baltic Basin and had become a small eutrophic lake by the time.

Introduction

Paleolimnological studies of northwestern Russian lakes provide the possibility to investigate the history of the lakes and to reconstruct the climate fluctuations during the Late Pleistocene and the Holocene. This problem has been the focus of several paleolimnological studies (e.g. Kvasov, 1975; Gey et al., 1978; Davydova & Kurochkina, 1981; Davydova & Raukas, 1986b; Subetto et al., 1991; Davydova et al., 1996a). Paleogeographical data have been described in detail and generalised in a special volume (Davydova et al., 1992). Some data were published in English (Davydova & Servant-Vildary, 1996) and all stages of deglaciation of the East European Plain and the borders of glacial lakes have been published in English by Kvasov (1979). The records from studied lakes and supporting documentation have been included in the Former Soviet Union lake-level data base (Tarasov et al., 1994, 1996). In this paper, paleolimnological data from lakes Valday, Kubenskoye and Vishnevskoye have been used to reconstruct the climate fluctuations of the Late Pleistocene and the Holocene. The lakes of the northwestern part of the Russian Plain (Figure 1) were formed after the retreat of the last ice cover 16,000 BP and the disappearance of large ice margin lakes (Kvasov, 1975, 1979).
Methods

Field and laboratory

Sediment cores were obtained with a rod-piston corer at the central part of the lakes during winter seasons from the ice cover. Cores were extruded and described in the field, placed in plastic bags and transported to the Institute of Limnology where they were stored at 4 °C, and subsampled into 2.5–10 cm thick sections without any gaps in order to avoid missing changes in lake ecosystems and vegetation. Lake silty gyttja and homogenous clays were subsampled into 2.5–5 cm sections, while the basal laminated clays and alterations of sand and gravel were subsampled into 10 cm thick sections because of the difference in sedimentation rates during the Post- and Late Glacial times.

The laboratory treatment of sediment samples consisted of determination of grain size, water content, loss-on-ignition, and chemical composition (N, P, C). Treatment for pollen followed standard techniques. 800–1000 pollen grains were identified per sample and the frequency of pollen grains per gram of sediment was calculated (Kvasov et al., 1986). For Lake Vishnevskoye, the regressive analysis of pollen and spores spectra in sediments was applied by Adamenko (1995) to calculate climate fluctuations (temperature and humidity changes) during the Mid and Late Holocene.

For diatom studies the following method was used for calculation of diatom abundance per g of dry sediment (Davydova, 1985). Five g of air dried sediment (d) was treated with H₂O₂ to destroy organic matter, washed in distilled water and centrifuged with heavy liquid (CdI₂+KI, cadmium iodine + kalium iodine) of 2.6 g specific gravity. The liquid containing diatoms was separated, centrifuged twice with distilled water (b), 0.02–0.04 ml of stirring liquid (e), put on the cover glass (areas 18 × 18 mm) (c), and mounted in Hyrax. Five hundred diatom frustules were identified on several microscope fields (f). The number of frustules (a) per 1 g of sediment was calculated by:

\[ a = 500 \cdot b \cdot c \cdot d^{-1} \cdot e^{-1} \cdot f^{-1} \]  

Diatom species representing more than 10% of the total count in a sample are defined as dominants and those with frequencies between 5–10 % as subdominants. The diatom abundances are recorded-as thousands or millions of frustules per g of the dry sediment (Figures 3, 5 & 8). In our opinion the diatom assemblages are represented better in such a way, especially for sediments where concentrations are low.

The chronology of sediment cores was established by pollen, and is in a good agreement with the regional scheme for the northwest of the European part of Russia (Khotinsky, 1977). The pollen and diatom results are plotted in diagrams, which have been constructed with the TILIA and TILIA GRAPH2 programs (Grimm, 1991).

Results and discussion

Late glacial development of lakes of the northwestern part of Russia

The evolution of lakes of the northwest started after the last deglaciation ca. 16,000–10,000 BP. Nearly all the lakes are relics of the great ice-dammed water basins. The most ancient lakes of the northwest can be found along the border of the last Valday (Weichselian) glaciation.

As an example of lake evolution at the southern part of the study region, the formation and evolution of

Figure 1. Location map of the study lakes: 1 – Lake Valday; 2 – Lake Kubenskoye; 3 – Lake Vishnevskoye.