Short communication

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# Late Glacial-Holocene environmental history of the East Sayan Mountains (Southern Siberia, Russia): a paleolimnological study of mountain lakes

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**ABSTRACT.** Palaeoenvironmental changes including vegetation, chemical weathering intensity, lake's water level fluctuations, and climate dynamics, from the East Sayan Mountains were investigated using multiple proxies such as pollen, mineralogical, petromagnetic, X-ray fluorescence analyses and radiocarbon dating.

***Keywords***: vegetation and chemical weathering history, climate, Late Glacial-Holocene, Oka Plateau, southern Siberia

## 1. Introduction

Climate is the major environmental factor that influences lake geosystems, directly and indirectly (O'Sullivan, Reynolds, 2005). At the end of the last glaciation, there was a general climate warming although it included fluctuations such as warmer Allerød or cooler Younger Dryas (Rasmussen et al., 2014). These fluctuations had a major impact on the environment. The main goal of our study is to investigate how major climate shifts in the Late Glacial period and Holocene influenced lake and catchment development.

## 2. Materials and methods

Sediment cores from two lakes were raised using a rope-operated UWITEC Piston Corer with PVC liners. Fifteen samples were radiocarbon dated using accelerator mass spectrometry (AMS) that was performed on bulk sediment samples at Poznan radiocarbon laboratory. The calibrated age model was constructed using the Oxcal 4.2 (Ramsey 2009). Magnetic susceptibility (MS), biogenic silica $SiO_{2bio}$, sediment physical properties were measured at 1 cm intervals. X-ray fluorescence spectra are measured according to Amosova et al. (2016). Grain size distributions were measured using a Fritish Analysette 22 laser grain size analyzer following standard procedures (Peng et al., 2005). A standard procedure was used to extract pollen (Berglund and Ralska-Jasiewiczowa, 1986).

## 3. Results and discussion

Multiproxy records from lakes Kaskadnoe (Ksk) and Khikushka (Khk) demonstrate distinct changes in regional vegetation, environment and climate since 14.6 ka BP (calibrated thousands years before present). The pollen record indicates a considerable development of shrub and herb tundra around the lakes ca. 14.6-13.77 ka BP. Rather high abundances of *Picea* and *Larix* pollen indicate their presence around the lakes. Maxima in MS and sediment dry bulk density (DBD) values in the records indicate a significant contribution of terrigenous material from the catchment area, probably carried by water originating from melting glaciers. The sediments within ca. 14.2-13.77 ka BP were deposited during the Bolling warming. Shrub tundra along with xeric herbs were widespread around the both lakes at ~12.9-11.6 ka BP. However, the increase in $SiO_{2bio}$ suggests that this cooling did not dramatically affect the lacustrine ecosystems and did not cause the decrease in their productivity. This interval ca. 11.5-9.0 ka BP is marked by pronounced climate amelioration, favoring the regional rather than local rise in the upper elevational limits of *Pinus sibirica* and the steady increase in *Pinus sylvestris* across the region. The appearance of *Pediastrum* is likely an indirect indication of increased summer temperatures. In Middle Holocene (~8.9 – 4.5 ka BP) there was a distinct peak in *Pinus sylvestris* pollen likely reflects a raising of elevational treeline in response to global/regional warming. Though other data support

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a predominantly treeless landscape in the lake basins. Late Holocene (~4.5 ka BP to present) was marked by an expansion of *Larix*, *Alnaster*, and *Salix* since ca. 4.5 ka BP. An increased presence of *Larix* at this time may reflect the beginning of a more continental climate region-wide. Geochemical proxies reflect three weakened periods of chemical weathering intensity CWI (i.e., ca. 11.5-9 ka BP, ca. 7.5-7 ka BP, ca. 6-3.5 ka BP) and two strengthened CWI periods (i.e., ca. 13.7-11.5 ka BP, ca. 9-8 ka BP and from ca. 3.5 ka BP afterwards).

## 4. Conclusions

Our new results provide additional evidence for sensitive responses of various boreal lacustrine ecosystems to global climatic changes in the Late Glacial. The Lake Ksk and Khk data document the changes of the environment and climate for the last 14.29 and 14.6 ka BP, respectively, and are the first continuous well-dated record for the Oka Plateau. These records evaluate the beginning of lacustrine sedimentation in the Oka high-mountain Plateau ~14.6 ka BP, impliyng that these high-mountain areas were nearly free of glaciers at that time because of climatic warming. Generally, environmental conditions in the East Sayn in the late Glacial and Holocene were controlled by the interaction of two large systems of atmospheric circulation - of the westerlies and the EASM. In turn, these two systems responded to external forcing (orbitally-driven insolation) and regional conditions (local ice volume, volcanic eruptions).

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