



The relative influences of climate and volcanic activity on Holocene lake development inferred from a mountain lake in central Kamchatka



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ABSTRACT

A sediment sequence was taken from a closed, high altitude lake (informal name Olive-backed Lake) in the central mountain range of Kamchatka, in the Russian Far East. The sequence was dated by radiocarbon and tephrochronology and used for multi-proxy analyses (chironomids, pollen, diatoms). Although the evolution of Beringian climate through the Holocene is primarily driven by global forcing mechanisms, regional controls, such as volcanic activity or vegetation dynamics, lead to a spatial heterogeneous response. This study aims to reconstruct past changes in the aquatic and terrestrial ecosystems and to separate the climate-driven response from a response to regional or localised environmental change. Radiocarbon dates from plant macrophytes gave a basal date of 7800 cal yr BP. Coring terminated in a tephra layer, so sedimentation at the lake started prior to this date, possibly in the early Holocene following local glacier retreat. Initially the catchment vegetation was dominated by *Betula* and *Alnus* woodland with a mosaic of open, wet, aquatic and semi-aquatic habitats. Between 7800 and 6000 cal yr BP the diatom-inferred lake water was pH 4.4–5.3 and chironomid and diatom assemblages in the lake were initially dominated by a small number of acidophilic/acid tolerant taxa. The frequency of *Pinus pumila* (Siberian dwarf pine) pollen increased from 5000 cal yr BP and threshold analysis indicates that *P. pumila* arrived in the catchment between 4200 and 3000 cal yr BP. Its range expansion was probably mediated by strengthening of the Aleutian Low pressure system and increased winter snowfall. The diatom-inferred pH reconstructions show that after an initial period of low pH, pH gradually increased from 5500 cal yr BP to pH 5.8 at 1500 cal yr BP. This trend of increasing pH through the Holocene is unusual in lake records, but the initially low pH may have resulted directly or indirectly from intense regional volcanic activity during the mid-Holocene. The chironomid-inferred July temperature reconstruction suggests cool periods between 3200–2800 cal yr BP and 1100–700 cal yr BP and a warmer period between 2800 and 1100 cal yr BP. Chironomid and diatom DCA scores decline from ca. 6000 cal yr BP, indicating compositional changes in these aquatic assemblages. In comparison declines in pollen PCA scores are delayed, starting ca. 5100 cal yr BP. The results suggest that while catchment vegetation was responding primarily to climate change, the biota within the lake and lake water chemistry were responding to localised environmental conditions.

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1. Introduction

The climate and environmental history of Beringia (northeast Russia, Alaska, and northwestern Canada), and Kamchatka in particular, is poorly known at present due to a lack of records from this region. This is a serious gap in our understanding of past climate change and the nature of climatic teleconnections between the North Atlantic and the

North Pacific. Sea surface temperature suggests a close atmospheric coupling between the North Pacific and North Atlantic until 10,000 cal yr BP, as evidenced by similarities in the NGRIP oxygen isotope record and reconstructed sea-surface temperatures from the western Bering Sea, NW Pacific and Sea of Okhotsk (Max et al., 2012). However, during the last 7000 years sea surface temperatures in the North Pacific have shown more complex variations, suggesting a strong regional overprint (Max et al., 2012). Climate models suggest that while evolution of the Beringian climate through the Holocene was largely driven by global forcing mechanisms, such as the amplified seasonal

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