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Oxygen isotope composition of diatoms as Late Holocene climate proxy at Two-Yurts Lake, Central Kamchatka, Russia

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ABSTRACT

Especially in combination with other proxies, the oxygen isotope composition of diatom silica ($\delta^{18}O_{diatom}$) from lake sediments is useful for interpreting past climate conditions. This paper presents the first oxygen isotope data of fossil diatoms from Kamchatka, Russia, derived from sediment cores from Two-Yurts Lake (TYL). For reconstructing Late Holocene climate change, palaeolimnological investigations also included diatom, pollen and chironomid analysis.

The most recent diatom sample ($\delta^{18}O_{diatom} = +23.3$‰) corresponds well with the present day isotopic composition of the TYL water (mean $\delta^{18}O = -14.8$‰) displaying a reasonable isotope fractionation in the system silica-water. Nonetheless, the TYL $\delta^{18}O_{diatom}$ record is mainly controlled by changes in the isotopic composition of the lake water. TYL is considered as a dynamic system triggered by differential environmental changes closely linked with lake-internal hydrological factors.

The diatom silica isotope record displays large variations in $\delta^{18}O_{diatom}$ from +27.3‰ to +23.3‰ from about ~4.5 kyr BP until today. A continuous depletion in $\delta^{18}O_{diatom}$ of 4.0‰ is observed in the past 4.5 kyr, which is in good accordance with other hemispheric environmental changes (i.e. a summer insolation-driven Mid- to Late Holocene cooling). The overall cooling trend is superimposed by regional hydrological and atmospheric–oceanic changes. These are related to the interplay between Siberian High and Aleutian Low as well as to the ice dynamics in the Sea of Okhotsk. Additionally, combined $\delta^{18}O_{diatom}$ and chironomid interpretations provide new information on changes related to meltwater input to lakes. Hence, this diatom isotope study provides further insight into hydrology and climate dynamics of this remote, rarely investigated area.

1. Introduction

Among terrestrial climate archives, lake sediments have great potential to provide high resolution and continuous information on environmental change (Leng and Barker, 2006). Multi-proxy studies of lake sediment cores contribute to the reconstruction of Late Quaternary climate from the terrestrial perspective allowing for correlation with continuous archives such as marine sediments (LR04 benthic stack: Lisiecki and Raymo, 2005) and ice cores of both hemispheres (i.e. NGRIP: Vinther et al., 2006; GISP2: Mayewski et al., 2004; EPICA Community, 2006). The use of oxygen isotopes in biogenic silica (diatoms) within aquatic sediments relates to milestone work by Labeyrie (1974) and Shemesh et al. (1992) and has become increasingly common since both, lacustrine and marine systems contain siliceous microfossils such as diatoms.

Diatoms are photosynthetic algae with cell walls composed of SiO_2 with a characteristic morphology and two intricately-patterned valves. Their ubiquitous growth in almost all aquatic environments make the analysis of fossil diatoms in lake sediments a particularly useful method for reconstructing spatial and temporal ecological, environmental and climate changes at the local to regional scale (Battarbee et al., 2005). However, it is difficult to estimate the exact palaeoenvironmental parameters from diatom species distribution.

The oxygen isotope composition of diatom frustules ($\delta^{18}O_{diatom}$) extracted from lacustrine sediments is used as a tool to assess changes in temperature, precipitation patterns, or evaporation in lacustrine ecosystems (Jones et al., 2004; Leng and Marshall, 2004; Leng and Barker, 2006). A substantial number of such records from different parts of the world underline the potential for reconstructing past climate changes from the oxygen isotope composition of biogenic silica ($\delta^{18}O_{Si}$).

However, a suitable lake for palaeoclimate reconstruction with oxygen isotopes in biogenic silica needs to be hydrologically known (Leng and Barker, 2006) including recent information on lake water temperature and isotope composition of the lake. Did the lake dry out or change its level during geological periods? What is the input signal to the lake and how did it change through time? What is the seasonality of precipitation to the lake? What is the hydrological balance (open/closed

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