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Holocene oxygen isotope record of diatoms from Lake Kotokel (southern Siberia, Russia) and its palaeoclimatic implications

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ABSTRACT

The oxygen isotope composition of diatom silica ($\delta^{18}O_{diatom}$) from marine and lake sediments is helpful for the interpretation of the past climate and environments, especially when complemented by other proxy records. This paper presents a Holocene oxygen isotope record of diatoms from Lake Kotokel, located 2 km east of Lake Baikal in southern Siberia, Russia. The isotope record displays variations in $\delta^{18}O_{diatom}$ from +23.7 to +30.3‰ from about 11.5 ka BP until today. Comparing the isotope composition of recent Lake Kotokel water (mean $\delta^{18}O = -12$‰) to that of the most recent diatom sample ($\delta^{18}O = +27.5$‰), an isotope fractionation in the right order of magnitude was calculated. The Kotokel $\delta^{18}O$ diatom record is controlled by changes in the isotopic composition of the lake water rather than by lake temperature. Lake Kotokel is a dynamic system triggered by differential environmental changes closely linked with various lake-internal hydrological factors. A continuous depletion in $\delta^{18}O$ of 6.6‰ is observed from early to late Holocene, which is in line with other hemispheric environmental changes (i.e. a mid- to late Holocene cooling). Enhanced evaporation effects and higher relative supply from a southeasterly moisture source explain the relatively heavy isotopic composition in a rather cold early Holocene. In summary, changes in the Holocene $\delta^{18}O$ diatom record of Lake Kotokel reflect variations in $\delta^{18}O$ of precipitation linked with both air temperatures (T_{air}) as well as evaporation effects and, to a lesser degree, meltwater pulses from the mountainous hinterland and changing atmospheric moisture sources.

1. Introduction

Lacustrine sediments have a great potential to provide high resolution and continuous terrestrial records of environmental change (Antipin et al., 2001; Hövsgöl Drilling Project Group, 2007; Brauer et al., 2008; Nakagawa et al., 2012). This is especially true for lakes that did not dry out during glacial periods or which have never been glaciated and existed for a long time as isolated systems (Bezrukova et al., 2008; Jones and Roberts, 2008; Swann et al., 2010; Wang et al., 2010). During the past decades multi-proxy studies of sediment cores from lakes greatly contributed to the reconstruction of late Quaternary climate and environment and allowed correlation with continuous archives stored in marine sediments and ice cores (Jones and Roberts, 2008; Svensson et al., 2008; Mügler et al., 2010).

The use of oxygen isotopes recorded from biogenic or sedimentary hosts within lake sediments has become an increasingly common technique (Leng and Marshall, 2004; Jones and Roberts, 2008). A large number of such records from different parts of the world (Leng and Marshall, 2004; Leng and Barker, 2006; Swann and Leng, 2009), including the Lake Baikal region (Morley et al., 2005; Kalmychkov et al., 2007; Mackay et al., 2008, 2011), have been published and demonstrate the potential for reconstructing past climate changes from the oxygen isotope composition of biogenic silica ($\delta^{18}O_{Si}$) in both quantitative and qualitative ways.

The oxygen isotope composition of diatom frustules ($\delta^{18}O_{diatom}$) extracted from lacustrine sediments is an important tool to quantitatively estimate changes in temperature, precipitation patterns, or evaporation in terrestrial ecosystems (Jones et al., 2004; Leng and Marshall, 2004; Leng and Barker, 2006). Diatoms are photosynthetic algae with cell walls of silica characterized by two

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