Palaeogeography, Palaeoclimatology, Palaeoecology 296 (2010) 185–198

ELSEVIER

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

PALAEO 3

Last glacial–interglacial vegetation and environmental dynamics in southern Siberia: Chronology, forcing and feedbacks

Elena V. Bezrukova [a], Pavel E. Tarasov [b,*], Nadia Solovieva [c], Sergey K. Krivonogov [d], Frank Riedel [b]

[a] Institute of Geochemistry, Siberian Branch Russian Academy of Sciences, Favorsky Str. 1a, Irkutsk, 664033, Russia
[b] Institute of Geological Sciences, Palaeontology, Free University, Malteserstr. 74-100, House D, Berlin, 12249, Germany
[c] Department of Geography, University College London, Gower Str., London WC1E 6BT, UK
[d] Institute of Geology and Mineralogy, Russian Academy of Sciences, Siberian Branch, Koptug ave. 3, Novosibirsk, 630090, Russia

A R T I C L E   I N F O

Article history:
Received 15 January 2010
Received in revised form 18 July 2010
Accepted 21 July 2010
Available online 25 July 2010

Keywords:
Eurasia
Pollen and diatom records
Quantitative vegetation reconstruction
Late Pleistocene interstadials
Last glacial maximum
Younger Dryas
Holocene climatic optimum

A B S T R A C T

Radiocarbon-dated pollen and diatom records from Lake Kotokel in southern Siberia help to reconstruct the environmental history of the area since ~47 kyr BP. Pollen spectra composition and reconstructed biome scores suggest predominance of a tundra–steppe vegetation and variable woody cover (5–20%) between ~47 and 30 kyr BP, indicating generally a harsh and unstable climate during this interval, conventionally regarded as the interstadial within the last glacial. The short-term climate amelioration episodes in the glacial part of the records are marked by the peaks in taiga and corresponding minima in steppe biome scores and appear synchronously with the hemispheric temperature and precipitation changes recorded in the Greenland ice cores and Chinese stalagmites. Transition to full glacial environments occurred between 32 and 30 kyr BP. The interval at ~30–24 kyr BP was probably the driest and coldest of the whole record, as indicated by highest scores for steppe biome, woody coverage <5%, absence of diatoms and reduced size of the lake. A slight amelioration of the regional climate at ~24–22 kyr BP was followed by a shorter than the previous and less pronounced deterioration phase. The late-glacial (~17–11.65 kyr BP) is marked by a gradual increase in tree/shrub pollen percentages and re-appearance of diatoms. After 14.7 kyr BP the climate became warmer and wetter than ever during ~47–14.7 kyr BP, resulting in the deepening of the lake and increase in the woody coverage to 20–30% ~14.5–14 kyr and ~13.3–12.8 kyr BP. These two intervals correspond to the Meiendorf and Allerød interstadials, which until now were interpreted as part of the undifferentiated Bølling/Allerød interstadial complex in the Lake Baikal region. The increase in tundra biome scores and pronounced change in the diatom composition allow (for the first time) the unambiguous identification of the Younger Dryas (YD) in the Lake Baikal region at ~12.7–11.65 kyr BP, in agreement with the formal definition and dating of the YD based on the Greenland NGRIP ice core records. The maximal spread of the taiga communities in the region is associated with a warmer and wetter climate than the present prior to ~7 kyr BP. This was followed by a wide spread of Scots pine, indicating the onset of modern environments.

1. Introduction

Worldwide terrestrial and marine sedimentary archives demonstrate that the last 50-kyr interval in the Earth's history experienced a number of long- and short-term climatic oscillations (Guiot et al., 1989; Vincens et al., 2005; Heusser et al., 2006; Bout-Roumazeilles et al., 2007; Svensson et al., 2008). High-resolution and accurately dated pollen and sedimentary records of the late-glacial/early Holocene interval exist for several regions of Europe (Litt and Stebich, 1999; Allen and Huntley, 2000; Brauer et al., 2008) and East Asia (Stebich et al., 2009), providing important insight into the environmental dynamics in the North Pacific and North Atlantic regions. However, a recent global-scale synthesis of the Holocene climatic data (Wanner et al., 2008) demonstrates a lack of palaeorecords of comparable dating quality and resolution from the vast areas of Eurasia, including Siberia and Central Asia. The dating problem becomes even more obvious, when the pre-Holocene interval of the late Quaternary is considered (Rudaya et al., 2009; Shichi et al., 2009).

Southern Siberia – the region of Russia between ~80–120°E and ~50–60°N – consists of numerous sub-latitudinal mountain ranges and lakes, including Lake Baikal in the east (Fig. 1a and b). The lake sediments are one of the most promising sources of detailed palaeoenvironmental information, which provide an opportunity for bridging the European and Asian palaeoclimate archives and addressing critical questions concerning Quaternary climatology, e.g. reconstructing atmospheric circulation patterns (Williams et al.,

* Corresponding author. Tel.: +49 30 83870280; fax: +49 30 83870745.
E-mail addresses: bezrukova@igc.irk.ru (E.V. Bezrukova), ptarasov@zedat.fu-berlin.de (P.E. Tarasov), nsolovie@geog.ucl.ac.uk (N. Solovieva), paleobio@zedat.fu-berlin.de (F. Riedel).

0031-0182/$ – see front matter
doi:10.1016/j.palaeo.2010.07.020

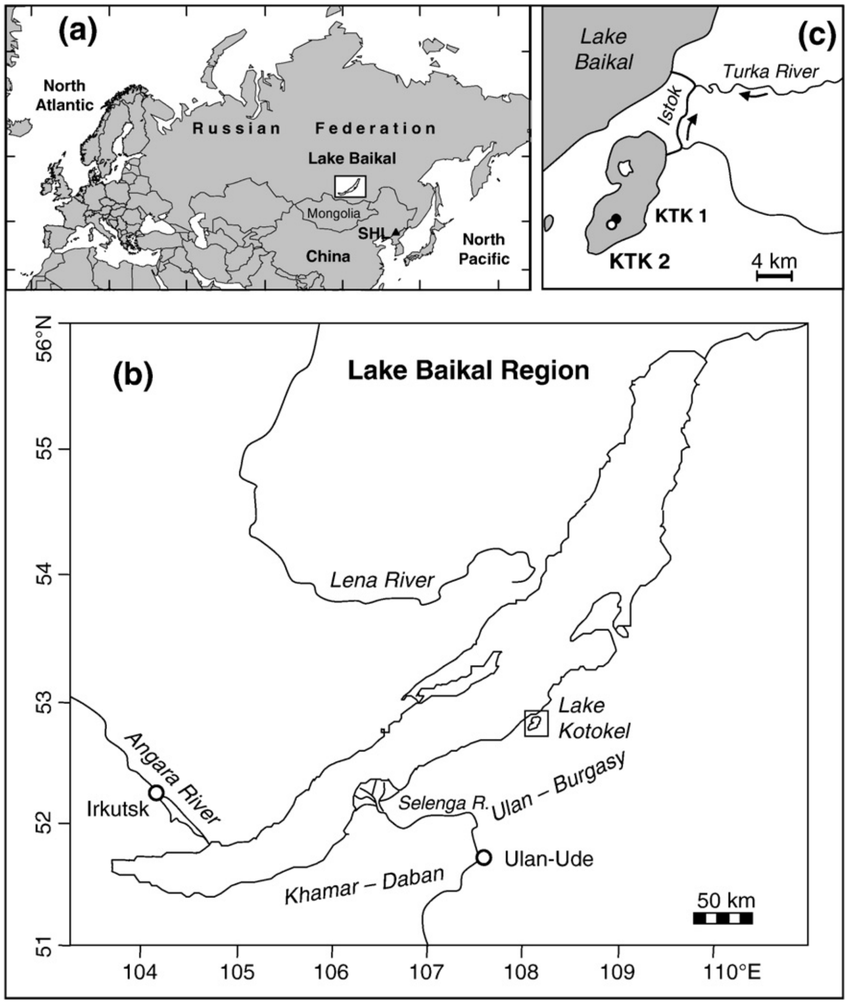

Fig. 1. Simplified maps, which show: (a) northern Eurasia and the Lake Baikal region, (b) the Lake Kotokel study area, (c) location of the 47-kyr long KTK2 core (this study) and the 15-kyr long KTK1 core (Tarasov et al., 2009). The location of Lake Sihailongwan (SHL) is indicated by a black triangle.

2001), and palaeoecology, e.g. discussing local presence/absence of boreal trees and shrubs during the last glacial (Grichuk, 1984).

Numerous publications on the Lake Baikal region (e.g. Kuzmin et al., 1993; Williams et al., 1997; Prokopenko et al., 2002; Shichi et al., 2009 and references therein) presented coarse-resolution (millennial- or multi-century-scale) qualitative reconstructions of the Quaternary environments. Although the long cores from Lake Baikal span millions of years (Williams et al., 1997; Khursevich et al., 2005), research was mainly focused on the Holocene and earlier interglacials (Demske et al., 2005; Tarasov et al., 2005, 2007a; Prokopenko et al., 2007, 2010). However, little is known about glacial intervals due to the problems associated with very low pollen concentrations, poor organic content, low sedimentation rates and poor dating (Horiuchi et al., 2000; Oda et al., 2000). Until recently, even the YD cooling was not unequivocally identified and dated in the Baikal records. This led to various hypotheses suggesting that Lake Baikal could either mask or delay the effect of global change (Bezrukova et al., 2005; Demske et al., 2005; Shichi et al., 2009).

This study presents new pollen and diatom records from Lake Kotokel (Fig. 1c) and aims to reconstruct regional vegetation and environmental history since ~47 kyr BP (1 kyr = 1000 cal yr); to compare it with the oxygen isotope records from the North Atlantic and North Pacific regions; and to discuss the underlying mechanisms of the environmental change in the region. Both time resolution and dating control are substantially improved in comparison to the earlier studies (e.g. Vipper and Smirnov, 1979; Bezrukova et al., 2008; Shichi et al., 2009).

2. Site setting and environments

Lake Kotokel (458 m a.s.l.) has an area of ~67 km^2, a maximum length of ~15 km and a maximum width of ~6 km (Galaziy, 1993). In the west a low-elevated mountain ridge (729 m a.s.l.) separates the lake from Lake Baikal (Fig. 1), and the Ulan-Burgasy Ridge (up to 2033 m a.s.l.) bounds it in the east. The average water depth is 5–6 m, and the maximum depth is about 15 m (Shichi et al., 2009; Tarasov et al., 2009 and references therein).

The regional climate is continental with long winters and a well-pronounced summer precipitation maximum (Alpat'ev et al., 1976). The mean January temperature is −20 °C near the lake, but decreases to below −26 °C with increasing elevation. The mean July temperature is 14–16 °C. The annual precipitation reaches 300–400 mm in the coastal area and above 500 mm in the mountains (Galaziy, 1993). In July and August westerly winds dominating through the year become weak, and southeastern cyclones bringing warm and wet Pacific air to the region cause heavy rainfalls at the eastern branch of the Polar front (Bezrukova et al., 2008). The Atlantic air masses entering the region with the westerly flow may bring precipitation all year round, but mainly during autumn and spring. Dry, cold and sunny winter weather is associated with the high pressure cell centred over eastern Siberia (Alpat'ev et al., 1976).

Modern vegetation east of Lake Baikal is a mosaic of boreal coniferous and deciduous forests (Galaziy, 1993) and swampy communities, widely distributed in the Selenga River delta and