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Climate of the Past Discussions

Interactive comment on "Climate in continental interior Asia during the longest interglacial of the past 500 000 years: the new MIS 11 records from Lake Baikal, SE Siberia" *by* A. A. Prokopenko et al.

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Reply to the Editor P.C. Tzedakis

As advised by the Editor, we (1) clarified the situation with drill cores, sites and new and old proxy records used in our synthesis of the MIS 11 data on Lake Baikal and (2) expanded the MIS 1 – MIS 11 comparison and illustrated this with a Figure (new section 12 and new Fig. 7 in the revised version of the manuscript). The quantitative reconstructions of the MIS 11 climate parameters in SE Siberia are now provided in the revised version.

In addition, we clarified the relationship of the Lake Baikal MIS 11 record to climatostratigraphic nomenclature, as quoted below from the revised version of the manuscript:

The ‘MIS 11 interglacial’ in Lake Baikal continental record corresponds to the event MIS 11c (or MIS 11.3) in the taxonomy of marine oxygen isotope stages (e.g. Prell et al., 1986). It is important to note, however, that unlike the younger substages MIS 9c, 7c, 5c, etc., which correspond to single respective peaks of orbital precession, the marine event designated ‘MIS 11c’ corresponds to two peaks of precession index coincident with an obliquity maximum (Fig. 3). The observed structure of the Baikal proxy records (Fig. 3) and the extended duration of this interglacial (Table 1) are consistent with this orbital configuration. The warmest, most humid and least continental climate in the Baikal region is recorded between 421 and 400 ka; the climate most similar to that of the elapsed portion of the Holocene (yet still warmer and less continental) is recorded in the latest portion of ‘MIS 11c’ between 406 and 396 ka. The end of the ‘MIS 11 interglacial’ in the Baikal continental record at ca. 396 ka corresponds to the marine oxygen isotope event MIS 11.2 (11b).

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Reply to Reviewer A. Mackay

We thank the reviewer for attention and helpful suggestions. Below we answer the key points of the review and explain modifications now included in the revised version of the manuscript.

The revised version of the manuscript addressed both key concerns of the Reviewer. Most importantly, we added quantitative reconstruction of the MIS 11 climate. Also, we highlighted the aspects of orbital configuration not merely from the point of age model construction but also with regard to phasing of proxy responses and the comparison of the MIS 1 and MIS 11 interglacials in the Baikal record.

Answer to comments on section 2, re recently obtained lacustrine records

Many of the recently retrieved lacustrine records fell short of penetrating several glacial-interglacial cycles; in addition, the establishment of robust correlation between lacustrine signals and marine oxygen isotope record is often difficult in these recently recovered archives. We tried emphasizing the recovered intervals of past interglacials rather than a number of sites drilled around the world. The 3-Ma Tule Lake record is certainly one of the longest and North America, however, low resolution and the lack of orbital age model in this record prevents discussing paleoclimate signatures of past interglacials at a desired level of detail.

Answer to comments on section 3 regarding weathering indices and grain size

We minimized the discussion of the prior use of X-ray diffraction patterns in interpreting sediment mineralogy to keep the length of the current manuscript reasonable. This is acceptable because recently we published a synthesis on mineralogical proxies and their prior use (Solotchina et al., 2009, referred to in the text multiple times), so that in the current MIS 11 study we could pick the best mineralogical proxies for MIS 11, rather than discuss all of them in detail. Because grain size record of Ochiai and Kashiwaya (2005) was measured on bulk sediment and thus averages the size of clastic grains AND the size of diatom frustules, we find this 'grain size' data of limited use to interpret changes in the depositional setting. Instead, we address the potential effect of sediment deposition processes on lacustrine proxy signatures and on age model/duration of the MIS 11 interglacial by comparing two drill cores from distinctly different depositional settings.

Answer to comments on section 5 regarding the BDP-99 age model:

We thank the Reviewer for pointing out the need to emphasize that the BDP-99 age model relies on diatom biostratigraphic boundaries previously identified in the orbitally-tuned BDP-96 record. This point is now strengthened in the section on the age model construction.

Answer to comments on section 8: why might BioSi and diatom records differ?

The TOC record differs from BioSi because algae other than diatoms contributed to the lake's primary production; the BioSi differs from diatom record simply because even though diatoms are present in sediments and observed microscopically, in some intervals there is just not enough of them to become a significant component of sediment when measured as percent dry sediment weight (the units of BioSi). The issue of the apparent differences between counted diatoms in microscope slides and total biogenic silica by wet alkaline extraction from bulk sediment was considered "surprising" by Swann and Mackay (2006). In our opinion, it is a matter of sensitivity of the method rather than a significant environmental signal. For instance, the new Figure 7 makes it apparent that even though BioSi contents during the Holocene and MIS 11 are not that dramatically different at the respective study sites, the total diatom abundance values differ by a factor of 2-4. This is due to the fact that during MIS 11 the bulk of the biogenic silica in Lake Baikal was produced by diatoms with small cell (frustule) size. The apparent discrepancy between the sustained level of BioSi and variable diatom abundance during several glacial-interglacial cycles was first highlighted in the earlier work by Khursevich et al. (2001).

Answer to comments regarding section 9 on pollen data:

Earlier we provided interpretation on the qualitative level not because we were 'reserving quantitative data for another publication' but simply because we have not completed this work at the time. We now include quantitative reconstructions (additional Figure 7 and additional section 12) in the revised version of the paper. This additional Figure 7 contains a synthesis of multi-proxy data for both the Holocene and the MIS 11 interglacials; this now eases the MIS 11-Holocene comparison and essentially answers the concerns of the Reviewer regarding the difficulty of comparing Figures from different papers (P1970-P1972)

Answer to comments regarding section 11 and the MIS 11/Holocene comparison

A new Figure and a new section were added to specifically address this comparison

(Fig. 7 and sec. 12 in the revised manuscript, see above).

Answer to Technical corrections:

P1953/4: the sentence has been tightened up

P1953/19: actually, MIS 5e and 7e are four precession peaks apart, MIS 7e and 9e are three precession peaks apart, so “3-4” is more accurate than “4-5”

P1956/1: diatom biostratigraphy of the holostratotype BDP-96-2 record (Khursevich et al., 2001) is reproduced in our Fig. 3 and previously by Mackay et al. (2008, Fig. 3, p. 369), and this is why we refer to that paper as the one dealing with diatoms and/or biogenic silica.

P1956/22: it is certainly possible to discuss the minimum duration even when a record is not complete

P1960: it is in fact hard to model the MIS 11 interglacial (hence “the MIS 11 problem”); comparison to other interglacials of the Brunhes chron certainly makes MIS 11 ‘remarkable’

P1964: reference to "biomarkers" was replaced with “photosynthetic pigments and carotenoids”

P1965: Baikal radiocarbon dates are certainly accurate to within 1 ka (possibly, within 0.5 ka), especially at the best sites, which are least affected by the deposition of organic matter from eroding older sediments in the catchment and/or by turbidites. Recently, we attempted to constrain the appropriate correction value for the Holocene radiocarbon chronologies on bulk sedimentary organic matter in Lake Baikal (Prokopenko et al., 2007).

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Reply to Reviewer S. Desprat

We thank the Reviewer for attention, detailed comments and recommendations. Below we answer the key points of the review and explain modifications now included in the revised version of the manuscript.

1) Re Eurasian palynological records

The sedimentary records at the Iberian margin are very important for linking terrestrial pollen signals of several glacial-interglacial cycles in Europe with multiple marine proxy signals. Yet, even though they contain terrestrial proxies, these are still "marine" records. In the introductory sections (now shortened somewhat in the revised version of the manuscript) we try staying focused on lacustrine records.

2) Clarity on the Baikal records and sites

To help better explain this, we added and appropriate references for each of the previously published data sets to each of the Figure captions; in addition, we clearly indicated which record is new and which is not

3) Methodology

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The section on sample preparation for palynological analysis was expanded, details were provided. We were surprised by the Reviewer's reliance on Granoszewski et al. (2005) and Demske et al. (2005) in assuming that "pollen grains on the species Pinus sibirica and Pinus pumila cannot be separated". It is likely that the lack of long-term experience in working with Siberian pollen records has prevented the cited authors from confidently separating pollen of these two species. Palynologists working in the Irkutsk Scientific Center (Siberian Branch of Russian Academy of Sciences) have a multi-year experience of identifying and separating pollen grains of these species; the collections of Pinus sibirica and Pinus pumila pollen are renewed annually during the fieldwork season. Some helpful characteristics for distinguishing pollen of these two species are listed below:

Pinus sibirica (Rupr.) Mayr. Siberian pine Length of grains is 60-72 μm, 66 μm on average; Height of body – 36-48 μm, 42 μm on average; Height of air sacks - 30-42 μm (35 μm aver.).

Pinus pumila (Pall.) Mayr. – shrubby pine Length of grains is 78-105 μm, 88 μm on average. Height of body – 45-60 μm, 53 μm on average Height of air sacks 35-51 μm, 45 μm on avergate

Pokrovskaya, I.M. (Ed.) (1959). Palynological Analysis. GIGL, Moscow, 1959, 553 pp. [In Russian]

4) Re millennial-scale variability

To better show the correspondence between proxies in the revised version of the paper we added a summary Figure and the new section on the MIS 11/Holocene comparison in the Baikal records (Fig. 7 and sec. 12 in the revised manuscript). In addition, we expanded the discussion of millennial-scale signals in parallel MIS 11 proxy records from two sites and their significance. Questions on millennial-scale links to the North Atlantic and/or correlations with other terrestrial sequences are difficult to discuss in detail without making the manuscript unreasonably long. The linkages to millennial-scale events in Lake Baikal record have been established previously for the Younger Dryas and the MIS 3 interval (Prokopenko et al., 1999, 2001a,b).

5) Re MIS 11/Holocene comparison

A new Figure and a new section were added to specifically address this question (Fig. 7 and sec. 12 in the revised manuscript). This new section and modifications to the discussion in part answer the Reviewer's questions regarding item (5).

6) Various

Redundant paragraphs indicated by the Reviewer were shortened and/or removed entirely; the significance of the alignment between Baikal BioSi and marine oxygen isotope record (here LR04 stack) is highlighted. The understanding of a "full interglacial" interval in Baikal proxy records is clarified as being similar to the present interglacial: dominance of arboreal vegetation in the catchment, expansion of diatom flora in the lake, high level of primary production, somewhat similar behavior of weathering indices and sediment mineralogy.

Re technical corrections

Reference to Abies and in Picea transport, Larix preservation and sub-recent spectra has been added (Bezrukova, 1998)

The difference between BDP-96 and BDP-96-2 has been clarified (two parallel drill cores BDP-96-1 and BDP-96-2 at the drill site BDP-96); appropriate changes to Figures were made.

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Alexander A. Prokopenko (on behalf of all co-authors)

Interactive comment on Clim. Past Discuss., 5, 1951, 2009.