Clim. Past Discuss., 9, C3099–C3104, 2014
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Interactive comment on "Magnetostratigraphy of sediments from Lake El'gygytgyn ICDP Site 5011-1: paleomagnetic age constraints for the longest paleoclimate record from the continental Arctic" *by* E. M. Haltia and N. R. Nowaczyk

E. M. Haltia and N. R. Nowaczyk

eeva.haltia@utu.fi

Received and published: 10 January 2014

REPLY TO REFEREES' COMMENTS REGARDING:

Magnetostratigraphy of sediments from Lake El'gygytgyn ICDP Site 5011-1: paleomagnetic age constraints for the longest paleoclimate record from the continental Arctic" by E. Haltia and N. Nowaczyk. Submitted to Climate of the Past for publication in the special issue "Initial results from lake El'gygytgyn, western Beringia: first time-continuous Pliocene-Pleistocene terrestrial record from the Arctic"

The primary objective of the proposed paper is to present an overview of the magnetostratigraphic data obtained from three long cores from El'gygytgyn from ICDP Site 5011-1 and to interpretate these data in order to set chronological tie-points for the long sediment record. A secondary aim of the paper is to provide the reader with basic information regarding mineral magnetic characteristics measured from sediments enclosed in core catchers, creek sediments and rock samples collected from the catchment (colluvium and bedrock). Mineral magnetic results are presented in the same paper together with magnetostratigraphy in order to provide the reader a wider, but hardly not exhaustive, understanding of the origin and characteristics of magnetic minerals in Lake El'gygytgyn. The aim of the paper, however, is not to provide a detailed analysis of sedimentary mineral magnetic characteristics and processes affecting them. This is because of 1) Sediments enclosed in u-channels were considered archival material and not available for the purposes of this study, 2) The aim of our working group was to reconstruct a geochronology for the sediments of El'gygytgyn from ICDP Site 5011-1, but not to conduct detailed mineral magnetic analyses, which was granted for other working groups. So far, mineral magnetic characteristics of sediments from Lake El'gygytgyn have been investigated by Nowaczyk et al. (2002), Murdock et al. (2012) and Minuyk et al. (2012).

REPLY TO THE SPECIFIC COMMENTS BY L. BROWN (REFEREE#1)

Referee#1 Comment (RC): Page 2546: '...The authors refer to earlier work by Nowaczyk et al (2007) and recent work by Murdock et al (2013) that strongly suggests the magnetite content (as represented by susceptibility variations) is controlled by climate conditions causing dissolution of the oxides. How does this established fact relate to the magnetic remanence story presented here? Does the dissolution of magnetite in the lake environment not alter any of the rock magnetic properties measured here? Does dissolution, complete or partial, alter the remanence of the lake sediments? Is this only a problem in intensity, or could directions be compromised?'

Author Comment (AC): Selective magnetite dissolution during cold climate intervals is

CPD
9, C3099–C3104, 2014

Interactive Comment

associated with reductive lake bottom conditions. Repeated cyclical variations in the magnetic susceptibility (MS) record from Lake El'gygytgyn are interpreted in terms of climatically controlled variations in lake bottom redox state driven by Northern Hemisphere insolation variations. Despite magnetite dissolution in Lake El'gygytgyn sediments is a fact, its implications to the our mineral magnetic results and the magnetostratigraphic record are not easy to resolve. There are several reasons for this. First of all, the major aim of our working group is to establish magnetic reversal stratigraphy to serve dating purposes for the 315-m long sediment sequence. Our research motivations were not designed with a detailed mineral magnetic investigation in mind, because this is the research interest of other working groups investigating sediments from Lake El'gygytgyn. The lake sediment samples we investigate come from core catchers, and because we do not have lithological description of these, so we cannot discuss the measured magnetic parameters in terms of sediment lithology. The magnetic results measured from rock samples collected from lake catchment and creek sediments provide a brief overview of the characteristics of magnetic minerals found in the catchment, which provide information of the magnetic material before it enters the lake. Therefore results from these materials serve a basis for discussions of the characteristics of these materials before happens to magnetic minerals after deposition.

The distribution of lake sediment samples in κLF vs. SIRM plot (Fig. 10), where Pleistocene samples indicate lower concentration of magnetic minerals compared to Pliocene samples, may reflect dissolution of magnetite in our samples. A comment has been added to the text. Interpretation of Day plot (Fig. 11) in terms of magnetite dissolution is not simple. Part of creek sediment samples are closely clustered in the region limited by Msr/Ms values from 0.12 to 0.14 and Bcr/Bc values from 2.8 and 3.3 and part of them plot to the right from mixing line 3. Part of Pleistocene sediment samples also plot right from mixing line 3, which indicates increasing coercivity. Increasing coercivity in the Pleistocene lake sediment magnetic assemblage can result from dissolution of magnetite and relative increase in the proportion of hematite.

CPD
9, C3099–C3104, 2014

With the data available it appears that only the intensity record, not the directional, is compromised by magnetite dissolution in Lake El'gygytgyn. More detailed mineral magnetic analyses, possibly combined with electron imaging techniques and x-ray microanalysis, would be needed to investigate magnetic minerals and their characteristics caused by magnetite dissolution in the sediments from Lake El'gygytgyn.

The sediments supposedly affected by dissolution still carry a magnetization that could easily be measured by a cryogenic magnetometer and that reflect directions according the coring site's latitude. This implies that a little portion of aligned minerals has survived dissolution processes.

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RC: Discussion of the sedimentation rates is another area that leaves a few questions. The authors spend considerable time discussing the high sedimentation rate seen in the lower part of the core, but little attention is given to the lower and very consistent rate seen within the Pleistocene. Additional discussion of why this rate is so consistent, even during geologic time with considerable climatic variations, would be interesting.

AC: In the text we discuss possible reasons for the higher sedimentation rate during Pliocene and lower sedimentation during Pleistocene. Most likely the higher sedimentation during Pliocene is due to more intensive weathering of the newly formed crater structure with steep flanks during the warmer and moister Pliocene climate regime. Erosion of the crater rim slowed down and with time. In late Pliocene sedimentation rate is <20 % (7.78 cm/kyr) of the value when the crater was newly formed (44.51 cm/kyr). It seems that sedimentation rate of pelagic sediments does not change in response to glacial-interglacial cycles of the Pleistocene but remains rather steady. With the available information it is difficult to hypothesize reasons for this. It is possible that the catchment has become matured (i.e. more quickly weathered minerals were removed in the early history of the crater structure) and the steady sedimentation observed for the Pleistocene is in balance with the catchment characteristics and the

CPD
9, C3099–C3104, 2014

prevailing climate, i.e. climate spends more time in glacial than interglacial mode.

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RC: As mentioned by the authors, the cores from Lake El’gygytgyn revealed many areas of disturbed sediment (over 300), assumed to be the locations of landslides within the lacustrine environment. A short discussion of how these were treated with respect to the magnetic measurements would be helpful. Were u-channels collected throughout the core – of disturbed and undisturbed material – and data from some segments removed after measurement? Or were the disturbed areas skipped when doing the paleomagnetic sampling? Were the regions long enough to effect sedimentation rates or correlations of the magnetic signal?

AC: U-channels were collected throughout the cores 1A and 1B. No attempt was made to skip disturbed areas. We now state in the text ”Cores 1A and 1B were sampled continuously using u-channels” to underline that sampling was not based on subjective decision-making by the team of students at the University of Cologne, where u-channel sampling was executed. When sampling core 1C (mainly by E. Haltia), mass movement deposits, at least their coarse-grained bases, were avoided. Mass movement deposits were excluded when creating a composite record, which then reflects (an almost pure) pelagic sedimentation.

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RC: Technical corrections: p. 5078, l. 4 – “lake fills partly” – partly fills l. 11 – replace “could” with can l. 20 – omit “mainly” p. 5079, l. 27 – Replace “This objective in prospect” with - With this objective in mind, p. 5081, l. 5 – replace “hitting” with intersecting p. 5086, l. 2 replace “foots” with base p. 5087, l. 16-19 – Sentence beginning “however< MAD values. . ..” Is confusing and I don’t follow the logic. Do you mean to say samples with multiple components do have higher MAD values? p. 5088, l. 25 – Replace sentence beginning “With an unfortunate. . ..” With: Unfortunately a core break occurs at 122m in core 1A as polarity shirts from normal to reversed. p. 5089, l.

CPD
9, C3099–C3104, 2014

11-13 –Overusing “more” – try to reword p. 5090, l. 1 – move “in catchment rocks” from end of sentence up to first line after polished sections p. 5092, l. 4 – replace “withhold” with hold p. 5097, l. 23-25 – Sentence needs another verb? Or use: However, due to the presence. . ..; also change “suggests” to suggest Figure 1 would be more complete with a location inset; especially useful as this paper will be used by some separate from the rest of the articles. Figure 7 has arrows in “Ores” view of part c – not mentioned in the caption. Figure 11 – Caption, 2nd to last line – add - to the – after plot, so it reads “. . .plot to the right from the theoretical mixing. . ..”

AC: All the technical corrections suggested by the Referee have been completed.

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Interactive comment on Clim. Past Discuss., 9, 5077, 2013.