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Climate of the Past Discussions

Interactive comment on "Testing the potential of OSL, TT-OSL, IRSL and post-IR IRSL luminescence dating on a Middle Pleistocene sediment record of Lake El'gygytgyn, Russia" *by* A. Zander and A. Hilgers

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Answers to the referees' comments We thank the referee for his attentive and detailed review and his constructive feedback. In the following, we respond to his questions and remarks one by one into his text which is labeled with "...".

"One major issue I see is that the authors do not clearly define the aims of their study. In the Abstract it is stated that "This study tests the sediment : the deposition history

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[of the core, derived from other methods]". At the end of the Introduction you say that "The objective of this study was to test different approaches of luminescence dating: : :"; this are opposing statements. Either you test the methods or the age model, but you should not test both at the same time. "

We will more clearly define the aims of our study and we changed the text to sharpen our statements: The aim of the study was to provide chronological information on the sediment core of Lake El'gygytgyn. Dating sediments older than 200 ka is challenging and finally resulted in application of different measurement techniques to evaluate the most appropriate method to produce reproducible results passing the quality criteria typically applied in luminescence dating studies. This is the routine way to start a dating study and the preferable dating method must always be tested in advance, regardless of whether the chronology is known or not. When we started our measurements in 2010, post-IR IRSL was just established and far away from being a standard method but it was finally the only dating method which provided dating results beyond 200 ka. It is generally not usual to present unsuccessful dating approaches but we thought it might be interesting to the reader to learn something about the luminescence properties and the limits of the different dating techniques if applied on sediments like presented here.

"Based on your decision of what is the aim of the article, you will have to re-write part of the Abstract and the entire Introduction (see below). Structure of the article The Title is long and intricate. I suggest a short and more handy alternative such as "Potential of different luminescence methods for dating Middle Pleistocene sediments from Lake El'gygytgyn, Russia"

We will precise the title of the paper slightly but we think it reasonable to name all the different methods in the title to enable an immediate overview of the used methods and to improve the impact of online search results. Our suggestion for a new title is: "Potential and limits of OSL, TT-OSL, IRSL and post-IR IRSL for Dating a Middle Pleistocene sediment record of Lake El'gygytgyn, Russia."

CPD

8, C2915–C2924, 2012

"The beginning of the Abstract is also a bit lengthy. The first two sentences provide information that is not essential for this paper. I suggest omitting."

Done, we will add a small section with regional, geographical and geological information.

"The Introduction does not provide a good positioning of your study in the research field. It requires complete re-writing. The first paragraph should highlight the importance of the research field (I suggest you focus on the need for independent age control for cross-checking age models of long lacustrine archives) followed by a concise summary of literature in this field (luminescence dating of lake sediments). [It might be appropriate to add a separate section where you summarise the principles of luminescence dating and the problems involved in more detail. There, you could also add present text parts introducing the different methods used in this study]. In the Introduction, you should then position your paper and define the research questions you are addressing, followed by an outline of this article. It might be a good idea to move all information on the site to a separate section (e.g., Regional setting). I regard it as mandatory that the two previous studies dating sediments from the lake (Forman et al. 2007; Juschus et al. 2007) are discussed in detail in an early part of the article. Both studies present a number of results important if not essential for this paper, which are almost ignored (i.e. discussion and solutions for the water content problem). I suggest you add a section heading "Methodology" with the subheading "Sample preparation", "Dose rate determination", and "De determination". Please do not mix methodological aspects with results."

We do not intend to present an extensive review on luminescence dating of lake sediments but we will go through the paper and restructure it. With this revision, the major dating studies from Forman et al. (2007) and Juschus et al. (2007) referring to Lake El'gygytgyn will move to an earlier part of the manuscript and will be introduced and presented in more detail. The structure will be improved by adding some more sections and subheadings but we do not think that a complete rewriting of the introduction

CPD

8, C2915–C2924, 2012

is necessary.

“Your present Section 4. is highly chaotic. Please move all technical aspects into the Methodology section. Also, please move all literature review of the different methods into one section together with the general introduction to luminescence dating. This could be placed, for example, after the general Introduction.”

As the aim of the study was not to compare the potential of all the methods we finally had to test, it does not make much sense to put all methodical aspects in one section on methodology. To allow the reader to follow the evaluation process we had gone through it seems more appropriate to explain why we started with one technique, why we decided that it failed and why we turned to the next technique. The aim of this study is not to evaluate the methods as such but to find the appropriate one to handle the sediments under study here.

“Detailed comments 4781, line 18ff: The statement that “Only very few studies have focused in luminescence dating of lake sediments: : :” is a bit misleading. There has been actually quite some research starting with Kronborg (1983, PACT 9) and Berger (1988, QSR; 1990, J. Geophys. Res.) and some dozend afterwards. I agree it is not very much but also not “ver few” (implying <10).“

To avoid further misunderstanding, the sentence will be reworded.

“The following leaves the impression that luminescence dating of lake sediment is highly challenging but none of the papers I am aware of (ca. 30) reports any major problems. The greatest challenge I see is sediment moisture but I have seen very little evidence for radioactive disequilibrium so far. Turbidites are usually identified when logging cores and can hence easily be avoided.”

We will reword this section and rework the dosimetry chapter.

“4784, line 24f: Were exactley 157 g measured at both labs?”

We will gather information about this.

CPD

8, C2915–C2924, 2012

"4784,1ff: Please add literature explicity showing disequlibrium in water-lain sediments. All siginificant disequilibrium I am aware of is related to either the presence of organic matter or carbonates. Do you have any of this in your sediments? Please also present an example showing that the effect of disequlibirum is substantial (cf. Preusser and Degering 2007, QI)."

The distribution of carbonate and organic contents in Lake El'gygytgyn sediments is not homogenous but is closely connected to climatic conditions and sedimentation units (Schwamborn et al. 2012, Melles et al. 2007). During sample preparation, the samples showed very low carbonate contents but some samples had a medium reaction to hydrogene peroxide, indicating an at least perceivable organic content. To demonstrate the potential effect of a disequilibrium in the uranium decay chain, we will present some model calculations with minimum and maximum values and specify our statement about the impact on our dating results.

"4784, 5ff: You imply that the gamma spec in Dresden is not sensitive in the high energy range, which is simply not true. In contrast to the gamma spec in Cologne, this machine is ADDITIONALLY sensitve in the low energy range (correctly saying the bachground level is lower). Since you are concerned about disequilibrium, you should have measured all samples in Dresen as your machine cannot detect this."

This is a misinterpretation, we did not want to imply, that the gamma spec in Dresden is not sensitive in the high energy range but stated that we need the information from the gamma spec in Dresden because our gamma spec in Cologne is not sensitive enough to quantify 234Th which has its main emissions in the lower energy spectrum. To avoid any further misunderstandings we will rephrase this paragraph.

"4784, 12ff: Please add reference showing that radium is mobile in lake sediments. You don0t observe a "decrease" but "lower values" (it could be an increase of 238U/234Th). What are "early isotopes"? You should decide wheather or not the disequilibrium is significant or not. Please carry out some calculation demonstrating the effect of dise-

CPD

8, C2915–C2924, 2012

qulibrium on your samples. We should not assume if it is “massive” or not.”

As mentioned above, we will rework the dosimetry section but we will not implement an extended discussion about mobility and solubility of nuclides of the uranium decay chain since this is basic knowledge that can be looked up in relevant text books like Umweltradioaktivität, e.g. Kemski et al. (1996) and Rühle (1996). Nevertheless we will add some model calculations as mentioned above, for example: Uranium contents determined for the Lake Elgygytgyn sediments range between 2.85 and 6.17 ppm. Total dose rates range between 2.2 and 3.8 Gy ka-1 for polymineral samples and between 1.9 and 3.1 Gy ka-1 for quartz samples using the measured water content. An underestimation of about 1 ppm Uran would result in age overestimations of about 6 to 8 %.

“4786, 8: :did not improve the data set and was hence rejected.” Please be a bit more specific.”

Another approach using the early background (EBG) subtraction method (Ballarini et al., 2007) with an integral of 0–0.4 s for De determination and a background integral of 1.0–1.4 s, as described by Lowick and Preußer (2011), did not improve the dataset. The EBG subtraction does not change the values calculated using a late background (LBG) subtraction and this suggests that the OSL signal is dominated by the fast component for which the SAR protocol was designed (Wintle and Murray, 2006). Using the EBG subtraction method is of no benefit then and was therefore rejected. It would only reduce the signal intensity and increase uncertainties.

“You are in this line using the proper writing of my name but I am ever since publishing using my pseudonym “Preusser”.”

This will be corrected.

“4790, 22ff: Your statement “: : :polymineral fine grains are not suitable for the standard SAR-IRSL50 dating protocol” is not supported by published evidence (Forman et

CPD

8, C2915–C2924, 2012

al. 2007, Juschus et al. 2007). It is based on the dose recovery tests for different preheat temperatures, which are using relatively low temperatures compared to previous studies. In fact, this is not a proper preheat test that would support the statement that insufficient preheat will deliver only minimum estimates. Your plateaus are falling and not rising! I consider your statements regarding this approach as not being sufficiently supported by data."

We have repeated the DRT-PHP test in the meantime and this new plateau test resulted in a stable PHP between 250 and 290 °C and measured to given dose ratios between 1.01 and 1.05. We therefore assume a technical problem during the measurement of the first pre-heat plateau and decided to measure the samples with the standard SAR-IRSL50. However, a good DRT does not ensure correct dating results, especially for samples beyond 200 ka, i.e. Juschus et al. 2007).

"4796, 21ff: I think that partial bleaching is not a likely explaination for the observed overestimation as the sediment input is (mainly?) aeolian. This is shown by the fact that you could extract quartz from the sediment – but the bedrock in the surroundings of the crater lake is basaltic and does not bear quartz. I have also worked on sediments from the direct surroundings of the lake and these have no quartz and terrible IRSL properties (e.g. fading rates between 5-10 g)."

In this context, we do not explain the overestimation of the 3 samples with partial bleaching but simply mention, that fine grain samples do not allow conclusions about the bleaching level. The referee might be right with his assumption, that some part of the sediment input is of aeolian origin and many of the minerals have experienced a long distance transport, but a large component is presumably also of local origin. Wennrich et al. (2012) described 26.9 % quartz, 26.0 % Plagioclase and 10.4 % K-feldspar from a bedrock sample of the Ergyvaam Formation and 26.1 % quartz, 20.8 % Plagioclase and 5.5 % K-feldspar for the fine grain sediments from the central basin. They observed an obvious enrichment of quartz in the silt fraction and an enrichment of feldspar in the coarse fraction of the sediments and explain this by cryogenic weath-

CPD
8, C2915–C2924, 2012

ering processes within the active layer of the permafrost in the lake surrounding. If this scenario is transferable to the earlier sedimentation history of the lake, a comparably large local component transported as suspended load is likely and an insufficient bleaching is not completely implausible. Juschus et al., 2007, 2009 and Niessen et al., 2007 have described mass movement deposits and debris flow deposits, indicating a significant sediment transport from the shelf to the deeper basins. Schwamborn et al. (2012) have observed an virtual absence of fine grain material in the alluvial fan delta on the western margin of the lake. They conclude that the finer portions of the sediment load are transported further downslope where they build up graded layers in the deeper basin, which define the basin floor record. The feldspar and quartz minerals hence represent a mixture of local, re-deposited and long distance transport minerals (i.e. Fedorov et al. (2012, Fig. 4))

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