Protocol of revising the manuscript on:
Alluvial fan dynamics in the El'gygytgyn Crater: Implications for the 3.6 Ma old sediment archive
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Clim. Past Discuss., 8, 2187–2222, 2012

Thank you for the careful reading and the thoughtful comments provided by the two reviewers! They were insightful and constructive and the corrections based on them have certainly improved the quality of the revised manuscript. We have reorganized some sections, have reorganised some figures, included new figures and revised the text accordingly. We hope this will meet the reviewers` requirements.
In the following (see supplement) we list the individual remarks by the reviewer and our responses. Partly the comments of the two reviewers overlap, so do the responses to the individual comments.
Changes made in the revised manuscript are marked in yellow.

Sincerely,
Georg Schwamborn (and co-authors)

RCI (First reviewer's comment)
The lake level chronology becomes important later in the paper (5.2), and the authors should devote a few sentences to explaining this chronology earlier in their presentation, possibly in Section 2. Placing the terrace levels in Figure 2 and adding relevant date/elevation sequence to the log information (e.g. Fig. 8) would further help the reader visualize the sequence.

AC (Author's comment)
We modified Fig. 1 (instead of Fig. 2) in a way that hopefully meets the reviewer's remark and we modified the subtitle of Fig. 1 accordingly: the dashed black lines indicate shorelines of the Middle Pleistocene (outer) and the Late Pleistocene (inner) according to Glushkova and Smirnov (2007). The dashed white line marks the lake level of the LGM according to Juschus et al. (2011).
As suggested by the reviewer we inserted the following sentences in Section 2: More past lake level reconstructions come from Glushkova and Smirnov (2007), who mapped a Middle Pleistocene-aged shore line at 540 m and a Late Pleistocene-aged shore line at 500 m. The latter one matches the reconstructed Allerød-time shore line mentioned above.
As suggested by the reviewer we modified Fig. 8 by adding a notion on the lake level change events to the log and modifying the figure's subtitle accordingly: LPF = Late Pleistocene flooding event; MPF = Middle Pleistocene flooding event.
In section 5.2 (Permafrost formation in the EAFD and lake level history) we added some notion to refer to the modified Fig. 8 with respect to the core layers that are interpreted as flooding events linked with the LPF and MPF lake levels. They are marked in yellow.

RC I
… the abstract should begin with a sentence or two describing the motivating research questions and/or working hypotheses.

AC
We added the following sentence to the beginning of the abstract:

The combination of permafrost history and dynamics, lake level changes and the tectonical framework is considered to play a crucial role for sediment delivery to El'gygytgyn Crater lake, NE Russian Arctic. The purpose of this study is to propose a depositional framework based on analyses of the core strata from the lake margin and historical reconstructions from various studies at the site.

RC I
Page 2195, line 5 and onward: there should be a fuller explanation of how pollen assemblages are correlated amongst lake and EAFD core sediments (also, Section 4.5). The reader is not otherwise able to evaluate how well things are correlated here - this would seem to be an important linkage in the study. A figure illustrating overlapping assemblages in 5011-3, 5011-1, Lz1024, and Lz1028 or perhaps some quantitative index of similarity would be helpful.

AC
A figure has been added showing the correlated pollen stratigraphy.

RC
ln. 14: there seems little to discuss in Figure 7, beyond "no obvious relation". Suggest either explaining further why this result is unexpected or important to the study, or consider using this figure slot for a dating (and/or possibly the lake-level framework), as discussed above.

AC
Figure 7 has been removed. Now there is a new figure (Fig. 6) displaying the grain size curves for the individual units.

RC I
2197 ln. 16 onward: Much of what is discussed in this paragraph cannot be readily discerned in the Figure 5 (Min. Ratios). Consider re-scaling to better show the patterns.

AC
The mineral ratios have been re-scaled accordingly.

RC I
2200 ln. 16. Figure 9: Examining Figure 4 from Melles et al (2011), I get the sense that the bedrock basin floor is considerably (300 m?) deeper than shown here. Indicate if this earlier interpretation has been revised, or otherwise resolve these two diagrams.

AC
The figure has been revised accordingly; we removed the underlying bedrock to avoid further confusion and added scale.

RC I
2200 ln 17-18 - "..a deeper position that forms the foreset beds..". Might these be bottomset beds, as in a Gilbert-type delta? Or could they be upper strata from a Pliocene Unit, as could be interpreted from the Melles et al. 2011 (Fig. 4) diagram?

AC
Correct - we corrected to "bottomset" beds in the text. The Melles et al. 2011 (Fig. 4) diagram was a preliminary interpretation without a true knowledge about possible Pliocene strata in core 5011-3. This is also true for Melles et al. 2012 (even though published). We prefer not to use these references for further interpretation of the core.

RC I
2201 ln. 12 and onwards: generally, this paragraph could be better structured; the discussion of the fate of fine sediment should be moved to its own preceding paragraph – as it is, it detracts somewhat from the interpretation presented here. You could also tie in the relationship between catchment mass wasting and lake core turbidite beds (2206 ln. 20 onward) in this paragraph.

AC
The discussion of the fate of fine sediment has been moved to its own preceding paragraph as suggested. The relationship between catchment mass wasting and lake core turbidite beds (2206 ln. 20 onward) has been tied in this paragraph as suggested.

RC I
2201 ln. 13-14: "relatively massive nature of the sand" in Unit 3 suggests mass wasting, though Figure 3 and Section 4.2 indicate at least two horizontally stratified sand units. Section 5.2 discusses transgression deposits in this unit. You may want to re-frame your interpretation here to better explain the variability and complexity of this unit, given the imprint of lake-level changes.

AC
We have added the following sentence to better clarify the sediment interpretation:
The variability and complexity of this unit is associated with a depositional setting in the near shore environment where lake-level changes have caused an imprint on the sediment deposition. This includes reworking of sediment in the surf zone or by ice shoving. Periodic snowmelt impulses carry migrating lobes of coarse-grained material into the shoals. Sediment cores extracted from the modern near shore zone below 10 m water depth show sandy material alternating with pebble-rich layers in the upper 2 core meters (Juschus et al. 2011).
Much of this paragraph is now restructured and some additional notes have been added.

RC I
2201 ln. 20 - how is the suspended load lost via wind? Do you mean the finer sediment fractions on banks or exposed bars, before potential entrainment by water flow?

AC
We replaced “wind” by “waves”. Initially the notion on “wind” was meant in a more general way including also subaerial depositional settings. The note can be left out for the interpretation of the subaqueous part of the core, where waves and currents act on the sediment deposition.

RC I
2202 ln. 4. Lz1024 should be on the map (e.g. Fig 1, 2 and/or 9), and its strata and dating framework should be introduced along with 5011-1, earlier in the paper. Also, consider incorporating the dating framework of PG1351.

AC
We added the position of Lz1024 to Fig. 1, since there are some links to this core in the manuscript. We leave out the dating framework of PG1351, since there is no particular reference to this core in the manuscript anymore. The “mass movement issue” is covered in detail in the Juschus et al., 2007 and 2009 papers. There is no need to refer to the Melles et al., 2007 paper anymore and this reference has been deleted from the manuscript.

RC I
2202 ln. 12 onward: it would be helpful to provide some basic quantitative measures of channel and/or fan surface slope, channel widths, etc. This allows the reader to compare, roughly, this system to others in their experience. Words such as 'coarse' or 'steep' (throughout the paper) should have some frame of reference. Any other observations of the modern channel sedimentology (Dmax, fining gradient, gravel/sand transition, etc.) would also help to characterize the system.

AC
We modified accordingly.

RC I
2203 ln. 26-27 - "..documented in unit 3 of the core." This should be introduced clearly in the previous section.

AC
The addressed section has been restructured.

RC I
Technical corrections related to wording and meaning.

AC
We corrected everything from the list accordingly.

RC II (Second reviewer's comment)
1. Introduction
The introduction describes about previous studies of Lake E sediment and does not provide general sedimentological information about alluvial fan delta. Therefore, the general scope in terms of alluvial fan delta sedimentology remains unclear after reading the introduction. Earlier sedimentological works on alluvial fan delta should be reviewed, and general information, question, and purpose on the alluvial fan delta is necessary in the introduction.

AC
In response to this remark we modified the title of the manuscript to avoid a wrong anticipation; the purpose of the manuscript is not to document a detailed study on alluvial fan architecture, but to provide insight into catchment sedimentation processes in the El'gygytgyn Crater and its consequences for interpreting the lake record. This study took place in the frame of studying the El'gygytgyn site as highlighted with the collection of papers in this special issue.

RCII
2. Geographical setting
The authors should explain tectonic setting. The authors wrote tectonic framework of the Lake E in the discussion section. Such background information should be provided in this section.

AC
Done. We moved the figure showing the tectonic setting (formerly Fig. 10; now Fig. 3) and the relevant text part into this chapter.

RCII
… ice cracks were present in the studied frozen core. This indicates the possible destruction of primary sedimentary structure and sediment grains. This raises questions on the utility of standard sedimentological analysis. The authors should evaluate what kind of analytical data are reliable, and what kind of data are not reliable for the sedimentological interpretation.

AC
We added a notion on that in the "Material and Methods" section.

RCII
4.1. The modern environment
They need to show more detailed data of modern sediment with figures (e.g., grain size data, photographs, etc.).

AC
This topic is covered fairly comprehensively in another manuscript of the special issue on El`gygytgyn studies (Wennrich et al., 2012). We added a notion on that to refer the reader to this article.

RCII
4.2. Lithostratigraphy
Lithostratigraphic description is not enough. Provide detailed description of the lithostratigraphic unit boundary. Lithological changes represent changes of formative processes in the Lake E sedimentary succession. This is critical in discussion of sedimentary dynamics of this paper. Other points which the authors should describe are sand/gravel boundary in each unit, modal composition of gravel, thickness of sand layer, color of sediment in Unit 3 and Unit 4.

AC
We added more detail in the text as suggested by the reviewer. In addition, there is now a new figure (Fig. 6), which displays the downcore gravel/sand boundary and the modal composition in the units 1 to 4.

RCII
4.3. Granulometry, mineralogy, and organic matter content
I would like the authors to show stratigraphic trend of mean grain-size and sorting in Fig. 5. …

AC
After adding the new Fig. 5 showing the downcore gravel/sand boundary and the modal composition in the units 1 to 4, we hope that downcore grain size trends are covered in a sufficient way. We deleted the first paragraph in section "4.3" and changed the section title into "4.3. Mineralogy and organic matter content" …, since the granulometry related contents have become obsolete after a more detailed description about grain size characteristics in the previous chapter. The previous chapter has been renamed accordingly into "4.2 Lithostratigraphy and granulometry".

RCII
4.4. Ground ice characteristics

I think first paragraph of this section could be incorporate with the section 4.2. Presence of ice cracks in the core could destroy sedimentary structure and sediment grains. The authors should describe whether the ice cracks destroy primary sedimentological information or not.

AC
We acknowledge this point by putting a particular emphasis on the fact that primarily most of the core (i.e. units 1 to 3) has been deposited under subaquatic conditions. We explain now in section 5.2 that this subaquatic portion has escaped frequent freeze-thaw cycles, which is typical for the soil. Frequent freeze-thaw cycling and associated physical weathering has happened in the deposits of unit 4 only, which accumulated under subaerial conditions. In fact, here we find an increased portion of fine grained material (sand and silt), which presumably resulted from frost weathering action. The post-depositional freezing of core units 1 to 3, which only happened twice after two episodic flooding events, did not produce a grain size fraction that is typical for longterm frost weathering action.

RCII
4.5 Pollen content
It is necessary to provide a full pollen diagram…

AC
A full pollen diagram is now included and the time-control in greater detail. Next to this a reference is made to the article by Andreev et al., 2012, which covers the pollen stratigraphy of the core and the correlation with other cores from the area in detail.

RCII
As the general scope of this paper is unclear, discussion on the global significance of the studied core sediment is unclear.

AC
Our paper is not meant to be of global relevance, but of regional significance. This is given by the fact that the paper is part of the multiple approach to study El`gygytgyn Crater lake and which is now documented in this special issue in Climate of the Past. To make it more clearly we emphasized our objectives in the beginning of the abstract.

RCII
5. Discussion
I think the important reference, Galloway (1975), is not suitable for discussion in this paper. … The authors should consider the alternative model for the interpretation.

AC
We now use Nemec (1990), as a reference that better mirrors sediment processes in the terrestrial realm in contrast to the marine setting described by Galloway (1975).

RCII
5.1 Interpretation of the depositional environment
… I think Fig. 9 is not necessary in this paper. Instead, I recommend the authors to illustrate age-depth plot for the core 5011-3.

AC
We admit that the scheme is a simplistic one (and emphasize it in the revised manuscript). Still, we feel that much of the interpretation presented in Fig. 9 is justified. For a more

complete explanation of the lake floor environment we have added the following notion: “In El’gygytgyn Crater lake such mass movements on the lake floor have been identified based on seismic and core data (Juschus et al., 2009).” This additional reference should help to support this Figure. This reference is now also included into the figure and the subtitle of the figure.
We do not construct an age-depth plot for the core 5011-3, since apart from the upper 10 m the dating is poorly constrained. Instead, we have included a new Figure (Fig. 10) that shows changing Quaternary lake levels with respect to the coring site.

RCII
Lithological evidence of core sediment is necessary in order to confirm wave-dominated processes.

AC
We agree on that and have deleted the relevant statement.

RCII
The authors should describe their method [“lake level changes”] based on core sediment analysis. … An illustration of relative lake level changes is necessary.

AC
We use the known lake level history for the interpretation of some of the sediment layers in our core (not the other way round). Nevertheless, we now provide an illustration of relative lake level changes (new Fig. 11) with respect to the core position.

RCII
5.3 EAFD formation and regional tectonics
… autostratigraphy is critical processes for the delta evolution. The authors need to consider alternative models and explain why they are rejected based on lithological evidence.

AC
An extranote on autostratigraphy and/or other forcings (i.e. climate, tectonics) has been included now in the text. However, we strengthened our interpretation that links sediment variations in our core (namely “the sand layers”) with known past lake level changes. We included a new figure into the manuscript that is supposed to back-up our interpretation and illustrates the connection between lake level changes and core lithostratigraphy.

RCII
Fig. 3: What is the difference between “sand” and “layered sand”? I speculate that “sand” of this figure show sand layer with amalgamated base. Color of layered sand is strange. Sand should use yellowish color.

AC
We revised that figure.

RCII
Fig. 5: This figure should be illustrated with the lithological log. Below 90 m-CSF, the authors did not conduct measurements of TOC content? Or TOC was not detected?

AC

We reorganized that figure. The curves of mineralogical ratios and TOC are now part of Figure 4, which has a lithological log. We specified how and where TOC measurements were conducted at the relevant place in the figure and in the section of the manuscript.

RCII
Fig. 6: Please explain specific information of this figure.

AC
The graphs showing the mineral ratios have been re-scaled and are now displayed in a better resolution in Figure 4. More notions have been added to the manuscript in order to explain the mineral ratios in the section 4.3 Mineralogy and organic matter content. We have created an own figure focusing on grain size data (new Figure 6). This follows the suggestions to show modal composition and gravel-to-sand-boundary (see above).

RCII
Fig. 8: I would like the authors to compile the pollen zone with available numerical age data.

AC
A new figure showing the pollen zones has been included.

RCII
Fig. 9: As mentioned above, the authors should reconsider about this figure.

AC
This figure has been modified and now includes the reference to Juschus et al., 2009. This study based on seismic and core data is thought to fill the spatial gap between the two cores 5011-3 and 5011-1. Moreover, we softened the subtitle of this figure to make clear that this figure is a simplistic view.

RCII
The tectonic framework…this figure should be Fig. 2 or Fig. 3 in this paper.

AC
We moved this figure to the front; now it is Fig. 2 with the associated text in the manuscript.