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Interactive comment on "Seasonal deposition processes and chronology of a varved Holocene lake sediment record from Lake Chatyr Kol (Kyrgyz Republic)" *by* Julia Kalanke et al.

Julia Kalanke et al.

juliak@gfz-potsdam.de

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We thank reviewer #3 for his appreciation of our work and his valuable suggestion that we include in our revision.

Referee comment: 1. There are several points in Section 5 (eg. Line 298; Line 401; Line 435) that refer to the role of glacial meltwater in the supply of detrital clastic material into the basin and their presence in the varve microfacies. Is it possible to include the area that is/was glaciated in Figure 1? There is no mention of this in Section 2 (Study Site) other than meltwater run-off and it is not clear if this is from a glaciated catchment. A little more detail on this would be helpful to the reader. Also permafrost

thaw is considered a possible contributor to older carbon in the lake water to explain the reservoir but this is not described within the site context. Could this also be included in the site context?

Author's response: The area displayed in figure 1 does not exhibit recent glaciers, but several glaciers exist further north-east on the central At Bashy range (Narama et al., 2007) at a level above $\sim$4000 m a.s.l. and some of them drain into the Chatyr Kol via the Kegagyr River. Recent glaciers are also located on the western Torugat range (not shown in Fig.1) but these glaciers do not drain into Chatyr Kol. We clarify glacier information in the chapter "study site". We further extend the formulation 'glacier and snow meltwater' because runoff includes also seasonal snowmelt. Finally, a photo of field observations displaying thermokarst/permafrost thawing structures observed at the Maloye Lake in < 2 km distance from Chatyr Kol is added.

Author′s change in manuscript: Line 65-68: The modern lake, which has a maximum length of 23 km, a width of 10 km and a maximum depth of 20 m in its western-central part, is endorheic and separated from the neighboring Arpa river basin in the north-west by a moraine (Shnitnikov, 1978). The moraine originated from glacial advances of unknown age from the western Torugat range. Present day glaciers on the Torugat and At Bashy range exist above $\sim$4000 m a.s.l. but only some of the At Bashy glaciers drain into Chatyr Kol via the Kegagyr River. The lake is moreover fed by convective rainfall events in summer (Aizen et al., 2001). A shallow watershed hinders outflow to the east.

Line 83-84: The permafrost level is located at a depth of 2.5-3 m in the littoral coast zones and the lake is covered by ice from October to April (Shnitnikov, 1978). Modern permafrost thawing results in instable shores visible at the Maloye lake located < 2 km to the South of Chatyr Kol(Fig. 1 Photo) and the development of small ponds on the shallow south-western shore of this lake and lake Chatyr Kol during the summer season.

Referee comment: 2. Microfacies section – the introduction to section 4.2 might be considered contradictory in that Line 166 states 'consists of mainly clastic lamination' but Figure 4 has clastic material in all of the microfacies. Later in the paragraph, it is stated that 'sub-types were named according to the order of their dominant contents', which has two occasions where either organic or calcitic laminations dominate the microfacies making the earlier statement invalid. If the first sentence said 'Clastic material is present in all of the macroscopically visible laminations below 63.0 cm depth, and intercalates with calcitic, aragonitic and organic sublayers that build-up cyclic successions. And then the final three sentences can remain and it is a truer reflection of the microfacies. Also it could be useful to state how the subtypes are named according to the their dominant contents (I assume that the dominant component comes first?).

Author's response: The referee is right that our formulation was not sufficiently clear and we will change the introduction to chapter 4.2 accordingly. We only want to point out, that (i) all six varve types include a clastic sublayer and that (ii) the differentiation of varve types relies on the composition of the alternating sublayers and the dominance of sublayers within a varve cycle. The latter criterium is used for varve type names. For example, the clastic-organic varve type is characterized by the dominance of the clastic sublayer, while in the organic-clastic varve type the organic sublayer prevails. The varve types names are not related to the order of sublayer succession within the varves. In addition to the revision of the introduction of chapter 4.2, we re-name the subchapters from 'Clastic-organic laminae' to Clastic-organic type' etc. to clarify that we are not presenting individual sublayers but varve types.

Author′s change in manuscript: Line 166: Microscopic sediment analysis revealed, that clastic sublayers are present throughout the finely laminated sediments below 63.0 cm depth (Fig. 4.1). These clastic sublayers are variably intercalated with calcitic, aragonitic and organic sublayers and thus form different types of cyclic successions. In total, we classified six different types of sublayer successions as described below. The name for these types reflects the dominant sublayer for each of the six types.

For example, the 'clastic-organic type' is characterized by the dominance of clastic sublayers, while in the organic-clastic type organic sublayers dominate. The names are not related to the order of sublayer succession within each type.

Referee comment: 3. Figure 4 is good at showing the broader differences in the microfacies in each of the LZ's. However, the detail in the schematic (varve depositional model) is difficult to evaluate within the images from the thin sections at their current magnification. Could a higher magnification image that reflected more closely the elements shown in the schematic also be included? Also a key for the symbols in the schematic is necessary, and I note that there is no obvious winter layer detected in the clastic-diatom and clastic organic/clastic aragonitic microfacies. Related to this, in the text is 'section 4.2.1Clastic-organic laminae' the lower schematic or the upper schematic? What is the difference between these two? It appears to be the aragonite and this is what is identified in the text, but the clastic-organic coming first in the Figure confuses this distinction. It would also be helpful that the order that is in the text was followed by the order in the figure to remove this confusion.

Author's response: We include additional microscopic images at higher magnification in the supplement. (Suppl. Fig. 2) In addition, we include μXRF element mapping of selected thin sections in order to better visualize the varve facies (new Fig. 4.2). Keys/Legends will be added for the used symbols in figure 4. Winter layers in clastic-organic/clastic-aragonitic varve deposition model are added in fig. 4. The reviewer is also right that the relation of schematics in figure 4 to section 4.2.1 is not clear. Therefore, we modified fig. 4 accordingly.

Author′s change in manuscript: We will change the order of the sub chapters in 4.2 according to figure 4.1 and revise the varve schemata label in fig 4.1.

Referee comment: 4. Section 5.4 provides a nice explanation of the broad environmental changes that lead to variations in the microfacies through the sequence. A criticism is that it is difficult to evaluate the thickness data of the different microfacies against the text, which starts by describing the frequency of the different microfacies in each of the Lithozones. A suggestion that could help the reader and also highlight the differences in microfacies that are observed between the LZ's would be to include on Figure 9 some percentage bar charts that collate the relative proportion of the different microfacies in each LZ. Such that for LZ I with clas-org 57%, clas-calc 29% and clas-arag 14%, clas-dia 0%,org-clas 0% calc-clas 0%. Then using the same order for the microfacies there could be a bar chart for LZ II, LZ III etc and then if aligned vertically the reader could draw a direct comparison between LZ's seeing the changes through the sequence. This could be a column on the right hand side of the current Figure. It would also be useful to arrange the thickness graphs for each of the microfacies in the same order as their description in Figure 4 and in the text of Section 4.

Author's response: The referee is right and changes in figure 9 have been made.

Author′s change in manuscript: Instead of using bar plots, pie charts are displayed for each lithozone in figure 9. The thickness graphs in figure 9 are ordered according to the order in the text in chapter 4.2.

Technical corrections:

Referee comment: Throughout the manuscript superscript is used inconsistently when it should be used e.g. for 14C. Lead-210 is used interchangeably with 210Pb, and cm-1 should be cm-1. Spaces should be included between ages and the ± symbol.

Author's response: agreed. The text will be changed accordingly.

Referee comment: Line 39 – states '.....which cover approximately 7,100 cal years BP....' , is that the duration of the record or the base of the sequence is dated using varves to 7,100 cal years BP. Is this also the case for Lake Sugan and is this also in cal yrs BP?

Author's response: The lake sediment record of Lake Telmen extends back to 7,100 cal years BP according to AMS radiocarbon dating of bulk sediment and pollen extracts.

Varves in the Telmen record were only found in sediments younger than 4,390 cal yr BP (AMS) and have not been counted because varve preservation is reported as discontinuous. Instead, Peck et al. (2012) extrapolated average couplet thickness for an indirect varve age estimate. For Lake Sugan, the authors counted laminae couplets on digital images of split core surfaces and compared these with 210Pb dating (CRS). The ages were not provided as cal yrs BP.

Author′s change in manuscript: In Kyrgystan, varves have been only reported from Lake Sary Chelek for the short time interval from ∼1940′s to 2013 (Lauterbach et al., 2019). Other varved records in the wider region are Lake Telmen in northern Mongolia which exhibits discontinuous varved intervals during the last ca. 4,390 cal years BP (Peck, 2002) and Lake Sugan in north western China covering the last ∼2,670 years BP (Zhou et al., 2007).

Referee comment: Line 44 – remove 'n' Author's response: Will be removed.

Referee comment: Line 92 – where they are archived in a cold store at 4âŮęC

Author's response: agreed

Author′s change in manuscript: All cores were opened, split and photographed at GFZ Potsdam, where they are archived in a cold store at 4°C.

Referee comment: Line 97 – remove 'continuously' and put 'Continuous' at the start of the sentence.

Author's response: agreed

Author′s change in manuscript: Continuous 10-cm-long sediment slabs with an overlap of 2 cm were taken from the whole composite profile to prepare large-scale petrographic thin sections.

Referee comment: Line 138- should a value for keV be included after 5.9%?

Author's response: The keV for 210Pb and 137Cs were mentioned already earlier in the text in line 134-135.

Author's change in manuscript: none

Referee comment: Line 175 – is there an image that illustrates how it is possible to distinguish between detrital and endogenic calcite?

Author's response: agreed

Author's change in manuscript: An image (new Fig. 4.2) (microscopic pictures) illustrating the differences is added to the manuscript.

Referee comment: Line 301- I was unclear on 'laminar denudation' is that erosion of the lamination?

Author's response: By "laminar denudation" we mean the superficial runoff associated with catchment runoff through the activation of widely dispersed smaller tributaries. We changed the wording from "laminar denudation" to "surface runoff" and clarify the meaning.

Author's change in manuscript: Runoff with suspended sediment load is then likely directed through the Kegagyr River in the east but may also be the result of surface runoff through the activation of several widely distributed smaller tributaries in the catchment.

Referee comment: Line 311 – replace 'overserved' with 'observed'?

Author's response: agreed.

Author's change in manuscript: Aragonite precipitates were only observed in the intervals between 600.0-605.0 and 609.0-616.0 cm composite depth.

Referee comment: Line 343-344 – I was not clear on the meaning of 'for each individual thin section comprising 324 and 13 years varve. My assumption is that this is the range, or maximum and minimum, in total number of varves observed on a single 10 cm thin section. However, I may have misread this.

Author's response: This is correct, this refers to maximum and minimum number of varves within individual thin sections.

Author's change in manuscript: For the floating varve chronology we therefore compare the results for each individual thin section comprising between a maximum of 324 (506.8-497.6 cm) and a minimum of 13 (varves) (65.4-63.0 cm) (Fig. 5a, Fig. 8).

Referee comment: Line 474 – unclear on the meaning of 'robust fundament'. Do you mean 'This robust chronology is fundamental for further detailed palaeoenvironmental.......'?

Author's response: Yes.

Author's change in manuscript: This robust chronology forms the base for further detailed palaeoenvironmental and palaeoclimatic reconstructions.

Referee comment: Line 479 – I assume that the increased windiness enable increased mixing of the lake waters and CO2 exchange with the atmosphere. Perhaps be explicit here.

Author's response: agreed.

Author's change in manuscript: Lower reservoir ages of $\sim$1000 years and less in the late Holocene might be related to enhanced atmospheric CO2 exchange when the lake was shallower due to silting-up of the lake basin and/or increased windiness inducing increased water column mixing favoring CO2 exchange with the atmosphere.

Referee comment: Line 480 replace 'which allowed developing' with....'that allowed the development of seasonal deposition models

Author's response: agreed.

Author's change in manuscript: The construction of the varve-based chronology was only possible through detailed micro-facies analyses of the entire sediment sequence in overlapping thin sections that allowed the development of seasonal deposition models for all observed types of fine laminations.

References Narama, C., Kääb, A., Duishonakunov, M., & Abdrakhmatov, K. (2010). Spatial variability of recent glacier area changes in the Tien Shan Mountains, Central Asia, using Corona (∼ 1970), Landsat (∼ 2000), and ALOS (∼ 2007) satellite data. Global and Planetary Change, 71(1-2), 42-54.

Figure 1 caption: Figure 1: Location of Lake Chatyr Kul, the composite profile (red dot) and the gravity cores (yellow dots). The orange square marks the location of 14C dated leaves (Poz-109830, Tab. 2) found in the top of a mid-Holocene-shoreline at ∼3540 m a.s.l. The relief map of Kyrgyzstan relies on the CGIAR-CSI SRTM 90m (3 arcsec) digital elevation data (Version 4) of the NASA Shuttle Radar Topography Mission (Jarvis, 2008). The figure was modified from Lauterbach et al. (2014). Photo of instable shores (white arrow) of Maloye lake.

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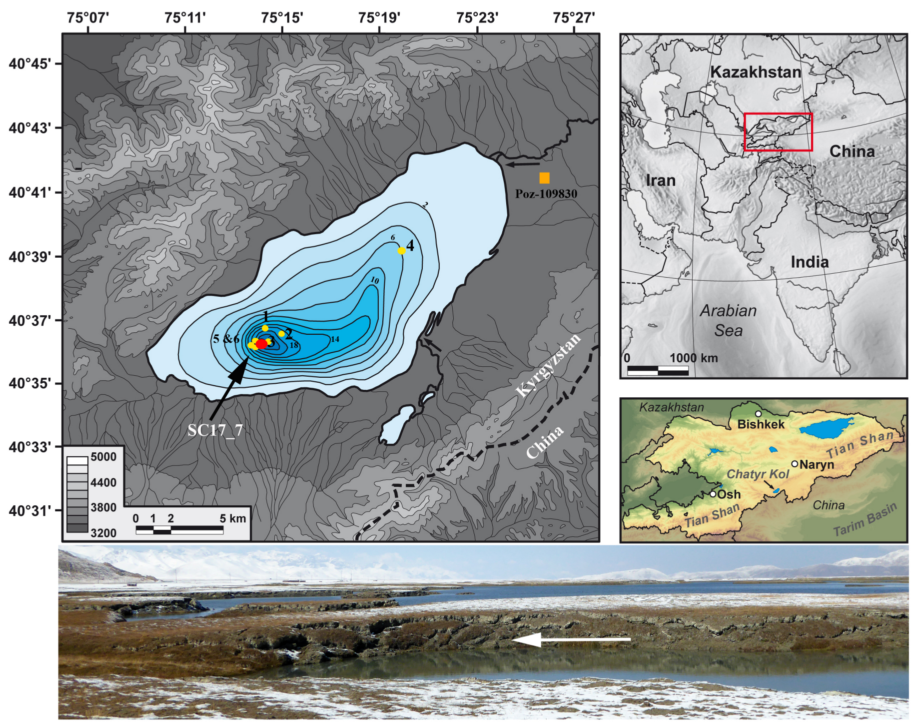

Fig. 1. Figure 1: Location of Lake Chatyr Kul, the composite profile (red dot) and the gravity cores (yellow dots). The orange square marks the location of 14C dated leaves (Poz-109830, Tab. 2) found in the t