Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2019-389-AC2, 2020

Biogeosciences Discussions
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Interactive comment on "The influences of historic lake trophy and mixing regime changes on long-term phosphorus fractions retention in sediments of deep, eutrophic lakes: a case study from Lake Burgäschi, Switzerland" *by* Luyao Tu et al.

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Received and published: 5 January 2020

RESPONSE TO COMMENTS of Anonymous Referee #2 Manuscript ID bg-2019-389 titled "The influences of historic lake trophy and mixing regime changes on long-term phosphorus fractions retention in sediments of deep, eutrophic lakes: a case study from Lake Burgäschi, Switzerland".

General comments: Luyao Tu and co-authors present a _120 year-long sedimentary

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record from Lake Burgäschi on the Swiss plateau discussing variations in the bottom-water oxygenation state, the trophic state and potential phosphorous retention/release during these varying conditions. The data set of the study including phosphorous fractions, carbon, sulfur and nitrogen concentrations, XRF core scanning, and hyperspectral imaging is extensive. Yet, in my opinion it is partly overinterpreted and partly not clearly presented. What I am missing is a better linkage of the data with the development of agriculture and deforestation in the lake's catchment area and with the lake's restoration history. Interpretations on the trophic state and the reconstruction of hypolimnetic oxygenation regimes are given in the discussion section but with only weak links to the human influences that are potentially responsible for these variations. However, since the study cannot contribute much to the already known chemical mechanisms of phosphorous retention/release in lake sediments, it seems important that the findings be interpreted with regard to these same human influences. Overall, my impression after having read the manuscript was that there is a lot of data, a lot of statistical analysis but the promise from the abstract that I would learn how hypolimnetic anoxia influence lake recovery from eutrophication was not accessible to me. It may be that it is included in the manuscript but then in a form that is difficult to access for the readership. Accordingly, the manuscript should be revised. More focus should be put on the interpretation of the data in a larger context. But the data should also not be overinterpreted as in section 5.3. Currently, the technical and statistical side dominates. I recommend for instance the design of scenarios in the form of conceptual models (sketches) demonstrating the processes that were dominating the lake during Zones I to IV. For the readership, this would make the outcome of this study much more attractive and accessible.

Response: We thank the Anonymous Referee #2 for the valuable and thoughtful comments which add substance to our manuscript, balance the interpretation (more cautious) and improve clarity and readability. Some of the are in line with Reviewer 1. Accordingly, we rephrased (clarified) the primary aims of our study, namely to assess and evaluate the lake remediation measurements (here syphoning of hypolimnetic wa-

ter) from the viewpoint of sediment profiles, i.e. with data on P fractions, P burial rates and risks for internal P release in and from lake sediments. In most cases remediation is assessed with limnological data. Here we can show that the largest effect of remediation is actually observed in the sediment P pool and its fractions; effects on lake productivity are marginal. The view from lake sediments is critical. Indeed, we confirm with sediment data what has been predicted from limnological data. But in contrast to shallow polymictic lakes, there are only a few studies showing sedimentary P fractions and pools for deep seasonally or permanently anoxic lakes. But we agree: our sediment data need much better discussion in the context of the general eutrophication history and hypolimnetic water withdrawal (with processes). Yes, we added a sketch figure (Fig. 8) with the conceptual model for the four stages discussed in the text.

Specific remarks:

1. Line 44: 'oxygen levels' (not only oxygen) More details should be given in the Introduction on the principle and aim of the phosphorous analysis. Also, one sentence more on the technique of the P analysis should be added to '3.4 Phosphorus fractionation scheme and bulk element analyses' where the authors simply refer to Tu et al. (2019) for the details (line 171). This shortness on the P analysis is questionable given the importance it has for the study. At one point or the other (Introduction or Material and methods) more detail should thus be provided.

Response: The correction has been made as suggested. Yes, the Introduction (specifically the Aim and Motivation for our study; the significance of sedimentary P-fraction retention; the research gaps) is rephrased accordingly. We added more text to the P extraction scheme and added a new Figure with the extraction scheme in the Fig. S3 in Supplementary online materials (SOM).

2. Line 90: A lake has always just one single outflow.

Response: Yes, Lake Burgäschi only has one outflow (clarified in new Line 98).

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3. Line 91-92: I guess it should read ‘the most important lowering’.

Response: We have changed it into “the most recent lowering”.

4. Lines 112, 113: Referencing to sections that come later in the manuscript is usually not accepted (to be checked for Biogeosciences).

Response: As suggested, the correction has been made.

5. 3.2 Chronology: Great detail on the activity analysis of 137Cs and 210Pb. Might not be necessary, but actually I welcome the point that it is once presented in a manuscript.

Response: Thank you. Yes, we decide to leave it as is. A proper presentation of the age-depth model is fundamental (and often not made).

6. Line 152: ‘The core surface. . ...’

Response: Done, corrected.

7. Line 156: Add the appropriate elements to the description for the 10 kV and the 30 kV run, respectively.

Response: As suggested, the correction has been made (Line 177-178).

8. Line 187: Provide at least a keyword on the method and not only the naked reference. As a reader I would like to know at least in which direction it goes before deciding if I want to search for the reference.

Response: More description about the method has been added in Line 197 (revised manuscript). Also the extraction scheme is added in Fig. S3 of SOM.

9. Line 304: This general increase in sedimentary green pigments I cannot see.

Response: The slight increase in “green-pigment” index can be seen more clearly from Figure 4d. We have corrected it (Line 332).

10. Line 305: ‘green-pigment concentrations’

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Response: Done, corrected.

11. Section 5.3: This section is rather a mix of already presented interpretations on the state of the lake and interpretations that are speculative and are lacking the necessary data foundation (not given by the results from this study).

Response: We have re-organized and re-written this section and make the interpretation from our results more logical and clear to follow, meanwhile with support of limnological monitoring data and previous studies.

12. Line 372: 'Fe contents control'

Response: Done, corrected.

13. Lines 438-442: Here, finally a clear statement linking the data with lake restoration, agricultural influences etc. Points like this should be more elaborated during the Discussion section and not only brought forward (a bit out of nowhere) in the Conclusions.

Response: We have added more context in Section 5.1 to explain how the agricultural activities can influence P loads into the lake and lake primary production (Line 337-340). This is a valuable additional comment to Reviewer 1.

14. Figure 3 with the lithological interpretations cannot come before the presentation of the XRF data in Figure 4 as you need the XRF data to define the lithologies.

Response: As suggested, we have changed the order of Figure 3 and 4.

15. Figure 4: Too many elements shown. This is a common issue with XRF data. Mg should be deleted, this is noise, Mg is too light to be measured with an Avaatech scanner. Either Al or K is sufficient; I recommend K as it is heavier and therefore presents the more robust result. Ti is sufficient here (delete Rb). You could show Al and Rb in the supplementary material if you wish.

Response: Yes, we agree. We have removed the XRF elements Al, Rb, Si, Mg and placed them into the new Fig. S6 (SOM).

16. Figure 6: Can be added to Figure 5. Might even be more illustrative to have all the P plots together in one graph.

Response: Yes, we understand the point. But in fact, the two figures illustrate something different: Figure 5 (curve plot) displays the time-series changes of P fractions and LOI data from Zone I to IV. In contrast, Figure 6 (stacked bar plot) mainly aims to show the average proportions of the five P fractions in the sediments. We prefer to leave them as two Figures.

17. Figure 7: I do not understand how the colored points of the individual cluster zones are added to this graph. Please explain in the figure caption.

Response: We clarify the source in the caption of Figure 7.

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2019-389/bg-2019-389-AC2-supplement.pdf

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Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2019-389, 2019.

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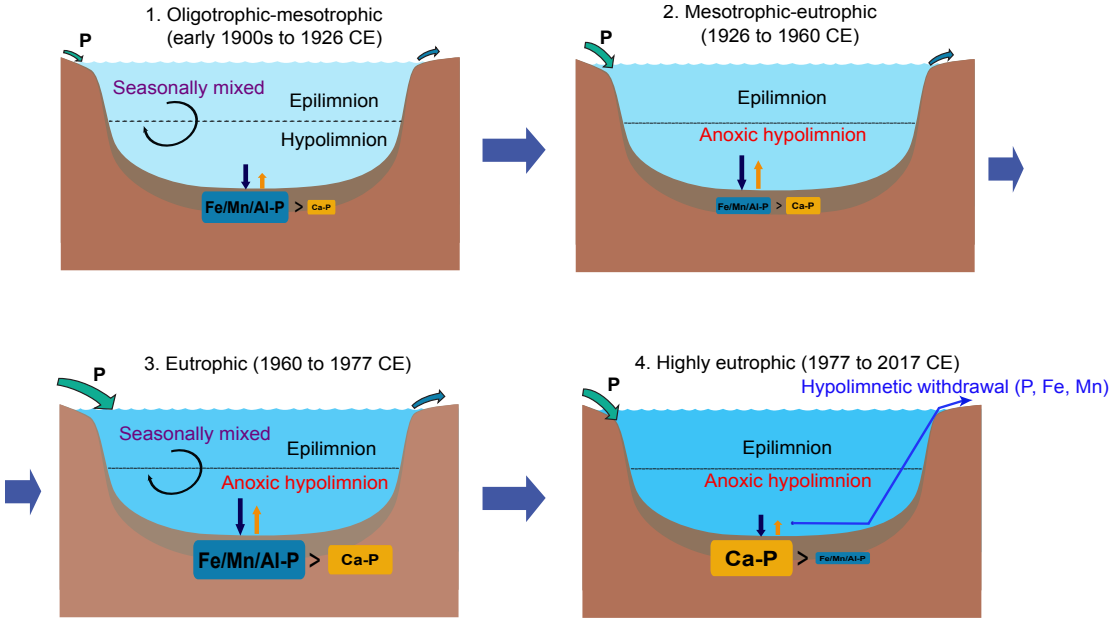

Fig. 1.

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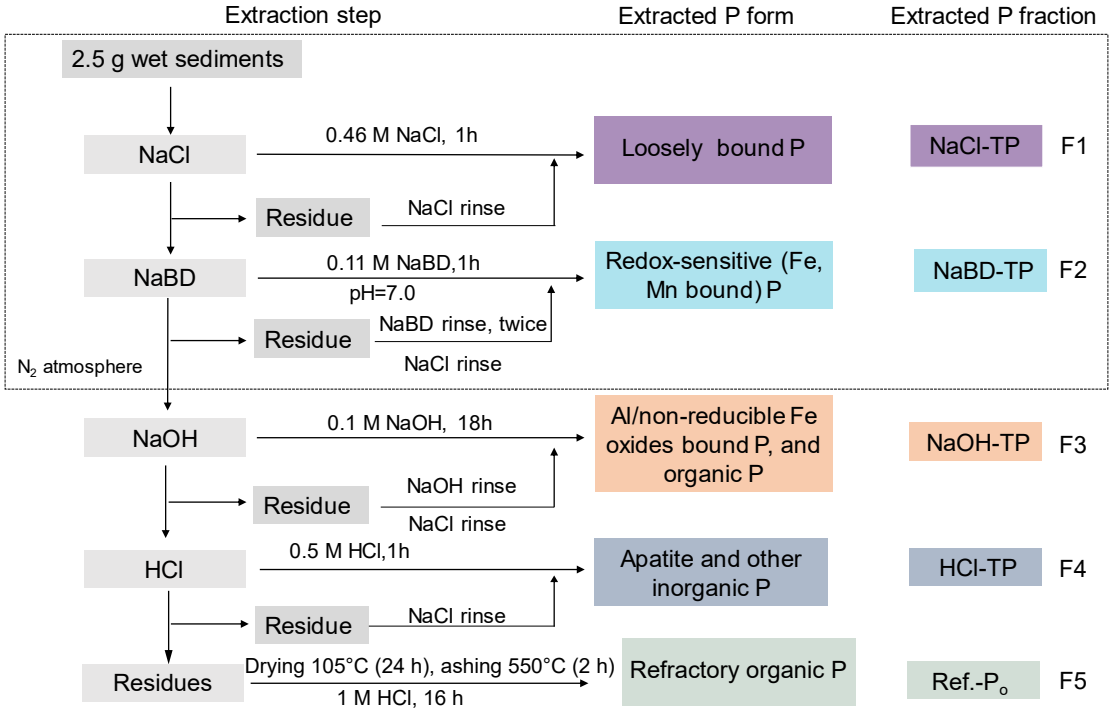

Fig. 2.

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