Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2020-441-RC3, 2021

Biogeosciences Discussions

Interactive comment on "Modern silicon dynamics of a small high-latitude subarctic lake" *by* Petra Zahajská et al.

Anonymous Referee #3

Received and published: 18 January 2021

General comments: This is an interesting manuscript that used multiple lines of evidence, including element, isotope, and water mass balances to inform their interpretation. It will be a valuable contribution to the scientific literature for its insights into both silicon biogeochemistry in these unique high arctic lake environments and the importance of groundwater as a source of dissolved silicon to lakes. I appreciated the scenario analyses that were undertaken for some of the calculations considering the limitations to the dataset.

I believe that the manuscript is of sufficiently high quality in terms of its methods and interpretation of its results and is a novel contribution to Biogeosciences. I have some minor comments for the authors to consider before it is ready for publication in Biogeosciences.

Specific comments:

Should appendices A, B and C be placed in the supplementary materials rather than in the main manuscript text file?

I recommend using the term "isotope ratio" instead of "isotopic signature" throughout the manuscript. I refer to Waterbirds, 35(2):324-331 (2012). https://doi.org/10.1675/063.035.0213 for isotope ratio reporting guidelines, which summarizes the recommendations of the Commission on Isotopic Abundances and Atomic Weights (CIAAW) of the International Union of Pure and Applied Chemistry (IUPAC).

Lines 3-4: Can you be more specific instead of just saying "factors and mechanisms". I realize that this is just the abstract.

Line 4: I somewhat disagree with the statement "While BSi formation and preservation is expected to occur in silica rich environments with high dissolved silicon (DSi) concentrations such as volcanic and hydrothermal inputs, the factors and mechanisms explaining high DSi and BSi concentrations in lakes remain unclear." What qualifies as a high DSi concentration? DSi concentrations are relatively high (in the 100 μM, or 6 mg SiO2 l-1, range) in most groundwater, rivers, and lakes that drain catchments with siliceous bedrock and soils, but also in most catchments overall. BSi formation and preservation also happens in these environments. I understand that this is just the abstract and you qualify these statements more in the introduction. Obviously, as you point out and discuss, the BSi concentrations in the lake's sediments are higher than many other lakes because of the low sedimentation rate, which is unique to high arctic lakes. But I don't think that you can say that the high DSi and BSi concentrations you observed in the lake water column are abnormally high compared to a temperate or tropical freshwater lake.

Even in your short summary on Biogeosciences, you say "The processes responsible for large accumulation of siliceous shells of a single-cell algae – diatoms – in lake deposits are poorly understood." I would somewhat disagree with this statement as

well. BSi preservation occurs when BSi production and deposition is greater than its dissolution. To me, it seems that the more specific description of the research gap is that “the Si budget of this the lake had not been fully characterized before to establish the drivers of BSi accumulation in this environment, which is a more specific description of what your research objectives were rather than just saying “that the processes responsible for BSi accumulation in sediments are poorly understood”

Line 30: What physical processes are you referring to that remove DSi from solution? Can you be more specific?

Line 117: Regarding “and 1000 is unit conversion.”: Please specify what the units of this unit conversion factor are.

Line 119: When you say “Assuming steady-state ($\triangle$DSi = 0)”: Can you elaborate more and be more specific for readers not familiar with steady state conditions what you are talking about. Something to the effect of “Assuming that the DSi fluxes in the lake are at steady state (i.e., the sum of the input fluxes is equal to the sum of the output fluxes and therefore that $\triangle$DSi = 0)”

Lines 181-186: What method did you use to measure the DSi content in your alkaline extractions? I assume that it was by the automated molybdate-blue method that was used to measure the DSi content in you water samples, but please add this detail to clarify for readers. Please also give a bit more detail about the extraction method and its requirement for a mineral correction factor. You could even do this by saying “Si-containing minerals” on line 184 instead of just “minerals”

Lines 403-408: Could these lines go in the Model uncertainties discussion section given that you have a section dedicated to discussing these uncertainties?

Lines 471-480: I think this discussion, which is the conclusions, belongs in its own discussion section about comparing your lake’s environmental controls on BSi accumulation with that of other lakes and environments where high BSi accumulation has

been observed, and the implications of this finding (regarding the fact that groundwater is likely a significant source of DSi to lakes and should be considered in lake Si budgets). Then, one sentence in your conclusions can summarize this discussion section.

Lines 474-476: Reconsider your discussion about high autochthonous carbon production in arctic lakes here. Autochthonous carbon production rates (that is, carbon fixation rates) are not independent of diatom DSi uptake rates and BSi production and burial rates.

A related thought, which might be outside of the scope of this work, but I thought I’d share nonetheless: Have you thought about the implications of your work for our understanding of carbon burial in arctic lakes. Specifically, I am thinking – could the high diatom productivity, driven by high DSi supply via groundwater, drive increased carbon burial in lakes with high groundwater discharge relative to lakes with less groundwater discharge (and therefore less DSi supplied)? Could this be a research hypothesis that you could put forth in this paper for others to answer? In other words, could you suggest that the implications of your work extend beyond understanding Si biogeochemistry and can inform our understanding of carbon fixation and burial rates in arctic lakes? It is especially interesting that you have sediment TOC concentration data, and they appear to be correlated with the sediment BSi concentrations.

You could refer to these papers: Wang, B., Liu, CQ., Maberly, S. et al. Coupling of carbon and silicon geochemical cycles in rivers and lakes. Sci Rep 6, 35832 (2016). https://doi.org/10.1038/srep35832 Krause, J.W., Schulz, I.K., Rowe, K.A. et al. Silicic acid limitation drives bloom termination and potential carbon sequestration in an Arctic bloom. Sci Rep 9, 8149 (2019). https://doi.org/10.1038/s41598-019-44587-4

Technical corrections:

A general technical comment: Check your pluralization of words and whether you need an article (a/an or the) in front of your nouns. For example, I would recommend that stream discharge does not need to be pluralized. I made note of some of these gram-

mar/technical corrections, but not of all of them.

Some suggestions for modifications to terminology used or sentence phrasing:

Line 1: “concentrations occur” instead of “concentration occurs”

Line 6: “stream discharge” instead of “stream discharges”

Lines 8-9: I would recommend re-phrasing to clarify that one fifth of the DSi that would otherwise be exported to the ocean is retained by lakes, something like: “estimated to retain one fifth of the annual DSi terrestrial weathering flux that would otherwise be delivered to the ocean” instead of “estimated to retain one fifth of the annual DSi delivery into the ocean”

Line 9: “DSi inputs being 3 times higher” instead of “DSi inputs 3 times higher”

Line 17: “dissolved silicic acid, H4SiO4, expressed here as dissolved silicon (DSi), and . . .” instead of “dissolved silicic acid H4SiO4, expresses here as dissolved silicon (DSi), and . . .”

Line 23: “One example is high-elevation” instead of “One example is the high-elevation”

Line 24: “high BSi concentrations” instead of “large BSi concentrations”

Line 30: “removed” instead of “taken up” (given that you refer to both physical and biological processes)

Lines 45-46: “Therefore, stable Si isotopes are an” instead of “Therefore, the stable Si isotopes provide an”

Line 60: I think you mean “850 m above the tree-limit” instead of “850 m a.s.l., above the tree-limit”

Line 184: Change wording: “As there were no changes in the amount of total Si extracted during the time course of dissolution” instead of “As no changes in the amount of total Si extracted during the time course of the dissolution”

Line 301: “accumulation” instead of “accumualtion”

Line 363: “The production consumes 63%” instead of “: “The production consumes from 63%”

Line 381: “The significance of groundwater-sourced DSi to the lake’s Si cycle” or “The significance of groundwater-sourced DSi to Lake 850’s Si cycle” instead of “The significance of groundwater on lake Si cycle”

Lines 410-435: Please specify every time that you mention the modelled groundwater δ30Si values that they are modelled. For example: please add this specification to lines 416 and 417.

Figures:

You use the shortform HTH core in the caption for Figures 3 and 4 but you don’t explain this shortform in the text. Please change this.

Can you increase the font size for the axis labels and numbers in Figure 3? And could the inset figures go in the Supplementary Information? They seem extraneous and are not thoroughly explained or discussed in the main text. I understand if this is difficult to do because of the default graphical output of the PLUM package.

Can you increase the resolution of Figure 5? It seems to be a lower resolution compared to the other figures, and the x-axis numbers are somehwat cut off at the top.

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