Biogeosciences Discussions

Biogeosciences Discuss., author comment AC2
https://doi.org/10.5194/bg-2022-149-AC2, 2022

Reply on RC2

Robin Havas et al.

Author comment on "Biogeochemical processes captured by carbon isotopes in redox-stratified water columns: a comparative study of four modern stratified lakes along an alkalinity gradient" by Robin Havas et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-149-AC2, 2022

Dear reviewer,

We first thank you for reading our manuscript and giving your constructive comments and we appreciate that they are supportive of our work.

Some minor comments were given and will be incorporated in the final publication(s) after clarification of the communication's structure. Furthermore, two major concerns were brought up and are answered in detail here below.

First, the reviewer noticed a mistake in the introduction which suggests "that biogeochemical processes are facing natural selection". As noticed by the reviewer, this is not backed up by empirical evidence but rather a problem of clarity and terminology. In the first sentence, it is the "C cycle and biogeochemical **conditions**" rather than processes which are suggested to have evolved throughout the Earth's history. We can make this clearer to avoid confusion. Then, we assess that "**processes** affecting the C cycle were likely different from those occurring in most modern, well oxygenated environments" because of the widespread stratification of past oceans. While this sentence mostly refers to biological processes – which indeed face natural selection – it also suggests that different processes (e.g. chemical) were in action but did not necessarily "evolve". For example, redox reactions did not fundamentally evolve themselves but their relative occurrences have changed with respect to changes in the oxidation state of Earth's surficial environments. Accordingly, we could rephrase this part as follows: "while biological processes evolved through time, dominant chemical processes occurring in anoxic conditions were likely not the same than in fully oxygenated oceans"

The second main point of the reviewer is about the length of the manuscript, and notably its discussion, which is indeed long and dense. In line with the comment of the first reviewer, it is suggested to drastically reduce the size of our manuscript and it is explicitly advised to split the current document "into two manuscripts".

We realize the size and density of the discussion may be tough to read and retain all at once. Besides, we agree that the dataset described here – although composed of interconnected data – could be presented as several independent ones. Therefore, we

agree that the study and its conclusions would benefit from splitting the manuscript in two.

In the current manuscript, we describe the effects of specific physico-chemical and biological parameters on the C cycle of four stratified lakes along a gradient of water chemistries using a unique methodology. Firstly, we aim at assessing the biogeochemical reactions occurring in the water column and how they are recorded in the surficial sediments, through "traditional" DIC and POC results. Then, we want to present the interests of additional DOC results for the understanding of these C cycles.

Your comment suggests to split the study into (i) a manuscript about concentration data ("Figures 2, 3 and 5") and (ii) "another one with isotope data". Additionally, you suggest to organize the result/discussion sub-sections as sources and fates of inorganic and organic C.

We think that presenting the sources and fates of the different C reservoirs is indeed a good way to describe the C cycles of these lakes and thus should be included (as we did for DOC – discussion part 5.3.1). However, we believe it is difficult to interpret isotopic signatures of the different C reservoirs without also discussing their concentration, since the first directly relates to the second. Thus, we suggest an alternative outline for the two papers which, compared to the initial manuscript, (i) puts the sources and fates of the C reservoirs more at the front and (ii) better reflects and connects the important messages of our work together.

In brief, we suggest to split the current manuscript in two manuscripts submitted in parallel as "Part 1" – "Part 2" publications with DIC/POC results on one side and DOC on the other. To illustrate the advantages and feasibility of this restructuring we present its potential outline in more detail below.

The first paper would aim at characterizing the sources and fates of DIC and POC using their elemental and isotopic signatures and putting the emphasis on (i) how the different water chemistries influence these C reservoirs and (ii) how this is recorded in their surficial sediments. This first publication will thus set the ground for understanding the C cycle of closely related stratified lakes under different physico-chemical constraints. Fostered by the integrated comparison of several environments, it will show how local effects and the alkalinity gradient (via distinct C sources) strongly influence the DIC record, whereas POC mainly reflects the variable ecosystems and redox structure of the lakes. Moreover, regarding the C sinks, it will show that upper sediment organic C captures different parts of the water columns, while carbonates are in isotopic equilibrium with oxycline DIC. Nonetheless, this conventional DIC/POC dataset leaves equivocal conclusions for the identification of some metabolisms (such as anoxygenic photosynthesis) and shows an incomplete carbon mass balance.

In the potential second paper, we would focus on this missing C reservoir, namely the DOC. Through the description of DOC elemental and isotopic signatures, this second manuscript would aim at highlighting how this innovative tracer complements and deepens our understanding of the C cycle in stratified environments, traditionally based on DIC and POC data. To achieve this, we would first present DOC sources and fates, then describe the inferences drawn for planktonic C uptake and release, and finally the implications for the geological record and "big DOC" hypotheses. As conclusions, DOC analyses (i) detail and unveil the location of photosynthetic organisms in the water columns, (ii) unravel planktonic cellular processes (C-uptake, -release) characterized using $d^{13}C_{DOC}$ but invisible via POC results and (iii) provide boundary conditions to the "big DOC" hypotheses.

We think that this reorganization will clarify the structure and thus the respective messages of each article in addition to considerably reducing their length.

We would like to thank the reviewer again for providing a thorough review up to proposing an alternative structure of the article. We hope that the details of the alternative suggested outline will also convince the reviewer.

Yours sincerely,

Robin Havas, on behalf of all co-authors