

Interactive comment on “Nitrogen cycling in the subsurface biosphere: nitrate isotopes in porewaters underlying the oligotrophic North Atlantic” by S. D. Wankel et al.

Anonymous Referee #2

Received and published: 13 October 2015

The paper of Wankel et al presents a detailed examination of pore water nitrate concentrations and isotopic composition in the pelagic sediments on the flanks of Mid-Atlantic Ridge in the North Atlantic, providing quantitative interpretation of the main contributing processes: nitrification and denitrification. The main novelty of the study (in addition to publishing deep pore water isotopic profiles for nitrate, of which very few have been published to-date), is an inference of a substantial contribution of (in all likelihood, biological) N₂ fixation to the pool of sedimentary organic nitrogen in these highly oligotrophic sediments. This conclusion is drawn based on the isotopic mass balance calculations performed as part of the depth-resolved reaction-diffusion model the relevant N and O isotopologues of nitrate. The paper is overall well written, though

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could benefit from further editing, particularly the first of the manuscript

More general comments: 1. I have the following comments/suggestions regarding the main conclusion of the paper about N₂ fixation. Since it is a rather novel observation, some further supporting discussion seems to be warranted:

1) The low values of d¹⁵N-NTR imply that a large fraction of organic nitrogen oxidized to nitrate originates from N₂ fixation, particularly at the sites where the lowest d¹⁵N-NTR is calculated. It would be instructive to provide the readers with some further quantitative assessment of what fraction of N oxidized comes from N₂ fixed (assuming the exported d¹⁵N of PON of 3.7 per mil as reported (in cited references) in this area).

Alternatively, in the context of N₂ fixation discussion, it would be helpful to have at least some idea of what d¹⁵N of the sedimentary N is in this area. However, this has not been done due to methodological difficulties. The N wt% is described as “extremely low” – Please, specify how low. Were there any estimates made on the N content of these sediments? Could the d¹⁵N of at least a couple of sediment intervals be measured using POR oxidations? Also, on p. 22, there is a statement about “exceedingly low” ammonium. Please, clarify, whether ammonium was measured, and if so, by what method (with Refs).

2) The reported rates should be compared to other published rates of N₂ fixation in the sediments (mostly coastal), as well as in the euphotic zone of the North Atlantic. Such comparison would put the findings in the more global context, and in fact show that the implied by the mass balance rates of N₂ fixation are in fact really high (e.g. Capone et al., 2005 reports the average rate of 0.9 nmol/cm³yr in the euphotic zone of the tropical Atlantic, here conversion made assuming 100 m euphotic zone depth).

3) On the same subject – to get a sense whether these high rates of N₂ fixation can be supported by previously reported rates of H₂ production, maybe compare at least orders of magnitude of the two processes).

BGD

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2. There is not much information about how well the model actually fits the data. The most straightforward way would be show the model-predicted d15N and d18O, as well as nitrate concentrations directly compared to the data with a specify set of input parameters. Or explain why such comparison is not presented.

3. Specify what type of storage (from frozen sediments, stored at -80C or pore waters stored at -20C) was applied to the samples which did contain measurable nitrite. This way it would be more clear for the reader whether these samples could be potentially compromised by some of nitrite oxidation during storage)

4. The O₂ concentration is reported down to the “detection limit”, but this value is not reported. Please, add the detection limit of O₂ measurements.

5. The denitrification is assumed to occur in the intervals with O₂ up to 40 uM of O₂. Please, provide an explanation for this upper limit (e.g. give a reference?)

Minor edits: P. 3, L. 10-15 I would reword the beginning of opening sentence as : “Below the sunlit surface, the dark ocean. . .” P. 4, L. 0-5 re-word to: “Furthermore, in the sediments overlying by relatively young and permeable” P. 4, L. 15-20 reword to “. . . may provide . . . into its role in global marine nitrogen. . .” P. 4, L. 25-30 “. . . sedimentary carbon. . .”

P. 5, L. 10-15 a) remove “however” b) Move the sentence which starts with “For example” before the preceding sentence c) replace “generally” with “. . . typically heterotrophic. . . or just “the heterotrophic” P. 5, L. 20-2 Remove “however”

P. 6, L. 5-10 replace with a) “. . . linearly coupled” or “linearly related” b) “. . . in resulting nitrate” instead of “for nitrate” P. 6, L. 15-20 Define here low-energy (this term is used through the text, so here it would be helpful to clarify that you mean “low organic carbon” P. 6, L. 20 – remove “constraints” in this line

P. 7, L. 0-5 replace with “. . . it was excluded from our study” P. 7, L. 15-20 replace with “. . . on the shipboard catwalk immediately after”

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P. 7, L. 20-25 move the sentence starting with “Porewaters were extracted...” before the preceding sentence.

P. 8, L. 10-20 Wrong reference for nitrite determination method, should be Cox reference

P. 9, L. 5-10 should read “10 mbsf”

P. 10, L. 5-10 should read: “. . .O₂ depleted zone...”

P. 11, L. 5 Remove the word “phase” P. 11, L. 10-15 After “Granger et al., 2008, replace the sentence with something like that for clarity: “the isotopic transformations of N and O are decoupled due to differently sourced N and O atoms in the resulting NO₃ molecule” P. 11, L. 20-25 replace “related” with “set by”

P. 12, L. 0-5 “canonically” does not fit here P. 12, L. 15-20 Label all atoms in the list of nitrate isotopologues.

P. 20, Line 0-5 Replace “sharer O₂ profiles” with “steeper O₂ gradients”

P. 28, L. 20-25 , remove a parenthesis after Granger et al., 2008. Also, clarify that study was purely experimental, but cited environmental fractionation factors.

P. 30, L. 15-20. Note that Townsend-Small et al (2014) reported co-occurring nitrification/denitrification in the water column. P. 30, L. 20 to the end of the page: High relevance for the global ocean models is mentioned in the summary, but not really discussed. Please, elaborate a bit on this.

Interactive comment on Biogeosciences Discuss., 12, 13545, 2015.

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