

## ***Interactive comment on “Mn / Ca intra-test variability in the benthic foraminifer *Ammonia tepida*” by Jassin Petersen et al.***

**Anonymous Referee #2**

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Petersen and co-authors present laser ablation derived Mn/Ca ratios of the benthic foraminifera species *Ammonia tepida* and propose to use them as a proxy for bottom water oxygenation. During three different months, living specimens were collected at a lake with seasonal changes in the redox status of the upper sediment. The results show a high intra-test variability in foraminiferal Mn/Ca ratios due to ontogenetic trends, seasonal changes in pore water Mn<sup>2+</sup> concentration and vertical migration of the foraminifera within the sediment. The authors ascribe the highest amount of the intra-test variability to variations in the Mn<sup>2+</sup> concentration of the pore waters and that differences in calcification histories might explain observed inter-test variability.

The manuscript is generally well written, logically organised and clear. The figures are mostly nice and clear. I think that this work is an interesting and important contribution

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and therefore suitable to be published in Biogeosciences. Nevertheless, I would like to see the points below addressed by the authors.

Main points

1) I think it is hard to compare this study with the results from the culture study from Barras et al., since their study is submitted to another journal and the reader has no access to the data which makes it hard to verify the results of Petersen et al. Is there another reference that could help here that is already published?

2) Some important information are missing or are not sufficiently explained: - It would be very helpful to have the lake pore water data for Mn<sup>2+</sup> and O<sub>2</sub> concentrations in actual numbers at least for the months investigated to better compare them with the measured foraminiferal Mn/Ca ratios and to assess the redox conditions in the upper sediment.

- In Section 2.3 you say that different spot sizes were used according to different chamber sizes. Did you do test measurements with different spot sizes (on standards and/or foraminifera tests) to show that the spot size does not affect the analysed Mn/Ca (and other) values? Please specify this.

- In Table 2, information about measured NIST 612 standard data are missing as well as measured Mg/Ca ratios for the USGS MACS-3 standard. I think this is important especially when you correct your analysed Mg/Ca ratios to the USGS MACS-3 standard considering the offset in Mg/Ca ratios for NIST 610 standard between your measurements and those of Jochum et al. 2011.

3) There is a contradiction between Sections 3.3 and 4.2.2 concerning ontogenetic trends. In Section 3.3 (page 10, L14-16), you mention that there are statistical significant ontogenetic trends for the analysed data and in Section 4.2.2 (page 14, L5-7) you suddenly say, there were no systematic ontogenetic trends observed. Please specify explicitly that this is only valid if all your data were combined (like you say on page 10,

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L16-17).

4) Your justification for analysing the standards in raster mode (page 7, L1-4) is not entirely correct. How can you keep the depth-related fractionation similar for raster and spot analyses, like you say in L2-3? It is true, that measuring in raster mode minimises the “down-hole” fractionation but the fractionation is most likely still different to spot analyses. Please rephrase this. Further, “down-hole” fractionation is probably negligible in foraminifera tests as the test walls are thin – especially when the test walls were entirely ablated within 10s at the mentioned laser settings.

Minor points

- page 1, L25 “intrinsic” – This term is explained later how it is meant in this context. So, please do not use this word in the abstract.

- page 2, L4-6 “. . .thereby relating bottom water oxygenation, . . .” – The word “relating” sounds odd in this context. Please rephrase.

- page 2, L17-18 “. . . lead to hypoxic BWO conditions. . .” – I think it is better to say here “hypoxic bottom water conditions” otherwise it is kind of double with “hypoxic bottom water oxygenation conditions”.

- page 4, L7-8 Did the Mn/Ca intrinsic variability only relate to changes in seawater Mn<sup>2+</sup> concentration in the study from Barras et al.? As mentioned before, the reader has no access to the (yet) unpublished study of Barras and co-authors, hence it is difficult to see which factors contribute to the intrinsic variations in Mn/Ca ratios of *A. tepida*. Please give some more details on this study or state the main/controlling factors for this variability. Is it the Mn<sup>2+</sup> concentration as briefly mentioned later?

- page 4, L9-10 Please put “in culturing experiments” in parentheses otherwise it is confusing if your study is based on culturing experiments or on field samples.

- page 4, L10-12 “. . .species complex. . .” Correct word? Species group?

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- page 4, L17-19 “. . .represent a suitable context. . .” – better “suitable location”

- page 4, L19-21 The sentence reads awkward, please rephrase. Maybe: “However, one complicating factor is that it has recently been shown that the activity of cable bacteria strongly influences the seasonal pattern of sediment geochemical cycles in Lake Grevelingen.”

- page 7, L17-18 Please insert “the” between “. . .processed with” and “GLITTER software”.

- page 10, L1-2 “. . .non-parametric test. . .” – Which one? Please name (again).

- page 10, L15-16 “. . . there was a slight, significant trend. . .” - Please delete “slight”. If the trend is statistically significant, the word “slight” does not fit.

- page 12, L18-20 Please reference Fig. 3 here instead of Fig. 2 as the variability is better seen in Fig. 3.

- page 13, L10-13 “. . .unlike Sr, Mg is strongly discriminated against in the calcifying fluid.” – What does that mean for the analysed ratios? Please explain briefly.

- page 16, L11-16 As mentioned above, please give the pore water Mn<sup>2+</sup> concentrations at least for the three months investigated, better for the entire year 2012, if the data were monitored, to better follow your interpretations.

- page 17, L4-8 Please spell OPD out as this is only used twice in the entire manuscript and I really had to look for the explanation.

- page 18, L7-9 “. . .although no systematic ontogenetic trends “ could be identified.” – Please insert here that this is only the case if the entire dataset is considered. Otherwise it will be a contradiction to your result section as mentioned above in the main points.

References – I am sorry but it is awful to read the reference list. Could you please use indentation “hanging” to make it easier to read?

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Figure 2, SEM image – This is actually Fig. 1. Out of curiosity, why does this test have 11 ablation holes if 10 spots were analysed at maximum (according to Fig. 2, plots)?

Figure 2, average Mn/Ca ratios per chamber and specimen – I really like this plot but each panel is very small which makes it hard to actually read the numbers. So, is there another way to show the data? Or at least, please lose the gray background and the grid lines and make each individual panel a bit bigger.

Scientific significance: good Scientific quality: good to fair Presentation quality: good

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