

## ***Interactive comment on “Seawater pH reconstruction using boron isotopes in multiple planktonic foraminifera species with different depth habitats and their potential to constrain pH and pCO<sub>2</sub> gradients” by Maxence Guillermic et al.***

**Anonymous Referee #2**

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The authors of this manuscript present new boron isotope data for multiple species of planktic foraminifera, which adds data to and expands existing calibrations for many of these species. The manuscript is well written, logically presented, and the results will be of interest to many in the paleoceanography community. While I have mostly minor suggestions for improving the manuscript (detailed below), I have a few more moderate concerns that may improve the manuscript prior to final publication.

Depth habitats of the foraminifers are used to link the habitat to oceanographic conditions at the core locations. The supplement has a fairly thorough explanation of how the

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various depths were determined (using  $\delta^{18}\text{O}_{\text{c}}$ , Mg/Ca-derived T, and published depth habitats; detailed in Table 6), but I couldn't determine which depth the authors chose to use for each species (or at least it wasn't consistently clear in the text) without seeking the information in Table 7. In the intro of the MS, the authors point the reader to table 3 for the depth habitats but table 3 doesn't include this information. Also, I don't understand why sometimes the authors used published references for depth habitats and in other instances is  $\delta^{18}\text{O}$  or Mg/Ca derived temperatures. For example: For core FC-01a, the Sime reference is cited for the depths used for *G. ruber*, *T. sacc.*, *O. universa*, but oxygen isotopes are used for *P. obliquiloculata* and Mg/Ca derived Ts are used for *tumida* and *menardii*. Clarification here is needed.

I don't understand why *O. universa* is considered a deeper dweller in this MS. There are some major assumptions made about why the  $\delta^{11}\text{B}$  of this species falls below the 1:1 line – this is also discussed in Henehan et al., 2013. Why *O. universa*  $\delta^{11}\text{B}$  is more like the deeper dweller non-spinose forams is indeed puzzling (esp. since it has same symbionts as *G. ruber* and *G. sacculifer*), but I don't think it can be attributed to a deep depth, especially given the size fraction used (>500). The larger size fraction of the samples used would suggest that these are living at a shallower depth (See Spero and Parker, 2003) and likely in the mixed layer. The correct depth habitat will impact the calibration.

Samples were cleaned using the full cleaning method including the reductive step (cite Boyle and Kiegwin 1985/1986 as well, since they developed the method). Why was the reductive step included here? Yu et al., 2007 suggests the reductive step isn't detrimental to B/Ca ratios, but the effect of this cleaning step on for  $\delta^{11}\text{B}$  analysis is unknown and according to Rae et al., 2018, the reductive step is typically not used during sample cleaning. There are documented dissolution effects that the authors discuss in the supplement (preferential dissolution of ontogenetic calcite occurs relative to the light  $\delta^{11}\text{B}$  of gam calcite) and if cleaning preferentially removes ontogenetic calcite, then the primary  $\delta^{11}\text{B}$  signal has been altered by the reductive cleaning. Addi-

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tionally, the reductive cleaning step IS detrimental to other elements, like Mg/Ca ratios (decreases ratios by up to 15%), which were used to estimate depth habitat for some of the species investigated here. Including the reductive step should be justified with an explanation of how this additional cleaning step could have affected results.

Li/Ca ratios are included in table 2, but never discussed?? Are they relevant for this MS? If not, perhaps remove?

Figure comments: Some of the fonts are very small, though this may be due to the orientation on the screen for the current version. I don't think Biogeosciences has figure font-size recommendations, but generally not smaller than 9pt.

Figure 1: Probably not needed, there are already many figures in the MS  
Figure 2: Fonts are v. small  
Figure 4: plots should be enlarged and figure moved to supplement  
Figure 5: the faint gray lines/symbols are quite hard to see. In print, nearly impossible. Please check font sizes, again they are quite small  
Figure 6: Check font sizes, they are very small. I recommend forgoing the use of yellow in figures. Too hard to see.  
Figure 7: I'm not sure I find this figure useful. Light percent? Perhaps change to PAR or something that can be related to a preferred habitat?  
Figure 8: I don't have specific suggestions for this figure, but there is a LOT of data with very small fonts. Would it be better to break this up into basins and put in the supplement?  
Figure 9: lacks a caption  
Figure 10 is mentioned in the text, but there is no figure 10.

Table 3: In the text on line 329 it is stated that chemo stratigraphic data is used to constrain depths, but this information is not summarized in the table, probably just a typo?

Other suggestions: Line 56-57: Not sure I agree with the statement in the abstract that the other species follow *O. universa* because of light limitation by symbiont bearing foraminifera. All of the deep dwellers have symbionts, all live in the photic zone.

Line 128: This sentence is poorly structured.

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Section 2.4: Origin of biological fractionation Paragraph beginning on line 172: very speculative and based upon benthic foraminifer experiments.

Section 2.5: The annual vs seasonal preferences for forams is largely dependent on temperatures. For example, in some regions *G. ruber* and *G. sacculifer* can be present throughout the year if  $T > 25^{\circ}\text{C}$ , but will have a summer/fall preference when  $T$  drops below 15. Their choice on seasonal vs. annual presence of these species will affect the hydrographic data used and perhaps impact results.

Section 3.2: Size fractions listed in this paragraph don't agree with size fractions in the Table.

Section 3.8: This section could/should include some of the information in the supplement regarding the depth used to obtain hydrographic information.

Line 339: Forams don't migrate in the water column (See Meiland et al., 2019), but deep dwellers may crust at depth during the END of their lifecycle, this should be clarified. This is later explained correctly (lines 452-453).

Lines 509-514: The concept of facultative symbiosis is outdated – all forams with symbionts are likely obligate and not facultative. See <https://www.biogeosciences.net/16/3377/2019/>. *G. tumida* doesn't have symbionts at all, so why does it align with the other species? Please discuss.

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