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Biogeosciences
Discussions

Interactive comment on "Weaving of biomineralization framework in rotaliid foraminifera: Implications for paleoenvironmental reconstructions" *by* Y. Nagai et la.

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Dear Inge,

We are pleased to submit the revised version of our Research Article manuscript "Weaving of biomineralization framework in rotaliid foraminifera: Implications for paleoenvironmental reconstructions" (bg-2018-295). We appreciated your constructive criticisms and comments, and we thank you for providing this opportunity for us to improve this manuscript and submit a revised version.

A point-by-point response to comments is included below. All files for the revised

manuscript (tracked changes and clean versions, figures, table, supplementary files) are contained in the .ZIP file uploaded with this revision.

We hope the present version is acceptable for publication in Biogeosciences.

Best regards,

Yukiko Nagai JAMSTEC

The study by Nagai and co autors ('Weaving of biomineralization framework in rotaliid foraminifera: Implications for paleoenvironmental reconstructions', bg-2018-295) shows new insights into the pseudopodial structured during foraminiferal chamber formation, leading to better understanding of processes involved in controlling the chemical signature of the precipitated carbonate shell. By timing calcium carbonate precipitation with the structure of organic layers gives crucial information about the closeness/openness of the site of calcification, and therefore the role of passive transport (seawater exchange), which is still heavily debated. In general, the manuscript is well-structured and well-illustrated and I just have some minor comments. We are grateful for these encouraging words and your constructive review of our manuscript.

Minor comments:

- Change numbering of figures: Reference to figure 7 (page 8/ line16) before Figures 5, 6. We preferred to keep the SEM plates of the microstructures together. We have thus added the following to the beginning of section 3.2 to justify the numbering (we also moved Fig. 3, the schematics, to the end as the new Fig. 7 according to a comment from Reviewer 2). 'Figures 3-6 show microstructures of different stages of chamber formation seen by the SEM.

- 4.2 It has been suggested pores are used for gas exchange/respiration (e.g. Berthold, 1976; Leutenegger and Hansen, 1979), and their size might change with e.g. seawater oxygen level (Kuhnt et al., 2013). Would this fit with your observations? Or are

the pores closed by pore plates and have no possibility to exchange? As O2 and CO2 used in respiration are nonpolar molecules, they are able to pass through the cell membrane. As such, the existence of pore plates made from cytoplasm seen in the present study should not influence respiration. Whether their size change with environment differences is a subject for future studies. Added the following in Discussion: 'Pores have been suggested to be used for respiration (e.g., Berthold, 1976; Leutenegger & Hansen, 1979). As O2 and CO2 used in respiration are nonpolar molecules, they are able to pass through the cell membrane. As such, the existence of pore plates made from cytoplasm seen in the present study should not influence respiration.'

- 4.3 Are there observed vesicles associated to seawater vacuoles? Was it possible to perform SEM-EDS on vesicles observed during chamber formation to potentially observe (amorphous phase of) calcium carbonate? Did you observe a difference in the intensity/size of vesicles during different phase of calcification and/or chamber size? In the present study, we were unable to observe amorphous phase of calcium carbonate within the 'vesicles'. In fact, as another reviewer pointed out, we do not have sufficient evidence to prove that these spherical structures indeed correspond to vesicles (and they are outside the cell!). Therefore, we have changed the terminology from 'vesicle' to 'spherical structure' throughout the revised MS. Although we did find these spherical structures with high Ca signals in our SEM-EDS analyses, we do not know for sure whether these signals are indeed from within the structures or from tests underneath. Making this clear requires future elemental analyses using thin-sliced embedded material.

- 4.4 Implications for element distribution: When looking at element distribution across the chamber wall, it has been shown for several elements (e.g. S, Na, Mg) there is a higher concentration band near the POS. The presence of gaps in the organic layers at the initial phase of calcification compared to its absence during llater phases does explain the difference observed in element distribution (i.e. band and no-band). Yes, we agree. However, when taking Mg as an example, these Mg/Ca bands close to the POS

are still much lower than expected from inorganic precipitation experiments. Based on your observations, is this because the system is not fully open, or simply because inorganic partitioning is different from foraminiferal partitioning, due to presence of other ions (inhibitors) or organic layers (adsorption)? Unfortunately, from the present results it is not possible to say how much seawater actually passes through the gaps in organic layers during chamber formation. From the beginning, the Mg content of the fluid is already decreased even the system is not fully closed, because the observed gaps are not sufficiently large to exchange seawater between the site of calcification and the exterior. But this is just speculative at this point. Would this suggest that comparing foraminiferal element partitioning to inorganic precipitation experiments is not useful, since the systems are so different (organics, open/closed system etc.)? We consider comparing foraminiferal elemental partitioning to inorganic precipitation still meaningful, as the partitioning from fluid to crystal follows the same chemical laws in both organic and inorganic systems. The key difference is that the elemental contents of the fluid in the site of calcification is strongly controlled in biomineralisation processes (and very different from inorganic processes), and in the future research we hope to clarify the elemental composition of the fluid at the site of calcification. We have added the following to Discussion: 'The elemental partitioning in foraminiferal tests must be strongly controlled through the elemental composition of the fluid in the SOC, which is a key subject for future studies.'

Textual suggestions (page number/line number): 2/14 ..from seawater, which implies active ion exchange. Changed as suggested.

2/24 ..(Haynes, 1981), and each species.. Changed as suggested.

2/25 ..modern days, during which they have.. Changed as suggested.

2/29 Moreover, the tests are.. Changed as suggested.

3/5 Even though the test morphology and chemical composition depend to a certain extent on the environment (), the calcification process.. Changed as suggested.

5/5 For specimens fixed at different time slides during the chamber formation process.. Changed as suggested.

5/15 ..the chamber formation process of A. beccarii with DIC for 59 times in total.. Changed as suggested.

6/19 ..the pseudopodial activity significantly differed. A fan-shaped.. Changed as suggested.

7/13 formed chamber, leaving an empty space in the new chamber.. Changed as suggested.

9/16 ..corresponding to the IOL, the POS, and the OOL respectively from inner to outer side.. Changed as suggested.

10/1 ..has been speculated in previous studies,.. Changed as suggested.

10/6 – in other words the organic layer is part of cytoplasm. Changed as suggested.

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2018-295/bg-2018-295-AC1-supplement.zip

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