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Discussions

Interactive comment on "Distribution of chlorine and fluorine in benthic foraminifera" *by* Anne Roepert et al.

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Referee Comments Anonymous Referee #1

Review for "Distribution of chlorine and fluorine in benthic foraminifera" by Roepert et al. This study looks at the incorporation of the anions chlorine and fluorine into the shells of benthic foraminifera. This has received almost no attention yet, although the conservative nature of these elements on the oceans would make them interesting to function as paleo proxies. Four different species, both rotaliid and miliolid, were cultured under controlled conditions. Analyses were performed using laser ablation and nanoSims. The distribution of chlorine and fluorine in the calcite varies between the low/intermediate-Mg species and the high-Mg species. Similar to other elements

the lower Mg species show a clear banding of Cl and F related to the organic linings formed during biomineralization. As the biomineralization process is different in the high-Mg species in that no banding is developed, this is also not visible in the Cl and F content. So, the distribution of Cl and F depends on the biomineralization process and seems mostly connected to organic content. The manuscript is well written and organized, it is easy to read and extensive details on the methods are given. I do miss a few things on the methods though, and a final implications section or paragraph (see below). I recommend that this manuscript makes a valuable addition to Biogeosciences after minor revisions have been made.

We thank the referee for this constructive feedback. Details of our response are given below.

Comment RC1.1: In the abstract the potential of these conservative elements as paleo-proxy is mentioned, but then apart from one sentence (Line 182) this is not coming back anymore. I suggest to include a final paragraph at the end of the discussion what these results imply for proxy development. Is it possible at all to conclude something about this? It is stated already that the number of samples and different setups is not large enough to identify trends, but could the extremely high-resolution also be an issue to determine their use as a proxy?

Answer: Our study did not aim at the development of a new proxy, but rather at exploring the incorporation of halogens. Consequently the data obtained do not allow to draw conclusions for proxy development. A more robust data set with, species-specific, replicated specimen per treatment would be needed. Also, large intra-test variability that is observed for many trace elements in foraminiferal shells using high-resolution imaging techniques implies replicate analyses on several chambers per specimen are necessary. Creating large data sets with replicate measurements on many specimens is not the strength of NanoSIMS and hence other analytical techniques are more suitable for studying potential proxy applicability. Still, our approach does provide distributional data of F and Cl so far not available.

Changes: We added a clearer statement to the discussion that potential proxy applicability of Cl/Ca and F/Ca cannot be evaluated based on our data.

Comment RC1.2: For a commonly used proxy as Mg/Ca you also see a very heterogeneous distribution when looking at the micro-scale that does not appear to correlate with environmental conditions. But the actual proxy is the ratio that is representative for the whole shell (or enough laser profiles). So, how representative do you think your results are? Just six specimens on four different species, and a laser profile through each one showing how heterogeneous the distributions are, is not very much.

Answer: We acknowledge that our data set is limited to few fields of view, on a limited amount of specimens. However, lateral profiles have also been made for the fields of view where the images are not shown. The panels in Figure 1 show a representative image per species of those we analysed, and based on the similarity between the images within one species we do not expect appreciable differences in elemental distribution patterns if we imaged more fields of view. For the purpose of presenting key differences between rotaliid and miliolid species we consider our data sufficient. The data that are shown in Figures 3, 4 and A4 are averages of 1, 2 or 3 fields of view per specimen including standard deviation. They resemble average elemental ratios as determined by LA-ICP-MS measurements, although, at a higher resolution. Since (in the case of the rotaliids) the field of view of the NanoSIMS images covered a cross-section through the shell wall, we expect the average of one NanoSIMS image to resemble an average LA-ICP-MS profile.

Changes: We have added “As such, lateral profiles that cover a representative fraction of a shell wall may be comparable to LA-ICP-MS profiles, albeit with a higher resolution.” to the methods section.

Comment RC1.3: Section 2.1: More details on the culturing experiments are needed. Part of them are in Appendix B, but I think this would be much better to include into the main text.

Answer: This comments echoes that of Inge van Dijk and for a detailed response see answer to Comment SC1.6.

Changes: more details have been added in the main text, see answer to Comment SC1.6.

Comment RC1.4: What I miss is on what part of the forams the analyses were done. I assume on the newly grown calcite, but how was this determined? Did you use a marker in the solution, or simply took the last chamber?

Answer: This comment relates to Comment SC1.3. Please refer to SC1.3 for a detailed answer.

Changes: See Comment SC1.3.

Comment RC1.5: A comparison with the original, naturally-grown calcite would also be interesting.

Answer: A valuable suggestion for future research, but for the scope of this pilot study we consider the current data set sufficient.

Comment RC1.6: What were the concentrations of these elements in the culture solutions; similar to sea water?

Answer: We did not determine the concentrations of Cl and F in the culture media directly. Since Cl and F are conservative elements following salinity, the concentrations are expected to resemble those in sea water with the same salinity.

Changes: The text has been modified to explicitly mention this: “The concentrations of Cl and F in the culture media were not directly determined. However, since Cl and F are conservative elements following salinity, the concentrations are expected to resemble those in sea water with the same salinity.”

Comment RC1.7: The saturation state of the angulatus and marginalis experiments is very high. Were there any indicators of inorganic precipitation of calcite, which could

have biased the results?

Answer: During the experiments there were no visual indicators of inorganic precipitation of calcite. The obtained specimens did not show visual overgrowth under the SEM.

Changes: We have added the following: “During the culture experiments there were no visual indicators of inorganic precipitation of calcite. Moreover, inspection with SEM of the measured specimens showed no inorganic calcite overgrowth.”

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