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

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Short Comment 1

Thank you for presenting for the first time data on the distribution of F and Cl in foraminiferal calcite. I have some short comments of issues I noticed during a quick read of the manuscript, which are mainly concerning the lack of details of the culture experiments and the graphical presentation of the data. I leave a proper review to the invited referees.

Thank you for the feedback. We will provide further details on the culture experiments and materials used.

Comment SC1.1: Fig 1. The miliolid species come from two salinity conditions, ac-

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cording to table 1. From which salinities are the specimens show in Fig. 1? And which chambers: ultimate, penultimate, etc?

Answer: The salinities for the specimens shown in Figure 1 were presented in Table 1. As this study does not focus on salinity, we decided not to report salinities (and other environmental parameters) in the figure or figure caption, but instead to provide an overview in Table 1. We agree that the information in Table 1 could only be linked to Figure 1 via Fig. A1, which was suboptimal.

Changes: To facilitate identification, we added specimen numbers to Figure 1 and we explicitly mention in the figure caption that details on the specimens used are presented in Table 1. Chamber numbers (F, F-1, etc.) were added to Fig. A1.

Comment SC1.2: I think a SEM picture of the studied areas would be a good addition to Fig. 1. I see the general overview pictures in the appendix, but I would like to see also the higher magnification image.

Answer: Figure 1 is already rather complex and we rather refrain from adding even more complexity to it. The context of the detailed nanoSIMS images are provided by SEM images shown in Fig. A1. These are high resolution images that can be zoomed in by the reader.

Comment SC1.3: Looking at the location of the measurements of the miliolids, and the explanation of the culture set-up, how can you assure the measurements were done on newly formed (experimental) calcite? Judging the orientation of the foraminifera in the SEM images in Appendix A1, it seems like you are not measuring e.g. the last chambers, which are a bit less complex. Especially in the case of Archaias, the last chambers seem to be on the top left of the image, and it looks likes the authors choose a quite complex location for the analysis. Why not analyse the last chambers, where the direction of growth is more clear? Also, the polishing of the Sorites doesn't seem to include the last chambers, because they appear to be still inside the resin (or was the specimen broken?).

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Answer: The cultures were started with juvenile specimens, possessing 2-3 chambers at the start of the experiment. All additional chambers were formed during the course of the experiment. The miliolid species were cultured in media containing the fluorescent indicator calcein to identify newly formed calcite in retrospect. Positions for nanoSIMS imaging were carefully selected based on the quality of the surface preparation and position in the specimen. Where possible, distal chambers have been measured, but more proximal chambers were preferred in case their cross-sectional surfaces were flatter or cleaner.

Changes: The following information was added to the methods section: “The fields of view for NanoSIMS imaging were carefully selected using SEM images on the basis of the position in the specimen and the quality of the surface preparation. Where possible, distal chambers were measured, but more proximal chambers were preferred if their cross-sectional surfaces appeared flatter or cleaner.”

Comment SC1.4: Please indicate the chamber numbers (F, F-1 etc) and, most important, which ones are precipitated in the experiment. This is crucial, since the authors compare to the culture conditions in Fig. 3 and Fig. A4.

Answer: This comment relates to SC1.3, see also the answer to SC1.3. We assume this comment refers to the rotaliid species, where chambers are commonly indicated with F, F-1, etc.

Changes: We indicated chamber numbers in Fig. A1 for the rotaliid specimens.

Comment SC1.5: Also, please mirror the scalebar in these figures for readability.

Answer: Done.

Changes: Scale-bar text mirrored for better readability.

Comment SC1.6: In my opinion, the culture experiments have to be described more in detail, clearly stating the differences between the set-ups. Even though the other experiments are published already, some basic details can be stated in sec-

tion 2.1. Also there is no clear indication how samples were cleaned, while the cleaning can have a major effect on the element distribution (Glock et al., 2019: https://doi.org/10.3389/feart.2019.00175). Digging through the publications of the other experiments, this information can be retrieved. But cleaning method is not presented for the unpublished experiment. Please add this information.

Answer: Done.

Changes: The following was added to the methods section: “The A. angulatus and S. marginalis specimens were collected in Sint Eustatius (Oranjestad Bay, 17.479751°N -62.987273°W). The culture experiments with A. angulatus and S. marginalis were conducted in the same manner as described in van Dijk et al. (2017), with the exception of media preparation. Culture media of different salinities were prepared by mixing natural 0.2μm filtered seawater with deionized water and ’instant ocean’ salt, to obtain a range in salinities between 25-45. Calcein was added during the course of the experiment, and fluorescence images were used to identify newly precipitated calcite. The A. lessonii specimens are from Burger’s Zoo, NL (van Dijk et al., 2019), with the culture conditions being reported in van Dijk et al. (2019). The specimens of A. tepida were collected on a tidal flat near Den Oever, the Wadden Sea, NL (Hayward et al., 2004), with the culture conditions being described in Geerken et al. (2018). For both the cultures of A. lessonii and A. tepida, 2-3 chambered juveniles were transferred into Petri dishes containing culture media with adjusted salinity and alkalinity, where the specimen precipitated additional chambers. Prior to embedding all specimens were cleaned using an adapted Barker protocol (Barker et al., 2013), only applying the organic removal/oxidation step, in which NaOH was replaced by NH4OH, as described in detail in Geerken et al. (2018).”

Comment SC1.7: How were the E/Ca measured for the milliolid species? Since these specimens are coming from an unpublished experiment, and are not “previously described (Geerken et al., 2018; van Dijk et al., 2019)”, as the authors state. Please give these details.

Answer: We meant the El/Ca ratios in the miliolid species were determined using the same methodology “as previously described [...]”.

Changes: for more clarity the text was adapted to “This was done by LA-ICP-MS for A. tepida and A. lessonii as previously described (Geerken et al., 2018; van Dijk et al., 2019). For A. angulatus and S. marginalis LA-ICP-MS analyses were performed using the same methodology as described in Geerken et al. (2018).”

Comment SC1.8: It looks like the Archaias angulatus cultured at salinity 40 has lower Na/Ca then the specimens from salinity of 30. What are the consequences for the Na/Ca – salinity proxy, and the idea that milliolids are precipitating from seawater vacuoles?

Answer: Large intra-specimen variability in Na/Ca has been shown for rotaliid species (e.g. Geerken et al., 2018). It may well be that miliolids exhibit even large intra-specimen Na/Ca variability as well, where a specimen cultured at salinity 40 can have a lower Na/Ca than a specimen cultured at a salinity of 30. To be able to draw any conclusions on what the consequences of individual specimen Na/Ca would be for the Na/Ca salinity proxy using miliolid species, further research is needed. This should involve culturing experiments using a statistically sound number of replicate specimen at a range of salinities.

Changes: As this manuscript focuses on the anions Cl and F, we have not included a note about the range in Na/Ca of the presented specimens.

Comment SC1.9: Also indicate the salinity conditions in the figures/captions in figures and tables, e.g. appendix A1, and table A1. Answer: See answer to comment SC1.1.

Changes: We have added the specimen number where missing to facilitate finding the respective environmental conditions in Table 1.

Comment SC1.10: Consider changing the terminology, from rotaliid to hyaline and milliolid to porcelaneous.

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Answer: We have considered different terminology, but chose for referring to the differences in terms of order instead of test appearance. We did so, because hyaline foraminifera also include globigerinids, which were not investigated in this study.

Comment SC1.11: For future work, please also consider to analyse also the natural chambers from the field for comparison with the experimental chambers. Especially for the specimens that were culture using Instant ocean salt, which is an industrial manufactured salt, lacking e.g. certain organic complexes.

Answer: a valuable suggestion for future work.

Comment SC1.12: Also, as indicated in van Dijk et al., 2019 (https://www.frontiersin.org/articles/10.3389/feart.2019.00281/full), there is a high intra- and inter-specimen variability for many elements. Therefore, please consider measuring several chambers and specimens to gain a robust dataset.

Answer: we are aware that a more robust data set is needed for drawing conclusions concerning proxy potential and relationships with environmental parameters. However, as we here present a pilot study into the spatial distribution of Cl and F in rotaliid vs. miliolid benthic foraminiferal species, we regard the current data set sufficient. We agree that future research using more replicates and consistent culturing conditions is needed to better understand the incorporation mechanisms and impact of environmental conditions on incorporation of Cl and F.

Changes: see also comment RC1.1. In our revised version, we have stated more clearly that the current data set does not allow for conclusions on proxy application.

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