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Biogeosciences Discussions

Interactive comment on "Encrustation and trace element composition of *Neogloboquadrina dutertrei* assessed from single chamber analyses, implications for paleotemperature estimates" *by* L. Jonkers et al.

Anonymous Referee #3

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This paper aims to quantify the trace element differences between the outer calcite 'crust' of N. dutertrei with that of the inner calcite. The crust has different trace element to calcium (Te/Ca) ratios in comparison to the inner calcite and, when comparing individuals obtained from the same sample, the crust is variable in thickness and in the number of chambers that are encrusted. Because the crust lowers the overall Mg/Ca ratio (used to reconstruct temperature) the variable nature of the crust means the overall affect on the Mg/Ca ratio of shells from the same sample is not equal. Overall, I find this is an interesting and paleoceanographically relevant study that clearly

demonstrates an issue with all foraminifers that form a crust: the crusts are variable in thickness and are lower in Mg in comparison to the 'inner calcite' and this is quite problematic for reconstructing paleo-temperatures in encrusted specimens. The variable thickness leads to a variable lowering of the overall Mg/Ca ratios and the implied Mg/Ca-derived SSTs are potentially inaccurate. This has implications for Mg/Ca-derived SST comparisons because encrustation is likely variable both geographically and through time.

I have three concerns with this paper, which I address here. Minor issues/comments and associated sections/page numbers/lines are detailed below.

1. The laser ablation data: Figure 3 details an example laser ablation profile that shows raw data and a 3-pt running mean. The data shown (symbols) in that plot is not very noisy (i.e. the 'spread' of the measurements in Mg/Ca space is small). The other ablation profiles (Figure 6) are quite noisy and the actual LA data points (the symbols) span 10 mmol/mol for some of the profiles (e.g. LGM, F-2, red spots span 1 to 10 mmol/mol) and the data are smoothed using a 25-pt running mean. I think the authors should comment on why the ablation profiles are so noisy, necessitating a 25-pt mean to smooth the data. The standard error of the measurements on those profiles is likely large. Are the average TE/Ca ratios of the different chambers statistically significantly different given such a large standard error?

2. The author's state in the methods section that they chose to analyze the F-2 chamber for all of the samples because 'previous studies suggest the F-2 chamber contains valuable information on the compositional variability of the whole test'. This is true for species like G. ruber and G. sacculifer because there are only 3 chambers in the final whorl (F, F-1, and F-2). If, as a chamber grows, calcite is added to the previously formed chambers, then yes, F-2 would contain a calcite layer formed with the F-1 chamber and the F chamber and therefore the F-2 chamber includes the growth history of the entire adult whorl. However this is not similar to N. dutertrei, which has variable (5+) chambers in the adult whorl. In fact, it is stated in section 4.1 (Crust and

element/Ca layering) that sometimes F-2 also didn't include a crust. Additionally, figure 5 shows variable Mg/Ca ratios in the F-0 – F-2 chambers, which appear to asymptote to similar Mg/Ca values in chambers F-3, F-4, and F-5. While this isn't detrimental to the study and results presented here, the results suggest older chambers may be better to focus on for future studies and chamber specific calibrations because the older chambers in N. dutertrei contain more information about the compositional variability of the whole test and the Mg/Ca ratios are similar in the older chambers, especially when comparing the inner calcite layers.

3. The author's do not specify which Anand et al, 2003 equation is used and what the implied temperatures. Von Langen, 2005 has a calibration for N. pachyderma and several calibration points for N. dutertrei (which overlap the N. pachyderma calibration curve). The Von Langen, 2005 equation may be more suitable for the Neogloboquadrinids. Additionally, the authors present sediment trap data but do not compare the Mg/Ca-derived temperatures to regional hydrographic data. The Mg/Ca ratios, especially the sediment trap samples, be converted to Mg/Ca-derived SSTs and any offset from the actual SST should be discussed.

Other issues/Comments: Text quoted from manuscript is in **BOLD**

Pg 10618, Line 10: The authors cite H. Spero and J. Bijma for the presence of symbionts in this species, however Gastrich, 1987 found chrysophyte intracellular algae in N. dutertrei. The Gastrich, 1987 paper should be cited here.

Pg 10618, Line 22: Hemleben and Spindler state crust formed below 15°C, however, they did not present any results from their culturing experiments in their paper. Did they try to culture above 15°C and not find any encrustation? What other temperatures did they use? Because the culture study and results were not presented thoroughly in the Hemleben and Spindler study, I don't think it is proper to cite this study unless you state that it is anecdotal evidence at best. Very little is known about crust formation in this species.

Pg 10619: Lines 1 and 12: Samples were taken from 2 locations, but then paragraph 2 mentions the Natal Bight. Where is the Natal Bight? Is it the same as one of the other locations? It would be good to include a small regional map highlighting study locations.

Page 10619, **Tests of the shells were picked from core top and LGM intervals from kasten cores from the SE African margin.** Weren't samples also picked from the Mozambique Channel core? If so, were they Holocene and LGM in age? Are the ablation results similar for the two locations? The Holocene and LGM samples were grouped, but from both locations or only from the SE African Margin? I'm a bit confused on exactly which cores you obtained fossil material and what shells were grouped and if you report data for both locations and group the data together.

Page 10620, Line 23: **Aluminum was taken as an indicator of detrital contamination.** What Al/Ca ratio did you use to suggest a sample was contaminated? Why can't aluminum/Ca be quantified (see Fig. 3 caption)? Other researchers report Al/Ca ratios (cf. Bolton et al, 2011).

Page 10621, Line 7: **The sediment trap specimens were analysed on F-2 only.** Why was only F-2 analyzed and compared to the core-top data? More data from the sediment trap specimens should be discussed. Is the chamber-to-chamber and/or inner vs. outer crust TE/Ca variability similar to the core top specimens?

Page 10622, Line 15: **the median value is 2.7 mmol/mol** Why report median values instead of an average? Comparing the median value in the Holocene vs. LGM samples is also quite meaningless. All you are saying is the middle value hasn't changed. But has the distribution changed? The box and whiskers plots are really useful in showing the change in the distribution of the TE/Ca ratios, but it would be more useful to report the average TE/Ca ratio and not the median value. The average value would be used to calculate SSTs, not the median.

Page 10624, Line 2: the word **specimen** should be specimens

Page 10624, Line 12: **This is however unlikely since formation of crust calcite is fundamentally different with encrustation occuring rapidly and simultaneously on all chambers**... Evidently crust formation does not occur simultaneously on all chambers. If it did, then the F-2, F-1, and final chambers in N. dutertrei would also always be encrusted and the crust would be uniform in thickness all over. This is not the case and we can infer from this that crust formation in N. dutertrei does not form simultaneously and on all chambers.

Page 10624, Line 13: **occuring** should be occurring

5.1 Implication for paleotemperature estimates: General comment: Average Mg/Ca ratios of inner calcite, outer calcite, entire chamber, and whole shell values are not converted to Mg/Ca derived temperatures. Are the temperatures accurate for this location using the calibration chosen to calculate temperatures? What is the implied depth range of crust formation, inner calcite formation, etc?

Page 10625, Line 12: **Both tests settled within the same 3-week period and therefore calcified under nearly identical conditions. This is reflected in the identical Mg/Ca values of the inner layer.** The conditions may not have been identical, N. dutertrei is known to span large depth range and therefore the difference in the geochemistry may be real and due to differences in calcification depth.

Page 10625, Line 14: **The Mg/Ca of the crust and the ratio of crust to inner layer calcite is however very different for both tests, causing the temperature estimates based on the entire profile to differ by over 2°C (Fig. 9).** I think it is more important to point out the differences in the Mg-Ca derived temperatures of the crust (as low as 10°C) and not the difference in the average temperature difference (2°C is not that large considering the depth habitat of this species is thought to span a large depth range). What is more significant here is the implied temperatures at which the crusts form (using an equation that is likely not accurate for this species). It is not likely the crust formed at 10°C water depth in this region which would occur at nearly 500 m

depth.

Page 10627, Line 11: **Both patterns in thickness and composition of the crust point at biological control on crust formation and composition, impacting the use of this species' Mg/Ca reconstruct past seawater temperature.** There is a strong biological control on the composition of the Mg/Ca ratio of all foraminifers, not just N. dutertrei.

Interactive comment on Biogeosciences Discuss., 9, 10615, 2012.