

Interactive comment on “Calcium isotopic composition of high-latitude proxy carrier *Neogloboquadrina pachyderma* (sin.)” by D. Hippler et al.

P. Mortyn (Referee)

graham.mortyn@uab.es

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Referee Comment of Graham Mortyn, for paper published on the Biogeosciences Discussions website.

authors: D. Hippler et al. title: Calcium isotopic composition of high-latitude proxy carrier *Neogloboquadrina pachyderma* (sin.)

General comments:

It is with pleasure that I reviewed this paper, in order to stay abreast of new developments in a burgeoning field of paleoceanography, that of ^{45}Ca thermometry. This

paper offers a unique and important contribution to this discipline for several reasons. Firstly, it provides robust evidence of a useful relationship that appears independent of genetic diversity. This by itself is a powerful result worth publishing. Secondly, it makes some interesting points regarding the parallels between this species and *G. sacculifer*, as well as contrasts to other species (e.g. *O. universa*) and inorganic precipitate experimental results. These points facilitate further research and improvements in our understanding of the proxy itself, as well as better defining the limits over which it may not be applicable. As the saying goes ? ?strength is in knowing your limitations?. Overall, this *N. pachyderma* (sin.)- ^{45}Ca paper fills an important niche where other proxy systems have fallen a bit short, as described well in the paper. Other foram-based T proxies, like Mg/Ca, $\delta^{18}\text{O}$, and assemblages, have real limits in these cold environments for different reasons – flat end of the exponential curve, brine/meltwater complications in the vicinity of ice, and nearly monospecific patterns, respectively. Alkenone-based T calibrations are also more problematic at the cold end of the spectrum. Yet, these are some of the most important regions in which T reconstructions are most relevant and crucial, especially regarding the link to convective overturning and deepwater formation, thermohaline circulation, etc. Therefore, my detailed suggestions for improvement (below) are relatively minor.

Specific comments:

In the introduction the point is made that genetic diversity necessarily warrants the need for independent proxy calibrations based on *N. pachyderma* (sin.) (near line 20 on page 3304). Is this necessarily true? Certainly genetic diversity is suggestive, but maybe more should be done to elucidate this point further. Which previous works or other evidence have provided explicit proof of this? If other works on various genotypes of the same morphotype, like this paper, have demonstrated property sensitivity independent of genetic diversity, then the authors might be ?shooting themselves in the foot? a bit. Anyway, I just felt this was worth clarifying.

The data points belonging to the ?cold-end paradox? are certainly interesting, as they

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appear to form a 'kink' to the otherwise-linear relationships. My sense however is that this may be a salinity effect more than anything else, as other data of similar T but presumably higher S seem to fit just fine. I therefore wonder if this 'kink' in the relationship should be discussed as a 'fresh paradox' rather than a 'cold-end' one.

Also from the same section (3.4), I was confused by the final sentence. What is the link between where the ^{45}Ca relationship breaks down and foram assemblages being mostly monospecific? I assume these 2 things to be independent of one another unless there is a convincing case made for the link between the 2. Maybe you can expound or speculate a bit further?

Another query comes from section 4.3. Is ^{45}Ca -based T agreement with ^{18}O -based T suggestive of both being correct, or equally incorrect? For ^{18}O applications, for example, vital effects and disequilibrium have been shown to explain significant offsets when using this approach. For purposes then of estimating calcification T, depth etc., these assumptions of isotopic equilibrium can lead to problems. Agreement with ^{45}Ca may not confirm validity of either approach. I feel that more caution needs to be applied to the text here.

In section 4.4, the point is made about potentially similar calcification strategies between *N. pachyderma* (sin.) and *G. sacculifer*, albeit at opposite ends of T extremes (cold, warm, respectively). Can you speculate further as to why there should be a link this way? What is it specifically about thermal thresholds that is suggestive of a similar calcification mechanism, ^{45}Ca sensitivity, or both?

Also in the same section (4.4), there was discussion about the offset between coral aragonite and inorganic aragonite. To me it seemed portrayed a bit negatively? offsets can be corrected for as long as they are known and T sensitivity is the same. There may be potentially interesting parallels between corals and forams for future work in this field. Can you put a bit more positive spin on what may be useful here?

Section 4.5 (just before the conclusions) seemed to end a bit abruptly. The discussion

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about 2 groups of *N. pachyderma* (sin.), in terms of their suitability as T proxy carriers is very interesting. Certainly the work by Bentov and Erez with calcification pathway differences can contribute substantially to this discussion. Can you say more about what was the 'upshot' of the Norwegian Sea vs. Arctic Domain comparison? I found this interesting, but to be left hanging a bit too abruptly – especially as an ending to the paper.

Maybe the last sentence of the conclusions is meant to clarify the final part of section 4.5? If so, then these need to be clarified better and in a way that is more together. The final parts of both 4.5 and the conclusions are ambiguous as is. I suggest combining more before the conclusions (section 4.5), as well as expanding a bit (see above), then later make a simpler and more general statement for the conclusions section.

Figure 2 needs to be in color rather than in grey-scale. Please also add the average open triangle symbols to the legend. It would also be helpful to explain the 'whiskers' to the weighted mean, and therefore the thickness of the grey bar.

In Figure 3, the caption implies all core-tops to be in triangle symbols, but the legend says that Type 1 core-tops are in diamonds. Can you please clarify and/or make more consistent somehow?

In Figure 4, panel A should also include the slope of the inorganic precipitate experiments, since it is discussed in the text. It would also stimulate further thought and discussion potentially. In panel B, what is the difference between black and grey for foram habitat ranges? This should be explained.

Technical corrections:

Line 4 in abstract does not need the word 'however'.

Line 17 in abstract 'affects' instead of 'affect'.

Also line 17, I suggest abbreviating Ca isotope composition like this (^{45}Ca) and then referring to it this way throughout the remainder of the paper.

Also line 17, a comma would be better before ?becoming?.

Introduction line 5, a comma is better before ?yet?.

In line 27 a first mention of a species should be spelled out, followed by abbreviated subsequent mentionings.

Line 4 from page 3304, I suggest abbreviating sea surface temperature as SST and then using throughout remainder of paper.

Line 18 from page 3305, insert ?to? before ?compare?.

Line 11 from section 2.1, delete the word ?approximately?.

Line 23 from section 2.4, a comma is better before ?Ca?.

Lines 2-3 from page 3308, ?genetic? instead of ?genetically?.

Line 7 from page 3308, better to say ?in the 125-250?m size fraction?.

Line 5 from page 3309, replace ?around? with ?near?.

Line 18 from page 3309, replace ?mention? with ?mentioned?.

Line 20 from page 3309, insert a comma before ?testing?.

Line 23 from page 3309, ?genotypes? needs to be plural.

Line 22 from page 3311, replace ?admits? with ?allows?.

Line 20 from page 3312, better to say ?as a T-proxy carrier? or something similar.

Line 26 from page 3315, ?these? rather than ?theses?.

Lines 10-11 from page 3316, the short sentence is probably better combined with the one just before it.

Line 11 from page 3317, insert the word ?Ontong? before ?Java??

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Line 27 from page 3317, replace ?plot offset? with ?deviate?.

Line 9 from page 3318, insert a comma after ?signatures?.

Line 1 from page 3319, insert a comma after ?carrier?.

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