Clim. Past Discuss., 11, C2456–C2461, 2015
www.clim-past-discuss.net/11/C2456/2015/

Climate of the Past Discussions

Interactive comment on "Revisiting carbonate chemistry controls on planktic foraminifera Mg/Ca: implications for sea surface temperature and hydrology shifts over the Paleocene–Eocene Thermal Maximum and Eocene–Oligocene Transition" *by* D. Evans et al.

D. Evans et al.

d.evans@yale.edu

Received and published: 23 November 2015

Remark: apply the Mg/Ca-pH corrections to Mg/Ca-T estimates in Holocene records from parts of the ocean with different mixed layer pH values – perhaps the eastern and western Pacific, using TR163-19 and ODP806b
Response: We fully agree that investigation along these lines would be worthwhile. However, the issue with using Pacific sites to address the problem is that a relatively

large dissolution correction is required below ∼1 km water depth, which mean the relatively small modern ocean pH heterogeneity is not visible. A global compilation may address this, as also suggested by reviewer 1, which we aim to work towards in the future. However, this will require a very large amount of work and is beyond the scope of this study.

Remark: Since there is an offset between Mg/Ca ratios generated from laser vs solution methods in fossil samples, should the Mg/Ca-pH relationship for G. ruber (obtained via laser) be applied to fossil (or other) samples as is, or with a correction?
Response: We stress that the offset that we observe between laser-ablation and solution ICPMS Mg/Ca measurements is smaller than the error of either technique. Furthermore, as we state on line 23, page 3155, if this offset is real (we only observe it for 3 out of 4 samples), it is small in comparison to uncertainties derived from seawater Mg/Ca or errors in pH reconstructions. We will re-word this paragraph to bring these points out more clearly.

Remark: Table 1: The pH values reported in Table 1 for G. bulloides and O. universa are the same as reported in the original Lea et al. 1999 and Russell et al. 2004 papers – so they are on the NBS scale, not the total scale as stated in the column header. These original values also appear to have been used in the figures, and I assume in the regresions.
Response: We would like to thank this reviewer for noticing this typographic error in table 1. However, it is not the case that this mistake was propagated through to figure 1 (notice that the Lea et al. [1999] datapoints are plotted at a lower pH than the values given in the table). We will correct the values in the table, but further changes are not necessary as these incorrect pH values were not used in the regressions.

Remark: Also – the Kisakurek 2009 data for G. ruber should be included in the table –

they're included in Figure 1 and I assume they're included in the regressions.
Response: We agree this data should have been included and will add it to table 1 upon revision.

Remark: p. 3146, line 4: The Kisakurek and Russell Mg/Ca-pH relationships for planktonic forams show a dependence for pH lower than ambient (8.1), so I suggest replacing "significantly different" with "significantly lower"
Response: We disagree that this is the case. Whilst the study of Russell et al. [2004] argued that the pH effect was not significant above ambient pH, it is clearly the case that *G. bulloides* Mg/Ca is lower at pH 8.35-8.45 than at ambient when all studies are considered together. This also appears to be the case based on the *O. univera* data or Lea et al. [1999].

Remark: p. 3154, lines 9-10: What is the justification for excluding the data point at pH 7.6?
Response: Data were excluded from regressions based on the following two criteria: (1) Greater than critical Cook's distance, and (2) residual relative Mg/Ca greater than $\pm$0.4 from the regression (all except one data point fall within $\pm$0.3). Figure 1 shows Cook's distance for the dataset discussed here. Point A is the high-Mg outlier that meets both these criteria which we exclude. Point B (the lowest pH data point) is an outlier as defined by Cook's distance but was not excluded from the calculation of the regressions because it has a small residual (-0.18). It has a greater than critical Cook's distance because it is the lowest pH datapoint and therefore exerts a relatively large control on the slope of the regression below the inflection point of the logistic curve at pH 7.8.

Remark: p. 3156, lines 1-6: According to De Nooijer, the volume of seawater contained in vacuoles is insufficient to deliver the Ca required for calcification so this

would require internal Ca pools. These pools were not observed in experiments by Nehrke. The fact that the role of vacuoles in calcification is still under debate should be mentioned here.
Response: It is true that Nehrke et al. observed no Ca pool in one juvenile individual of one species of benthic foraminifera. However, the existence of Ca pools has been shown in several other species [see e.g. Erez, 2003]. Nonetheless, it is true that no consensus exists on the importance of vacuoles, and a statement to this effect will be added to the revised manuscript.

Remark: p. 3156-3157: According to your model, I can see that pH is important – but [CO3] may still be important because of its effect on calcification rate. The relative rates of calcification versus Mg pumping (to remove excess Mg) could play an important role.
Response: This is an excellent point, which we cannot address in the absence of experiments with variable [CO_3^{2-}] at constant pH. We will add a statement that the effect of [CO_3^{2-}] may be present by unidentifiable in our data because of the covariation of pH and [CO_3^{2-}]. We also suggest that pH may actually exert a larger control on calcification rate, because lower seawater pH would reduce the efficiency of the carbon concentrating mechanism, if present. Furthermore, the relationship between Mg/Ca and pH is tighter than between Mg/Ca and [CO_3^{2-}].

Remark: Figure 3: What do the error bars in part b represent, ie standard deviation or standard error (1 or 2); based on actual analyses or bootstrapped? (also - this caption is missing a noun and has a typo).
Response: The laser-ablation errors are 2SE of all analyses, whereas the solution ICPMS errors are the long term precision (quoted as RSD) of the original study. This will be added to the caption. The missing noun is 'chamber'. Comparison will be spelled correctly in the revised version.

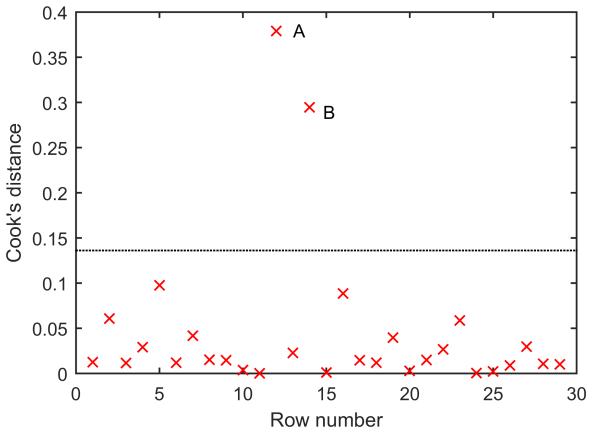

Fig. 1. Cook's distance for the data used to calculate the logistic Mg/Ca-pH regression.