

## ***Interactive comment on “Sensing Seasonality in the Arabian Sea: a coupled $\delta^{18}\text{O}$ –Mg/Ca approach” by W. Feldmeijer et al.***

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We thank the reviewer for the consideration of our manuscript. Please find outlined below our responses to the comments and corrections for the resubmission of the manuscript.

This study employs Mg/Ca and  $\delta^{18}\text{O}$  measurements from individual foraminifera tests in order to investigate changes in seasonality and stratification at two sites in the Arabian Sea during Heinrich Stadial 4 and Dansgaard-Oeschger event 8. While the analytical methods and resulting data look to be of high quality I do not have much else positive to say and my review will be fairly short as a complete reworking is required. Firstly, the age models employed are extremely poorly documented. The reader has no way of determining how well constrained the dating is for each of the intervals used in

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each core. Much more has to be added to the paper in this respect and then a proper assessment can be made. Until then it is unreasonable to interpret the results in terms of conditions at the specified times.

- Age models for both cores are previously published and therefore not extensively repeated here (see last paragraph of section 2.0). That of NIOP478P is based on foraminiferal  $\delta^{18}\text{O}$  (Reichart et al., 1998) and  $^{14}\text{C}$  (Reichart et al., 2002) and the age model for NIOP905P is published in Ivanochko et al. (2005). Still, comparing the intervals as such does not depend on absolute age, but confidence of inter-core correlation. For the intervals in both cores, sample selection was based on  $\delta^{18}\text{O}$  and high-resolution XRF scans (Figure 1). The sample selection procedure, XRF core scanning and the age models on which sample selection was based has been extended (line 114–115) to justify comparison of the H4 and IS8 samples.

The second major problem with the paper is the interpretation of individual test Mg/Ca ratios. On line 10 of page 3859 the authors state that foraminiferal shell Mg/Ca ratio is primarily determined by temperature and yet on line 18 of page 3857 they state that the ranges they observe in Mg/Ca cannot be explained solely by temperature. This really highlights a weakness of this paper. It is clear from the growing number of LA-ICPMS studies that there is a very large range of Mg/Ca to be found within and between individual tests within single samples that probably does not reflect ambient calcification temperatures. Ignoring intra-test variability for a moment, the authors apply calibrations based on averages of several shells to determine Mg/Ca-based temperatures for individual tests (as shown in Figure 7). But if one goes back to the calibration papers, it is clear that individual tests show a very large range in Mg/Ca for any given temperature. For example, the Marr et al., (2011) calibration for *G. bulloides* (their Fig. 4a) has individual test Mg/Ca ratios ranging from 1 to 7 mmol/mol for a single calcification temperature of 19°C. While the average of several tests results in a Mg/Ca ratio that agrees with bulk sample approaches one would not apply the same calibration to the individual test with a Mg/Ca ratio of 7 and calcification temperature of 19°C because

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the answer would be incorrect by definition! This means that it makes no sense to interpret individual test Mg/Ca values in terms of temperature. Even within Fig. 4 of the present ms there is the implication that the range of Mg/Ca values is representative of the range in calcification values - this is probably not the case. The point is made even more apparent in Fig. 7 of the present ms, which shows how poorly the estimates from Mg/Ca versus  $\delta^{18}\text{O}$  match up (in this respect it is almost astonishing that the authors do not show the fruits of their efforts by showing a plot of Mg/Ca versus  $\delta^{18}\text{O}$  for individual tests – I thought this was the whole point!).

- We partly agree with the reviewer on this point. A classical solution-based Mg/Ca measurement using 10-20 specimens (e.g. Elderfield et al., 2002; Anand et al., 2003) will reflect the same value as the average of 10-20 single-specimen Mg/Ca analyses. Therefore, calibrations based on whole specimens can be applied to single specimen measurements. Several papers have shown this to be a robust approach (e.g. Sadekov et al., 2009; Hathorne et al., 2008; Duenas Bohorquez et al., 2011). The relatively high variability between (and within) specimens does not imply that these single specimen Mg/Ca values are not determined (in part) by temperature. In addition there might be, as hinted at by this reviewer, a hitherto unknown mechanism that offsets these values from the 'average' Mg/Ca. This implies that part (but not all!) of the observed inter specimen variability is not related to temperature. This is exactly the reason why we base our discussion to the average Mg/Ca values and compare those to the obtained  $\delta^{18}\text{O}$ . The issue raised by the reviewer is –in our opinion- one of the most pressing, outstanding questions in this field and we have mentioned this in the text (line 261-268).

The authors also do not document which chambers were analyzed for each test and show no profiles to allow assessment of their selection criteria. This is not good enough – again, it is clear from previous studies just how large the offsets are between different chambers within a single test and it is therefore of paramount importance to explain / describe exactly what is represented by the measurements presented here: Are they really bulk test or weighted towards inner / outer chambers – this is really important!

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- 'Final' and further information added to methods and results

Other points: Page 3855 line 3; "Single-specimen Mg/Ca ratios of all species and of both locations are significantly different between HE4 and IS8" – is this really the case? The distributions overlap to a large degree. Having different mean values does not constitute a significant difference.

- 'Significantly' removed

Page 3855 lines 17-24; The authors discuss data that are not shown – this needs to be amended so we can assess what they are talking about.

- Figure added

Figures: Use larger fonts for all axes. Add specific months/seasons to Fig. 1.

- Months added to caption. Font size is something we would like to have checked by the text editor in due time.

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Interactive comment on Clim. Past Discuss., 10, 3847, 2014.

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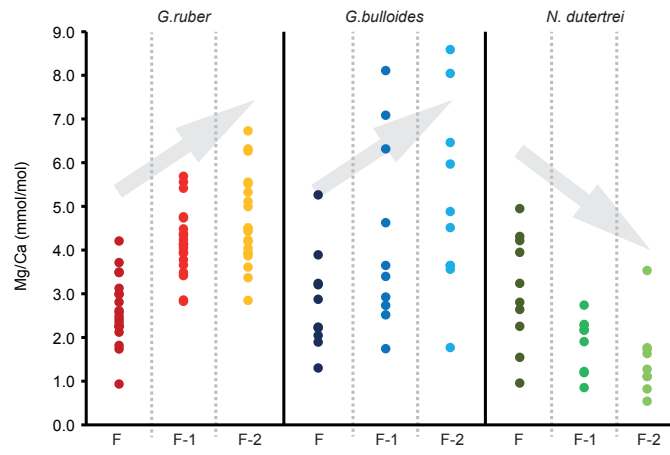


Fig. 1. Figure\_6\_Mg/Ca\_Chambers

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