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Biogeosciences Discussions

Interactive comment on "The effect of meter-scale lateral oxygen gradients at the sediment-water interface on selected organic matter based alteration, productivity and temperature proxies" *by* K. A. Bogus et al.

K. A. Bogus et al.

ka_bo@uni-bremen.de

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We thank the reviewer and very much appreciate the constructive comments. In the following responses, we address the points raised in the review.

1. "Firstly, the authors incorrectly cite a number of papers in support of a statement that 'bottom oxygen concentration is the primary control on OM preservation' across the Pakistan margin (p 11362, l 3-7)...Contrary to the authors' assertion, the other papers that are cited by the authors (Cowie et al, Keil and Cowie and Schulte et al,

which also focused on the Pakistan margin) actually concluded (to varying degree) that oxygen was a contributing factor but not necessarily the primary factor...Either the uncertainty and debate need to be acknowledged and statements altered accordingly, or, more simply, the authors should state what is important and relevant to this study, which is that their OMZ transect and below OMZ see transect unquestionably represent differences in bottom-water oxygen concentration."

We will change the wording mentioned in the introduction so that the bottom water oxygen concentration is not stated to be the primary controlling factor on organic matter (OM) preservation. It is one specific facet among many in the cited papers that contribute to the degree of OM preservation. It was the factor that we chose to investigate in this study as the oxygen concentrations at the sediment surface influence the oxygen exposure time because it affects bioturbation as well as the actual presence of oxygen. Therefore, the statement will now reflect that varying bottom water oxygen conditions at the sediment-water interface simply represent one important component influencing the OM preservation.

2. "A second problem arises with the methodology. Although method descriptions are otherwise good, we are never told the depth interval(s) used for the surface samples analysed at each site, or even if a common depth interval was used. This needs to be addressed."

The surface sample material was all from the uppermost unconsolidated sediment layer. This corresponds to < 1 cm in the multi- and push cores. While this is pointed out in the text (p. 11366, line 17), we will emphasize this more clearly in the revised manuscript. The other depth intervals refer to the pore water geochemical measurements of the sediment column and are as follows: every 2.5 mm for the O2 penetration depth (p. 11368, line 7), and every 1 cm for Fe2+ and Mn2+.

3. "The authors need to acknowledge that observed alteration is a composite effect of microbial and faunal processes, and, because of reworking and sediment mixing,

inevitably more a reflection of differences in overall OM alteration and oxygen exposure time than bottom-water oxygen concentrations."

We agree with this comment in that our observed proxy trends represent not just the effects of bottom water oxygen concentrations per se but also how these concentrations influence the extent of benthic activity and, thus, the overall amount of time that the surface sediments are exposed to oxygen. In light of this, we will discuss these effects in more detail in the first section of the discussion. However, if the changes in the proxy trends were mainly due to only microbial/faunal processes, we would have expected to see trends consistent with this along the oxygen minimum zone (OMZ)-seep transect.

4. "Above all, they need to remove references to "rapid" OM cycling that they infer from the meter-scale seep transect, because they do not have a timescale on which they can base such statements."

This will be corrected in the revised manuscript as the reviewer is quite right in that we cannot specifically claim a time interval for the observed changes in the proxies. The term "rapid" was meant to convey the fact that, through the use of surficial sediments, our studied material demonstrates the initial OM cycling after deposition on the sea floor.

5. "With respect to the export production indices, it would be sensible for discussion to consider what the cross-margin transect data indicate relative to what is actually known, or might be guessed, about cross-margin trends in productivity and export production. It would also be helpful to know how all of these values relate to bulk organic C content. At present, it would seem that differences are assumed to be due only to post-depositional alteration."

We acknowledge that there are possible differences in the productivity of the surface waters along the OMZ transect as we cover an area from close to the coast towards a more open oceanic environment. This might affect export production to the sea floor, but we argue that our changes in proxy ratios show the largest influence as a result of

post-depositional alteration. This is mainly a result of the similar trends between the OMZ transect and the below OMZ-seep transect. The variability in productivity along the OMZ transect is not conclusively known but the CTD profiling of the upper waters during RV Meteor cruise M74/3 showed varying chlorophyll concentrations between 1-1.2 mg/m3 (data in Bohrmann et al., 2008). Regardless, any cross-margin trend present in the OMZ transect is expected to be larger than any variability in surface waters above the approximately one meter scale seep sediment transects. While there is still likely to be a difference in the amount of OM reaching the sea floor in the shallow OMZ-anoxic versus OMZ-oxic, the trends in the proxy values cannot only be due to differences in either productivity or export production. Again, we will mention this more clearly in the revised manuscript.

We, unfortunately, did not have enough material to perform bulk total organic carbon (TOC) measurements on our samples. However, previous studies involving the OMZ of the Pakistan margin suggest that TOC values within the OMZ are much higher than outside of it (e.g., Paropkari et al., 1992; Schulte et al., 2000), and were in many cases (well) above 1%. In contrast, TOC measurements of a gravity core retrieved from the same station as OMZ-oxic (GeoB 12331) demonstrate TOC values less than 1% (Fischer et al., in preparation).

6. "There are numerous compound words in the text which, debatably, need hyphenation. Hyphens are included in some cases and not in others, and I think that the authors need advice as to the journal's policy."

We will maintain consistency in the hyphenation of compound words throughout the manuscript.

7. "The authors use the terms "anoxic", "suboxic" and "oxic". Definitions are (more or less) included in the text, but I would take issue with the term "anoxic" when there are clearly non-zero bottom-water oxygen levels at some "anoxic" OMZ-seep sites (given the presence of clams, etc.). Notably, the presence of bacterial mats does not actually

indicate the extreme of anoxia (i.e. zero oxygen). I think that “hypoxic” might be a better term."

We agree with this critique of our use of the term “anoxic”, which is generally defined as oxygen concentrations below measurable amounts, and will subsequently refer to the samples retrieved from the lowest oxygen conditions as “hypoxic”. All necessary wording changes will thus be made. Furthermore, we acknowledge that there is some controversy regarding the exact use of descriptive words such as “suboxic” (e.g., Canfield and Thamdrup, 2009); however, we chose our definitions as a means to merely to describe the relative differences between the bottom water oxygen conditions along each of our three transects. In this context, “suboxic” would refer to intermediary oxygen concentrations between our fully “oxic” conditions and the much-depleted oxygen conditions in our “hypoxic” samples. We will also further clarify this in the revised manuscript.

8. "Figure 3 needs definitions of symbols and error bars. Also, oxygen concentrations at the SWI (expressed in uM) are quite different from values (several fold higher at the oxic site) from the CTD-based bottom-water oxygen concentrations for the same sites that are listed (as ml/l) in Table 1."

This will be remedied in the revised version of the manuscript.

References

Bohrmann, G., Bahr, A., Brinkmann, F., Brüning, M., Buhmann, S., Diekamp, V., Enneking, K., Fischer, D., Gassner, A., von Halem, G., Huettich, D., Kasten, S., Klapp, S., Nasir, M., Nowald, N., Ochsenhirt, W.T., Pape, T., Ratmeyer, V., Rehage, R., Rethemeyer, J., Reuter, M., Rossel, P., Saleem, M., Schmidt, W., Seiter, C., Stephan, S., Thomanek, K., Wittenberg, N., Yoshinaga, M., and Zonneveld, K.: Report and preliminary results of R/V Meteor cruise M74/3, Fujairah – Malé, 30 October – 7 November, 2007, Cold seeps of the Makran subduction zone (Continental margin off Pakistan), Berichte, Fachbereich 5, Universität Bremen, edited by: Bohrmann, G. and Ohling, G.,

Bremen, Germany, 161 pp., 2008.

Canfield, D. E., and Thamdrup, B.: Towards a consistent classification scheme for geochemical environments, or, why we wish the term ‘suboxic’ would go away, Geobiol., 7, 385-392, 2009.

Cowie, G.L., Calvert, S.E., Pedersen, T.F., Schulz, H., and von Rad, U.: Organic content and preservational controls in surficial shelf and slope sediments from the Arabian Sea (Pakistan Margin), Mar. Geol., 161, 23-38, 1999.

Fischer, D., Poulton, S. W., Frederichs, T., Alvarez, R., Bohrmann, G., and Kasten, S.: Impact of gas hydrates and methane seepage on the formation of authigenic iron sulfides at the Makran convergent margin, in preparation for submission to Chem. Geol.

Keil, R.G., and Cowie, G.L.: Organic matter preservation through the oxygen-deficient zone of the NE Arabian Sea as discerned by organic carbon:mineral surface area ratios, Mar. Geol., 161, 13-22, 1999.

Paropkari, A.L., Prakash Babu, C., and Mascarenhas, A.: A critical evaluation of depositional parameters controlling the variability of organic carbon in Arabian Sea sediments, Mar. Geol., 107, 213-226, 1992.

Schulte, S., Mangelsdorf, K., and Rullkötter, J.: Organic matter preservation on the Pakistan continental margin as revealed by biomarker geochemistry, Org. Geochem., 31, 1005-1022, 2000.

Interactive comment on Biogeosciences Discuss., 8, 11359, 2011.