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Biogeosciences Discussions

Interactive comment on "Biomarker evidence for the occurrence of anaerobic ammonium oxidation in the eastern Mediterranean Sea during Quaternary and Pliocene sapropel formation" *by* Darci Rush et al.

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This new paper explores the occurrence of anammox (anaerobic oxidation of ammonium) in the water column of the Eastern Mediterranean during sapropel deposition. Not being a biomarker or anammox specialist but interested in chemical processes in low-oxygen environments, I found this publication very insightful and well presented. I have only minor comments that aim at clarifying the message.

General comments:

1) It might be useful for non-anammox specialists to draw a little sketch to show where you expect anammox to take place in the water column (e.g. from present-day OMZ) and its relationships with euxinia and anoxia (for instance with schematic O2 and H2S profiles, chemocline, redoxcline. . .) and competition with phytoplankton. It would also help to visualize the interpretations that you discuss regarding the patterns of anammox in the various sapropels.

2) In general, I am missing a bit a comparison between the interpretations drawn here in term of water-column chemistry with other type of data. For instance, relationships between the build-up of anoxia or the presence of euxinia are mentioned in the text but do not appear in the figures. For S5 at higher resolution (64PE406), it might be useful to give temporal indications so that it can be compared to other records. Along a similar line, the relationships between deep-water stagnation, eutrophication and eutrophia have been widely explored for S5 and it might be useful to place your record in a wider context (also to highlight its relevance).

3) Another point which I am missing is a more structured discussion on the effects of post-depositional diagenesis on your markers. Diagenesis associated with changes in sedimentation rates and level of TOC in and around sapropels has been well-documented and generally allows to identify specific horizons in sapropels layers (proto-sapropel, oxidized "burn-down" sapropels). Higher BHT isomer values and the presence of SC ladderanes below and above S5 and the Pliocene sapropel should be discussed in this context.

4) What can help you decipher whether anammox occurred in the water column or in the sediments? I understand that the presence of free sulfides is preventing anammox to occur but would anammox happen in sediments where the overlying water is not euxinic and where sulfates are present (say until the sulfate-methane transition zone)? This is related to my previous points and questions the role of sediment-bound anammox in your records: would processes occurring during early diagenesis (i.e., when redox and chemical fronts shifted) in the sediments be able to trigger anammox (and

overprint the water-column derived biomarker record)? Is it possible for anammox to occur in the sediment core after retrieval and during storage? This might help understand why there are ladderanes in S5 in LC21 but not in 64PE406: i) storage and sediment handling artefact, ii) "unknown degradation mechanism" or iii) spatially non-uniform occurrence of anammox (e.g., in the Aegean but not in the Levantine Basin)?

5) Finally, can you rule out that anammox biomarkers were not brought to the core site by runoff (say a "detrital/exogenous" anammox component)? If I am not mistaken, anammox occurs in freshwater and coastal environments as well, but would the BHT isomer biomarker resist fluvial transportation and exposition to oxic conditions?

Specific comments:

I agree with reviewer #1 that information is missing in the figures:

Fig. 3: add data for BHT isomers in other cores (S5 for 64PE406 and S73 for ODP 160)

Fig. 4: it would indeed be insightful to show ratios and SC ladderanes (see comments by reviewer #1). Drawing a line between points would also be helpful. The depth scale can be removed for the plot 4b (and generally, a and b are not needed). If possible, indicate the various sub-layers in the sapropel (proto-sapropel, oxidized sapropel) using the Ba and Mn concentrations (or as ratio over Al or Ti). Ba is a good indicator for sapropel extend and Mn shows the upper extend (upper redox front), so the oxidized part of the sapropel (where the TOC is low). If you have some time indication, it might be interesting to indicate/plot some results from other records (isorenioratene, forams, etc. . .) to get a fuller picture of the changes in water-column properties.

Such a figure (depth profile) is missing for LC21, although a lot of data has been gathered on this core. This would allow direct comparison between other proxies and the anammox biomarkers, even at low sampling resolution.

Fig. 5: please also connect dots with a line in 5b and if possible, indicate the various

horizons in the sapropel (see comments for Fig. 4).

While reading section 3.1, I was wondering why ladderanes had not been measured in 64PE406, and it is only when I read section 3.2 that I got my answer. It should be clear from the beginning that ladderanes were measured both in LC21 and 64PE406 (also in the method part, section 2.4.2) but that they could not be detected in the latter one.

Introduction line 48-54: perhaps introduce the meaning of anoxia vs. euxinia for non-specialists? In general, it would be more accessible if terms would be better introduced (e.g., chemocline vs. redoxcline) or shown on schematic representations.

l. 365-371: I find this part quite obscure: what is meant by "Then, once monsoonal discharge brought in the initial pulse of nutrients from the Nile, [. . .]"? I do not follow the order of events. Perhaps making that appearing on fig. 4 would be helpful (e.g., by comparing to timing of freshwater pulses and development of anoxia)? Or draw small sketches?

Similarly, with the proposal that the observed signal might be related to "split-anoxia": not very clear why that happens and might be useful to provide a visualization.

But once again, I enjoyed reading this paper and feel that it will contribute value to our understanding of changes in the marine environment related to deoxygenation processes, which were recently highlighted as a growing concern for present oceanic basins.

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