

Interactive comment on “Occurrence and distribution of ladderane oxidation products in different oceanic regimes” by D. Rush et al.

D. Rush et al.

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We thank Dr. Hardison for her review of our manuscript. Below are our responses to her specific comments.

p. 2345, line 25 You focus on oxic biodegradation products in this study. Did you find evidence for anoxic biodegradation products in your previous work? You mention later in this paper that further degradation occurs (with depth) in anoxic sediments, which suggests that some sort of anoxic degradation pathway exists.

page 2356, lines 12-13 Can you expand your discussion on potential anaerobic degradation pathways (from your own work or others)? Do you know what the potential degradation products might be (i.e. other short-chain ladderane fatty acids)?

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- We generally observe a decreasing concentration of ladderane lipids with depth (of sedimentary records; Jaeschke et al., 2009), but unfortunately we don't know if this is caused by chemical, physical or microbiological processes. We will expand the manuscript to mention this limitation.

p. 2347, line 12 Do you mention H₂S concentrations because it interferes with the anammox reaction?

- H₂S does not affect the anammox reaction (as seen in the Black Sea; Kuypers et al., 2003). However, the hydrogen sulphide concentration is noted because H₂S is a result of anaerobic organic matter degradation. We use it in the Cariaco Basin water column to indicate the absence of molecular oxygen. Therefore, we hypothesised that no aerobic degradation of ladderane fatty acids to short chain ladderane fatty acids would take place at depths where H₂S is detected.

p. 2351, lines 7-9 Do you have reason to believe that anammox bacteria in the OMZ were exposed to the “average” temperature of the OMZ rather than a more stable temperature at a specific depth? I do not understand why the NL5 temperature data does not correlate better with in situ temperature. Perhaps this is not a robust proxy for temperature in the environment.

p. 2354, line 9-15 I am more willing to accept that the NL5 value in the sediments can represent the “average” OMZ temperature because it is derived from a lipid signal that is a composite of particulate material likely produced at various depths (and temperatures) within the OMZ that have sedimented over time. I still do not think the NL5 values from the water column SPM, collected at discreet depths, make sense (see my comment above).

- These two comments reflect a concern that Dr. M. Elevert expressed in his review as well. Here, we wish only to use NL5 as a means to highlight the difference between the production of original ladderane fatty acids in the water column and the in situ production in the sediment in the Arabian Sea. We believe that the NL5 temperature in the

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OMZ water column also reflects a “dead material pool” (the NL5 was derived from IPLs from living as well as dead anammox cells sinking through the water column). Anammox bacteria was found to reside at a specific depth (600 m; Pitcher et al., 2011). The CTD measured temperature at this depth (12.0°C) is a good fit with the NL5 derived temperature (13.9°C), as the in situ signal of ladderane fatty acids dominates over the dead pool. However, in the rest of the water column, the dead sinking pool gives more of a mixed water column signal. This would explain why we have a constant temperature profile in the water column and no trend with depth. Nevertheless, we will carefully amend to the manuscript to state the reason for our use of NL5, as well as the caution that must be used when applying it.

p. 2353, line 6 You detected significant ladderane fatty acids in the residue left after the Bligh-Dyer extraction of Peru Margin sediments. What does this mean for your Arabian Sea sediments, for which you only analyzed the TLEs for ladderane lipids? How important is it to consider both the matrix-bound and freely-extractable fractions for future studies?

-Though the Arabian Sea sediments were extracted using an Accelerated Solvent Extractor, which probably resulted in the extraction of more matrix-bound lipids than the gentler Bligh-Dyer extraction, we do expect that we would find ladderane fatty acids in the saponified residues of these samples. For studies intent on past anammox activity, we recommend that residues also be considered when analysing sediment samples. We will amend the manuscript to include this suggestion.

page 2355 For station 10, how can you rule out changes over time in the flux of anammox lipids to the sea floor, which you suggest might have occurred at station 4?

-Indeed, the increase in ladderane fatty acids at Station 10 may be due to increased fluxes and accumulation rates at the time of deposition. This alternative cause for lipid variation will be included in the manuscript.

References used

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