ANAEROBIC AMMONIUM OXIDATION IS AN IMPORTANT NITROGEN CYCLE PROCESS DURING MEDITERRANEAN SAPROPEL DEPOSITION

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Introduction

The microbial process of anaerobic ammonium oxidation (anammox) removes bioavailable species of N (ammonium and nitrite) from the marine system. Estimates indicate that anammox is responsible for 30-50% of the N lost from marine settings (Ward, 2013). As N is often the limiting nutrient for primary production, subtle changes in N loss can disturb the marine carbon cycle, greatly affecting global climate. It is therefore crucial to understand how anammox affected nutrient availability for primary production in ancient systems in order to better predict the effect future climate change will have on the marine N cycle. Yet, there are only few studies of anammox in past marine systems, which represents a genuine gap in our understanding of a potentially major component of past biogeochemical cycles.

The primary reason for the lack of anammox studies on geological sediments is that the established biomarkers for anammox, ladderane lipids (Sinninghe Damsté et al., 2002), are not recalcitrant enough to be detected in sediments > 145 ka. However, recent evidence points towards a stereoisomer of bacteriohopanetetrol (BHT isomer) being an alternative and highly promising biomarker for tracing anammox in the past (Rush et al., 2014). Here, we investigated the distribution of BHT isomer in modern (7 – 125 ka; S1 – S5) and Pliocene (2.63 – 2.97 Ma; S63 – S73) Mediterranean sapropel sediments (Fig. 1). For validation and calibration, we also analysed ladderane lipids in the modern sapropel sediments.

Results

Ladderane fatty acids were detected alongside BHT isomer in the most recent S1 sapropel (Fig. 1), but their concentration decreased significantly in S5, compared to S1. However, BHT isomer was detected in all sapropel sediments, indicating potential for BHT isomer as a biomarker for anammox in older sapropels.

Pliocene sapropels were sampled in high resolution for bacteriohopanepolyols, which showed that BHT isomer abundance was highest at the onset of and recovery from the sapropel units. Conversely, BHT isomer concentration decreased within the cores of the sapropels. This trend may reflect increased sulfidic conditions at peak anoxia, as sulfide inhibits anammox activity (Jensen et al., 2008). Anammox may then have decreased bioavailable nitrogen during peak sapropelic conditions, thereby decreasing primary productivity, and ultimately decreasing the amount of organic matter being exported from the photic zone. However, it is also possible that anammox aided in maintaining sedimentary anoxia, creating positive feedback by continuing the loss of nitrogen.

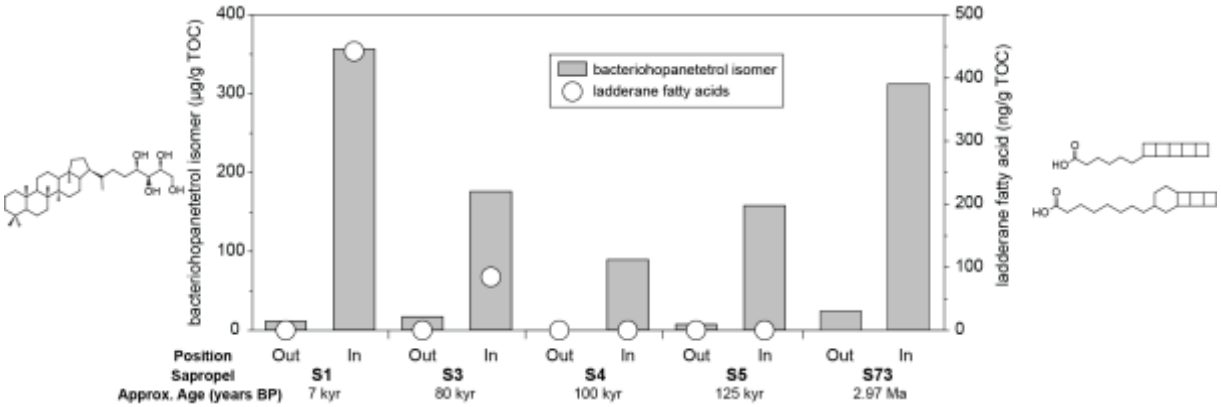

Figure 1 *Bacteriohopanetetrol isomer (µg/g TOC) and ladderane fatty acid (ng/g TOC) concentrations from outside (Out) and within (In) Mediterranean sapropels in modern (S1 – S5; LC 21) and ancient (S73; ODP 967) systems.*

Conclusions

Using BHT isomer, we were able to detect anammox in sediments as old as 2.5 Ma. This is the oldest detection of anammox to date. Thus, BHT isomer as a biomarker greatly extends the detection of the anammox process in marine paleo-systems. The presence of BHT isomer in all sapropel sediments studied suggests that anammox played an important, if not yet fully understood, role during these redox transitioning events. In order to clarify this role, we are currently increasing the resolution of analyses in the modern, more widely studied, sapropel events.

References

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