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Biogeochemistry of methane-related carbonates: an insight from the lipid biomarkers

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Anaerobic oxidation of methane (AOM) is the main process inducing the formation of authigenic carbonates at the seafloor due to an increase of alkalinity level resulted from the production of bicarbonate ions. AOM is a process accomplished by a consortium of methanogenic archaea and sulfate reducing bacteria (SRB) (Boetius et al., 2000; Hinrichs and Boetius, 2002) but the metabolic interactions of these prokaryotes are still unclear. We studied lipid biomarkers present in authigenic carbonates to reveal molecular patterns that can provide insight in the composition of microbial communities involved in AOM. Methane-derived carbonate crusts and surrounded sediment were collected from different seepage and mud volcano areas with diverse geological history and present-day fluid venting environments: the Western Black Sea, Nile Deep Sea fan (Eastern Mediterranean), and the Gulf of Cadiz (NE Atlantic). Gas chromatography, gas chromatography – mass spectrometry, isotope ratio monitoring gas chromatography mass spectrometry, and high performance liquid chromatography – mass spectrometry were applied to provide biomarker information. The carbonates exhibited diverse range of 13C-depleted lipid biomarkers, which indicate that they harbour a diverse microbial community. The biomarker composition revealed the presence of two distinct types of ANaerobic MEthanotrophic archaea: ANME-1 and ANME-2. However, the composition of archaeal lipids indicated difference in the community structures from crusts to crust. Distinct sets of biomarkers indicated different environments characterized by high and low methane partial pressures during the formation of these carbonates. Lipid biomarkers from non-identified sulfate reducing bacteria, i.e. non-isoprenoidal dialkyl glycerol diethers, were also detected almost in all carbonates although their content varied. Our investigation supports the role of methanotrophic archaea and SRB in the formation of authigenic carbonates. We show that specific sets of AOM-derived lipid biomarkers can be used as an indicator of specific methanotrophic community that thrive at high or low methane partial pressures in the vent systems. The comparison of our results with already published work suggests that the rate of methane transport is the driving factor that rules the selective presence of one methanotrophic guild over the another.

Reference:

Boetius A., Ravenschlag K., Schubert C. J., Rickert D., Widdel F., Gieske A., Amann R., Jørgensen B. B., Witte U. and Pfannkuche O. (2000) A marine anaerobic consortium apparently mediating anaerobic oxidation of methane. Nature 407, 623–626.

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