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Investigation of the Anaerobic Oxidation of Methane by applying Biomarkers at the Middle American Trench, Costa Rica

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Abstract:

Anaerobic oxidation of methane (AOM) is an important process which converts uprising methane formed in deep sediments to carbon dioxide. This process is of significant relevance since AOM reduces methane efflux to the hydrosphere as well as the atmosphere, where it is a 20 times more effective greenhouse gas than carbon dioxide. AOM is mediated by a consortium of archaea and bacteria which live in syntrophic consortia (BOETIUS et al., 2000). Specific biomarkers have been identified of which fatty acids have been detected indicative for sulphate-reducing bacteria (ELVERT et al., 2003) and acyclic isoprenoidal hydrocarbons diagnostic for archaea (BRASSELL et al., 1981). The microbial incorporation of methane-derived carbon into cellular biomass enriches the heavier carbon isotope ^{13}C in the remaining methane pool whereas the lighter carbon isotope ^{12}C is preferentially assimilated into lipid biomass, thus forming biomarkers with highly ^{13}C-depleted carbon isotope values.

The aim of this study was the investigation of the occurrence of AOM at the Middle American Trench (Costa Rica) using biomarkers. The results from two selected vent sites, which were identified by increased methane concentrations in the overlying water column and distinctive vent organisms (i.e. *Beggiatoa* mats), are presented.

Both sites, a mud diapir located at 1000 m water depth and a landslide at 400 m water depth, were sampled using a TV – guided multiple corer. Stable carbon isotope measurements of biomarkers indicative for AOM-performing microorganisms have been used to identify the most active region (horizon) in the sediment cores. δ^{13}C-values of specific fatty acids ($C_{16:1w5c}$and $cyC_{17:0w5,6}$) and unsaturated irregular C_{25} isoprenoids (2,6,10,15,19-pentamethyleicosane) as low as -140 $^{o}/_{oo}$ vs. PDB have been found which probably suggests that there is a high upward flux of isotopically light methane. This indication is supported by high methane concentrations found in the overlying water column with concentrations of up to 680 nmol/L relative to a common background value of 1-2 nmol/L (G. Rehder, personal communication). Nevertheless a great portion of the methane is biodegraded as can be seen from the sediment pore water (mmol/l) and water column (nmol/l) profiles. Furthermore, two regions of AOM (5-7 cm and 18-22 cm sediment depth bsf) in the core have been identified. This is unusual and probably contrary to other sites studied for AOM (i.e. Hydrate Ridge cold seeps, Mediterranean Ridge mud volcanoes) where only one active AOM region (ELVERT et al., 2003; PANCOST et al., 2001) in the sediment has been reported so far.

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