Geophysical Research Abstracts, Vol. 7, 08097, 2005
SRef-ID: 1607-7962/gra/EGU05-A-08097

Multiple Archaeal Groups Control Methane Emissions of a North Sea pockmark

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Anaerobic oxidation of methane (AOM) in marine sediments is one of the largest sinks for methane on earth. So far, most studies focusing on activity, identity and distribution of AOM related microorganisms were conducted in highly active, deep-sea seep environments. The present data were acquired as part of the 6th FP EU project METROL. One of the goals of this project is the scientific exploration of methane seeps in shallow, marine shelf environments. In this study, we report of an actively seeping pockmark located in the so-called Tommeliten area, central North Sea, at 80 m water depth. Here, uprising, thermogenic methane forces a buried marl horizon to bulge, forming accoustically recognizable dome-like sub-surface structures. Methane migrates then through cracks into overlying sediments. Vibrocoring and subsequent methane concentration measurements revealed a distinct methane transition zone (MTZ) in subsurface sediments (ca. 1.5 m bsf) correlating with authigenic carbonates. A combination of AOM and sulphate reduction (SR) rate measurements, lipid biomarker analysis and molecular techniques (FISH, DNA) give evidence that AOM, mediated by archaea of the ANME1b group and sulphate reducing bacteria (SRB) of the Seep SRB1 cluster, controls methane efflux at this site. Moreover, the imprint of 13C- depleted lipid biomarkers show that AOM was involved in carbonate precipitation. However, overall rates, lipid concentrations and cell numbers are 2-3 orders of magnitude lower in comparison to highly active seep environments. The depth of

the MTZ migrates upwards towards the apex of the marl dome where methane fluxes are probably increased. As a consequence, sea floor video observations and hydroacoustic profiling revealed point sources where methane escapes into the water column and potentially to the atmosphere. Associated with these bubble vents were patches of bacterial mats, most likely consisting of Beggiatoa, as well as slabs of carbonate crusts containing 13C-depleted, ANME2 specific lipids. Our observations confirm previous hypotheses that with time, gas channels at Tommeliten become self-sealed by AOM-related carbonate precipitation . The carbonate cements represent rare hard-substrate habitats in the otherwise sandy North Sea sediments and are populated by a variety of sessile organisms.