Geophysical Research Abstracts, Vol. 8, 01327, 2006
SRef-ID: 1607-7962/gra/EGU06-A-01327

Microbial Methane Turnover at Mud Volcanoes of the Gulf of Cadiz

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The Gulf of Cadiz is a tectonically active area of the European continental margin and characterised by a high abundance of mud volcanoes, diapirs, pockmarks and carbonate chimneys. During the R/V SONNE expedition "GAP- Gibraltar Arc Processes (SO-175)" in December 2003, several mud volcanoes were explored for gas seepage and associated microbial methane turnover. Pore water analyses and methane oxidation measurements on sediment cores recovered from the centres of the mud volcanoes Captain Arutyunov, Bonjardim, Ginsburg, Gemini and a newly discovered, mud volcano-like structure called "No Name" show that thermogenic methane and associated higher hydrocarbons rising from deeper sediment strata are completely consumed within the seabed. The presence of a distinct methane-sulphate transition zone (SMT) overlapping with high sulphide concentrations suggests that methane oxidation is mediated under anaerobic conditions with sulphate as the electron acceptor. Anaerobic oxidation of methane (AOM) and sulphate reduction (SR) rates show maxima in distinct subsurface sediment horizons at the SMT. The position of the SMT varied between mud volcanoes at depths from 20 to 200 cm below sea floor. In comparison to other fluid flow impacted environments of the world oceans, AOM activity ($<$383 mmol m^{-2} yr^{-1}) and diffusive methane fluxes ($<$321 mmol m^{-2} yr^{-1}) in mud volcano sediments of the Gulf of Cadiz are low to mid range. Corresponding lipid biomarker and 16S rDNA clone library analysis give evidence that AOM is mediated by a mixed community of anaerobic methanotrophic archaea and associated sulphate reducing bacteria (SRB) in the studied mud volcanoes. Little is known about

the variability of methane fluxes in this environment. The ^{13}C-depleted lipid imprint incarbonate crusts that litter the sea floor of mud volcanoes in the northern part of the Gulf of Cadiz shows that extensive, methane-related carbonate precipitation once took place. However, actual sea floor video observations showed only scarce traces of methane emission and associated biological processes at the seafloor. No active fluid or free gas escape was observed visually. In combination with the observed depletion of methane in subsurface sediments, this indicates that the emission of methane from the structures studied here to the hydrosphere is insignificant at present.