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Anaerobic methane oxidation reduces methane efflux in sub-surface sediments of mud volcanoes in the Gulf of Cadiz

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The Gulf of Cadiz has been intensely surveyed with geophysical methods and sampling, since the discovery of the first mud volcanoes in this area, in 1999. Numerous fluid escape structures were revealed, such as mud volcanoes, mud diapirs, pockmarks and an extensive field of carbonate chimneys and crusts, but little is known about the activity and the potential hazard of mud volcanoes in the Gulf of Cadiz. During the SONNE-175 GAP Cruise (Dec 2003), several volcanoes were investigated for active seepage of gases and fluids. Pore water analysis of sediment cores recovered from the summits of Captain Arutyunov, Bonjardim, Ginsburg, Gemini and a newly discovered mud volcano, show that thermogenic methane and associated higher hydrocarbons, as well as sulphate, are consumed in sub-surface sediments. Also, elevated sulphide concentrations show evidence that methane and higher hydrocarbon oxidation processes are mediated under anaerobic conditions. Anaerobic methane oxidation (AOM) and sulphate reduction rates (SRR) peak in a narrow sediment horizon at the methane-sulphate transition zone (SMT), which is generally found at depth below 25 cm bsf. In comparison to other methane dominated environments of the world oceans, mean AOM and diffusive methane fluxes with values $<$383 and 321 mmol m^{-2} yr^{-1}, respectively, are low to mid range in the mud volcano sediments of the Gulf of Cadiz.

SRR and diffusive sulphate fluxes were found to exceed AOM and methane fluxes, respectively, because a substantial fraction of the SR is most likely fuelled by anaerobic oxidation of higher hydrocarbons. Furthermore, underwater video observations revealed only scarce traces of seep related chemosynthetic communities in the surface sediments. This, together with the absence of visible fluid or gas escape and the observed consumption of methane in sub surface sediments, indicates that the contribution of methane to the hydrosphere and potentially to the atmosphere from mud volcanoes investigated in the Gulf of Cadiz is insignificant at their present state of activity.

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