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Aerobic and anaerobic oxidation of methane in sediments of Håkon Mosby Mud Volcano, Barents Sea

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The Håkon Mosby Mud Volcano (HMMV) is an active methane seeping mud volcano of ca. 1 km in diameter at 1250 m water depth on the Norwegian margin of the Barents Sea (72˚00'N, 14˚45' E). Previous and recent videographic mapping of the seafloor indicates three distinct habitats: (1) a central area covered by greyish muds; concentrically enclosed by (2) a belt of blackish, highly reduced sediments covered with white mats of the thiotrophic bacterium *Beggiatoa sp.*; (3) and an outer rim of brownish sediments, which are densely populated by pogonophoran worms. During dives with the remotely operated vehicle (ROV), another more fractured type of habitat was discovered at the boundary of the centre. Here, and in the vicinity of gas ebullition sites, patches of reduced sediments covered with greyish microbial mats were found. These four habitats were sampled in 2003 with the ROV Victor 6000 (IFREMER) by push cores, a video-guided multiple corer and gravity cores for *ex situ* measurements of aerobic and anaerobic methane oxidation as well as sulphate reduction rates. Aerobic or anaerobic oxidation of methane dominates biogeochemical processes in the HMMV sediments and is carried out by different microbial communities in distinct zones of the mud volcano. Chloride and bromide concentration profiles provide evidence that differences in advective flow of pore water is a main factor determining this zonation. In the centre, a high upward flow of sulphate-free subsurface fluids strongly limits the penetration depth of sulphate and oxygen. Here, aerobic oxidation of methane (MOx) is restricted to the top cm sediment layer with rates of 0.9 mol m^{-2} yr^{-1} and anaerobic oxidation of methane (AOM) is absent. In the patches of reduced sediments covered with grey mats, a deeper penetration of sulphate from seawater was observed, fueling AOM activity down to $>$12 cm with rates of 12.4 mol m^{-2} yr^{-1}. Adjacent to the centre at the *Beggiatoa* site, decreased upward fluid flow and the activity of the Beggiatoa filaments allows for an AOM zone of ca 5 cm at the sediment surface with rates of 4.5 mol m^{-2} yr^{-1}. The stoichiometry of anaerobic oxidation of methane with sulphate was 1:1. Furthermore, *in vitro* incubations of surface sediments from the centre and the *Beggiatoa* site revealed the adaptation of aerobic and anaerobic oxidation of methane to the ice-cold temperatures of -1˚C at the seafloor. At the outer rim of the HMMV, bioventilation of the pogonophoran worms irrigates a much deeper zone with oxygen- and sulphate-rich seawater. MOx activity of the free-living methanotrophic community in the oxygenated surface sediments was comparably low with 0.2 mol m^{-2} yr^{-1}. A defined methane-sulphate transition zone was found just beneath the roots of the tubeworms at 67 to 77 cm sediment depth. Here, AOM activity was high with 7.1 mol m^{-2} yr^{-1}. With respect to the area size of the different habitats at HMMV, microbial consumption reduces the methane efflux of HMMV by ca 7* 10^{-5} Tg yr^{-1}, i.e. 22 to 55%.

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