Methane flux control in ocean margin sediments

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Anaerobic oxidation of methane (AOM) is a microbiological process responsible to prevent methane outgasing from marine environments. The EU-Project METROL aims to determine which geochemical factors control the effectiveness of AOM as a methane barrier, and how methane fluxes are regulated by this process in diffusion dominated coastal margin sediments.

In this project, sediment samples were investigated from the Baltic Sea, where methane sulfate transition zones are very distinct and microbial communities efficiently turn over methane. These sites were compared to samples taken in the Black Sea, where the methane profile change very gradually and form an extended transition zone. At both locations, pore water profiles of involved chemical gradients were analyzed and process rates determined by tracer measurements. In addition, FISH techniques were applied to relate the geochemical information to microbial community structure.

In these diffusive systems rates of AOM are considerably lower than at methane seep sites, but the communities very effectively to retain methane within the sediments and prevent it from reaching the water column. Methane an sulfate concentrations as well as organic carbon content are key factors in regulating these processes.

Rates of methanogenesis and methanotrophy in deep-sea sediments

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We have used the carbon isotopic composition ($\delta^{13}C$) of dissolved inorganic carbon (DIC) in pore fluids from Leg 175 of the Ocean Drilling Program (ODP) along the West African Margin to quantify rates of methane production (methanogenesis) and oxidation (methanotrophy) in deep-sea sediments. The rates were quantified by modeling the diffusive and reaction processes affecting $\delta^{13}C_{DIC}$ profiles of the pore fluids.

Model results show that anaeorobic methane oxidation (AMO) occurs in the transition zone between sulfate and methane, and methanogenesis occurs below these depths in a confined zone shallower than 250 m depth below sea floor at all sites. Methanogenesis and AMO rates were between $1 \cdot 10^{-7}$ to $1 \cdot 10^{-10}$ $mol \cdot cm^{-3} y^{-1}$ in all sites; higher rates were found in sites where sulfate was depleted in shallower depths. In sites where the total organic carbon (TOC) was less than 5% of the total sediments, AMO dominates sulfate reduction. Higher rates of AMO were accompanied with increased of carbonate minerals exchange. We did not find any correlation between methanogenesis rates and TOC, the carbonate content, porosity, sedimentation rate, or C/N ratio. Higher rates of methanogenesis occur at sites that are in the center of the upwelling system.

Methane profiles from different ODP Legs are consistent with the methanogenesis rates calculated with the model. However, the decrease in methane at greater depths at all sites represents a mystery as it implies either that methanogenesis at its current depths began only 0.5 to 1.0 m.y. ago, or that there exists a sink at depth that does not affect the DIC pool. We explore the energetic of a biogenic sink of methane at depth, and discuss its implications for sediment chemistry.