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Indications for near-surface fluid circulation cells at bacterial mats

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At submarine cold vents off Costa Rica detailed sediment sampling along transects across bacterial mats was conducted during expedition M66/2 with RV METEOR deploying a remotely operated vehicle (ROV). Bacterial mats occurred in patches of several m^2 in size covering the sediment surface. Porewater analyses of the pushcore sediments revealed rapid sulfate consumption due to anaerobic methane oxidation (AMO) below the bacterial mats. SO_4 was depleted at $\sim$5 cm sediment depth in the center of the mat and penetrating deeper into the sediment towards the rim of the mat. Pushcores taken in the center of these mats, however, showed a subsequent increase of sulfate concentrations below a sediment depth of $\sim$10 cm. Other dissolved compounds, such as Cl, Br, H_2S, TA, NH4, PO_4, and SiO_4, showed a similar behaviour with concentrations returning towards bottomwater values. Since this trend is common to all of the solutes, it is most likely explained by a physical process. We assume that focussed fluid outflow near the center of the bacterial mat creates a convective flow cell with bottom waters penetrating into the adjacent sediment area and directed towards the flow channel.

A set of different 2-D and 3-D transport-reaction models were developed to test this hypothesis. Fluid flow in the central channel turned out to be homogeneous and thus, could be resembled as boundary condition of the surrounding sediment domain. The model also includes AMO as the most important reaction of a cold vent system. Model results indicate that the observed porewater sulfate and chloride profiles can be reproduced fairly well, for example, when applying an advection velocity of 100 cm/a in the central fluid channel and a mean background advection of 3 cm/a in the sediment domain. A detailed sensitivity study has been performed determining the parameters dominating the establishment of the near-surface flow cell.