

## **The sulfur cycle below the sulfate-methane transition of marine sediments**

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The study of sulfate reduction below the sulfate-methane transition (SMT) in marine sediments requires strict precautions to avoid sulfate contamination from seawater sulfate or from sulfide oxidation during handling. We experimented with different methods of sampling porewater sulfate and found that modifications to our sampling procedure reduced the measured sulfate concentrations from hundreds of micromolar to ten micromolar or less. We here recommend some key modifications to porewater sampling when measuring very low sulfate concentrations below the SMT of marine sediments. At three sites in Aarhus Bay, the sulfate concentrations below the SMT remained around ten micromolar. The calculated free energy change,  $\Delta G_r$ , available for sulfate reduction by such low concentrations is between -17.9 and -11.9 kJ mol<sup>-1</sup> sulfate. This is near or below the energy yields that have previously been calculated for microbial sulfate reduction in marine sediments. The three sites are characterized by measurable and very different sulfate reduction rates depending on the depth and sediment age of the SMT. Our data show that sulfate is being consumed below the SMT in spite of the low sulfate concentrations. As sulfate is not drawn down to even lower concentrations, it must be continually regenerated below the SMT, most likely by sulfide oxidation concurrent with the sulfate reduction. We conclude that the low sub-SMT sulfate concentrations are in steady state between reduction and production and are thermodynamically controlled by the minimum  $\Delta G_r$  requirements by sulfate reducing bacteria while sulfate reduction rates are controlled by the rate of sulfide oxidation.