Anaerobic oxdiation of methane in marine sediments: A global synthesis

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Methane acts as a powerful greenhouse gas in the Earth's atmosphere and its emissions from marine sediments are substantially reduced by anaerobic oxidation coupled to sulfate reduction within a distinct sulfate/methane transition zone (SMTZ). Despite recent breakthroughs in our understanding of the biological mechanisms of anaerobic oxidation of methane (AOM), the global removal of methane in the seafloor remains poorly quantified.

In this study, we establish a comprehensive marine database of methane and sulfate fluxes, as well as related parameters from > 700 sediment cores. Our analyses reveal a linear correlation between the magnitudes of diffusive fluxes of methane and sulfate to the SMTZ and the corresponding depth of the SMTZ over several orders of magnitude. The depth of the SMTZ, in turn, shows a linear correlation with the associated sedimenation rates. Using these linear relationships in combination with gridded data sets of key environmental parameters (e.g. water depth and sedimentation rate) we develop a spatially resolved AOM budget for marine sediments, covering different oceanic regions.

We also demonstrate that most flux ratios between methane and sulfate do not show a 1:1 relation, as would be expected from a simple AOM stoichiometry, but rather indicate a higher sulfate flux relative to the methane flux. Our findings thus further provide new insights into the biogeochemical coupling of the sulfur and carbon cycles in marine sediments. In particular, we discuss possible explanations for the discrepancy between sulfate and methane fluxes to the SMTZ.