Using an isotope, reaction-transport model to assess controls on the efficiency of anaerobic methane oxidation in Baltic Sea sediments

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Methane is produced in anoxic, sulfate-depleted marine sediments and consumed in the sulfate-reduction zone via anaerobic methane oxidation. The flux of methane that reaches the sediment surface is, in part, regulated by the balance between production and anaerobic oxidation. A recent study[1] concludes that the efficiency of anaerobic oxidation (i.e., the fraction of methane production that is oxidized in sulfate-containing sediments) is reduced by high sedimentation rates. We test this hypothesis at four stations across the Baltic Sea that experience a wide range of oxidation efficiencies and sedimentation rates. We use a multi-component (sulfate, methane, DIC, ammonium) reaction-transport model that includes ^{13}C:^{12}C ratios in methane and DIC pools. The model—tuned and validated using measured depth-distributions of concentrations, isotope ratios, and sulfate-reduction rates —yields methane production and oxidation rates (i.e., oxidation efficiency), an estimate of the flux and reactivity of organic matter deposited at each site, and constraints on methane production pathways. This information may be used to constrain the mechanisms that control the efficiency of anaerobic methane oxidation.

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