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Constraining the anaerobic oxidation rate of sedimentary organic carbon in coastal seas using benthic fluxes of rhenium and uranium

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Degradation and burial of organic carbon in marine sediments determine the biological pump efficiency and climate change. Because continental shelf sediments are the hotspots for the carbon cycle, quantifying the degradation rates of organic carbon is essential for understanding the global carbon cycle. Total benthic organic carbon mineralization rate is commonly evaluated using sediment oxygen consumption (SOC) based on a relatively constant respiratory quotient. In contrast to the widely studied SOC, anaerobic oxidation rate of sedimentary organic carbon is rarely evaluated in suboxic to sulfidic conditions typically observed in continental sediments.

This study focuses on the biogeochemical processes and benthic fluxes of Re and U in oxic to anoxic sediments in the East China Sea. We present pore water profiles of chemicals in organic carbon oxidation (e.g., O_2, NO_3^-, NH_4^+, Fe^{2+}, Mn^{2+}, Mo, Re, and U). Rhenium and U were not removed in the oxic layer, where aerobic oxidation of organic carbon occurred. Instead, Re and U decreased below the oxic layer to minima in the deeper anoxic layers where anaerobic oxidation (nitrate, manganese, iron, and sulfate reduction) occurred. The difference in the minima is presumably due to the different uptake rates of these metals into the solid phase, which is associated with the anaerobic oxidation rate of organic carbon within sediments.

To test the use of benthic Re and U fluxes as a (quasi-)quantitative proxy for the anaerobic oxidation rate of sedimentary organic carbon, we quantified the benthic Re and U fluxes using a novel $^{224}Ra/^{228}Th$ disequilibrium method. We found Re and U fluxes strongly correlated to the anoxic organic carbon oxidation rate (R^2=0.80 and 0.70 for Re and U, respectively). Increased Re and U uptake rates with increasing anaerobic oxidation rates are consistent with their accumulation in suboxic/anoxic sediments. The exceptions to the correlation showed Re and U remobilization from a solid phase in the oxic layers. Overall, this study highlights the potential of benthic Re and U fluxes as a (quasi-)quantitative proxy for the anaerobic oxidation rate of organic carbon within sediments.