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The role of benthic fauna for the magnitude and δ^{56}Fe signature of benthic dissolved iron fluxes

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Iron plays a central role in marine biogeochemical cycles. Over the last 100,000 years, iron has been a limiting micronutrient for marine primary productivity in large parts of the ocean and has been proposed as a driver for glacial-interglacial cycles by modulating atmospheric CO_2 concentrations. Yet, many of the aspects of the iron biogeochemical are not well understood, in part because of the difficulty of quantifying iron supply from hydrothermal and continental margin sources. Stable iron isotopes (δ^{56}Fe) are a particularly useful tool to quantify the significance of different sources and sinks of dissolved iron (DFe) in the ocean, but the isotope signature of the benthic DFe source is poorly constrained.

Here, we use a 1-D reaction-transport model of marine sediments to investigate the effect of (i) the rate of iron (oxyhydr)oxides (FeOOH) deposition on the sediment surface, (ii) the organic carbon mineralisation rate in the sediment, (iii) bottom-water oxygen concentrations, and (iv) the activity of benthic fauna (bioturbation) on both the magnitude and the δ^{56}Fe signature of the benthic DFe flux. We find that an increase in the rain rate of FeOOH particles linearly increases the benthic DFe flux, but has no impact on the δ^{56}Fe signature. In contrast, lower bottom-water O_2 concentrations and higher carbon mineralisation rates increase the benthic DFe flux while also increasing the δ^{56}Fe value of the DFe flux. Bioturbation was found to be a critical factor for the magnitude of the benthic DFe flux. In the absence of bioturbating fauna, the global DFe flux from continental slope and shelf sediments decreases from ~103 Gmol yr^{-1} to ~53 Gmol yr^{-1}. Consequently, ocean deoxygenation, and the associated decrease of habitable area for benthic fauna, will lead to a significant decrease in benthic DFe fluxes. We propose predictive functions for the DFe flux and its δ^{56}Fe signature that can easily be applied in global biogeochemical models and will help constrain marine iron sources and sinks.