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Un-muddying the waters: using Fe isotopes to investigate the sediment dissolved Fe source

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Marine sediments are now well established as an important source of dissolved iron (dFe) to the oceans. In the last two decades, stable Fe isotope ratios (δ^{56}Fe relative to IRMM-014) have provided insight into the speciation, transport, and longevity of dissolved Fe sourced from marine sediments. Sediments are thought to release Fe via two main mechanisms. First, studies of the ferruginous zone within sediments show that a large isotope equilibrium effect is expressed during bacterial reduction of Fe(III) minerals, coupled to oxidation of organic matter, generating a porewater dissolved Fe (dFe) pool which has lower δ^{56}Fe than sediments (-1 to -2 vs +0.1‰). Further equilibrium-driven isotope fractionation during oxidative precipitation within porewaters or overlying bottom waters may drive the δ^{56}Fe of the dFe pool even lower (-3 to -5‰). Second, a non-reductive dissolution is thought to generate dFe with a bulk sediment δ^{56}Fe signature (+0.1‰). As such, reductive and non-reductive fluxes of dFe from sediments may both have diagnostic δ^{56}Fe signatures that can be used to trace and constrain sediment-derived dFe addition to the ocean. However, questions remain about the longevity of such signatures, fractionation associated with dFe complexation with organic matter, and kinetic isotope effects as dFe is lost via oxidative precipitation and/or adsorptive scavenging. Attenuation of the sediment-derived signature may happen either at the local oxic-anoxic or sediment-water interface, or during transport. Here, using both open-ocean and marginal GEOTRACES δ^{56}Fe studies, we will synthesize the δ^{56}Fe signatures of dFe attributed to sediments, the evidence for long-distance transport of sediment-derived Fe that may maintain diagnostic Fe isotope signatures, and the constraints on the fractionation mechanisms that may attenuate these signals. We will especially focus on work from the Antarctic marginal seas, where both dissolution mechanisms are important, and the North Pacific where synthesis of GEOTRACES sections (GP02 & GP15) demonstrates the long-distance transport eastward (~6000 km) of a conserved δ^{56}Fe signature from reductive dissolution of sediments through the North Pacific Oxygen Minimum Zone, despite dFe loss by particle scavenging.