Delivery and Accumulation of Highly Reactive Iron to the Open Ocean and Its Implications

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Iron (Fe) is the fourth most abundant element in Earth's crust; however, due to its low solubility under oxidizing seawater conditions, Fe has limited bioavailability and is postulated to modulate primary production in large regions of the ocean and thus carbon cycling and CO_2 abundances. In this study, we explore distributions of potentially bioreactive Fe in deep-sea sediments using state-of-the-art Fe speciation techniques and see surprising insensitivity to glacial vs. interglacial climatic and oceanographic controls.

Iron fluxes into the ocean and their bioavailability vary with many factors including the mineralogy of the source material and are dominated by near-shore and terrestrial inputs. Iron can undergo chemical transformations between insoluble Fe (III) and more soluble Fe (II), but the latter is limited by oxidation in the dominantly oxic portions of the ocean. In order to further explore the spatiotemporal distributions of bioavailable Fe delivered to the open ocean and specifically assess its potential relative reactivity, we investigated patterns for Fe mineralogy as a possible proxy for bioavailability.

We used five deep-sea cores from the IODP (Integrated Ocean Drilling Program) collected throughout the Pacific and Atlantic Ocean to estimate variability in Fe delivery. In an effort to go beyond past Fe studies in the deep ocean, geochemical analysis emphasized a sequential extraction scheme designed to isolate Fe phases with past and/or present bioavailability, including Fe bound in carbonate, iron sulfides, iron oxides and magnetite. This approach allows us to evaluate potential diagenetic overprints. Importantly, these procedures were performed on size separates meant to isolate the dust-dominated fraction.

Results suggest spatial variability in dust accumulation and Fe bioavailability. However, our results to date reveal little evidence for enhance delivery of potential bioreactive phases on glacial-interglacial time scales based on similar Fe contents and speciation across these intervals.