Quantifying sources of iron to the Oceans using iron isotopes

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Iron (Fe) is an essential micronutrient in the oceans, required by phytoplankton for both nitrogen fixation and photosynthesis. The supply and availability of Fe in the surface ocean therefore influences marine primary productivity and the global carbon cycle on short and long timecales. Aerosol dust, sediments and submarine hydrothermal vents are the main sources of Fe to the oceans. However, the relative importance of these to the dissolved Fe inventory is hotly debated with estimates of the contribution from each varying by orders of magnitude.

Stable Fe isotope ratios (δ^{56}Fe) are a novel oceanographic tool which illuminate the sources, sinks and cycling of Fe within the ocean. Here, we present the first high-resolution oceanic section of dissolved [Fe] and δ^{56}Fe, with 21 open-ocean profiles from the US GEOTRACES North Atlantic Transect from Lisbon to Woods Hole, via Mauritania. We use this large dataset to show that the different sources of Fe to the ocean have distinct δ^{56}Fe signatures, which may be traced throughout the water-column.

By assigning distinct end-member δ^{56}Fe values to different sources, we directly quantify their contributions to the transect. Overall, we calculate that 72-88% of the Fe in the section is from aerosol dust, 10-18% from oxic sediments on the North American Margin and 2-4% from eastern-margin reductive sediments under the Mauritanian upwelling regime. Additionally, direct sampling of a hydrothermal plume allows us to isotopically fingerprint Fe released from the Mid-Atlantic Ridge, show that Fe travels ~1000 km west from the ridge, and calculate that submarine vents contribute 2-6% of the Fe across the section.

Oxic sediments and hydrothermal Fe are likely to be less sensitive to climate change than aerosol dust and reductive sediments, and so source variability may be an important control on the dissolved Fe cycle and feedback on global climate. Additional data from the South Atlantic and the North Pacific add to this picture by showing that different sources control the availability of Fe in different regions of the ocean.