Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.7595

Scavenging and Advection - Resolving the Neodymium Paradox in the South Atlantic

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Significant gaps in our understanding of the oceanic cycling of neodymium (Nd) and the other rare earth elements (REEs) remain despite decades of research. These include the “Nd paradox” which is that the concentration of dissolved Nd is nutrient-like and increases with depth while Nd isotopes appear to reflect conservative water mass mixing in the intermediate and deep ocean. We present a detailed study of the dissolved Nd isotopic composition across UK GEOTRACES section GA10 at 40°S in the South Atlantic where there is large spatial variability of inputs, particulate cycling, and deep water mass advection at depth. This variability has also made the South Atlantic a critical region for reconstructing past changes in ocean processes such as biological productivity changes and deep ocean circulation.

We use Nd concentrations and isotopic compositions to separate control by horizontal conservative water mass mixing and vertical non-conservative transfer by biological and non-biological particles. We show that the relative significance of these processes is generally changing with water depth, and primarily depends on horizontal advection versus particle vertical flux. We constrain sources of Nd to the South Atlantic surface ocean and exhibit detailed conservative vs. non-conservative processes throughout the water column. We attribute the “Nd paradox” in the South Atlantic to the insensitivity of Nd isotopic change to non-conservative processes which occur when particles exchange Nd with seawater as they fall across a water mass boundary between a water mass that low Nd concentration (i.e. NADW) and a deeper one with a higher preformed Nd concentration (i.e. AABW).