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Rare earth elements in the pore waters of abyssal sediments

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Our understanding of the marine budget of the rare earth elements (REEs) is plagued by concerns of both the input and internal cycling of these trace elements (and their isotopes). Contrary to established views, we argue that marine REE cycles are driven from the bottom up, rather than top down. That is, surface inputs (e.g., rivers, dust) and possibly some of the internal cycling processes (e.g., reversible scavenging) are of only limited importance compared to benthic sources and processes that dominate these cycles. However, existing observational data is limited and largely only from marginal sites; it is unclear if these observations are applicable to the broader ocean basins.

We present new REE pore water data from the abyssal Pacific Ocean. The sites are at 11°N, 7°N and 3°N along the 150°W GEOTRACES meridional Pacific transect. The sediments are all largely red clay, with significant siliceous and carbonate components at 7°N and 3°N, respectively. The REE shale normalized patterns of the pore water are all similar, with the heavy REEs elevated above the light REEs and a small middle REE enrichment. The cerium anomaly is <1 in the majority of samples, consistent with the redox state of the pore water. The REEs at all three sites are all elevated above bottom water (at ~35 pM [Nd]): the uppermost ~1cm section of sediment pore water has [Nd] of ~75 pM, and increases with depth to [Nd] of ~110 pM at 20 cm depth in the core. There is strong indication that the pore water concentrations of REEs are, in fact, significantly more concentrated than this in these oxic sediments. Thus, a minimum calculated benthic flux from these sediments is 3.5 pmol/cm^2/yr, which is close to the value of 10 pmol/cm2/yr that Du et al. (2016)[1] used to in their simple model of the Pacific. If extrapolated globally to the area of sea floor >4000m, this relatively small benthic flux is at least one order of magnitude a larger input of REEs to the ocean than all surficial inputs combined.

[1] Du, Haley and Mix (2016) Geochim. Cosmochim. Acta 193, 14-35.