Light rare earth depletion during methanotropy: are there implications for oceanic distributions?

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Light rare earth elements (LREEs: La, Ce, Pr, and Nd) have generally been thought not to have a biological role. However, recent work has demonstrated that the LREEs are essential for at least some methanotrophs, being co-factors in the XoxF type of methanol dehydrogenase (MDH). We show here that dissolved LREEs were significantly removed in a submerged plume of methane-rich water during the Deepwater Horizon (DWH) well blowout. Furthermore, incubation experiments conducted with naturally methane-enriched waters from hydrocarbon seeps in the vicinity of the DWH wellhead also showed LREE removal concurrent with methane consumption. Metagenomic sequencing of incubation samples revealed that LREE-containing MDHs were common. Our field and laboratory observations provide further insight into methanotrophy and the abundance of certain types of bacteria during the DWH blowout. Additionally, our results are the first observations of direct biological alteration of REE distributions in oceanic systems. In view of the ubiquity of LREE-containing MDHs in oceanic systems, our results suggest that biological uptake of LREEs is an overlooked aspect of the oceanic geochemistry of this group of elements previously thought to be biologically inactive. We explore the implications of these observations and whether they might be relevant to upper ocean REE cycling and distributions.