Using a global model to evaluate processes that control the oceanic Zn distribution

SETH G. JOHN[1] AND THOMAS S. WEBER[2]

[1]Department of Earth Sciences, University of Southern California, Los Angeles, CA 90089. sethjohn@usc.edu
[2]School of Oceanography, University of Washington, Seattle, WA 89195. tsweber@uw.edu

Zinc has a nutrient-type distribution in the oceans, with low concentrations in the surface ocean where it is assimilated by phytoplankton as a micronutrient, and increasing concentration with depth. Compared to other important nutrients such as nitrate and phosphate, however, Zn appears to remineralize more deeply in the water column. Thus Zn has a deeper concentration maximum, similar to Si. While the distribution of Zn in the oceans is now fairly well known, the processes responsible for this distribution are not well understood.

We have developed a spatially resolved global model of the marine Zn cycle in order to better understand which processes might control the distribution of Zn in the ocean. Three hypotheses were tested within the context of this model: 1) rapid uptake of Zn in the surface Southern Ocean decreases preformed Zn delivery to mid-depths, 2) a portion of phytoplankton Zn is present within a refractory phase which remineralizes slowly when sinking through the water column, and 3) Zn is scavenged onto sinking particles.

We find that rapid Southern Ocean uptake cannot adequately reproduce global ocean Zn observations on its own, but does bring the model into better agreement with data when applied in combination with a refractory Zn phase or scavenging.

Models which include a refractory Zn phase provide a good fit to data when the quantity and δ^{66}Zn of the refractory Zn pool is unconstrained. However when the amount of refractory Zn in diatoms is limited to <37% of the cellular total, based on obervations of Zn in a Southern Ocean diatom, the model does not fit observations well. Also, the model does not reproduce global δ^{66}Zn given the known preference of for biological assimilation of lighter Zn isotopes, even if phytoplankton partition high δ^{66}Zn into their refractory phase.

A model which includes scavenging can reproduce both Zn and δ^{66}Zn distributions in the world ocean, and is consistent with previous experimental and field observations about Zn and δ^{66}Zn in cells. We conclude that scavenging is key to the marine distribution of Zn and δ^{66}Zn, and that despite their similar distributions, the cycles of Zn and Si are not tightly coupled mechanistically.