

The Acceleration of Cobalt's Stoichiometry due to Biological Uptake, Remineralization, and Scavenging in the Atlantic Ocean

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With the smallest oceanic inventory of any inorganic nutrient, cobalt provides a unique case for considering the stoichiometric coupling between dissolved and particulate phases in the context of Redfield theory. Total dissolved cobalt (dCo) data was examined from the U.S. North Atlantic GEOTRACES transect and the South Atlantic GEOTRACES-compliant transect (GA03/3_e and GAc01), by Redfieldian analysis of its statistical relationships with the macronutrient phosphate. Positive dCo:P slopes were observed in the euphotic zone that often accelerated towards the surface, likely due to the combined influence of depleted phosphate, phosphorus sparing mechanisms, increased alkaline phosphatase metalloenzyme production (a zinc or perhaps cobalt enzyme), and biochemical substitution of Co for depleted Zn. Consistent with this, dissolved Zn (dZn) was found to be drawn down to only twofold more than dCo, despite being more than 18-fold more abundant in the ocean interior. Metaproteomic results from the Bermuda Atlantic Time-series Study (BATS) station found cyanobacterial isoforms of the alkaline phosphatase enzyme to be prevalent in the upper ocean, consistent with accelerating stoichiometries. Negative slopes were observed in the ocean interior and in coastal environments, becoming increasingly vertical with depth, consistent with the sum of scavenging and remineralization processes. This study provides insights into the coupling between the dissolved and particulate phase that ultimately create Redfield stoichiometric ratios, demonstrating that the coupling is not an instantaneous process and is influenced by the element inventory and rate of exchange between phases.