Geophysical Research Abstracts
Vol. 19, EGU2017-14234, 2017
EGU General Assembly 2017

Dissolved strontium and calcium levels in the tropical Indian Ocean

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Measurements of seawater alkalinity and dissolved calcium concentrations along oceanic transects are often used to calculate calcium carbonate precipitation and dissolution rates. Given that the distribution coefficient of strontium in $CaCO_3$ varies greatly between different groups of organisms, adding precise measurements of dissolved strontium concentrations provides opportunities to also track relative contributions of these different groups to the regional $CaCO_3$ cycle. However, there are several obstacles to this approach. These obstacles include unresolved systematic discrepancies between seawater calcium and alkalinity data, very large analytical noise around the calcium concentration measurements and the unconstrained role of acantharia (radiolarian precipitating SrSO4 skeletons) in the marine strontium cycle. During the first cruise of the second International Indian Ocean Expedition (IIOE-2) water samples were collected along 67°E from 9°N to 5°S to explore the dissolution rate of calcium carbonate in the water. The dissolution rate can be calculated by combining measurements of water column potential alkalinity with calcium and strontium concentrations measured by ICP-OES and calcium concentration measurements using isotope dilution thermal ionization mass spectrometry (ID-TIMS). $CaCO_3$ mineral saturation state calculated using pH and total alkalinity suggests that along 67°E, the aragonite saturation horizon lays at depth of $\sim$500 m on both sides of the equator. Across the cruise transect, dissolved strontium concentrations increase by 2-3% along the thermocline suggesting rapid recycling of strontium rich phases. This is particularly evident just below the thermocline at 8-9°N and below 1000 m water depth, south of the equator. The deep, southern enrichment in strontium does not involve a change in the Sr/Ca ratio, suggesting that this strontium enrichment is related to $CaCO_3$ dissolution. In contrast, in the intermediate waters of the northern part of the section Sr/Ca ratios increase significantly. This finding is opposite to expectations based on plankton net tows collected during the cruise, where we found high abundance of acantharia in the southern parts of the section, while the preferential enrichment in strontium is in the northern part of the section. When potential alkalinity is calculated by correcting the normalized total alkalinity for the effects of nutrient accumulation below the thermocline, we observe that the increase in alkalinity begins at 100 m, well above the aragonite saturation horizon. The total change in dissolved calcium concentrations between 0 and 2000 m is similar to the total change in potential alkalinity yet their profiles do not overlap; calcium concentrations increase faster than total alkalinity between 100-1000 m and the gap is closed between 1000-1500 m. This suggests an additional, unaccounted process that is likely occurring in the Red Sea and Persian Gulf, the intermediate water sources of this region.