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Using natural radionuclides 210Po and 210Pb in GEOTRACES data from the North Atlantic to estimate particulate and biologically reactive trace element scavenging and regeneration

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Central to understanding the coupling of oceanic carbon and nutrient cycles are trace elements that can limit ocean production and ultimately climate change. These include elements that are both lithogenic (particle reactive) and biogenic (biologically reactive) central to particle scavenging, exchange and bioavailability. The natural 210Po and 210Pb radionuclide (granddaughter/parent) pair provides the radiometric means to model particle scavenging and exchange in the ocean on monthly to annual time scales.
Data on dissolved (<0.2 μm) and particulate (>0.2 μm, >53μm) 210Po (t1/2= 138.4 d) and 210Pb (T1/2 = 22.3 y) are available from seven complete water profiles during two U.S. GEOTRACES cruises that transited the North Atlantic during fall 2010 and 2011. The transects correspond to a wide range of marine environments: coastal slopes at the western and eutrophic up-welling at the eastern margins, Saharan dust sources from the east, hydro-thermal vents in the TAG plume on the Mid-Atlantic Ridge, and oligotrophic gyres in both the western and eastern basins.
Steady state box modeling at each depth interval was employed to estimate radionuclide exchange rates at the fine-large particle and fine particulate-dissolved interface, in terms of biological uptake, and net of radioactive support or decay. By proxy, the results should predict the rates of biological (210Po) and particle reactive (210Pb) trace element adsorption and resorption, vertical particulate and carbon export, and respective residence times.
The model results show the contrasting chemical behaviour of the two nuclides over the large range of oceanic conditions encountered in the North Atlantic. In the surface ocean, 210Po scavenging is linearly correlated with the concentration of particulate organic carbon (POC) in large particles, supporting the role of biogenic particles in 210Po bioaccumulation and export. At depth, 210Po exhibits significant widespread deficit with respect to 210Pb, which could in part be attributed to in situ 210Po scavenging, and may be related to surface biological productivity. Aeolian eastern sources of 210Pb in surface waters are evident as large excess of the largely conservative grandparent 226Ra, but deficient at depth with scavenging rates higher at ocean margins. At depth, 210Pb deficiency increases as does benthic scavenging, and eastward due to the increase of adsorption sites available plus a regional contribution of particle flux i. The benthic nepheloid layer (BNL) and the hydrothermal TAG plume distinctly enhance 210Pb scavenging due to increased surface adsorption on resuspended particles, or freshly formed precipitates. In contrast, 210Po does not appear to be significantly scavenged in these areas due to its relatively short half-life and the longer residence time of the particles. In the eastern boundary, enhanced surface production is evident, supported in part by lithogenic trace elements from nearby dust sources. Likewise biogenic trace elements are supplied from equatorial upwelling off Africa from benthic regeneration associated with benthic boundary scavenging.