The influence of boundary scavenging and particle composition on dissolved and buried ^{230}Th and ^{231}Pa in the subarctic North Pacific

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The well-known production rates of insoluble ^{230}Th and ^{231}Pa in seawater via decay of soluble uranium make them useful tracers of scavenging processes in the modern ocean. Additionally, their half-lives (75.7 and 32.5 kyr, respectively) and preservation in the sediment record make them attractive tools for understanding the particle flux of the late Pleistocene ocean. Yet, multiple processes affect the distribution of these radionuclides in the ocean including particle flux, particle composition, advection and eddy diffusion. Based on the available, spatially-limited, modern ocean observations, it is often unclear which factor has the primary control on a particular seawater profile or surface sediment survey. This ambiguity hinders our understanding of the behavior of other trace metals that undergo scavenging (such as the micronutrient Fe) in addition to our ability to interpret sediment ^{231}Pa/^{230}Th records which have important paleoceanographic and paleoclimtologic consequences.

New observations of ^{230}Th and ^{231}Pa in the water column and in surface sediments are presented here from the Innovative North Pacific Experiment cruise (INOPEX, Jul-Aug 2009) which crossed large gradients in particle flux and particle composition. Boundary scavenging, or preferential removal at high particle flux sites, appears to have little impact on lateral gradients in the concentrations and ratio of dissolved ^{230}Th and ^{231}Pa. As well, concentrations in surface sediments compared with those in the immediately overlaying bottom water allow calculation of pseudo-distribution coefficients for the scavenged elements and fractionation factors for the ^{231}Pa/^{230}Th ratio. These parameters in light of sediment compositions demonstrate the relative importance that the chemical composition of particulate matter plays in scavenging. A new paradigm for understanding the removal of particle-reactive elements from the ocean may need to necessarily include the differential scavenging intensities of variable particle types as well as seafloor processes, which will also be investigated here through high depth-resolution profiles of water within 200 m of the bottom.

Mineral evolution: What's next?

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The central thesis of mineral evolution is that the near-surface mineralogy of terrestrial planets and moons diversifies through time owing to processes such as planetary accretion and differentiation, the evolution of igneous rocks, fluid-rock interactions, and the influences of life. Studies of mineral evolution thus seek to frame mineralogy in an historical context by focusing on temporal changes in near-surface characteristics, including mineral diversity and associations, relative abundances of mineral species, ranges of chemical and isotopic compositions, and grain sizes and morphologies [1,2]. Mineral evolution also exemplifies aspects of other complex evolving systems, in that we observe complexification (i.e., diversification) through time and each stage of mineral evolution depends on the sequence of prior stages [3]. Recent efforts in mineral evolution research have focused on first reported appearances of mineral species containing specific chemical elements, e.g., U, Be, B, Hg and Mo through time [4,5]. These studies reveal striking increases in the diversity of mineral species, notably between 2.0 to 1.7 and 0.6 to 0.2 billion years ago. Other on-going studies correlate the relative abundances of minerals to geologic conditions, with special attention on changes in clay mineralogy, both in absolute and relative terms [6]. Variations in the extent of incorporation of non-essential elements in specific minerals through time, notably redox sensitive elements, represents a third promising avenue of research, e.g., reported increased incorporation of Re and W in molybdenite (MoS_2) during the past billion years. These efforts are being facilitated by development of a Mineral Evolution Database linked to the comprehensive mindat.org platform [7].

[1] *Am. Mineral.*, 2009, **93**, 1693-1720; [2] *Elements*, 2010, **6**, 9-12; [3] *ibid.*, 43-46; [4] *Am. Mineral.*, 2009, **94**, 1293-1311; [5] *GSA Abstr. Prog.*, 2010, **42**(5), 199; [6] *ibid.*, 199; [7] *Am.Mineral.*, 2011, **96**, in press.