Geophysical Research Abstracts,
Vol. 11, EGU2009-8243-1, 2009
EGU General Assembly 2009

Distribution of $^{230}Th_{xs}$ and $^{231}Pa_{xs}$ in sediment particle classes of opal-rich and carbonate-rich sediments

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In many paleoceanographic studies $^{230}Th_{excess}$-normalization and the $^{231}Pa_{excess}/^{230}Th_{excess}$-ratio are used as tools for reconstruction of particle fluxes and ocean circulation. $^{230}Th_{xs}$ and $^{231}Pa_{xs}$ analyses are usually performed on bulk sediment samples. However, it is conceivable that these two particle-reactive radioisotopes are not equally distributed between the sedimentary components of bulk sediments, because Th and Pa show preferential adsorption to specific particle types (e.g. Geibert and Usbeck, 2004). This is particularly relevant for opal-rich sediments.

Lateral transport during particle settling exerts a sorting effect on particles according to different grain size classes and sinking velocities, thus affecting the sedimentary isotopesignal as well. This process may affect the applicability of $^{231}Pa_{xs}$ and $^{230}Th_{xs}$ as particle flux tracers. Currently discussed problems such as apparently high focusing factors in the Panama Basin, or the applicability of $^{231}Pa_{xs}/^{230}Th_{xs}$-ratios for the reconstruction of ocean circulation patterns might be related to this particle sorting effect.

For this study we performed particle size specific analyses of $^{230}Th_{xs}$ and $^{231}Pa_{xs}$ on deep sea sediment samples from contrasting sedimentary settings, including the subtropical Atlantic Ocean (Walvis Ridge), the Southern Ocean and the tropical Pacific Ocean (Panama Basin). Bulk sediments were split into distinct particle size and density classes by sieving and settling. In opal-rich and carbonate-rich sediment, most of the $^{230}Th_{xs}$ is bound within the particle size class $<20\mu$m accounting for 90% and 60-77% of the total $^{230}Th_{xs}$ inventories, respectively. High focusing factors of up to 10 as found in the Panama Basin seem to be mainly (80%) caused by the accumulation of fine-grained sediment ($<20\mu$m).

The $^{231}Pa_{xs}$ in opal rich material is mainly adsorbed onto the smallest size class $<20\mu$m, comparable to $^{230}Th_{xs}$. But unlike $^{230}Th_{xs}$, $^{231}Pa_{xs}$ shows a strong affinity to biogenic opal particles. The ratio of $^{231}Pa_{xs}/^{230}Th_{xs}$ in the biogenic opal particles is increased up to 2.5 times compared to bulk values. If $^{230}Th_{xs}$ and $^{231}Pa_{xs}$ are bound to different particle types, lateral transport involving particle sorting has the potential to affect the isotope ratios of the bulk sediment.

Reference:

Geibert and Usbeck (2004): Adsorption of thorium and protactinium onto different particle types: Experimental findings. Geochimica et Cosmochimica Acta, 68(7): 1489-1501