Distribution of protactinium and thorium isotopes in the Arabian Sea

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During the German JGOFS program protactinium and thorium isotopes were measured in water samples, sediment trap matter and surface sediments from the Arabian Sea (see Fig. 1). Sediment samples were measured conventionally via alpha spectrometry. In water samples of only 10 litres the concentrations of ^{231}Pa, ^{230}Th and ^{232}Th were determined using thermal ionization mass spectrometry (TIMS).

^{231}Pa and ^{230}Th are produced in the water column at constant rates ($^{230}Th/^{231}Pa$ production ratio of 10.8) by decaying uranium, which is, due to its long residence time, homogeneously distributed throughout the ocean. Both nuclides are highly particle-reactive and, therefore scavenged from the water column by sinking particles. This leads to residence times for ^{231}Pa and ^{230}Th of 80–150 a and 20–50 a, respectively, which are much shorter than their half-life times ($T_{1/2}(^{231}Pa)$ = 32.5 ka; $T_{1/2}(^{230}Th)$ = 75.4 ka).

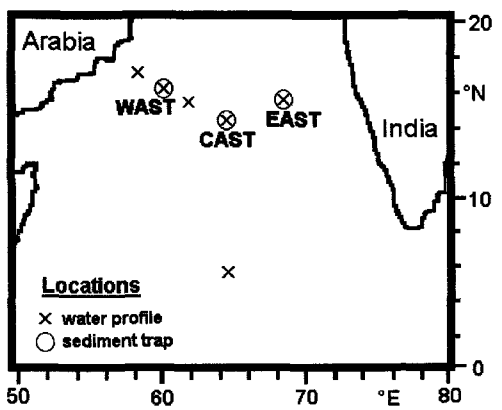

FIG. 1. Sample locations for protactinium and thorium determination in the Arabian Sea. Water profiles include six depth steps each and were collected during FS Sonne cruises SO117 in spring and SO120 in summer 1997.

These radionuclides are useful for the study of particle dynamics and as a tool for the trapping efficiency calibration of sediment traps. Further, they are tracers for varying scavenging activities, due to changing bioproductivity, detrital input or water mass transport.

The bioproductivity, particle fluxes and water mass circulation in the Arabian Sea are forced by the seasonality of the monsoon. During the SW monsoon (between June and September) coastal upwelling occurs on the western margins of the Arabian Sea near the Oman Shelf. Combined with a higher detrital input due to strong winds carrying lithogenic matter from the Arabian Peninsula and Somalia and a deeper mixing of the upper water column this produces a strong gradient in the particle fluxes from the centre to the western margins of the Arabian Sea. The gradient of particle fluxes is clearly reflected by the distribution of ^{231}Pa and ^{230}Th. The residence time in the water column for ^{230}Th decreases from 25a in the Central Arabian Sea to 5a near the Oman Shelf. At the same localities the residence time of ^{231}Pa displays a significant but less pronounced decrease from 102a to 68a. The concentration of both radionuclides in the surface sediments indicate a strong ^{231}Pa export from the Central Arabian Sea to the high productive areas at the margins, where $^{230}Th/^{231}Pa$ ratios of less than 5 were found, in contrast to ratios of approx. 20 in the basin centre.

The water profiles of ^{230}Th show a nearly undisturbed scavenging behaviour, with a linear increase of ^{230}Th concentration with water depth. Advective and diffusive influences seem to be neglegiable as strong scavenging at the boundary predominates.