Surface concentrations of ^{228}Th, ^{230}Th and ^{231}Pa in the Atlantic Sector of the Southern Ocean – the effects on palaeoenvironmental applications

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^{230}Th and ^{231}Pa in palaeoenvironmental applications

The natural radionuclides ^{230}Th and ^{231}Pa are produced continuously in seawater by decay of ^{234}U and ^{235}U, respectively. Their production at well known rates, their radioactive half-life of 75200 and 32500 years, respectively, and their particle reactivity make them a tool for the reconstruction of marine particle fluxes in the late Pleistocene and Holocene period.

In the last five years the ^{231}Pa/^{230}Th ratio has been used as a proxy for changes of bioproductivity in the past (e.g. Kumar *et al.* 1993). ^{230}Th activities in sediments have been used extensively to correct sediment accumulation rates for lateral sediment redistribution effects. Both applications require ^{230}Th and ^{231}Pa concentrations not to be influenced by advection.

But still little is known about the influence of lateral advection of water, particle composition and seasonal changes in bioproductivity on the scavenging of Th and Pa. Rutgers van der Loeff and Berger (1993) found evidence for a ^{230}Th contribution of deep water to surface ^{230}Th concentrations south of the ACC-Weddell Gyre boundary. Particle composition has been shown to play an important role for Pa/Th ratios in the South Atlantic south of the Polar Front by Walter *et al.* (1997). But there was still a lack of data for ^{230}Th surface concentrations in combination with data on particle composition. For ^{231}Pa, concentrations at the sea surface were not known.

Sampling locations and sampling techniques

During the expedition ANT XV/2 of RV 'Polarstern' (Nov. 1997-Jan. 1998), we had the opportunity to take samples for ^{228}Th, ^{230}Th and ^{231}Pa on several transects across the ACC/Weddell Gyre boundary and across the Polar Front (see Fig. 1 for sample locations). Two different sampling strategies were used to obtain the particulate and dissolved concentrations of ^{228}Th, ^{230}Th and ^{231}Pa near the sea surface. One sampling technique was the separation of particles by a 1 µm filter cartridge, followed by two MnO_2-coated filter cartridges in series for adsorption of dissolved radionuclides (Fig. 1, open circles). In the remaining samples, particles were separated by a centrifuge (Fig. 1, filled squares), followed by two MnO_2-coated filter cartridges for adsorption of the dissolved radionuclides. The particulate matter obtained by centrifuging large volumes of seawater (average about 3000 litres) gives us the opportunity to analysze the contents of several trace metals, radionuclides and main components of a single sample.

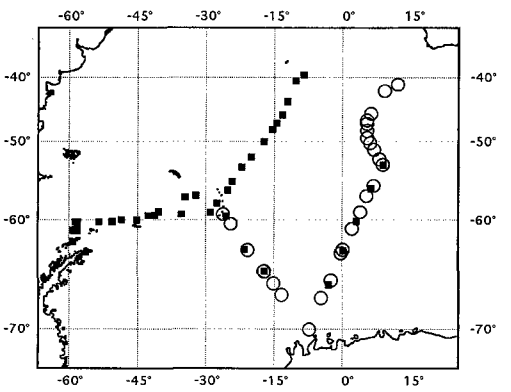

FIG. 1. Map locations of surface sampling by filtration (open circles) and centrifugation (filled squares). Data refer to eastern transect.

Southward increase in ^{230}Th and ^{231}Pa concentrations at the sea surface

Here we present first preliminary results on a transect from Cape Town to Neumayer Station. We observe a southward increase of dissolved ^{230}Th concentrations at the sea surface (depth = 11 m) south of the Polar front by a factor of about 4. The concentrations remain high throughout the whole Weddell Sea. This can be caused by deep upwelling of Lower Circumpolar Deep Water according to Rutgers van der Loeff and Berger (1993). Some values in the sea ice of the Weddell sea were even higher, indicating Th accumulation in the sea ice. Concentrations of dissolved ^{231}Pa show a pattern similar to ^{230}Th, but less pronounced.

Dissolved ^{228}Th concentrations show the opposite trend. The highest concentrations are observed at about 45° south, followed by a southward decrease by a factor of 10. ^{228}Th (half-life 1.91 yr) is the grand-daughter nuclide of ^{228}Ra (half-life 5.75 yr) so ^{228}Th concentrations are closely coupled to ^{228}Ra. ^{228}Ra may serve as a natural tracer for exchange between water masses and continental shelves and so does ^{228}Th. So the high ^{228}Th concentrations north of 45°S indicate stronger continental influence in these water masses.

Conclusions

We observe an increase of ^{230}Th and ^{231}Pa in the surface water south of the Polar Front which is probably due to upwelling. This has implications for the use of ^{230}Th and ^{231}Pa in palaeoenvironmental applications. The correction of sediment accumulation rates with ^{230}Th fluxes in this region will require more detailed information about Th distribution and scavenging efficiency. The ^{231}Pa/^{230}Th ratio is no reliable palaeoproductivity proxy if lateral ^{230}Th contributions in the water column of the Weddell Sea cannot be excluded. We will discuss these effects and present new data for Th/Pa fractionation factor and total ^{230}Th and ^{231}Pa concentrations in the surface waters of the ACC and the Weddell Sea.

References

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