^{230}Th, ^{231}Pa and ^{232}Th as tracers of supply, removal and internal cycling in the Arctic Ocean

Bob Anderson, Lamont-Doherty Earth Observatory <boba@ldeo.columbia.edu>
Larry Edwards, University of Minnesota <edwar001@umn.edu>>
Brad Moran, University of Rhode Island <sbmoran@mail.uri.edu>

SCIENTIFIC OBJECTIVES:

1. Boundary scavenging: The known and uniform source of dissolved ^{230}Th and ^{231}Pa will allow us to use their measured distributions to test the hypothesis that high biological productivity around the seasonally ice-free margins of the Arctic Ocean creates a region of enhanced removal of trace elements by scavenging to particles.
2. Sensitivity of scavenging to varying particle composition: In collaboration with other investigators, we will use the partitioning between dissolved and particulate phases among stations with a range of particle composition (ranging from dominantly lithogenic to dominantly biogenic) to establish the relative affinity of different particle phases for different trace elements.
3. Historical movement of deep water masses: a) First we will test the hypothesis that concentrations of dissolved ^{230}Th and ^{231}Pa increase with increasing age of deep water masses along the path from the deep Atlantic into the deep Canada Basin, and then b) We will compare GEOTRACES data with historical data to test the claim that there was a recent (within the past decade) movement of deep waters from the North Pole region into the Canada Basin.
4. ^{231}Pa /^{230}Th ratios in Arctic Ocean sediments were recently used to conclude that the deep Arctic was ventilated during the last ice age as rapidly as it is today (Hoffmann et al., 2013). By contrast, studies using radiocarbon as a tracer have concluded that the deep Arctic water masses sat isolated from the rest of the ocean for thousands of years (Thornalley et al., 2011). A synthesis of the data to be generated under our proposed project will help reconcile these conflicting interpretations.

Our proposed work on each of these topics will be informed by results of prior investigations (Edmonds et al., 2004; Moran et al., 2005), but will also benefit from the much greater sampling resolution anticipated for the GEOTRACES Arctic initiative.

ANTICIPATED SCIENTIFIC COLLABORATORS:

1. Investigators operating in situ pumps to collect particulate material; solid-solution partitioning.
2. Investigators measuring Nd isotopes and REE.
3. Investigators studying the Th and Pa among solution, colloids, and particles.

4. Investigators studying ^{7}Be, ^{210}Pb, and ^{234}Th to characterize sensitivity of scavenging to particle composition.
5. Investigators studying circulation and water mass history.
6. International GEOTRACES teams encompassing the full breadth of the Arctic Ocean.

SAMPLING REQUIREMENTS:

Water samples can be collected using standard Niskin rosettes. Collaborating with the team measuring REE and Nd isotopes has worked very well on past US GEOTRACS cruises so we proposed a similar collaboration here. Altogether, this team will require 15 liters of filtered seawater from each sample depth

We will request approximately ¼ of the Supor filters from each *in situ* pump samples.

We will request approximately 3 cc wet volume of surface (0-2 cm) sediment at each station.

BERTH REQUIREMENTS:

One berth minimum.

For the Atlantic and Pacific cruises of the US GEOTRACES program, one person each from the Th-Pa group and from the Nd-REE group handled sampling of Niskin bottles for all parameters requiring shipboard sample filtration. We believe that a similar arrangement will serve the Arctic expedition well. However, if the volume of water to be collected and processed increases significantly above that collected for the Atlantic and Pacific cruises, for example due to the addition or expansion of other projects, then a third and possibly even a fourth berth may be needed.

References

Edmonds, H.N., Moran, S.B., Cheng, H. and Edwards, R.L., 2004. ^{230}Th and ^{231}Pa in the Arctic Ocean: implications for particle fluxes and basin-scale Th/Pa fractionation. Earth and Planetary Science Letters, 227(1-2): 155-167.

Hoffmann, S.S., McManus, J.F., Curry, W.B. and Brown-Leger, L.S., 2013. Persistent export of 231Pa from the deep central Arctic Ocean over the past 35,000 years. Nature, 497(7451): 603-606.

Moran, S.B., Shen, C.C., Edwards, R.L., Edmonds, H.N., Scholten, J.C., Smith, J.N. and Ku, T.L., 2005. ^{231}Pa and ^{230}Th in surface sediments of the Arctic Ocean: Implications for $^{231}Pa/^{230}Th$ fractionation, boundary scavenging, and advective export. Earth and Planetary Science Letters, 234: 235– 248.

Thornalley, D.J.R., Barker, S., Broecker, W.S., Elderfield, H. and McCave, I.N., 2011. The Deglacial Evolution of North Atlantic Deep Convection. Science, 331(6014): 202-205.