Short-lived U-Th Series Radionuclides and Large Volume Pump Management

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Scientific Objectives

We plan to submit a proposal on Feb 15th to participate in the Arctic GEOTRACES program with a focus on the shorter lived U/Th series (^{234}Th, ^{228}Th and all 4 Ra isotopes), which are ideally suited to study the sources and sinks of TEIs on time and space scales that are required to interpret lateral and vertical distributions of the TEIs in this basin.

In the Artic, gradients in productivity, scavenging and subsurface remineralization have been successfully tracked using short lived Th isotopes (^{234}Th–$t_{1/2}$ = 24 days and ^{228}Th–$t_{1/2}$ = 1.9 years). Also, naturally occurring radium isotopes (^{226}Ra–$t_{1/2}$ = 1600 years, ^{228}Ra–$t_{1/2}$ = 5.75 years, ^{224}Ra–$t_{1/2}$ = 3.66 days, and ^{223}Ra–$t_{1/2}$ = 11.4 days) have been used to quantify lateral mixing processes between Arctic shelves and the open ocean, while the longer-lived Ra isotopes have been useful as water mass tracers (Pacific inflow water, river plumes, etc.).

We would propose to include these isotopes as part of the efforts being planned for the US GEOTRACES Arctic Ocean study. The half-lives of ^{234}Th and ^{228}Th make them ideal for the study of upper ocean particle export, mesopelagic export and remineralization, particle aggregation/disaggregation rates, and scavenging associated with benthic nepheloid layers. TEI fluxes and remineralization rates are determined by linking the ratio of TEIs/Th measured on particles (large and small size classes obtained here via in-situ pumps). The radium quartet would allow us to quantify TEI (1) boundary sources and exchange rates on short and intermediate time scales (days-months); (2) terrestrial sources including submarine groundwater discharge, rivers, and permafrost melt; and, (3) diapycnal mixing rates across the thermocline or in the benthic boundary layer.

We will also propose to undertake the large volume in situ pump (LVP) management responsibilities. We have considerable experience with these tracers and LVPs, including our leading the GEOTRACES intercalibration of these isotopes and participation in the GEOTRACES Atlantic (2010, 2011) and Pacific (2013) cruises.

Sample Requirements

The sampling effort requires water from the CTD (4L ^{234}Th), larger volumes from surface pumping (for Ra isotopes), and large volume samples for vertical profiles of dissolved & particulate ^{228}Ra and ^{228}Th. For the large volume radionuclide samples, we would attach a single Mn cartridge to the LVP flow path after filtration. We would be analyzing the cartridge for Ra and Th isotopes, and at least part of a particle filter (of about 500L equivalent) for ^{228}Th and ^{234}Th. For radionuclides alone, we do not need specialized pumps or trace metal clean sampling. Equipment built up for the Atlantic and Pacific GEOTRACES cruises (6000 m plastic jacketed Vectran cable, pump filter holders, Mn cartridge housings, flow meters and specialized plumbing for McLane pumps) would be reused at significant savings to the project.

In addition to the water collected using standard CTD/Rosette casts, two casts with 8 in situ pumps each will be needed, one shallow (6 hrs) and one deep (9-10 hrs, and

only at stations where the bottom exceeds roughly 1000-2000 m); therefore most full ocean depth stations will have a 16-depth profile for large volume particulates and radioisotopes.

Berthing Requirements

Our prior experience suggests that this effort will require a minimum of 3 berths, and includes personnel responsible for pump maintenance and deployment as well as on board processing and counting of ^{234}Th and ^{223}Ra/^{224}Ra isotopes (a requirement due to their short-half life relative to the planned cruise length). As for particle sampling from the LVPs, we are assuming a separate group will be responsible for preparation and distribution of the filters used for TEIs and other radionuclides and that they will contribute 2 additional persons to help with pump logistics. We have found this combination of water sampling, large volume pumping, and on board detection of short lived Ra and Th isotopes allows for the most efficient use of wire time and berths required for collection of these six radionuclides.