Proposed Research

With the guidance of Dr. [redacted], I have developed my interest in abrupt climate change phenomena over the past four years; I have become proficient with light isotope preparation of marine foraminifera, and trace metal techniques; under the direction of Dr. [redacted], I have broadened my analytical experience to include amino acid liquid chromatography. However, in graduate school, I will shift my focus to another technique capable of developing highly resolved records of circulation events: ^{231}Pa / ^{230}Th. Dr. [redacted] of [redacted] University has pioneered the use of this technique of ^{231}Pa/^{230}Th towards resolving abrupt ocean circulation events. I hope to use this technique to explore abrupt changes in ocean circulation. With the help of my mentor Dr. [redacted], I have initiated a dialogue with Dr. [redacted] in which he views my working with him in a favorable light.

Dr. [redacted] laid the groundwork for this ^{231}Pa/^{230}Th technique with a paper discussing the collapse and rapid resumption of the Atlantic meridional circulation (MOC) in 2004, published in *Nature*. His study extended a detailed circulation record through the last glacial maximum. My current research focuses on resolving Dansgaard-Oeschger (DO) events occurring just prior to Dr. [redacted]'s. I would like to combine my interest in these events with techniques he has pioneered with the objective of determining whether asynchronous changes in circulation have produced a corresponding disparity in global temperature records. This research is entirely novel, and will help researchers and modelers understand the link between sudden climate shifts and the production of North Atlantic Deep Water (NADW) - one of the world's major carbon sinks.

DO events are well represented in the Greenland Icecore Project (GRIP) and North Greenland Icecore Project (NGRIP) ice core records. These δ^{18}O ice core records show DO related increases in temperature of 5-8 C; the signature of these abrupt climate swings can be found in lower latitudes and are synchronous over large expanses of the globe[1]. These events are followed by a gradual cooling over several hundred years. This pattern is regularly repeated twenty three times in the GISP2 record; twenty three DO cycles have a periodicity of around 1470 years with an error of 12%[2]. DO events are also thought to have an associated overturning signature, an idea which my current research will either refute or substantiate. Heinrich (H) events drastically reduce the production of NADW through inundation with massive freshwater discharge associated with a collapsing ice sheet. This freshwater forms a lens, more buoyant than ocean water, capping sites of NADW, shutting down the ocean conveyor. Each H Event is preceded by a period of warming associated with a DO event. DO events are postulated to trigger H events through warming the ice sheet, leading to melting and catastrophic destabilization[3]. However, H events occur on the order of ten-thousand years, much less frequently than DO events; this interval represents the building of a continental ice sheet to an unstable level. On the other hand, substantial evidence for a trigger causing these DO events has yet to be put forward. The most widely accepted mechanism behind DO events has been the "see-saw" thermodynamic pump: thermal energy generated from solar radiation at the tropics oscillates between predominantly northward and southward transport. In this model, DO warming events are triggered by the latent heat of water traveling northward. During an H event, a fresh water lens interferes with the production of NADW, and thermal energy is redirected southward where an analogous instability is created in the southern hemisphere's ice sheets. Cyclic hemispheric asynchrony has been measured in temperature records in Antarctica, Chile and New Zealand[4]. ^{231}Pa/^{230}Th is an ideal tracer for pinpointing these regular and dramatic ocean circulation shifts.

^{231}Pa and ^{230}Th are generated through the radioactive decay of heavier parent isotopes

^{235}U and ^{234}U respectively. In ocean water both ^{231}Pa and ^{230}Th are scavenged through flocculation and fall to the sea floor. The flocculate rates differ; ^{231}Pa has a residence time of 100-200 years, while ^{230}Th has a residence time 20-40 years[5]. As these two radioactive isotopes reside in marine sediments, they continue the decay chain; from the isotopes of the elements present in the sediment samples the original abundance of ^{231}Pa and ^{230}Th can be reconstructed. The differential flocculation rate of ^{231}Pa and ^{230}Th give an exceptionally accurate method of determining the movement of the water column above the sampling site with a potential resolution limited only by the sedimentation rate of the core.

The analytical techniques used to resolve these isotopic records involve methods and instruments with which I am familiar; the inductively coupled plasma mass spectrometers used to measure the relative concentration of the isotopes is very similar to the optical emission plasma mass spectrometer I used to measure trace metals while the ion-exchange chromatographic techniques used for ^{231}Pa and ^{230}Th separation are similar to the chromatography I used to resolve amino acids while conducting my research at University of [redacted]. I am familiar with the concept of isotope dilution, a necessary step in the analysis.

Understanding how the world's climate oscillated in response to shifting ocean currents will give the scientific community a great insight into the workings of the earth's climate system. Modelers, who make projections of our earth’s future climate, base their models in large part upon observations; because dramatic alterations in ocean circulation have manifested themselves outside of the scope of human experience, reconstructions of past ocean circulation provide key information to modelers. Modeling results often form the basis for discussion of climate legislation and international agreements. The IPCC has delineated the enormous role the ocean plays in the sequestering of carbon through the production of NADW, among other functions vital to humanity[6], while acknowledging many mechanisms are at this time imperfectly understood.

1 Lynch-Stieglitz, J., Hemispheric Asynchrony of Abrupt Climate Change, *Science*, *304*, 1919-1920, 2004.

2 Ramstorf et al, Timing of abrupt climate change: A precise clock., *Geophysical Research Letters*, *30*,1510, 2003.

3 Bond, G. and Lotti, R., Iceberg discharges into the North Atlantic on millennial time scales during the last glaciation. *Science*, *267*, 1005-1010, 1995.

4 Lynch-Stieglitz, J., Hemispheric Asynchrony of Abrupt Climate Change, *Science*, *304*, 1919-1920, 2004.

5 McManus et al. Collapse and rapid resumption of Atlantic meridional circulation linked to deglacial climate change, *Nature*, *428*, 834-7, 2004.

6 Baede, A., IPCC, Fourth Assessment Report, Intergovernmental Panel on Climate Change,54 . 2007