

Factors governing nutrient exchange through the Arctic Gateway: An International GEOTRACES study

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Project Summary

This PhD project will use novel Si and N stable isotope measurements of dissolved silicic acid and nitrate to understand silicic acid and nitrate cycling in the Arctic Ocean and processes that govern nutrient exchange to the Atlantic Ocean.

Project background

The Arctic is currently the most rapidly warming region of the planet. It is projected that the Arctic will experience 5°C warming by the end of this century, which is twice the global mean (IPCC 2007). The environmental consequences of this rapid change are already apparent within the Arctic, as highlighted by the recent reduction in summer sea-ice extent which is unprecedented in the human record. The biogeochemical impacts of Arctic warming remain unclear.

The Arctic Ocean plays an important role as a source of Si to the North Atlantic Ocean through the Fram Strait (Arctic Gateway) fueling diatom production (Varela et al., 2016). Similarly, relatively N-poor Arctic-sourced waters contribute to excess P required for N fixation in the tropical Atlantic Ocean (Yamamoto-Kawai et al., 2006). The role of the *Arctic* throughflow as a source of nutrients to the Atlantic Ocean is subject to change. Arctic climate change can affect this process in various ways: First, by changing Pacific- and Atlantic-sourced water masses from and to the Arctic. Pacific water entering through the Barents Sea is an important source of silicic acid to the Arctic Ocean. Second, the decline in sea ice and the increase in fresh water run-off can influence biological productivity, nutrient inputs from terrestrial sources and nutrient cycling within the Arctic Ocean.

Project and Objectives

The key research objective is to document the nature of nutrient cycling in the Arctic Ocean and understand how associated process will change with warming trends, water mass circulation and sea ice loss in this region. This will be achieved through determinations of Si isotopes of dissolved silicic acid along with stable N and O isotopic signatures of nitrate in seawater samples collected along international GEOTRACES cruise transects in the Arctic Ocean and the Ellett line in the subarctic Atlantic Ocean. The stable silicon isotope $\delta^{30}\text{Si}$ of silicic acid and $^{15}/^{14}\text{N}$ and $^{18}/^{16}\text{O}$ signatures of dissolved nitrate are sensitive to biogeochemical cycling of Si and N and can provide information about the nutrient origin and N and Si cycling processes that occur during transport of water masses (Sigman et al., 2000). These geochemical proxies have been used to trace Si and N cycling processes such as biological uptake and regeneration in various regions of the ocean (Rafter et al., 2013; Varela et al., 2016). These measurements will then be used:

- (1) to document various water masses in the Arctic ocean and how Si and N cycling processes contribute to their Si, N and O isotopic signatures of silicic acid and nitrate respectively
- (2) to document and understand the various sources and sinks of Si and N in the Arctic ocean and their relative importance for the Atlantic Ocean nutrient budget
- (3) to understand and elucidate the consequences of Arctic climate change on nutrient throughflow to the Atlantic Ocean

Methodology

The student will participate in international GEOTRACES Cruises in the Arctic (see <http://www.geotraces.org/> and <http://www.ukgeotraces.com/>), as well as UK cruises along the Ellett

line (<http://prj.noc.ac.uk/ExtendedEllettLine/>) to collect water samples. The Si, N and O isotope analysis of water samples will be carried out in the Multi-collector ICP facility and Wolfson's Mass Spectrometry Laboratory at the School of GeoSciences, University of Edinburgh using state-of-the-art laboratory infrastructure. The data set collected will be interpreted in the context of a wide range of oceanographic and biogeochemical data collected as part of the International GEOTRACES study, providing ample opportunity to interact and work with an international team of marine scientists.

Research training

The School of GeoSciences provides a comprehensive training programme for generic transferable and professional skills tailored to PhD students. Project-specific training in a suite of geochemical analyses, oceanographic methods and field sampling will be provided, including hands-on training in mass spectrometry for isotope analysis. The student will also be given training in a full set of skills central to a research career (data handling and interpretation, critical review, scientific writing etc.). The project will provide excellent opportunities to enhance the student learning experience by networking with high-calibre research teams both within the UK and abroad involved in the GEOTRACES research community.

Requirements

We are looking for a highly-motivated student with a Master's or Bachelor's Degree (2.1 minimum) in earth sciences or in related subjects of oceanography, marine science, environmental science/chemistry and geochemistry. Laboratory analytical experience is desirable.

References

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