EARTHSCIENCES

Cycling of Trace Metals in Framvaren Fjord- Understanding Proxies for Past Marine Conditions

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Key words:	paleoenvironment; trace metal proxies; Framvaren; anoxia
Research theme(s):	Oceanography, Climate and Palaeoenvironment
Eligible courses for this project:	• DPhil in Earth Sciences • Environmental Research (NERC DTP) • Interdisciplinary Bioscience (BBSRC DTP)

Overview

There have been many dramatic changes in climate and the carbon cycle in the geological record, including periods of widespread ocean anoxia and related global climate shifts during Oceanic Anoxic Events (OAEs). At other times, local basin conditions have also led to oxygen depletion and enhanced C burial. A key source of information for these periods is from concentrations and isotope compositions of trace elements in sediments from marine basins from which the chemistry of past overlying ocean waters can be constructed. This relies on a firm understanding of the controls on metal transport into sediments, based upon observations in limited modern day analogues of euxinic marine environments.

One key location is Framvaren Fjord, Norway, which represents the extreme of anoxic waters and contains the highest levels of H_2S reported in a marine basin. With oxic near surface waters supplied by shallow inflows, there is a strong stable chemocline where complex chemical and microbial processes and vertical transport occur. From a small boat in the sheltered fjord, it is possible to collect high resolution vertical profiles to understand the dynamics involved.

The overall goal of this project is to understand how trace metals are removed from throughout the water column and enriched in underlying sediments, and how sediment variations in relative trace metal abundances and isotope ratios serve as proxies for environmental conditions such as the supply rates of C, nutrients, and weathering-derived metals, diverse microbial metabolisms, and the extent of basin isolation. This involves investigating interactions with inorganic and organic metal carrier phases, chemical changes in different redox conditions, interactions with microbial communities and chemical cycling between different levels.

This DPhil project is part of a broad research effort that is addressing the speciation of metals across redox changes, surface interactions on particles, bonding of metals by

dissolved and particulate organic matter, interactions of the biogeochemical S cycle including the roles of sulfur-cycling bacteria, and metal isotope variations that reflect these processes.This project will primarily focus on the composition of metal-bearing organic particulates and metal-microbe interactions, and how these control chemical cycles, with scope to pursue particular student interests.

Methodology

During fieldwork in Framvaren Fjord, Norway, samples will be collected to 40m and metals that are dissolved or associated with organic compounds, nanoparticles, colloids, particles and microbial cells will be measured. Previously collected samples might also be used. Samples for characterisation of microbial communities and lab experiments on metal-microbe interactions in enrichement cultures will also be collected from the different redox environments and properly preserved.

The processes controlling the cycling and removal of trace metals to underlying sediments will be further quantified and applied to records of past environments by developing models that bring together chemistry, physics, microbial metabolisms, and observations.

Timeline

Year 1: Doctoral training courses, review of the literature and available data, initial laboratory and safety training, prepare sampling equipment, field trip to Framvaren

Years 2 and 3: Training in analytical equipment; lab experiments and analyses; modelling results; collaborations

Year 4: writing thesis and papers for international journals; Major conference presentation

Training & Skills

Field skills in collecting and preserving water, particle, colloid, and microbe samples; clean lab methods for trace metal analyses, microbiology techniques including cell culturing, and DNA sequencing. Opportunities to develop familiarity or proficiency in analytical methods for characterising organic compounds, colloids, and microbial communities using mass spectrometry, spectroscopy, imaging methods, and the Diamond Synchrotron. Training in data interpretation and modelling, conference presentation, and scientific writing skills.

References & Further Reading

A Bryan, A Dickson, F Dowdall, W Homoky, D Porcelli, G Henderson, Controls on Cd isotope composition of modern marine sediments. Earth Planet Science Letters 565(2021),116946

N Tribovillard, TJ Algeo, T Lyons, A Riboulleau, Trace metals as paleoredox and paleoproductivity proxies: an update.Chemical Geology 232 (2006), 12-32

P Swarzenski, B McKee, J Skei, J Todd, U biogeochemistry across the redox transition zone of a permanently stratified fjord: Framvaren, Norway. Marine Chemistry 67 (1999) 181-198

Further Information

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