National Oceanography Centre

University of Southampton

# GSNOCS Project

## Nitrogen cycling in the subsurface biosphere – an analogue for early life on Earth

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**Rationale:**

Nitrogen is essential to all life as we know it, for the making of proteins and nucleic acids, and sometimes also for energy generation. While much has been learnt about the possible conditions and settings for the emergence of life on Earth – e.g. abiotic syntheses of energy and organic compounds in serpentinising systems, where water-rock reactions couple oxidation of ferrous iron to the generation of hydrogen[1], triggering production of methane, simple organics and hyperalkaline hydrothermal fluids, and thus proton and redox gradients – missing in these considerations is the source of nitrogen. It remains unclear how subsurface/early-Earth microbes obtain their nitrogen, and how nitrogen is cycled from one form to another, and if such cycling reactions further provide energy for life.

Using a serpentinizing system as an analogue system for early life, this project aims to characterise active nitrogen cycling within the Oman ophiolite[2]; and to trace the source of nitrogen for subsurface microbes. How the above may evolve along fluid flows across sharp pH and redox gradients, and how diverse nitrogen-cycling reactions[3] may power life in the subsurface biosphere simulating early life will be investigated. This may provide important insights into how life has evolved on Earth and beyond.

**Methodology:**

An interdisciplinary approach will be used to tackle the research questions. This will include geochemical measurements and experimentation with deep subsurface biosphere, peridotites and associated fluids, flux measurements of inorganic/ organic nutrients and state-of-the-art stable isotope analyses and tracer experiments. These would be combined with genomics- and transcriptomics- based molecular analyses on the resident microbial communities, as well as microscopy-based techniques like fluorescence *in situ* hybridisation, Raman micro-spectroscopy and nanoSIMS to examine their spatial distribution in fluids, within fractures or on rock surfaces. The student will play an active role in the field campaign at the Samail ophiolite, Oman. It hosts well-exposed regions of active peridotite alteration, characterized by numerous alkaline springs and is thus ideal for the study of low-temperature serpentinizing system.

This project will use the existing sampling sites and infrastructures established in the ICDP funded Oman Drilling Project (http://www.omandrilling.ac.uk/) targeting the Samail Ophiolite, thus effects of microbial activities on subsurface microbial nitrogen cycling can be interpreted in a much wider context. There will also be exposure and opportunities to interact with the international research community of the Oman Drilling Project.

**Location:**

University of Southampton

**Training:**

The INSPIRE DTP programme provides comprehensive personal and professional development training alongside extensive opportunities for students to expand their multi-disciplinary outlook through interactions with a wide network of academic, research and industrial/policy partners. The student will be registered at the University of Southampton and hosted at School of Ocean and Earth Science, University of Southampton. Specific training will include:

The student will join a multidisciplinary research team, with exposure to a wide variety of biogeochemical, molecular biological and bioimaging techniques, and how these analyses can be integrated together to solve questions in geobiology and geochemistry. Full training will be provided in the range of techniques as required, including field sampling and experimentation with fluid samples, microsensor and stable isotopic measurements, epifluorescence microscopy and Raman microspectroscopy, as well as meta-omics analyses. The student must be fit and able to join research expeditions and have an aptitude for practical fieldwork. Opportunities to attend and present results at relevant national/ international conferences and workshops are available throughout the course of study and are strongly encouraged.

**Eligibility & Funding Details:**

Please see https://inspire-dtp.ac.uk/how-apply for details.

**Background Reading:**

[1] Russell, M. J., Hall, A. J. and Martin, W. (2010). Serpentinization as a source of energy at the origin of life. *Geobiology* **8**(5): 355-371 DOI: 10.1111/j.1472-4669.2010.00249.x.

[2] Rempfert, K. R., Miller, H. M., Bompard, N., Nothaft, D., Matter, J. M., Kelemen, P., Fierer, N. and Templeton, A. S. (2017). Geological and Geochemical Controlson Subsurface Microbial Life in the Samail Ophiolite, Oman. *Frontiers in Microbiology* **8** DOI: 10.3389/fmicb.2017.00056.

[3] Lam, P. and Kuypers, M. M. M. (2011). Microbial Nitrogen Cycling Processes in Oxygen Minimum Zones. *Annual Review of Marine Science* **3**(1): 317-345 DOI: doi:10.1146/annurev-marine-120709-142814.

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