The University of Oxford Department of Earth Sciences

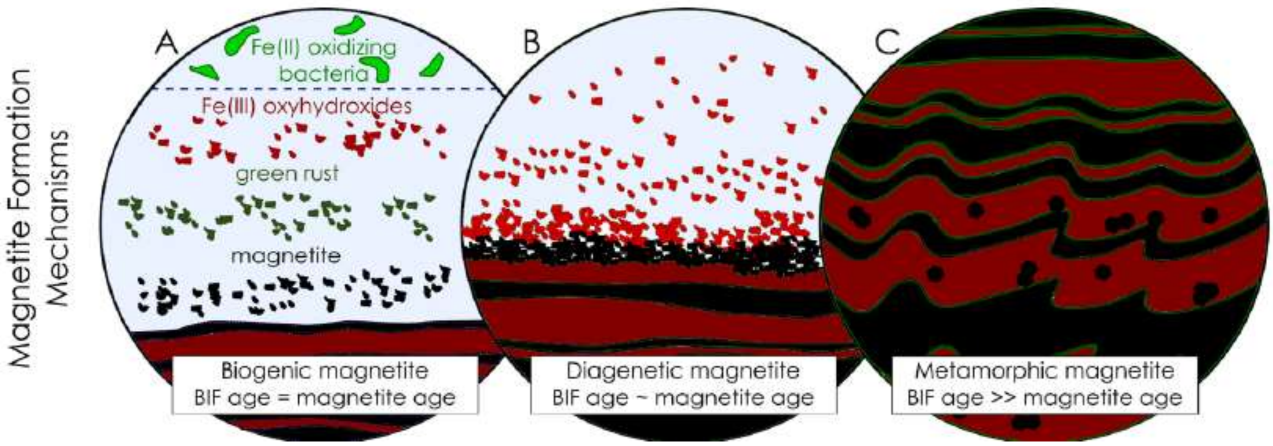
EARTHSCIENCES

UNIVERSITY OF OXFORD

Banded iron formations and early Earth environments

Supervisory Team	• **Claire Nichols** **https://www.earth.ox.ac.uk/people/claire-nichols/** • **Jon Wade** **https://www.earth.ox.ac.uk/people/jon-wade/**

Key Words	**Banded Iron Formations, Early Earth, Origins of Life**



The potential mechanisms by which magnetite forms in banded iron formations, which may help us to understand the information they hold about Earth's deepest history and habitability.

Overview

Banded iron formations (BIFs), marine sedimentary rocks that were deposited extensively prior to the great oxygenation event (GOE) may hold key information about the relationship between the biosphere, hydrosphere and atmosphere on early Earth. However, in order to understand the environment in which BIFs were deposited, we need to know which minerals were originally precipitated.

Magnetite is a ubiquitous mineral in BIFs, although its origin is debated. Some magnetite is argued to be primary, formed by Fe(II) oxidising bacteria in the water column, for example. However, a significant proportion of the magnetite observed in BIFs today likely formed at a later stage via either diagenesis or metamorphism. For the late-stage magnetite it will be necessary to determine how and when it formed, and what the precursor mineralogy was before interpreting the depositional environment.

The size, shape, distribution and orientation of magnetite grains will be interrogated to determine its origin. Advanced and novel experimental approaches will be used to disentangle different populations of magnetite within a single sample.

The project will investigate BIFs deposited in a variety of settings and time periods in order to understand the controls on their present day mineralogy, and the processes responsible for the rocks observed today. Results will be used to determine how much information BIFs preserve about early Earth environments, and whether they can be used as evidence for some of Earth's earliest lifeforms.

Methodology

This project will use a variety of techniques including triple Fe isotopes and electron backscatter diffraction (EBSD) to identify the origin of magnetite populations and their precursor minerals. Different populations of magnetite will be identified by making use of their different magnetic properties to identify grains of different sizes, shapes and compositions. We will use principal component analysis to distinguish between populations identified using first-order reversal curve (FORC) diagrams.

Timeline

Year 1: Rock magnetic characterisation and EBSD on pre-collected BIF samples.

Years 2 and 3: Fieldwork to collect BIF samples from Canada, South Africa and/or Australia. Full characterisation of samples using rock magnetism and electron microscopy. Triple Fe isotope analyses on targeted samples.

Year 4: Thesis writing. Attend AGU Fall meeting. Publish results of experimental work.

Training & Skills

The successful student will join the Oxford Magnetism Group at the University of Oxford, UK, which has a history of research excellence in rock magnetism, early Earth and planetary magnetism and tectonic reconstructions. They will also have the opportunity to integrate with faculty at external institutions and industry partners at annual career fairs.

The student will be trained how to plan and conduct a field campaign, and to prepare and analyze samples returned to the laboratory for study using a range of novel paleomagnetic techniques. They will also receive training in preparing samples for isotope geochemical analyses, and to image samples using the scanning electron microsope, including EBSD.

The student will also be mentored on how to prepare scientific results for presentation at international conferences to an expert and/or general audience, and how to write papers for publication in high-profile, international journals.

References & Further Reading

I. Halevy, Y. Feldman, R. Popovitz-Biro et al., A key role for green rust in the Precambrian oceans and the genesis of iron formations. In *Nature Geoscience* (2017).

K. O. Konhauser, et al., Iron formations: A global record of Neoarchaean to Palaeoproterozoic environmental history. In *Earth Science Reviews* (2017).

B. Rasmussen & J. R. Muhling, Making magnetite late again: Evidence for widespread magnetite growth by thermal decomposition of siderite in Hamersley banded iron formations. In *Precambrian Research* (2018).

N. J. Tosca, S. Guggenheim, & P. K. Pufahl, An authigenic origin for Precambrian greenalite: Implications for iron formation and the chemistry of ancient seawater. In *Bulletin of the Geological Society of America* (2016).

J. E. Johnson, J. R. Muhling, J. Cosmidis, et al., Low-Fe(III) Greenalite Was a Primary Mineral From Neoarchean Oceans. In *Geophysical Research Letters* (2018).

Further Information

Contact: Claire Nichols
(Claire.nichols@earth.ox.ac.uk)