The University of Oxford Department of Earth Sciences

EARTHSCIENCES

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Filling the early Tonian gap in the fossil record of complex life

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Key Words	**Early eukaryote evolution, Geobiology, Palaeobiology, Proterozoic Eon, Tonian Period**

Overview

Take a look at the life around you and you'll see a world full of complex eukaryotes (including ourselves). However, life on Earth didn't always have this array of morphological complexity. Understanding when and why complex eukaryotes first diversified is a fundamental question in the history of life on our planet. Genetic and fossil data suggest that eukaryotes first evolved over 1,600 million years ago but didn't diversify or become ecologically significant until just prior to the Cambrian Explosion, 700–600 million years ago. Why is there such a significant lag time between when complex life arose and diversified? Was the lag a consequence of the difficulty in acquiring biological machinery or a function of constraints based on the habitat into which these organisms evolved? This project will grapple with some of these most fundamental questions about life on our planet.

Exposure of the ~900 million-year-old Veteranen Group at Faksevågen, Ny Friesland, Svalbard. *Arctica* boat in bottom right shows the scale of the ~4km-thick succession.

Methodology

Fossils placed in geological context provide a means to directly ask when eukaryotes diversified, and to test correlations to environmental changes which may have acted as evolutionary drivers. However, prior to the Phanerozoic adoption of biomineralisation, we are reliant on unusual sedimentary conditions that fossilised decay-prone organisms. Consequently, fossils that describe the rise of complex life are rare. In fact, the fossil record of early eukaryotes that can be allied to modern groups, with the exception of one fossil species, is younger than 800 million years old, much younger than genetic estimates for their ages.

The relatively unexplored ~950 million-year-old Veteranen Group of Svalbard, therefore, contains sedimentary rocks of the right age to fill a critical gap in our understanding of early eukaryotic evolution. Although preliminary studies showed its strata to be fossiliferous, much of the stratigraphy remains unexplored (Knoll 1982, Knoll and Swett 1985). Adjacent strata have proved some of the most fossiliferous in the Proterozoic Eon (Butterfield et al. 1994), emphasizing the potential of the Veteranen Group for new discoveries.

This PhD will focus on the palaeontology of the succession, revealing new fossils that will give an insight onto the nascent eukaryotic world. Existing collaborations with geologists at Dartmouth and Yale universities will provide a wealth of geological information on the contextual palaeoenvironment. This will allow hypotheses relating Tonian environmental changes and early eukaryotic evolution to be tested.

Timeline

Year 1: Training in geochemical methods such as XRD, and in fossil extraction and identification. Sample acquisition and mineralogical analyses to determine horizons best suited to fossil preservation.

Years 2 and 3: Sample analysis via fossil extraction and examination.

Year 4: Data integration, thesis completion, papers for international journals/conference presentation.

Training & Skills

This project will provide the student with an interdisciplinary skillset in sedimentary geology and palaeontology. A significant portion of the project will be lab-based, where the primary skills acquired will by those of microfossil extraction and examination. The student will also become familiar with the use of a raft of state-of-the-art geochemical techniques currently employed in geobiology (e.g., XRD, SEM-EDS). The supervisor has recently shown a mineralogical signature for the sediments most conducive to the fossilisation of non-mineralised organisms (Anderson et al. 2018). This mineralogical signature provides a vital new toolkit for identifying those sedimentary horizons most likely to preserve these rare early fossils. Fieldwork in Svalbard is also possible subject to funding, and the student would be encouraged to present their research at major international conferences (e.g., PalAss, GSA).

References & Further Reading

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Further Information

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