NASA Astrobiology Early Career Collaboration Award Report

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Collaborators:

- Prof. Andrew Czaja (Masters advisor) Assistant Professor, University of Cincinnati, Department of Geology
- Dr. Kenneth Williford, Astrobiogeochemistry Lab, NASA Jet Propulsion Laboratory (JPL)
- Prof. John Valley, Wisconsin Secondary Ion Mass Spectrometer Laboratory (WiscSIMS), University of Wisconsin–Madison

Fossils of sulfur-oxidizing bacteria were recently discovered from black cherts in the Neoarchean (~2.52 Ga) Gamohaan Formation of South Africa, and bulk organic carbon isotope measurements were made for rocks of the same unit as part of my Masters research at the University of Cincinnati with Prof. Andrew Czaja. To gain a more detailed understanding of the paleoecology of this ancient microbial ecosystem, we proposed to investigate the preservation and distribution of stable isotopes, particularly that of carbon and sulfur, at high-resolution using secondary ion mass spectrometry (SIMS). This technique has become an invaluable tool for acquiring detailed isotopic measurements on the scale of individual microfossils.

Preparing samples of Precambrian rocks for analyses via SIMS is an extensive and highly specialized process. For the purposes of this study, sample preparation was performed in collaboration with Dr. Kenneth Williford at the Jet Propulsion Laboratory (JPL) in Pasadena, CA. Thin sections were first cut, polished, and surveyed for microfossils and pyrite grains that are adequately exposed at the surface of the thin section, and are therefore appropriate for analysis with the SIMS instrument. After cleaning the thin sections to remove any contaminants, fossils and grains selected for analysis were imaged using transmitted and reflected light microscopy at increasing magnifications, and their coordinates documented so that the target area could be readily located under the SIMS microscope. In addition, it proved useful to image the samples via scanning electron microscopy (SEM) and to perform high-resolution elemental analyses using energy dispersive X-ray spectroscopy (EDS) to assess fine-scale features, and to confirm the presence of surface-exposed carbon and sulfur.

Following sample preparation at JPL, the samples were delivered to Prof. John Valley at the University of Wisconsin-Madison. There, over the course of two separate analytical sessions in the WiscSIMS Lab, I measured the composition of carbon isotopes ($\delta^{13}C$) within individual organic-walled microfossils and sulfur isotopes ($\delta^{34}S$) in sedimentary pyrite grains. Our results revealed significant isotopic heterogeneity on relatively small spatial scales within chert samples from the Gamohaan Formation. Such variability is often indicative of active biogeochemical cycling of carbon and sulfur within the ecosystem, and may potentially reveal specific microbial metabolisms (e.g., carbon-fixation pathways, sulfide-oxidation, etc.) as significant components of this early microbial community. Findings from this project are currently being prepared for publication.

This collaboration effort was very worthwhile and rewarding, both scientifically and personally. The opportunity to meet and work directly with experts in my field of interest not only expanded my breadth of networking and communication, but also my depth of knowledge in several areas. Specifically, I was able to gain hands-on experience applying instruments such as SEM and SIMS to problems encountered in Precambrian paleobiology, and to understand how aspects of stable isotope geochemistry can be used to address questions concerning the evolution of Earth's early microbial biosphere. I am extremely grateful for receiving the NASA Astrobiology Early Career Collaboration Award, and I am confident this opportunity will continue to promote scientific collaboration in my future research. Working with Dr. Williford and Prof. Valley has certainly been a remarkable highlight of my graduate education, and I greatly appreciate their generous support.