Benjamin W JOHNSON Report rcvd. 8.24.18
Lewis and Clark Fund for Exploration and Field research in Astrobiology

PALEOARCHEAN SEAWATER TEMPERATURE, NUTRIENT LEVELS, AND DEPTH: RECONSTRUCTION FROM ALTERED OCEANIC CRUST IN THE PILBARA CRATON
Project Report.

The Lewis and Clark Grant awarded to Benjamin W Johnson (BWJ) was used for exploration, sampling, and travel to the Pilbara Craton, Australia, from July 15-August 7, 2018. The main purpose of this field work was to sample sections of 3.2 billion-year old altered ocean crust to use as a repository for ancient seawater chemistry. I also had two goals before the trip, namely sampling granites in the area for apatite thermochronology and for nitrogen analysis. In addition, another project, characterizing a dolomite dike, emerged during the trip. In this report, I will first review the motivation for the field work, then I will provide a narrative of the work and field excursion.

Specifically, I spent time in the Panorama VMS District (S 21.20741667, E 119.2387667) sampling the Kangaroo Caves Formation and Strelley Granite. I was able to, with the help of others listed below, familiarize myself with the area, which is one of the best-preserved hydrothermal systems anywhere on the planet. Seeing the way this extremely interesting and important process for life on Earth is preserved in the rock record will help me interpret new data I gather.

Indeed, the entire excursion was extremely enlightening from an astrobiologic perspective. The Archean Earth, recorded in the Pilbara, was a world markedly different on its surface than today. The conditions under which early life arose and expanded was fully without atmospheric oxygen, perhaps had fewer continents, and orbited around a dimmer Sun. If life on other worlds follows the same emergence pattern as on Earth, it is this time period we must understand.

Thus, sampling the Panorama district will give us insight into this fascinating time in Earth history. Using altered ocean crust as a record of seawater chemistry opens up a whole new area to investigate life on the early Earth, which has direct implications for astrobiology. In addition, the interaction of water with the basaltic ocean crust is a process that occurs on many different worlds, and the way it transports nutrients and other elements to and from the ocean is critical for life.

The field season was a great success. I was able to work with a diverse group of scientists, including professors (Dr. Eva Stueken), research scientists (Dr. David Flannery), graduate students (Jana Meixnerova, Jordan Todes), and local Australian geologists (Dr. Carl Brauhart, Dr. Margaret Hawke, Jonathan Schneider).

In particular, the Australian geologists were a great help and central to the work. In particular, Dr. Brauhart provided a ton of field gear, knowledge of the tracks and roas, and great humor. Indeed, by collaborating with the Australian geologists, we were much more successful this season than otherwise might have been.

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We flew into Perth, and rented a mine-spec Toyota Hilux. After two days of driving we arrived in Marble Bar. This was a central location for the first phase of field work. We spent time granite-hunting. My collaborator, Eva Stueken, collected a number of Archean granites to measure N in them. Nitrogen is an important element for life, but its long-term and geologic cycle is not well known. The way geology affects nutrients is really important for life on Earth and other worlds. I was able to collect granites as well for thermochronology.

The evolution of the land surface in the Pilbara is poorly known. Having undeformed, ancient rocks so close to the surface for many billions of years provides a unique geologic environment, one that is important for life in Australia but also how continents weather and release nutrients into the ocean. By collaboration with Dr. Rebecca Flowers at CU-Boulder, we will be able to characterize the uplift and erosion history of the Pilbara in a way that has not been done before.

We spent most nights camped in dry, sandy river beds, with occasional forays into spinifex-infested rocky plains. Having a large crew meant we had ample room for food, water, gear, and supplies. Camp was comfortable every night, and we were able to gather wood and cook over a fire for both dinner and breakfast.

The second half of the trip we were in and around the North Pole dome (S 21.078302, E 119.348931) and Panorama VMS district, to the north and west of Marble Bar. Here we were greeted by Jeff and Fay, caretakers of the Normay Minesite. They operate a small bunkhouse and keep historic mining equipment in operation, including a massive bulldozer from the 1950s.

Here, we spent a few nights camped in the Shaw river, and alternated between the Dresser Formation, looking into basalt alteration and ancient stromatolites, and slightly younger Strelley Pool Stromatolites, among the best preserved, accepted biologic fossils on Earth. Seeing the environment in which early life thrived, on a regional scale, was transformative. These shallow water, volcanically influenced environments must be telling us something about the world viable for life.

I was able to sample a number of Dresser formation basalts, to analyze and help constrain Archean seawater composition. This was an unexpected opportunity to complement the planned sampling at Panorama, but the outcrop and sample quality in the area were both great quality.

We then drove along well-maintained mining roads into the Panorama area, where we were guided to key outcrops by Carl Brauhart. While the sampling time was somewhat shorter than I originally anticipated, I was able to get a good collection of extrusive volcanics and intrusive granites. One of the highlights of this part of the trip was a day travelling deep into the Strelley

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Granite, the heat engine that drove hydrothermal circulation in the area. The granite is full of interesting geology/mineralogy, including a molybdenite-bearing vein, which could be an analogue for molybdenum sources to the Archean Earth.

While the majority of the trip was very successful, there were some lessons to be learned. Most of these relate to organization and managing expectations. While the size of the group (nine at most) made some aspects of camping easier, the size and differing goals of the participants made some practical day-to-day operations more difficult. In the future, establishing a clearer leadership structure, and insisting on a more organized communication structure would be a great help. While we were lucky that everyone on the trip got along, making a clearer system of organizing gear, food, and plans would have made things run more smoothly.

I ended up bringing back of 60 kg of samples, and these should provide the basis for not only my current postdoctoral research, but for future projects of my own and students. My first explorations into the Archean Earth were fascinating, and strengthened resolve in astrobiology.

Below are a few pictures, the first is of stromatolites from Strelley Pool, the second a view of pillow basalts from Panoama, and the third a view of the Panorama area. The pocketknife in the photos is 8 cm long.

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