2022 NASA Astrobiology Early Career Collaboration Award Report

# Scanning Electron Microscopy & Elemental Mapping of Antarctic Carbonate Structures from an Ephemeral Stream

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Collaborators: Dr. Erica Barlow and Dr. Georgia Soares, Pennsylvania State University

## Research Background

Antarctic carbonate rock coatings recently found in an ephemeral stream of the McMurdo Dry Valleys resemble hot spring silica sinters, often used as analogs to early life on Earth and to potential life on Mars. I am determining the mineralogy, morphology, and texture of these newly-discovered Antarctic digitate rock coatings to create a foundation for understanding their formation processes. Characterizing these Antarctic structures will inform the range of environmental conditions necessary for creating these types of morphologies and preserving *in situ* biosignatures both on Earth and Mars.

At Penn State University, I planned to work with Dr. Erica Barlow and Dr. Georgia Soares for two weeks, using Environmental Scanning Electron Microscopy (ESEM) and energy dispersive x-ray spectroscopy (EDS) to determine compositional changes between laminae, describe detrital inclusions and infilling fractures, and characterize any potential microfossils present in my samples. The week before my planned visit, I received notification that the ESEM at Penn State was down and was not going to be fixed by the following week. We were unable to reschedule my trip due to logistical constraints and previously scheduled commitments, so we chose to proceed anyway. Despite this setback, I worked with Drs. Barlow and Soares to use other instrumentation affiliated with the LionChron Facility and with Prof. Jennifer Macalady's lab in the Department of Geosciences to conduct petrographic analyses of my thin sections. We used a *Zeiss AxioScan.Z1* fully-automated slide scanner to create high resolution images of entire thin sections for contextual characterization (**Fig. 1**). We then used a *Zeiss AxioImager.A2m* petrographic microscope with a digital camera system to finely characterize laminae, detrital inclusions, infilling fractures, potential microfossils, and various other types of textures in plane polarized, cross polarized, and reflected light. After identifying potential microfossils and other potential organic material in the thin sections, we used an Echo Revolve fluorescence microscope to capture any fluorescence within the samples (**Fig. 2**). While I was unable to perform part of my work as originally proposed, Drs. Barlow and Soares ensured my visit was successful, and I received training and results equally important as the ones I sought to achieve.

## Objectives Achieved

I obtained valuable experience working with both Dr. Barlow and Dr. Soares. I gained intimate knowledge of my samples at the microscale and learned how to characterize various features and morphologies throughout my thin sections. I also learned how to create

publication-quality images and carefully interpret the potential processes that created these structures. While the data we collected opened more doors than it did answer questions, I realized how unique these structures are and how difficult it is to find and interpret features indicative of certain processes in modern carbonate rocks, let alone ancient ones. Drs. Barlow and Soares challenged me to think about the processes that could have formed these structures from a range of perspectives, and ultimately, every conversation with them taught me how to begin to interpret various processes from the specific textures we were seeing. For example, with regards to microfossils we found, Dr. Barlow taught me how to best identify them using specific criteria, and we talked extensively about biotic, abiotic, and ambiguous signatures of life in the rock record. Additionally, in preparation for using the SEM, Dr. Soares taught me how to polish and etch billets to reveal microfossils in carbonate rocks, which I can now do back at my home institution, Northern Arizona University. Most importantly, both Dr. Barlow and Dr. Soares helped me focus this broad, overwhelming project into a cohesive chapter of my dissertation and a first step towards being able to assess the processes driving the formation of these unique structures.

**Future Work**

While I was unable to get the ESEM imaging and elemental mapping as originally planned, Drs. Barlow and Soares helped me realize that I have enough data to begin writing this chapter of my dissertation, which was a goal of working with them. I may still need to do some additional SEM and EDS analysis back at Northern Arizona University, but I now realize this is not absolutely necessary to achieve the outcomes of this project. Overall, Drs. Barlow and Soares not only acted as scientific collaborators but also as mentors in this experience. I am truly grateful to them both for teaching me how to identify the boundaries of content for scientific publications and validating the work I did before and during our time together.

Outside of the conclusion of this project, my work with Dr. Barlow and Dr. Soares marks the beginning of our collaborative relationship. Through the discussion of the data, lots of interesting work remains to fully understand the processes driving the formation of these Antarctic laminated carbonate rock coatings. Our passion and excitement for this project is evident, and we discussed the types of future analyses that can be conducted on these samples. The ability to work with both of them in person also strengthened the relationship we had prior to this experience, and I am hugely grateful to have future collaborative partners beyond this project.

**Acknowledgements**

The NASA Astrobiology Early Career Collaboration Award provided me with a unique opportunity to work with experts in my field and gain skills I would not have developed without it. Despite setbacks to the project, it was a hugely rewarding experience to work with Drs. Barlow and Soares as well as being included in Prof. Christopher House's lab group for the time I was at Penn State. Special thanks to Dr. Joshua Garber for his support in using the *Zeiss*

*AxioScan* and *AxioImager* instruments and to PhD student Roger Ort for imaging my samples using the Echo Revolve fluorescence microscope in Prof. Macalady's lab. Thanks also to Angeline Kumar at NASA Ames Research Center for scheduling my flights to and from Penn State. Lastly, a big thanks to Dr. Melissa Kirven-Brooks at NASA Ames Research Center for her continued support throughout the duration of the award. I am so thankful to the NASA Astrobiology Program for making this collaborative work possible and for supporting me in my research endeavors.

**Figure 1:** Thin sections being prepared for imaging using the *Zeiss AxioScan.Z1* fully-automated slide scanner (left). PhD candidate Schuyler Borges using the slide scanner software to prepare samples for imaging (middle). Image of a thin section from the *Zeiss AxioScan.Z1* fully-automated slide scanner (right).

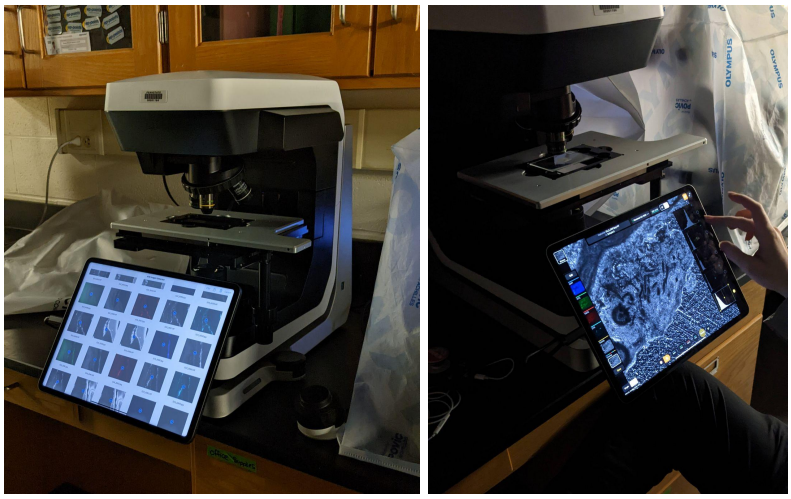

**Figure 2:** The Echo Revolve fluorescence microscope with images from thin sections (left). PhD student Roger Ort taking a picture of microfossils in our samples using the Echo Revolve fluorescence microscope (right).