BIOAVAILABILITY OF MINERAL-BOUND IRON TO A SNOW ALGAE COMMUNITY AND IMPLICATIONS FOR LIFE IN EXTREME ENVIRONMENTS. Z.R. Harrold[1], E.M. Hausrath[1], C.L. Bartlett[1], A.H. Garcia[1], O. Tschauner[1], A.E. Murray[2], J. Raymond[3] [1]University of Nevada, Las Vegas, Department of Geoscience, 4505 S. Maryland Pkwy, Las Vegas, NV 89154. [2]Desert Research Institute 2215 Raggio Parkway Reno, NV 89512, [3]University of Nevada, Las Vegas, School of Life Sciences, 4505 S. Maryland Pkwy., Las Vegas, NV 89154.

Introduction: Earth's icy environments are known to harbor a diverse array of life spanning all three domains: bacteria, archaea and eukaryotes [e.g. *1, 2, 3*]. Icy planets and moons such as Mars, Enceladus and Europa are therefore of particular interest in the search for life beyond Earth. Microbial inhabitants face numerous challenges in these icy environments, including desiccation, low temperatures and nutrient limitations. In order to select, detect and interpret astrobiological mission targets on icy worlds, it is imperative to first understand how microbial communities survive in, interact with and influence these cold environments.

On the snow surface, communities of algae and bacteria "bloom" during seasonal snowmelt [*2*]. While algae provide a primary production pathway within the microbial community, their productivity is at least partially reliant on acquiring sufficient micronutrients. Iron in particular plays a key role in photosynthesis and respiration among other cell functions [*4*]. Iron deficiencies can also inhibit algal cell division and induce chlorosis [*4*].

Deficiencies in nutrients such as iron limit snow algae growth and development in the oligotrophic snow environment [*5-7*]. Aeolian dust and detritus provide the most abundant source of iron on the snow surface and within the snow pack. Direct alga-mineral contact in snow has been suggested to play a role in micronutrient acquisition by algae [e.g. *8, 9*]. In iron-deficient oligotrophic marine environments, some algae appear to acquire iron through a symbiotic relationship with bacteria [*10*]. Numerous questions remain, however, regarding how and where snow algae acquire sufficient iron to support snow surface blooms.

In this work we investigate algae-mineral interactions and their role in iron acquisition via both field and laboratory studies. Special focus is given to testing (1) the ability of a xenic culture of the snow alga *Chloromonas brevispina* to utilize nontronite, an iron clay, as a primary iron source, (2) the mechanism of iron acquisition, and (3) the effect of snow surface communities on mineral dissolution and secondary precipitate formation.

Methods: Mineral, snow algae and soil samples were collected from snow pits and surface blooms in January through May, 2015 at Mount Anderson Ridge, CA. Some samples were stained with DAPI while others were freeze-dried and analyzed by scanning electron microscopy (SEM), synchrotron X-ray diffraction (XRD) and synchrotron X-ray fluorescence (XRF).

Xenic cultures of *C. brevispina* were grown in a modified M1 medium [*11*] containing aqueous iron (Fe-EDTA), mineral-bound iron (nontronite) or iron deficient M1. Each condition was performed in duplicate. Cultures were incubated in polypropylene flasks at 4 ºC under a T5 High 1 bulk output fluorescent grow light. Samples were collected for cell counting.

Results and Discussion: SEM images from field samples show alga closely associated or in direct contact with minerals and particulates in the snow pack and on the snow surface (Figure 1). Synchrotron-XRD and XRF analysis of the minerals reveal high Fe concentrations. DAPI-stained samples further indicate alga-bacteria associations including bacteria directly adhered to the alga surface. Together these observations indicate alga-bacterial-mineral clustering occurs in snow surface environments. The close association of Fe-rich minerals and algae-bacterial clusters further suggests these minerals serve as a micronutrient source in snow surface communities. The direct association of algae and bacteria is also suggestive of an algae-bacteria symbiosis that may play a role in iron acquisition.

We tested the ability of a xenic *C. brevispina* culture to obtain mineral-bound iron from nontronite. Preliminary results indicate cultures incubated with nontronite achieved higher cell concentrations compared to *C. brevispina* grown in the modified M1 medium.

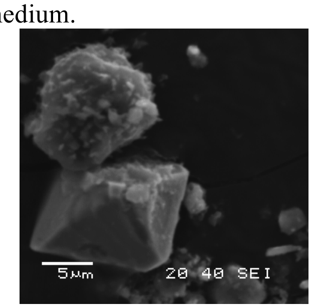

Figure 1 SEM image (15 kV) of a lyophilized snow algae (top) covered in particles, likely both bacteria and minerals, and magnetite (bottom) collected from Mount Anderson Ridge, CA

Conclusions: Laboratory results show cultures of *C. brevispina* and the accompanying bacterial consortia are capable of obtaining iron from nontronite. Observations from the field further suggest that iron-bearing minerals are an important source of micronutrients for snow algae-bacterial communities. Future work will probe the mechanisms of iron uptake and role of bacteria-algae interactions.

References:

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