INTERACTIONS OF SNOW ALGAE, MICROORGANISMS AND MINERALS IN SNOWY MARS-ANALOG ENVIRONMENTS PROVIDE POTENTIAL ELEMENTAL AND MINERALOGICAL BIOSIGNATURES

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Introduction: Biological activity such as the release of organic acids can form important biosignatures used to interpret paleoenvironments on Earth. These biosignatures include changes in elemental composition and mineralogy, which can persist for long time periods allowing future detection. In laboratory experiments, for example, direct microbial extraction of elements from minerals has been documented [1] which can form elemental biosignatures. Organic acids secreted by organisms or produced by cell lysis can also result in elemental signatures [2], and Fe and P are examples of such elemental biosignatures observed in terrestrial paleosols [3]. Analyses of serpentinite- and diabase-derived soils also indicate that organic acid production by Fe-oxidizing bacteria at the rock: soil interface may generate elemental biosignatures [4, 5].

Differences in solution chemistry, mineral composition and temperature on Earth and Mars can impact the interpretation of such elemental and mineralogical biosignatures. Early Mars received more abundant organic carbon from meteorites and interplanetary dust particles than did early Earth [6]. These organic compounds can impact elemental mobility [7], which, together with differences in dissolution of phosphate minerals [8], can affect the interpretation of potential P biosignatures. Mars also has much less available water than Earth, resulting in high salinity brines, which can slow dissolution [9-12] and precipitate salts such as anhydrite [10]. Much of the water present on Mars today also occurs in polar ice caps. Potential elemental and mineral changes occurring due to biota-mineral interactions in such cold environments are therefore needed to understand potential biosignatures on Mars.

Investigating biosignature formation in snowy Mars-analog environments:

In order to investigate potential biosignatures formed under Mars-relevant cold, water- and nutrient-limited conditions, we are examining interactions between snow algae, microorganisms and minerals in both field environments and laboratory experiments. Snow, dust, snow algae and microorganisms were sampled from our field area on Mount Anderson Ridge, CA. Samples were density separated to isolate snow algae and particles strongly attached to the snow algae surfaces from bulk dust present in the snow. Synchrotron microXRF of algae-attached particles indicate that they are Fe-rich and may therefore be an important micronutrient source. Laboratory experiments growing the xenic snow algae culture *C. brevispina* with Fe-rich minerals show close association between the minerals and the snow algae (Figure 1) and enhanced growth of cultures in the presence of the minerals. Importantly, secondary Fe precipitates were also observed by synchrotron microXRD in minerals in the presence of snow algae cultures that were not present in minerals in abiotic controls, indicating the potential for Fe-rich mineral biosignatures. Ongoing and future work includes experiments, analyses, and field work to better understand potential elemental and mineral biosignatures, their presence in terrestrial field environments, and their potential detection on Mars.

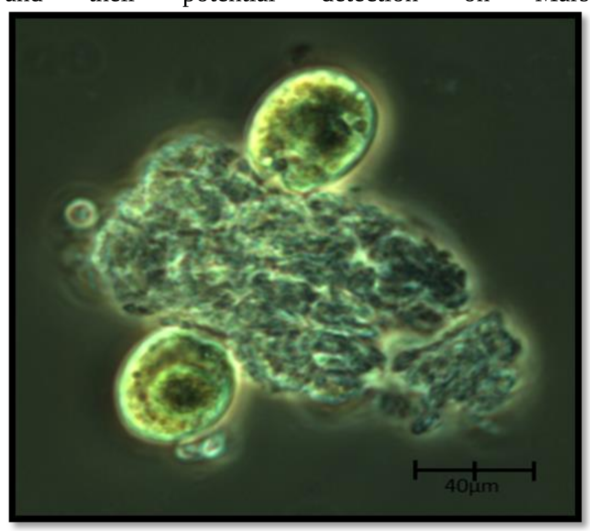

Figure 1. *Optical image of C. brevispina and the Fe-rich mineral nontronite showing close association of the snow algae with the mineral surfaces.*

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