CHARACTERIZATION OF SULFUR-RICH MATERIALS IN SUPRAGLACIAL ICINGS AT BORUP FIORD PASS, CANADIAN HIGH ARCTIC.

G. E. Lau[1], C. B. Trivedi[2], S. E. Grasby[3], J. R. Spear[2], and A. S. Templeton[1], [1]University of Colorado Boulder (2200 Colorado Ave., Boulder, CO 80309; astrobiologist3@gmail.com, alexis.templeton@colorado.edu), [2]Colorado School of Mines (1500 Illinois St., Golden, CO 80401; ctrivedi@mines.edu, jspear@mines.edu), [3]Geological Survey of Canada - Calgary (3303 33 Street Northwest, Calgary, AB, Canada; steve.grasby@nrcan-rncan-gc-ca).

Introduction: Sulfur is one of the most ubiquitous elements in the universe and one of the most crucial for life's building blocks. Characterizing the geochemical and biological processes of sulfur cycling, as well as the biosignatures produced from such processes, in modern terrestrial environments aids in the search for life beyond our planet. Borup Fiord Pass, on Ellesmere Island in the Canadian High Arctic, provides a unique glacial environment dominated by the chemistry of sulfur. In this system, hypothesized microbial cycling of sulfur in fluids that circulate in the subsurface appears to connect to surface processes through sulfur springs that form large icing structures and sulfur mineral deposits on the toe of the glacier [1].

The connection of subsurface and surface processes at this glacial site makes Borup Fiord Pass an ideal analogue for our future astrobiological investigations of Europa, especially in regions where fluid or ice derived from the subsurface ocean may have been in contact with the surface. In addition, alteration features in the proglacial region of Borup Fiord Pass may provide targets for understanding ancient spring activity on the surface of Mars. The features, termed paleopipes [2], appear as concentric structures composed primarily of gypsum hosted within carbonate rock that may represent ancient expressions of the sulfur spring system.

Our research seeks to characterize the geochemistry and biosignature inventory within the ice plumes and other materials from Borup Fiord Pass. We are in the process of determining the speciation of sulfate salts, zero-valent sulfur, and polysulfides within the ice that dynamically freezes and melts at the glacial interface. We will pair the speciation of sulfur in the icy materials with microbial communities and biological processes within the subglacial and supraglacial system as determined through marker gene and metagenome sequencing.

Current Work: In the summer of 2014, our team traveled to Borup Fiord Pass to assay the sulfur spring system and to collect samples for laboratory analysis. Sulfide within ice and fluid samples from the field site was determined through zinc sulfide precipitation. The concentrations of sulfide within the ice (up to 3.9 mM) were almost as high as the maximal value previously reported for the active springs (4.2 mM, [3]).

FE-SEM/EDXS has been used for high-resolution imaging and elemental analysis of 2014 samples. Elemental sulfur formed on bubbles of hydrogen sulfide within melt pools from the icing appear as aggregations of nanospheres which form larger globules. We hypothesize that polysulfides play an important role in the formation of these elemental sulfur deposits and potentially in biological sulfur metabolisms within the deposits. The application of cyclic voltammetry will allow us to characterize the concentrations of polysulfides in these samples as well as to dynamically capture the process of elemental sulfur formation in thawing ice and within microbial culture samples. Also, the speciation of zero-valent sulfur within polysulfide, elemental sulfur, and polythionates pools will be assessed. From this approach we will determine the role that polysulfides and other carriers of zero-valent sulfur play in biological and abiotic transformations of sulfur at this site.

We are using synchrotron-based μXRF mapping and μXANES analysis to characterize variations in sulfur speciation at the microscale, especially within the paleopipe materials. Previous investigations of paleopipe samples with μXRF/μXANES appear to show that sulfide, elemental sulfur, and sulfate coexist within microscale regions of the paleopipes. Also, organosulfur spatially related with elemental sulfur has been observed in these materials. Our current work seeks to confirm and expand upon this finding, which may show that the paleopipes have a unique history of formation through biological activity.

Our sequencing work thus far has included barcoded next-generation sequencing of 16S rRNA on the Illumina MiSeq platform. Capturing the microbial community dynamics within the samples we are characterizing will build upon our model of biological processes occurring at Borup Fiord Pass. Pairing the chemistry of materials at this site with known biological processes will aid in our future astrobiological investigations of Mars and Europa.

References:

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