$\delta^{13}C$ and $\delta^{15}N$ Stable Isotope Evidence for Dynamic Diagenetic Climate Coupling in a Rosickyte Mars Analogue Microbial Community. R. Archer[1,2] and A. Ralat[3], University of Colorado at Denver, NASA Ames, [3]ARRA Environmental.

Introduction: The discovery of the presence of a potential microbially mediated biosignature (rosickyite) from Bad Water Basin, California, by Douglas and Yang [1] invited the proposal that rosickyite may be stable over geological timescales and if found on Mars, indicate past life. We resampled this same location thirteen (13) years later to test the hypothesis of rosickyite as a robust biosignature over the decadal scale [2] detectable by bulk powder XRD and to again examine both the $\delta^{13}C$ and $\delta^{15}N$ stable isotope profile and pore water pH. Isotopic $\delta^{13}C$ and $\delta^{15}N$ profiles, and pH pore water analysis from the same 2002 microbial mat as Douglas and Yang (*ibid*) indicated bulk primary production consistent with nitrogen fixation in the upper canopy driving downcore biogeochemistry. In this study, we explore modeling $\delta^{13}C$ and $\delta^{15}N$ isotopic results and mineral diagenesis as a localized expression of planetary scale climate variability and its implications for MSR mission biosignature false negatives..

Results In contrast to findings of 2002, XRD results from 2015 failed to find evidence of rosickyite within bulk powder XRD signals, while scanning electron microscopy (SEM) determined the presence of filamentous sulfur in the presence of organic compounds. Nitrogen fractionation was modeled as a piecewise function where both data sets, recovered from the same location but separated by fourteen (14) years. Base $\delta^{15}N$ values for both years was 2.62‰ $^{+/-}$0.02 at 8.6cm $^{+/-}$0.3. Overlying diffusion between ~1cm to ~8.6cm follows the function y= -0.23+2.64*log(x) in 2002 (R^2=0.65), and, alternately, as y= 3.52-0.87*log(x) in 2015 (R^2=0.88). Photosynthesis zone endmember behavior for both 2002 and 2015 was complex. Downcore pH varied (4.21 to 7.92 pH) within initial 2.5cm. Lowered pH as a function of cell death was ruled out. Cell viability was in excess of 90% throughout. Isotopic $\delta^{34}S$ varied between 18.16‰ and 20.89‰ $^{+/-}$0.02, consistent with modern $\delta^{34}S$ seawater values. Sulfur $\delta^{34}S$ is both mass dependent (y=17.425+3.5027log(x), R^2= 0.89) and depth dependent (y= 0.036+0.023*x-0.0016*x^2, R^2=0.98). Canopy values for $\delta^{13}C$ were similar between 2002 and 2015, (-15.22‰ and -14.31‰) conversely 2015 average $\delta^{13}C$ depth values were heavier, relative to 2002 by approximately 3‰. Ratios of carbon to nitrogen (C:N) are outside of expected Redfield ratios (6.625). Complimenting these results, C:N values as a function of depth may be modeled as y= 13.404-2.14$x^{0.1922}$ (R^2= 0.96).

Conclusion: Isotopic $\delta^{15}N$ and $\delta^{13}C$ suggest local ecosystem oscillation to external forcing, possibly due to hydrological reorganization associated with both the PDO and ENSO. No robust XRD signal was found for the same sampling location as 2015. We propose that any 2015 rosickyite present may exist below detectable MSL ChemMin (Terra) XRD thresholds. SEM results were inconclusive. Work by Cosmodis and Templeton (2016) suggests that filaments such as those found in our study may indicate C/S abiotic interaction leading to "self-assembly of biogenic-like materials" (4) but should not be assumed to have formed biologically (*ibid*). In this study, 2015 $\delta^{13}C$ and $\delta^{15}N$ stable isotope results together with pH and together with new $\delta^{34}S$ results indicated a shift in metabolic regimes in the presence of sulfate reduction. We hypothesize that net dissolution of previously present rosickyte is associated with carbon burial and associated microbially mediated diagenesis. Implications for these results are two-fold. The first implication is that terrestrial Mars analogues are dynamic systems warranting continuous sampling over changing stressors such as periods of protracted drought [3]. Secondly, rosickyte appears to be particularly vulnerable to post depositional diagenesis as a local expression of global hydrological variation, including at geological timescales, both on Earth as well as on Mars, leading to biosignature false negatives. .

References:

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