

Distinguishing microbial mat formed Mg carbonate from weathering formed Mg carbonate using dual clumped isotopes and fluorescence microscopy

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A major goal of Mar's Perseverance rover is to collect Martian carbonate samples – which are primarily Mg and Fe carbonates [1] – for eventual return to Earth [2]. Thus, it is crucial to develop a framework to assess whether microbial life is involved in Mg carbonate precipitation on Earth and Mars. We collected both “biogenic” (forming within microbial mats) and “abiotic” (forming from ultramafic bedrock weathering) Mg carbonate from lake and playa basins in Atlin and the Caribou plateau in British Columbia. We characterized the facies and measured the $\Delta_{47}\text{-}\Delta_{48}$ values of both types of Mg carbonate. For the microbial facies, we used fluorescently labelled thin sections [3] to evaluate the life positions of cells and associated microbialite textures. We hypothesized that the microbial carbonate facies would have $\Delta_{47}\text{-}\Delta_{48}$ disequilibrium signatures due to microbial perturbation of the dissolved inorganic carbon system and resulting kinetic isotope effects [4], but that the abiotic facies would have $\Delta_{47}\text{-}\Delta_{48}$ values that resemble equilibrium due to the slow kinetics of the weathering reactions. We found that the $\Delta_{47}\text{-}\Delta_{48}$ values of the microbial carbonate facies have disequilibrated values in the $-\Delta_{47}/+\Delta_{48}$ direction in the surface microbial mats, but values moved toward the $\Delta_{47}\text{-}\Delta_{48}$ equilibrium line with ~5-15 cm burial in sediment. By comparing the microbial carbonate facies to the abiotically formed carbonate, we will determine whether dual-clumped isotopes paired with fluorescence microscopy can distinguish biogenicity of Mg carbonate minerals.

[1] Scheller, E. L. *et al.* Aqueous alteration processes in Jezero crater, Mars—implications for organic geochemistry. *Science* **378**, (2022)

[2] Williford, K. H. *et al.* Chapter 11 - The NASA Mars 2020 Rover Mission and the Search for Extraterrestrial Life. in *From Habitability to Life on Mars* (eds. Cabrol, N. A. & Grin, E. A.) 275–308 (Elsevier, 2018)

[3] Cassady, V., Petryshyn, V., Bernhard, J., Hofmann, F., Berelson, W., Cooperdock, E., & Corsetti, F. (2022, May 17). Examining Microbial Influence on Microbialite Texture Formation, Little Hot Creek, CA. AbSciCon

[4] Ingalls, M., Leapaldt, H. C., & Lloyd, M. K. (2024). Microbial Autotrophy Recorded by Carbonate Dual Clumped Isotope Disequilibrium. *Geochemistry, Geophysics, Geosystems*, 25(6), e2024GC011590