Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.18486

Studying habitability and biosignatures formation in laboratory-simulated martian environments

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Evidence indicates that Mars harboured fluvial-lacustrine environments that may have been habitable for life. On Earth, microbial communities isolated from analogue sites can be used to study this putative habitability; for example, the microbial community from the terrestrial anoxic inter-tidal zone (e.g., the Dee Estuary, UK), which contains taxa associated with chemolithoautotrophic and chemoorganoheterotrophic metabolisms. By utilising these microorganisms in laboratory-controlled experiments it is possible to study habitability and the formation of biosignatures, which can be used as evidence of life. For this, a simulated environment is developed, which mimics the physicochemical conditions predicted for the ancient fluvial-lacustrine environments based on mineralogical and geochemical observations. For example, we have previously studied the Rocknest sand shadow at Gale Crater. A regolith simulant was developed (within 3% variation in elemental abundance based on ground-truth data), and a groundwater fluid chemistry was thermochemically modelled based on the regolith chemistry. The simulated environment was inoculated with the analogue community (sub-culturing was repeated seven times to ensure that the community was solely able to grow on the defined, simulated chemistry). The sub-culturing resulted in a reduction in microbial abundance and diversity. Microorganisms associated with sulfate reduction, acetogenesis and fermentation dominated the final community. To study the formation of inorganic biosignature formation, an abiotic control was run in parallel. However, from these experiments alone, it was difficult to predict over geological timescales whether these changes were exclusively caused biotically. For this, thermochemical modelling is needed to predict the alteration minerals produced under abiotic conditions to single out the signatures that could be used as biosignatures for life detection missions. Preliminary results based on the Rocknest sand chemical composition suggested that, in a martian fluvial-lacustrine setting, biological activity may promote the formation of a secondary mineral assemblage composed of chlorite, quartz and variable amounts of celadonite.