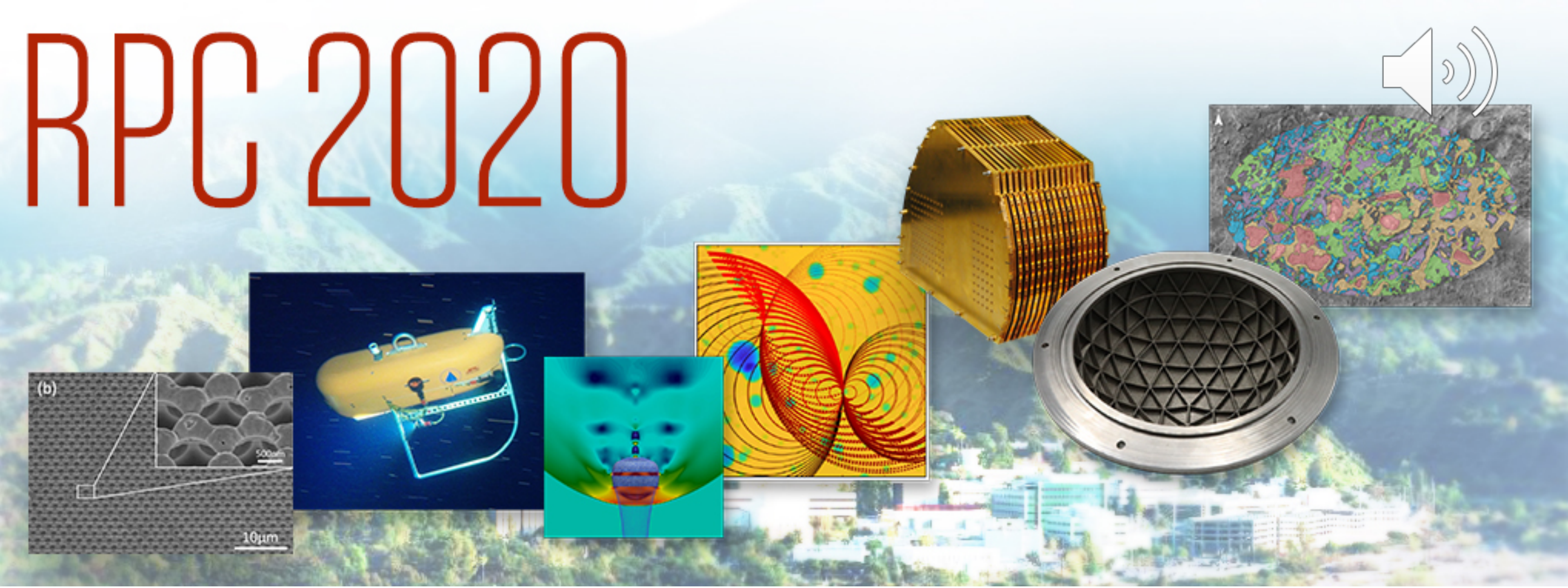

Virtual Research Presentation Conference

Experimental Constraints on Groundwater Driven Redox Gradients on Mars

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Program: Strategic Initiative

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Tutorial Introduction

Abstract

The martian subsurface has moved to the forefront in the search for martian habitable environments because it could harbor all the ingredients necessary for a microbial biosphere: groundwater rich in cations, an energy source, and protection from radiation. Although we have observed evidence of groundwater environments across the surface of Mars, the connectivity of these environments to the surface is poorly understood. The objective of this work is to answer a specific question about these connections, namely **"Did Mars have a way to abiotically move nitrogen between groundwater/surface reservoirs, establishing a primitive nitrogen cycle on Mars and making nitrogen biologically available?"** To examine this, we are constructing sediment column analogs of the martian subsurface to isolate the conditions under which abiotic nitrogen cycling may occur and running a series of experiments to test the link between environmental conditions, chemical gradients, and changes in nitrate reservoir sizes through time. We will identify if there are abiotic pathways by which nitrogen cycling can occur in the martian subsurface. Work in this task will advance our understanding of how to search for martian habitable environments, both in samples that might be returned from Mars and for future in situ Mars missions.

Problem Description

a) **Context**: The martian subsurface has moved to the forefront in the search for martian habitable environments, and any upwelling of the groundwater could have moved biosignatures or environmental indicators of habitability to the surface where they could be observed and explored today. Although we have observed evidence of groundwater environments across the surface of Mars, the connectivity of these environments to the surface is poorly understood. What chemical environment existed in martian groundwater and how did that environment change when the groundwater emerged on the surface? Assessing habitability of the subsurface requires an improved understanding of how subsurface water produces solute concentration gradients, and how redox gradients depend on environment type. What is the expected composition of water in the pore space of martian rocks? How deep would the redox gradient be, and could it be a source of energy?

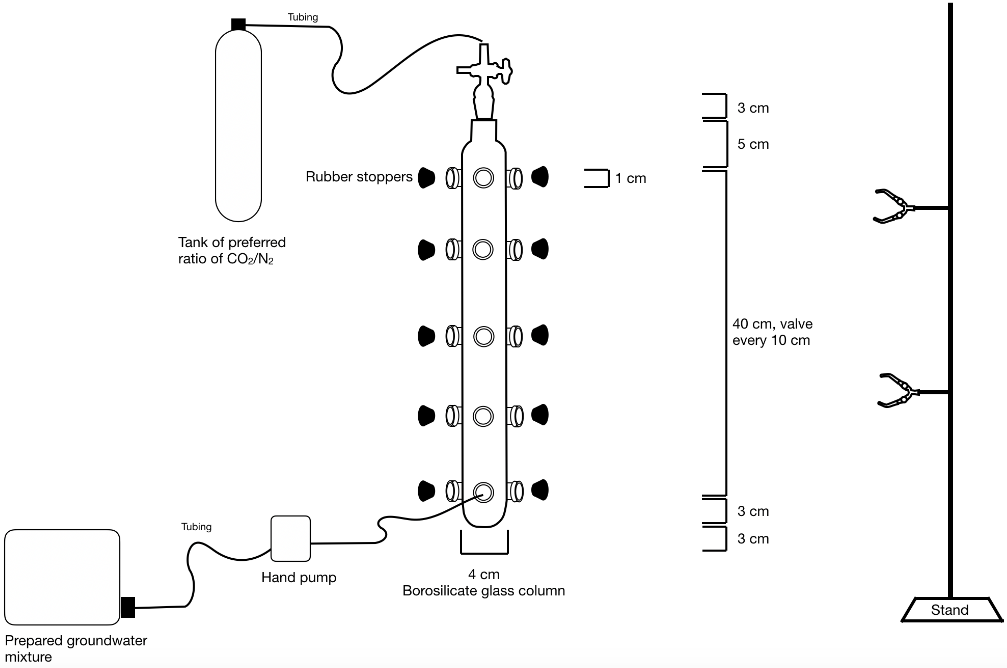
b) **SOA (Comparison or advancement over current state-of-the-art):** This work applies detailed terrestrial soil/subsurface characterization techniques to an entirely new research area to answer pressing questions on the forefront of Mars geoscience. These critical details about martian groundwater are generally investigated using geochemical modeling. Using physical simulants will allow us to isolate the effects of the fluid composition and subsurface characteristics on this environment in a novel way.

c) **Relevance to NASA and JPL (Impact on current or future programs)**: The work we do in this initiative will advance our understanding of how to search for martian habitable environments, both in samples that might be returned from Mars and for future in situ Mars missions. This initiative will also more broadly enhance our knowledge of martian geochemical processes that link the surface and subsurface environments, maintaining JPL’s leadership in Mars science.

Methodology

a) **Formulation, theory or experiment description**: We will form simulated sediment columns using custom-ordered glass tubes filled with sediment. Simulated groundwater will be pumped into the base of the column. Valves on the side of the column will allow for sampling at multiple locations and thus measurement of chemical gradients. **Conditions in the fluid will be monitored through time**, and concentration gradients will be monitored through time by analyzing each fluid sample separately. Nitrate composition of the fluid will be calculated using colorimetry or ion chromatography. After each experiment is concluded, the sediment will be taken out in discrete sections under an anoxic environment so that mineralogy and texture can be analyzed in detail using visible-near infrared (VNIR) spectroscopy, scanning electron microscopy (SEM), and X-ray diffraction (XRD).

b) **Innovation, advancement:** Such sediment columns (Winogradsky columns and similar) used in terrestrial research are often batch equilibrium style with no means to regularly measure water and sediment as the experiment is ongoing. This innovation will allow for careful monitoring of the timescales of such relevant geochemical reactions. It is also an advancement to the field to apply these methods to martian systems.



Results

a) This a 2 calendar year project spread over 3 fiscal years. It began Aug. 2020 and access to laboratories are still heavily restricted due to COVID, so no results are available yet.

b) We expect the work in this initiative will advance our understanding of how to search for martian habitable environments, both in samples that might be returned from Mars and for future in situ Mars missions. This work will also more broadly enhance our knowledge of martian geochemical processes that link the surface and subsurface environments, maintaining JPL's leadership in Mars science.

c) Next steps: Order custom glassware, finalize decisions on Martian simulants and groundwater compositions, run experiments, analyze results.

Publications and References

There are no publications from this work yet.