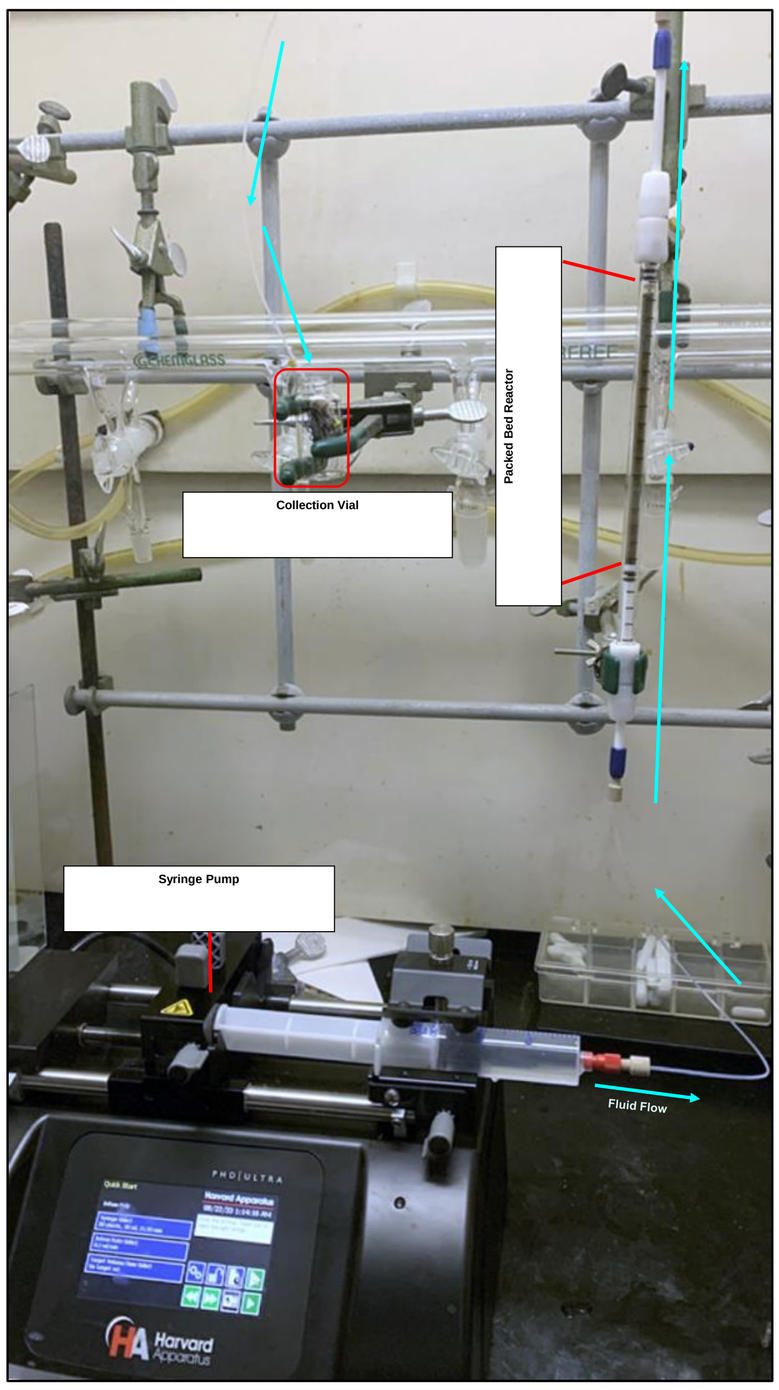
National Aeronautics and Space Administration

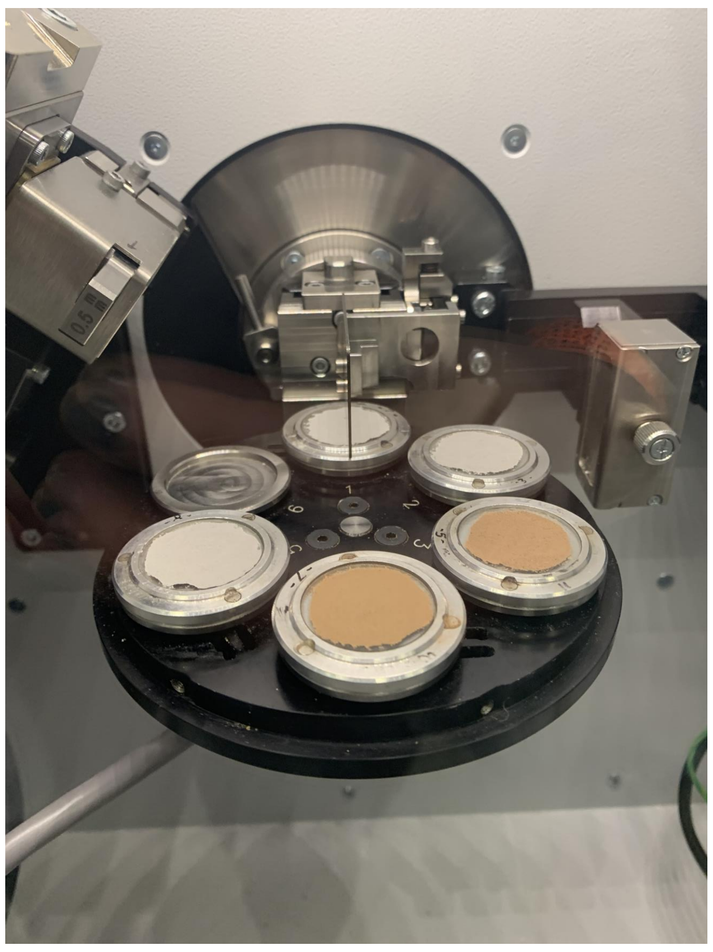
Novel Continuous Flow Reaction Design to Test Martian Weathering

Principal Investigator: Laura Barge (322); Co-Investigators: Jessica Weber (322), Rachel Sheppard (322), Laura Rodriguez (322)

Program: FY22 R&TD Innovative Spontaneous Concepts



Above: Image of continuous flow set up for Mars weathering tests
Below: Mineral samples collected post reaction prepared for XRD analysis

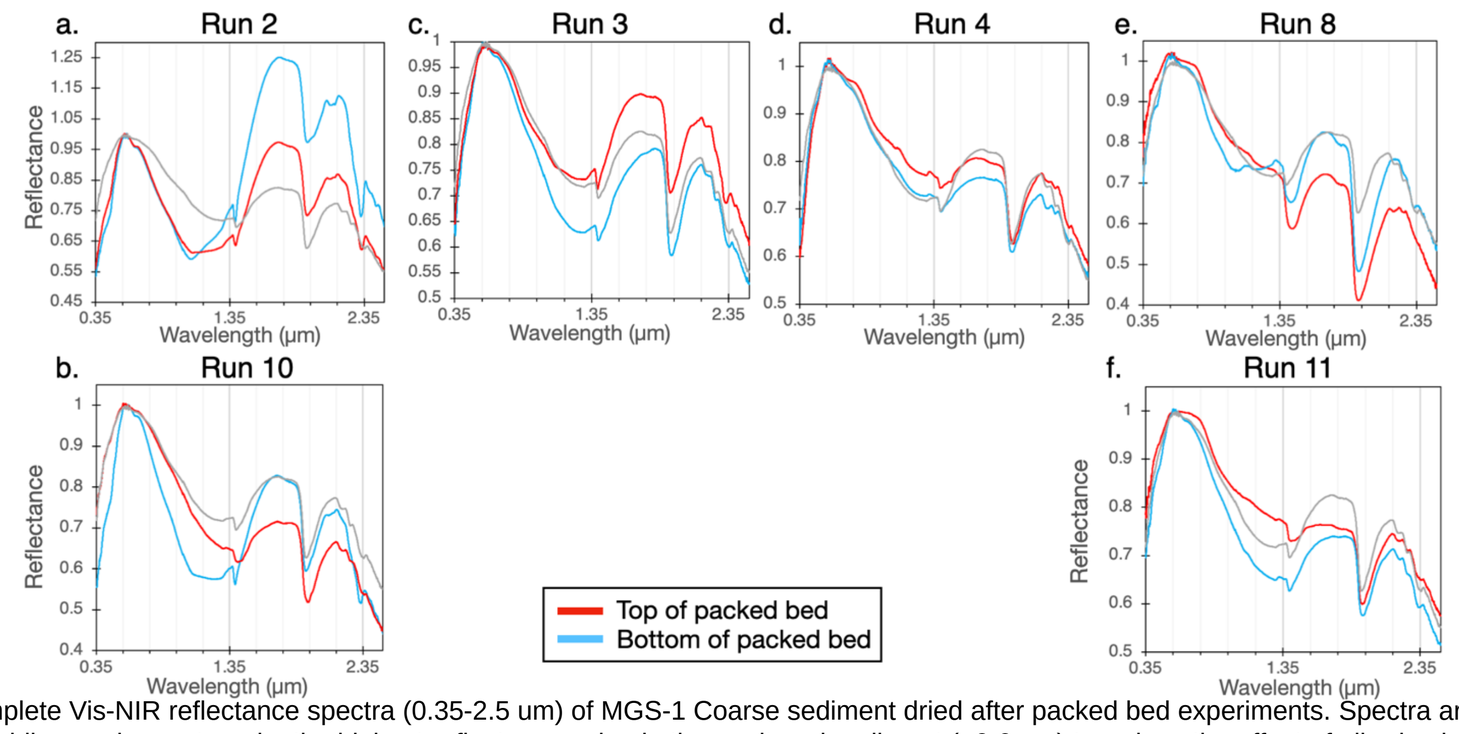


Objectives:
We sought to develop a modular continuous flow reactor system in order to test the weathering of different martian simulants under groundwater analog conditions.

Background:
Continuous flow chemistry is a reaction technique that uses tubing based reactors and is utilized in pharmaceutical synthesis. We have adapted these techniques to explore the weathering of Mars sediments and address unanswered questions about mineral alteration via groundwater weathering and connect laboratory studies to mission data.

Approach and Results: A packed bed filled with the desired Martian analog mineral can be exposed to a flow of different aqueous conditions to efficiently and precisely test the effect on the mineral, including dissolution, reprecipitation, cation substitution, or effects on crystallinity. Three mineral sediments were explored: MGS-1, MMS, and MGS-1 Coarse. Both the outgoing solution and resultant mineral phases were then collected and analyzed post-reaction by Mars mission-relevant instruments as well as typical laboratory techniques (IR, IC, XRF, XRD, LIBS) to analyze the weathering effects. With this knowledge, we could better understand observations from current and future missions, including the origin and stability of observed mineral assemblages. We observed changes in the IR and IC spectra obtained indicating that the ionic solutions did have an impact on the analog sediments. We hypothesize that this is due to removal of mineral phases in most cases.

Significance/Benefits to JPL and NASA: Herein, we have designed a modular system to test weathering under Martian groundwater conditions and explored the impact of different ionic solutions with martian sediments. Our results help address what kind of weathering could have occurred on Mars, which is relevant to ongoing missions including MSL and Perseverance. While this has shown its usefulness in exploring Mars groundwater conditions, this reaction system can be applied to other sites of interest including the early Earth and Venus.



Complete Vis-NIR reflectance spectra (0.35-2.5 um) of MGS-1 Coarse sediment dried after packed bed experiments. Spectra are scaled by dividing each spectrum by the highest reflectance value in the unaltered sediment (~0.6 um) to reduce the effect of albedo changes. Unaltered MGS-2 Coarse (gray), bottom of packed bed (blue), and top of packed bed (red). (a) Run 2 and (b) Run 10 were both exposed to pure H_2O. (c) Run 3 was exposed to dissolved Mg sulfate. (d) Run 4 was exposed to dissolved Fe sulfate. (e) Run 8 and (f) Run 11 were both exposed to dissolved Li.

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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

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Publications:

[A] Weber, J. M.; Martinez, E.; Sheppard, R. Y.; Rodriguez, L. E.; Barge, L. M. *"Understanding Habitability and Prebiotic Chemistry with Continuous-Flow Terrestrial Analogs." Invited Abstract. AbSciCon 2022,* 1030579
[B] Weber, J. M.; Martinez, E.; Sheppard, R. Y.; Rodriguez, L. E.; Barge, L. M. *"Mars Weathering Experiments: Development and Use of Continuous-Flow Packed Bed Reactor for Geologic Experiments." 2022 Lunar Planet. Sci. LIII.* 1053.
[C] Weber, J. M., et al. "Mars Weathering Experiments in a Continuous Flow Reactor" *JGR Planets.* **2022**, *in prep.*

PI/Task Mgr. Contact Information:

Email: Laura.M.Barge@jpl.nasa.gov