REFLECTANCE SPECTROSCOPY OF MARS ASTROBIOLOGY- AND HABITABILITY-RELEVANT MINERALS EXPOSED TO MARS-LIKE SURFACE CONDITIONS

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Introduction:

Our study focused on the spectral changes accompanying long-duration (~26 months) exposure of a suite of nine hydrated minerals, including zeolites, sulfates, and hydrated silica-rich materials, to Mars-like surface conditions in the laboratory: a longer duration than previously studied [1, 2]. The samples were subjected to 763 days of simulated daytime Mars surface condition and included two periods of ultraviolet (UV) light irradiation. Throughout this period, diffuse reflectance spectra were acquired 33 times.

Objectives:

- assess spectral and structural changes associated with exposure to Mars surface conditions (including effects of UV irradiation).
- relate these spectral changes to compositional or structural changes.
- determine which changes are reversible by re-exposing the samples to Earth's environment.

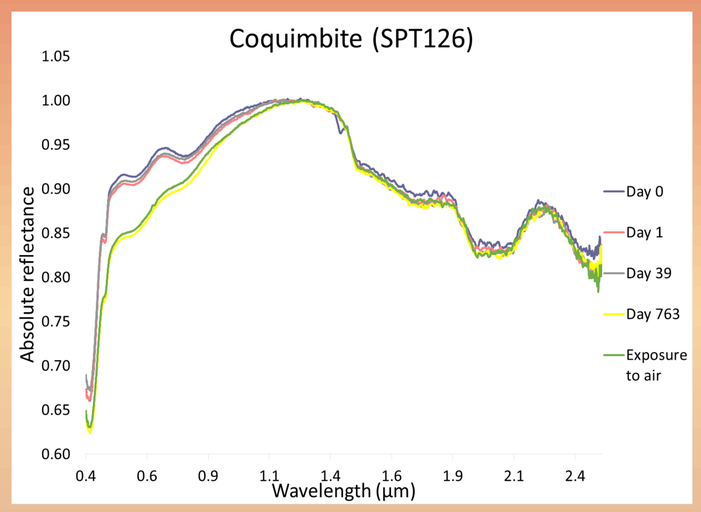

Figure 1: Coquimbite (SPT126) reflectance spectra (with sapphire window)

SPT126 Coquimbite:

- The Fe^{3+} bands (near 0.43, 0.55, and 0.8 µm) all exhibited a decrease in depth with time, and were very subdued by the end of the run (Figure 1).
- The loss or reduced depths of these bands was accompanied by a steeper spectral slope below ~1.4 µm.
- The 0.43 and 0.80 µm bands had the same gradual decrease in depth, while the 0.55 µm band showed a similar trend but may have increased slightly after day 517.
- A weak OH/H_2O band near 1.4 µm disappeared rapidly, from day 0 to day 1, and did not come back with re-exposure to terrestrial conditions.
- This mineral appears to be stable on the Martian surface.

References: [1] Cloutis et al. (2007) GRL, 34 (20), L20202. [2] Poitras et al. (2018) Icarus, 306, 50-73.

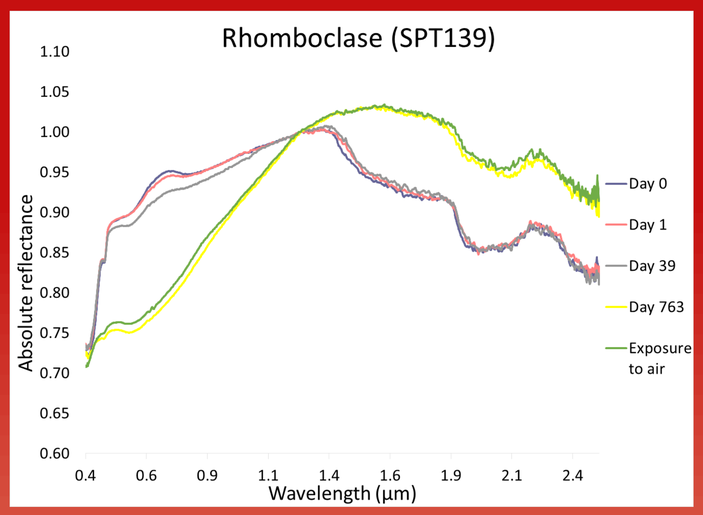

Figure 2: Rhomboclase (SPT139) reflectance spectra (with sapphire window)

SPT139 Rhomboclase:

- The sample started white-light gray and turned black, while the other sulfates showed only slight color changes: darkening or reddening.
- The 0.43 µm band was reduced in depth from day 1 to ~day 147, and then stabilized (Figure 2).
- The 0.53 µm Fe^{3+} band decreased in depth over time in association with the color change; it be-came narrower and deeper until day 237, after which it stayed constant.
- The 0.79 µm band disappeared completely around day 92 and did not return with re-exposure to ambient terrestrial conditions.
- Accompanying the change in slope, the peak reflectance shifted from ~1.4 to ~1.7 µm.
- The H_2O band at 1.9-2.1 µm exhibited a change in shape (widened) and a gradual reduction in depth (Figure 3).
- The final spectrum bears little spectral resemblance to the initial one, but still retains some evidence of being a ferric iron and water-bearing material.

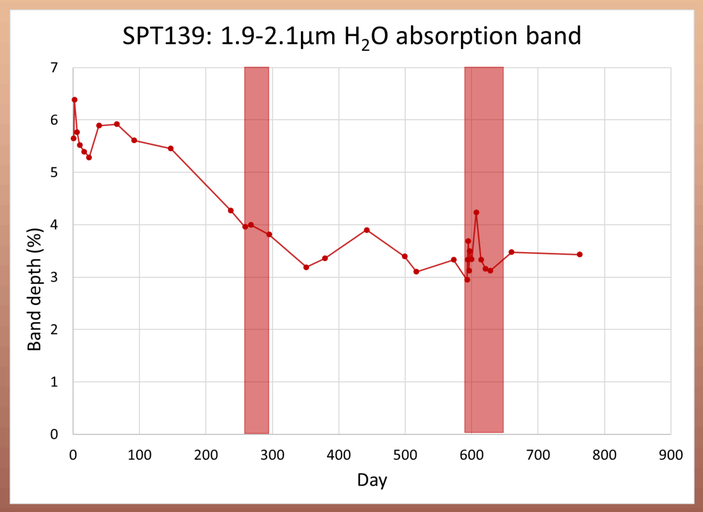

Figure 3: SPT139 Rhomboclase band depth (%) over time (763 days) for the H_2O 1.9-2.1 µm band with two periods of ultraviolet (UV) light irradiation

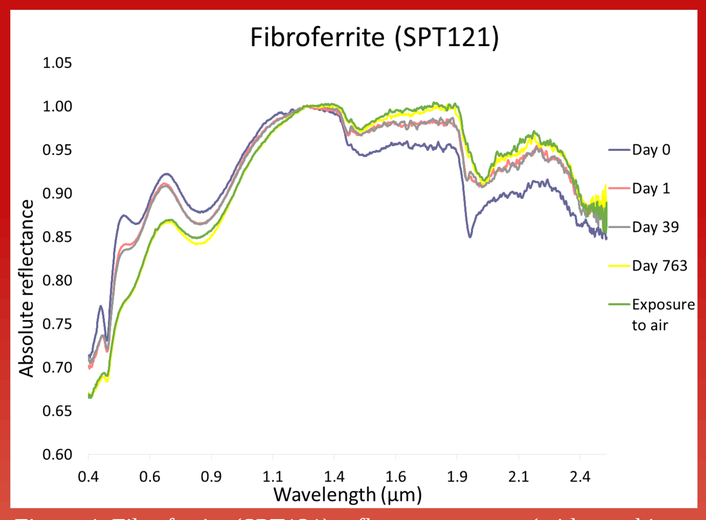

Figure 4: Fibroferrite (SPT121) reflectance spectra (with sapphire window)

SPT121 Fibroferrite:

- All three Fe^{3+} bands at 0.43, 0.55 and 0.85 µm gradually reduced in depth and did not return with re-exposure to terrestrial conditions (Figure 4).
- The 0.55 µm band progressively became shallower throughout the run and almost disappeared by day 237.
- The OH/H_2O band at 1.4 µm initially decreased in depth until around day 92.
- The H_2O band near 1.9 µm did not seem to have any definitive depth decrease over time, however it did change shape (Figure 5).
- From day 0 to day 1 the spectra exhibited a change in shape, associated with H_2O being rapidly pulled out of the sample.
- Changes occurred in the ~1.4 µm band, as well as a change below ~1.1 µm to a steeper slope, likely due to changes in Fe oxidation state or Fe-O/OH binding.
- The spectra did not appreciably change after re-exposure to terrestrial ambient conditions.
- The final spectrum suggest that SPT121 is stable on the Martian surface.

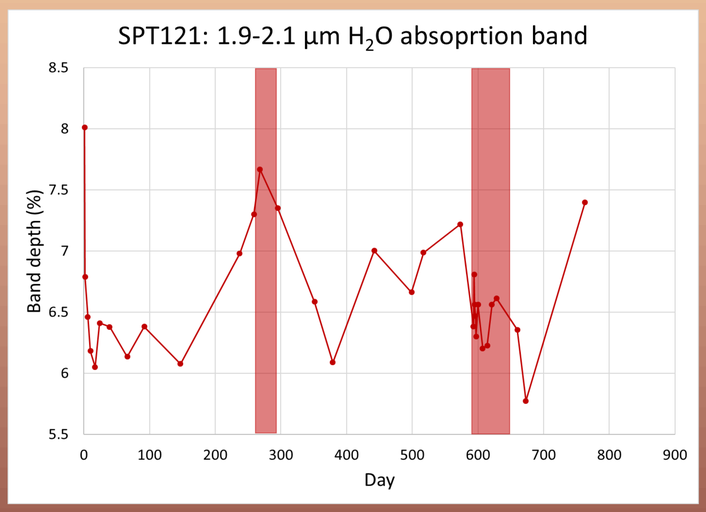

Figure 5: SPT121 Fibroferrite band depth (%) over time (763 days) for the H_2O 1.9-2.1 µm band with two periods of ultraviolet (UV) light irradiation

Summary:

- The Fe^{3+} bands have all change in depth due to the slope that affects all three of these bands.
- The H_2O bands do not always disappear in Mars like conditions, both the 1.9-2.1µm bands in Rhomboclase and Fibroferrite exhibited very different spectral changes.
- Rhomboclase exhibited unique spectral changes associated with color affecting the minerals absorption bands not present in other spectra.

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