

VARIATIONS IN REFLECTANCE SPECTRA ASSOCIATED WITH EXPOSURE OF HYDRATED MINERALS TO SIMULATED MARS SURFACE CONDITIONS. J. P. Mann¹, E. A. Cloutis¹, M. S. Rice², M. A. Craig³, G. M. Berard¹, ¹Dept. of Geography, Univ. of Winnipeg, 515 Portage Ave., Winnipeg, MB, Canada R3B 2E9, p-mann@shaw.ca, ²Dept. of Astronomy, 406 Space Sciences, Cornell Univ., Ithaca, NY, USA 14853, ³Dept. of Earth Sciences, Univ. of Western Ontario, 1151 Richmond Street, London, Ontario, Canada N6A 5B7.

Introduction: Understanding the stability of hydrous minerals on the surface of Mars and how their spectral properties may vary when exposed on the surface of Mars can lead to a better interpretation of observational spectral data. [1] demonstrated that spectral changes occur in a silica sinter and Fe-sulfates when exposed to simulated martian surface conditions for one year. The data presented here are a continuation of that study taking it to a two year completion with a larger sample suite.

Methodology: Nine hydrated mineral samples (six sulfates: sodium sulfate decahydrate, hydronium jarosite, fibroferrite, copiapite, coquimbite, rhomboclase; two zeolites: heulandite, chabazite; and a silica sinter) were ground using an alumina mortar and pestle, dry sieved to <45 μm and subjected to 763 days of simulated Martian daytime surface conditions (atmospheric composition, pressure, temperature and two periods of ultra-violet light exposure) using the University of Winnipeg's Miniature Mars Environment (Mini ME) chamber [2] [3]. Throughout the duration of the experiment, the samples were exposed to a continuous flow of dry CO_2 while sustaining an atmospheric pressure of 5 Torr (660 Pa CO_2). The chamber was equipped with a water circulation system that was in thermal contact with the samples to limit their maximum temperature to approximately the current maximum surface temperatures on Mars, $\sim 20^\circ\text{C}$ [3]. Two separate intervals of ultra-violet (UV) irradiation (days 260-295 and 593-650) were carried out using an air-cooled 25 W deuterium lamp placed directly above the chamber illuminating the samples through a 10 mm thick sapphire window. It had been established by [3] that the incident UV radiation over one day of laboratory exposure was approximately equal to 10 years of UV exposure on Mars.

Diffuse reflectance spectra were acquired through the sapphire window relative to halon measured at $i=0^\circ$ and $e=0^\circ$ using a bifurcated cable with an ASD Field-Spec Pro HR spectrometer over the wavelength range of 0.35 to 2.5 μm .

Spectra were acquired 33 times over the 763 day period while under Mars surface conditions as well as before and after the experiments were conducted. It should be noted that because of light scattered by the sapphire window and reflecting off the aluminum walls

of the chamber, the overall reflectance of the samples increase and absorption bands become less intense. For this reason, spectra were also acquired at ambient conditions with and without the sapphire window in place as a reference at the start and end of the experimental run. Here we present selected results.

Zeolites: Chabazite. Chabazite is a hydrated Ca-bearing zeolite. All absorption features below 2.5 μm can be ascribed to OH and/or H_2O . A weak O-H absorption band was observed at 0.97 μm and a combination of O-H and H_2O was found at 1.16 μm [4-6]. The ~ 1.4 μm region displays an absorption feature which is comprised of a bound H_2O combination band at 1.43 μm and a less intense adsorbed H_2O combination band at 1.47 μm [7][6]. The absorption feature at ~ 1.9 μm contains a strong bound H_2O combination band at 1.92 μm with a weaker adsorbed H_2O combination band appearing as a shoulder at 1.97 μm [5-7].

Spectral changes include a shift in spectral shape from concave to convex below 1.10 μm . The overall reflectance varies by only a few percent from day to day but a slight systematic decrease was observed. The depth of both the ~ 1.40 and ~ 1.90 μm bands decrease with time over the first 259 days but increase again, slightly, when irradiated with UV. Following the irradiation, the bands became less distinct again until the second interval of UV light regime. An absorption band near 1.78 μm due to H_2O vibration-libration combination [8] shifted slightly to longer wavelengths at some point during the experiment but this feature is only noticeable in the spectra obtained without the window.

Sulfates: Rhomboclase. Rhomboclase is a hydrous ferric sulfate with three absorption features that are a result of the Fe^{3+} spin forbidden ligand field transitions at 0.43, 0.53 and 0.79 μm [8]. A weak H_2O absorption that is only apparent in the spectra without the sapphire window is found at 1.45 μm while the two stronger bands in the ~ 1.75 and ~ 2.00 μm regions are due to an OH combination band and an H_2O combination band respectively [3].

Exposure to the Martian conditions caused a reddening of the spectrum with a drop in reflectance below $\sim 1.4 \mu\text{m}$ and an increase above that. The intensity of the Fe^{3+} absorption at $0.43 \mu\text{m}$ decreases to a minimum in the first ~ 150 days and remains constant after that. A demise of the $0.79 \mu\text{m}$ band is also evident within this time period. Alternatively, the $\sim 0.53 \mu\text{m}$ feature continuously becomes more distinct until the first phase of the UV light regime, where it decreases in band depth and stabilizes. The OH band at $\sim 1.75 \mu\text{m}$ also recedes but only after 237 days. For the remainder of the experiment the spectra appear to have stabilized and are not further affected.

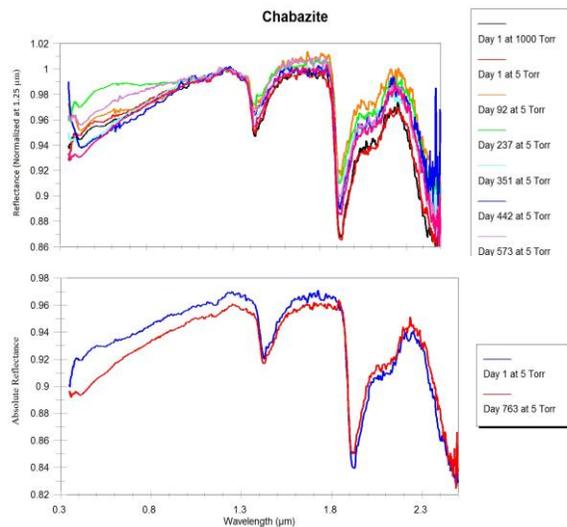


Figure 1. Reflectance spectra of chabazite through 763 days of simulated Mars surface exposure (a) Normalized at 1250 nm (b) Absolute.

Discussion: Spectral variations of the ~ 1.40 and $\sim 1.90 \mu\text{m}$ band intensities of chabazite in relation to the exposure of UV light suggest possibly adsorbed H_2O is being remobilized to sites of bound H_2O within the structure. Although disparities in the spectral properties occurred throughout the exposure, the last spectrum attained under pressure in the CO_2 environment is very similar to the first beyond $\sim 0.5 \mu\text{m}$ indicating little structural H_2O was lost. These findings imply that chabazite is stable under current martian surface conditions.

Deviations observed in the rhomboclase spectra can be associated with the loss of OH/ H_2O from various sites which can affect the overall crystal structure and in turn the position and intensities of the Fe^{3+} absorptions in the visible regions [1].

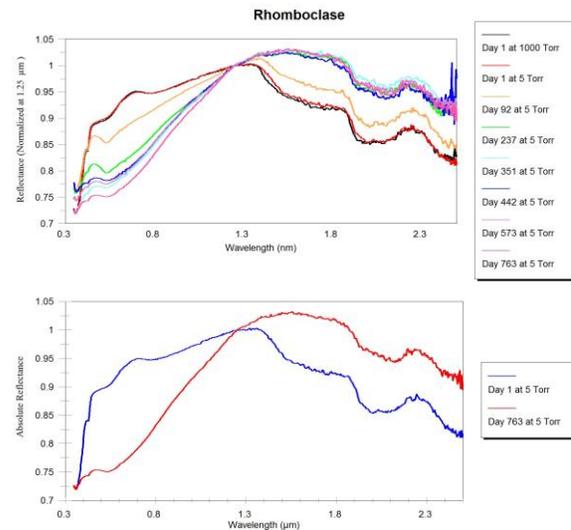


Figure 2. Reflectance spectra of rhomboclase through 763 days of simulated Mars surface exposure (a) Normalized at 1250 nm (b) Absolute.

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