INVESTIGATING THE ORIGIN OF MARS RECURRING SLOPE LINEAR THROUGH LABORATORY EXPERIMENTS UNDER A RELEVANT ENVIRONMENT. C.A. Hibbitts[1], A. Mushkin[2], A. Gillespie[2], B. Irvin[1], B. Wing[1], [1]JHU-APL, 11100 Johns Hopkins Rd., Laurel, Md., 20723.; karl.hibbitts@jhuapl.edu; chris.paranicas@jhuapl.edu, [2]Dept. of Earth & Space Sciences, Univ. of Washington, Seattle, Wa.

Introduction: Recurring slope linea (RSL) are meters wide 100s meter long dark streaks on the inside of Martian crater walls that form, grow, and fade repeatedly over days and months. Because of their small size they were not detected until the arrival of HiRISE [e.g. 1] and Figure 1. RSLs are generally agreed to be formed via a wet mechanism, with hydrated perchlorates having been recently identified in association with RSLs [2]. However, the precise formation mechanism remains unclear. Two leading wet origin hypotheses are seepage of near surface water [3] and deliquescence of atmospheric water [4]. We have investigated the possibility the darkening associated with RSLs is simply the result of wetting and subsequent drying and is not evidence for current hydration. We conducted experiments under Mars atmospheric pressure where a granular sample is wetted from below, and allowed to dry while being monitored with a visible to infrared reflectance spectrometer for spectral and brightness changes. The major question we are addressing in this research is: Could liquid that permeates to the surface under Martian surface conditions increase the small-scale unresolved (HiRISE) surface roughness and darken the surface?

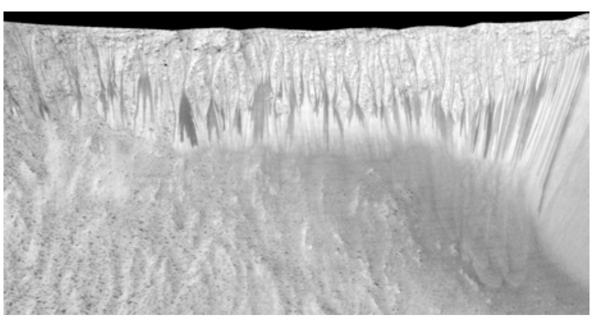

Figure 1. Recurring slope linea are ubiquitous on the inside walls of Martian craters as shown in this image of Garni Crater. Image courtesy of NASA/JPL-Caltech/Univ. of Arizona.

Results & Discussion: We have preliminary results of experiments analogous to seeping of fresh water on Mars. This work is different from similar investigations by others [e.g. 5] conducted at Mars pressure because of our ability to dose from underneath, simulating the transport of subsurface liquid sources on Mars to the surface. Palagonite was dosed from underneath with distilled water under Mars conditions (Mars pressure, N_2-atmosphere), monitored with an ASD Vis-SWIR spectrometer during the dosing and while drying, and imaged both before dosing and after drying. The palagonite sample was dosed at Mars pressure, with water wicking up from the subsurface, until the sample was visibly and uniformly dark but there was no standing water; i.e. saturation was achieved but free-standing water was avoided, which would be incongrous with current Mars conditions. The images in Figure 2 show that after drying and unique to dosing from the bottom and drying while at Mars pressure, the surface is roughened at the grain scale, and thus is darker than pre-dose because of grain shadows. The roughening occurred upon drying, and was not due to disturbance during dosing. Our procedures have been refined to prevent any 'outbursts' or 'geysering', and this structure appears to be the result of the direct sublimation of the water from the surface that only occurs when dosing and drying under vacuum. Dosing under ambient pressure does not result in this texture possibly because of the water's much slower evaporation.

Spectra were also obtained. The VisNIRSWIR spectra remain unchanged except for the effects of water while wet; such as formation of water related bands near 1500 and 2000 nm (Figure 3) and darkening due to index matching by water in the pore spaces

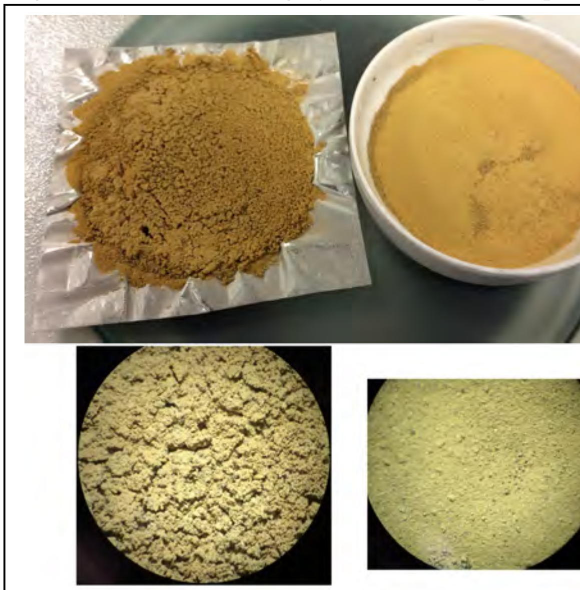

Figure 2. Dying of palagonite under Mars pressure results in a rough and thus darker surface. (top left) Palagonite after dosing with water and subsequent drying under Mars pressure. (top right) Palagonite before the experiment. Field of view of microscope ~ 2cm.

between the grains. Upon drying the spectra are similar to undosed palagonite, though darker due to surface roughness and retain a slightly deeper 2000nm band after drying for a day at Mars pressure and room temperature (Figure 3). Future experiments will determine if this 2000nm returns to a pre-dosing depth with longer exposure to Mars pressure. This water band is likely due to molecular water adsorbed onto the very hydroscopic palagonite [e.g. 6].

Conclusion: If the origin of Mars RSL is due to the action of water, our laboratory experiments demonstrate that they may represent a remnant physical expression of very recently lost water and are not evidence of actual wetness nor necessarily a chemical change.

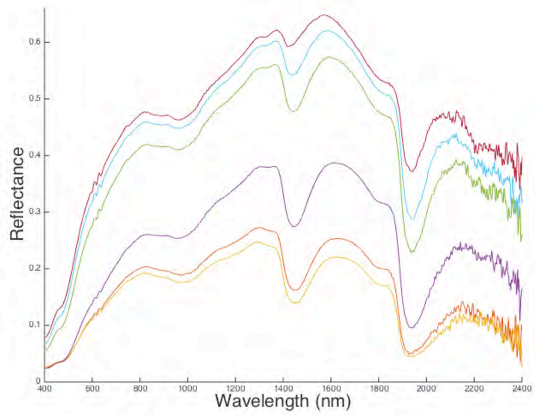

Figure 3. As water evaporates from palagonite under Mars conditions, the depths of the 1500 and 2000 nm bands decrease and the spectra brighten. Spectra trend from just wetted to more dried.

Addendum (Experimental Description): The Mars Analog Reflectance Spectroscopy (MARS) chamber includes a central Plexiglas vacuum box capable of maintaining ~ 10 to 15 torr while the sample is injected from below with liquids and subsequently dries, under an N_2 atmosphere and at room temperature. This pressure is sufficiently low (similar to Mars) that water and brines will evaporate within hours at room temperature. An N_2 environment provides a low oxygen atmosphere (via an N_2 purge in the outer chamber) similar to Mars. The fluid is introduced at Mars pressure into the bottom of the sample through a leak valve, a process that takes about 30 minutes and is wicked up, to eventually wet the top of the sample. Concurrently, bi-directional reflectance spectra are obtained with a fiber-fed ASD Field SpecPro spectrometer (400 nm to 2400 nm spectral range) with illumination provided by a fiber-fed quartz halogen source that is fed through a multimode fiber. The illumination incidence angle is 30^o and the emission angle (the ASD fiber) is nadir. The spectrometer fiber and the illumination fibers are inserted into the their re-

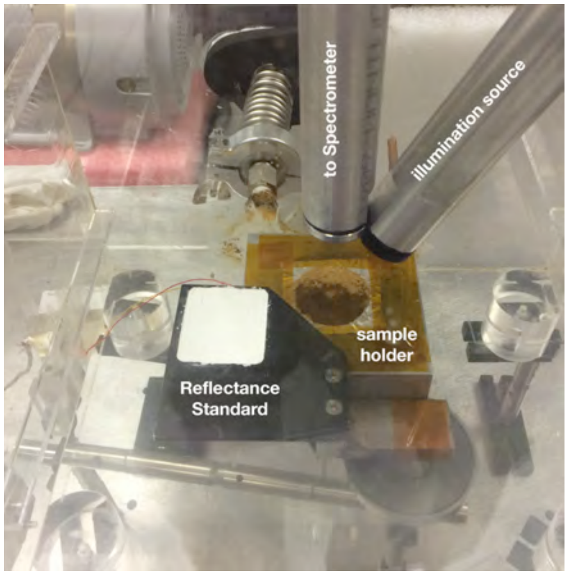

Figure 4. The dosing of the sample under Mars pressure at a very slow rate enables the sample to be wetted the formation of standing water or disturbing the structure of the sample. Not breaking vacuum to obtain spectra enables consistent results to be obtained.

spective vacuum tight aluminum tubes that each protrudes into the chamber (Figure 4). Each tube is equipped with a glass double convex lens to either focus the illumination into a spot (approximately 5 mm diameter), or to focus the reflected illumination into the fiber. Having both the illumination and spectrometer fiber close the sample (approximately 1” above it) and the focusing lenses, allows the acquisition of high SNR spectra. Spectra are obtained without breaking vacuum, including obtaining a ‘reference’ spectrum of a calibration target. The calibration target is on a platform that can be rotated over the sample and away from the sample for acquiring reference measurements under the same illumination geometry as for the reflectance spectra of the sample, ensuring photometric accuracy of these measurements. Powered Teflon (the unpressed material that is used as Spectralon) is used as a standard. Surface roughness measurements are also obtained through stereoscopic imaging.

References: [1] McEwen et al., 2011. Science, 333, 740, doi: 10.1126/science.1204816; [2] Ojha et al., 2016. Nature Geosci. Lett., doi: 10.1038/NGEO2546; [3] Stillman et al., 2014. Icarus, 233,328-324; [4] McEwen et al., 2015. EPSC 786; [5] Masse et al., 2014. Planet. Space. Sci., 92, 136-149; [6] Fanale, F and Canon, 1971. Nature, 230, p 502.