Investigating the Formation of Mars Recurring Slope Lineae through Laboratory Experiments.

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Introduction: We have constructed and tested a Mars Analog Reflectance Spectroscopy (MARS) chamber for simulating the formation and spectral evolution of RSL's on Mars. We are exploring conducting experiments to simulate the downslope evolution of RSLs at temperatures relevant to Mars.

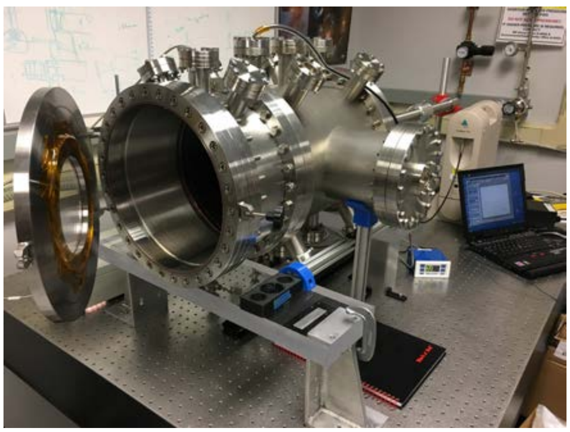

Figure 1. The Mars Analog Reflectance Spectroscopy (MARS) chamber. Achieve Mars pressure, N_2 or CO_2 background, Mars chamber, and equipped with an ASD FieldSpec Pro for spectral acquisition from 0.4 to 2.4 µm.

Background: Recurring Slope Lineae (RSLs) are dark, thin bands that appear to grow and disappear down Martian slopes. Their origin is still not determined. Their presence may indicate presence of granular flow dynamic angle of repose or be indicative of subsurface water seepage. Spectra of RSLs have no significant absorption features and they generally occur during warm summer months possibly suggesting transient liquid origin. The presence of low albedo streaks on crater slopes, Recurring Slope Lineae (RSLs), may be evidence for present-day intermittent and repeated flow of water or brine on the surface of Mars.

RSLs grow, fade, and can grow again [e.g. 1,2]. Although distinguishable by being darker than surrounding terrain, they have no diagnostic absorption features [3] with the exception of a ferric feature, which may be related to grain size [4], and the notable discovery of hydrated perchlorates at the base of one set of RSLs [5]. To explore liquid-based hypotheses for the formation of RSLs, we have constructed an environmental chamber that can simulate Martian surface conditions. The chamber maintains Martian pressure and oxygen fugacity while allowing for the wetting and drying of Mars analog soils and concurrently taking spectra from ~ 0.4 to 2.4 microns. The development of this chamber follows upon the successful completion of preliminary tests under a terrestrial atmosphere [6] to prove the optical design and subsequently under Mars pressure to verify the technical approach [7]. The Mars Analog Reflectance Spectroscopy (MARS) chamber is capable of exposing soils to brines from underneath to simulate possible subsurface wetting for RSL formation. Various brine compositions can be investigated; iron chlorides are being investigated as a salt that can lower the albedo without inducing a spectral absorption feature whereas other salts brighten the surface after drying or retain significant water [8]. Another possible darkening mechanism is also being explored; experiments have shown that evaporation of liquid from palagonitic soils under Mars pressure create ubiquitous grain scale cavities within the surface [7]. This micro-roughness increases shadowing and darkens the surface; and may be a process of darkening that is independent of brine composition.

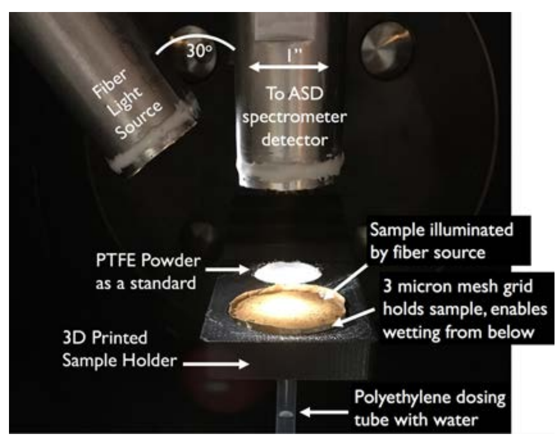

Figure 2. A sample and standard in the sample holder in the MARS chamber while illuminated by fiber optic light during spectral collection. We are modifying the sample holder to be ~ 6" long and capable of exploring downslope transport of water and mass movement.

Current Results:
We have completed a series of experiments with water to explore the role of grain disturbance during sublimation at Mars pressure with the possible result of increased micro-roughness. The results are promising and we are continuing to explore this process.

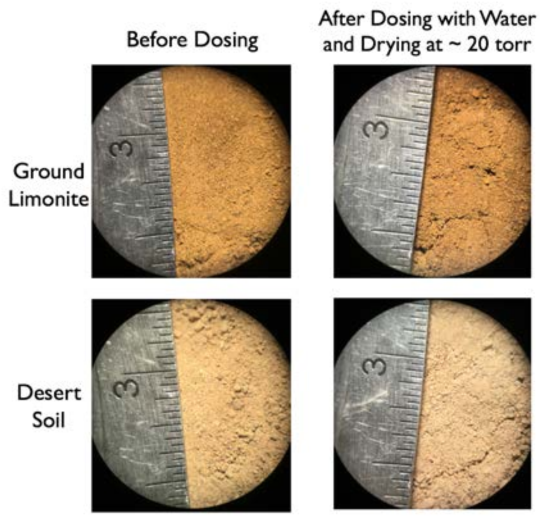

Figure 3. The surface of the sample is roughened as water sublimes from sample under Mars conditions. This roughness increases shadowing that could explain the darkening of RSLs even when moisture is no longer present.

Construction of the chamber has been completed, with first results presented at the past Fall AGU meeting [9]. It is designed to test various subsurface liquid origin hypotheses for RSL formation under Mars conditions. We are able to feed various liquid solutions into analog sample from below while maintaining pressure similar to that of the Martian surface. The sample is continuously observed during the experiment and visible and near-infrared spectra of sample is obtained with an ASD FieldSpec Pro. We are in the process of modifying the sample holder, extending it to retain a sample that fills a reservoir ~ 6” in length, 2” in width, and ~ 0.5” in depth, that can be held at a range of angles, to explore downslope moving of subsurface and surface moisture and mass movement effects. We will simulate the angle of repose. The mean slope of RSLs ranges between 28°and 37°[10].

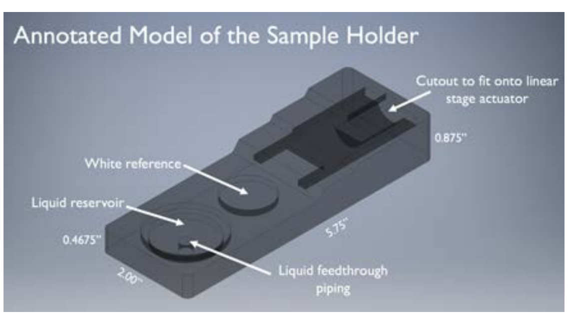

Figure 4. Current sample holder, which is being improved.

Conclusions: Current results show that sublimation of water under Mars conditions increased microporosity. This could be a mechanism to explain the darkening of RSLs without inducing spectral/compositional changes. The extent of this effect varied between samples. There may be due to differences in chemical composition. We are modifying the sample holder to explore downslope movement of water and material.

References: [1] McEwen et al., (2011) Science, 333, 740-743, [2] Sullivan et al., (2001) J. Geophys. Res., 106, E10, 23607-23633; [3] Mushkin et al., (2010) Geophys. Res. Lett., 37, L22201, doi: 10.1029/2010GL044535, [4] Ojha, L. et al., (2013. GRL, 40, 5621-5626; [5] Oja et al., (2015) Nature Geosci, doi:10.1038/NGEO2546; [6] Wing et al., (2014), Fall AGU, #P31D-4010; [7] Hibbitts et al., (2016), 47th LPSC, #1903, p. 2902; [8] Masse et al., (2012), 43rd LPSC, #1856. [9] Cantillo et al., (2017) Fall AGU, P41C-2845.[10] Dundas et al., Nature Geoscience 10, 903–907 (2017) doi:10.1038/s41561-017-0012-5