

Volatile Adsorption on Irradiated Lunar Surrogate Surfaces. M. J. Poston, SwRI, San Antonio, TX.

Introduction: We are presently in an era of reexamining the behavior and abundance of volatiles on the Moon, Mercury, Ceres, Phobos/Diemos, and small bodies. While evidence consistent with diurnal variations in adsorbed water content has been primarily at low-to-mid latitudes, this process has implications for both migration of water to the poles, and also for the adsorption behavior of water molecules in the polar regions. Differing techniques and modelling approaches have resulted in orders-of-magnitude differences in the quantity of migrating water inferred from spacecraft observations [1,2,3,4]. New laboratory measurements are needed to answer outstanding questions from recent missions and telescopic observations, regarding the possible diurnal water cycle on the Moon. [5] quantified the water desorption dynamics from Apollo lunar samples, placing some limits on water behavior, but concluded that the samples may not have been fully lunar-like. This is because [6] demonstrated that in order to reproduce lunar-like behavior for argon adsorption, it was necessary to activate mineral surfaces immediately before conducting the measurements. They did this by crushing a lunar rock in high vacuum, which is challenging and destroys the lunar rock being analyzed. I seek to demonstrate an improved technique that would reduce the amount of lunar sample required to perform the measurement. The technique is also much faster than the legacy measurement, which should provide higher fidelity measurements – accessing the highest energy adsorption sites before the residual gas present even in ultra-high vacuum can react with the fresh sample surfaces.

Ion-irradiation experiments performed by numerous investigators in the space weathering community have shown creation of nano-phase iron, amorphous rims, and other aspects of space weathered extraterrestrial samples, but little/no work has been published examining volatile sorption behavior to such an artificially-weathered surface. I am performing experiments to test the following hypothesis: *ion irradiation will activate grain surfaces for lunar-like volatile adsorption*. Should the hypothesis prove true, it will open up a new and widely available technique for creating active grain surfaces. Such a technique would

have the potential to revolutionize our ability to understand and predict the behavior of volatiles on rocky, airless bodies. The technique is being tested on lunar surrogates, and if successful, will then be used to measure the adsorption behavior of water on activated lunar grain surfaces.

Experimental: The Regolith Optical and Sorption Experiments (ROSE) apparatus has been constructed at Southwest Research Institute specifically to address spectroscopic and gas adsorption behaviors of samples that undergo simulated space weathering. The sample is located at the center of a spherical ultra-high vacuum chamber (no-bake 48 hour pressure typically $<1\text{E-}8$ torr, $\sim 3\text{E-}9$ torr with cryostat chilled) on a thermally-floating sample mount. A 10 K closed-cycle helium cryostat is moved into contact with the copper sample cup to chill the sample and disconnected for sample heating; meanwhile, a Si diode is used to monitor the temperature of the sample cup. The powder layer in the cup is only a few 10s of microns thick, to minimize thermal gradients and volatiles diffusion in the particle film. Solar-wind space weathering is simulated by a differentially-pumped and mass-selective ion gun. Argon and/or water are introduced through a micro-capillary array doser, which reduces background volatiles during the experiment by $> 90\%$ compared to purely background dosing. Volatiles desorption during the heating phase of the experiment is monitored by a quadrupole mass spectrometer. Meanwhile, diffuse reflectance spectra of the sample are collected from the UV through the MIR at key stages of the experiment, further connecting the experiments with the spacecraft observations.

Status: The apparatus is functioning and powder experiments are beginning as this abstract is due.

References: [1] Hendrix et al. (2019), GRL, 10.1029/2018GL081821. [2] Li and Milliken (2017) Sci. Adv., 10.1126/sciadv.1701471. [3] Bandfield et al. (2018) 10.1038/s41561-018-0065-0. [4] Wohler et al. (2017) Sci. Adv., 10.1126/sciadv.1701286. [5] Poston et al (2015) Icarus, 10.1016/j.icarus.2014.09.049. [6] Bernatowicz and Podosek, (1991) Proc Lunar Planet Sci Conf 21st, 21, 307.