CHARACTERIZING REGOLITH ROUGHNESS FOR PARAMETERIZATION OF LABORATORY DESORPTION AND SPUTTERING MEASUREMENTS. A. K. Woodson[1] (akw8r@virginia.edu) and C. A. Dukes[1] (cdukes@virginia.edu), [1]University of Virginia, Charlottesville, VA 22902

Significant temporal and spatial variation in the distributions and abundances of Mercury's exospheric species have been observed by the MESSENGER spacecraft and ground-based telescopes [1–11]. Models suggest that thermal desorption of metal volatiles from Mercury’s sunlit regolith and ion sputtering due to solar wind precipitation at the magnetic cusps contribute strongly to this variation and to the planet's overall exospheric budget. Yet there are still significant discrepancies between model and observation [7, 12–14]; thus, careful quantification of metal volatile ejection rates due to different physical mechanisms is critical for understanding the dynamics of Mercury's exosphere.

Atoms and molecules that are thermally desorbed or sputtered from the surfaces of airless bodies may be ejected into vacuum or onto adjacent regolith surfaces. Several theoretical and numerical studies have shown that surface roughness can reduce sputtering yields from 25% to 90% as compared to flat surfaces [15–17]. Moreover, while very few laboratory measurements have explored the effects of granular-surface roughness on measured sputtering rates, irradiation of olivine [18] and multi-element powdered mixtures [19] exhibit a range of 15% to 67% reduction in sputtering yield as compared to smooth, solid targets.

In preparation for upcoming experiments in which we will measure thermal desorption and solar wind sputtering of metal volatiles from Mercury regolith analogs, we are developing a methodology to meaningfully parameterize our measurements according to sample surface topography. A Thermo Phenom XLG2 Scanning Electron Microscope (SEM) with "shape-from-shading" 3D imaging capability is used to reconstruct the topographies of both loose granular and pressed pellet samples (Olivine, Forsterite, and Lunar soil) of several different <1 mm particle size fractions. SEM images of Forsterite samples for several different particle size fractions are shown in Fig. 1. These 3D surface reconstructions are then used to calculate a fractal surface model and its associated shape parameters [20] as well as a statistical model of our own design to encapsulate the distribution of topographical features (e.g., the distribution of grain facet orientations and grain spacings) that most influence the desorption and sputtering processes.

To test whether this methodology can provide mathematically unique, physically intuitive parameterizations of desorption and sputtering yields as a function of surface roughness, we conduct simple Monte Carlo simulations of desorption and sputtering yields from the 3D-reconstructed sample surfaces and compare the resulting yields to those obtained from surfaces that are randomly generated based on the distribution of topographical features encoded in the roughness models.

Pressed pellets are commonly used in laboratory measurements of planetary surface analogs because they are easier to mount and contain than samples consisting of loose grains, and are therefore less likely to contaminate or damage vacuum system components. However, compressing regolith analog material alters its surface topography and porosity (see the bottom left and bottom right panels of Fig. 1), and may thereby fundamentally change its physical response to space weathering. Thus, as an application of the above analysis, we additionally assess the extent to which pressed pellet samples are appropriate for use as regolith simulants in laboratory space weathering studies.

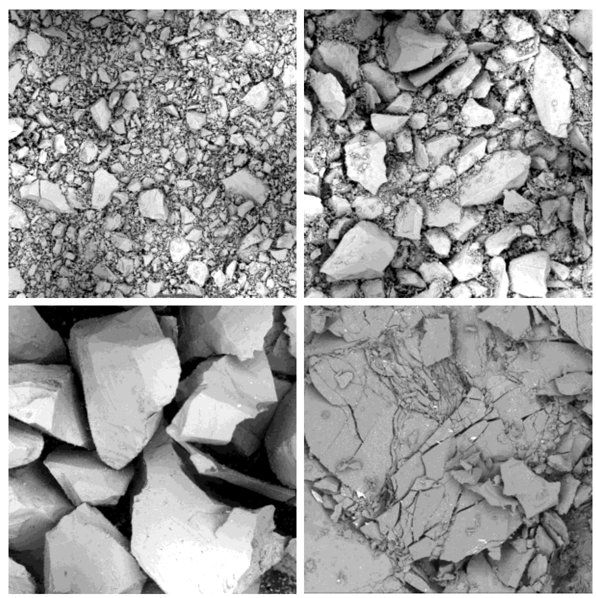

Fig 1. Crushed, sieved Forsterite samples imaged at 1000x magnification using the Thermo Phenom XLG2 SEM. The images show the surface topographies for loose samples with grain sizes <45 µm (top left), 45-125 µm (top right), and 125-170 µm (bottom left), as well as a pressed-pellet sample consisting of 125-170 µm grains compressed into a small Al ring (bottom right).

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