ESTIMATING SURFACE POROSITIES OF ANALOG SAMPLES USING MICROSCOPIC IMAGING ANALYSIS.

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Introduction: Mid infrared (~3-50 μm) spectroscopy has been used to determine the chemical and mineral composition of planetary bodies for at least the past half a century [e.g., 1]. The shape and position of spectroscopic features of a mineral are dependent on several parameters such as mineral chemistry, albedo, particle size, porosity, and near-surface thermal gradients [e.g., 2-7]. Very low gravities and the lack of atmospheric disturbances has resulted in porosities significantly higher than typical terrestrial analogs [e.g., 5,6]. An increase in a sample's porosity results in a larger physical separation of the particles. They begin to act as optically thin volume scattering particles, scattering independently resulting in less pronounced spectral features [e.g., 3]. This decrease in spectral contrast is especially pronounced on Solar System airless bodies with discernable regolith on their surfaces [e.g., 5,6]. Several studies have attempted to simulate high porosities in the laboratory; however the porosities of the samples were not quantified instead the relative porosities were provided [e.g., 2, 8,9].

Salisbury and Wald [2] attempted to characterize the effects of porosity on mid infrared spectra of 'fluffy' and 'packed' samples. They used two sized fractions of particles (250-75 μm and < 75 μm) and used both cleaned (removed fine particles electrostatically attached to those in the larger size fraction) and uncleaned samples. Wang et al. [8] used electrostatic lofting of fine particles to create highly porous structures with many highly charged voids. Wang et al. [8] determined that this mechanism could be responsible for observed features on the Moon and asteroids such as the lunar horizon glow and "dust ponds" on the near-Earth asteroid, 433 Eros. Blum et al. [9] created highly porous structures (~85%) of silica (SiO_2) spheres via slow impacts (< 1.1 m/s). This "hit-and-stack" impact behavior is thought to be reminiscent of the formation of protoplanetary material [9].

In this initial investigation we will create a 'fluffy' and 'packed' sample reminiscent of a lunar and asteroid analog. We aim to quantify the porosity of the near surface of each sample using imaging techniques and a pycnometer [10]. Quantifying the porosity of the near surface is important, as this is the layer sensed by mid infrared remote techniques.

Samples: We have chosen San Carlos olivine as our analog sample for this initial investigation. The sample was ground using a mortar and pestle and separated by particle size fraction. We generated five particle size distributions from this method (>200 μm, 200-125 μm, 125-75 μm, 75-45 μm, < 45 μm), here we will be using the smallest sized particles, those less than 45 μm. We will gently pour sample material (approximately 2 g) into an aluminum sample cup with an internal radius of 11.0 mm and a depth of 4.0 mm.

Methods: Using an Aven Mighty Scope digital microscope, we will take an image of the center of the sample under a 10- and 200-times magnification. This sample will then be compressed with a several kg mass. This packed sample will also be imaged under both magnifications. We will load our images into Adobe Photoshop and convert them into gray scale. We then save several versions of our images, an unmodified image, and several images with varyingly boosted contrast. We then load these images into a Python computer program to bin the image colors via the "k-means" algorithm to measure the number of voids and mineral grains. For our study we will be using several different bin sizes to discern dark void spaces from bright olivine grains to estimate the porosity of the near surface of the sample. These porosities will then be compared with porosity measurements using a helium pycnometer [10].

Future Work: In future studies we will use this method on samples with a range of porosities that have been measured across the mid infrared. We will then characterize the effects of porosity on the spectroscopic measurements. We will also make physical mixtures with a range of particle sizes more reminiscent of the lunar regolith [e.g., 7]. If successful, we will use this method on other lunar analogs including lunar simulants generated by the University of Central Florida's Center for Lunar and Asteroid Surface Science (CLASS) Exolith Lab [11,12].

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