MORPHOLOGIC AND SPECTRAL CHARACTERIZATION OF REGOLITH BREAKDOWN DUE TO WATER ICE.

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Introduction: The low abundance and distribution of surface-exposed water ice on the Moon is unique among Solar System airless bodies in the ways it is accumulated and trapped within permanently shadowed regions (PSRs), and may be directly linked to the Moon's formation, evolution, and current geomorphological processes [e.g., 1]. Thermal studies have shown that reflectance-temperature trends of increasing reflectance with decreasing temperature at the lunar poles are distinct from trends observed at other regions on the lunar surface [e.g., 2], suggesting that the regolith at polar latitudes is different, namely from the presence of OH, H_2O, and other volatile species. This suggests that the weathering processes affecting the regolith environment at the high latitude poles may be different from the processes that dominate at lower latitudes. Solar wind and micrometeorite impacts regularly vaporize and garden material on the lunar surface, but the increased porosity of the regolith and fine-grained "fairy castle" structures at the poles within PSRs show that other methods of regolith breakdown may be occurring [e.g., 3, 4].

The need to further study the presence, abundance, and form of water on the Moon and how it interacts with the regolith is then necessary in understanding the evolution of the lunar surface. As humanity faces its long-awaited return to the Moon, more questions about the lunar environment, especially the lunar polar environment, arise. The geotechnical properties of the lunar soil proved to be challenging in many respects to the Apollo astronauts of the 1970s [e.g., 5], so understanding the properties of lunar regolith at future polar landing sites is essential to be able to create tools and rovers capable of more effectively working on the lunar surface and with the regolith itself.

Here, we characterize the morphologic and spectral changes of lunar regolith simulants when exposed to varying concentrations of water and freezing temperatures in order to better understand how water ice exists in, interacts with, and ultimately alters the polar regolith.

Methods: Three lunar regolith simulants were mixed with increasing concentrations of water in small batches before placing in a freezer for a period of either one, six, or twelve months. At the time of removal, the samples were heated at low temperature (50°C) to remove the added water before undergoing several types of analyses to characterize any morphologic and spectral changes that have occurred.

Lunar simulants. This experiment utilizes three regolith simulants: (1) JSC-1A, which approximates the soil of the lunar maria [6], (2) LHS-1, an Exolith Lab lunar highlands simulant, and (3) LMS-1, an Exolith Lab lunar mare simulant that more closely matches the composition of mare soils compared to JSC-1A [7].

Ice mixing. Samples were created in 2 g batches to account for the amount of material necessary to obtain thermal infrared spectral characterizations of each mixture. Concentrations of 1, 10, and 30 wt% of water were chosen in line with the current abundances suggested to exist at the lunar south pole [e.g., 1, 8].

Morphologic analysis. The unaltered and frozen simulants were analyzed using an AccuScope system along with the ExpertShape image analysis software package to provide statistical analysis on multiple particle size and shape parameters, including sphericity, elongation, area, and more to aid in characterizing changes in particle shape and in the particle size distribution of the sample.

Spectral analysis. Thermal infrared spectral measurements were made in the Planetary Analogue Surface Chamber for Asteroid and Lunar Environments (PASCALE), which has the capability to simulate ambient ("Earth-like") and lunar-like conditions [9]. Taking spectra under these desired near-surface environments allow for comparison of lab spectra to remote sensing observations of the Moon.

Results: Here, we present results LHS-1 and LMS-1. Unaltered (dry) LHS-1 was compared to our samples of LHS-1 mixed with different concentrations of water, all of which were frozen for one month. As a general trend, average particle sphericity appears to increase by ~27% while average particle elongation decreases by ~15% for the < 63 μm particle size fraction of ice-mixed LHS-1 compared to its dry counterpart. For the > 250 μm particle size fraction, the opposite appears to be true, with sphericity decreasing by ~7% and elongation increasing by ~6%. As expected, the fines weather more drastically than the larger particle size fractions.

Similar behaviors have been seen in the other simulants, as well, with LHS-1 weathering the most as evidenced by the change in sphericity and elongation. JSC-1A weathered the least out of the three by the same standards, likely due to its relative lack of fine particulates in comparison to the other simulants used.

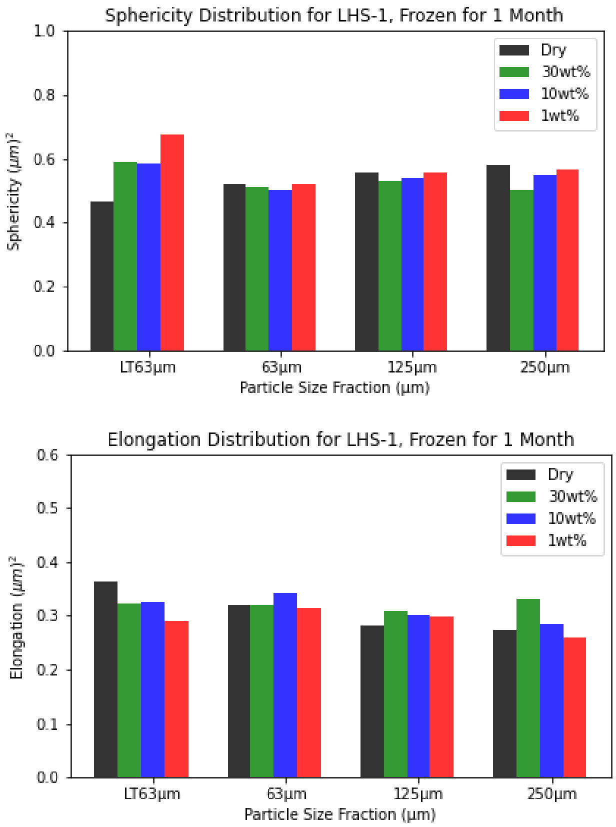

Figure 1. Sphericity (top) and elongation (bottom) across four particle size distributions of dry and ice-mixed LHS-1.

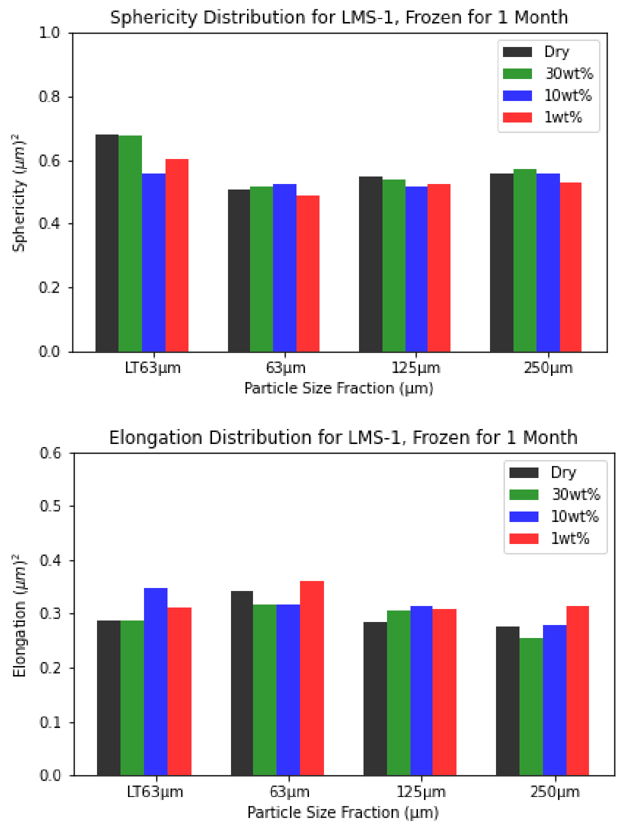

Figure 2. Sphericity (top) and elongation (bottom) across four particle size distributions of dry and ice-mixed LMS-1.

Finally, no distinct changes have been observed in ambient or simulated lunar environment thermal infrared spectra thus far, so no spectra are presented in this abstract.

Future Work: Analysis of simulants will continue as each batch becomes ready. Our next set of samples are scheduled for removal and analysis in mid-February, so preliminary results for our six-month samples will be ready for presentation by the conference. We also plan to begin taking TEM/SEM images of the simulants in order to observe how particle morphology changes and affects the behavior of the lunar regolith on a larger scale, as analysis is currently done solely for individual grains.

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