EXAMINATION OF LUNAR REGOLITH SIMULANTS BY SEM-EDS AND IMAGING RAMAN SPECTROSCOPY Ernest K. Lewis[1], Saunab Ghosh[2], Ryan S. Jakubek[2], Cecilia L. Amick[2], Julie D. Stopar[3], Rostislav Kovtun[2], Ane Slabic[2], Timmons Erickson[2], Kimberly Allums[2], Christopher L. Harris[2], Marc D. Fries[4], John E. Gruener[4], Francis M. McCubbin[4], Jeremy W. Boyce[4]

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Introduction: The Artemis series lunar missions will include sample returns from the lunar south pole. [1] Lunar regolith simulants (RS) generated in the lab provide opportunities to compare two surface science techniques: scanning electron microscopy (SEM-EDS) and Raman induced surface spectroscopy [2-4]. The results will also be applicable for supporting future commercial lunar payload services (CLPS) and Artemis surface [5]. Surface characterization contributes to continued development of lunar regolith studies and adds to various regolith databases [6-7]. In characterizing various lunar regolith simulants, part of the aim should be to standardize techniques and utilize anticipated methods available for astromaterials studied during, or returned from, upcoming missions, particularly samples collected from the Moon's south pole and permanently shadowed regions (PSRs) [1]..

An initial survey of available simulants has been started with Raman scanning process for particle counting the results of which will enrich the NASA-JSC Simulant Development Lab (SDL) simulant properties database and the Colorado School of Mines Planetary Simulant Data Base [7]. An SEM-EDS dataset of raw regolith simulant materials are collected.

Experimental: Elemental spectral mapping of simulated lunar regolith NASA USGS Lunar Highlands Type NU-LHT-4M obtained from the SDL at JSC were performed through SEM-EDS characterization with a JEOL 7900F instrument**.** Lunar regolith simulant samples were provided by the SDL at JSC. Samples were dusted onto carbon tape by gently pressing the particulate sample into the mount, followed by a ~10 nm carbon coating to increase conductivity and avoid surface charging. Samples were examined with SEM-EDS, in attempt to develop a method for standardized surface spectral mapping. Additional samples were provided to the JSC Raman Spectroscopy Laboratory to collect particle counts and Raman spectra.

Results: Figure 1 shows an example of the SEM-EDS spectral map of Ti, Ca, Al, and Mg. This 'raw' simulated regolith material, where 'raw' is defined here as non-epoxy fixed regolith. Carbon coating and slight angling of sample can reduce bright spots and shadowing on the image.

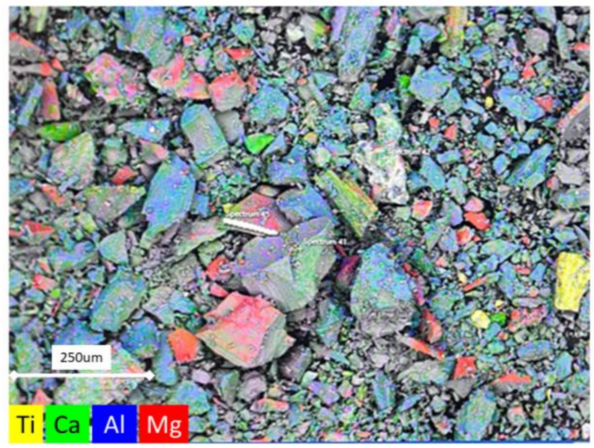

Figure 1. The SEM of the NU-LHT-4M sample shows a wide dispersion of particle sizes and shapes, along with compositions containing titanium (yellow), calcium (green), aluminum (blue), magnesium (red). It is demonstrated that regolith simulant can be scanned without being epoxy fixed.

Particle counting, size-distributions, along with Raman spectra can be obtained, and a high-contrast particle distribution image is shown in Figure 2. Being able to count particles and obtain a size distribution of regolith along with some morphology during the studies of the simulated regolith. For Raman microscopy-based particle counting, particles must be dispersed and lightly cover the microscope slide for the particle-counting software (WITec ParticleScout) software to be effective. The Raman imaging microscope has the potential for providing particle distributions within the field of view and Raman spectra from each particle as well. This means a multi-parameter capability of size distribution, and spectra from each particle. This is very useful regarding studies of particulates, and possibly subsequent chemistries.

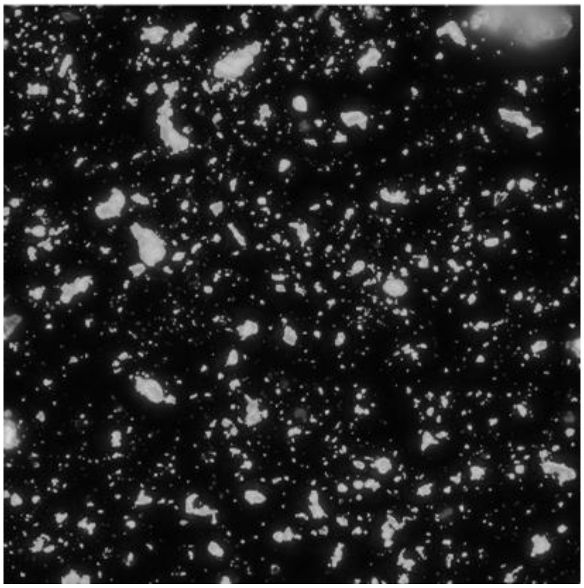

Figure 2. High contrast image of a dispersed regolith sample prepared for particle counting and providing opportunity for surface scanning Raman Spectroscopy of each particle.

Future Applications. This process of scanning various samples can be programmed for repeatability expanded to other regolith simulants in use, and/or applied as process control feedback into regolith simulants databases, such as the SDL simulant properties database at JSC, or the Planetary Simulant Database [7], and potentially the National Institutes of Standards and Technology [8]. It is envisioned that this method could add substantially to the knowledgebase of regolith simulant materials in a wide range of planetary surface applications.

We believe that this technique will add a significant amount of detail to the community of researchers and companies interested in improving lunar regolith simulant systems as well as adding to the needed knowledge base for advanced curation of these materials for Artemis missions in the future.

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