Structural, Physical, and Compositional Analysis of Lunar Simulants and Regolith. K. Street, P. Greenberg, J. Gaier, NASA Glenn Research Center, 21000 Brookpark Road, Cleveland, OH 44135, Kenneth.W.Street@nasa.gov.

Introduction: Relative to the prior manned Apollo and unmanned robotic missions, planned Lunar initiatives are comparatively complex and longer in duration. Individual crew rotations are envisioned to span several months, and various surface systems must function in the Lunar environment for periods of years [1]. As a consequence, an increased understanding of the surface environment is required to engineer and test the associated materials, components, and systems necessary to sustain human habitation and surface operations.

One such environmental factor is the fine fraction of surface regolith, generally referred to as Dust. The problematic nature of this material is widely discussed, appearing early on in the crew logs of Apollo astronauts [2]. Subsequent analyses have described both the details and mechanisms of degradation resulting from dust deposition and interactions [3]. Anticipating the need for a variety of dust resistant technologies, both NASA and the private sector have initiated a number of programs aimed at meeting this objective. These efforts span a host of considerations, ranging from basic properties of materials, to complex mechanical, thermal, fluidic, and optical systems. Also being addressed are the fundamental aspects of the Lunar environment that influence the charging, transport, and deposition of fine particulates.

By definition, these initiatives must also consider the intrinsic properties of the dust itself. This includes physical attributes (e.g. size and shape distributions), as well as structure and composition. The bulk of existing knowledge obtained from Lunar returned samples pertains to the larger, super-micron fraction. Many properties are observed to correlate with particle size, so the extensibility of these measured properties to the smaller dust fraction remains largely unresolved.

Given the relatively small quantities of actual Lunar samples, the collective demands for testing the performance of flight components and systems must be largely accommodated through the use of regolith simulants. A number of simulant materials were derived in support of the Apollo program, and remain useful in many aspects. However, the increased demands of longer, more complex missions require simulants of higher fidelity. In turn, this situation drives the need for a more thorough characterization of Lunar regolith itself, particular for the smallest size fractions where many properties remain largely outstanding.

The effort described here concerns the analysis of existing simulant materials, with application to Lunar return samples. The interplay between these analyses fulfills the objective of ascertaining the critical properties of regolith itself, and the parallel objective of developing suitable stimulant materials for a variety of engineering applications. Presented here are measurements of the basic physical attributes, i.e. particle size distributions and general shape factors. Also discussed are structural and chemical properties, as determined through a variety of techniques, such as optical microscopy, SEM and TEM microscopy, Mossbauer Spectroscopy, X-ray diffraction, Raman micro-spectroscopy, inductively coupled argon plasma emission spectroscopy and energy dispersive X-ray fluorescence mapping. A comparative description of currently available stimulant materials is discussed, with implications for more detailed analyses, as well as the requirements for continued refinement of methods for simulant production.

References

[1] http://www.nasa.gov/pdf/55583main_vision_space_exploration.pdf. [2] Apollo 17 Technical Crew Debriefing, MSC07631 (1973). [3] Gaier, J. R. (2007), The effects of lunar dust on EVA systems during the Apollo Missions, NASA/TM-2005-213610/REV1.

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