NASA LSII LUNAR SIMULANT PROJECT.

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Introduction: America has entered a new era of exploration. NASA's Artemis program will lead humanity forward to the Moon and prepare us for the next giant leap, the exploration of Mars [1]. To champion technologies needed to live on and explore the Moon, NASA's Space Technology Mission Directorate (STMD) established the Lunar Surface Innovation Initiative (LSII) [2]. LSII's technology development portfolio includes: Utilizing the Moon's resources; Establishing sustainable surface power; Building machinery and electronics that work in extreme environments, like super-chilly permanently shadowed craters; Mitigating lunar dust; Carrying out surface excavation, manufacturing and construction duties; and Extreme access which includes navigating and exploring the surface/subsurface. To support the development and testing of these technologies, LSII created the lunar simulant project, to create and/or acquire low-, medium- and high-fidelity lunar simulants to match the needs of STMD projects at all levels of technology readiness levels (TRL), as well as other NASA programs. There is not one bulk lunar simulant that will satisfy the needs of all projects.

NASA's Approach to Simulants: Just as LSII's activities are being implemented through a combination of unique NASA work and public-private partnerships, NASA will work with commercial simulant providers to acquire simulants that meet NASA's needs. If warranted, NASA will develop simulants using government agencies, as was done with the NASA/USGS Lunar Highlands Type (NU-LHT) series of lunar simulants [3]. NASA is also collaborating with the Johns Hopkins University Applied Physics Laboratory (JHUAPL) Lunar Surface Innovation Consortium (LSIC) in the development and characterization of lunar simulants [4]. Within NASA, a small team (< 10 people) is coordinating simulant activities across the agency, with team members located at several NASA centers. The overall objective of the project is to procure lunar simulants in sufficient amounts for earth-based testing of subsystems and systems in a variety of environments (i.e., laboratory, high-bay, thermal-vacuum chambers), required for Artemis missions to the Moon, as well as other missions carrying NASA lunar payloads, such as the Commercial Lunar Payload Services (CLPS) program [5].

Lunar Highlands Simulant: NASA's Artemis Program is targeting the lunar south pole region for initial human missions and the Artemis Base Camp. Hence, the LSII lunar simulant project is currently focusing on the mineralogy and properties of lunar highlands regolith [6 and 7]. Plagioclase-rich rocks (e.g., anorthosite, norite) are the dominant constituent in highlands simulants, with Shawmere, Stillwater, and White Mountain anorthosites being used in commercially available simulants. However, because these feedstocks are terrestrial in nature, they include hydrated minerals, carbon-bearing minerals, and other chemical signatures that are not present on the Moon, and these minor mineral assemblages need to be taken into account when trying to understand test procedures and results.

Glass Component: While much attention has been placed on the rock/mineral component of lunar simulants, glass is just as important when creating simulants. The glass component in lunar regoliths is often greater than 50% by volume [8]. This component includes impact melt glass, dark matrix breccias, and agglutinates. However, this component is difficult, time-consuming and expensive to make. Most lunar simulants, past and current, have relied on basaltic cinder as a feedstock for glass. Getting better glass components at a lower cost, particularly agglutinates and glass with an anorthositic composition is a near-term objective that the NASA simulant project is trying to address.

Characterization: It is extremely important for lunar simulants to be characterized by several analytical methods. Gruener et al. [9] and JHUAPL LSIC [10] conducted initial assessments of some of the commercially available simulants in 2019 and early 2020, before the global pandemic. Further analyses are needed to better quantify important parameters such as, modal mineralogy and glass content, particle shape, and particle size distribution. These quantified results can then be used in determining figures of merit (FOM) that show how well simulants compare to lunar regolith [11 and 12].

References:

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