IN SITU MEASUREMENTS OF PERMANENTLY SHADOWED REGIONS NEEDED TO DEVELOP ICY SIMULANTS. H. M. Sargeant[1], K. Šļumba[1], J. Long-Fox[1], P. Easter[1], and D. Britt[1]. [1]University of Central Florida, hannahmarie.sargeant@ucf.edu.

Introduction: The regolith in the lunar south polar region is thought to contain water-ice deposits inside permanently shadowed regions (PSRs). The extreme low temperatures, lack of temperature cycling, and presence of volatiles will likely impact the physical properties of PSR regolith. Such properties are expected to vary laterally and with depth due to variations in mineralogic composition, grain geometry, relative amounts of compaction, impact gardening, and expected ice content [2,3,4].

To safely land in PSRs and perform extraction of volatiles from the regolith, we must design appropriate hardware to operate in that environment. Accurate simulants will be used to test rovers, drills, and excavators in preparation for mission operations, however we do not yet have suitable icy simulants that can be used as proxies for PSR material. Here, we highlight some of the key in situ measurements still required to develop appropriate icy simulants for the research community.

Current knowledge of PSR properties: To date, we have yet to perform in situ studies inside PSRs, aside from the LCROSS impactor that struck Cabeus crater [5]. Results from LCROSS indicate water content of ~5.6 ± 2.9 wt% for that single location. Water concentrations of up to 30 wt% have also been predicted from spectral modelling [6]. Other properties of PSRs have been inferred from remote sensing data, such as relatively high porosities (~70%), and potential increases in bearing capacity [7,8]. However, there remains a significant gap in knowledge of the form, distribution and homogeneity of water ice present in PSRs, and the resultant effects on the geotechnical properties of the regolith.

Icy simulant types: With the limited knowledge of PSR regolith properties, there have been some attempts to infer the physical properties of PSR regolith with icy simulants. It has been shown that as water ice content increases, regolith simulants exhibit higher mechanical strength [9,10]. However, the icy simulants produced for these studies were formed using relatively crude techniques of mixing water and simulant in terrestrial ambient conditions (called 'mud pies'). Icy regolith on the Moon is instead likely formed through vapor deposition in a vacuum, in combination with regolith mixing from micrometeorite impacts. The physical properties of icy lunar regolith and the aforementioned terrestrial icy simulants are expected to be significantly different. Higher-fidelity icy simulants were developed by [11] who performed volatile vapor deposition onto lunar simulant in a vacuum chamber. Vapor deposition is more representative of the conditions expected on the lunar surface, however, it is significantly more complex than the 'mud pie' method and requires investment in large vacuum chambers and for subsequent experiments to be suitable for operation within the chamber.

Latest developments in icy simulants: Newer methods of icy simulant production utilize atomizers to produce a fine mist of water that is incident on liquid nitrogen to form small ice grains [12]. In the case of the in-development icy simulants at the University of Central Florida (UCF) Center for Lunar and Asteroid Surface Science (CLASS) Exolith Lab, using atomizers has resulted in a porous, icy simulant with controllable water-ice concentrations [13]. We plan to perform a series of geotechnical measurements on this simulant such as density, shear strength and pressure-sinkage.

Required in situ measurements: In situ measurements of frozen, volatile-laden lunar regolith will be used to inform icy simulant production, which will then be used to help interpret future in situ measurements and test polar prospecting and excavation technologies. Upcoming missions to the lunar poles, such as the VIPER mission, will provide footpad sinkage and angle of repose measurements [14]. However, further in situ measurements are required to fully characterize PSR regolith, such as the shearing and excavation tests proposed in NASA's MMPACT project [15].

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