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Planning for an Initial Assessment of Volatile-bearing Polar Regolith During Artemis Missions

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Initial assessments of potentially volatile-bearing regolith in small permanently shadowed regions (PSRs; such as a boulder shadow or small crater), or along the edges of larger PSRs on the Moon, should be designed to (i) measure volatiles in their natural state, unaffected or minimally affected by sampling protocols, and (ii) evaluate the modification of volatile substances by impact cratering processes that constantly garden the lunar regolith. Volatile substances, in contrast to rock samples, lend themselves to in situ analyses. Thus, initial analyses using deployable instruments, which have heritage use throughout the solar system, could be used to measure the chemical and isotopic composition of any volatile material. Analyses might be best conducted robotically, rather than by crew with a venting exploration mobility unit (xEMU) system. However, it is also important to note that there is no reported portable life support subsystem (PLSS) contamination of Apollo samples. To understand the context of in situ analyses or of any core sample returned to Earth, a nearby site should be trenched. Ideally, trenching should occur before a site for in situ analyses or core recovery is selected. It is essential to expose subsurface regolith textures to understand the transport, depositional, and modification processes that affected sampled volatile materials. A trench will provide answers to several important questions: Do the abundances and compositions of ices vary along a spatial gradient? For example, do the relative abundances of dry ice and water ice vary with depth or laterally through the regolith? Do ices occur along grain and clast boundaries, in pore spaces, or both? Are ices concentrated along lithologic boundaries, such as the boundary between regolith layers, between ejecta layers, or along faults, that may have been pathways for volatile element movement? Have impact cratering processes produced breccias that mixed ice-bearing clasts with ice-free matrix or vice versa? Did the subsequent thermal equilibration of clasts and matrix cause diffusion of volatile material between those components and through the regolith? Is there any evidence of post-breccia diffusion that might reflect a modified thermal regime due to a modified depth of burial? Observations that allow those questions to be addressed will provide the means to test existing models of volatile evolution in regolith and, thus, the resource potential (RP) of that regolith. Those observations will also greatly enhance the value of any chemical and isotopic analyses. Finally, we note, argon ages of any regolith returned to Earth will provide an important temporal constraint on the geologic evolution of samples and their volatile constituents.

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