LUNAR RECONNAISSANCE AND SITE CHARACTERIZATION AT THE MARIUS HILLS SKYLIGHT.

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Introduction: The Marius Hills volcanic complex in Oceanus Procellarum is noted for its diverse assortment of lava flows, domes, cones, pits, and sinuous rilles [1]. The distinctive geology of this volcanic field prompted its inclusion as a candidate site for an Apollo landing, although ultimately it was not selected [2]. More recently, the discovery of a "skylight" (a lava tube ceiling collapse) in the region by the lunar orbiting satellite SELENE (KAGUYA) once again brought attention to Marius Hills [3]. Lava tubes are potentially important sites for the long-term human presence on the Moon because they provide shelter from surface hazards, including micrometeorites, radiation, extreme temperatures, and dust [4-5]. The discovery of this skylight as well as other skylights or pits on the Moon [6-7] and Mars [8] is compelling motivation for robotic and eventually human exploration missions to these sites for in situ investigations and site assessments to determine viability for habitation and utilization of lunar resources. Therefore, prior to any construction or emplacement of infrastructure, lunar reconnaissance and site characterization is essential [9-10].

Scientific Value: Basic scientific understanding of lava tube skylights is critical for constraining theories about lava-flow thermodynamics and mare emplacement. The layered sequence of basaltic lava flows, combined with their associated pyroclastic deposits, preserves a record of the compositional and mineralogical history of the mantle and is essential for understanding lunar geologic evolution.

Remote sensing measurements are the foundation for understanding the regional geology of the Marius Hills skylight and other lunar pits. Our preliminary analysis prescribed a research plan that includes algorithm development to address (i) multi- and hyperspectral data analysis; (ii) radar data analysis; and (iii) topographical and morphological characterization. Cartographic products derived from these analyses include (i) a mineral resources map, (ii) geomorphologic and surface roughness maps, and (iii) terrain characterization (slope and rock abundance maps). A geomorphological investigation is an essential component of site selection because the characterization of the pit, slopes, and landforms is crucial for determining the location of field traverses and approach routes to the skylight.

Resources and Green Reconnaissance: Permanently shadowed regions of the lunar poles may serve as cold traps for the possible accumulation of volatiles, including water frost and ice [11-12]. It is not known whether lunar lava tubes or caves serve as similar reservoirs, but their potential volatile accumulations may yield valuable deposits of mercury or metal sulfides.

An additional challenge is to preserve these pristine cave environments during first contact from the employed reconnaissance technologies. For example, a "green reconnaissance" approach would employ criteria to minimize site contamination from lunar lander blast ejecta and the fuel exhaust plume. Another green reconnaissance technique would involve descending the pit and entering the cave for the first time in an unobtrusive way. For instance, after autonomously deploying a cable line across the opening from a robotic platform located at the pit edge, an instrument suite would be lowered into the void [13]. LiDAR could collect a 3D point cloud of the lava tube and evolving gas could be detected by a mass spectrometer [14-15] either connected to the cable or placed on the pit rim.

Conclusion: The discovery of lava tube skylights is an incentive for reconnaissance and site characterization studies to determine their feasibility for habitation and their potential proximity to lunar resources. An additional challenge is to balance planetary protection with the technologies necessary for their exploration.

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