POLAR VOLATILES EXPLORATION IN PEARY CRATER ENABLED BY NASA'S KILOPOWER PROJECT.

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Introduction: For more than 50 years, scientists have discussed the possibility of the existence of water ice and other frozen volatiles at the lunar poles [1]. However, it was not until the 1990s when the polar orbiting spacecraft Clementine and Lunar Prospector collected data supporting these hypotheses [2]. Subsequent missions, including the Lunar Reconnaissance Orbiter (LRO) mission [3], and the Lunar Crater Observation and Sensing Satellite (LCROSS) mission [4], provided further evidence that supports the existence of water ice deposits at the lunar poles.

During NASA's Constellation Program, several areas at both lunar poles polar were included in 50 Regions of Interest (ROI) for intensive study by the Lunar Reconnaissance Orbiter Camera (LROC) [5]. These polar ROI focused on peaks and craters rims that received high amounts of solar illumination, assuming initial missions back to the lunar surface would utilize solar arrays to generate electricity.

Recently, the successful demonstration of NASA's Kilopower Project at the National Nuclear Security Administration (NNSA) Nevada National Security Site makes it possible to consider lunar polar missions at locations other than highly illuminated regions. The Kilopower Project was initiated in 2015 to demonstrate subsystem-level technology readiness of a small space fission power system [6]. This abstract describes the science objectives and operations for a mission concept developed at NASA Glenn Research Center's COMPASS Concurrent Engineering Team for a 1-year exploration of Peary Crater focused on prospecting for lunar polar volatiles.

Peary Crater: Peary Crater (diameter 73 km), located near the lunar north pole, has high potential for containing lunar polar volatiles on its crater floor. While parts of the crater floor receive up to 45-60 % illumination during a lunar day in summer [7], smaller craters within Peary remain permanently shadowed [8]. It is these permanently shadowed regions (PSRs) that are of interest for lunar volatiles prospecting, with a proposed landing site of approximately 88.3° N, 36° E (figure 1).

Science Objectives: Based on NASA's Strategic Knowledge Gaps (SKGs) for lunar polar regions [9], and the Lunar Exploration Analysis Group (LEAG) Lunar Exploration Roadmap and recent specific action team reports [10], the primary science objectives for this mission concept are: determine the form and species of the volatile compounds within Peary Crater; determine the lateral and vertical distribution and concentration of the volatile deposits; determine the volatile flux in the near-surface exosphere; and determine any secondary alteration mineralogy of the local regolith. Most of these objectives could be met by a robotic rover with science instruments, subsurface drill, and mobility capabilities similar to NASA's Resource Prospector Advanced Exploration Systems (AES) Project [11]. Understanding the volatile flux could be accomplished at a stationary science station near the lander.

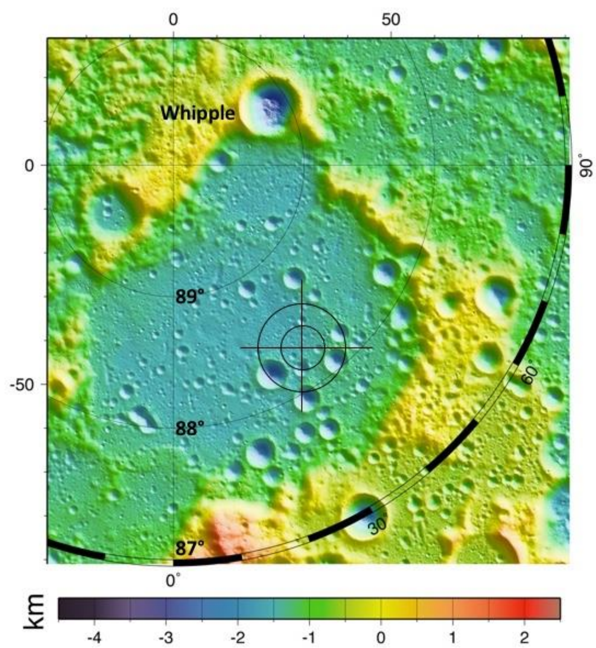

Figure 1 Lunar Orbiter Laser Altimeter (LOLA) topographic map of Peary Crater. Landing site, with inner ring radius of 5 km and outer ring radius of 10 km. From https://lola.gsfc.nasa.gov/feature20110228.html.

Because of the long-lived nature of the Kilopower fission power system, additional primary science objectives based on the National Research Council (NRC) Planetary Science Decadal Survey [12], include the geophysical investigations of seismometry, heat flow, and surface magnetization. These measurements would be made at a stationary science station near the lander.

Science Operations: To address the science objectives, the mission concept involves a long-distance mobile robotic explorer/prospector, and a tethered science station that is deployed 30-m from the lander and connected to the 1-kW Kilopower system that remains on the lander. Once deployed, the fixed science station would include a long-lived geophysical station, volatile flux instrument(s) and an additional communications node located at a distance sufficient to mitigate the radiation environment of the Kilopower system. The mobile robotic rover would explore out to a radius of 5-10 km from the lander, allowing for the assessment of several PSRs and the prospecting for water ice and other volatiles (figure 2). The mobile rover can recharge itself during sunlit conditions using an on-board solar array. During the night, the mobile rover returns to the tethered science station for night power via an inductive charging node. The Kilopower charging station also allows the potential for the mobile rover to perform shorter-duration battery-powered night excursions. A laser-based power beaming technology demonstration is planned, hosted on the tethered service station, that would permit remote charging of the mobile rover within line-of-sight.

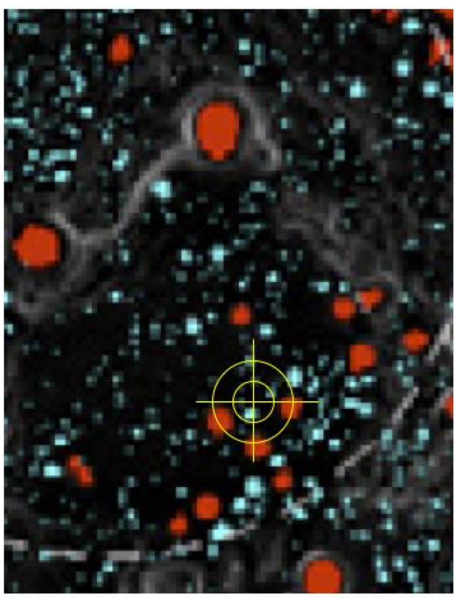

Figure 2 Permanently shadowed regions (PSRs) in Peary Crater. Larger PSRs are shown in red, while smaller PSRs are shown in cyan. Landing site, with inner ring radius of 5 km and outer ring radius of 10 km. From Mazarico et al. (2011).

References:

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