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DIGGING INTO THE FREEZER: EXPLORING THE FLOOR OF AMUNDSEN CRATER – AN ACCESSIBLE PERMANENTLY SHADOWED REGION AND COLD AREAS WHERE VOLATILE ORGANIC COMPOUNDS MAY BE PRESERVED FOR ASTROBIOLOGIC STUDY. N. E. Petro and C. J. Ahrens; Planetary Geology, Geophysics, and Geochemistry Lab, NASA GSFC, Greenbelt, MD 20771

Introduction: The lunar south pole represents an extremely unique environment with everything from areas of permanent shadow, areas of extended illumination, and regions of extreme cold [1]. While much of the interest around the volatiles present at the south pole involve those materials that can be used for resources (*e.g.*, water for cooling, hydration of crew, rocket fuel), there is an additional benefit for exploring the volatile inventory of the south pole, specifically sampling organic compounds that are stable at very low temperatures [i.e., 2, 3]. Here we identify a candidate area on the floor of Amundsen Crater that maintains a low temperature even while illuminated [4] and is also proximal to a region of permanent shadow that could be accessible *via* a rover.

Landing Area(s): The floor of Amundsen crater, particularly the northern rim of the crater, is in permanent shadow (Figure 1). An example site that receives some amount of sunlight, but in an area < 100 K continually is near 83.8° South, 88.1° East. Sunlight at this site is sparse, occurring only ~1% (~60 days) of the time over an 18.6-year cycle. The deep cold of this region, between 60 – 70 K, allows for volatile organic compounds (VOCs) to remain stable at the surface and near surface.

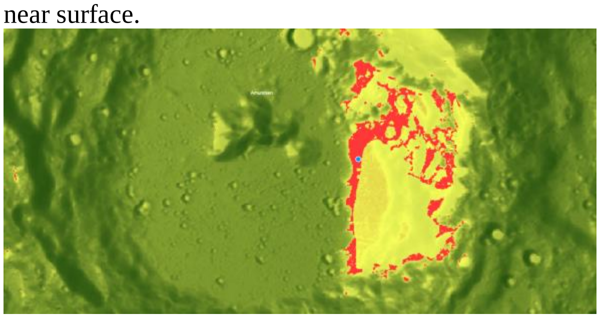

Figure 1. Lunar QuickMap view of Amundsen Crater, showing maximum polar summer temperature (areas in yellow are below 100K) with the region that is both flat (slopes <15°), cold (<100K), and illuminated by the Sun for a brief period in red.

Science Objectives: A mission to this area should measure any activated volatiles, and/or measure materials condensed onto the regolith. The overarching goal of such a mission is to investigate the nature (composition, abundance, variation as a function of temperature) of volatiles within illuminated and unilluminated surfaces. The identification of multiple volatiles with stabilities at low temperature will enable testing of hypothesis of delivery mechanisms/sources [3].

Lunar Astrobiology?: The measurement of VOCs is a goal of astrobiology, to identify materials and their possible sources which may trace to early solar system processes [1, 3]. It is **not** about finding life itself, more the building blocks and/or ingredients for life. Such VOCs that may survive at such extreme temperatures at Amundsen Crater < 100 K, especially the deep cold regions < 70 K, include formaldehyde (CH_2O) [5]. Other volatiles that may be linked to the behavior of VOCs with other volatiles include methanol and hydrogen sulfide [6].

Required and Desired Capabilities: The nature of this mission requires operations in cold regions (<100K) and potentially in the dark. Such a mission could be done via *in situ* measurements or *via* sample return, if coupled with cold storage. This mission would benefit from a rover, however measuring volatiles heated off the surface by either natural or induced temperature variations on a static lander done rapidly after landing would be ideal. A rover would enable sampling regions outside of the blast zone, and traverse deeper into the large area of permanent shadow (Figure 2).

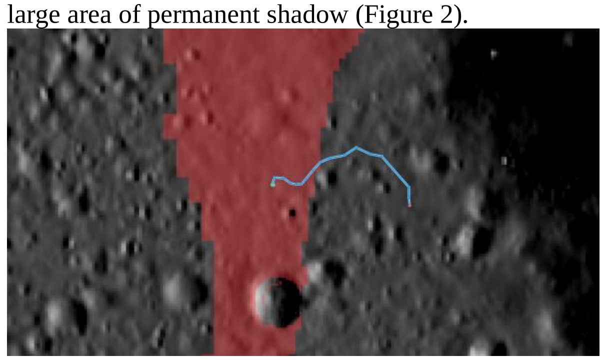

Figure 2. Notional 3.6 km traverse from landing site (Fig. 1) to a region inside the permanently shaded region on the floor of Amundsen with slopes <6°. Developed in the Lunar QuickMap tool.

References: [1] NASA, (2020) Artemis III Science Definition Team Report, SP-20205009602; [2] Fisher, E. A., et al., (2016) Search for Lunar Volatiles Using the Lunar Orbiter Laser Altimeter and the Diviner Lunar Radiometer, 47, 2574; [3] Zhang, J. and D. Paige, (2009) *GRL*, 36; [4] Williams, J.-P., et al., (2019) *Journal of Geophysical Research: Planets*, 124; [5] Fray, N. and Schmitt, B. (2009) *PSS*, 57 (14-15); [6] Mitchell, J., et al. (2018) Lunar Polar Volatiles Workshop, Abstract 5014, LPI.