LUNAR SURFACE TRAVERSE AND EXPLORATION PLANNING: FARSIDE LOCATIONS.

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Introduction: We are systematically assessing (from both scientific and operational perspectives) locations on the Moon [1] considered to be likely locations for near-term robotic precursor missions. In order to maximize the practical utility of the research, our goals are directly traceable to three generalized examples of robotic missions (short-duration rover, long-duration rover, and automated sample return) that have been recommended as desirable precursor missions [2]. However, the results of this study will also be applicable to future human lunar exploration.

Our previous efforts have focused on nearside sites of high-near term exploration potential, but an optimized lunar exploration program will include farside locations of high scientific interest, where exploration will provide important new information about the composition of the lunar crust and the temporal evolution of lunar volcanic processes. One prime example of a geologically complex far side exploration site is the Dewar geochemical anomaly.

Background: Dewar (Fig 1.) is an Imbrian-age crater with a diameter of approximately 50 km, located north of the South Pole-Aitken (SPA) basin [3]. An anomalous area exhibiting low albedo materials can be discerned northeast of the crater. This low albedo area correlates with an area of enhanced FeO, TiO_2, and thorium abundance, which [3] concluded were ancient buried mare basalts, also referred to as “cryptomare”. The mode of emplacement for a small mare basalt deposit in this farside location remains poorly understood, and for this region, Dewar was a Constellation Region of Interest [4]

Dewar is an example of a geologically complex field location where sample return, possibly enhanced by a limited-duration rover, will provide new science and exploration results (Fig 1). Dewar is also a relatively representative area in the central far side highlands, rendering the systematic assessment methodology here generically relevant to a variety of far side exploration tasks.

Methods: We are fusing LROC (NAC, WAC, and DTMs), Diviner, and LOLA datasets with Moon Mineralogy Mapper (Chandrayaan-1), Kaguya Terrain Mapping Camera, Clementine, and Apollo Metric Camera frames. The integrated datasets are being used to determine important lithologies and geologic units, identify productive exploration locations and resources such as pyroclastic deposits, and then identify candi-

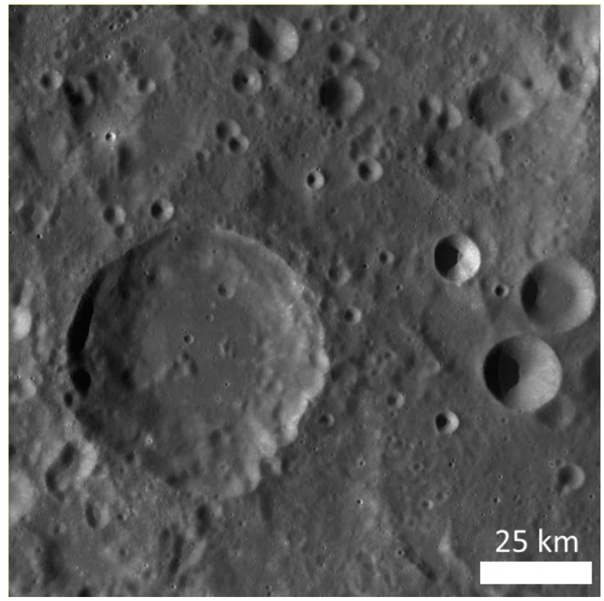

Figure 1: Wide Angle Camera (WAC) of Dewar crater and environs.

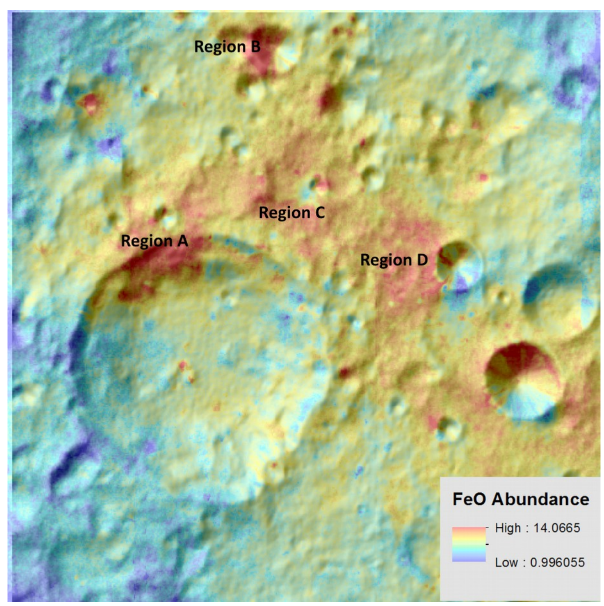

Figure 2: Clementine-derived FeO Abundance Map overlaid upon a GLD100 synthetic hillshade data product.

date landing sites. LROC DTM datasets are being used to assess the accessibility of each site in terms of the Terrain Ruggedness Index [5] and slopes. Finally, we have developed a preliminary path planning algorithm [6] based on a generalized least-energy model for planetary rovers, altered for the lunar use case [7]. This algorithm identifies least energy traverse paths and allows us to determine capabilities (rolling resistance, turning capability, maximum slopes) that are required to reach specific targets.

Results: The key science goal of exploring the Dewar region is determining the composition of the cryptomaria exposed by the Dewar satellite impact craters, making this an ideal candidate location for automated sample return. Cryptomaria exposures can be straightforwardly distinguished through the Clementine FeO abundances. Accordingly, through our data fusion process, we selected four candidate regions of interest (Figure 2) for automated sample return based on the accessibility of the basalt exposures (Table 1). Accessibility analysis of the morphometric properties of the four candidate regions of interest indicated that, in general, Site D offered the most accessible locality for the exposed cryptomaria. Site D is also partially includes a Constellation Region of Interest, so the full range of Constellation data products can therefore be leveraged for a rigorous science operations assessment.

Analysis of the LROC Narrow Angle Camera DTMs identified three sites within Region D (Figure 3) where automated sample return could be reasonably executed. Sample return from these locations will require autonomous landing technology capable of executing a landing within a well-defined 2-km diameter region of interest. Additionally, while near-side locations are more feasible short-term destinations for surface exploration, the importance of far side targets like Dewar means that technologies required to enable far-side communication must remain part of the exploration roadmap moving forward.

References: [1] S. J. Lawrence et al. (2014) LPSC 45, Abstract 2785. [2] LEAG (2011) “Lunar Exploration Roadmap”. [3] S. J. Lawrence et al. (2008) doi:10.1029/2007JE002904 [4] Gruener and Joosten (2009) LPI Contrib. 1483, p. 50-51. [5] M. F. J. Wilson et al. (2007) Mar. Geod., 30, 1–2, 3–35. [6] E. J. Speyerer et al. (2013) LPSC 44 1745. [7] G. Ishigami et al. (2007) 2007 IEEE International Conference on Robotics and Automation, pp. 2361–2366.

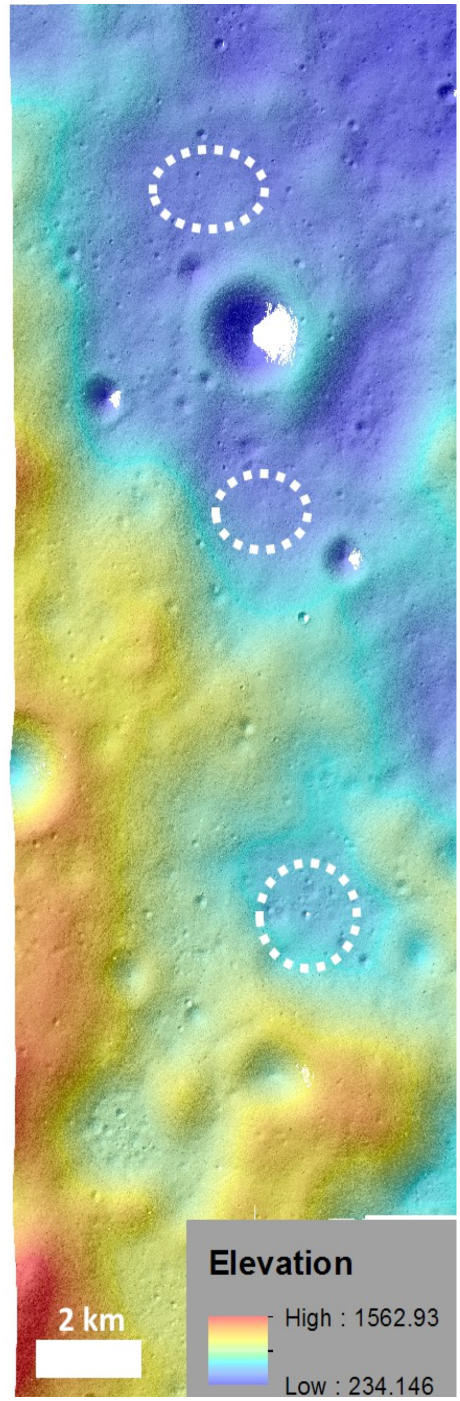

Figure 3: NAC DTM with recommended candidate automatic sample return locations highlighted.

Table 1. Physical Parameters of Notional Dewar Region Scientific Regions of Interest

Location	Mean FeO (wt %)	Max FeO (wt %)	Mean DRA	Mean TRI	Mean WAC Slope	Max WAC Slope
Region A	8.785	14.067	3.745	14.164	10.34	26.66
Region B	11.067	12.474	3.519	10.743	7.91	18.7
Region C	10.665	13.631	4.199	11.064	8.05	25.87
Region D	11.283	13.482	3.216	5.9	4.35	17.82