GEOLOGICAL EVA SCIENCE AMONG IMPACT CRATERS AND PERMANENTLY SHADOWED REGIONS NEAR A SUMMIT RIDGE ON MALAPERT MASSIF.

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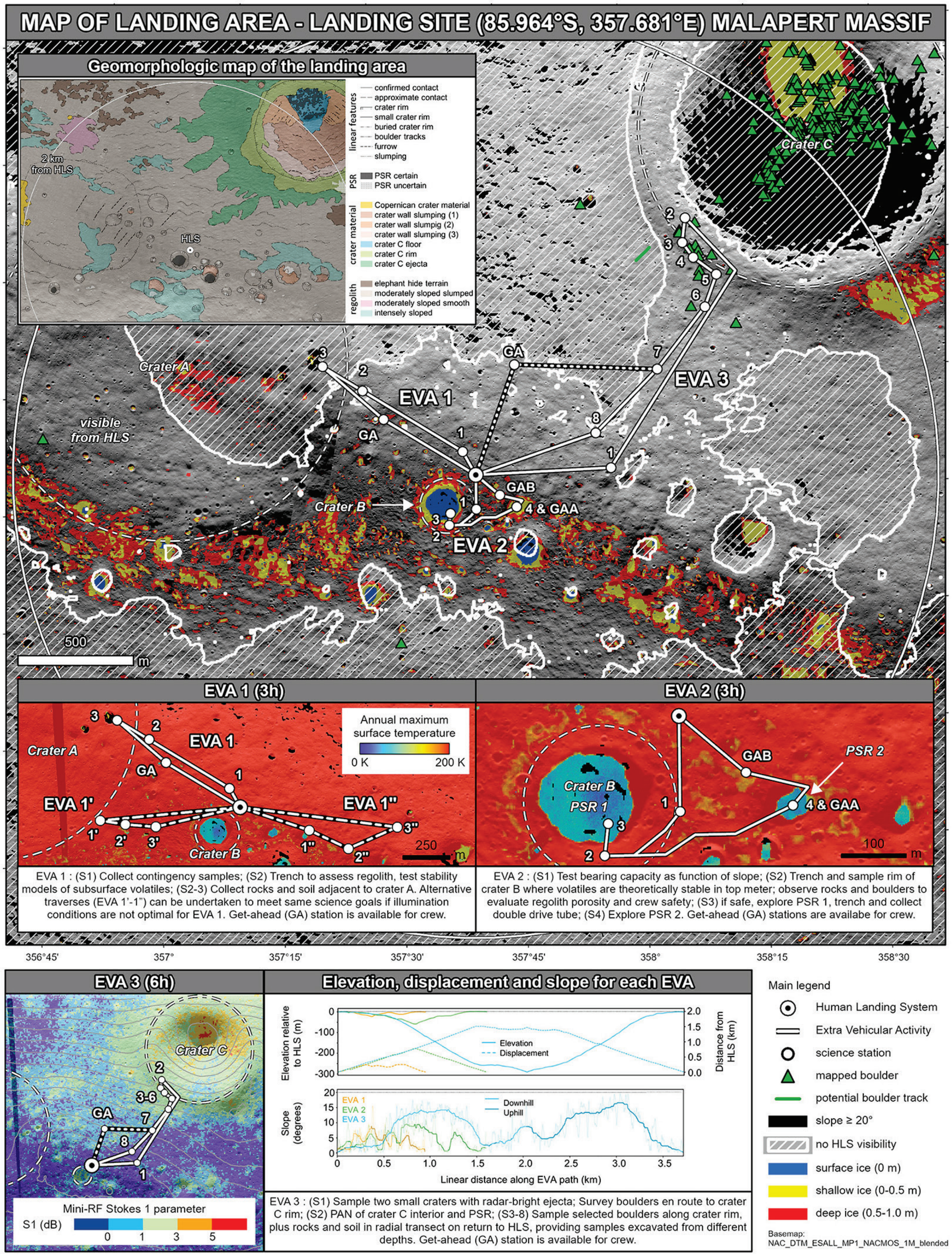
Geological Extravehicular Activity (EVA) Plan: We conducted an analysis of a Malapert summit ridge landing site (**Fig. 1**) with three geologic traverses: EVA1 (3 hr, 1.28 km, 3 stations, 11 samples) surveys the landing site, recovers SPA and post-SPA massif material, and tests thermal stability models of polar volatiles; EVA2 (3 hr, 0.95 km, 4 stations, 13 samples) recovers volatiles within the two coldest permanently shadowed regions (PSRs); and EVA3 (6 hr, 3.7 km, 8 stations, 19 samples) radially examines chronologically-sequenced crater ejecta for crustal lithologies and impact melt deposited by SPA and younger impact events. Those traverses were augmented with alternative traverses to accommodate modified lighting conditions generated by potential launch delays and with get-ahead (GA) stations following NASA EVA scheduling protocols. Spacecraft data were processed to produce a series of maps: LRO hillshade, topography, slope, and terrain ruggedness index, all at 2m/px; an LROC mosaic with boulders and PSRs at 1m/px; Mini-RF radar backscatter; bearing capacity; surface temperature; thermal models of water and dry ice accessibility within 2 m of the surface; Earth visibility for communication; and lander visibility for safety. LROC images were also post-processed to show craters, boulders, and regolith textures within PSR interiors.

Massif Geology: A geologic analysis of Malapert massif indicates it is a block of crust that was uplifted and rotated by the SPA impact, then covered with SPA ejecta that forms the dip slope of the massif, and then covered again by a series of post-SPA ejecta units. Post-SPA ejecta units are relatively thin due to smaller impact events and because the horizontal component of ballistic ejecta emplacement carried ejecta downslope off the summit region. An analysis of 11,000 craters indicates those >1.3 km in diameter reflect a 4.16 to 4.20 Ga massif age, consistent with SPA, while smaller craters indicate an ~3.84 Ga age, consistent with Imbrian resurfacing.

EVA Constraints: EVA paths maintain visibility with the lander, are within 2 km of the lander, do not exceed 20° slope, are traversed with speeds that do not exceed 2 km/hr based on Apollo and recently obtained NASA EVA data that account for slope, distance between stations, and complexity of traverse activities. A detailed photodocumentation regimen was designed based on tests using a Nikon Z9 camera.

Geologic, Volatile, and Physical Property Sampling: EVA1 recovers a contingency sample (station S1); regolith, breccia, and crystalline rock samples from SPA and post-SPA ejecta (S2-3); a trench sample (S2) from ~50K regolith that may have H_2O and CO_2 ice, S-species, and C-based molecules; and a second contingency sample per the Artemis 3 Science Definition Team Report (SDTR) (S3). EVA2 expands massif sample diversity (S1); trenches and samples a crater rim where dynamic spillage from a crater floor PSR may deposit volatiles (S2); trenches and collects a double-drive tube within the PSR (S3) that, at ~35K, may have H_2O and CO_2 ice, S-species, ammonia, carboxylic acids, linear amides, aromatic hydrocarbons, simple organics, and clathrates; and samples a second PSR (S4). EVA3 samples a small radar-bright crater (S1); provides a panoramic surface image of the largest PSR (S2); and provides a survey of boulders, boulder tracks, and regolith radially distributed around a Meteor Crater-size crater that, because it formed on a slope, provides a foreshortened (and, thus, very efficient) sampling of subsurface lithologies (S2-8). Stations have different estimated bearing capacities and thermal histories, so regolith sampling and photography can be used to evaluate physical property models.

Mission Outcomes: The geologic plan addresses 7 science goals, 25 science objectives within those goals, and 90 specific investigations of varying priority in the Artemis 3 SDTR (43 high-, 40 medium-, 2 medium-high-, and 5 low-priority investigations); *e.g.*, test and reveal new details about the lunar magma ocean hypothesis, the basin-forming epoch and implications for Solar System architecture, sources and distribution of volatiles, and regolith physical properties relevant to human and robotic exploration.



EVA 1 : (S1) Collect contingency samples; (S2) Trench to assess regolith, test stability models of subsurface volatiles; (S2-3) Collect rocks and soil adjacent to crater A. Alternative traverses (EVA 1'-1") can be undertaken to meet same science goals if illumination conditions are not optimal for EVA 1. Get-ahead (GA) station is available for crew.

EVA 2 : (S1) Test bearing capacity as function of slope; (S2) Trench and sample rim of crater B where volatiles are theoretically stable in top meter; observe rocks and boulders to evaluate regolith porosity and crew safety; (S3) if safe, explore PSR 1, trench and collect double drive tube; (S4) Explore PSR 2. Get-ahead (GA) stations are availabe for crew.

EVA 3 : (S1) Sample two small craters with radar-bright ejecta; Survey boulders en route to crater C rim; (S2) PAN of crater C interior and PSR; (S3-8) Sample selected boulders along crater rim, plus rocks and soil in radial transect on return to HLS, providing samples excavated from different depths. Get-ahead (GA) station is available for crew.

Figure 1. Map of EVAs 1, 2, and 3 around a candidate Human Landing System (HLS) landing site near a summit ridge on Malapert massif. Water-ice-stability areas (top panel) are modeled depths to be tested by EVAs.