ARTEMIS 2024: POTENTIAL EVA TARGETS AT THE LUNAR SOUTH POLE. C. M. Gilmour[1], A. J. Gawronska[2], N. Barrett[3], S. J. Boazman[4,5], S. H. Halim[6], Harish[7], K. McCanaan[8], A. V. Satyakumar[9], J. Shah[10] and D. A. Kring[11,12]. [1]York University, Toronto, Canada (email: cgilmour@yorku.ca). [2]Miami University, Oxford, OH, USA. [3]University of Alberta, Edmonton, Canada. [4]Natural History Museum, London, UK. [5]University College London, UK. [6]Birkbeck, University of London, UK. [7]Physical Research Laboratory, India. [8]University of Manchester, UK. [9]CSIR – National Geophysical Research Institute (CSIR-NGRI), India. [10]The University of Western Ontario, London, Canada. [11]Lunar and Planetary Institute, Universities Space Research Association, Houston, TX, USA. [12]NASA Solar System Exploration Research Virtual Institute.

Introduction: The lunar south pole is the destination for NASA's 2024 Artemis mission. The south polar region has large topographic variations, resulting in areas of near constant illumination juxtaposed with permanently shadowed regions (PSRs) (Fig. 1; [1]). Areas of high illumination are sought for solar power, while PSRs may preserve volatile species for *in situ* resource utilization (ISRU) (e.g., [2]) and for addressing several scientific objectives [3].

The south pole lies on the rim of Shackleton crater, a morphologically simple crater with a diameter of 21 km and depth of 4.1 km (Fig. 1). Shackleton is of early Imbrian age, is within the South Pole-Aitken Basin (SPAB), and crosscuts a ridge that may have been produced by the SPAB impact [4]. Therefore, Shackleton crater may expose crustal material affected by the SPAB impact event. Sampling impact melts, ejected boulders, and regolith can provide a record of the geological processes that shaped the south polar region [5]. Shackleton appears to expose purest anorthosite (PAN; [6]), which was likely distributed within its ejecta blanket during the crater forming event. Here we explore those extravehicular activity (EVA) options with a more detailed analysis of potential sample targets. These targets may provide clues about volatile resources on the Moon, the SPAB impact forming event, lunar crustal differentiation, and the lunar magma ocean hypothesis.

Data and Methods: A combined photogeological and topographic survey of the south polar region was conducted using data from the Lunar Reconnaissance Orbiter (LRO) [7-9]. A Lunar Orbiter Laser Altimeter (LOLA) 5-m scale digital elevation model (DEM) was used to create topography maps and LOLA-derived slope maps of the south polar region. LRO Camera (LROC) Narrow Angle Camera (NAC) images with ~0.5 to 1.2 m/pixel resolution and ~87° to 91° incidence angle were used to identify outcrop scale features.

Boundaries: EVA sample opportunities will be bound by the range and slope limits of a mission. We consider two boundaries: unassisted EVAs that are limited to a 2 km radial distance on terrains with slopes <15°; and rover-enabled EVAs expanded to 10 km and 25° slopes [10,11]. Two and 10 km radial boundaries were selected around the south pole and two points of high illumination in the region (Fig. 1). The rim crest of Shackleton crater is effectively another boundary, as the crater walls are too steep to safely navigate.

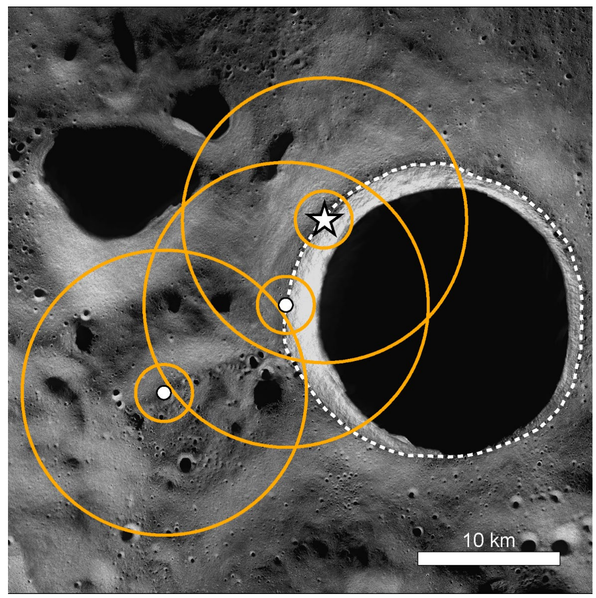

Fig. 1. Averaged NAC mosaic (*Moon Trek*) showing 2 and 10 km radial boundaries around the south pole (white star). Two additional points of highest illumination (white circles) [1] are shown: one on the rim of Shackleton (89.78°S, 155.73°W), and one on the intersecting ridge (89.45°S, 137.31°W).

EVA Targets: Thirteen potential EVA targets have been identified; 11 within the south pole radial boundaries and two within the 10 km boundary of the highest illumination point on the rim. These targets consist of rock exposures, boulders, and craters. Figure 2 shows the locations of representative targets on slope maps.

Boulders are scattered throughout the ejecta blanket of Shackleton and commonly found in abundance near small, superimposing craters (Fig. 3a,b). Most boulders and rock exposures in the region have high albedo, which may be ejecta from PAN also exposed in the crater wall (e.g., [6]) or some other highland lithology. High-albedo rock exposures (~20 to 200 m sizes) may be larger blocks of those crystalline crustal components (Fig. 3b,c). Dark boulders have also been identified (Fig. 3d), suggesting that the Shackleton region is composed of heterogenous material. Of the rock exposures identified for EVA, one location may host a PSR (Fig. 3e), although additional study is needed for confirmation. If this site is indeed a PSR, the location will be significant for volatile investigations. Other PSRs are predicted along the rim of Shackleton and throughout the region based on LOLA data.

Small craters around the Shackleton region can be used to probe the subterranean structure, because samples from craters of different diameters will provide material from different depths [12]. Additionally, regolith samples can be used to investigate weathering process on airless bodies [13].

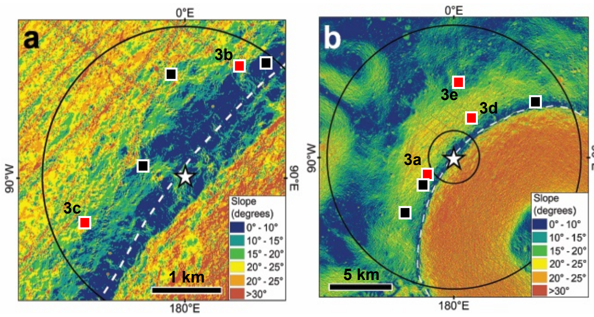

Fig. 2. Slope maps of the south pole region with the locations of the potential EVA targets (black and red squares). The red squares and IDs correspond to the EVA targets in Fig. 3. (a) 2 km radial exploration zone. (b) 10 km radial exploration zone.

Discussion and Conclusions: Slope maps reveal that the rim of Shackleton has average slopes <15°; however, the majority of EVA targets occur on the flanks of the ejecta blanket where slopes exceed 15° (Fig. 3). Therefore, a rover would be a valuable asset to the Artemis mission.

Observing and sampling large exposures of PAN would provide an opportunity to assess its role in the differentiation of the Moon and subsequent periods of magmatism [6,14,15]. Moreover, the units appear to have been derived from massive exposures of crystalline rock in a massif uplifted by the SPAB impact event [16]. As such, the samples will provide clues about the consequences of the SPAB impact event [3,4]. For all those reasons, the high-albedo boulders and rock exposures are among the highest priority targets for EVA.

Sampling of small PSRs is also possible and important for assessing models of volatile sources, transport, and deposition that address scientific objectives [3] and help resolve ISRU uncertainties. We note that any small PSR is likely a young geologic feature and, thus, a vessel dominated by solar wind-derived volatiles rather than older sources of volatiles [5].

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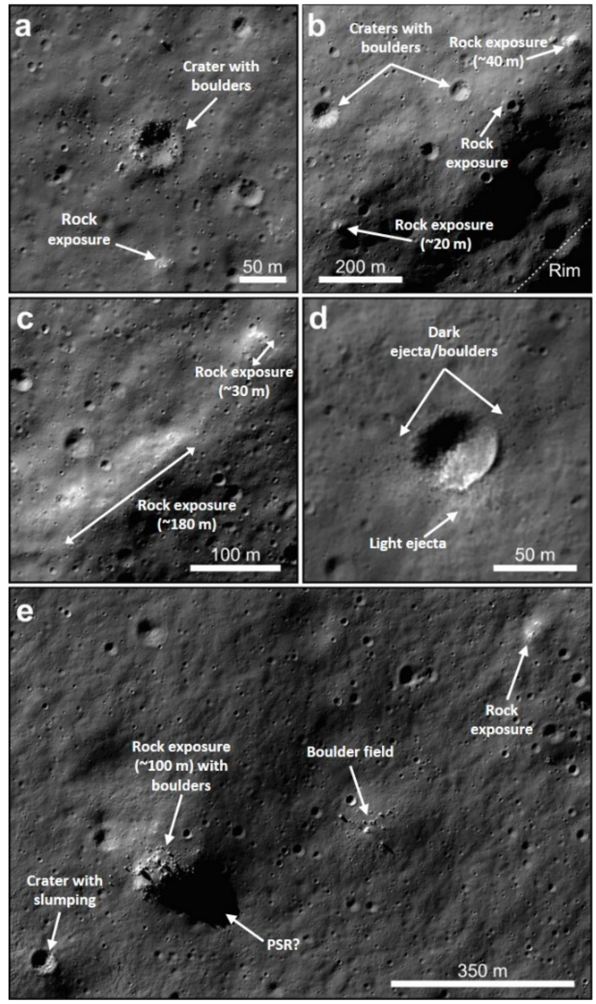

Fig 3. Potential EVA targets in the 2 km and 10 km radial boundaries from the south pole. Refer to Fig. 2 for locations.

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