ANCIENT LUNAR MANTLE EJECTA PRESERVED ON THE LUNAR FARSIDE. D. P. Moriarty[1,2], N. E. Petro[1,2], R. N. Watkins[3], S. N. Valencia[1,2], J. D. Kendall[1,2], N. Dygert[4], and J. T. Keane[5], [1]NASA Goddard Space Flight Center, Planetary Geology, Geophysics, and Geochemistry Laboratory [daniel.p.moriarty@nasa.gov], [2]Center for Research and Exploration in Space Science and Technology, University of Maryland, [3]Arctic Slope Regional Corporation Federal/NASA Headquarters, [4]University of Tennessee, Knoxville, [5]NASA Jet Propulsion Laboratory.

Science Objectives: For several decades, the nature of thorium anomalies associated with the South Pole – Aitken Basin (SPA) on the lunar farside has been debated [1-3]. Recently, integrated remote sensing analyses incorporating mineralogy, elemental chemistry, impact models, geologic context, and dynamical models of early lunar evolution suggest that observed thorium-bearing materials are ancient mantle ejecta excavated during the SPA-forming impact [4].

The lunar sample collection does not currently include any confirmed mantle materials [5]. Therefore, identifying, sampling, and characterizing mantle materials is among the highest priorities in lunar science [6]. This will enable scientists to address a broad range of fundamental, high-priority planetary science relevant to primary differentiation, thermal evolution, and hemispherical dichotomies. SPA Th-bearing materials currently represent the highest-confidence exposures of lunar mantle materials currently preserved on the surface.

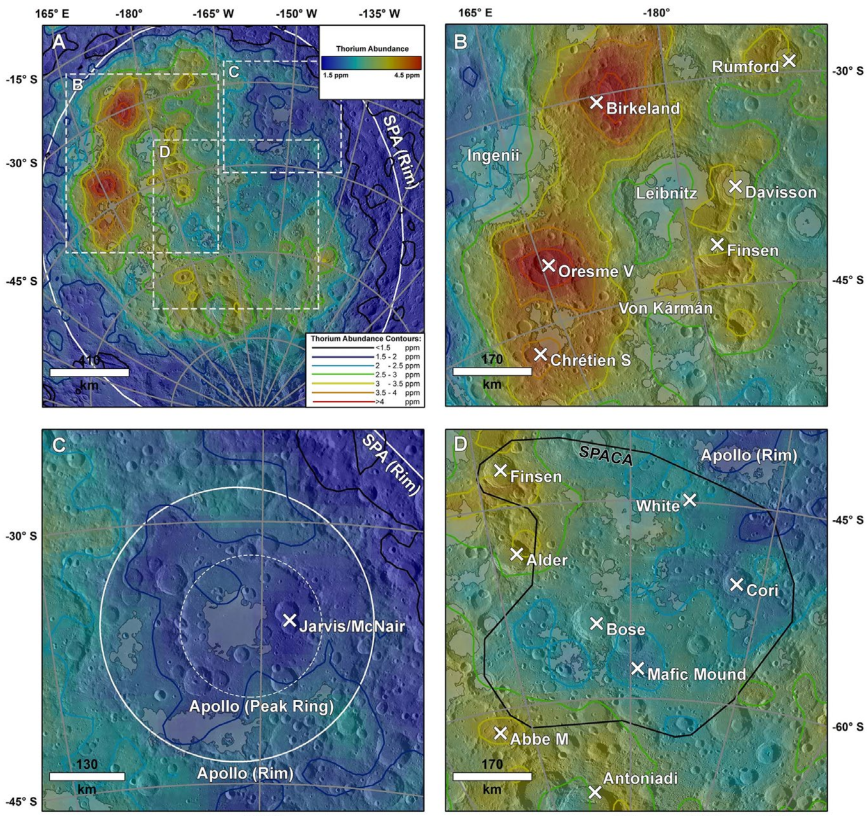

Fig. 1: Thorium abundance[7] across the South Pole – Aitken Basin reveals the distribution of ancient KREEP-bearing mantle ejecta[4]. Notable features are labeled, and mare basalts are shaded grey[8].

Proposed Landing Areas: SPA is ~4 gyr or older, and its ejecta blanket was subject to billions of years of subsequent geological evolution, resulting in significant dilution and obscuration[4]. However, geologically recent impacts have re-excavated SPA mantle ejecta from beneath the mixed and diluted regolith, resulting in a pattern of local Th maxima across SPA (Fig. 1). The two highest-abundance Th hotspots are associated with the ejecta of Birkeland and Oresme V craters in NW SPA. These represent the most attractive landing sites for obtaining ancient SPA mantle ejecta. However, these sites are not the only options. Based on Th abundance maps [4,7], mantle ejecta is present (although at lower surface abundances) within a ~2000 km crescent-shaped distribution. Several second-tier local maxima in Th ("warmspots") are also likely to host significant SPA mantle ejecta at the surface. These include Finsen, Abbe M, Chretien S, and Rumford. Conversely, resurfacing deposits that obscure mantle ejecta (such as mare basalts, the SPA Compositional Anomaly (SPACA), and Mafic Mound [8-10]) are associated with local Th minima. Large basins (Apollo, Ingenii) appear to have completely excavated through the SPA ejecta blanket and are associated with low Th.

Required Capabilities: Because mantle materials are not currently represented in the lunar sample collection, these are highest-priority samples that justify sample return of at least 1 kg of >1 cm rocklets, enabling analyses in a full suite of terrestrial laboratories with diverse capabilities.

Acknowledgments: Work supported by NASA under award number 80GSFC21M0002. Lunar Prospector data hosted by the PDS was used in Fig. 1.

References: [1]Stuart-Alexander (1978), *USGS* **1047.** [2]Lawrence et al. (2000), *JGR* **105,** [3]Hagerty et al. (2011) *JGR* **116**, [4]Moriarty et al. (2021) *JGR* **126,** [5]Shearer et al. (2015), *MAPS* **50,** [6]Moriarty et al. (2021) *NCOMMS* **12**, [7]Lawrence et al. (2002), *LPSC* **1970,** [8]Nelson et al. (2014), *LPSC* **2861,** [9]Moriarty and Pieters (2018), *JGR* **123** [10]Moriarty and Pieters (2015) *GRL* **42.**