MINERALOGICAL DIVERSITY OF THE ARTEMIS EXPLORATION ZONE. D. P. Moriarty[1,2,3] and N. Petro[1], [1]NASA GSFC (8800 Greenbelt Rd, Greenbelt MD, Daniel_Moriarty@NASA.gov), [2]University of Maryland, College Park, [3]Center for Research and Exploration in Space Sciences.

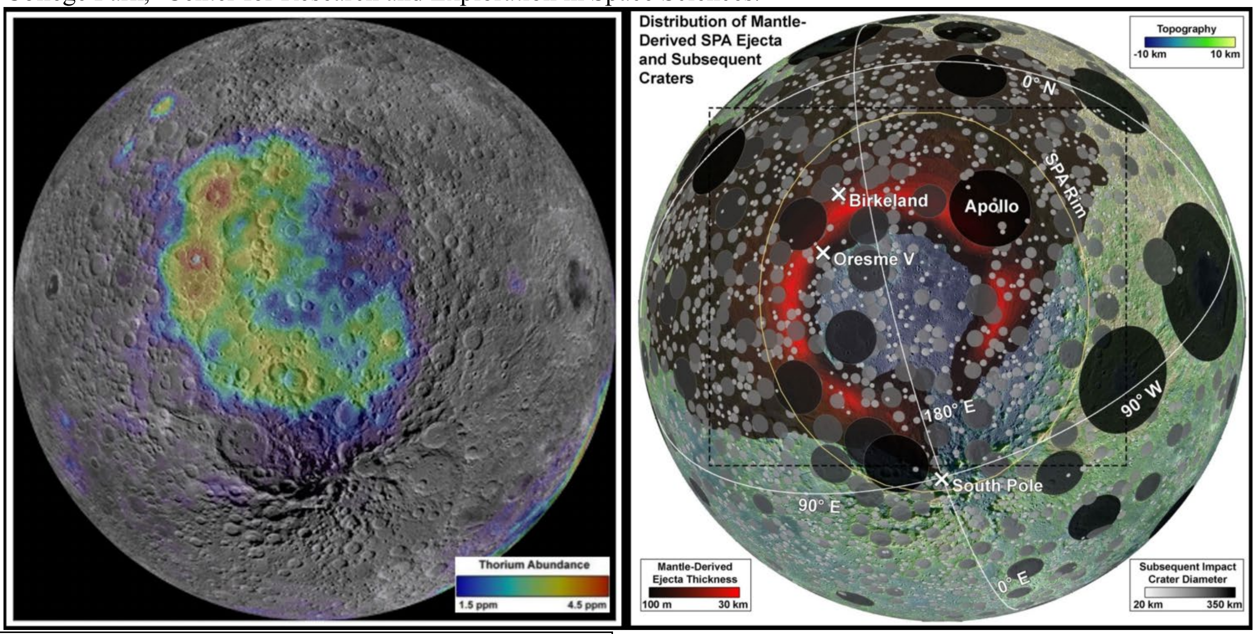
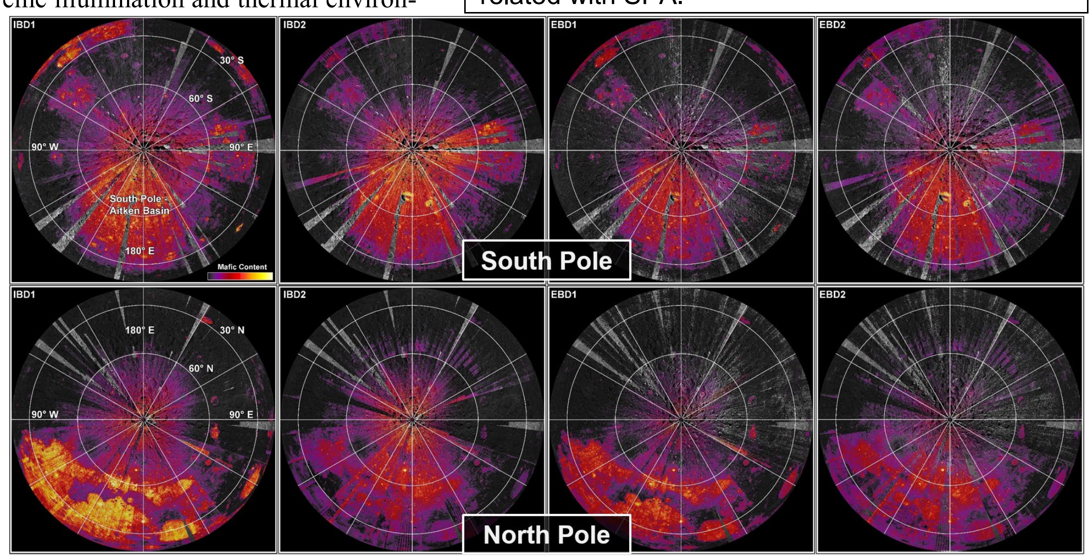


Fig. 1: Th is a possible tracer of late-stage lunar magma ocean cumulates, and its distribution across SPA(left) [1] closely matches the expected distribution of mantle materials ejected by SPA [2] and modified by subsequent impact events (right) [3]. Small elevations in Th persist across the Artemis exploration zone.

Introduction: Within the next decade, humans will return to the Moon via NASA's Artemis Program. A driving goal of this program is to establish a sustained presence at one or more sites near the lunar south pole. Artemis astronauts are expected to participate in a diverse suite of scientific investigations, many of which leverage the extreme illumination and thermal environment at the lunar poles [4]. The Artemis exploration zone is also relevant to geological investigations providing new insight into fundamental planetary processes. Specifically, Goal 1b of the Artemis III Science Definition Team Report [4] is to probe planetary differentiation and evolution processes including formation of a magma ocean, crust, mantle, and core.

Artemis astronauts will address this goal in several ways. The lunar south pole is set within highlands crustal terrane far-removed from previous lunar sample return missions (e.g., the Apollo and Luna programs). Sampling local crustal material will provide important insight into ancient crust-building processes (i.e., differentiation of the lunar magma ocean).

Fig. 2: Integrated band depth and band depth parameters for the north and south poles indicate the presence of mafic minerals at the south pole correlated with SPA.



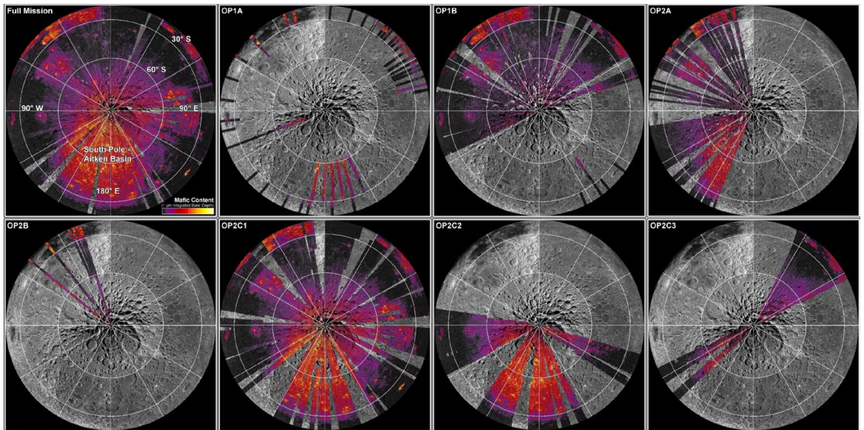


Fig. 3: 1 micron integrated band depth for the south pole across each M^3 mission phase.

Ejecta from nearby impact basins will provide further insight into a wider range of planetary processes. Specifically, the lunar south pole is in the vicinity of the ~2000 km South Pole – Aitken Basin (SPA), the oldest and largest impact structure preserved on the Moon. Due to its size, age, and unique geophysical properties, SPA impact melt and ejecta samples are critical to unraveling lunar differentiation, the interior structure of the lower crust and upper mantle, and lunar chronology.

SPA ejecta is associated with pronounced geochemical and mineralogical signatures, including Th, Fe, Ti, KREEP, and high-Ca pyroxene elevated relative to the surrounding highlands [3]. These compositional properties are consistent with exposure of late-stage lunar magma ocean cumulates. These ancient mantle materials excavated by SPA are concentrated in the NW quadrant of the basin, downrange from the impact [2,3]. However, the relevant compositional signatures are also observed across the southern region of the basin, encompassing the lunar south pole.

Using these compositional properties as a guide, Artemis astronauts will be able to identify and return candidate lunar mantle materials for detailed analyses in terrestrial laboratories. Detailed remote sensing analyses of the Artemis exploration zone is a critical precursor providing essential context for mission planning and interpretation of *in situ* analyses and returned samples.

Data and Observations: Moon Mineralogy Mapper (M^3) [5] data offer the highest combined spatial and spectral resolution measurements of the lunar surface, with near-global coverage at ~100-250 m/pixel with 85 spectral channels from 430 to 3000 nm. Passive optical instruments such as M^3 require incident illumination from an external light source (*i.e.*, the sun). At high latitudes, lighting conditions and geometry pose challenges, exacerbating artifacts from photometry and signal-to-noise (SNR). Conversely, M^3's polar orbit enabled numerous overlapping observations of the Artemis exploration zones across several mission phases (with different illumination conditions, detector temperatures, and orbital altitudes).

Using 1 km/pixel global mosaics with improved SNR for a regional characterization, the lunar south pole is associated with elevated 1 and 2 micron absorption band depths indicating the presence of mafic minerals (Fig. 2). This enhancement is correlated with SPA, consistent with excavation of deep mafic materials.

The validity of this observation is established in several ways. The mafic enhancement is observed in both the depth and integrated band depth of both the 1 and 2 micron absorption features (Fig. 1). The mafic signature is significantly stronger at the south pole than the north pole, indicating that this is not simply a latitude-related artifact. Furthermore, this signal is observed across every mission phase, and is therefore independent of orbital altitude/geometry and detector temperature.

For each of the 13 candidate Artemis regions (Table 1), multiple M^3 observations are available at full spatial resolution with differing illumination conditions and orbital altitudes. This enables a detailed characterization of the mineralogical diversity of each candidate region. Uncertainties in M^3's orbital geometry result in variable misregistration to LRO data, resulting in photometric errors and precluding stacking overlapping frames to improve SNR. However, recalibration efforts recently proposed to NASA would greatly improve M^3 data quality globally, and especially at high latitudes.

Table 1:

Region	# of M3 Observations
Amundsen Rim	8
Connecting Ridge	108
Connecting Ridge Extension	128
de Gerlache Rim	111
de Gerlache Rim 2	89
de Gerlache-Kocher Massif	28
Faustini Rim A	24
Haworth	28
Leibnitz Beta Plateau	13
Malapert Massif	18
Nobile Rim 1	16
Nobile Rim 2	14
Peak Near Shackleton	52

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References: [1]Lawrence *et al.*, (2003), *J. Geophys. Res. Planets*, vol. 108, no. E9. [2]Melosh *et al.*, (2017), *Geology*, vol. 45, no. 12,[3]Moriarty *et al.*, (2020), *J. Geophys. Res. Planets*.[4]Weber *et al.*, in *Lunar and Planetary Science Conference*, 2021, no. 2548.[5]Green *et al.*, (2011), *J. Geophys. Res.*, vol. 116.