**Impact Resurfacing of the Artemis Exploration Zone: Sample Locations for Primordial Crust, South Pole-Aitken (SPA) and Post-SPA Ejecta.**

**Introduction:** The Artemis program will initially explore an area within 6 deg of the south pole (the Artemis Exploration Zone, AEZ). The south polar region is an impact-cratered, feldspathic highlands terrain [1-3] situated on the rim of the largest and oldest lunar impact basin, the South Pole-Aitken (SPA) basin [4]. Lunar regolith in this region will likely contain material from the primordial lunar crust and the uppermost mantle that was subsequently modified by SPA and post-SPA impact events [5]. The goals of this project are to analyze the proposed 13 Artemis III candidate landing sites for sampling those materials and to identify potential geologic targets.

**Data and Methods:** We took a two-stage approach by modelling crater excavation depths and ejecta distribution within the AEZ and comparing those results with a spectrally-derived regolith composition map. First, we manually mapped all craters and basins with diameters >10 km in the AEZ and within one crater diameter distance of the AEZ. Secondly, we extracted and added all craters with diameters >1 km within, intersecting, or within one crater diameter distance of the Artemis III candidate landing regions, using the lunar crater catalog of [6]. Next, we assigned a stratigraphic age for the crater formation based on their stratigraphic relationships and morphology [7,8]. By utilizing crater scaling techniques, we derived transient crater diameters and excavation depths [9-12]. To generate a cumulative ejecta stratigraphy of those craters, we utilized a Python model called "Moon Polar Ice and Ejecta Stratigraphy" (MoonPIES), developed by [13]. The model assumes symmetrical ejecta distribution, which is a good approximation for numerous small craters but may break down when applied to a small number of large basins.

Regolith composition maps were constructed by classifying 1×1 km pixels based on the proportions of plagioclase, olivine, orthopyroxene (low-Ca pyroxene), and clinopyroxene (high-Ca pyroxene) from the mineral maps of [14]. Based on the classification scheme of [15], we defined an average regolith composition for each pixel.

**Results:** We mapped 85 craters >10 km (Fig. 1) and added 336 smaller craters from the global lunar crater catalog [6]. Nine potential secondary craters were excluded. The derived excavation depths range from ~100 m to 23.6 km (Amundsen-Ganswindt). Post-SPA ejecta is generally thicker (up to 1.7 km), in the eastern part of the AEZ (towards 90°E) than in the west (up to 0.5 km towards 90°W) due to Amundsen-Ganswindt, Schrödinger, and a higher abundance of large craters (Fig. 1). On the western side, larger craters are generally further spread out (Fig. 1). There is a potential ancient 120 to 150 km diameter crater between Cabeus and the de Gerlache-Kocher massif, which was not included in our model (Fig. 1). Our assigned stratigraphic ages differ from crater count-derived ages of the interior crater floors [16], resulting in a different stratigraphic sequence.

The spectral map shows that most of the AEZ and candidate landing regions are covered by an anorthositic noritic and anorthositic troctolitic composition regolith, consistent with average Apollo 16 highland soil compositions [17]. No pixels were classified as troctolitic or ultramafic, as the minimum measured plagioclase value by [14] was 50%. Felsic material has a higher abundance within the candidate landing regions ‘Connecting Ridge’ and ‘Connecting Ridge Extension’, where anorthositic regolith is present (also detected by [18,19]). A notable presence of mafic composition is evident for the candidate landing regions ‘Amundsen Rim’, ‘Nobile Rim 2’, and ‘Haworth’, including anorthositic gabbroic and gabbronoritic materials. Outside of the proposed landing sites, the highest percentage of mafic material is observed around Kocher crater. Other regions with increased mafic abundance are at the rims of Amundsen-Ganswindt and the possible ancient crater.

**Discussion:** The distribution of the primordial crust, SPA, and post-SPA materials within the AEZ is dependent on the thickness of the SPA and post-SPA ejecta layers and the excavation depth of adjacent craters. We assumed that immediately after the SPA-forming impact, the early feldspathic highland crust at the south pole was solely covered by SPA ejecta. Based on the 3D iSALE model of [5], this layer is between 1 m and 10 km thick. By reconstructing the underlying stratigraphy of craters and using their excavation depths, the type of each crater’s ejecta can be inferred, i.e., if its primordial crust, SPA, post-SPA ejecta, or a mixture. For a SPA ejecta blanket thickness of 1 m, all craters in our assessment excavate primordial crust. In comparison, if this thickness is 10 km, only the 6 largest craters will excavate primordial crust, while the rest...
excavate SPA or post-SPA ejecta. All craters >10 km pierce through the post-SPA ejecta blanket.

Post-SPA impacts diluted or concentrated SPA ejecta depending on the region, while maintaining a generally feldspathic regolith signature. Therefore, there are a few areas that have higher proportions of anorthositic material implying the presence of primordial crust, and more mafic components, suggesting the presence of mantle-derived materials. Mantle-derived materials, including impact melt, likely originate from the SPA-forming impact or from the Amundsen-Ganswindt and Schrödinger basins. Felsic regions might be related to a regionally thin SPA ejecta blanket (Fig. 1), crustal megablocks, or uplifted structural SPA rims.

**Conclusion:** Mafic material is abundant throughout the AEZ, which is consistent with previous estimations of tens of percent of SPA material in the AEZ [20]. Regions exhibiting higher percentages of mafic or felsic material are high priority targets for sampling mantle or primordial crust derived materials, respectively, which allow to test several crustal concepts [21].

To better constrain the stratigraphy and understand the depth origin of material returned from the AEZ, future work should focus on further constraining the SPA ejecta thickness and distribution.

**Acknowledgments:** This work is supported by the USRA-LPI, CLSE, and NASA SSERVI.

**References:**


**Figure 1.** The deepest excavated material from all craters larger than 10 km with varying SPA ejecta thickness of 1 m and 10 km. The material excavated from craters completely within other craters is undefined (white). The craters are projected on the cumulative post-SPA ejecta thickness model (for the Copernican epoch) and a LOLA hillshade [22]. The numbering of the Artemis III landing regions is: 1: de Gerlach-Kocher Massif; 2: Faustini Rim A; 3: Peak Near Shackleton; 4: Connecting Ridge; 5: Connecting Ridge Extension; 6-7: de Gerlach Rim; 8: Haworth; 9: Malapert Massif; 10: Mons Mouton (Leibnitz Beta Plateau); 11: Nobile Rim 1; 12: Nobile Rim 2; 13: Amundsen Rim.