SELECTING AND CERTIFYING LANDING SITES FOR MOONRISE IN SOUTH POLE-AITKEN BASIN.

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Introduction: MoonRise is a New Frontiers mission concept to return samples from the South Pole-Aitken (SPA) basin, for mineral, chemical, petrologic, geochronologic, and physical properties analyses to answer science questions relevant to early evolution of the Solar System. Science associated with this mission concept is described elsewhere [e.g., 1-7]; here we discuss selection of sites within SPA to address science objectives using recent scientific studies (orbital spectroscopy, gravity, topography), and new data (Lunar Reconnaissance Orbiter – LRO, and Moon Mineralogy Mapper – M^3) to select and certify safe landing sites for a robotic sample-return mission such as MoonRise.

Scientific Site Selection: Owing to impact mixing, rock components of SPA regolith will include a likely mixture of: (1) SPA impact-melt rocks and breccia (key to determining the age of the impact event and what materials were incorporated into the huge SPA impact-melt deposit); (2) impact-melt rocks and breccia from large craters and basins (other than SPA) that represent the post-SPA late-heavy bombardment interval; (3) ancient volcanics or "cryptomare" (buried volcanics excavated by impact craters) to determine the early volcanic history of SPA basin; and (4) later basalts derived from the post-SPA mantle. All of these rock types are sought as returned samples

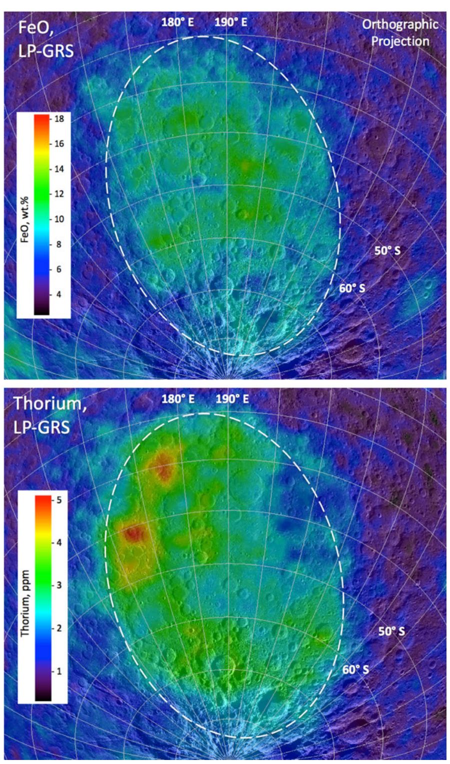

Figure 1. Lunar Prospector GRS data, half-degree binning [8], overlain on LROC WAC morphology mosaic.

Existing orbital, chemical, and mineralogical data guide our approach to scientific site selection. FeO and Th data from the Lunar Prospector gamma ray spectrometer revealed an elliptical geochemical anomaly ~1200 km across, corresponding to the SPA basin interior [8; Fig. 1]. Within this context, mineralogical data (M^3, Chandrayaan-1) indicate several concentric zones within SPA that correspond in part to variations of the SPA impact melt and breccia deposits and redistribution by subsequent large impacts into SPA, and volcanic rocks that have erupted into the deepest parts of the basin [9-11; Fig. 2]. Coupled with studies that predict the makeup of regolith at a given location on the basis of ballistic mixing of ejecta from large craters [12,13], we use these criteria to focus on a region in the interior of SPA between 45-60°S and 175-200°E. Post-SPA impacts have excavated SPA "substrate" – mainly the upper layers of SPA impact melt, distributing these materials laterally and mixing them back into the rego-

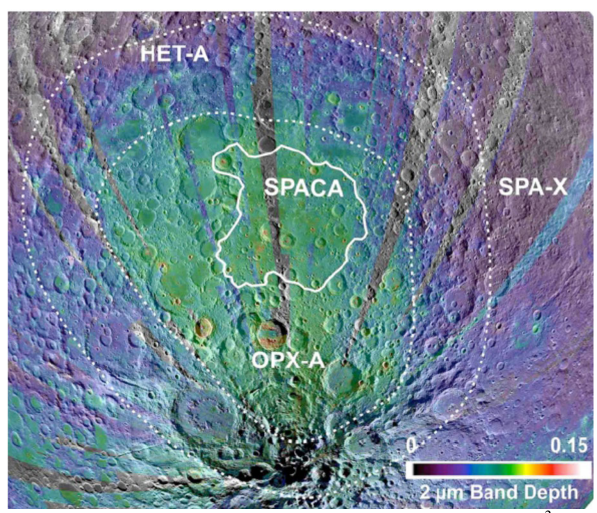

Figure 2. SPA mineralogical zones [14] based on M^3 data. The SPA Compositional Anomaly (SPACA) has a high-Ca pyroxene signature and is surrounded by a low-Ca pyroxene annulus (OPX-A). HET-A (heterogeneous annulus) is a zone of mixing between SPA materials and exterior (SPA-X) materials.

lith in the basin interior. Subsequent small impacts further mixed this material, generating a regolith rich in original SPA materials as well as impactites from subsequent large impacts. Relatively smooth inter-crater plains in the basin interior also provide access to ejecta from small impacts into cryptomare and nearby mare surfaces. All of these materials are of interest to address SPA sample return science objectives.

Within the basin, many areas exist that are of specific interest based on local geology and the likelihood of returning samples that can address multiple science objectives. For example, E-SE of Bhabha crater, the surface consists of inter-crater plains expected to contain ejecta from a large craters such as Bhabha, Bose, and Stoney, mare and cryptomare deposits from the vicinity and north of the site, and even material from the enigmatic, potentially volcanic "Mafic Mound" to the south [15, Fig. 3]. Other areas of special interest are located south and west of Bose crater, and as far south as 60°S latitude in the area of the Constellation Interior site (Cx, Int., Fig. 3) [16,17].

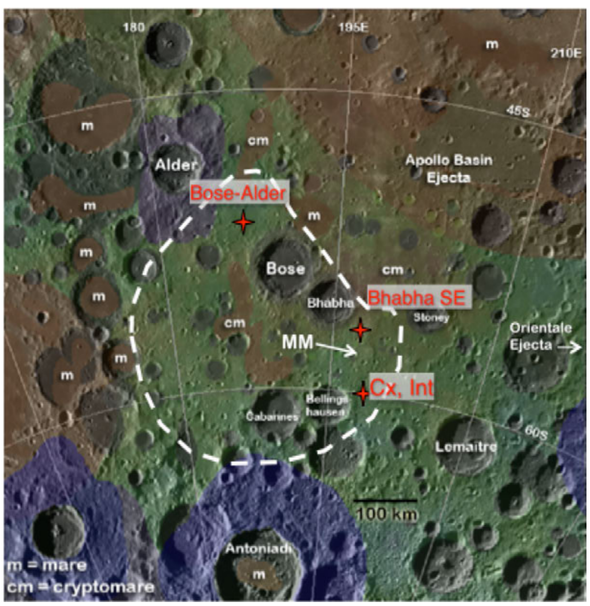

Figure 3. Design reference sites; Cx, Int is the Constellation Interior site. MM is "Mafic Mound."

Landing Site Safety Assessment. Science-rich landing sites for MoonRise occur in many locations within the SPA basin, and available, high spatial-resolution imaging and topographic data are sufficient to fully characterize potential hazards, and to select and certify safe landing sites.

Digital terrain models derived from the Lunar Orbiter Laser Altimeter (LOLA), LROC Wide Angle Camera (WAC) [18], SELENE Terrain Camera [19], and LROC Narrow-Angle Camera (NAC) [20] provide topographic context at all needed scales. Full coverage of the basin exists for WAC-LOLA and SELENE-LOLA DTMs. At the lander scale, DTMs derived from NAC images provide slope and surface roughness data needed to certify a landing ellipse as safe. NAC DTMs undergo a meticulous production process [20], and DTMs are then subjected to a rigorous evaluation similar to the process for Mars landing sites [21]. NAC DTMs provide slope data at a 2 m baseline; examples of these products are shown in Fig. 4.

Boulders >1 m are identified and size-frequency distributions are determined using NAC images [22] and the abundances and size-frequency distributions of rocks of all sizes are estimated using Diviner data [23,24]. Apollo landing sites provide validation for all of these methods. All these considerations ensure a safe and scientifically productive mission.

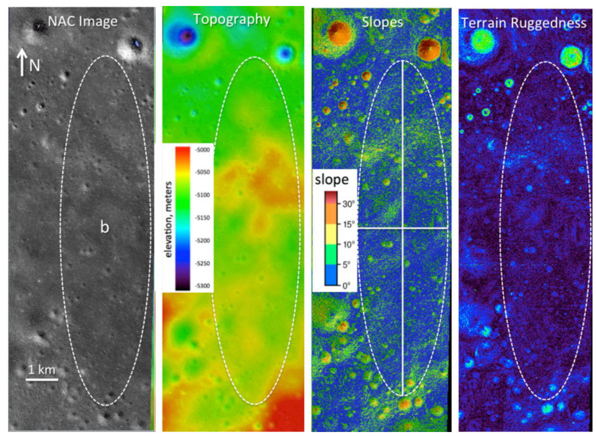

Figure 4. Terrain visualization products for Bhabha East Plains site. NAC DTM undergoes rigorous validation similar to that used for landing sites on Mars. In landing ellipse b, 99.98% of all slopes are less than 15°.

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