DESTINATIONS FOR SAMPLING IMPACT MELT PRODUCED BY THE SOUTH POLE–AITKEN BASIN IMPACT EVENT. Debra M. Hurwitz[1] and David A. Kring[1]; [1]Center for Lunar Science and Exploration, NASA Lunar Science Institute, Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX, 77058, (hurwitz@lpi.usra.edu)

Introduction: The intensity of impact activity during the earliest history of the Solar System is poorly constrained due to the lack of samples collected from ancient planetary terrains. The South Pole – Aitken (SPA) basin is the oldest basin identified on the Moon based on stratigraphic superposition and, thus, represents a key target for characterizing this earliest impact record [1,2]. To determine the absolute age of SPA, rocks that formed as a result of the impact, such as impact melt, must be identified, collected, and analyzed. In this paper, we use high-resolution images obtained by the Lunar Reconnaissance Orbiter Narrow Angle Camera (LROC NAC) to explore locations that potentially contain SPA impact melt. These observations are integrated with spectral analyses of surface compositions and models of melt sheet differentiation to identify destinations where SPA impact melt samples can be collected.

Identifying SPA Impact Melt: Petrological modeling suggests that the melt sheet generated in the transient crater during the impact event would have differentiated, forming a shallow layer of low-Ca pyroxene (pyx) + plagioclase (plag) beneath a layer of quenched melt [3-5]. This quenched melt would have the same bulk composition as both the initial melt within the melt sheet and the melt ejected from the transient cavity. Modeling suggests this initial impact melt composition would have been dominated by low- and high-Ca pyx with plag [4,5].

These results are consistent with spectral observations of the SPA interior. Clementine, Lunar Prospector (LP), Kaguya Spectral Profiler, and Moon Mineralogy Mapper (M^3) spectral data (e.g., [6-9]) indicate a vast region of elevated FeO and Th content within the SPA interior (Fig. 1). SPA melt may also be found in material ejected from the basin, but the anomalous signatures shown in Fig. 1 likely correspond to the highest concentration of this melted material. Spectra indicate the dominant mafic mineral throughout SPA is low-Ca pyx (e.g., [6-9]), with occurrences of high-Ca pyx and non-mafic minerals increasing with distance from the basin center (e.g., [8]) outside the extent of the predicted transient crater (e.g., [10]). Exposures of crystalline low-Ca-bearing materials have been identified in the walls and central peaks or peak rings of several craters (e.g., Bose, Bhabha, and Finsen [7,8,11]) and basins (e.g., Leibnitz, Apollo, and Schrödinger [7,11,12]) within SPA. Anomalous high-Ca pyx materials have been identified near the basin center in Mafic Mound [7]; this composition might be consistent with a rafted portion of the quenched melt layer from the SPA melt sheet (e.g., [4,5,13]). These outcrops of potential impact melt represent crucial destinations for collecting and returning samples that can refine our knowledge of the earliest impact record.

Analyses: Using LROC NAC images, we investigated areas within craters and basins that might contain SPA impact melt (labeled in Fig. 1). We specifically looked for outcrops and fallen rocks that are both characterized

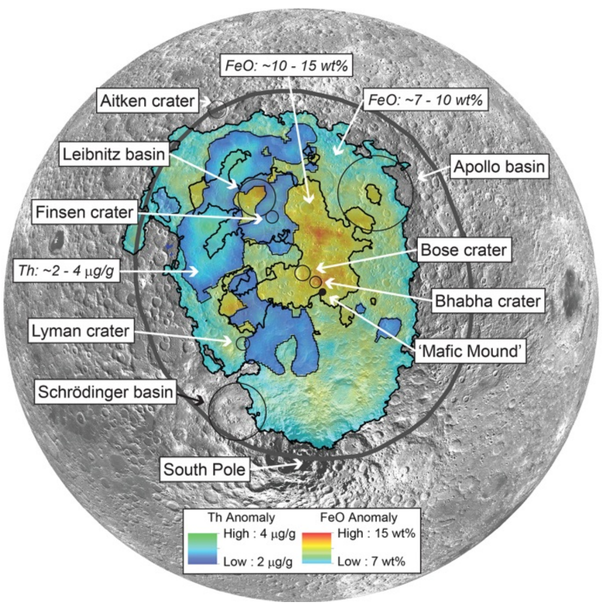

Figure 1: FeO (red-yellow tones) and Th (green-blue tones) anomalies from LP data in SPA, shown with images from the LRO Wide Angle Camera (WAC). Features of interest are labeled. SPA melt may also be found in material ejected from the basin, but the anomalies identified above indicate the highest concentration of this melted material.

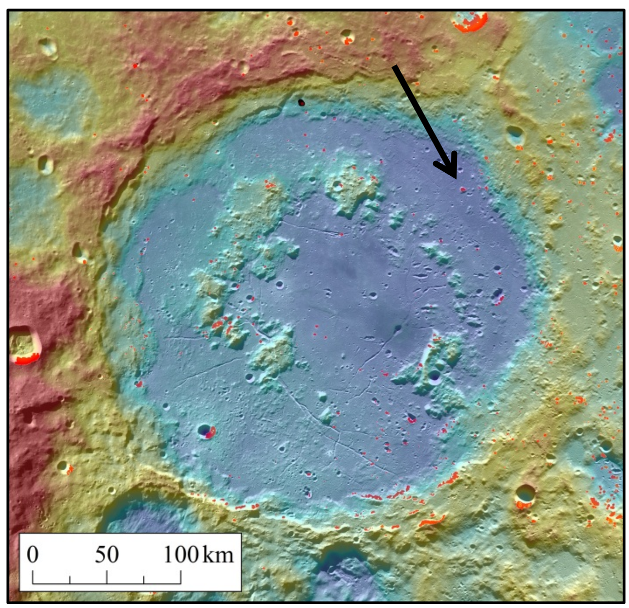

Figure 2: Schrödinger basin, with Lunar Orbiter Laser Altimeter data overlying a WAC mosaic. Red and orange spots represent locations of opx and pig, respectively, identified using M^3 spectra [12]. Arrow indicates mound shown in Figure 3.

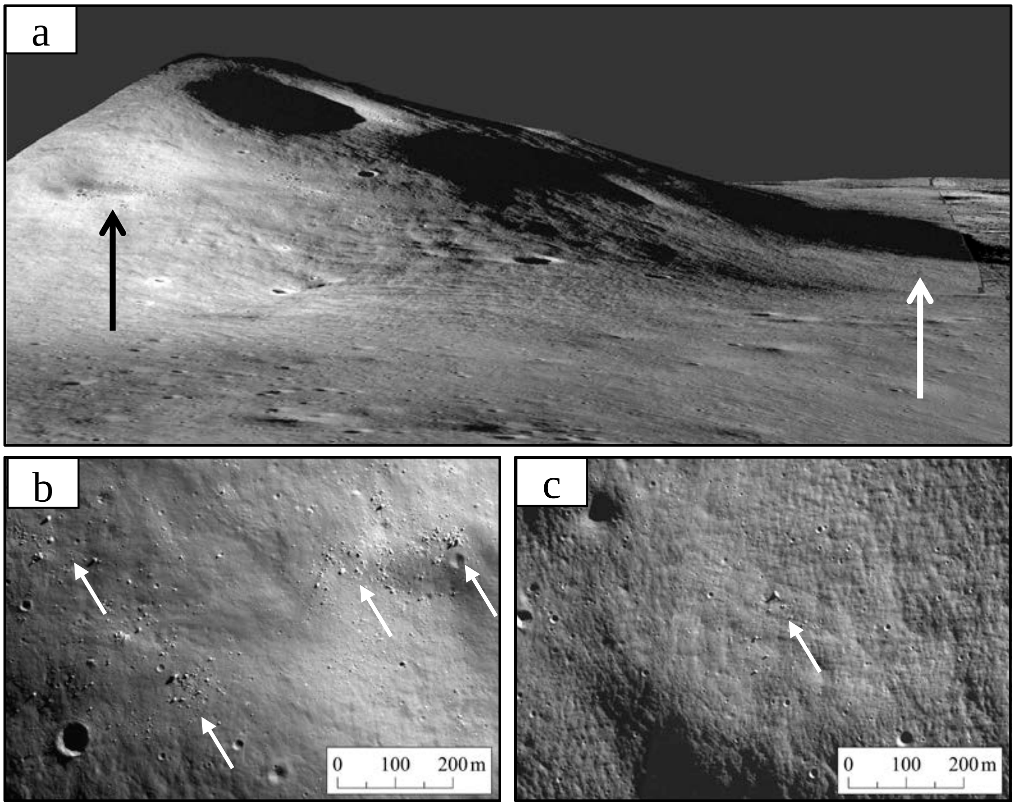

Figure 3: (a) Perspective view of the low-Ca px-bearing mound observed in northeastern Schrödinger basin (black arrow in Figure 2). The black arrow on the left side of (a) corresponds to the outcrops observed in (b), and the white arrow on the right corresponds to the rocks observed in (c). The isolated rocks on the plains likely rolled down from outcrops at the higher elevation. The two rock clusters are ~2 km apart in distance and ~200 m apart in elevation. All features shown in this figure are observed in LROC NAC images M159011304L/RE.

by low-Ca pyx-bearing materials and located at elevations accessible by robotic and human-operated rovers. One example of such a site is located within the outer ring of NE Schrödinger basin (arrow in Fig. 2).

A mound located on the floor of this region (Fig. 3) has a spectral signature similar to that identified on the nearby basin wall, suggesting that this mound originated in the wall before slumping to the basin floor. The mound is located in a low-lying region with little topography and few topographic obstructions, increasing the likelihood of a safe landing. The mound rises ~800 m above the surrounding plains, and it has a cluster of rocks located ~300 m high on its northern flank (left side of Fig. 3) that possibly formed either in situ as an outcrop or in ejecta from a relatively recent impact into the mound. Several rocks rolled down the mound, settling ~2 km downrange on the surrounding plains (right side of Fig. 3), providing an easily accessible collection site for rovers and humans alike. The low slope (~5.7^{o}) of the mound may allow robotic and human-operated rovers to traverse the distance between the outlying rocks and the outcrops, facilitating analyses and comparisons of the rocks in both locations. Depending on the longevity of the mission, the rover might continue to the nearby (~16 km) basin wall, where additional analyses of outcrops might verify if the mound originated at the valley wall.

The east and southeast regions of Schrödinger basin also contain low-Ca pyx material (red spots in Fig. 2) and are characterized by the same elevated [FeO] as the majority of the SPA interior (Fig. 1). Although additional outcrops of SPA impact melt should occur in the SE region of the basin, mission operations might have to endure more challenging illumination and communication conditions than in the NE region.

Concluding Remarks: Rocks identified in this study represent material exposed during the Schrödinger-forming impact event, an event that likely penetrated into and redistributed material formed during the SPA-forming impact event. Sampling SPA material within the Schrödinger basin is attractive for other reasons too. Because it is a relatively young basin with some spectacular rock exposures, missions to that locality can also sample materials that address a broader range of lunar science and exploration objectives (e.g., [1,2,14]). Through the collection and analysis of these impact melt samples, we will be able to constrain the most ancient impact record and gain insight into the environment present during the formation not only of the Moon but also of all planetary bodies in the inner Solar System.

References: [1] National Research Council, 2007; [2] National Research Council, 2010; [3] Vaughan, W.M. et al., 2013, *Icarus*, *223*(2), 749; [4] Hurwitz, D.M. and Kring, D.A., 2013, *LPSC*, *44*, abstract 2224; [5] Hurwitz, D.M. and Kring, D.A., in review; [6] Pieters, C.M. et al., 1997, *GRL*, *24*(15), 1903; [7] Pieters, C.M. et al., 2001, *JGR*, *106*(E11), 28,001; [8] Moriarty, D.P. et al., 2013, *JGR-P*, *118*, 1; [9] Nakamura, R. et al., 2009, *GRL*, *36*(L22202); [10] Potter, R.W.K. et al., 2012, *Icarus*, *220*, 730; [11] Borst, A.M. et al., 2012, *PSS*, *68*(1), 76; [12] Kramer, G.Y. et al., 2012, *Icarus*, *223*, 131; [13] Kring, D.A., 2012, *Conf. Lunar Highlands Crust*, *2*, abstract 9028; [14] Kring, 2013, *ESA-ESTEC*.