

SCIENCE-RICH MISSION SITES WITHIN SOUTH POLE-AITKEN BASIN, PART 1: ANTONIADI CRATER. A. L. Fagan¹, M. E. Ennis², J. N. Pogue³, S. Porter⁴, J. F. Snape⁵, C. R. Neal⁶, and D. A. Kring⁷;

¹Department of Civil Engineering and Geological Sciences, University of Notre Dame, Notre Dame, IN, USA abacasto@nd.edu; ²Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN, USA mennis2@utk.edu; ³Earth and Planetary Sciences Department, University of California, Santa Cruz, CA, USA james.n.pogue@gmail.com; ⁴School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA simon.porter@asu.edu; ⁵Department of Earth Sciences, University College London, UK j.snape@ucl.ac.uk; ⁶Department of Civil Engineering and Geological Sciences, University of Notre Dame, Notre Dame, IN, USA neal.1@nd.edu; ⁷ Lunar and Planetary Institute, Houston, TX, USA Kring@lpi.usra.edu.

Introduction: NASA is evaluating lunar surface architectures that involve sortie and outpost-based exploration within the South Pole-Aitken (SPA) Basin [e.g., 1]. To assist with that evaluation, our team studied the geology of the SPA Basin to locate mission sites that best address the nation's highest lunar science priorities (NRC 2007, [2]). Our study reveals that crew can begin to address most science objectives within the SPA Basin, which is the oldest (>4 Ga) and largest (~2500 km diameter) impact basin on the Moon and is both topographically and compositionally distinct from the rest of the lunar surface. The study also suggests there are three particularly science-rich mission sites within the SPA Basin: Schrödinger Basin, Antoniadi Crater, and Von Kármán Crater. Mission options within Schrödinger Basin have been previously outlined [3]. Here we describe opportunities within Antoniadi Crater and, in a companion abstract [4], we discuss Von Kármán Crater.

Antoniadi: Antoniadi is an Upper Imbrian (~3.2-3.8 Ga), 143 km diameter [5], peak ring crater [6] located at ~69.5°S, 173.2°W [e.g., 5, 7]. Clementine [8] and Kaguya [9] data indicate the lowest point on the Moon is located within Antoniadi, with the most recent Kaguya (SELENE) data suggesting a depth >9.0 km below the baseline ellipsoid. Antoniadi is also the site of some of the youngest mare [10, 11] on the lunar farside with recent crater counting suggesting an age of ~2.58 Ga - significantly younger than the Imbrian-Eratosthenian boundary [12]. Additionally, spectral data indicate the presence of noritic material [13], rich exposures of orthopyroxene [14], a relatively high Th abundance (2.3-3.5 µg/g) [15], and a central peak with 15-16 wt % FeO [16]. Given its age, unique spectral data, the presence of young mare, and its relatively close distance (~620 km) to a possible future base at the lunar south pole, Antoniadi is an attractive location for surface studies.

Achievable NRC [2] Concepts: Five of the eight concepts can be investigated within Antoniadi Crater.

- Constrain lunar bombardment history by determining the age of Antoniadi (and possibly SPA) impact melt samples (Concept 1)

- Study the lunar interior at the deepest point of the Moon by examining possible exposed lower crust and upper mantle material (Concept 2)
- Examine the diversity of crustal rocks: Th-rich, Orthopyroxene-rich, noritic, FeO-rich, mare, and impact melt (Concept 3)
- Quantify variability in origin, composition, and age of farside and nearside lunar basalts (Concept 5)
- Examine the melt sheet to determine the existence and extent of differentiation, as well as investigate the origin of peak rings (Concept 6)

Potential Landing Sites: We identified three potential landing sites, or operational centers, within Antoniadi Crater. All three sites (Fig. 1) occur on the smooth, mare-flooded crater floor [11]. Traverse stations are limited to radii of 10 km around the sites, reflecting the current walk-back safety limits for crew during Extra-Vehicular Activity (EVA) [1]. All three sites provide access to high FeO material (relative to non-mare lunar regions), which is characteristic of the SPA Basin [17]. The presence of this FeO anomaly, after >4 billion years of subsequent overprinting, suggests a prevalence of SPA-derived impact melt throughout the basin that may be sampled at a variety of locations [e.g., 18, 19], particularly within SPA's transient crater diameter. Given the close proximity to the south pole, the potential sites within Antoniadi may be regarded as "sortie" type mission landing sites or operational centers for missions involving long-duration traverses from an outpost.

Site #1. The first site is located near the center of Antoniadi, directly west of the central peak. The eastern portion of the EVA circle is characterized by relatively high Th (compared to other regions of SPA), which may be a tracer for KREEP [e.g., 20]; this is part of the SPA Th-anomaly, though at lower values than found at Birkeland (~32°S, 174°E) and Oresme V (~40.5°S, 165.5°E) craters [21] in the NW portion of SPA. Every sampling location (a-e) is within the mare unit EIm [11], allowing ample opportunities to collect basalt samples. Station 1a is at a ~5km long rille located NW of the central peak, providing an opportunity

to investigate lithologies below the top layer of mare; this rille has a secondary rille extending orthogonally to the NE, which is visible in imagery from the Kaguya terrain camera [12]. Station 1b is adjacent to the central peak, which will provide exposures of the deepest material excavated by the impact event. Station 1c is at a ~1km diameter crater, providing another means of examining beneath the upper mare surface. Stations 1d and 1e are either massifs or remnants of a ring surrounding the central peak; excavated materials from depth may also be present here and the overall structure may provide clues as to the origin of crater rings.

Site #2. The second site is located to the NW of site #1 and is part of an area with slightly lower Th values. It appears to straddle the edge of the mare unit (Elm, [11]). The first two stations provide basalt sampling locations. Station 2a is at the edge of one of the largest remnant portions of the ring structure. Station 2b is at a slightly elliptical, ~1km diameter impact crater. Station 2c is at the edge of a rough terrain area in the NW portion of Antoniadi. It is possible that Antoniadi impact melts may be more accessible here than at site #1, because the mare unit, which covers the melt elsewhere, appears to terminate nearby, leaving the impact melt exposed.

Site #3. The third site is located in the SE portion of Antoniadi and is situated entirely within a high-Th area, but is only partly within the mare unit (Elm, [11]). The mare unit can be sampled at this (landing) site. Furthermore, Station 3a provides an opportunity to collect samples from the remnant crater peak ring and possibly to collect impact melted material from the Antoniadi (and possibly SPA) impact event. A cross-section of upper crust, exposed in a collapsed block of the crater wall, may be photographed and sampled at Station 3b. Station 3c is near an ~1 km diameter impact crater that may expose material beneath the mare surface, while also providing an opportunity to photograph a portion of the remnant peak ring of Antoniadi.

Recommendations: To further assess Antoniadi as a potential sortie landing site or potential operational target for a long-duration mobility traverse from an outpost, several products are needed:

(1) Slope maps from digital elevation maps (DEMs) to refine landing sites, to assist with detailed traverse design for crew and their rover(s), and to determine if it is possible to enter small impact craters (e.g., from LOLA data)

(2) High-resolution multi-spectral data to identify the best sites for collecting impact melt, a variety of basalts, and other rock types

(3) High-resolution imagery (such as that from Kaguya or LROC) to identify surface features such as smaller impact craters within Antoniadi.

(4) Use (1) - (3) to create more detailed geologic maps. The existing 1979 Wilhelms map [11] of the lunar south pole was produced using Lunar Orbiter imagery and has limited detail within the Antoniadi crater.

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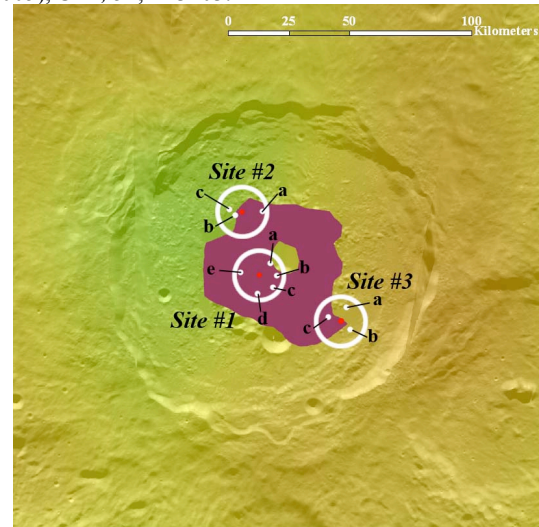


Fig. 1: Clementine shaded relief mosaic overlain by Th concentration map (higher Th=yellow-orange), mare unit EIM (in burgundy, [11]), and locations of potential exploration sites (red points represent the middle of 10km radius EVA limit circle; white points are stations described in text).