LUNAR FARSIDE VOLCANISM: POTENTIAL SAMPLING LOCALITIES WITHIN SOUTH POLE-AITKEN BASIN. M. E. Ennis[1], A. L. Fagan[2], J. N. Pogue[3], S. Porter[4], J. F. Snape[5], and D. A. Kring[6] [1]Planetary Geoscience Institute and Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN, USA mennis2@utk.edu; [2]Department of Civil Engineering and Geological Sciences, University of Notre Dame, Notre Dame, IN, USA abacasto@nd.edu; [3]Earth and Planetary Sciences Department, University of California, Santa Cruz, CA, USA james.n.pogue@gmail.com; [4]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA simon.porter@asu.edu; [5]Department of Earth Sciences, University College London, UK j.snape@ucl.ac.uk; [6]Lunar and Planetary Institute, Houston, TX, USA Kring@lpi.usra.edu.

Introduction: The *National Research Council* (*NRC*) described eight major science concepts and outlined 35 goals to address the future of lunar science and exploration with regards to the Constellation Program [1]. This study focuses on Concept 5 with respect to the South Pole-Aitken (SPA) Basin. Concept 5 states "Lunar volcanism provides a window into the thermal and compositional evolution of the Moon" [1]. This concept is subdivided into four science goals addressing (1) the origin and variability of lunar basalts, (2) age of lunar basalts, (3) compositional range and extent of lunar pyroclastic deposits, and (4) the flux and evolution of lunar volcanism. Global studies are needed to fully address this concept and its science goals. We found, however, that it is possible to begin to address all of the science goals outlined within Concept 5 via field studies within the South Pole-Aitken Basin (SPA), which is located on the south-central farside of the Moon. We identified several locations within SPA where each science goal of Concept 5 may be addressed. The SPA Basin is the largest (~2500 km diameter), and oldest confirmed impact basin on the Moon and potentially the largest impact basin in the solar system [2]. Due to its immense size, exploration of the entire basin is not feasible by a single mission and should be carried out either as a series of traverses from a permanent lunar outpost [3] or as individual exploratory missions with multiple landing sites (i.e., Apollo-style missions).

Farside Lunar Volcanism: Mare basalts cover ~17% of the lunar surface and typically occur as basaltic plains in the topographic lows of near side basins [4, 5]. Only a small fraction of mare deposits exist on the far side (Fig. 1) and most of them are found within SPA [6]. Despite SPA's age (Pre-Nectarian), low lying topography, and underlying thin crust, extensive basaltic flood deposits are not present. Rather, the deposits are limited to small, dispersed regions. None of these basalts have yet been sampled, although they have been characterized with remote sensing techniques. Geologic mapping of the lunar far side has revealed ~52 separate mare deposits within SPA, as well as dark mantle deposits that were interpreted as pyroclastic deposits [2, 7-9].

Science Goal 5a-Determine the Origin and Variability of Lunar Basalts [1]: Despite the mafic nature of SPA's Basin floor (8-12 wt.% FeO [10]), mare deposits that typically contain >14 wt.% FeO [11] are readily identifiable using Clementine spectral data; all of these mare are basaltic in composition [9, 12]. Analyses of Clementine data also revealed areas of cryptomaria [13] and have shown that volcanic deposits within SPA have medium to medium-high Ti contents, and none have the high-Ti contents seen on the near side.

Apollo South (~41.8°S, 154°W) is one of four mare regions associated with the Apollo Basin in SPA. The mare deposit is located along the southwestern rim of the basin and appears to embay the basin rim structure. This mare is representative of the few high-Ti mare deposits on the lunar farside; therefore, sampling this unit may provide a point of comparison between SPA Basin mare and nearside mare deposits.

Chrétien Crater (~45.9°S, 162.9°E) is located in the central northwest region of SPA Basin within the Th anomaly [14]. The crater has been filled by a magma that erupted through Th-rich crustal material. Assimilation of Th-rich crustal rocks by the magma may result in a chemical signature unique to this region. Clementine data shows that the basalts within the crater have Ti concentrations between Apollo's high-Ti and low-Ti basalts, which may indicate they represent a previously unsampled basalt type.

Science Goal 5b-Determine the Age of the Youngest and Oldest Mare Basalts [1]: Mare deposits within SPA are mapped as Imbrian or Eratosthenian [2, 7, 8]. Antoniadi Crater (~69.7°S, 172.0°W), located in the south central region of SPA, hosts the youngest mapped mare deposit within the basin [2, 7]. Sampling the flow will provide an upper limit for the temporal extent of volcanism within SPA.

High Ca-pyroxene reflects the basaltic composition of the mare material within SPA [13] in contrast to the low Ca-pyroxene, which is representative of the non-mare material [12, 16]. Using high Ca-pyroxene as a proxy, possible cryptomaria deposits have been mapped directly south of the Apollo South mare deposit. These suspect cryptomaria are predominately situated within the smooth intercrater plains on the basin floor. Sampling cryptomaria will provide a lower limit to the constraints on the duration of volcanism within SPA.

Science Goal 5c-Determine the Compositional Range and Extent of Lunar Pyroclastic Deposits [1]: Compositional analyses of the pyroclastic glasses collected at various Apollo landing sites have shown that the glasses are not related to the mare basalts at the same localities; instead, they represent more primitive magmas than the mare basalts [17]. There are a limited number of locations available for sampling pyroclastic material within SPA, but regions such as Oppenheimer Crater or Schrödinger Basin may provide ample opportunity.

Oppenheimer (~35.2°S, 166.3°W), a floor-fractured crater west of Apollo Basin, contains seven pyroclastic deposits of varying sizes that appear to be associated with the floor fractures [18]. The relatively high concentrations of FeO and TiO within these deposits may make them an attractive target for in situ resource utilization.

The youngest pyroclastic deposits on the lunar surface may reside in Schrödinger Basin (~75.0°S, 132.4°E) [15], which has been previously identified as one of the best locations on the lunar surface to address all the NRC concepts and goals [19].

Science Goal 5d-Determine the Flux of Lunar Volcanism and its Evolution Through Space and Time [1]: Little is known about the flux of lunar volcanism. To begin evaluating the flux, one needs to determine the volume of eruptives [6]. The geographic extent of basalts can, in many cases, be determined from orbit, but requires ground truth. The thicknesses of deposits can also, in some regions, be estimated from orbit, but those estimates are often contradictory and uncertain. In situ measurements of flow thicknesses are needed. There are many locations within SPA where these measurements can be made, such as Antoniadi Crater, Chrétien Crater, Von Kármán (~44.8°S, 175.9°E), and Apollo South. Fieldwork at those locations (e.g., stratigraphic measurements, in situ sampling, description of morphological features), when integrated with orbital data, will provide the insights needed to determine the flux of lunar volcanism through time.

Sample Collection: Sample return missions are essential to provide additional compositional data and remote sensing ground truth. Samples from the Apollo missions and lunar meteorites have provided a range of typical lunar basalt compositions, but remote sensing indicates there is a much broader compositional range not represented by these collections. Currently, no in situ samples have been collected from the lunar farside surface; therefore, sampling any volcanic region within SPA should reveal new insight into the thermal evolution of the Moon. With repeated mission opportunities, most of the diversity of basalt compositions on the far side can be captured within the SPA Basin Unfortunately, with the exception of Antoniadi Crater and Schrödinger Basin, most of the mare deposits within the SPA Basin are located in the northern portion of the basin and will not be readily accessible on 500 km traverses or even 1000 km traverses from a permanent base located at the South Pole. These localities may require short-duration sortie missions.

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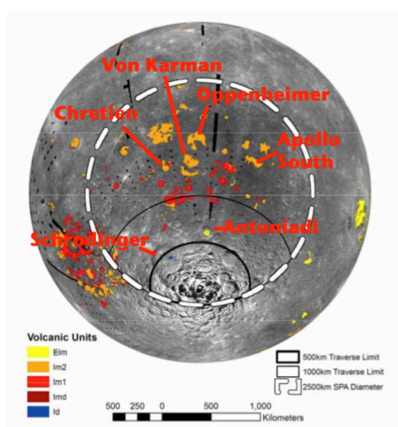

Fig. 1: Map of mare units [2,7] within SPA with locations of suggested sample sites.