SOUTH POLE-AITKEN SAMPLE RETURN MISSION: COLLECTING MARE BASALTS FROM THE FAR SIDE OF THE MOON.

J. J. Gillis[1], B. L. Jolliff[1], and P. G. Lucey[2], [1]Department of Earth and Planetary Sciences and the McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130, [2]Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI 96822. (gillis@levee.wustl.edu)

Introduction: We consider the probability that a sample mission to a site within the South Pole-Aitken Basin (SPA) would return basaltic material. A sample mission to the SPA would be the first opportunity to sample basalts from the far side of the Moon. The near side basalts are more abundant in terms of volume and area than their far-side counterparts (16:1 [1]), and the basalt deposits within SPA represent ~28% of the total basalt surface area on the far side. Sampling far-side basalts is of particular importance because as partial melts of the mantle, they could have derived from a mantle that is mineralogically and chemically different than determined for the nearside, as would be expected if the magma ocean solidified earlier on the far side. For example, evidence to support the existence of high-Th basalts like those that appear to be common on the nearside in the Procellarum KREEP Terrane has been found [2,3,4]. Although SPA is the deepest basin on the Moon, it is not extensively filled with mare basalt, as might be expected if similar amounts of partial melting occurred in the mantle below SPA as for basins on the near side. These observations may mean that mantle beneath the far-side crust is lower in Th and other heat producing elements than the nearside.

One proposed location for a sample-return landing site is 60°S, 160°W [5](Fig. 1). This site was suggested to maximize the science return with respect to sampling crustal material and SPA impact melt, however, basaltic samples would undoubtedly occur there. On the basis of Apollo samples, we should expect that basaltic materials would be found in the vicinity of any landing site within SPA, even if located away from mare deposits. For example, the Apollo 16 mission landed in an ancient highlands region 250-300 km away from the nearest mare-highlands boundary yet it still contains a small component of basaltic samples (20 lithic fragments ranging is size from <1 to .01 cm [6,7]).

A soil sample from the floor of SPA will likely contain an assortment of basaltic fragments from surrounding regions. In terms both of selecting the best landing sites and understanding the geologic context for returned samples, it is important to understand the compositional distribution of basalts within SPA basin.

Data acquisition and analysis: We investigate the spectral characteristics of surface materials surrounding the landing site and out to 300 km, and examine extensive basalt deposits throughout the basin using Clementine 5-band UVVIS data [8], which were processed using the latest radiometric and photometric calibrations [9] and at 100m/pixel [10]. Distribution of FeO and TiO_2 are calculated using the Clementine spectral reflectance data [11,12,13]. Optical maturity levels (omat) were calculated using the algorithm of Lucey et al., [14]. Omat values are used to acquire compositions (Table 1) and spectra (Fig. 2) from fresh craters for use in mixing model analysis. The Lunar Prospector γ-ray data for Th, K, and FeO are also used to assess the compositions of basalt units within SPA [11, 15, 16].

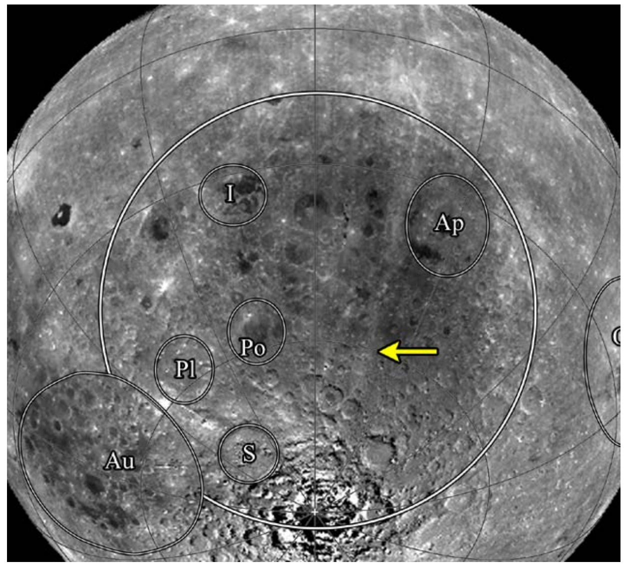

Fig 1. Clementine 750 nm image mosaic of SPA centered on 56°S, 180. The arrow points to the site discussed in the text.

Regional SPA Geology: Basalt deposits within SPA are found in three principal geologic settings: basins, craters, and intercrater. Apollo (Ap), Ingenii (I), and Poincaré (Po), the three youngest basins within SPA, collectively contain ~44% of the basalt deposits. Basalts within Apollo exhibit the highest TiO_2 concentrations within SPA. There are 17 basalt-filled craters, which contain another ~44% of the basalt on the floor of SPA. A survey of the crater size distribution reveals that basalt filled craters range in diameter from <25 km to over 245 km (e.g., Leibnitz). Crater size does not correlate with volume of volcanics because, for example, Van De Graff (233 km) and Schrodinger (S) (312 km) contain only minor basalt flows and Planck (314 km) contains no basalt at all. Intercrater basalt deposits constitute the remaining portion of mare. The majority of intercrater basalt deposits occur in the area southwest of Apollo Basin, which corresponds with the lowest elevations within SPA. The surface compositions of all basalt flows within SPA tend to have low FeO and TiO_2 concentrations. Thus we use the compositions of fresh craters in these deposits in an attempt to extract the original basalt composition (Table 1). The compositional data demonstrate that SPA basalt compositions exhibit limited variability; FeO ranges from 17-20 wt.%, TiO_2 from <1-3 wt.%, and Th 1-2 ppm.

Table 1 Compositions for several basalt deposits in SPA compared with the compositions of fresh craters within the same geologic unit. *LP-GRS FeO [15]

Deposit	surface TiO_2	surface FeO	crater FeO
60°S, 160°W	<1	11.0	
nonmare basin floor*	<1	9.0	
intercrater basalt	1.5	17.4	18.5
western Apollo	2.4	17.1	19.4
central Apollo	1.3	18.6	19.8
Southern Apollo #1	3.0	18.7	19.6
Southern Apollo #2	2.5	16.9	19.0
Poincare (high-Ti)	1.3	17.2	18.0
Poincare (low-Ti)	<1	15.2	18.4
Leibnitz	2.6	19.0	21.0
Ingenii	2.0	17.0	19.2

Getting Basalt out of the Deposit: The area surrounding the potential sampling site mentioned above exhibits subdued topography, shallow craters, and a paucity of preNectarian and Nectarian craters, suggesting a resurfacing event has occurred in this area some time after the SPA event. The resurfacing event may have been an ancient basin impact [17](e.g., Grissom-White Basin; 44°S, 199°), an eruption of basalt [18], or both. Within 300 km radius there are multiple small intercrater basalt deposits and buried basalt deposits. These deposits are identified by a high-Ca pyroxene ferrous absorption centered at 950 nm, and elevated FeO and TiO_2 concentrations relative to the average basin floor material. The margins of these deposits exhibit embaying relationships and lobate boundaries, which suggests they originated as volcanic flows. After eruption, subsequent influx(es) of basin ejecta possibly from Apollo or Orientale [18] mixed and buried the volcanic deposits. The presence and extent of the intercrater basalt flows also hints at the possibility that there is an even greater volume of basalt trapped in near surface hypabyssal deposits within this area. Lateral and vertical mixing by cumulative cratering would be highly efficient at mixing basaltic and SPA basin floor material in this area.

In addition to the intercrater basalt deposits there are several large-crater basalt deposits (Minkowski, Baldet, Antoniadi). None of the basalt deposits in these craters have large craters that would deliver the exotic material directly to the landing site. Getting basalt from these craters would involve a series of ejections from small craters. Consequently, this would be an inefficient process that would yield a low number of basalt samples. Distributing basalt from one of the filled basins would be easier on the basis that large craters have hit and distributed a greater amount of material farther from the deposit's source. This process is still an inefficient means to disseminate basaltic material over large distances as it would still would likely require multiple impact events.

Discussion: We examined the spectra and composition of fresh crater ejecta immediately surrounding the model landing site in order to identify the lithologic components in the soil. We did this by comparing the spectra of fresh craters in the vicinity of the hypothetical landing site with the spectra of the intercrater basalts north of the site, the low and moderate TiO_2 basalts of Apollo Basin, and fresh basin floor material excavated by Antoniadi (70°S, 172°W; 143 km dia.), which lies 300 km to the south. The average spectrum of fresh craters (omat >0.35) surrounding 60°S, 160°W is similar to the average spectrum of fresh craters for the intercrater basalt units (Fig. 2). We used a linear mixing model of the 5-band spectrum and FeO concentration of the intercrater basalt and nonmare basin floor material north of Antoniadi to calculate that a mixture of 15:85 basalt and nonmare basin floor material would reproduce the spectrum and composition of the fresh crater materials surrounding the landing site. This mixture is 25:75 basalt/basin floor material if the spectrum of a low-Ti basalt from Apollo is used.

Conclusions: The possibility that the regolith in the location of 60°S, 160°W could contain ~20% basaltic material suggests that it would make a great target for collecting basaltic material and SPA basin material.

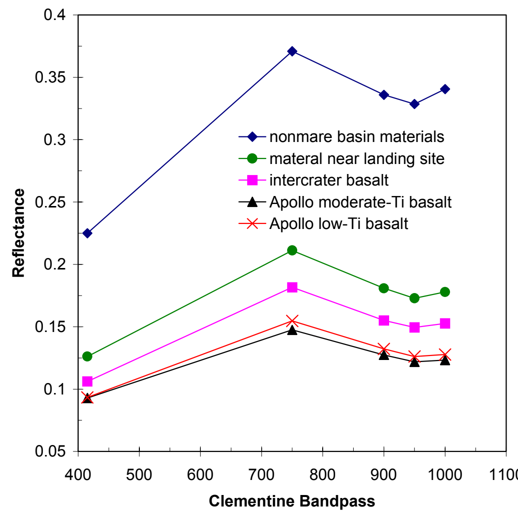

Fig 2. A comparison of Clementine 5-band spectra for various materials within SPA.

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