SAMPLE RETURN MISSION TO THE SOUTH POLE AITKEN BASIN. M. B. Duke[1], B. C. Clark[2], T. Gamber[2], P. G. Lucey[3], G. Ryder[1], and G. J. Taylor[3], [1]Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston TX 77058, USA (duke@lpi.jsc.nasa.gov; zryder@lpi.jsc.nasa.gov), [2]Lockheed Martin Astronautics, Denver CO, USA (benton.c.clark@lmco.com), [3]University of Hawai'i at Manoa, Honolulu HI, USA (lucey@pgd.hawaii.edu; gjtaylor@pgd.hawaii.edu).

The South Pole Aitken Basin (SPA) is the largest and oldest observed feature on the Moon. Compositional and topographic data from Galileo, Clementine and Lunar Prospector have demonstrated that SPA represents a distinctive major lunar terrane, which has not been sampled either by sample return missions (Apollo, Luna) or by lunar meteorites. The floor of SPA is characterized by mafic compositions enriched in iron, titanium and thorium in comparison to its surroundings [1,2]. This composition may represent melt rocks from the SPA event, which would be mixtures of the preexisting crust and mantle rocks. However, the iron content is higher than expected, and the large Apollo basin, within SPA, exposes deeper material with lower iron content. Some of the iron enrichment may represent mare and cryptomare deposits. No model adequately accounts for all of the characteristics of the SPA and disagreements are fundamental. Is mantle material exposed or contained as fragments in melt rock and breccias? If impact melt is present, did the vast sheet differentiate? Was the initial mantle and crust compositionally different from other regions of the Moon? Was the impact event somehow peculiar, for example, a low velocity impact? The precise time of formation of the SPA is unknown, being limited only by the initial differentiation of the Moon and the age of the Imbrium event, believed to be 3.9 by.

The questions raised by the SPA can be addressed only with detailed sample analysis. Analysis of the melt rocks, fragments in breccias, and basalts of SPA can address several highly significant problems for the Moon and the history of the solar system. The time of formation of SPA, based on analysis of melt rocks formed in the event, would put limits on the period of intense bombardment of the Moon, which has been inferred by some to include a "terminal cataclysm." If close to 3.9 billion years, the presumed age of the Imbrium basin, the SPA date would confirm the lunar cataclysm. This episode, if it occurred, affected all of the planets of the inner solar system and in particular, could have been critical to the history of life on Earth. If the SPA is significantly older, a more orderly cratering history may be inferred. Second, melt rock compositions and clasts in melt rocks or breccias may yield evidence of the composition of the lunar mantle, which could have been penetrated by the impact or exposed by the rebound process that occurred after the impact. Third, study of mare and cryptomare basalts could yield further constraints on the age of SPA and the thermal history of the crust and mantle in that region. The integration of these data may allow inferences to be made on the nature of the impacting body.

Secondary science objectives in samples from the South Pole SPA could include: analysis of the regolith for the latitudinal effects of solar wind irradiation, which should be reduced from its equatorial values; possible remnant magnetization of very old basalts; and evidence for Imbrium basin ejecta and KREEP materials. If a sampling site is chosen close enough to the poles, it is possible that indirect evidence of polar ice deposits may be found in the form of oxidized or hydrated regolith constituents.

A sample return mission to the Moon may be possible within the constraints of NASA's Discovery Program. Recent progress in the development of sample return cannisters for Genesis, Stardust and Mars Sample Return missions suggests that a small capsule can be returned directly to the ground without a parachute, thus reducing its mass and complexity. Return of a 1 kg sample from the lunar surface would appear to be compatible with a Delta II class launch from Earth, or possibly with a piggyback opportunity on a commercial launch to GEO. A total mission price tag on the order of $100 million would be a goal. Target date would be late 2002. Samples would be returned to the curatorial facility at the Johnson Space Center for description and allocation for investigations.

Concentration of milligram to gram-sized rocklets is a very effective strategy for sample studies of the lunar regolith. A rake accomplished this type of sampling in the Apollo missions. For the SPA sample return mission, either a small rover or an arm on a lander would deliver regolith to a sieving mechanism that retains fragments in the 1-10 mm size range. Approximately 10% of the mass of Apollo 16 regolith samples, which were from possibly similar highland terrain, consisted of fragments in the size range. To return 1 kilogram of rock fragments, approximately 5×10^3 cm^3 of regolith would have to be sampled. [3] suggested 7–10 mm as the optimum size for individual samples, which would require more regolith to be sieved.

This mission would represent the first landed mission to the lunar far side and, as such, requires that a communication link be established with the Earth. A growing number of assets at the Sun-Earth L-1 libration point may provide access to a viable communication link, avoiding the need for a communications orbiter. The mission need only be designed to last through a single lunar day, which could make it relatively straightforward; if a rover is chosen as the implementation for sampling, it may be possible to keep the rover alive for longer. This would be a cost/benefit tradeoff to be determined as part of the mission analysis.

Issues on which the lunar sample community should make input include: identification of additional scientific problems that can be addressed by samples from SPA; choice of landing site to maximize the probability of addressing the first-order problems; sample size and the distribution between regolith and rocklet samples; details of sample collection (range from lander, depth, avoidance of contamination from lander); and environmental control constraints on samples (maximum temperatures, acceptable leak rates on Earth). The premise is that this mission will have to be kept as simple and as low cost as possible to be selected by the Discovery program.

References: [1] Lucey et al. (1998) *JGR, 103*, 3701–3708. [2] Lawrence et al. (1998) *Science, 281*, 1484–1489. [3] Warren et al. (1995) *EOS Trans. AGU*, *77*, 33.