ROBOTIC SAMPLE RETURN I: ADVANCING OUR UNDERSTANDING OF PLANETARY DIFFERENTIATION. C.K. Shearer[1], S. Lawrence[2], and B.L. Jolliff[3]. [1]Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131(cshearer@unm.edu), [2]School of Earth and Space Exploration, Arizona State University, Tempe, Arizona 85287, [3]Department of Earth and Planetary Sciences, Washington University in St. Louis, St. Louis, Missouri, 63130.

Introduction. The Moon is an exceptional target for sample return (SR) because it is easily accessible, a witness plate for early Solar System events (e.g. impact history), preserves a record of early terrestrial planet processes that may be applicable to other planetary bodies (e.g. differentiation, crustal formation and evolution), exhibits an extended thermal and magmatic history of an evolving planet, and provides a near-Earth environment to demonstrate SR technologies that may feed forward to more distant destinations and complex mission architectures. Here, we examine the role of lunar SR for advancing our knowledge of the early differentiation of the Moon and other planetary bodies. A companion abstract by S. Lawrence addresses other science themes that may be fulfilled by SR.

SR and Links to LEAG Roadmap. The Lunar Exploration Analysis Group (LEAG), chartered by NASA to analyze key components, time phasing, and prioritization of lunar exploration, developed a roadmap for the robotic and human exploration of the Moon (http://www.lpi.usra.edu/leag/ler_draft.shtml). The roadmap consists of three themes - Science, Feed Forward, and Sustainability - divided into goals, objectives, and investigations. SR is intimately integrated into all three themes. For example, developing and implementing SR technologies and protocols is one of the Feed Forward objectives. Conducting a comprehensive resource and market assessment of commercial support for scientific and exploration activities is one of the sustainability objectives that require prospecting and assaying of lunar surface materials. SR is given a relatively high priority in the roadmap for fulfilling lunar science goals across various time phases. Time phasing includes various stages of exploration from simple non-mobile robotic SR to more complex robotic SR (with mobility) and human-enabled SR.

Examples of SR targets for understanding Planetary Differentiation and Crustal Evolution. Here, we provide examples of SR targets that will further our understanding of fundamental processes tied to the differentiation of the terrestrial planets. Interpretation of returned samples from the Moon within the context of recent mission results (e.g. GRAIL, LRO) will further enrich the science return from all these missions.

Example 1. South Pole-Aitken Basin (SPA) sample return: The Moon's SPA has been identified as a high-priority target for SR by numerous NRC studies and decadal surveys as well as NASA advisory committees. SPA SR will directly enable a more comprehensive understanding of the nature of the far-side crust and mantle with implications for planetary differentiation will be accomplished through a SPA SR. For example, sampling of basalts is important because they represent materials produced by melting of the lunar interior. Basalts returned from SPA Basin can be used to determine the composition of the mantle from which the basalts were derived, as well as the depth and extent of melting and chronology of mantle melting-crustal growth. These results can be used to test a variety of models relevant to the primordial differentiation of the Moon, origin and nature of lateral asymmetry in the Moon's mantle and its relationship to the well-defined crustal asymmetry, as well as test theoretical models for the effects of large basin-forming impacts. Samples of basalt, including cryptomare and volcanic glasses, are needed to determine the chemistry, petrology, and history of the sub-SPA mantle.

Example 2. Sampling of the "primordial lunar crust" from the farside highlands: A fundamental concept derived from the samples returned from the Apollo Program was that the Moon experienced large scale melting (Magma Ocean (MO)) and that primordial crust was formed during this event as a result of plagioclase flotation. This primordial crust is thought to be represented by the ferroan anorthosites (FANs). This MO concept has been extended to many of the terrestrial planets. However, more recent crystallization ages for FANs using multiple chronometers have yielded relatively younger ages than expected for most MO models. These ages (4.3 to 4.4 Ga) have been interpreted in several divergent ways: (a) a young Moon, (b) a Moon-wide thermal event, (c) FAN samples collected during Apollo do not represent primordial crust, or (d) there was no MO. Sampling FANs from farside targets is one feasible pathway to provide valuable insights concerning a fundamental planetary process and solar system chronology.

Example 3. Sampling of the deep lunar crust excavated in central peaks: Unlike the Earth, in which the deep crust and shallow mantle are accessible through tectonic and volcanic processes, the deep crust (and perhaps the shallow mantle) on the Moon are accessible in central peaks associated with large impact basins. Sampling central peaks will allow the reconstruction of the chronology of lunar crustal growth and the thermal history of both the lunar crust and mantle.