Preparing for the Next Generation of Lunar Sample Return.

Charles Shearer[1], Gary Lofgren[2], and Clive Neal[3]. [1]Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131 (cshearer@unm.edu). [2] KT, Johnson Space Center, Houston, TX. [3] Department of Civil and Geological Engineering, University of Notre Dame, IN 46556

Introduction: Sample return missions provide a unique perspective not offered by either orbital or surface missions – the opportunity to study the returned material in well equipped Earth labs. This unique perspective is based on scale (down to angstroms), precision, sample manipulation capability, and the ability to modify analytical experiments as logic and technology evolves [1]. The return of samples during the Apollo Program and subsequent analysis of samples over a period of almost 40 years illustrates these points. Now that we are planning on returning to the Moon, what lessons have we learned from the Apollo Program and ensuing lunar science that will shape our strategy for sampling and curation of lunar materials during the next generation of lunar exploration?

Sampling:

Sample Mass. The total mass of sample returned during the Apollo Program was approximately 381.7 kg. The Apollo 17 mission, which is our closest approximation to initial future human missions in terms of mobility, expected crew training, duration on surface, returned a mass of 110.5 kg. An analysis of sample capabilities for future lunar exploration conducted by CAPTEM concluded that a total mass capability of 250 to 300 kg is appropriate to accommodate all materials and associated containers from the lunar surface [2].

Placing Samples within Geologic Context. Compared to the Apollo Program, the geology, mineralogy, and geochemistry of the lunar surface will be far better documented during future lunar surface activities. The availability of such data will result in refined training techniques and surface planning activities and provide a better geologic and scientific context for sample collection. Samples will be selected within local-, regional-, and planetary-scale context making them scientifically more valuable. Providing precise ground truth will feedback into improving and refining orbital observations. Linking samples with local geophysical networks will increase the scientific value of both. Investments must be made in both state-of-the-art imaging capabilities that are transferable from training activities on Earth to surface activities on the Moon.

Sample Analysis on Surface. As demonstrated by Apollo, the training of astronauts to perform as scientists and geologists on the surface of the Moon is key to collection of important samples and placing them in the context of local geology. An important augmentation to human observations is the development of simple analytical tools that assist the astronaut in sample selection. Clearly, these tools need to be miniaturized, user friendly, safe, and provide rapid results. However, it is important that the astronaut not be over loaded with instrumentation that makes the surface analyses cumbersome and overly long: simplicity is the key. Therefore, investments must be made in the technology to perform relatively quick and simple analyses on the lunar surface, always keeping in mind the strategy behind sample selection.

Sample Contamination. The Apollo Program was extremely successful in reducing contamination levels during sample collection. There were, however, some mistakes. The choice of Indium for the seal material in the rocks boxes precluded the scientific use of that element. More damaging was the inadvertent Pb contamination of the core stems for the deep drill on A-15 during the manufacturing process. Such mistakes point to the need for close cooperation between the science and engineering communities during the design and manufacture of hardware – preserving sample pristinity must take precedence over standard engineering materials that might make acquiring samples relatively easy, but in doing so contaminate the sample.

Preservation of Sample. The procedures for the return of samples much be reevaluated in light of past experience and future needs such as return sample container weight. Understanding the extent and properties of volatile-rich material within permanently shadowed lunar polar regions is a near-term high priority exploration objective for both scientific and engineering / resource availability reasons. In addition, retaining volatiles that occur on grain surfaces in the lunar regolith and minimizing modification to minerals susceptible to phase changes or chemical alteration in a non-lunar environment is also critical. The design of new containers for the return of samples that contain volatiles is a top priority. Technologies for cold/cryogenic and organic-contamination-free collection-storage are necessary to enable the sampling of these types of samples. In addition, pressure, humidity, and temperature management are necessary to maintain sample integrity and minimize sample phase changes.

Curation:

Curation facility and Infrastructure needs. The mass of samples returned by Apollo will be exceeded within 1-2 years if 180-200 kg of lunar samples is returned per mission, and there are 2 lunar missions per year. Therefore, it is important to examine the current capacity and infrastructure available at the Lunar Sample Facility at the Johnson Space Center and the White Sands Test Facility.

Advanced curation of fragile or environmentally sensitive samples. As noted above, icy regolith, volatile-rich materials, and reactive-samples present new technological challenges for curation. New curation techniques must be developed for preliminary examination, preservation, contamination, and allocation. Perhaps the first step is to examine some of the uniquely collected and stored sample returned during the Apollo program [3].

References: [1] Shearer and Borg (2006) Chemie der Erde 66,163-185. [2] Shearer et al. (2007) Analysis of Lunar Sample Mass Capability for the Lunar Exploration Architecture, CAPTEM Document 2007-1. [3] Lofgren (2008) 39th LPSC abstract# 2199.