AN APOLLO LEGACY. SAMPLES, THE GIFT THAT KEEPS ON GIVING TO FUTURE GENERATIONS. Charles K. Shearer[1], Harrison H. Schmitt[2], Bradley L. Jolliff[3]. [1]Institute of Meteoritics, Department of Earth and Planetary Science, University of New Mexico, Albuquerque, New Mexico 87131. [2]University of Wisconsin-Madison, P.O. Box 90730, Albuquerque, NM 87199. [3]Earth & Planetary Sciences and the McDonnell Center for the Space Sciences, Washington University, St. Louis, Missouri 63130.

Introduction: The Apollo Program returned 381 kg of samples. Subsequent analyses of these samples provided fundamental insights into the origin and history of the Earth-Moon system and how planets and even Solar Systems work. These samples have provided ground truth for every post-Apollo mission to the Moon for the interpretation of remotely sensed data. After 50 years of analysis and study, our sophistication for handling and examining samples has greatly increased. This increase in sophistication has resulted in the targeting of numerous "new' Apollo samples to examine. There are several types of "new" Apollo samples. (a) ***Reevaluated samples:*** Previously documented and studied samples that provide great insights with the application of new analytical technologies and approaches and the re-examination of astronaut observations and photography. For example, NanoSIMS analyses of "water" in volcanic glasses [1]. (b) ***Hidden samples***: Clasts of highland lithologies and ancient basalts that may be identified in breccias through micro-computed tomography imaging. (c) ***Special samples***: Samples that were collected or preserved in unique containers or environments and remain unexamined by standard or advanced analytical approaches. This abstract examines the types of Special Samples that are available and focuses on important magmatic, impact, and regolith processes that may be revealed by the Apollo 17 (A17) *Core Sample Vacuum Container* (CSVC).

Special Samples: With great foresight, Apollo mission planners and sample scientists devised sample containment and preservation approaches that more rigorously attempted to capture delicate and potentially transitory characteristics of lunar samples that were disturbed or lost during standard sample collection and handling. In many cases, the purpose of samples placed in sealed containers was to protect characteristics that could be modified by interactions with spacecraft cabin conditions, the Earth's environment, or agitation of regolith samples [2]. A total of 9 containers of lunar samples were sealed on the lunar surface and transported to Earth during the Apollo Program. Two of the larger sealed samples were collected from Apollo 17. Three sealed samples from Apollo 15, 16, and 17 remain unopened. Special sample containers include the (a) Gas Analysis Sampling Container (GASC), (b) Core Sample Vacuum Container, (c) Special Environmental Sample Container (SESC), (d) Lunar Environment Sample Container (LESC), (e) Magnetic Shield Sample Container and (f) Contact Soil Sample Container. The SESC and CSVC have knife edge-indium seals. Current unopened samples include two CSVCs (69001 and 73001) and a SESC (15014). For the CSVC from both Apollo sites, drive tube cores were immediately placed in vacuum containers on the lunar surface. Upon return to the Lunar Receiving Lab each CSVC was placed in an additional vacuum container. The samples were stored in the Lunar Laboratory Pristine Sample Vault. Combined these three unopened samples contain 1.7 kg of unstudied and probably pristine lunar material. This mass exceeds the mass returned by all of the robotic Soviet Luna missions and projected returned masses for some future lunar robotic missions. In addition to these sealed samples, selected Apollo samples were also handled and curated using non-standard approaches. Upon return, several sample splits for drill core 70001-70006 were frozen. Samples from an Apollo 14 SESC were removed and stored under helium rather than nitrogen. Several shadowed and subsurface samples were collected in partially sealed Teflon bags.

Analysis of Unopened Samples: As the total sample mass within the unopened containers exceeds projected masses returned by future robotic missions, each unopened sample should be treated as an individual lunar mission. As these samples must be examined in a very systematic manner, Shearer [3] outlined a potential methodology for the study of unopened samples in a consortium approach. This approach includes sampling head gases in both the outside vacuum container and the CSVC. The possibility and practicality of sending splits of these special samples in containers sealed under the dry nitrogen atmosphere to facilities for unique analyses was evaluated [3]. This approach would minimize or eliminate contamination for particular measurements (e.g., bulk D/H, organics). Such a methodology must be examined and reviewed by JSC Curation and CAPTEM, as these groups provide recommendations on sample handling to NASA HQ. It is prudent to assume that analytical techniques will continue to improve in the future and science goals will change with additional observations and data. We advocate opening a single sample container and saving the remaining two samples for future generations of lunar scientists.

Apollo 17 CSVC: 73001 was collected at Station 3 located on the surface of a 75-100 Myr old avalanche from the South Massif [4]. It contains approximately 809 grams of sample. It is one of three remaining special containers that are the least likely to be contaminated [5-7]. CSVC 73001 is the lower portion of the core tube that may have been "frozen" (250 K) *in situ* at the time it was sealed and therefore provides a sampling of a volatile cold trap as indicated by the heat flow experiment [8]. The 73001 sealed core is paired with upper core sample 73002, neither of which has been examined. The contents of 73002 have been imaged using X-rays. The combined double drive tube represents a continuous stratigraphy of possibly two avalanche deposits from the South Massif [4] that may be characterized in detail by integrating samples, new remote sensing data, and surface field observations (Fig. 1). Based on these attributes, the Station 3 double drive tube provides an opportunity to examine (a) the lunar volatile record preserved in a CSVC, (b) a unique lunar feature (landslide deposit), (c) material derived from the South Massif of the Taurus-Littrow Valley (TLV), and (d) potential effluents from a young thrust fault.

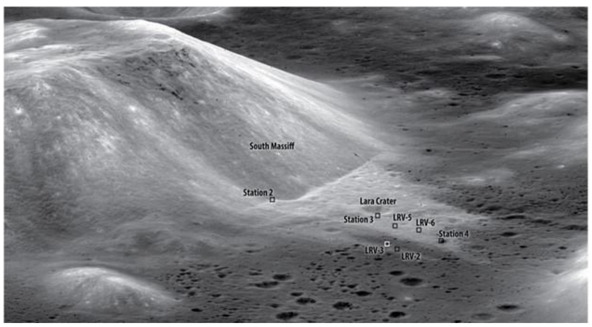

Figure 1. LROC Narrow Angle Camera oblique image of the Taurus Littrow Valley, centered on South Massif and the light mantle deposits. Locations of Station 3 and other nearby sampling areas are marked. (NASA/GSFC/ASU).

Apollo 17 CSVC Science: Numerous investigations can be pursued using the samples in the Apollo Station 3 double drive tube that leverage the uniqueness of both the sample containment and the geological setting.

Investigations of the volatile reservoirs and volatile cycles on the Moon: Over the last decade numerous studies and missions have pointed to a lunar volatile cycle with three principal components: primordial (interior) volatiles, surficially-formed volatiles, and polar (sequestered) volatiles. Lunar regolith contains evidence for these various volatile reservoirs, their origins, and their interactions. The CSVC may better preserve weakly bound volatiles and volatile coatings on mineral surfaces, and limit contamination of lunar H-species, Xe, Pb isotopes, and organics. The results of this integrated study of volatiles in lunar regolith and lithic clasts will shed light on (1) the concentration and behavior of volatiles in the lunar regolith; (2) the interactions among lunar volatile reservoirs; (3) the potential existence of pre-mare degassing events [4,9]; (4) the noble and other gas composition of the solar wind as recorded on the Moon; and (5) the indigenous noble gas content of the Moon.

Investigations of new lunar lithologies to reconstruct the lunar magmatic-volatile-thermal-impact history: What is especially intriguing about the Station 3 double drive tube is that it samples an avalanche deposit from the South Massif adjacent to the TLV. New lithologies may be examined, including possible Tycho impact-melt materials. New magmatic lithologies will establish models for the degassing of the lunar mantle, chronology of magmatic events, mantle geochemistry, and primordial differentiation. New impact lithologies will increase knowledge of the chronology of impact crater- and basin-forming events, and the excavated materials.

Determine the stratigraphy and chronology of lunar avalanche deposits to refine our understanding of lunar surface processes: Establishing a stratigraphy for the double drive tube provides an important context for other data collected from the core. Further, it defines the regolith evolution processes active in the upper portion of a lunar avalanche deposit, important variables in lunar avalanche events, and properties of the regolith that are important for the concentration and retention of lunar volatiles. Identification of South Massif components represented in the regolith combined with the exposure chronology of the light-mantle deposit(s) will enable interpretation of other lunar events or Moon-wide processes.

Examine the contribution of meteoritic components to formation and evolution of the lunar regolith and near-surface volatile reservoirs: In coordination with these petrologic studies, Mo and Ru isotopic analyses of stratigraphically controlled soil samples can be used to characterize the genetic make-up of the dominant impactor components as a function of depth. These data will identify the meteoritic components, with implications for their contributions of volatiles [10].

An Exploration Benchmark for Future Missions: *Provide an integrated and overarching evaluation of the collection and preservation of volatile-rich samples for future exploration:* Future lunar missions will emphasize the definition of lunar volatile reservoirs and their ISRU potential. In-situ analyses will provide information concerning undisturbed volatile reservoirs prior to sampling. For both in-situ measurements and sampling, methods should be designed that are cleaner and simpler than used for Apollo, and that disturb the soil less drastically. These samples represent our best chance to evaluate these approaches and to inform future missions on requirements for in-situ measurements. Furthermore, they will provide engineering guidance for the design of future containment of lunar volatiles.

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