Unopened Treasures in the Apollo 17 Sample Collection. A Perspective for Future Research and Missions.

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Introduction: The Apollo 17 mission provides a blueprint for future human exploration of the Moon. As a J-style mission, significant mobility enabled sample collection over a wide area in Taurus-Littrow Valley traveling a total distance of 36.9 km. The Apollo 17 mission returned 110.5 kg of a variety of sample types. This was approximately 30% of the total sample mass returned by the Apollo Program (381 kg). 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. Although these samples were carefully and strategically collected and well-preserved in a clean environment during preliminary examination and curation, in many cases some delicate and perhaps transitory characteristics were significantly disturbed or lost (e.g., volatiles, volatile coatings on mineral surfaces). The importance of many of these fragile characteristics is acknowledged by lunar orbital observations from such missions as Lunar Prospector, Lunar Reconnaissance Orbiter, and Chandrayaan 1 (e.g., [1-3]). These orbital missions identified substantial and many distinct volatile reservoirs on the Moon. With great foresight, Apollo mission planners and sample scientists devised sample containment that more rigorously attempted to capture these fragile sample characteristics. A total of 9 containers of lunar materials 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. Since the Apollo and Luna missions our sophistication for examining samples has greatly increased, and since 2009 the importance of volatiles on the Moon has been dramatically highlighted (e.g., [4]). Now is the right time to consider opening at least one of these sample containers. This abstract documents these special samples, outlines a preliminary examination-curation-analysis approach, and identifies the importance of these samples for the continuation of lunar exploration.

Special Samples: Numerous "special samples" were collected during the Apollo Program in an attempt to preserve their unique and fragile characteristics. 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 or the Earth's environment. One obvious case that illustrates potential interaction between sample and post-collection environment is 66095 ("rusty rock"). It has long been debated the extent 66095 has reacted with the Earth's environment (e.g., [5,6]).

Special sample containers include (a) Gas Analysis Sampling Container (GASC), (b) Core Sample Vacuum Container (CSVC) (Figure 1), (c) Special Environmental Sample Container (SESC) (Figure 2), (d) Lunar Environment Sample Container (LESC), (e) Magnetic Shield Sample Container (MSSC) and (f) Contact Soil Sample Container. SESC and CSVC have indium seals and were both used on the Apollo 17 mission. 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 Pristine Sample Vault. Combined these three unopened samples contain 1.7 kg of pristine and unstudied lunar material. This mass exceeds the mass returned by all of the robotic Soviet Luna missions and projected returned masses for many future lunar robotic missions.

Sample 73001 contains approximately 809 grams of sample. The sample, the bottom segment of a double drive tube from below 22 cm depth was collected at Station 3 (Figure 3). It may have been "frozen" (250° K) at the time it was sealed [7]. Although not in a CSVC, the upper drive tube (73002) has not been examined and remains sealed and unopened. However, its contents have been examined by X-ray. There is a similar sealed and unopened drive tube from the Apollo 17 (70012). A single unstudied rock (71036) has been kept frozen.

Analysis of Unopened Samples: As the total sample mass within the unopened containers exceeds projected masses returned by future robotic missions, each unopened samples should be treated as an individual lunar mission. As these samples must be examined in a very systematic manner, Shearer [8] outlined a potential methodology for the study of unopened samples in a consortium approach. This includes sampling head gases in both the outside vacuum container and the CSVC. Also, the possibility and practicality of sending splits of these special samples in containers sealed under the N atmosphere to facilities for unique analyses was suggested by Shearer [8]. This would minimize-to-eliminate contamination for particular measurements (e.g. bulk D/H, organics). Such a methodology must

Figure 1. The CSVC (stored in the a vacuum container) used during the Apollo 17 mission had a length of 41 cm, an outer diameter of 6.1 cm and a weight of 493 g.

be closely examined and reviewed by JSC curation, and CAPTEM. These groups provide recommends on sample handling to NASA HQ. It would be prudent to assume that analytical techniques will continue to improve in the future and science goals will change with additional observations and data. Therefore, we are advocating opening a single sample container and saving the remaining two samples for future generations of lunar scientists.

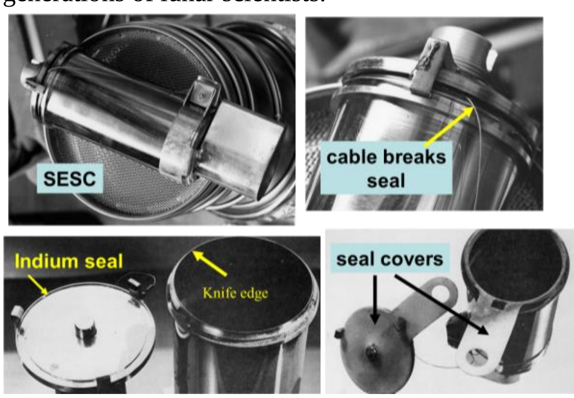

Figure 2. The SESC has a length of 21 cm, an outer diameter of 6.1 cm, a volume of 360 cm^3 and a weight of approximately 360 g. During their use on the lunar surface, some seals were broken by cables trapped between the indium seal in the lid and the knife edge of the container.

A Guide for Future Missions:

Exploring and sampling lunar volatile surface reservoirs: During future lunar missions there will be significant emphasis on the definition of lunar volatile reservoirs and their ISRU potential. In situ analyses will provide information concerning

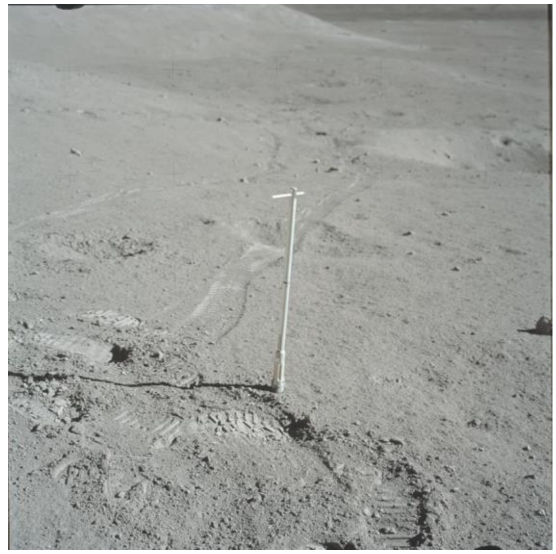

Figure 3. Collection site for 73001 ~50 meters east of Lara crater and ~1500 meters southwest from Shorty crater.

undisturbed volatile reservoirs prior to sampling. For both in situ measurements and sampling, methods should be designed that are cleaner and simpler and that disturbs 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.

Design of SESC and CSVC containers: The containers used during the Apollo program were a reasonable attempt to preserve many characteristics of the lunar regolith. These types of sample containment should not only be utilized during future human missions to the Moon, but may be applicable to robotic missions to Moon and other planetary bodies. Future SESC and CSVC design should include (1) better, long lasting vacuum seals without the potential for indium contamination, (2) easier to use containers, (3) involve an overall general design that can be modified for specific samples, and (4) enable cryogenic cooling of samples to better preserve initial form of volatile compounds.

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