REVISITING APOLLO AND PREPARING FOR ARTEMIS: A PERSPECTIVE FROM THE ANGSA INITIATIVE. C.K. Shearer1,2, F.M. McCubbin2, and The ANGSA Science Team2. 1Dept. of Earth and Planetary Science, Institute of Meteoritics, University of New Mexico, Albuquerque, New Mexico 87131; 2Lunar and Planetary Institute, Houston TX 77058 (cshearer@um.edu); 3ARES, NASA Johnson Space Center, Houston (JSC) TX 77058-3696, *the list of co-authors includes all members of the ANGSA Science Team (https://www.lpi.usra.edu/ANGSA/teams/JSC/), which includes members of the JSC curation team that participated in ANGSA (https://www.lpi.usra.edu/ANGSA/teams/JSC/).

Introduction: For a very short period of time in history humans walked, explored and carried out science goals on the surface of a planetary body beyond Earth. The science yield from the Apollo Program provided a completely new perspective concerning the Solar System and our place in it. It stimulated the launch of a new episode of robotic exploration of the Earth-Moon system and beyond in the decades that followed.

One major science achievement of the Apollo Program was the return of 381 kg of samples. Analyses of these samples have provided a foundation for understanding the origin and chronology 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. With great wisdom and foresight, the earliest Apollo planners and sample scientists not only promoted the collection a variety of special samples during the Apollo program, but they also set aside several of these special samples for future generations of lunar researchers to use once more sophisticated handling, examination, and analysis methods became available. The Apollo Next Generation Sample Analysis (ANGSA) Program was designed to examine a subset of these special samples. The program was promoted and designed to function as a sample return mission with site characterization, processing, preliminary examination and analyses utilizing new and improved technologies and recent mission observations. The ANGSA Program links the first generation of lunar explorers (Apollo) with future explorers of the Moon (Artemis). The purpose of this abstract is to illustrate how the ANGSA initiative is fulfilling goals set down during Apollo and preparing the next generation of scientists for the future exploration of the Moon.

Apollo Goals and Special Samples: Two distinct types of samples are being investigated by ANGSA Program teams: (1) an Apollo 17 double drive tube comprising an unopened vacuum-sealed core sample (Core Sample Vacuum Container; CSVC 73001) and its unsealed but unstudied companion core 73002; and (2) samples that were placed in cold storage approximately one month after their return in the early 1970s. Core samples 73001 and 73002 constitute the double drive tube core that penetrated a lunar landslide deposit in the Taurus-Littrow Valley (Fig. 1). Some of the original Apollo 17 mission goals for this double drive tube included sampling gases potentially derived from the Lee-Lincoln scarp and trapped within the overlying landslide deposit; and penetrating a lunar landslide deposit to better understand its stratigraphy, triggers, dynamics, and chronology. Not completed during the Apollo Program, they will be completed during the ANGSA program. The total double drive tube core length is approximately 71 cm with 73001 representing the deeper part of the core. The temperature at the bottom of the core was approximately 250 K [1]. Sample 73001 was placed in a CSVC on the lunar surface and its upper companion core resided unexamined (until 11/2019) in a sealed aluminum double drive tube [2,3]. The Apollo samples that were stored at 253 K for almost 50 years will be handled and curated at that temperature.

![Image](https://www.lpi.usra.edu/ANGSA/teams/JSC/)

Fig. 1. Perspectives of the light mantle deposit and Station 3 illustrating new views of in sample site. (a) Topography of the TLV (from defense mapping agency, 1974). b. and c. LROC images of the TLV and station 3. d. LRO Mini-RF m-chi decomposition map which can be used to examine rock distribution with depth [4].

Beyond Apollo:

Teams: The ANGSA Science Team consists of nine teams funded by NASA and JSC lunar curation personnel. The team consists of over 100 scientists and engineers who bring centuries of experience working on lunar samples and a wide range of expertise. Their responsibilities include: (a) sample measurements such as organics, traditional and non-traditional stable isotopes, chronology, geochemistry-mineralogy-petrology, noble gases; (b) placing samples in the context of field and orbital observations; (c) design of new tools and instruments for sample collection, preservation, documentation, and analysis; and (d) new curation methodology for retaining sample pristinity.
What is new since Apollo: Was it worth waiting 50 years to open new samples? Yes. There are numerous intellectual and technical changes that allow a fresh look at these “new” samples. Our understanding of the Moon has changed (e.g., volatile reservoirs and cycles), identifying new concepts to explore. Numerous lunar missions (e.g., Lunar Pathfinder, LRO, Kaguya, Chandrayaan-1, Chang’E missions) allow development of a fresh geological context for the samples. New tools have been developed to conduct preliminary examination (e.g., micro-XCT). New analytical instruments have been developed to examine samples at the nano-meter scale (e.g., SEM-FIB, TEM), analyze smaller masses of material due to increased sensitivity (e.g., TIMS, ICP-MS, SIMS), and apply newly developed isotopic systems (e.g., Cl, Cu, Zn, K).

What is the chronology of major lunar events (e.g., differentiation, basin formation, magmatism)? (g) What are the characteristics and chronology of episodes of lunar magmatism and how do these events deliver indigenous volatiles to the lunar surface?

Preparing for Artemis: Will ANGSA prepare us for future lunar exploration by providing a valuable generational link between Apollo and Artemis? Yes, in several manners: (a) ANGSA provides a forum for the scientific interaction between multiple generations of lunar scientists; (b) New approaches are being developed for sample examination, processing, and handling (Fig 4). These include cold curation, whole core and component imaging, and handling of pristine samples; (c) During Preliminary Examination Team (PET) activities early career scientists and engineers get their first taste of examination and processing of new lunar samples; (d) Tests of the capability of the Apollo-generation sealed sample containers (CSVC) at preserving the volatile record of lunar samples and protocols for extracting the volatiles will inform development of future CSVCs.

Fig. 2. Collection of 73001/2 double drive tube at Station 3.

Fig. 3. Sealed containers used during the Apollo missions. The CSVC’s were used during Apollo 16 and 17. Neither has been opened. How well these containers worked and possible improvements for sampling volatiles are goals of ANGSA.

Apollo-ANGSA Science Goals: ANGSA has numerous science goals that fulfill Apollo mission goals and address new science concepts developed over the last 50 years. Here are only a few: (a) Are indigenous gases released from tectonic features (e.g., scarps) and trapped in the overlying regolith? (b) What are the reservoirs of lunar volatiles, how do they interact, and how well are they preserved in the lunar regolith? (c) What is the origin and sources of organic compounds on the Moon and other airless bodies? (d) What triggers episodes of lunar landslides? (e) What are the dynamics of lunar landslide deposits and what is the role of volatiles in this process? (f) What triggers episodes of at least sensitivity (e.g., TIMS, ICP-MS, SIMS)?


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