THE APOLLO SAMPLE COLLECTION: 50 YEARS OF SOLAR SYSTEM INSIGHT.

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Introduction: The Apollo program was the seminal moment in modern human history and the crowning technological achievement of the 20th century. Scientific results from the Apollo samples have had a lasting impact on a range of scientific fields, particularly planetary science and cosmochemistry. Studies of Apollo samples continue to make significant insights into planetary bodies throughout the solar system. Here we will discuss the history of Apollo samples collection, curation, and study, and also look forward to expected new developments in the coming years.

Apollo Samples: From 1969 to 1972, the Apollo astronauts collected 382 kg of rock, regolith, and core samples from six geologically diverse locations on the Moon. The Apollo samples span an incredible range of sample types, including: large rock samples, multiple rocks chipped from large boulders, bulk surface, trenched, and shaded lunar soils , multiple 30-60 cm drive tubes, deep drill cores samples up to ~3 meters in depth, and several different types of special vacuum-sealed regolith and drive tube samples. There have been 3158 unique lunar sample requests from >500 different Principal Investigators from over 15 different countries in the past 50 years and the total number of samples allocated is >50,000 individual subsamples. Currently 145 active lunar PIs are studying >8,000 samples.

Discussion: Studies of the Apollo samples, both early and more recent, continue to yield significant insights into the formation, evolution, and maturation of the Earth-Moon system, as well as many other planetary bodies in both the inner and outer solar system. Listed below are a subset of results that highlight the wide-ranging, long-lasting, and diverse nature of studies of Apollo samples: (1) The Moon formed from the debris of a giant impact between the proto-Earth and a large bolide early in the solar system history [1]. (2) The Moon had a Lunar Magma Ocean, and evolved akin to a global (though asymmetric) layered-mafic intrusion [2]. (3) A prevalence of ~3.9 Ga ages of lunar impact melts suggests that there might have been a "Lunar Cataclysm" at that time, which would have affected all of the inner solar system [3]. (4) The potential prevalence of impacts ~600 Ma after solar system formation (i.e., the "Lunar Cataclysm") was one of the factors leading to new dynamical models for the evolution of the entire solar system, e.g., the Nice Model [4]. (5) By tying the ages of Apollo basalts to the crater densities in the regions of the Apollo landing sites, relative crater counting ages can be given absolute ages on the Moon, as well as elsewhere in the inner solar system [5]. (6) Despite decades of null results for volatiles in lunar samples (e.g., H_2O), recent results [e.g., 6,7] have shown that the Moon is not "bone dry" and these volatile abundances inform the models for lunar formation. (7) The composition of Apollo samples have directly contributed to the interpretation of remotely sensed data sets, including their use as ground truth for both Clementine and Lunar Prospector global geochemical maps [8].

Future Apollo Studies: NASA recently solicited proposals as part of the Apollo Next Generation Sample Analysis (ANGSA) program [9]. The ANGSA program includes previously unopened, vacuum-sealed drive tubes and bulk soil samples, cold-curated samples (-20°C), and samples only handled in a He-purged environment. Furthermore, JSC Curation can now scan samples using X-ray Computed Tomography (XCT); XCT scans of polymict breccias are expected to identify "new" lithic clasts for PIs to study. Similarly, there are 10,000s of small particles in the >110 kg of bulk lunar regolith, and a portion of these will also be classified and made available to PIs after a retroactive preliminary examination process utilizing XCT, micro X-ray Fluorescence, and Imaging micro-Raman Spectroscopy. Additionally, a new searchable database for lunar geochemical data called MoonDB has been brought online [10].

Conclusions 50 years of study of Apollo samples yielding important insights into a wide-variety of topics and planetary bodies has shown that sample return missions are "the gift that keeps on giving." Many of the results highlighted in this abstract were not yet conceived of (or the instruments not yet invented) when the samples were first brought back. However, because the samples have remained available, and been maintained in a pristine manner, future generations of scientists continue to extract greater and increasingly novel value beyond the initial studies. Despite the costs, complexity, and risk (real or perceived) associated with sample return missions, the long-lasting legacy of scientific return for sample-return missions more than offsets these mitigating factors. This is not to say that sample-return missions and sample-related studies are the only type of planetary science that should be pursued, but rather that they are a key component of a holistic way of studying the solar system, combined with remote-sensing and *in-situ* missions, as well as modelling-based and experimental-based studies on Earth.

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