

Rock Types of Apollo Sampling Stations and Beyond. L. Sun¹, P. G. Lucey¹, G. J. Taylor¹ and L. M. V. Martel¹.
¹Hawai'i Institute of Geophysics and Planetology, Dept. of Earth Sciences, University of Hawai'i at Mānoa, 1680 East-West Rd. Honolulu, HI 96822, USA (lsun@higp.hawaii.edu).

Introduction: It has been 50 years since the first Apollo sample was returned, and most of the Apollo rock and soil samples have been intensively studied by former researchers [1]. The “J” missions, Apollo 15, 16 and 17, explored areas with complex geological settings on the Moon [2]. However, even though the major rock types of the returned lunar samples are already well known, their origin is still not fully understood, which is possibly due to the highly mixed ejecta of basins and craters. With the help of spectral un-mixing, we conducted a joint study of the returned lunar samples and remotely sensed images, which could provide a broader view of lunar samples.

In this study, we will make use of mineral maps [3] derived from radiative transfer modeling and Multi-band Imager (MI) images [4] to search areas on the Moon that have similar rock types to Apollo 15, 16 and 17 sampling stations. Our mineral map will be validated by the mineral abundances derived from quantitative XRD analysis.

Methods: Ninety-eight Apollo samples were sieved to <150 μm and then analyzed with an Olympus Terra XRD instrument [5], and their mineral abundances were extracted from XRD patterns with Rietveld refinement from the Jade program. In this study, only glass-free minerals are considered. We averaged the mineral contents of samples that were collected from the same station by comparing to the locations marked by catalogs of Apollo 15-17 rocks, and we finally get mineral modes from forty stations. We built geological correlation between the Apollo traverse map from LROC and MI images, and extracted the mineral abundances from the same sampling station to the XRD dataset using a 3x3 box.

Fig. 1 plotted mineral modes derived from MI mineral maps and those measured by XRD. Overall MI plagioclase tend to be a little bit higher than XRD results. The correlation coefficient R is as high as 0.95, suggesting MI minerals have a good correlation with those of lunar soils.

Results and discussions: Each sampling site was classified by its geological setting. For Apollo 15, we

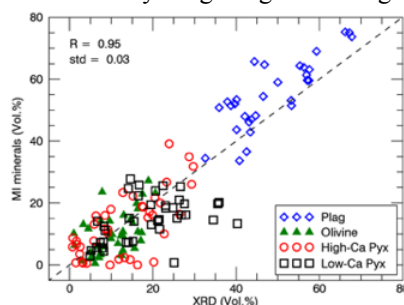


Fig. 1. Mineral modes from MI mineral maps vs. XRD analysis of lunar soil samples (glass free). Dashed line is 1:1 ratio.

have Mare (LM), Rille (S9, S9A), Apennine Front (S6, S6A, S7), Elbow (S1) and Dune (S4). For Apollo 16, we have North Ray (S11, S13), South Ray (S6, S8, S9), Cayley plains (LM, S1-2) and Descartes Mountains (S4-5). For Apollo 17, we have Valley, South Massif (S2), Light Mantle (S2A, S3-4, LRV5), North Massif (S6-7, LRV10), and Sculptured Hills (S8, LRV11). The rock type of each group was characterized by the rock classification diagram Stöffler et al. (1980) [6].

Based on this classification, we then take the mineral content range of plagioclase, olivine, low-Ca pyroxene and High-Ca pyroxene for samples from each geological setting as criteria to search areas on the Moon that have similar rock types to the sampling stations. We were only searching within immature area (OMAT > 0.25, [7]). Taking the Apollo 16 sampling stations as an example, shown in Fig.2, North-Ray has similar rock types to many fresh craters from lunar far-side, and South ray rock type is consistent with lunar near side highlands. This suggest Apollo 16 samples to be representative of lunar highlands materials. Cayley plains are suggested to be light plains formed by basin ejecta deposits [8], and from our map, it can be seen that they may be part of Orientale ejecta, which is consistent with Meyer et al. (2018) [9]. The matching area of Cayley plains are largely overlapped Descartes Mountains, suggesting they might have similar origins.

References: [1] Papike J. J., et al. (1998) *Rev. Mineral. Geochem.*, 36, 5.1-5.234. [2] Spudis and Pieters, *lunar source book*, 595-632. [3] Lemelin, M., et al. (2015). *JGR*, 120(5), 869-887. [4] Ohtake, M., et al. (2013). *Icarus*, 226(1), 364-374. [5] Taylor G. J. et al., 2019 (submitted). [6] Stöffler, D., et al. (1980). *Proc. Conf. Lunar Highlands Crust*, 51-70. [7] Lucey P. G. et al. (2000). *JGR: planets*, 105, E8. [8] Eggleton R. E. and Schaber G. G., 1972, *NASA Special Publication*, 315: 29-7. [9] Meyer et al. (2018), *LPSC 49*, #2083.

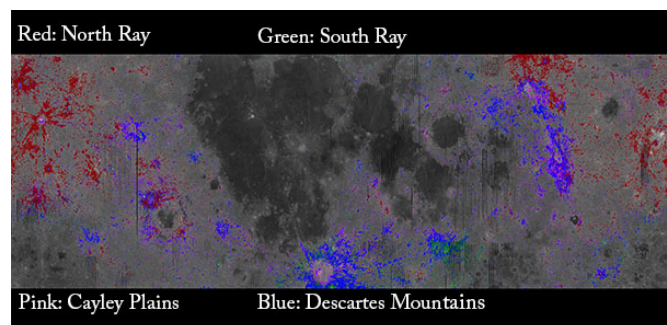


Fig.2. Area having similar rock types to Apollo 16 sampling stations