Multispectral Imaging Results of Apollo 17 Double Drive Tube 73001/2. L. Sun[1], P. G. Lucey[1], A. Flom[1], R. A. Zeigler[2], J. Gross[2,3] , N. Petro[4], C. Shearer[5], F. M. McCubbin[2] and The ANGSA Science Team[6], [1]Hawaiʻi Institute of Geophysics and Planetology, University of Hawaiʻi at Mānoa, Honolulu, HI 96822, USA, lzsun@higp.hawaii.edu, [2]NASA Johnson Space Center, Houston, TX 77058, USA. [3]Rutgers State University of New Jersey, Department of Earth & Planetary Sciences, Piscataway, NJ 08854, USA, [4]Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA, [5]Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, USA, [6]ANGSA Science Team list at https://www.lpi.usra.edu/ ANGSA /teams/.

Introduction: The Apollo 17 double drive tube sample 73001/2 was collected at Station 3, located on the Light Mantle deposit of the Taurus-Littrow Valley [1]. The double drive tube samples are next to the 620 meter-diameter Lara Crater and the 10 meter-diameter Ballet Crater, and may contain ejecta material from the two craters.

The lower part of the double drive tube (core 73001) was vacuum sealed on the lunar surface, and the upper part 73002 was returned unsealed but curated under dry N_2. The ANGSA science team aims to study these pristine Apollo cores that were not previously opened and examined, as well as provide training for future sample return missions like Artemis [2].

Core 73002 was opened in November, 2019 by the curation staff at NASA Johnson Space Center, and it sampled about 18 cm depth from the lunar surface [2]. Part of the soils at the bottom of 73002 fell off during the collection. Core 73001 was opened in March, 2022, and its sampling depth ranges from ~18–51 cm. We have measured spectral images for the three dissection passes of both core 73001 and 73002 using the same multispectral imager as was used in [3]. In this abstract, we present integrated results of the spectral measurements of the double drive tube samples, and summarize some lessons learned from measuring spectral data during the preliminary examination of pristine extraterrestrial samples.

Instrument and Data: We used a multispectral imager that is comprising a monochrome imaging camera, a 6-position motorized filter wheel equipped with 6 narrow band interference filters, lenses and light source (Figure 1). The center wavelengths of the six filters are: 415 nm, 570 nm, 750 nm, 900 nm, 950 nm, and 990 nm. These wavelengths share some of the bands used by the Clementine UVVIS camera, the Lunar Reconnaissance Orbiter Camera Wide Angle Camera and the KAGUYA Multiband Imager. The field of view is about 47 mm × 36 mm and the spatial resolution is 60 μm/pixel. Images were collected at 15° incidence angle, 0° emission angle, and 15° phase angle. The small incidence angle reduces shadowing of the dissection surface of the core samples. To ensure accuracy of image mosaic, each image overlaps at least 50% with the previous one. Finally, the reflectance is derived using the raw image, subtracting a dark, and ratioing a Spectralon standard. To reduce possible vibrations of the glove box while moving the spectrometer forward, the spectral system was made of light-weight materials and components.

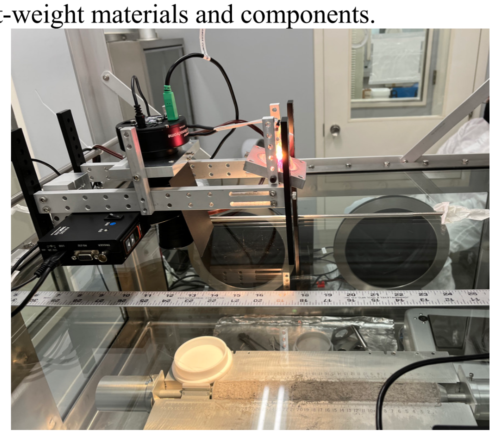

Figure. 1 The multispectral imager on top of the glovebox of core sample 73001.

Results: Using the dissection pass 2 scans as an example, we present a comprehensive spectral result of the double drive tube 73001/2, shown in Figure 2. The double drive tube as extruded contains 51 cm samples in depth. The 750 nm reflectance image and the RGB image in Figure 2 exhibit two distinct zones (divided by a line): a spectral darker and redder top zone and a brighter and less red lower zone. The top zone is more mature than the lower part of the core, and experienced a longer time of space weathering. The OMAT profile shows that the top mature zone has a depth around 10 cm. This top zone also has higher FeO content (10 wt%) and slightly lower TiO_2 content (<1.5 wt%) compared to the rest of the core. These maturity and compositional differences indicate that the top zone may have a different origin from the lower zone, for example, impact ejecta from nearby small craters located at the basaltic Taurus-Littrow Valley floor.

The lower zone is about 40 cm long and is relatively homogeneous in composition. The abundances of FeO and TiO_2 are around 8 wt% and <2 wt%, respectively, and they vary little with depth.

However, the maturity does vary within the lower zone. A slight darkening and reddening trend from top to bottom of the core within the lower zone can be observed from Figure 2. The OMAT profile shows a decreasing trend at 10-50 cm depth, indicating the maturity of the soil is increasing toward the bottom of the core. This increasing maturity might be caused by mixing with the more mature material from the surface of the basaltic valley or the earlier avalanche, and the bottom of the core might be close to but hasn't penetrated to the bottom of the light mantle deposit.

In addition, we observed a black clod (at ~45 cm depth, about 1 cm×1cm in size) on the derinded pass of core 73001, and the spectrum is plotted in Figure 3. The spectrum of this black clod is very similar to the spectrum of Apollo 17 black beads from Shorty crater at Station 4, which represents dark mantling material from the valley [4-5]. The black clod has very different optical properties from its surrounding soils (Figure 3), and we infer that it might have been swept up during the avalanche or was shot into the light mantle as a bullet ejecta projectile.

Discussion: Measuring spectral imaging of extra-terrestrial samples is a convenient and fast way of obtaining some basic information like maturity and compositions from outside of the glovebox, which can aid participating scientists in requesting sample for more detailed analysis.

Some improvements can be made for the spectral examination of future extra-terrestrial sample returns. Placing the core closer to the top of the glovebox (e.g., <5 cm) would allow us to measure the core at micron-scale spatial resolution, which is at least ten times better than the current dataset. The glass walls of glovebox limited our measurement to <2.5 microns wavelengths. A centimeter-scale infrared window (e.g., made of diamond) mounted on the top of glovebox would allow us to measure at wavelengths at 3 microns and longer, which could help determine the abundance of H_2O/OH, other possible volatiles and silicate mineralogy with no risk of sample contamination or damage.

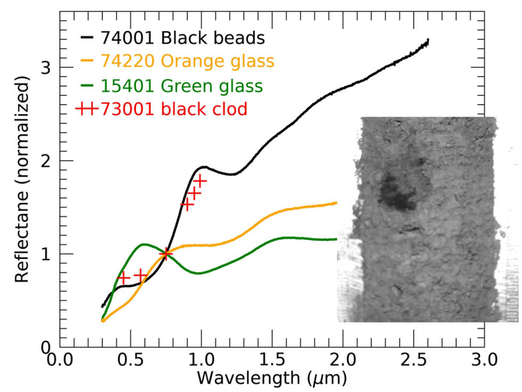

Figure 3. Spectrum of the 73001 black clod compared to Apollo black, orange and green glasses.

References: [1] Butler P. (1973) NASA MSC 03211, Lunar Receiv. Lab., Houston, Tex. [2] Shearer C. K. et al. (2020) 51st LPSC *abst.* #1181. [3] Sun et al. (2022), 53rd LPSC *abst.*# 1890. [4] Adams et al. (1974) 5th LPSC, 5, 171-186. [5] Pieters et al. (1974) Science, 183,1191-1194.

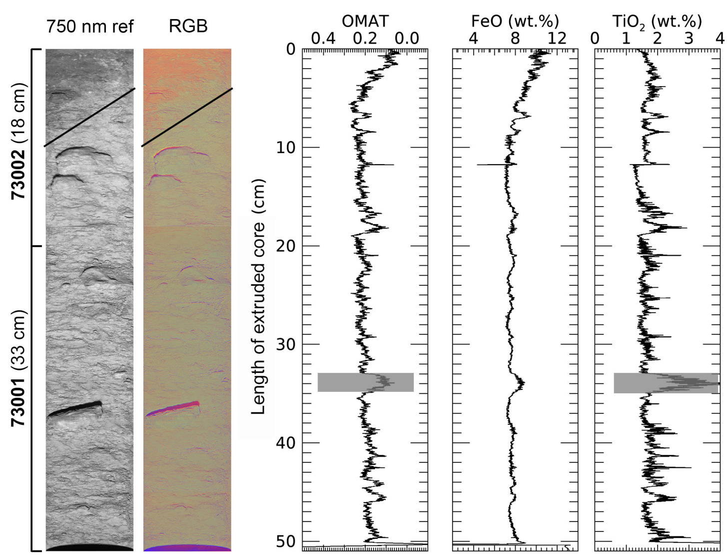

Figure 2. The combined spectral images (left two) and compositional profiles (right three) of Apollo 17 core samples 73001/2, and both are from dissection pass 2. For the RGB image, red=750 nm/415 nm, green=750 nm/950 nm, and blue=415 nm/750 nm. The line in the left two images shows the edge of the top and lower zones.