Multispectral Imaging of Apollo 17 Core Sample 73002. Lingzhi Sun[1], Paul Lucey[1], Abigail Flom[1], Chiara Ferrari-Wong[1], Ryan A. Zeigler[2], Juliane Gross[2,3] , Noah Petro[4], Charles Shearer[5], Francis M. McCubbin[2] and The ANGSA Science Team[6], [1]Hawai'i Institute of Geophysics and Planetology, University of Hawai'i 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 of the Taurus Littrow valley [1]. The double drive tube samples are located near the 620 meter diameter Lara Crater and the 10 meter diameter Ballet Crater. The Light Mantle is suggested to have formed from a landslide of the South Massif, and the soil samples collected from the Light Mantle and the base of South Massif show noritic and anorthositic compositions [2].

The lower part of the double drive tube (sample 73001) was vacuum sealed on the lunar surface, and 73002 was returned unsealed but curated under dry gaseous N_2. Both samples remained unstudied until 2019. On Nov. 5, 2019, the Apollo Next Generation Sample Analysis Program (ANGSA) opened the upper segment of the drive tube, core sample 73002, at NASA Johnson Space center [3]. 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 [3].

In this abstract we report spectral measurements of each dissection pass of core sample 73002. We have finished scanning three dissection passes of core 73002, supported by the ANGSA science team and the Apollo curatorial facility [3]. We presented the preliminary results for dissection pass 1 in [4], and here we present the spectral scanning results of the two latest dissection passes for core 73002.

Methods: We use a multispectral imager that is composed of a monochrome imaging camera, a 6-position motorized filter wheel equipped with 6 narrow band interference filters, lenses and light source. 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 (LROC WAC) and the KAGUYA Multiband Imager (MI). The field of view is about 47 mm × 36 mm and the spatial resolution is 60 μm/pixel. We measure at 15° incidence angle and 0° emission angle, and the phase angle is 15°. The use of a small incidence angle is to reduce shadowing of the dissection surface of the core samples. The total length of the core is about 18.5 cm, and we took 7-8 scans along the core for each dissection pass. To ensure accuracy of image mosaic, each scan overlaps at least 50% to the previous image. Finally, the reflectance is derived using the raw image, subtracting the dark, and ratioing a Spectralon standard. To reduce possible vibrations of the glove box while scanning, the spectral system is made of light-weight materials and components.

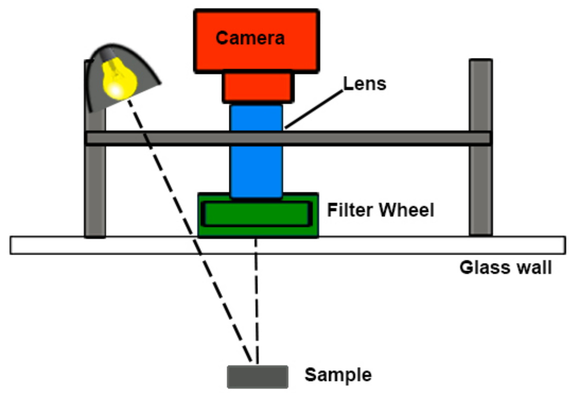

Figure 1. Schematic diagram of the spectral measuring system.

Results: Dissection pass 2 and 3 of core 73002 both show increased darkening and reddening from bottom to top of the core, indicating an increase in the degree of space weathering toward the surface. A dark and red mature zone is observed on the top of the two dissection passes in Figure 2 (area above the dashed line), and the area of this mature zone is larger in pass 3 compared to pass 2.

Using the composition of Station 3 soil samples as ground truth and the color ratio method [5], we calculated the FeO and TiO_2 contents and OMAT values, shown in Figure 3. The FeO content is relatively uniform from bottom to top of the core, except for a slight increase for the mature zone on top of the core. From bottom to top of the core, the FeO content varies from about 8 wt.% to 10 wt.% (± 1 wt.%). The distribution of TiO_2 is homogeneous within the two passes, and the abundance is around 2 wt.% (± 0.5 wt.%). The FeO and TiO_2 values are consistent with the 73002 core samples measured using ICP-MS [6]. The mature zone on top shows similar TiO_2 abundance to the lower part of the core. The optical maturity (OMAT) decreases from bottom to top of the core, and an elevated high maturity zone is observed at the top of the core, indicating an increased degree of space weathering.

The top mature zone shows slightly higher FeO content and higher maturity compared to the lower part of the core, indicating that the top layer might contain ejecta from nearby small craters (e.g., from the Taurus Littrow Valley floor basalts).

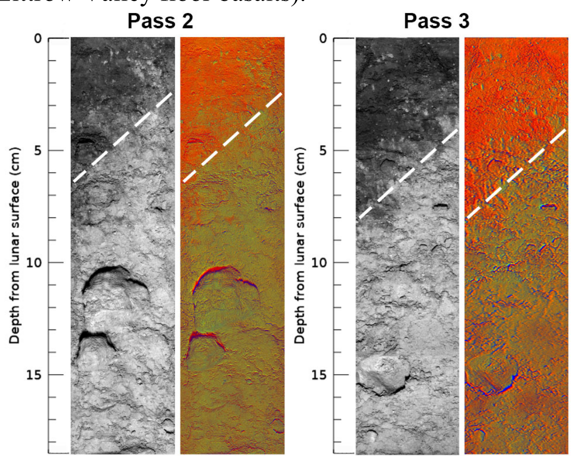

Figure 2. The 570 nm reflectance image and color ratio image, red=750 nm/415 nm, green=750 nm/950 nm and blue=415 nm/750 nm. Left is pass 2 and right is pass 3.

Conclusions: We developed a multispectral imaging system that allows us to scan the spectral images at high spatial resolution from above the glove box. We measured the visible and near-infrared spectral images of the three dissection passes of Apollo core sample 73002. The core shows increasing darkening and reddening effects from bottom to top of the core, indicating an increase in space weathering. Using the color ratio method, we derived the FeO and TiO_2 abundances and the OMAT values of the dissection passes. The average FeO and TiO_2 content are 9 wt.% and 2 wt.%. The dissection passes 2 and 3 show a spectral dark and red zone at the top of core. This mature zone also contains slightly higher FeO content compared to the lower part of the core. We infer the top part may contain impact ejecta of nearby craters.

Future Work: This work demonstrates that spectroscopy can be used to obtain compositional and space weathering information from a sample inside a glovebox using an instrument that is outside of the glovebox. Visible and Near-infrared spectral imaging is a convenient technique for basic characterization and/or preliminary examination of pristine extra-terrestrial materials. This work also demonstrates the importance of carrying out imaging prior to dissection of the core.

We observe some intense shadowing effect due to lightening while scanning pass 3 (Figure 3). In order to solve this issue, we have adjusted the position of the light source so the incidence angle can remain small for all dissection passes. The lower segment of the double drive tube 73001 will be extruded soon, and we are ready to collect the spectral images for core 73001.

References: [1] Butler P. (1973) NASA MSC 03211, Lunar Receiv. Lab., Houston, Tex. [2] Bence et al., *5th LPSC, 5*, 785-827. [3] Shearer C. K. et al. (2020) *51st LPSC abst.* #1181. [4] Sun L. et al., (2021) *Meteoritics & Planet. Sci., 56, 8,* 1574-1584. [5] Lucey et al., *JGR: Planets, 105, E8*, 20297–20305. [6] Neuman et al., *52nd LPSC, abst*. #2548.

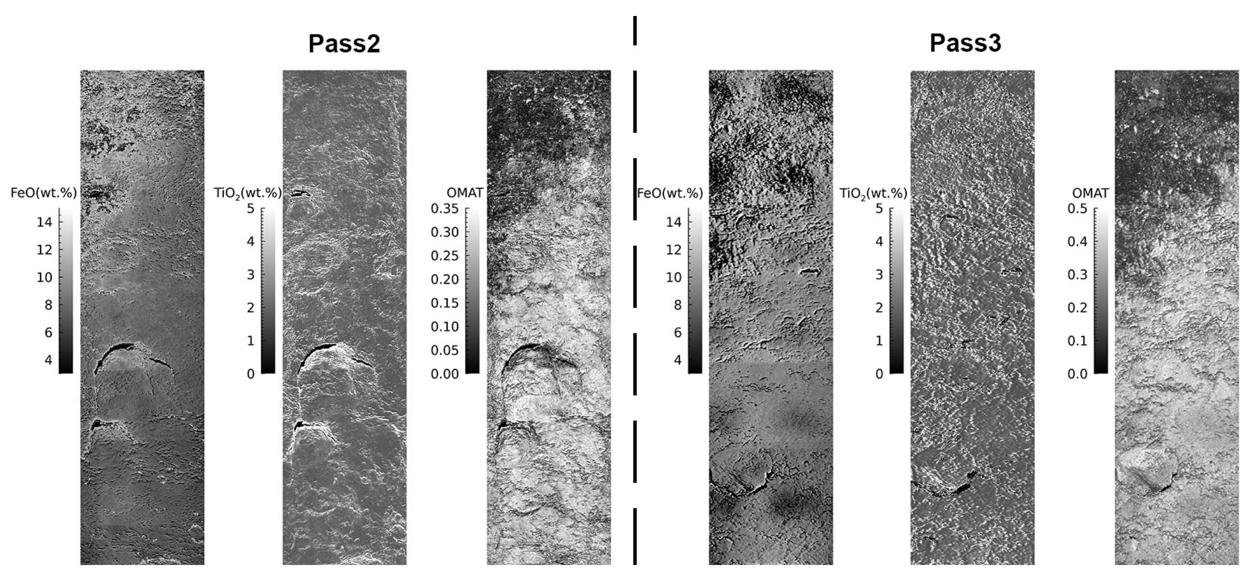

Figure 3. FeO, TiO_2, and OMAT maps for dissection pass 2 and pass 3 of core 73002.