Investigation of Pyroclastic Deposits in Taurus Littrow Valley Using Apollo 17 Core Sample 73001.

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Introduction: The Apollo 17 landing site contains several diverse compositions from multiple sources. The eastern rim of Serenitatis Basin is mantled by low albedo mantling material that likely has a pyroclastic origin, and this dark mantling material (DMM) may partially cover the Taurus-Littrow Valley floor [1]. The Light Mantle landslide deposits in the south-west of the valley partially covers the DMM in the valley floor. Samples collected at Shorty crater, located near the northern runout edge of the light mantle, contain abundant volcanic glass beads, and the double drive tube 74001/2 sampled 68 cm depth of material consisting of orange and black glasses [2].

The Apollo 17 double drive tube sample 73001/2 was collected at Station 3, located on the Light Mantle deposit to the south-west of Shorty Crater [3]. This double drive tube sampled around 59-70 cm in depth (some material fell out of core 73002 after sampling), and may contain additional DMM materials from beneath (or mixed into) the Light Mantle.

The lower part of the double drive tube (core 73001) was vacuum sealed on the lunar surface. Core 73001 was opened in March, 2022, and its pre-extrusion length was 35.5 cm, likely sampling ~35-70 cm below the present-day surface. The ANGSA science team has studied these pristine Apollo cores that were not previously opened or studied, and provided training for future sample return missions like Artemis [4].

In this abstract, we present the spectral examination results of the lower core 73001 and its implications to the distribution of pyroclastic deposits in the Taurus Littrow valley.

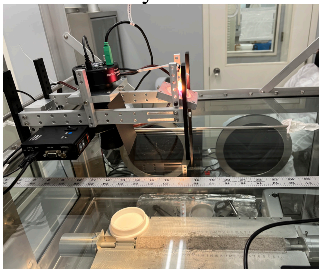

Fig. 1 The multispectral imager on top of the glovebox of core sample 73001.

Instrument and Data: With the core samples still within a N_2-purged processing cabinet, we used a multispectral imager including a monochrome imaging camera, a 6-position motorized filter wheel equipped with 6 narrow band interference filters, lenses and light source (Fig. 1). The center wavelengths of the six filters are: 415 nm, 570 nm, 750 nm, 900 nm, 950 nm, and 990 nm. These wavelengths were chosen to share some of the bands used by the Clementine UVVIS camera, the Lunar Reconnaissance Orbiter Camera Wide Angle Camera and the KAGUYA Multiband Imager (MI). 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. The lightweight camera was placed on the glovebox ceiling looking down at the core. Reflectance is derived by ratioing a Teflon standard that is cross calibrated to Spectralon.

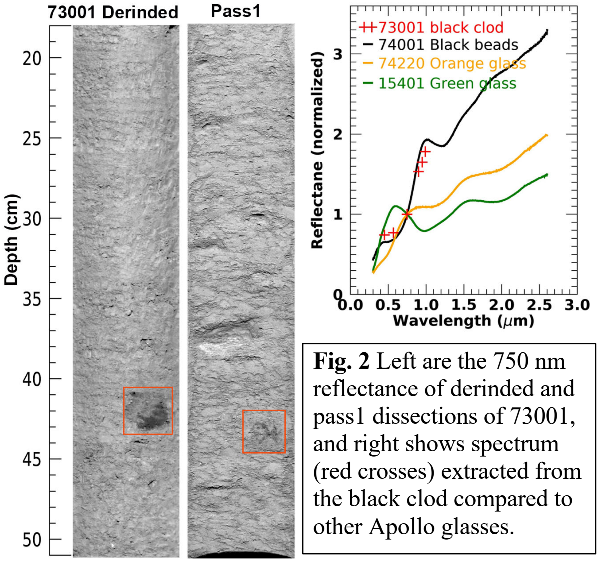

Fig. 2 Left are the 750 nm reflectance of derinded and pass1 dissections of 73001, and right shows spectrum (red crosses) extracted from the black clod compared to other Apollo glasses.

Results: The 750 nm reflectance images of the derinded and first dissection passes of 73001 are shown in Fig. 2. The core has relatively homogeneous color and compositions [5], except one black clod (2 cm×2 cm) that was found near 42 cm depth (24 cm on 73001) on the derinded pass. This black clod crumbled while being removed during the first pass dissection [6], allowing us to measure the spectrum of the black clod. Figure 2 shows the spectrum of the black clod overplotted with Apollo 17 black and orange glasses sampled at Shorty Crater and Apollo 15 green glass.

These three different colored glasses show distinct spectral features at 0.4-1.0 µm wavelengths. The orange and green glass show a weak absorption near one micron due to presence of ferrous Fe in glasses. The black glass has steeper slopes than the green and orange glasses, doesn't have 1-micron absorption but shows one strong absorption near 0.6 µm, which is caused by abundant thin ilmenite lathes covering the exterior glass of the beads [1]. The spectrum of the black clod from 73001 core sample is consistent with the black glass from Shorty Crater.

To further investigate the origin and distribution of the black glass, we applied a spectral match by correlating the black glass spectra to the entire western rim of Serenitatis basin using MI dataset from Kaguya [7], covering the Taurus-Littrow Valley. Figure 3 shows areas having correlation coefficients with the black glass spectrum larger than 0.65, and they are largely consistent with the range of dark mantling deposits at the western rim of Serenitatis [1,8]. This spectral matching result shows the distribution of almost pure black glasses; other areas may also contain black glasses but their spectral feature is less characteristic due to space weathering or mixing with local regolith.

Most of the black glasses concentrate near the western part of the Taurus-Littrow Valley rather than the entire Valley floor, and they seem abundant near the edge of the Light Mantle. Sampling stations overlapping with local black glass concentration include Station 4 (Shorty Crater) and LRV 7, which contain the most abundant black glasses among all the sampling stations from Apollo 17 sample analysis [9].

Discussions: The black clod in the lower portion of core 73001 may have been swept up off the valley floor during the emplacement of one of the Light Mantle landslide events. The spectral measurement of the 73001 dissections shows a slight increase in spectral reddening and darkening trend from top to bottom of the core [5], however, this trend was not observed in the I_s/FeO variation, indicating that this spectral variation may not be a result of space weathering [10]. Since black glass also features red and dark spectrum, we infer that this reddening and darkening trend might be caused by black glasses mixing into the Light Mantle regolith, and this mixing zone may be close to the interface of Light Mantle and the original valley floor that are enriched in DMM.

The spectral matching result also shows that black glasses are abundant surrounding the Light Mantle, implying that DMM may be abundant underlying the Light Mantle, consistent with the suggestion of [8].

The black clod from 73001 shows similar spectral features to the black glass beads collected from Shorty Crater, indicating that they may also be similar in composition, which contains abundant fine-grained ilmenite in the glass beads. These black glasses may have originated from the same vent that created the pyroclastic dark mantling area at western Serenitatis.

Conclusions: We measured the spectra of core 73001 during its dissections and found a black clod that share similar spectra to the black beads from Shorty Crater, and these black glasses contain abundant ilmenite. They may have originated from the dark mantling deposit at western Serenitatis.

Using correlation coefficient for spectral matching can only reveal pure black glasses but not such material mixed with the regolith. In the future, we will develop a radiative transfer model to quantify glass and mineral distribution for pyroclastic deposits.

References: [1] Pieters C. et al. (1974) Science, 183(4130), 1191-1194. [2] Nagle J. S. (1978) 9th LPSC, 1509-1526. [3] Butler P. (1973) NASA MSC 03211, Lunar Receiv. Lab., Houston, Tex. [4] Shearer C. K. et al. (2020) 51st LPSC *abst.* #1181. [5] Sun L. et al. (2022) LPI Contributions, 2704, 2021. [6] Gross J. et al. (2022). LPI Contributions, 2704, 2012. [7] Ohtake M., et al. (2013) Icarus 226.1, 364-374. [8] Schmitt H. (1973) Science 182.4113, 681-690. [9] Heiken G. & McKay D. S. (1974) 5th LPSC, 843-860. [10] Morris, R. V. & Haney N. C. (2022) LPI Contributions, 2704, 2047.

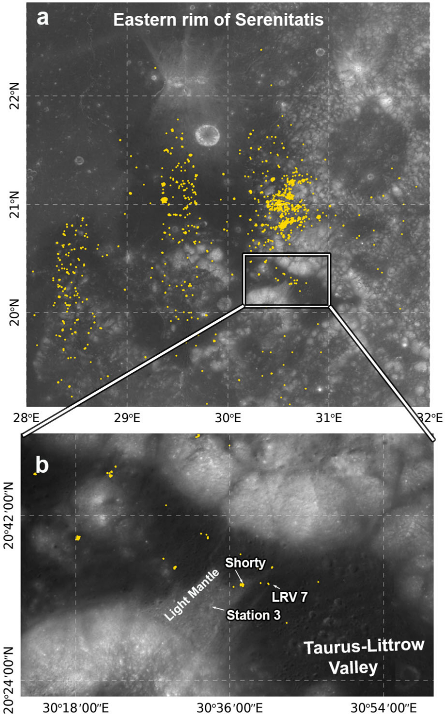

Fig. 3 (a) spectral matching black glass to east rim of Serenitatis using MI data. (b) Zoom in on Taurus Littrow Valley. Yellow dots are areas with a correlation coefficient higher than 0.65.