A SURVEY AND INTERPRETATION OF LITHOLOGIES FOUND IN THE <1mm FRACTION OF SOIL FROM THE TAURUS-LITTROW VALLEY (TLV) IN THE APOLLO 17 DRIVE TUBE 73002. M.J. Cato[1], S.B. Simon[1,2,3], C.K. Shearer[1,2,4], and the ANGSA Science Team[5]. [1]Dept. Earth and Planetary Sci., Univ. of New Mexico, [2]Institute of Meteoritics, Univ. of New Mexico, Albuquerque, NM 87131, [3]Field Museum of Natural History, Chicago, IL,[4]Lunar and Planetary Institute, Houston, TX 77058, [5]ANGSA Science Team listed in https://www.lpi.usra.edu/ANGSA/teams/. ***mcato@unm.edu***

Introduction: The double drive tube core sample 73001/73002, collected at Station 3 during the Apollo 17 mission, was taken within the light mantle deposit at the base of the South Massif of the TLV. Orbital data suggest that this deposit represents multiple landslide events that were triggered by movement along the Lee-Lincoln scarp [e.g., 1] or impact events [e.g., 2,3]. Although numerous core and trench samples were collected during the Apollo program and numerous landslide deposits have been identified on the lunar surface by orbital missions [e.g., 3], the Station 3 double drive tube is the only core to have sampled a landslide deposit. Thus, it is expected to contain a variety of lithologies from both the South Massif (SM), the TLV floor, and perhaps even excavated material from the North Massif and Sculptured Hills [4].

As part of the Apollo Next Generation Sample Analysis (ANGSA) program, the contents of 73001/2 are being examined for the first time. The upper portion, 73002, has been completely processed and samples are being studied at multiple institutions, while 73001 will be extruded for dissection in early 2022. Here, we give an overview of the examples of lithologies we identified in our examination of the <1mm fraction of samples along the entire length of 73002. A companion abstract [5], reports the modal petrology and important lithologies from the 1mm to 150µm fraction of 73002.

Methods: Bulk <1mm samples, representing 0.5cm depth intervals from the surface to ~18 cm depth along Dissection Pass One of 73002, were sieved into six size fractions (<20µm, 20-90µm, 90-150µm, 150-250µm, 250-500µm, and 500-1000µm) at the University of New Mexico (UNM) then mounted onto glass slides in epoxy and polished. High-resolution backscattered electron (BSE) images were obtained using a TESCAN Lyra3 scanning electron microscope at UNM equipped with an IXRF silicon drift energy-dispersive X-ray detector running Iridium Ultra software. Each particle was classified into one of eight categories: agglutinates, regolith breccia, impact melt rock, glass, mare basalt, highland igneous, monomineralic, and other. Mineral chemistries (qualitative and quantitative) were obtained with the same instrument. Every size fraction has been examined for this study, with images here from 20-90µm, 150-250µm, and 250-500µm size fractions.

Agglutinate: Agglutinates (vesicular, irregular, particles composed primarily of fines enclosed in glass formed at the lunar surface from soil by micrometeorite impacts) are present throughout the entire core. They are significantly more abundant in the upper, dark horizon of the core and decrease significantly as the horizon tapers off between 5.5 and 7.5 cm. This corresponds to the change in I_S/FeO documented by Morris et al [5]. As seen in Fig. 1a and b, it is common for agglutinates to incorporate grains which were too big to be melted by micrometeorite impacts.

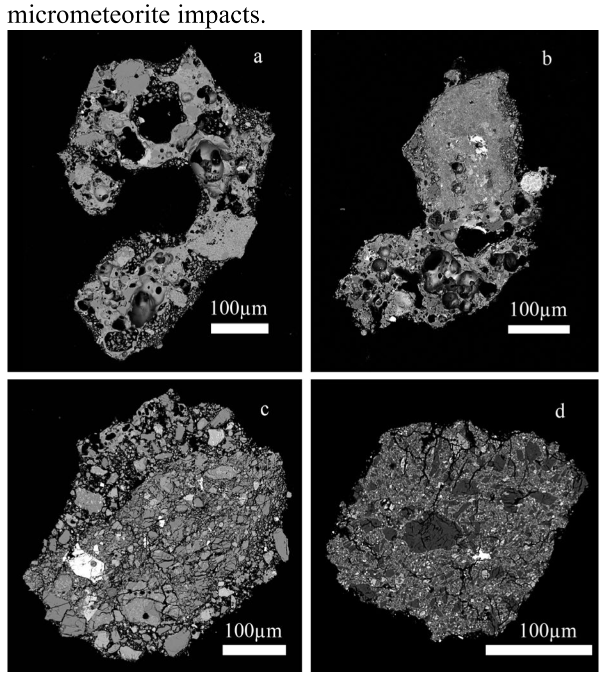


Fig. 1: Representative BSE images of agglutinates (a,b) and regolith breccias (c,d).

Regolith Breccia: Regolith breccia fragments are also common throughout the core. They are composed of lithified regolith, but the degree of lithification and cohesion between grains varies significantly (fig. 1c & d). Unlike agglutinates, regolith breccias can be considered "fossil soils" and may contain clasts of lithologies not found in other lunar samples.

Impact Melt Rock: Fragments of impact melt rocks plus regolith breccias compose about half of all the lithic fragments that we observed in 73002. Impact melts are formed by large impacts in which the target material is melted. The resulting material can range from melt breccias (fig. 2a) with some preserved grains to completely recrystallized melts (fig. 2b). They may have originated from local craters in the TLV or from distant basins such as Tycho. Our results suggest that impact melt rocks are an important component of the SM. This is consistent with observations of [6].

Glass: Glasses are not as abundant as other components in 73002, but are present throughout the length of the core. Lunar glasses can form through both impacts and volcanism, and in 73002 range from clast-free beads to devitrified fragments.

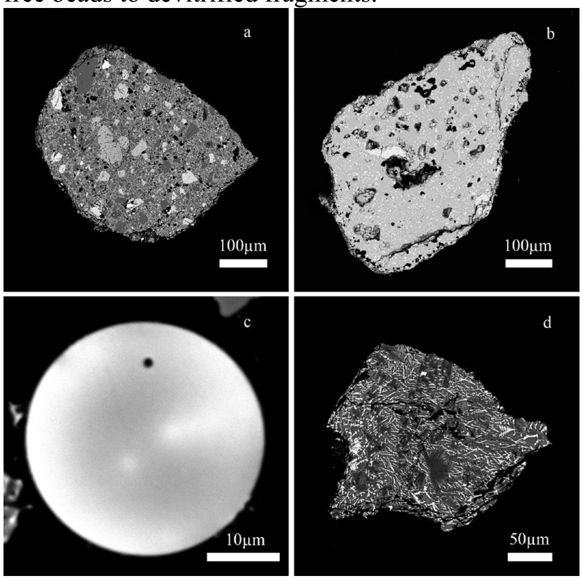


Fig. 2: BSE images of (a) an impact melt breccia, (b) a recrystallized impact melt, (c) a clean glass bead, (d) heavily devitrified glass.

Mare Basalt: Mare basalts are the primary lithologies that fill the impact basins of the Moon, including the floor of the TLV. In 73002, high-Ti mare basalts are the dominant basalt (fig. 3a), and multiple flow units and cooling histories are represented [7]. High-Ti basalts are easily identified by the presence of relatively large amounts of ilmenite, and we observe a variety of ilmenite morphologies in the high-titanium basalts, ranging from thin needles (e.g. fig. 3a) to massive and blocky (fig. 3c). Rare low-titanium basalts (fig. 3b) are also observed in this suite of lithic fragments. Even with ilmenite absent, low-Ti basalt fragments can be identified from features such as the abundance of pyroxene and its TiO_2 and FeO contents.

Highland Igneous: This is a diverse group of plagioclase-rich rocks, divisible into two major groups:

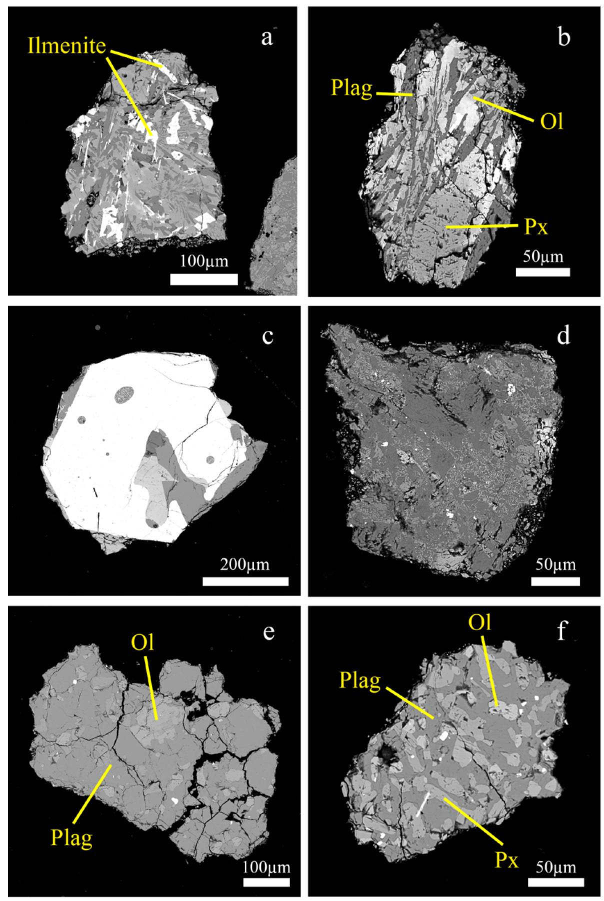
Mg-suite: The majority of highland igneous lithologies observed in 73002 are related to the Mg-suite. Lithologies include troctolitic anorthosite (fig. 3e), gabbros (fig. 3f), norites, and troctolites. A unique spinel-bearing dunite [7] was identified and to our knowledge, is the first of its kind to be reported in the lunar sample collection. The Mg-suite is distinguished from other highlands plutonic rocks by their plagioclase composition and Mg# of their mafic silicates [8].

Ferroan Anorthosite (FAN): Minor amounts of FANs (fig. 3d) were identified among the lithic fragments although they may be represented in the monomineralic grain population. These lithologies are distinguished from other anorthosites (Mg-suite) by the lower Mg/(Mg+Fe) of their mafic silicates [8].

Monomineralic: The proportions of monomineralic grains (plagioclase, pyroxene, olivine) increase with decreasing particle size range.

Felsites: Several felsite fragments have been identified (e.g., fig. 3g). Their distribution is not correlated with size fraction or depth in the core. They represent evolved melts and are dominated by silica, K-feldspar, and sodic plagioclase.

References: [1] Schmitt H. (2017) *Icarus 298*, 2-33. [2] Arvidson R. et al. (1976) *Proc. LPSC* 7, 2817-2832. [3] Bickel V. et al. (2020) *Nature Communications*, *11*(1), 1-7. [4] Schmitt et al. (2017) Icarus 298, 2-33. [5] Morris et al. (2022) This volume. [6] Robinson and Jolliff (2002) JGRP 107,20-1. [7] Simon S. et al. (2022) This volume. [8] Shearer C. et al. (2021) LPSC 52, abstract #1155.



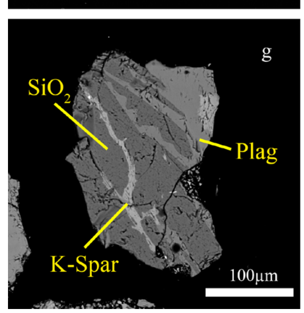


Fig. 3: BSE images of (a) a high-Ti basalt with ilmenite needles, (b) a low-Ti basalt, (c) a massive ilmenite crystal with remnants high-Ti basalt still attached, (d) a shocked FAN, (e) a troctolitic anorthosite, (f) an Mg-suite anorthitic gabbro, and (g) a felsite.