MAJOR AND TRACE ELEMENTAL VARIATIONS AND LITHOLOGIC COMPONENT ANALYSIS IN APOLLO 17 DRIVE TUBE 73002.

M. Neuman[1], P. Koefoed[1], K. Wang[1], B. L. Jolliff[1], R.V. Morris[2], and the ANGSA Science Team[3]. [1]Department of Earth & Planetary Sciences and the McDonnell Center for the Space Sciences, Washington University in St. Louis, MO 63130; [2]ARES, NASA Johnson Space Center, Houston, TX 77058; [3]www.lpi.usra.edu/ANGSA/teams/ (mdneuman@wustl.edu)

Introduction: Lunar sample 73002, the upper portion of Apollo 17 double drive tube 73001/73002, is the focus of renewed study since its opening in late 2019 as part of the Apollo Next Generation Sample Analysis (ANGSA) initiative [1]. Careful dissection and preliminary examination of this core permits efficient allocation of materials to scientists investigating a variety of questions [2]. For example, recent work has focused on examining the many lithic fragments found within the core [e.g., 3, 4, 5], using traditional petrography and X-ray Computed Tomography (XCT) [6]. Partial analysis of dissection pass 1 intervals (<1 mm, sieved material) were completed and proportions of proposed lithologic components were found to vary with depth in 73002 [7].

To build on existing data and gain a clearer picture of the chemistry and lithology of the entire 18.5 cm core, we analyzed 37 samples from dissection pass 2 of 73002, representing the <1 mm size fraction material from every interval (0.5 cm increments). Prior to chemical analysis, ferromagnetic resonance (FMR) and magnetic measurements were conducted on the same fractions for soil maturity [8]. Concentrations of 47 elements were determined for each interval, and were used to model the major lithologic variations in the core. This work also serves to help guide other investigators when requesting samples.

Methods: The 37 subsamples (50 mg each) were ground and homogenized using a mortar and pestle. Approximately 45 mg of each was dissolved in a 3:1 mixture of double-distilled HF and HNO_3 for one week and then fluxed with concentrated HCl and HNO_3 separately. Solutions were prepared at high and low dilution factors for major and trace element analysis, respectively, using a quadrupole-ICP-MS (Thermo Fisher Scientific iCAP Qc) at Washington University in St. Louis. The instrument was calibrated with USGS standards of known concentrations, and samples were run multiple times using a 5 ppb In internal standard to correct for drift.

The remaining 5 mg of each sample were processed for fused bead electron microprobe analysis (FB-EPMA). Powders were fused on an Mo strip heater under pressurized Ar to form glass beads following the methods of [9]. These beads were mounted in epoxy, polished, and compositions were measured with the JEOL 8200 at Washington University in St. Louis. Fifteen spot analyses were completed for each fused bead to assess homogeneity. Changes in chemistry such as

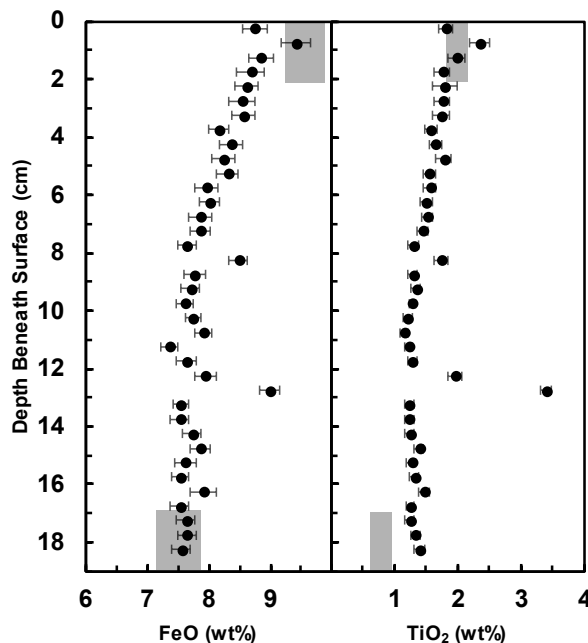Mo gain and Fe loss were minimal and did not require corrections.

Figure 1. FeO and TiO_2 concentrations of each 73002 core interval from dissection pass 2. The shaded regions at the top of each panel are the respective concentrations of 73261,71 from our measurements. Shaded regions at the bottom are our values for 73131,6.

Results: ICP-MS and FB-EPMA results gave very good to excellent agreement for elements measured in common. Fused beads were determined to be homogenous at 95 and 99% confidence intervals for many of the abundant elements (e.g., Si, Al, Ca, Fe, Mg). Because we do not analyze SiO_2 by ICP-MS, we use the FB-EPMA values. Additionally, we found that the fused beads gave better Al_2O_3 and CaO data (i.e., better precision and more accuracy when measuring known samples). All other elemental concentrations are from the ICP-MS analyses. These results were compared to our previous measurements of 73261, a Station 3 trench soil, and 73131, a friable regolith breccia from Station 2a (Fig. 1). Systematic chemical compositional variations in relation to depth were observed. Elements with similar geochemical behavior, such as Fe, Ti, Sc, V, and Cr, were found to be highly correlated.
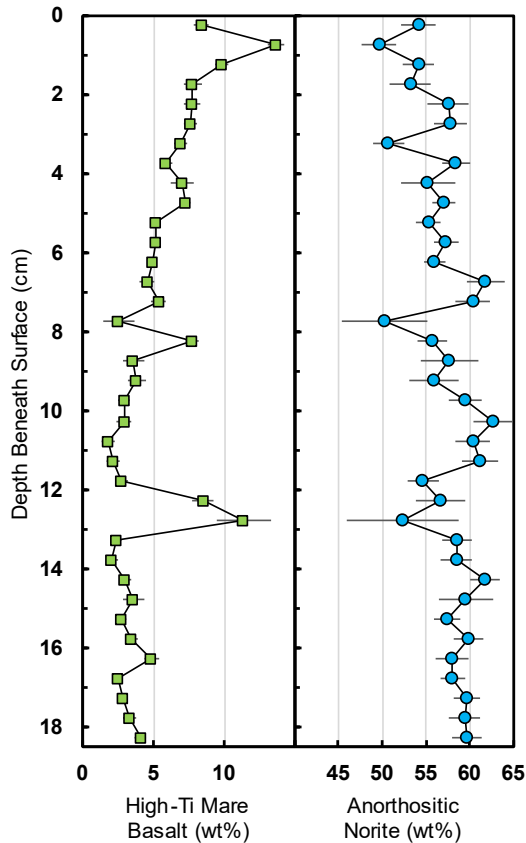
Figure 2. Results of lithologic component mixing calculations. Uncertainties associated with each point are affected by weighting of individual elements and lithologic component compositions. We used a simplified four-component model using high-Ti mare basalt, anorthositic norite, noritic impact melt breccia, and carbonaceous chondrite (latter two not shown).
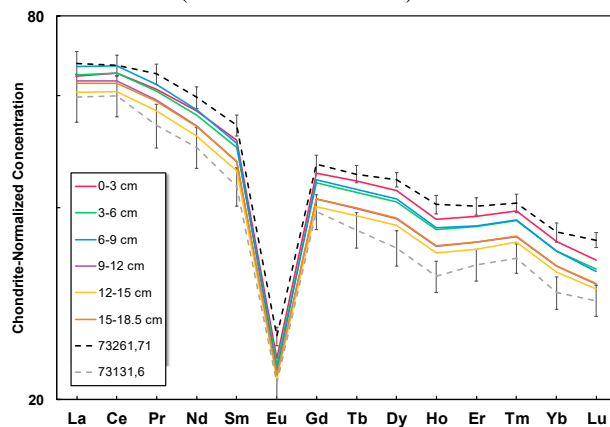

Figure 3. REE patterns for 3 cm averaged sections of the core, compared to Station 2 (73261, top pattern) and Station 2a (73131, bottom pattern) materials. Error bars for middle patterns are omitted for visual clarity, but are equal to or smaller than the top and bottom patterns.

Discussion: All of the observations in pass 2 chemistry are consistent with what was previously seen in the preliminary pass 1 analyses [7]. Compositions near the surface closely resemble those of 73261 whereas the bottom of the core has compostitions that match well with 73131, as reflected by major elements (Fig. 1) and rare earth element patterns (Fig. 2).

To explain the observed trends, we conducted mixing calculations to determine the proportions of multiple lithologic components, using an error-weighted, linear-least-squares approach [10]. The four selected end-member components were Apollo 17 high-Ti mare basalt (HT), noritic impact-melt breccia (NB), an anorthositic norite (AN), and carbonaceous chondrite (CI). These components have been shown to be the primary constituents of soils from Stations 2, 2a, and 3 [10]. The mixing results showed the largest component was AN, ranging from about 50-60%, followed by NB at 35-40%, 2-10% HT, and typically <1% CI (Fig. 2). While not displayed in this abstract, NB and CI proportions are relatively constant through the length of the core, with some scatter. Spikes in the CI content up to about 2% are clearly related to large, correlated increases of Ni and Co. The most obvious trend is a decrease in the HT content from the surface, of up to 13%, down to 3 or 4% at the bottom of the core. The decrease in HT was accompanied by a complementary increase of AN from about 50% at the surface up to 60% near the bottom. A higher proportion of HT near the surface could indicate a more recent preference for local ejection and subsequent deposition of mare materials rather than those from the highlands. The relationship between HT and AN components likely reflects incomplete *in-situ* physical mixing of younger mare basalts and older feldspathic highland materials.

References: [1] Shearer C. K. et al. (2021) *Lunar Planet. Sci.* **52** #1566 [2] Gross J. et al. (2021) *Lunar Planet. Sci.* **52** #2684. [3] Jolliff B. L. et al. (2021) *Lunar Planet. Sci.* **52** #2548. [4] Valenciano J. L. et al. (2021) *Lunar Planet. Sci.* **52** #2548. [5] Simon S. B. et al. (2021) *Lunar Planet. Sci.* **52** #1562. [6] Zeigler R. A. et al. (2021) *Lunar Planet. Sci.* **52** #2632. [7] Neuman M. D. et al. (2021) *Lunar Planet. Sci.* **52** #1470. [8] Morris R. V. et al. (2022) *Lunar Planet. Sci.* **53** #1849. [9] Brown R. W. (1977) *Geochim. Cosmochim. Acta*, **41**, 435-438. [10] Korotev, R. L., and D. T. Kremser (1992) *Proc. Lunar Planet. Sci.* **22**, 275-301.