

COMPOSITION, MINERALOGY, AND NOBLE-GAS CONTENT OF APOLLO 17 PARTICLES AND SOILS FROM THE 73002 DRIVE TUBE. B. A. Cohen¹, N. M. Curran^{1,2}, S. N. Valencia^{1,3}, E. S. Bullock⁴, C. M. Corrigan⁵. ¹NASA Goddard Space Flight Center, Greenbelt MD (barbara.a.cohen@nasa.gov); ²The Catholic University of America, Washington, DC; ³University of Maryland, Baltimore County, Baltimore, MD; ⁴Carnegie Institution for Science, Washington DC; ⁵Smithsonian Institution, National Museum of Natural History, Washington DC.

Introduction: As part of the Apollo Next-Generation Sample Analysis (ANGSA) program, our Moon United team studied particles and soil samples from the 73001/2 drive tube to understand the lithologies at the sample site and provide constraints on the regolith age. We report the bulk composition, mineralogy, petrology, and noble-gas assays of 21 lunar particles and two soils. Our petrologic and noble-gas data constrain the origin and exposure and gardening history of the lunar regolith at the Apollo 17 site and thereby provide crucial context to the exposure history experienced by volatile and organic compounds in these samples.

Bulk Composition, Petrology and Mineralogy: The particles are derived from lithologies of the South Massif, including anorthosites, anorthositic breccias, high-Ti basalts, noritic impact-melt breccias, agglutinates, and regolith breccias (Fig. 1).

Four particles in our allocation had basaltic characteristics. The two we investigated in detail are Type-1, high-Ti basalts (*i.e.*, ilmenite basalt), which is typical for the Apollo 17 site [1, 2]. The plagioclase, pyroxene, and olivine compositions are in family with previously-studied Apollo 17 high-Ti basalts. Given their mineralogical and chemical similarities, we infer that 73002,183A and 73002,186A are similar to previously studied Apollo 17 high-Ti basalts and likely originated from similar magmatic conditions.

Three particles are composed nearly entirely of feldspar and are interpreted as cataclastic anorthosites or anorthositic fragmental breccias. The very high Ca content of the feldspar (An₉₆₋₉₇) is consistent with their derivation from ferroan anorthosite. Four particles are interpreted as regolith breccias, containing a variety of mineral and lithic clasts, while one particle is interpreted as an agglutinate. The feldspar in the regolith breccias

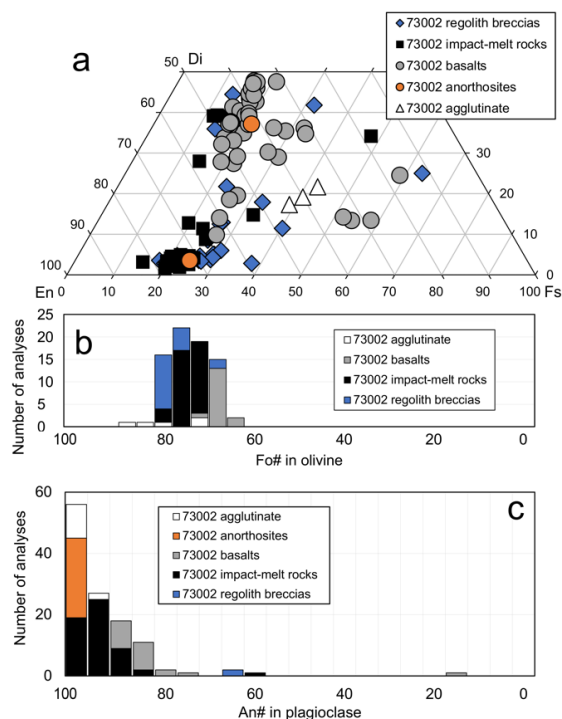


Figure 1. Mineral compositions of 73002 anorthosites, basalts, regolith breccias, and impact-melt particles: a) feldspar; b) pyroxene; c) olivine.

is dominantly anorthositic (An₉₆₋₉₈) with several potassium feldspar grains measured. The mineralogy of the regolith breccias is consistent with sampling a mix of parent lithologies present at the sampling site [e.g., 3].

Nine of the clasts are interpreted as impact-melt breccias. The mineralogy and texture of these impact melt rocks are all very similar to each other, containing feldspar with significant Na and K, and magnesian olivine and pyroxene, possibly deriving from an Mg-suite precursor lithology (Fig. 2). Notably, several of the

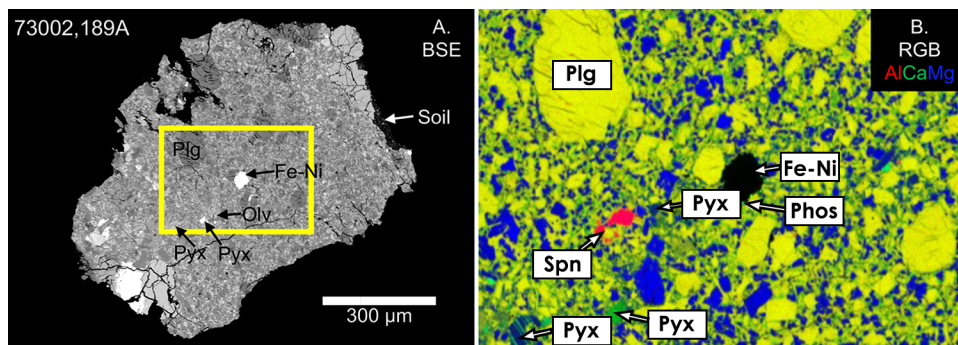


Figure 2. A. Backscattered electron image and B. false-color WDS element map of impact-melt breccia particle 73002,189A showing representative texture and mineralogy.

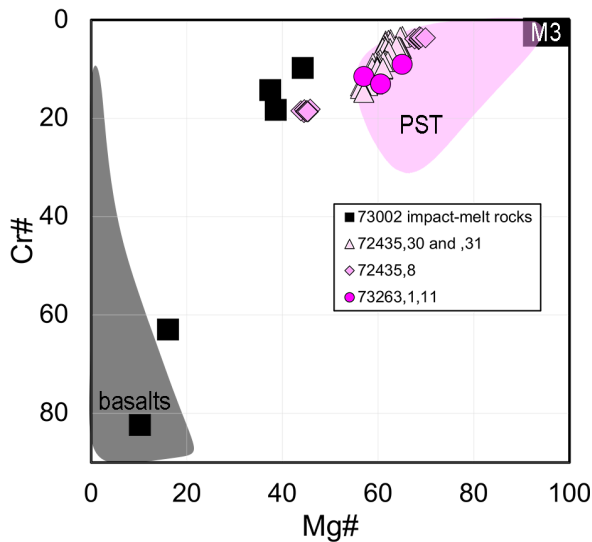


Figure 3. Spinel compositions in the 73002 impact-melt rock particles compared with high-Mg spinel reported in other Apollo 17 rocks and the pink spinel troctolites in lunar meteorites and Moon Mineralogy Mapper (M3) data.

clasts contain high-Mg spinel (Fig. 3) similar to the "pink spinel" pleonaste previously reported in multiple Apollo samples and lunar meteorites and observed in remote sensing data [4, 5].

Noble gas measurements: We measured the Ne and Ar concentration for two soils and two particles from 73002. The noble-gas abundances fall within the typical concentrations and isotopic ratios for the range in soils and regolith breccias from the lunar sample collection. However, elemental ratios for $^{36}\text{Ar}/^{20}\text{Ne}$ have some of the lowest concentrations when compared to other stations of the Apollo 17 landing site.

The measured $^{20}\text{Ne}/^{22}\text{Ne}$ and $^{38}\text{Ar}/^{36}\text{Ar}$ ratios are close to the endmembers for solar wind and fractionated solar wind. Trapped $^{20}\text{Ne}/^{22}\text{Ne}$ and $^{38}\text{Ar}/^{36}\text{Ar}$ is present in all samples and over 95% of the Ne and Ar concentrations are sourced from the solar wind and/or fractionated solar wind components. This indicates that the majority of the neon and argon are purely trapped components accumulated during the samples' lifetime at the immediate surface of the Moon (*i.e.*, top tens of nanometers).

The bulk soils and breccia particles contain uniform concentrations of $^{21}\text{Ne}_{\text{cos}}$ and $^{38}\text{Ar}_{\text{cos}}$, enabling calculation of cosmic-ray exposure ages (Fig. 3). The derived cosmic-ray exposure ages representing emplacement of the light mantle unit at 60 Ma preceded by soil exposure in an avalanche emplaced surface around 110 Ma, consistent with previous interpretations and geologic observations [6].

References: [1] Brown, G.M., et al. (1975) *Proc Lunar Sci Conf* **1**, 1-13. [2] Papike, J.J., et al. (1976) *Reviews of Geophysics* **14**, 475-540. [3] Jolliff, B. L., et al. (1996). *Met Planet Sci* **31**, 116-145. [4] Prissel, T.C., et al. (2014) *Earth Planet Sci Lett* **403**, 144-156. [5] Shearer, C., et al. (2015) *Am Min* **100**, 294-325. [6] Schmitt, H.H., et al. (2017) *Icarus* **298**, 2-33.

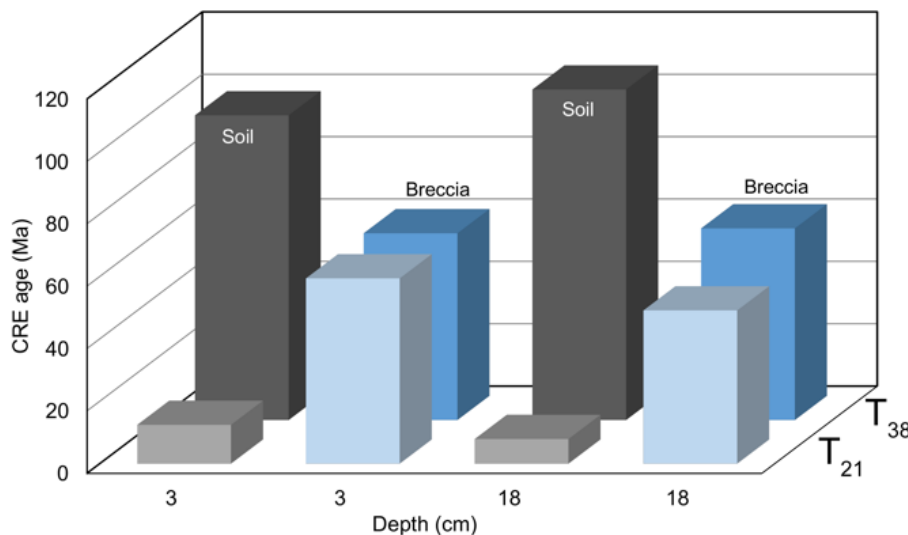


Figure 4. Comparison of the cosmic-ray exposure ages determined by neon (T_{21}) and argon (T_{38}) for the soils and particles from different depths in the 73002 double-drive tube.