PETROGRAPHY AND MINERALOGY OF BASALT FRAGMENTS IN APOLLO 17 DOUBLE DRIVE TUBE 73002 AND 73001. S. N. Valencia¹,², J. Valenciano², Z. E. Wilbur³, N. M. Curran²,³, E. S. Bullock¹, C. M. Corrigan¹, B. A. Cohen², J. J. Barnes³, C. R. Neal¹, and the ANGSA Science Team, ¹University of Maryland, College Park, MD 20742. ²NASA Goddard Space Flight Center, Greenbelt, MD 20771. ³Center for Space Sciences and Technology, Baltimore, MD 21250. (sarah_n.valencia@nasa.gov), ⁴University of Notre Dame, Notre Dame, IN 46556. Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, 85721. ⁵The Catholic University of America, Washington D. C. 20064. ⁶Carnegie Institution for Science, Washington D.C. 20015. ⁷National Museum of Natural History, Smithsonian Institution, Washington D. C. 20560.

Introduction: The ANGSA program was formed, in part, to examine previously unstudied Apollo 17 double drive tube samples. As a part of this project, the Moon United team received eight basalt fragments from 73001 and 73002. Here we present the petrography and mineralogy of these basalt fragments.

Methods: We analyzed the petrography and mineralogy of the 73001/73002 particles using Electron Probe Microanalysis (EMPA) at both Carnegie Institution for Science and the Smithsonian Institution. We made quantitative compositional maps for each sample following the methods of [1,2].

We used one fragment, 73002,186A to calculate the crystal size distributions (CSD) in both 2D and 3D. Fragment 73002,186A was scanned using X-ray computed tomography (XCT) with the Nikon XTH 320 instrument at NASA’s Johnson Space Center (JSC).

Several user-selected 2D “slices” from the XCT scan of 73002,186A were taken and then imported into Corel Paintshop Pro 2020 [3]. We identified and traced ilmenite (and armalcolite) crystals. We imported the resulting crystal traces into ImageJ, where the area, best-fit ellipse, and axes of each crystal were calculated using the known scale of each clast. The major and minor axes data was exported to CSDSlice and compared to a database of >700 crystals in order to determine the best shape of each 2-D crystal tracing [4]. We used CSDCorrections to group crystal sizes into bins and plot the natural log of the population density against the major axis length of each crystal [5].

To determine the 3D mineralogy, potential fabrics, and vesiculation textures, the XCT scans were reconstructed using CT Agent Pro and visualized using Dragonfly™ software. Vesicles and ilmenite grains were separated and measured with Blob3D [6], and fabrics were quantified using Stereonet 11 [7] following the methods of [5].

Petrography & Mineral Chemistry: The samples studied here are all high-Ti basalts. The petrography and mineralogy of each are summarized below and pyroxene compositions are presented in Fig. 1.

73001,366B. Pyroxene, plagioclase, and ilmenite dominate sample 73001,366, a 6.12 mg fragment. Plagioclase (An98Ab12) occurs as one continuous grain, while the rest of the sample is mostly dominated by a single pyroxene grain and ilmenite. Ilmenite has small inclusions of pyroxene. Trace sulfides also occur.

73001,367. Three fragments of basalt comprise the 73001,367 basalt sample. The fragments are composed of plagioclase (An88Ab12), pyroxene, and ilmenite. Minor silica and troilite each occur in one of the fragments. Phosphates and sulfides also occur as trace minerals. In these samples, pyroxene and plagioclase
are intergrown, with ilmenite laths cutting through the fragments.

73002,183A. This fragment is 5.2 mg and the section used here is 745 x 665 µm (Fig. 2). 73002,183A is dominated by two large Fo56-66 olivine grains, the largest being 560 x 320 µm in size. The other major minerals include pyroxene, plagioclase, and ilmenite, along with minor to trace armalcolite, chromite, phosphates, and sulfides. Plagioclase (An87Ab13Or1) and pyroxene are intergrown with plagioclase both enclosing and being enclosed by pyroxene.

73002,186A. The largest of the fragments studied here, 73002,186A, is 16.1 mg rocklet. The mapped portion is 4 x 2.5 mm. This fragment is largely composed of pyroxene, plagioclase, and ilmenite. Minor to trace olivine, trolilite, phosphates, silica, and armalcolite also occur. Plagioclase (An82Ab18Or1) and pyroxene are subhedral to anhedral. In addition to being intergrown with plagioclase, pyroxene also occurs as discrete minerals grains. Ilmenite also occurs with two habits. First, ilmenite occurs as acicular grains, up to ~900 µm long, intergrown with plagioclase and pyroxene. Ilmenite also occurs as semi-rectangular grains, two of which have cores of armalcolite.

73002,189C. This fragment is 6.9 mg and is dominated by a single large pyroxene grain along with minor ilmenite. This fragment is likely unrepresentative of the larger fragment from which it originated.

73002,337. This basalt, plucked from a bulk soil sample, is composed predominantly of pyroxene and ilmenite. Plagioclase (An87Ab13Or1) grows interstitially to the pyroxene grains. Ilmenite occurs as discrete clasts that are subhedral to anhedral. Plagioclase is composed of pyroxene, plagioclase, and ilmenite, along with minor to trace olivine, troilite, phosphates, and sulfides. Ilmenite occurs with two habits. First, ilmenite occurs as acicular grains, up to ~900 µm long, intergrown with plagioclase and pyroxene. Ilmenite also occurs as semi-rectangular grains, two of which have cores of armalcolite.

XCT Results: 73002,186A displays a linear slope (Fig. 3), indicating that it experienced a constant cooling rate. From the 2D CSD, this sample is 12.1 vol.% ilmenite. The Slope-Intercept plot of basalt ilmenite CSDs defines an upper faster (shallower) and a lower slower (steeper) cooling trends. 73002,186A plots among other Apollo 17 samples, including other basalts from 73002, and falls within the “faster” cooling trend, with a slope of -10.6±0.4 and intercept of 8.8±0.2.

For the assessment of 3D mineralogy, due to the similarity in linear attenuation coefficients of certain phases, minerals were grouped together for modal abundances [6]. The basalt contains lath-like ilmenite with armalcolite cores (14.4 vol.% ilmenite + armalcolite; Fig. 3) surrounded by pyroxene and olivine (33.5 vol.% pyroxene + olivine). The basalt contains 25.1 vol% plagioclase + silica and trace metal and sulfide phases (~0.1 vol.%), and 0.8 vol.% of pore space. The vugs are most observed near fine-grained pyroxene and plagioclase. We measured 64 vugs for their volume and sphere-equivalent diameters in Blob3D [6]. The calculated strength parameter, C, of the vugs is higher than previous measurements of high-Ti basalts (C = 1.5; [8]), and the shape factor, K, displays a cluster distribution (K = 1.9) for the voids along their primary axis.

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