TEXTURAL ANALYSES OF APOLLO 17 HIGH-TITANIUM BASALTS USING CRYSTAL SIZE DISTRIBUTIONS. P. H. Donohue* and C. R. Neal, Department of Civil Engineering & Geological Sciences, University of Notre Dame, Notre Dame, IN (*pdonohu1@nd.edu).

Introduction: The Apollo 17 mission yielded a plethora of high-titanium basalts (HTB; >6 wt% TiO_2) that originated as partial melts of late stage mafic cumulates [1]. Subsequent analyses showed that the HTB suite originated from multiple source regions, and consequently these rocks were divided into several types (A, B1, B2, C, D, and U) [1-4]. The high TiO_2 content is reflected by early and prolonged crystallization of ilmenite [1,3,5]. Armalcolite often crystallizes before ilmenite under high-Ti and low-fO_2 conditions [6] these conditions, and is present in trace amounts in some samples [1,5]. Plagioclase is commonly a late-stage crystallizing phase, though some textural and experimental studies have shown it can crystallize earlier with or slightly before ilmenite [1,7]. This work presents new textural data in the form of crystal size distributions (CSDs) for ilmenite, plagioclase and armalcolite for the different A17 HTB types.

CSDs have been applied in many terrestrial studies since their initial application in textural studies [8-10]. A CSD plots crystal size versus population density, where the slope of the resulting line is a function of growth rate (G) and residence time (τ). A linear CSD indicates closed system processes (i.e. constant G, τ), whereas curved CSDs may reflect magma mixing, crystal settling, changes in cooling rate or equilibrium state (e.g., assimilation processes), or other open-system processes [8,10]. Crystal settling deflects CSDs concave down, while crystal influx through magma mixing deflects CSDs concave up [8].

Samples and Methods: This study investigated 16 Apollo 17 HTBs:
Type A (70135,64; 71048,6; 75015,52);
Type B1 (70315,27; 71557,7; 75075,86; 78575,10);
Type B2 (70275,35; 71035,32; 77516,30; 79516,9);
Type C (71509,5; 74255,55; 74275,312; 75115,4); and
Type D (79001,2187).

CSDs for these samples were generated from thin section views. Photomicrographs of thin sections at 5x magnification were mosaiced together and phases of interest traced in *Adobe Photoshop*. The lower limit of resolution for this method was 0.05 mm (~33 pixels). Ilmenite and armalcolite were distinguished in reflected light. Plagioclase was traced using cross-polarized images, and distinguished from pyroxene in plane-polarized light. The ImageJ Image processing and analysis program (http://rsbweb.nih.gov/ij/) was then used to measure the length, width, and area of each crystal. To correct for intersection effects, the *CSDSlice* (v4) program converted length and width

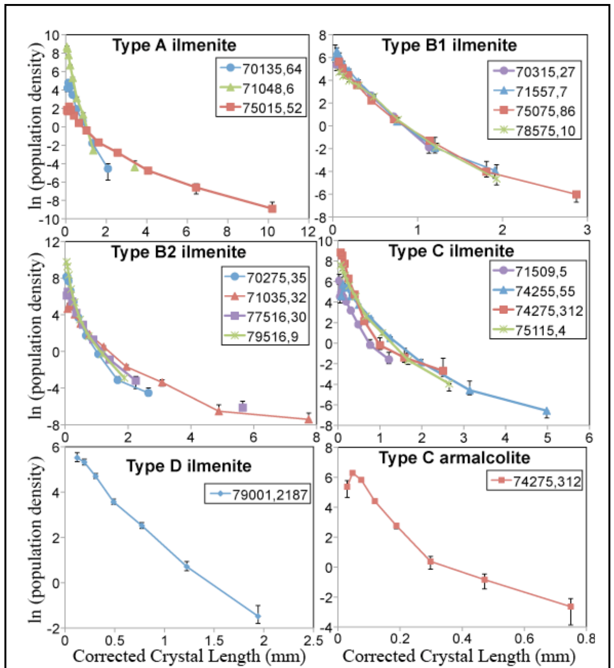

Figure 1. Ilmenite and armalcolite CSDs (crystal length vs. population density) of investigated samples. Error bars represent calculated min and max population density for that crystal bin size.

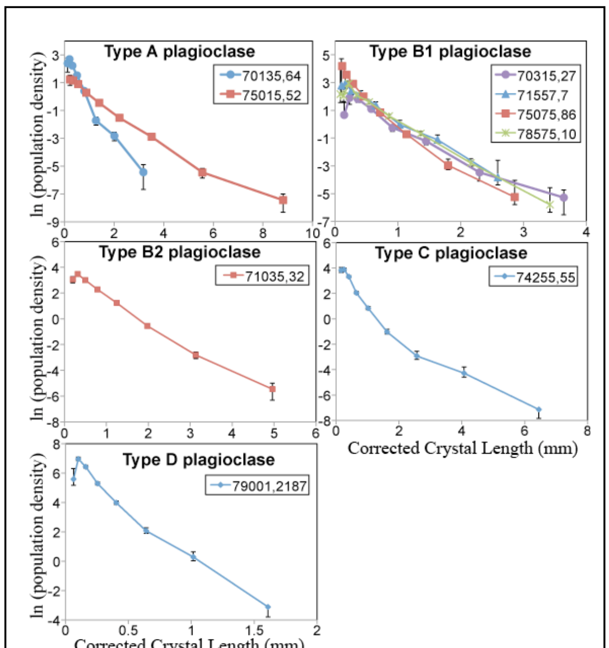

Figure 2. Plagioclase CSDs of investigated types. Note that plagioclase CSDs were not generated for all samples. Error bars as in Fig. 1.

measurements to their most-probable 3D shape [11]. Then *CSDCorrections* (v1.3.9) was used to generate CSDs from these parameters [10].

Results and Discussion: Ilmenite CSDs (Fig. 1) were generated for all samples, while plagioclase CSDs (Fig. 2) were only generated for coarser samples. Only sample 74275,312 contained enough armalcolite crystals (n=300) to generate a CSD (Fig. 1).

Type A: Sample 71048,6 has a steep slope sub-parallel to 70135,64, but following a break in the CSD profile, the largest bin size of ,6 is coarser than predicted by the slope. The two plagioclase CSDs for Type A basalts are sub-parallel to ilmenite CSDs for their respective samples.

A "fanning out" pattern is apparent here, in which the coarsest-crystallized sample (75015,52) has the largest crystal size and lowest y-intercept. This follows previous descriptions of these type A samples, in which 75015 was described as a coarse grained ophitic sample, while 71048,6 (subvariolitic, olivine porphyritic) and 70135,64 (plagioclase poikilitic) were finer grained. Mechanisms to explain such CSD fans include Ostwald ripening, nucleation- and size-dependent growth [12-14]. The break in the CSD profile of 71048,6 reflects elongated ilmenite crystals resulting from quench crystal growth, also indicated by ilmenite sawtooth margins and subvariolitic groundmass (e.g., [5]).

Type B1: Ilmenite CSDs are parallel to sub-parallel, with 71557,7 and 75075,86 being slightly concave up. Plagioclase CSDs are also nearly linear and sub-parallel, with 75075,86 the most concave. Plagioclase CSD slopes are shallower than ilmenite. 75075,86 has a slightly larger corrected ilmenite crystal length and sub-parallel profiles for ilmenite and plagioclase. The Type B1 CSD profiles as a group are among the steepest of both ilmenite and plagioclase CSDs.

The near-linear CSDs of type B1 samples likely result from closed system crystallization. Euhedral ilmenite crystal faces are frequently bounded or enclosed by plagioclase. Thus the steeper ilmenite CSD slope may result from an initially high rate of ilmenite nucleation whose growth of larger crystals decreased when plagioclase came on the liquidus.

Type B2: All ilmenite CSDs are concave up and fan out, with coarser crystallized samples resulting in shallower, more concave CSD profiles. Plagioclase could only be confidently traced in the coarsest sample 71035,32, which yielded a linear CSD parallel to the <3 mm ilmenite crystal population.

Rapid cooling (quench crystal growth) of type B2 basalts is evident from sawtooth and acicular ilmenite. Sample 71035,32 also exhibits the coarsest subvariolitic texture of clinopyroxene and plagioclase of the type B2 basalts.

Type C: All CSDs of ilmenite, armalcolite and plagioclase are concave up to some extent. Sample 71509,5 is nearly linear, but has a slight upturn at the largest crystal bin size. Samples 71509,5, 74255,55, and 75115,4 are sub-parallel.

The concavity of all CSD s of all phases is consistent with two crystal populations. That these CSDs are curved rather than "kinked" indicates post-mixing processes affected the CSDs. This could be a result of prolonged ilmenite crystallization that "curved" the kinked ilmenite pattern, or reflects ilmenite crystallization only after the different crystal populations were mixed.

Type D: The CSDs for ilmenite and plagioclase in sample 79001,2187 are linear. The plagioclase CSD is steeper than ilmenite and all other plagioclase CSDs. A constant cooling rate proposed in previous studies [e.g. 4] is supported by the linear CSDs of both phases.

Summary: This study highlights the microscale variability possible between samples from the same source, which can be lost in whole-rock analyses. CSDs can be used to identify crystal populations of interest for further characterization. In the A17 HTBs, ilmenite is on the liquidus for a majority of crystallization and generally has a non-linear CSD profile. Plagioclase has a simpler crystallization history reflected by linear CSDs.

References:

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