APOLLO 17 HIGH-TITANIUM BASALT PETROGENESIS REVEALED BY CRYSTAL SIZE DISTRIBUTIONS AND MINERAL GEOCHEMISTRY. P. Donohue and C.R. Neal, Dept. of Civil Eng. & Geo. Sci., University of Notre Dame, Notre Dame, IN 46556, USA (pdonohu1@nd.edu) (neal.1@nd.edu).

Introduction: Quantitative textural data for Apollo 17 (A17) high-Ti mare basalts provide constraints on their crystallization and mineral growth histories. Crystal Size Distributions (CSDs) are presented for ilmenite crystals in a Type B2 (70275,35) lunar sample, and two Type C (74255,55 and 74275,312) lunar samples. Ilmenite was chosen because it began t crystallize early in the Apollo 17 basalts (Papike et al., 1976) and remained on the liquidus for the majority of the solidification (e.g., [1]). This study uses the composition of ilmenite to trace the evolution of the Apollo 17 high-Ti basalts as they crystallized. Mineral geochemical data (major and trace element) will be presented at the conference.

Crystal Size Distributions are plotted as the natural log of the population density versus crystal length. The shape and interpretation of CSD curves are useful in determining initial nucleation density, nucleation rate, growth rate, and whether the system was closed or open [2-4]. A linear CSD results from uninterrupted nucleation and growth rates during cooling. Curved CSDs may reflect magma mixing, crystal settling, changes in cooling rate or equilibrium state (e.g., assimilation processes), or other open-system processes [3,4]. Crystal settling deflects CSDs concave down, while crystal influx through magma mixing deflects CSDs concave up [3].

Methods: Thin section imaging of the basalts in plane polarized light (Fig. 1a-c), cross polarized light, and reflected light were used to identify ilmenite crystals. Crystal outlines traced and filled in *Adobe Photoshop*, measured with *ImageTool*, and processed by CSDSlice converted the 2D thin section crystals into their most-probable 3D crystal form [5]. *CSDCorrections* utilized *ImageTool* measurements and *CSDSlice* shape information to calculate the population density per crystal length interval [6].

Select ilmenite crystals from each thin section will be sampled for major elements (via electron microprobe) and trace elements (using LA-ICP-MS) from core to rim. Major and trace element analyses of ilmenite crystals by electron microprobe and laser ablation inductively coupled mass spectrometry (LA-ICP-MS) will supplement CSD data. Crystals present throughout cooling will reflect parent magma compositions at the core, with the later stage magma compositions being represented in subsequent growth zones around the initial crystal core.

Major elements and X ray images will be obtained via JEOL JXA-8200 Electron Microprobe (EMP) at Washington University, St. Louis. Trace elements will be obtained at the University of Notre Dame using the *Element 2* high resolution Inductively Coupled Plasma Mass Spectrometer (ICPMS) coupled to a 213 nm New Wave laser ablation system coupled to the Element 2 high resolution ICP-MS (http://www.nd.edu/~icpmslab). The raw counts will be calibrated using the CaO content determined by EMP as an internal standard and abundance data will be obtained for each spot using the data reduction program *Glitter* developed by Simon Jackson at Macquarie University in Australia (http://www.glitter-gemoc.com/).

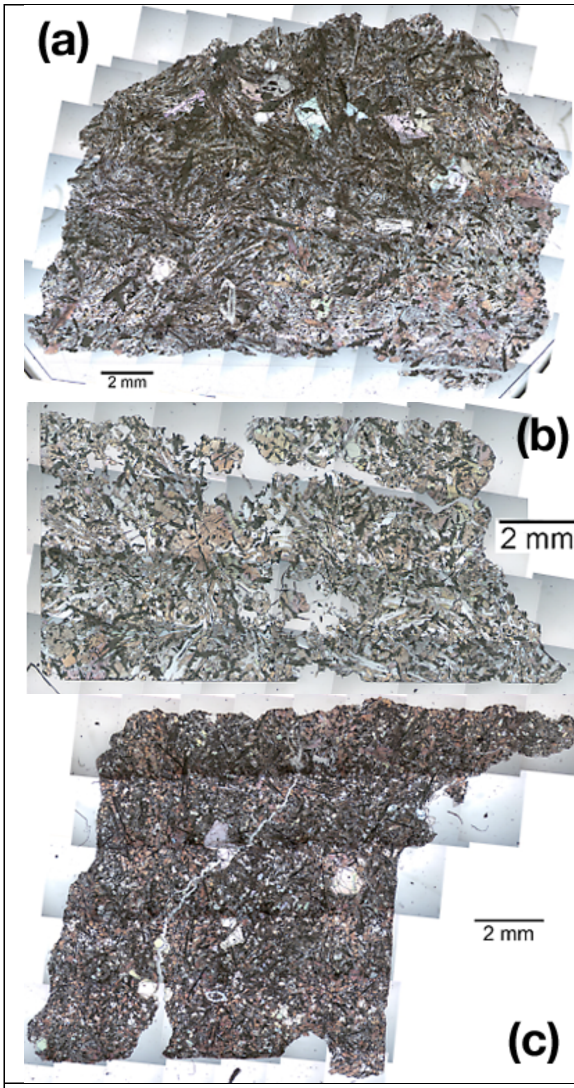

Fig. 1: Thin sections of a) 70275,35; b) 74255,55; c) 74275,312 in plane polarized light.

Results: CSDs for samples 70275, 74255, and 74275 are concave up (Fig. 2a-c). The initial slope (representing smaller crystals) of 70275 is the steepest, with gradient changes at 0.4 and 1.4 mm resulting in three distinct slopes. Sample 74255 is more linear, although once again the initial slope is steepest. The gradient change in this case occurs at just over 1 mm. The CSD for sample 74275 also exhibits a gradient change at approximately 1 mm.

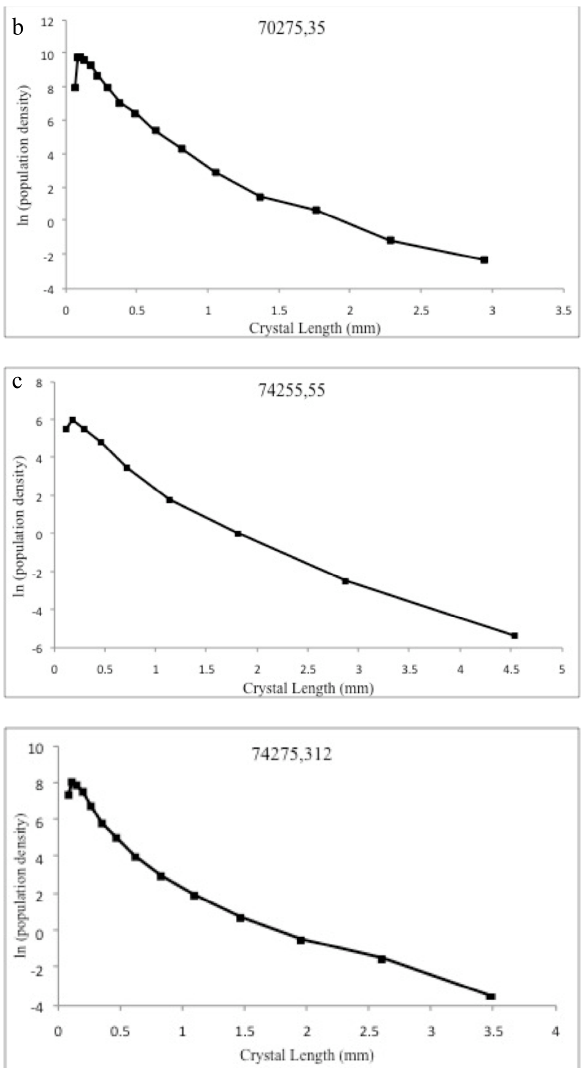

Fig. 1: CSDs for Apollo 17 high-Ti basalts. a) 70275,35, b) 74255,55, and c) 74275,312.

Discussion: The concave up nature of the Apollo 17 basalt 70275,35 CSD slope indicates accumulation within the magma chamber prior to eruption. Three crystal populations are inferred from the three distinct slopes. Sample 74255 also exhibits a concave up CSD slope associated with crystal accumulation. There are two crystal populations in 74255, given the distinct break in the gradient at 1 mm.

Each sample may have experienced two (for 74255 and 74275) or three (for 70275) crystallization events or cooling regimes, and crystal resorption due to magma influx, or the mixing of crystal populations. Completion of the elemental data analysis of crystals from each population will allow a quantitative evaluation of the models suggested by the CSDs.

The CSDs can be used to evaluate residence time of crystals in a magma as the slope is a function of average crystal growth rate (G) and the residence time in the system (τ): CSD Slope = $-1/G\tau$. Several studies (e.g., [2, 3]) have examined the crystal growth rates of a wide range of volcanic systems, and determined that crystal growth rates only vary over an order of magnitude, 10^{-10} to 10^{-11} cm/sec. We assumed a growth rate of 10^{-10} cm/sec. We have divided the CSDs into a steeper gradient (smaller crystal sizes t1) and a gentler gradient (larger crystal sizes t2), the division being where there is a break in the gradient on the CSD. 70275,35 has three distinct slopes corresponding to residence times of 3.3, 5.2, and 12.9 years. 74255,35 has a residence time of 6.8 years for smaller crystals, and 15.2 years for larger crystals. 74275,55 has a t1 of 4.2 years and t2 of 14.5 years.

References: [1] Papike J.J., et al. (1976) *Rev. Geophys. Space Phys.* 14, 475-540. [2] Cashman K. and Marsh B. (1988) *Contrib. Mineral. Petrol.* 99, 292-305. [3] Marsh B. (1988) *Contrib. Mineral. Petrol.* 99, 277-291. [4] Marsh B. (1998) *J. Petrol.* 39, 553-599. [5] Morgan D. and Jerram D. (2006) *J. Volc. Geotherm. Res.* 154, 1-7. [6] Higgins M. (2000) *Amer. Mineral.* 85, 1105-1116.