CRYSTAL SIZE DISTRIBUTIONS AND TRACE ELEMENT PROFILES OF PLAGIOCLASE CRYSTALS IN APOLLO 14 HIGH-ALUMINA BASALTS. J. Oshrin[1] and C.R. Neal[1], [1]Dept. of Civil Eng. & Geo. Sci., University of Notre Dame, Notre Dame, IN 46556, USA (joshrin@nd.edu) (neal.1@nd.edu).

Introduction: This study focuses on the petrogenesis of Apollo 14 high-alumina basalts from the Frau Mauro region. The basalt samples from this site originated from at least three unique source regions, and are comprised of three groups, termed A, B, and C, of ages ~4.3 Ga, ~4.1 Ga, and ~3.95 Ga, respectively [1—5]. On the basis of whole-rock analyses, Neal and Kramer [3] hypothesized that Group A basalts evolved from closed-system crystal fractionation, while Groups B and C basalts evolved from open-system processes with a combination of assimilation and crystal fractionation (AFC). Additionally, Neal and Kramer [3] suggested that one sample, 14072, does not have the elemental characteristics of any of the defined groups, possibly indicating the presence of a fourth (and poorly sampled) high-alumina basalt group at the Apollo 14 site. The current study measures the crystal size distribution of plagioclase crystals in samples from each of the groups to gain insight into the evolution of the source magmas. Additionally, major and trace elements will be measured from the core to the rim of plagioclase crystals to determine if compositional variations are consistent with the processes suggested by the textural and whole rock analyses.

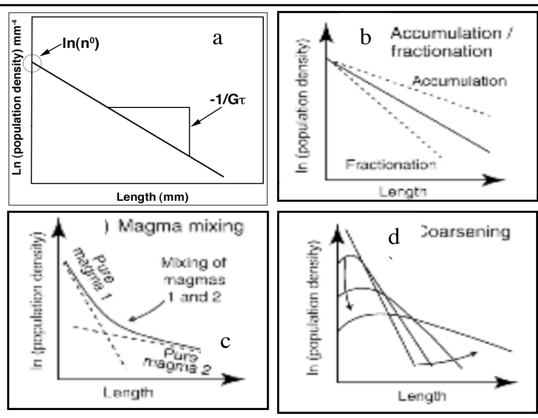

Fig. 1: a) CSD slope, growth rate, & residence time. G = growth rate; τ = residence time; n° = nucleation density. b) Effects of crystal accumulation and fractionation on CSDs c) Effects of magma mixing on CSDs d) Effects of textural coarsening on CSDs (Figures from Higgins and Roberge, [9]).

Textural Analysis: Crystal size distributions (CSDs) are a simple method of quantitatively investigating igneous processes, and are typically used as a complement to compositional analysis. They involve the measurement of the number of crystals of a particular size per unit volume of rock, and are usually plotted as the natural log of the population density with respect to crystal size length (Fig. 1 [6,7]). If the nucleation and growth of crystals progress uninterrupted, as in a closed magma system, a linear distribution of crystal sizes results; however, several factors can alter crystal growth in the magma and yield a non-linear CSD (Fig.1b-d; [6-9]). For example, accumulation of crystals produces a concave up CSD, while a concave down CSD is indicative of crystal fractionation, because larger crystals are removed from the population (Fig. 1b; [6-9]). If the magnitude is sufficient, whole-rock chemical analysis can detect accumulation or fractionation of plagioclase crystals as positive or negative Eu anomalies, respectively. The mixing of magmas with distinct CSDs generates a kinked CSD with steep slopes at the smaller crystal lengths and shallower slopes at the larger crystal lengths (Fig. 1c; e.g., [10]). Closed systems can also yield non-linear distributions through textural coarsening, which occurs when crystals below a critical size are resorbed for the benefit of larger crystals' growth [9-11]. The resulting CSD has a shallower slope and lower intercept (Fig. 1d).

Compositional Analysis: Previously, whole-rock analysis was used to measure trace elements in Apollo 14 high-Al basalts (e.g. [3],), which does not offer much detail about the events that occurred during magma evolution. In addition to textural analysis, this study will measure major and trace element variations between the cores and rims of plagioclase crystals using electron microprobe and laser ablation inductively couple mass spectrometry (LA-ICP-MS). The compositional profiles will be used to examine the consistency of processes suggested by the crystal size distributions, as well as previous petrogenetic models.

Methods: High-resolution photomicrograph maps were made of the sample thin sections under both plane-polarized light and cross-polarized light. The plagioclase crystals in the ppl photomicrographs were outlined and filled in using Adobe Photoshop®. The crystal shapes were measured by *ImageTool* [12], then processed by *CSDslice* [13] to convert the 2D drawing into its most-probable 3D crystal form. Using the measurements from *ImageTool* and the shape information from *CSDslice*, *CSDcorrections* [12], calculated the population density per crystal length interval.

Plagioclase crystals will be selected from thin sections from each identified Apollo 14 group and 14072, and sampled for major and trace element abundances. An electron microprobe and LA-ICP-MS will be used to take a series of measurements from the core of the crystals to the rim, similar to the method described in Kinman and Neal [14].

Results: The CSDs of each group of samples and impact melts fall into distinct ranges of gradient, with very little overlap (Fig. 2). The impact melts (green) have the shallowest slope and largest maximum crystal sizes. Sample 14072 (purple) falls between Groups B (yellow) and C (red), which contradicts whole rock chemical analysis that places the sample as intermediate between Groups A and C [3].

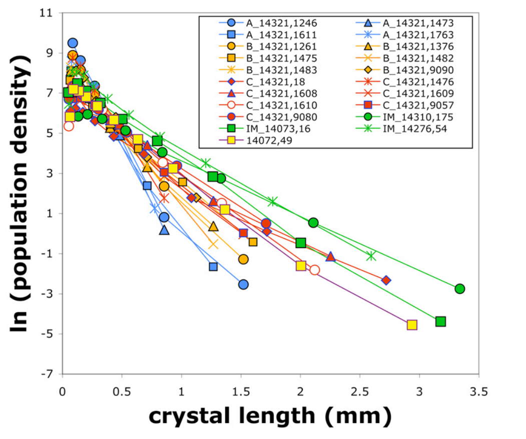

Figure 2: Crystal size distribution of plagioclase crystals in sample 14072, impact melts, and Groups A, B, and C. IM = Impact Melt.

Discussion: The relatively steep slopes and small maximum crystal size of Group A CSDs (Fig. 2) indicate a short and simple crystallization process, consistent with previous conclusions that it evolved through closed-system crystallization [3]. Groups B and C basalts exhibit a larger span of CSD gradients (and some have a change in gradient) suggesting several processes (e.g., textural coarsening, open system behavior, etc.) may have affected the magma during crystallization. Group C has a broad range in characteristic lengths and plagioclase abundance (Fig. 3), which could be the result of a thick flow and long cooling period. Measuring the core-to-rim chemical variations within plagioclase crystals will confirm the processes suggested by the CSDs. In doing so, we will concentrate on those samples that show a change in CSD gradient (Fig. 4) to quantify the various processes that such CSDs could indicate. These data will be presented at LPSC.

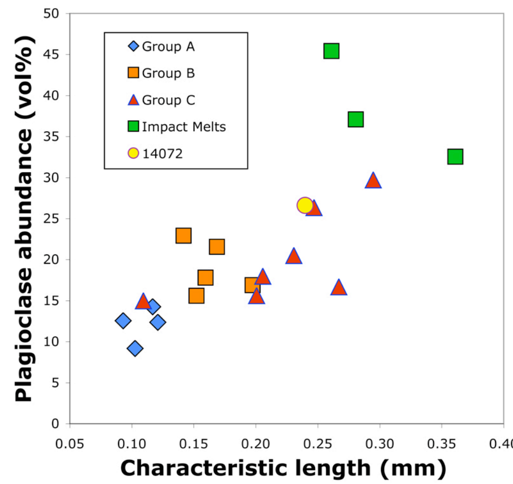

Figure 3: Plot of the volumetric plagioclase abundance vs. characteristic length of each CSD. Characteristic length is equal to the mean length of all crystals in a straight CSD that extends from zero

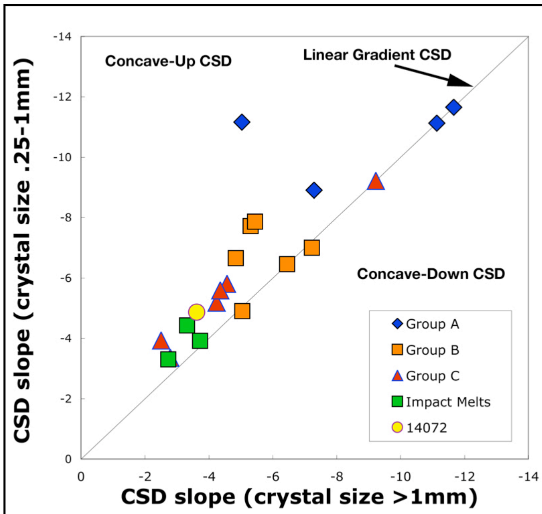

Figure 4: Comparison of CSD gradient above and below 1mm crystals length. Samples with concave-up CSDs plot above the one-to-one line.

References: [1] Papanastassiou & Wasserburg (1971) *EPSL* **12**, 36-48; [2] Dasch et al. (1987) *GCA* **51**, 3241-3254; [3] Neal & Kramer (2006) *Am. Min.*, **91**, 1521-1535; [4] Neal et al. (1988) *PLPSC 18th*, 139-153; [5] Hagerty et al. (2005) *GCA*, **69**, 5831-5845; [6] Marsh (1988) *CMP*. **99**, 277-291; [7]] Marsh (1998) *J. Pet*. **39**, 553-599; [8] Cashman & Marsh (1988) *CMP* **99**, 292-305; [9] Higgins & Roberge (2007) *JVGR* **161**, 247-260; [10] Higgins (1996) *JVGR* **70,** 37-48; [11] Higgins & Roberge (2003) *J. Pet*. **44,** 1401-1411; [12] Higgins (2000) *Am. Min*. **85,** 1105-1116; [13] Morgan & Jerram (2006) *JVGR* **154**, 1-7; [14] Kinman & Neal, (2006) *JVGR* **154**, 121-157;