USING QUANTITATIVE PETROGRAPHY TO DISTINGUISH BETWEEN PRISTINE BASALTS AND IMPACT MELTS FROM THE MOON. C. R. Neal[1] and P. Donohue[1], A. Fagan[1], H. Hui[1], K. O'Sullivan[1]. [1]Dept. of Civil Eng. & Geological Sciences, University of Notre Dame, Notre Dame, IN 46556, USA (neal.1@nd.edu).

Introduction: Distinguishing between pristine basalts and basaltic impact melts has proven to be difficult [1-5]. Traditionally, such distinctions required time consuming experiments to be performed (e.g., [4,5]), or destructive analyses to determine the highly siderophile element contents of the samples (e.g., [6]). Preliminary data for a non-destructive method using quantitative petrography for distinguishing impact melts from pristine mare basalts, was presented at LPSC 41 [7].

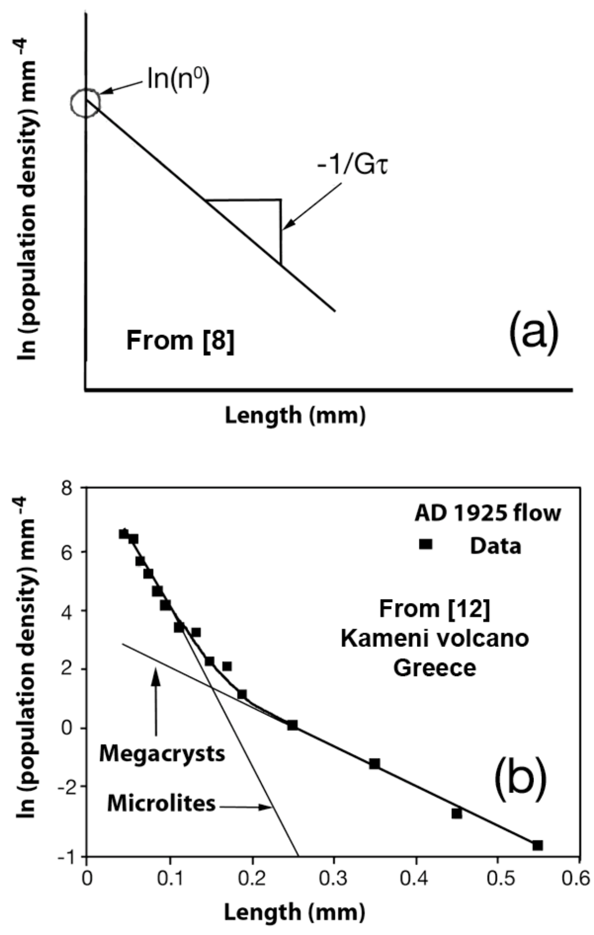

Fig. 1: (a) Anatomy of a CSD; (b) Example of a CSD depicting mixed crystal populations.

Method: Crystal size distributions (CSDs) are used to quantify population densities within particular size bins of a given mineral phase (e.g., [8-10]). CSDs are normally displayed on a log-normal plot of population density (number of crystals per unit volume rock) versus crystal size (L) [8]. The slope of a CSD is -1/G (growth rate) multiplied by τ (residence time) (Fig. 1a). Crystal nucleation rate generally increases as an initially wholly molten flow cools [11]. If nucleation and growth continue uninterrupted, the CSD is linear or near linear [13]. If the magma arrives at the surface carrying macroscopic crystals, the final rock will likely yield a non-linear, "kinked" CSD (Fig. 1b), but if the phenocrysts settled appreciably, the final CSD would be concave-up [13]. Crystals carried in the initial magma may vary in size and can easily be interpreted as phenocrysts crystallized from the present host magma [14,15]. Non-linear CSDs indicate dynamic and/or kinetic processes affected crystallization [9,11]. Curved CSDs may reflect the different nucleation and growth conditions of distinct crystal populations in the rock (e.g., [9,12,16]).

Plagioclase is ubiquitous in both pristine mare basalts and impact melts so this has been the mineral focused upon in this study. Building upon [7], plagioclase CSDs have been constructed for three Apollo 12 basalts (12031, 12038, and 12051), five Apollo 16 impact melts (60635, 65795, 67559, 67741, and 67948), and nine Apollo 17 basalts (two from Type A: 75015, 70135; four from Type B1: 71554, 75075,78575,70315; one from Type B2: 71035; one from Type C: 74255; and the only Type D basalt thus far recognized: 79001,2187 [17]). These are in addition to the Apollo 14 high-alumina basalts and impact melts reported by [7].

Thin sections were photographed under 5x magnification and plagioclase and olivine crystals were traced in *Adobe Photoshop*. Crystal outlines were then imported into *ImageTool* [18] to obtain the length, width, and roundness of each crystal. Length and width measurements were then imported into *CSDslice* [19] to get the most probable crystal shape. Crystal lengths and widths along with the most probable crystal shape were then imported into *CSDcorrections* [18] to yield the CSD plotted as the natural log of the population density versus crystal length.

The samples used in this study exhibit a variety of CSD profiles. As such, the steepest slopes on the CSDs were the focus (represented by "Microlites" in Fig. 1b). This represents a range 0.1 to 1 mm. The slope of the CSD within this range was calculated using size bins that showed an increasing population density. If size bins within the range showed a decrease in population density (thus impacting the CSD slope), they we omitted from the calculation. The intercept of the slope with the y-axis [ln(n^O) in Fig. 1a] was calculated using the same data points used to calculate the slope. This represents the nucleation density [8].

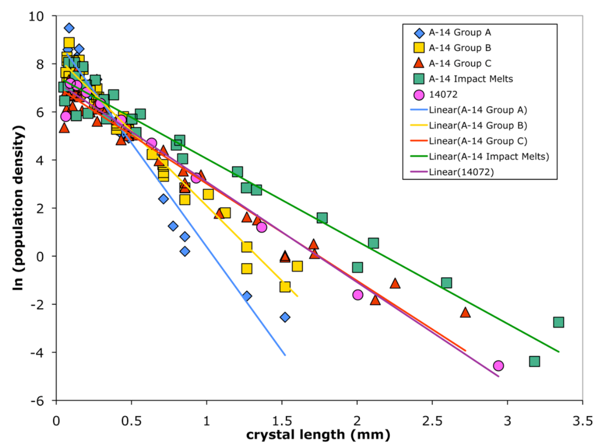

Fig. 2: CSD plot for the Apollo 14 high-alumina basalt groups and impact melts.

Discussion: Neal et al. [7] hypothesized that, on the basis of Apollo 14 data, that impact melts tended to exhibit plagioclase CSDs with a flatter gradient that pristine basalts (Fig. 2). This hypothesis has been tested in this study. Marsh [9] concluded that igneous systems display a significant range of relations between CSD slope, maximum crystal size, and intercept. Here, the intercept of the CSD in the size range 0.1-1 mm is plotted against the ratio of the slope to the intercept (Fig. 3). This can be interpreted as being a plot of nucleation density versus growth rate/nucleation density. On the basis of these data, the impact melts appear to be differentiated from the pristine basalts.

As noted above, the negative slope of a CSD is a measure of the product of overall population growth rate and mean age (residence time) [8]. The interpretation from Fig. 2 is that impact melts have a lower nucleation density with a lower growth rate relative to the pristine basalts. If the slope were considered a function of residence time, then the impact melt plagioclases would then have a longer residence time in the magma than the pristine lavas (see also [20]).

Interestingly, Apollo 12 basalt 12038 plots with the impact melts in Figure 3. 12038 is the only member of the feldspathic suite of Apollo 12 basalts [21,22]. It has an age of 3.35 Ga [23] and is not enriched in siderophile elements. 12038 has always been interpreted as a pristine mare basalt sample. Further studies are underway to examine the evolution of 12038 using crystal stratigraphy to see if it is consistent with the evolution determined for other impact melts. In addition, more samples (both pristine basalts and impact melts) are being examined using quantitative petrography to see

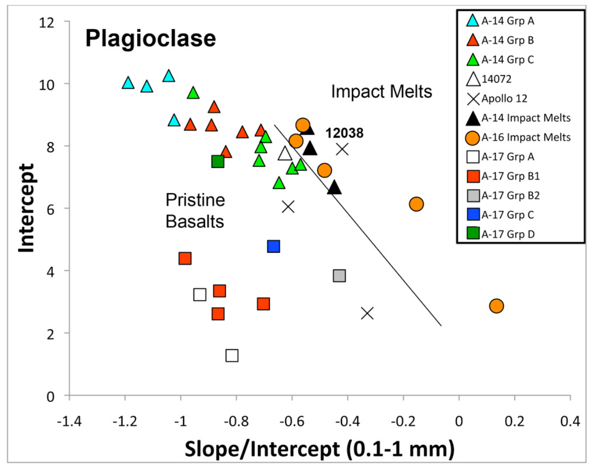

Fig. 3: Plot of CSD Intercept (nucleation density) against the ratio of CSD Slope/CSD Intercept (growth rate/nucleation density) for the samples used in this study.

if the relationships shown here continue to be consistent. If they are, then the petrogenesis of 12038 will need to be re-examined.

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