Investigating the Crystal Cargoes of Lunar Basaltic Magmas: Application of Crystal Size Distribution Analysis to Apollo 12 Basalts. J. R. Davis[1], A. J. Gawronska[1], C. L. McLeod[1]. [1]Dept. of Geology and Environmental Earth Science, Miami University, Oxford, OH 45056. (davisjr5@miamioh.edu).

Introduction: Textural characteristics associated with the crystal populations of igneous rocks can provide detailed information on the cooling history of magma(s). One approach to quantifying these characteristics is the application of Crystal Size Distribution (CSD) analyses, which will be used here to assess the petrogenesis of Apollo 12 basalt samples. Eventually, the acquired CSD analyses on select samples will be compared with 3D particle size distributions (PSDs) acquired via computed tomography in order to wholly evaluate the textural characteristics of these samples [1]. Advantageously, CSD analysis is a non-destructive method for unraveling details about a sample's history. This is crucial for rare, invaluable samples such as the Apollo basalts [2].

The physical characteristics of the crystal populations within the Apollo basalts can provide insight into past magmatic activity and subsequent impact activity [3]. Lunar impact melts, for example, can often appear texturally similar to the products of endogenic magmatism [2]. Using CSDs however, these two rock forming processes can be differentiated from each other. This approach therefore works to provide an understanding of the primary magmatic processes associated with the petrogenesis of Apollo basaltic samples.

The size and shape of crystals in a sample depend on the crystallization and cooling histories that the sample experienced throughout its petrogenesis. Varying crystal sizes within a sample can represent complex crystallization histories such as variable nucleation densities, changing cooling rates, or multiple crystallization events, all which will be considered here within the CSD framework [2].

Preliminary investigation of the crystallization and cooling histories associated with magmas at the Apollo 12 site has begun with samples 12038 and 12043. Both represent relatively coarser grained (**Figs. 1-2**), holocrystalline low Ti basalts, and will be studied through CSD [4, 5] and PSD methods [6].

Methods: Thin section images of samples 12038, 64 and 12043, 6, provided by The Apollo Virtual Microscope Collection, are being utilized to create CSDs [7]. Distributions of plagioclase feldspar, and, if possible, olivine and ilmenite, will be determined in this study (**Figs. 1-2**), and later compared to 3D PSDs [2, 6-7]. For each set of crystals in a thin section, as many plagioclase feldspar (target minimum 250), olivine (target minimum 70), and ilmenite crystals will be measured for their sizes [2, 8]. The crystals of the

Figure 1. Image of Apollo sample 12038, 64 in plane polarized light (PPL) via The Apollo Virtual Microscope Collection. Scale bar in lower left corner measures 1 mm [7].

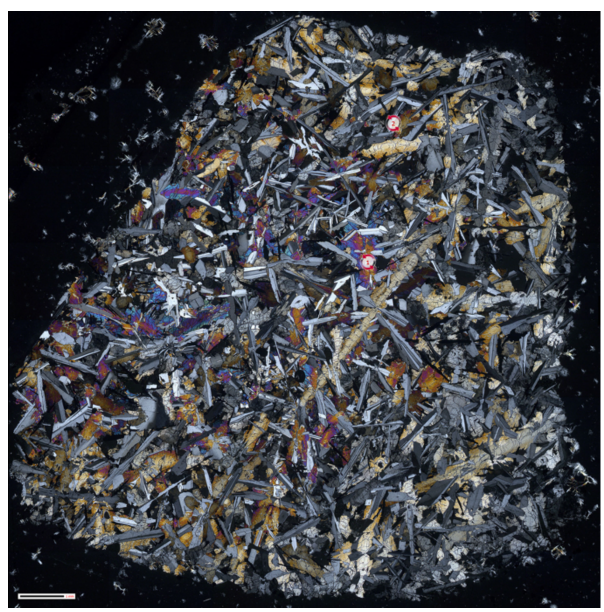

Figure 2. Image of Apollo sample 12038, 64 in crossed polarized light (XPL) via The Apollo Virtual Microscope Collection. Scale bar in lower left corner measures 1 mm [7].

mineral phase of interest (such as plagioclase, olivine, or ilmenite) will be outlined and these tracings uploaded into *ImageJ* in order to obtain precise crystal measurements [9]. Data produced will include the measurements of the major and minor axes, roundness, and area of the individual crystals [2].

The CSD is created when this data is summarized in *CSDSlice* [2] and *CSDCorrections* [2] and a plot similar to that in **Fig. 3** is generated. This is then used to interpret the petrogenesis of the sample.

Results and Discussion: Depending on how the population density of crystals vs. the length of the crystals plot (**Fig. 3**), the crystallization history can be determined [2]. The slopes and y-intercepts of the best fit lines of the coordinates of crystal size and population density in these plots work to distinguish the various crystallization events [2]. The slope distinguishes the crystal growth rate while the y-intercept signifies the nucleation density of the samples. Any "kinks" in the slopes of the CSDs can be interpreted to indicate an event (or events) during the samples' petrogenetic history e.g., multiple crystallization events or magma mixing events [2]. CSDs with curved profiles for example could signify variable nucleation and growth conditions [2]. Previous studies have been able to specifically utilize olivine to show that olivine crystals from impact melts have steeper CSDs than those of mare basalts [2].

Future Work: The purpose of this research is to advance our understanding of the petrophysical characteristics of lunar basalts. In the future, these samples will be analyzed through computed tomography to compare and contrast observations in different dimensions (2D vs. 3D). The combined study aims to provide a novel perspective for analyzing and understanding the magmatic processes and conditions through which the Apollo basalts crystallized. With such non-invasive, non-destructive techniques such as CSD and PSD analyses, valuable information is extracted from these Apollo basalts while conserving the bulk sample. This therefore works to preserve the samples for future studies which may be destructive in nature (i.e. chemical analyses). Collectively, these approaches ultimately work to advance our understanding of lunar magmatic processes.

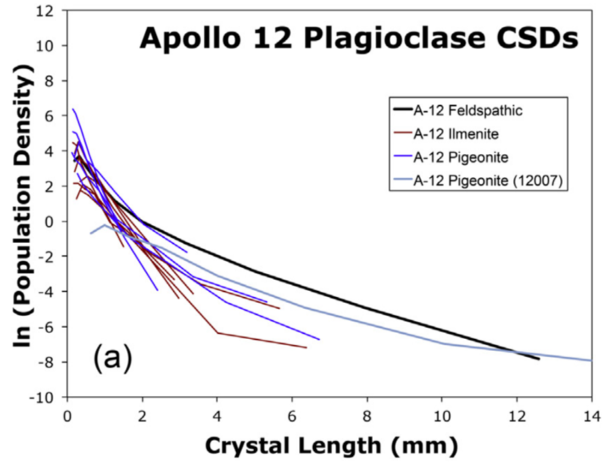

Figure 3. Sample CSD graph of the log of the population density of samples vs. the length of the samples from Neal et al. 2015 [2]. Similar graph will be obtained from the samples used in this study.

Acknowledgments: We thank the Apollo Virtual Microscope team for creating such as website where images of the samples can be accessed and investigated freely.

References: [1] Gawronska A. J. et al. (2019) *LPSC L*, #1660. [2] Neal C. R. et al. (2015) *Geochim. et Cosmochim. Acta 148,* 62–80. [3] Fagan A. L. et al. (2013) *Geochim. et Cosmochim. Acta 106*, 429-445. [4] Morgan D. J. & Jerram D. A. (2006) *J. Volcanol. Geoth. Res. 154,* 1–7. [5] Higgins M. D. (2000) *Am. Mineral. 85,* 1105-1116. [6] Gawronska A. J. et al. (2020) *LPSC LI*, #1245. [7] Gibson E. K. et al. (2018) *LPSC L,* #2083. [8] Donohue P. H. & Neal C. R. (2015) *Geochim. et Cosmochim. Acta 149*, 115-130. [9] Schneider C. A. et al. (2012) *Nature Methods 9(7)*, 671-675.