UNDERSTANDING THE CRYSTALLIZATION HISTORIES OF MARTIAN AND LUNAR METEORITES. Stu Webb1, M. Borden1, C.R. Neal1, and J.M.D. Day2 1Department of Civil and Environmental Engineering and Earth Science, University of Notre Dame, Notre Dame, IN 46556, USA [gwebb1@nd.edu; cneal@nd.edu]. 2Scripps Institution of Oceanography, University of California San Diego, La Jolla CA 92093-0244, USA.

Introduction: Crystal Size Distribution (CSD) data are a valuable tool for evaluating the crystallization histories of igneous samples [1-3]. Plotting CSD slope and y-intercept data for different minerals from meteorite samples can identify different crystallization histories and origins, and it may also help provide constraints on whether some basaltic lunar meteorites represent impact melts [4]. Previous studies have examined CSD data for lunar meteorites and lunar basalts [5], and this study aims to take such investigations to Mars through the examination of martian meteorites. To date, no crystalline rocks from Mars have been considered serious contenders as impact melts, making them a good test for examining the robustness of CSDs for making this distinction. New pyroxene CSD data for martian nakhlite meteorite thin sections MIL 03346,9, MIL 03346,117, and Nakhla,78 are reported together with olivine CSD data for intermediate lherzolitic shergottites ALH 77005,7 and ALH 77005,120. Plagioclase (maskelynite) CSDs are reported for lunar meteorite NWA 4734 and martian thin sections ALH 77005,120 and RBT 04262,26. Some of these meteorites have previously been included in quantitative textural studies (e.g. [6]), but the specific thin sections analyzed in this abstract have not.

Methods: CSD data for this study was collected in a manner similar to that listed in [4], but with slight variations. Photomicrographs of the thin sections were obtained using a Nikon petrographic microscope in plane-polarized light, cross-polarized light, and reflected light. A 4× objective was used for all images. Once the images were collected they were then stitched together using Microsoft Image Composite Editor© to create a photomosaic representing the entirety of the sample (Figure 1). These stitched photomosaics were then opened in Corel Paintshop® Pro 2019 Ultimate and crystals of the relevant mineral phase (olivine, pyroxene, or plagioclase) were traced using an active stylus. In the case of intersecting crystals, multiple layers were generated in Paintshop® Pro to ensure that each crystal was recorded discretely and that no crystals were merged together while tracing. Care was taken to trace the absolute maximum number of crystals available in each sample area in order to achieve population density values that are as accurate as possible [7]. Element maps of the thin sections were obtained using a Cameca SX50 electron microprobe, these were used to ensure that olivine and pyroxene crystals were properly identified in the CSD traces. Once the crystal traces were completed the photomosaics were removed from the background and the crystal traces were filled-in with a solid color. Those images were exported to ImageJ®, where the known scale of the images was used to determine the area, best-fit ellipse, and major/minor axis of each crystal and the sample area itself. These data were then input into CSD-Slice [2] and CSDCorrections [3] to determine the overall shape and size distribution of the crystals. CSDCorrections measurement options were set to Ellipse Major Axis and the size scale was five bins per decade. The resulting CSDCorrections data was used to plot the natural log of population density versus the length of each crystal’s major axis, and the slope and y-intercept data from these plots were used to compare the CSDs to those of other meteorites and lunar basalts [4].

Results and Discussion: The CSD data for lunar meteorite NWA 4734 maskelynitized plagioclase plots near Apollo 12 and 17 basalt samples and outside of the impact melt field (Fig. 2). It shows a significantly reduced y-intercept and shallower slope than other lunar
meteorite CSD data that has been reported. This could be due to maskelynitization having obscured the grain boundaries of the original, smaller plagioclase crystals. If the original plagioclase crystals were smaller than the maskelynite traces then the population density of crystals (y-intercept) would increase and the CSD slope would become steeper, moving the data point closer to other reported lunar meteorites. When compared to lunar basalts and meteorites, the ALH 77005 olivine CSDs plot near lunar endogenous melt basalts and meteorites (Fig. 3). The slope and y-intercept results for ALH 77005 are similar to lunar meteorites NWA 032 and NWA 8632, as well as many Apollo 12 and 17 basalt samples. The olivine data for ALH 77005,120 exhibits a somewhat lower y-intercept and shallower slope than ALH 77005,7. This can be explained by the large melt pocket and shocked zone present in thin section ALH 77005,120, as it is included in the area of the sample trace but obviously does not contain as high a population density of olivine crystals as the crystalline portion of the sample (Fig. 1a,d). All of the maskelynite CSDs from this study plot near plagioclase CSDs of endogenous Apollo 12 and 17 basalts, and none of them plot within the impact melt field. The pyroxene results for MIL 03346 are in agreement with those published in [6]. Pyroxene CSD results for Nakhlite have a steeper slope and greater y-intercept than the results for the MIL 03346 thin sections, which is consistent with MIL 03346 having the largest average grain size of the nakhlite meteorites [8].

Conclusions: All of the martian meteorite CSDs plot near lunar samples that are considered to be endogenous, consistent with the idea that shergottites and nakhlites are melts from the interior of Mars. None of the samples in this study plotted in the field that has been established for lunar impact melts [4,5]. Mineral analyses are underway to constrain these conclusions further, but recent HSE abundances and Os isotope compositions also support this result [9,10]. CSD analysis of additional martian samples, as well as new lunar samples, can help further constrain the endogenous melt and impact fields for expansion of this method on planetary basalts in general.