EXAMINING CHONDRULE AND CLAST SIZES IN THE CM CHONDRITES LAPAZ ICEFIELD 04514, LAPAZ ICEFIELD 04527, AND LAPAZ ICEFIELD 04565. M. D. Louro[1], N. M. Abreu[2], and J. M. Friedrich[1,3], [1]Department of Chemistry, Fordham University, Bronx, NY 10458, [2]Earth Science Program, Pennsylvania State University, Du Bois Campus, Du Bois, PA 15801, [3]Department of Earth and Planetary Sciences, American Museum of Natural History, New York, NY 10024.

Introduction: Understanding chondrule size is important for the classification of chondrites into chemical groups, the development of astrophysical models for the formation of chondrules, and for understanding how to utilize asteroidal resources in space exploration [1]. There are several challenges associated with measuring chondrule diameters in the CM chondrites. First, the CM chondrites have experienced extensive aqueous alteration [4-7], rendering the unambiguous identification of chondrules and their boundaries more difficult than chondrule boundaries in, for example, unequilibrated ordinary chondrites. Second, there are a variety of chondrule and chondrule-like objects in the CM chondrites [8]: the most common two categories being generally described as aggregate chondrules and completely melted chondrules [e.g. 2]. Presumably, the former experienced incomplete or partial melting during the chondrule-forming event while the latter experienced higher nebular temperatures [8]. The final challenge with determining chondrule sizes in CM chondrites is that mean chondrule diameters are relatively small, sometimes overlapping with materials that may be considered large fragments of matrix minerals.

The sizes (diameters) of chondrules and mineral fragments in CM chondrites have been previously investigated by others examining thin sections using optical microscopy [2-3]. King and King [2] reported average grain sizes among 7 CM chondrites to range from 113µm to 178µm. Rubin and Wasson [3] used optical transmitted light microscopy to measure 100 randomly chosen chondrules in the Murray CM chondrite and found a diameter of mean of 270 µm. A subset of more aqueously-altered (phyllosilicate-rich) chondrules had a mean diameter of 80 µm. In this work, we will investigate the sizes of chondrules and clasts (mineral fragments) in several CM chondrites to add additional information to the issue of chondrule sizes in the CM chondrites.

Samples and Methods: We used scanning electron microscopy (SEM) to collect back scattered electron (BSE) images of three thin sections of CM chondrites. We chose the CM chondrites LaPaz Icefield (LAP) 04514, LAP 04527, and LAP 04565 because they are among the least altered CM chondrites available [9]. Their lack of alteration makes chondrule and clast identification easier since the compositions of chondrules and mineral fragments is more varied. To quantify the sizes of chondrules and clasts, we digitally identified the area of individual objects and used the result to quantify a circle-equivalent-diameter for each. Chondrule or grain rims were not included in the areas. We avoided measuring clasts and chondrules on all cut surfaces and or fusion-crusted areas within our sections. Figure 1 shows an example of an annotated CM chondrite using our methods.

Figure 1. Digitally annotated BSE image of the CM chondrite LAP 04514. Chondrules and clasts (n = 745 in total) have been digitally tagged (orange) for measurement on the right half of the thin section.

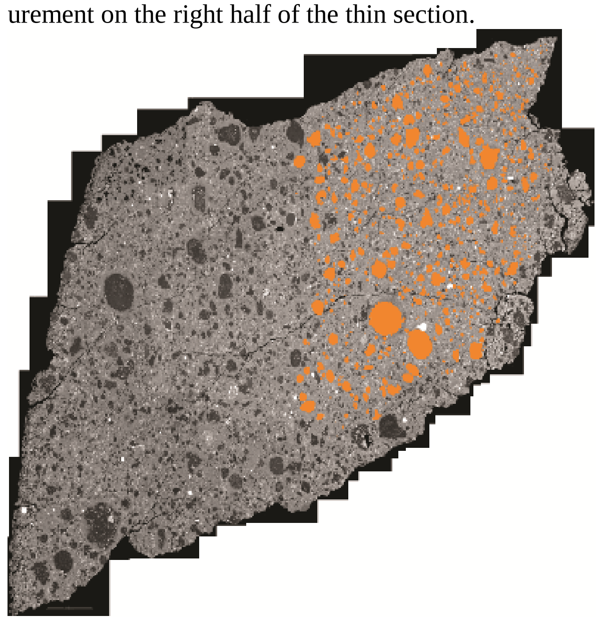

Table 1. Statistical descriptions of aggregate 2D clast and chondrule dimensions in three CM chondrites.

		distribution, $\bar{x} \pm 1\sigma$ (µm)	
chondrite	n	normal	log-normal
LAP 04514	745	76 ± 70	58^{+117}_{-29}
LAP 04527	1126	26 ± 23	20^{+40}_{-10}
LAP 04565	529	32 ± 29	24^{+49}_{-11}

Results: Our initial results are shown in Table 1. In the past, it has been assumed that chondrule or clast size frequency distributions follow either normal, log-normal, Weibull, or other statistical distributions [1]; however, the true statistical distribution function of chondrule size frequencies is unknown. Because of this, it can be informative to calculate descriptive statistics for our data assuming simple and familiar normal and log-normal distributions for comparison with previous results. Note that the data in Table 1 has not been corrected for 2D → 3D stereological effects [10]. Because we have included both clasts (mineral fragments) and chondrules in the initial analysis presented here, our diameters are lower than those reported by [2] (~150 µm, see above) or [3] (80 µm for phyllosilicate-rich and 270 µm for other chondrules). This is especially the case for LAP 04527 and LAP 04565, wehre we found a mean of ~25 µm in diameter. However, we note here that for LAP 04514, while our results (76 ± 70, Table 1 above) are lower, they are within errors of the results reported by King and King [2].

Discussion and Future Directions: Although all three of the chondrites in our study are undoubtedly CM chondrites [9], the size distributions of chondrules and clasts in sections of LAP 04527 and LAP 04565 seem to resemble each other more closely than either resemble LAP 04514. Friedrich et al. [9] proposed that LAP 04527 and LAP 04565 are paired and our data seem to support this hypothesis.

One of the challenges of this work is determining what constitutes a chondrule and what may better be described as a clast. This is especially difficult when chondrules in CM chondrites are sometimes "incompletely melted" or aggregate chondrules. We are investigating using grain composition and shape data to improve our judgment between associated (a single distinct chondrule) or unassociated (a clast in matrix) objects within our sections.

Our data offer future opportunities to examine the frequency and types of chondrules and clasts with respect to size and angularity. We can also begin to investigate the thicknesses of fine-grained rims around CM chondrites. Our dataset may also be used as in [11] to examine the idea of complementarity between chondrules, matrix, and other components in chondrites.

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