CRYSTAL SIZE DISTRIBUTIONS IN THE UNBRECCIATED EUCRITES: A PRELIMINARY STUDY.
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Introduction: The size of a crystal in a given crystalline rock is a function of both growth rate (G) and residence time (τ) [1]. Therefore, the study of crystal size distribution (CSD) can be used to understand the processes and conditions under which crystallization occurred, helping to establish the rock's thermal history [e.g. 1,2]. CSD theory states that, in a steady-state crystallizing system, continuous nucleation and growth will produce a log-linear relationship between population density (n) and crystal size (L) [1]:

$$n = n_0 \exp(-L/G\tau)$$

Therefore, for a linear CSD plot (Figure 1a) if either growth rate or residence time are known, the other can be calculated. However, CSDs are often not straight lines and, while linear regression analysis of the curves can provide a measure of the growth rate-residence time relationship, the shape of the CSD curve itself reflects different crystallization processes (Figure 1b). A convex-up curve (original CSD deflected up) can be a result of many different process, such as accumulation of crystals, non-steady state nucleation rate, destruction of fines, and magma mixing [1]. If the original linear CSD plot is defelcted downwards then fractionation or loss of larger crystals may have occurred [1].

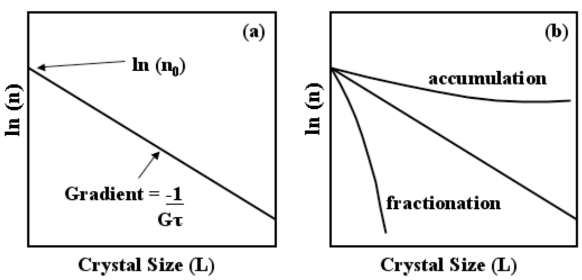

Figure 1: (a) Linear CSD plot . Where n = population density, n_0 = initial population density, G = growth rate, τ = residence time, L = crystal size in mm. (b) The effects of accumulation and fractionation processes on the linear CSD plot. Accumulation deflects the plot upwards, fractionation downwards. Adapted from [1].

CSD is commonly used to study the growth histories of both igneous and metamorphic terrestrial rocks [e.g. 3,4,5]. Its application to meteorites has, so far, been limited mostly to lunar and martain samples [e.g. 6,7,8]. Here we present results of CSD analysis on unbrecciated eucrites as part of a study into their petrology and texture [9].

Methodology: Thin-section photomicrographs were collected in both plane and cross polarized light for selected unbrecciated eucrites. The outlines of plagioclase and/or pyroxene crystals were traced digitally. Grain sizes (maximum lengths and widths) were calculated using 'ImageJ'. Grain-size data were processed with 'CSDslice' to determine the three-dimensional (3D) crystal habit from the collected two-dimensional data [10]. This information was then used in conjunction with grain-size to stereologically correct the data to true 3D CSDs using 'CSDcorrections' [2]. Both length and width data were collected but only length data are presented here. Residence times were calculated using estimated growth rates for silicate minerals in basaltic melts of 1-5 x 10^{-10} mms^{-1} [3].

Results: Here we present preliminary results on the CSDs of the unbrecciated eucrites, using the plagioclase data for three samples (MAC 02522, EET 92023, and Moore County). Calculated grain aspect ratios are given in Table 1, and resulting CSD plots in Figure 2.

	x	y	z
MAC 02522	1.00	5.00	9.00
EET 92023	1.00	1.15	1.50
Moore County	1.00	1.25	2.10

Table 1: Grain aspect ratios calculated using 'CSDslice' for plagioclase in each of the three unbrecciated eucrites.

All three unbrecciated eucrites have CSD plots with approximately linear slopes, with a decrease in ln (n) at smaller grain sizes. Linear regressions were performed and give residence times for eucrite plagioclase in the range of 1 x 10^2 to 1 x 10^3 years (Table 2).

Sample	Slope (-1/Gt)	τ in yrs (G=1 x 10^{-10})	τ in yrs (G=5 x 10^{-10})
MAC 02522	-2.97	107	21
EET 92023	-3.70	86	17
Moore County	-2.47	128	26

Table 2: Range of residence times calculated for MAC 02522 and Moore County from CSD plots. Growth rates (G) are given in mms^{-1} and were taken from[cashman and marsh 1998].

Discussion: Of the three unbrecciated eucrites discussed here, MAC 02522 is the only basaltic sample. It is relatively coarse-grained and has an ophitic texture. Moore County and EET 92023 are both cumulate eucrites with similar textures. However, EET 92023 contains metal grains with compositions not found in

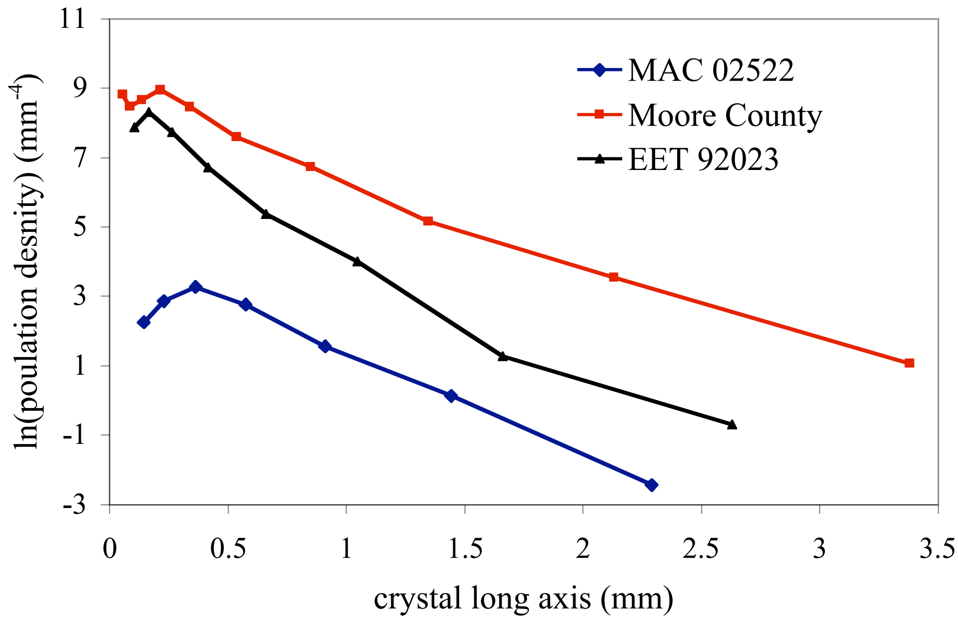

Figure 2: CSD plots for Moore County, MAC 02522, and EET 92023. Ibitira is also shown separately as it contains a much steeper slope than the other samples and is also finer-grained.

the rest of the eucrites [9,10,11] and has, therefore, been suggested as a gabbroic clast from a mesosiderite [11].

All three samples show a decrease in population density at smaller grain sizes. This can be attributed to annealing, where large crystals grow at the expense of smaller ones; however, it can also be a result of the increased difficulty in tracing the smallest size grains [1]. Both MAC 02522 and Moore County have linear CSD plots that yield similar residence times, but they differ in their initial nucleation density, which was lower for MAC 02522 (4.4 mm^{-4} vs 9.0 mm^{-4}). EET 92023 has an initial nucleation density value of 8.3 mm^{-4}, which is comparable to that of the other cumulate sample, Moore County (9.0 mm^{-4}). Its slightly steeper slope gives it more confined range of residence times than the other two samples (Table 2).

All three unbrecciated eucrites studied here show an approximately log-linear relationship between population density and crystal size, suggesting that they formed under conditions of steady state growth and nucleation. None appear to require more than one crystallization event to explain their growth histories. EET 92023 and Moore County are cumulate samples and their long residence times support slow-cooling, beneath the surface of Vesta. MAC 02522, however, is a basaltic sample with a residence time akin to that of the cumulates, although with a lower intial nucleation density. This suggests MAC 02522 was not erupted on the surface, but instead crystallized at depth within the crust.

Future Work: In total eleven unbrecciated eucrites have been chosen for CSD analysis. They span the range of textures, grain sizes, and proposed formation mechanisms fond within the group. Once all eleven samples have been analyzed we hope to be able to gain a deeper understanding into the crystallzation conditions that exist with the upper crust of Vesta.

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