GRAIN SIZE DISTRIBUTION IN THE MATRIX OF PRIMITIVE METEORITES.

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Introduction: The matrix of primitive carbonaceous chondrites is among the most pristine extra-terrestrial material available and is thought to be comprised largely of dust from the protoplanetary disk [1]. Due to the small size of its components (≤1 μm) it has been traditionally investigated using TEM, a technique requiring destructive and time consuming preparation of TEM sections from selected, but limited areas. We have tested the ability of a new generation of SEM-EDX detector to provide insight into matrix components from bulk specimens (e.g. polished thin sections and blocks). Here we describe the abundances and size distribution of discrete grains of different phases (silicate vs. opaque) observed within the matrix of four primitive meteorites: Acfer 094 (C2-ung.), ALHA77307 (CO3), MIL 07687 (C3-ung.) and QUE 99177 (CR2).

Methods: High-resolution images were acquired for regions of matrix (total area ~1000 μm^2 per sample), using the Zeiss Ultra Plus FEG-SEM at the NHM. Element maps of the same matrix regions were acquired at 5kV using the FEI Quanta 650 SEM with an innovative XFlash QUAD 5060F Bruker detector - an annular silicon drift EDX detector located beneath the pole piece giving high count rates from a high take-off angles with capability for low kV, high spatial resolution, mapping. Images and element maps were used to identify discrete grains whose surface areas were then estimated using Image J and converted to average radii assuming spherical grains. Grains <10nm in diameter were deemed too small to accurately identify and measure. These 2D parameters were then converted into 3D values using the regression equation of [2]. The geometric mean radii (M_r in nm) and standard deviations (+σ and –σ in nm) were calculated graphically from cumulative frequency distributions plotted as a function of ln(r) using methods outlined in [3] and [4]. This allowed a direct comparison between grain sizes for the discrete silicate ($M_{r\text{-}si}$) and opaque ($M_{r\text{-}op}$) grains (typically sulfides and/or metal) in the matrices of our four samples.

Results and Discussions: Our data suggest the four meteorites can be split into two groups based on differences in relative abundances and sizes of discrete grains in their matrix:

ALHA77307 and MIL 07687 have 8-9 times more silicate grains than opaque grains yet the M_r values of these phases are similar ($M_{r\text{-}si}$ = 130nm vs. $M_{r\text{-}op}$ = 115nm in ALHA77307, and $M_{r\text{-}si}$ = 164nm vs. $M_{r\text{-}op}$ = 182nm in MIL 07687).

Acfer 094 and QUE 99177 have more opaque grains than silicate grains (6 times more for Acfer 094 and 1.5 times for QUE 99177) with each phase exhibiting different values of M_r ($M_{r\text{-}si}$ = 136nm vs. $M_{r\text{-}op}$ = 29nm in Acfer 094, and $M_{r\text{-}si}$ = 78nm vs. $M_{r\text{-}op}$ = 23nm in QUE 99177). We will discuss how the observed differences in abundances and size distributions of these matrix components may be evidence of different parent body processes (e.g. aqueous alteration) and/or protoplanetary disk processes.

References: [1] Buseck P. R. 1993. *Annu. Rev. Earth Planet. Sci.* 21:255-305. [2] Friedman G. M. 1958. *The Journal of Geology*, 6:394-416. [3] Wozniakiewicz P. J. et al. 2012. *ApJ* 760:L23. [4] Wozniakiewicz P. J. et al. 2013. *ApJ*, 779:164-170.