THE ORIGIN OF Mn-RICH CHONDRULE RIMS IN CO3.0 CHONDRITES.

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Introduction: Chondrites are a classification of meteorites which contain once molten spherical inclusions called chondrules. Previous work using high-resolution synchrotron maps identified the presence of Mn-rich regions along the rims of chondrules in CO3.0 chondrites [1]. We studied four of these chondrites to better characterize these features and determine how they were formed, whether they are related to nebular or parent body processes.

Methods: We used synchrotron maps from Telus et al [1] to identify host chondrules with Mn-rich rims in four CO3.0 samples with varying petrologic type. We also analyzed chondrules without these rims for comparison. The samples analyzed were Dominion Range 08006 (CO 3.0), Allan Hills 77307 (CO 3.0), Dominion Range 10104 (CO 3.1), and Miller Range 090038 (CO 3.2). We characterized the chondrules using the Oxford Instruments UltimMax energy dispersive x-ray spectroscopy detector (EDS) on the scanning electron microscope (SEM) at University of California Santa Cruz (0.80 nA and 15 kV beam). We analyzed the composition of the chondrules using wavelength dispersive spectroscopy on the JEOL JXA-8230 electron microprobe (EPMA WDS) at Stanford University (20 nA and 20 kV beam).

Results: Most of the chondrules that have Mn-rich rims are FeO poor, type 1 chondrules. The chondrules with rims fall into two general categories. The first is FeO-poor porphyritic olivine and pyroxene chondrules with igneous rims (<10 μm wide) of Ca-rich pyroxene. The second observed category consists of porphyritic olivine chondrules and olivine fragments with enrichments of Mn along the chondrule rim, but no distinct igneous rim [2]. EPMA analysis of igneous Mn-rich rims shows that they are enriched in moderately volatile elements (i.e., Mn, Na, and K) compared to host chondrules and no-rim chondrules (Fig.1 right) [2]. The rims were determined to be igneous in origin based on the observed igneous textures, including glassy mesostasis, zoned olivines, and rounded metals existing in the rims (Fig.1, left). These same signatures were observed by Krot et al. 2004 and attributed to an igneous origin [3].

Discussion: The compositions of the rims do not vary with petrologic type of the host meteorite, indicating that the Mn-rich igneous rims from CO3 chondrites likely reflect nebular processing. The rims are significantly more enriched in the volatiles Mn and Na compared to host and unrimmed chondrules, which indicates that the rims formed in a region of the nebula enriched in these elements. The host and unrimmed chondrules themselves parallel each other in volatile element trends (Fig. 1, right), suggesting that they formed in similar regions or under similar conditions while the rims did not. The volatile enrichment of Mn-rich chondrule rims in CO3s is similar to results for silica-rich igneous chondrule rims in CR chondrites [3], suggesting partial melting of chondrules as the origin for these rims.

Figure 1 - (Left) An example of a chondrule characterized using EPMA analyses from sample MIL 090038 (CO 3.2). (Right) Averages taken from each component of measured chondrules normalized to CI values. Average values of host chondrules, corresponding rims, and no-rim chondrules are made of pyroxene from CO 3.0 samples (this study) compared to average host and rim values from CR 3.0 samples from Krot et al. 2004 [2].