MICRON-SCALE DISTRIBUTION OF MANGANESE IN ALLENDE AND IMPLICATIONS FOR CONSTRAINING CONDITIONS OF METAMORPHISM.

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Introduction: Many classes of carbonaceous chondrites have experienced significant secondary alteration on the parent body (see [1]). Attempts to constrain the timescales of these processes have often relied on short-lived chronometers; specifically, ^{53}Mn-^{53}Cr has been used to date alteration due to the incorporation of Mn into secondary phases, such as carbonate (e.g. [2]) and fayalite (e.g. [3]). *In situ* dating, however, is hampered by finding minerals with sufficient Mn and Cr to enable analysis. By analyzing these samples with a Synchrotron x-ray source, we were able to look at these minor element trends between Allende components from mm- to μm-scale. This dataset allows for targeting areas of interest based on ppm concentrations over 2- μm areas.

Methods: Analysis of a standard thin section of Allende was undertaken on the X-ray Fluorescence Microscopy beamline at the Australian Synchrotron, Victoria, Australia [4].

Subsequent mapping was undertaken at CSIRO using a Zeiss Ultra FEG-SEM with coupled Bruker X-Flash EDS detector using a 20KeV 2nA beam.

Results: The Synchrotron data showed that the highest concentration of Mn over the thin section was around a single chondrule. Several smaller chondrules hinted at Mn enrichment, and several areas of matrix also showed elevated concentrations. Chromium enrichment was found in many chondrule rims, as well as in sulfide throughout the meteorite. We directed our study to the chondrule rim.

The chondrule is predominantly olivine with varying fayalite (fa) content; the edge composition matched that of matrix olivine (Fa_{40-45}). Adjacent is a rim (thickness 10-15 μm) of fine-grained Fe-Ni sulfide (in addition to Fa-rich olivine). Outside this lies a layer of Ca-rich pyroxene (grain size~10 μm) with ~2 weight % Mn and Cr. Both Mn and Cr are also observed in the sulfide layer. No alkali enrichment is observed in the chondrule or rim and is instead found entirely within matrix.

Implications: There are two different explanations for the unique rim around this chondrule: 1. rims formed under a variety of different conditions in the Solar Nebula; 2. the composition of rims is determined during metamorphism by the initial composition of the chondrule. Given evidence for hydrothermal metamorphism in Allende [5] and the observation that rim chemistry is more homogeneous and closer to matrix composition than enclosing chondrules [6], we favor the later. In which case, this technique may be quick way of identifying targets ideal for further work in constraining metamorphic timescales.

References: [1] Brearley A. J. and Jones R. H. 1998. *Reviews in Mineralogy* 36:3-1-3-398. [2] de Leuw S. et al. 2009. *GCA.* 73:7533-7442. [3] Hutcheon I.D. et al. 1998. *Science* 282:1865-1967. [4] Ryan, C.G., et al., *AIP Conference Proc.* 1221 (2010) 9-17 [5] Krot A.N. et al. 1998. *Meteoritics & Planetary Science* 33:1065-1085. [6] Rubin A.E. and Wasson J.T. 1987. *GCA.* 51:1923-1937.