TRACE ELEMENT ZONING IN CM CHONDRITE CARBONATES: INSIGHTS FROM COMPOSITIONAL MAPPING USING NANOIMS
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Introduction: Carbonates have been widely recognized in CM carbonaceous chondrites and have the potential to constrain conditions and processes of aqueous alteration in this complex group of meteorites. SEM and CL studies show that carbonate grains in CM chondrites exhibit complex zoning that is a function of minor or trace element contents [1]. However, the distribution of minor and trace elements in these grains is not well understood. To address this problem, we have used the Cameca NanoSIMS at LLNL to study the distribution of a suite of trace elements (Mg, Mn, Fe, Cu, Ba, Sr, Pb, Cr) in calcite grains in the Y791198 CM chondrite. We are particularly interested in the distribution of Mn in calcites for studies of the Mn-Cr systematics of CM carbonates to extend our previous work [1,2].

Results: These studies have been highly successful at revealing complex trace element zoning in calcites that generally correlates well with the zoning observed by CL investigations. A common feature of many of the carbonate grains is the presence of distinct, localized regions within the grains that are enriched in Mn. These regions vary in size and shape, but are typically less than 5 μm in size and generally correlate reasonable well with regions of high CL. Without exception in the grains studied so far, the enrichments in Mn are never at the center of the grains, but are usually present in zones close to the grain edges. In several grains, Sr/Ca ratios are spatially anticorrelated with Mn/Ca ratios and many grains show an increase in the Sr/Ca ratio at their rims. In addition, in some grains we have observed distinct hot spots with extremely high Sr/Ca or Ba/Ca ratios, whose origin is currently obscure.

Discussion: The NanoSIMS trace element maps confirm that there is remarkable diversity in zoning behavior from one calcite grain to another. Although some grains appear to share common zoning characteristics (e.g. increased Sr at grain edges), many do not. We suggest that the diversity in zoning is a reflection of variations in the trace element chemistry of the fluid as a function of both space and time. We have recently suggested that some of the textural characteristics of CM chondrites, particularly the spatial distribution of carbonates and phosphates, could be explained by the presence of localized variations in fluid chemistry (i.e. microchemical environments)[3]. These variations in fluid chemistry are controlled by alteration reactions on a highly localized scale (10s of microns). The zoning in the carbonates appears to be compatible with such a scenario. In this model, specific trace elements are enriched in the fluid depending on what primary minerals are being altered locally at a particular time. Changes in fluid chemistry will occur as particular phases are consumed or trace elements are fractionated into new alteration phases.