

ORIGINS OF REFRACTORY INCLUSIONS IN CM AND CV CHONDRITES: CONTINUITY OR DICHOTOMY? K. D. McKeegan and M.-C. Liu, Department of Earth, Planetary, and Space Sciences, UCLA, Los Angeles, CA. (mckeegan@epss.ucla.edu)

Introduction: The early recognition of the large, white inclusions of the Allende CV meteorite as compositionally similar to the first mineral phases expected to condense from a cooling solar nebula [1] and the subsequent discovery that they are enriched in ^{16}O relative to terrestrial materials along a non-mass dependent trajectory [2], opened Pandora's box. Intensive study by an evolving suite of mass spectrometric techniques has revealed anomalies in both stable and short-lived radioactive isotopes that clearly demonstrate that the inner solar nebula was, in fact, not fully homogenized by passage of all incoming presolar materials through processes of evaporation, mixing, and recondensation (neglecting possible subsequent melting and alteration in asteroids). Some individual (micron-sized) grains somehow escaped thermal processing and mixing, and these are clearly recognized as original stellar condensates by virtue of their extreme isotopic compositions [3]. The isotopic anomaly signatures, reflecting distinct admixtures of nucleosynthetic components, also persist at spatial scales of individual CAIs (sub-mm to cm) up to planetesimal (10's of km), with generally decreasing magnitude. By virtue of their very heterogeneous distributions among different classes of primitive meteorites [4], and their isotopic differences from chondrules and other chondritic components, CAIs are generally thought to be xenoliths, perhaps formed near the Sun and then later introduced into the accretion regions of chondrites [5]. Among issues that are not clear is the relationship(s) between these small scale anomalies and large, nebula-scale, distributions of isotopic signatures, some of which (e.g., Mo, Ti) have been interpreted as reflecting a fundamental dichotomy in accretion regions and/or timing in the nebula [6].

Seven months after the fall of Allende, an even more exotic gift arrived above the skies of south-eastern Australia in the form of the Murchison CM chondrite. CM chondrites contain refractory inclusions that, while distinctive in petrology, mineral chemistry, and some isotopic compositions from CV CAIs, are likewise generally thought to have formed in the solar nebula [6]. These inclusions are also presumably xenoliths that, for unknown reasons, are very rare in other classes of chondrites, including in particular, the CV chondrites. Fifty years of study of the Murchison and Allende meteorites presents an opportunity to reconsider the relationships of the refractory phases present as xenoliths in different class of chondrites in light of new perspectives gained regarding the nature and distributions of isotopically anomalous material in the solar nebula, including oxygen isotopes, short-lived radioactivity, and distinctive nucleosynthetic components.

CM hibonite grains: The remarkable isotopic anomalies in major elements (e.g., Ca, Ti) of CM hibonite grains are only exceeded by (some) anomalies in stellar condensate grains. Importantly, nucleosynthetic anomalies are highly distinctive compared to those exhibited by CAIs in CV chondrites in at least two ways: they can be larger by more than a factor of 100 and they can be both "positive" and "negative", i.e., exhibiting either excesses or deficits of the most neutron rich isotopes relative to chondritic and planetary values [7]. Ireland [8] identified a petrologic class of such inclusions consisting of single platy hibonite crystals ("PLACS") that exhibit the largest ^{48}Ca and ^{50}Ti anomalies but generally lack ^{26}Al . PLACS have been shown to contain ^{10}Be and non-radiogenic Mg isotope anomalies [9], ^{244}Pu , and a wide variety of trace element patterns. They have solar-like oxygen isotopes but their heavy stable isotope compositions (e.g., Mo) and formation ages are presently unknown. This contribution will explore the relationships between these different refractory components of two of the most important meteorites in our collections.

References: [1] Grossman, L. et al. *Geophys. Res. Lett.*, 2, 37, 1975; [2] Clayton et al., *Science* 182, 485, 1973; [3] Zinner, E., et al. *Nature*, 330, 730, 1987; [4] MacPherson, G. J., *Treatise on Geochemistry*, 2nd edition, 139, 2014; [5] McKeegan et al., *Science* 281, 414, 1998. [6] Burkhardt, C., et al. *Earth Planet. Sci. Lett.*, 391, 201, 2014; [7] Fahey et al. *Ap. J.* 323, L91, 1987; [8] Ireland, T. R. *Geochimica et Cosmochimica Acta*, 52, 2827, 1988. [9] Liu et al. *Geochimica et Cosmochimica Acta*, 73, 5051-5079, 2009.