

RECYCLING IN THE EARLY SOLAR SYSTEM; EVIDENCE FROM OXYGEN AND MAGNESIUM ISOTOPES AND TRACE ELEMENT ABUNDANCES IN CAI AND CHONDRULES. R. D. Ash¹,

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Introduction: The relationships, if any, between chondrules, calcium-aluminum-rich inclusions (CAI) and matrix is complex. The chronometric information relating to formation times is in a state of flux, with measurements made to extraordinarily high precision, but with some debate as to their accuracy. Hence the chronological relationship between CAI and chondrule formation is much tested but remains muddled [1-5].

Calcium Aluminium-rich Inclusions (CAI) are usually considered the oldest solid materials formed in the solar system, with high resolution (20,000 – 50,000 years) Pb-Pb and Al-Mg measurements demonstrating a time difference between CAI and chondrule formation of 1-3Myr. However recent measurements have suggested that these apparent time differences may be a result of nucleosynthetic and chemical effects causing variations in initial isotopic abundances.

Major, minor and trace elements in CAI are diagnostic of their high temperature formation and can be used as a characteristic tracer of their origins and fate. Similarly oxygen and magnesium stable isotopes in CAI are not endogenous in other chondritic components, hence may be used as tracers in conjunction with elemental abundances to track CAI.

Methods: We have taken a suite of chondrules from carbonaceous, ordinary and enstatite chondrites carried out petrographic and mineralogical characterization and determined their trace element abundances, in particular their rare earth element patterns and Nb/Ta which are characteristic of particular types of CAI. In some cases we have measured Mg isotope abundances as well as oxygen isotopes.

Results: Results show that the Allende chondrules show a far greater range of trace element behavior than either the ordinary or the enstatite chondrite chondrules. Half (8) of the chondrules exhibit non-chondritic REE patterns and these samples also show Nb/Ta lower than the chondritic value of 19.9 [6], reaching as low as 3.8 for the most Nb depleted chondrule (CAI ratios may reach unity). The REE patterns are strongly reminiscent of CAI REE patterns see figure 1.[7]. Where we have oxygen isotopic compositions for these chondrules they exhibit non-mass dependent characteristics, lying along the Allende CCAM line. Furthermore where determined these chondrules also show evidence for fractionated MG isotopes and an excess of ²⁶Mg [8]. None of the OC chondrules exhibit fractionated REE abundances or any variation from the chondritic value for Nb/Ta. There is some

variation in the EC chondrules, but none that are reminiscent of CAIs, but may be the result of chalcophile behavior and fractionation.

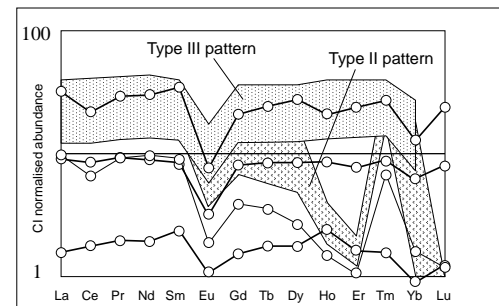


Figure 1. CI normalised REE abundances in fractionated Allende chondrules (circles) and CAIs [7]

At present we have neither oxygen nor magnesium isotopic data for the ordinary or enstatite chondrite chondrules.

Discussion: The presence of a significant population of chondrules in Allende that exhibit correlated CAI-like chemical and isotopic behavior indicates that there is recycling of CAI material in the chondrule forming region sampled by the CV chondrite parent body that was available in neither the enstatite nor the ordinary chondrite sampling regions.

This implies that the CAI are exogenous to the chondrule forming region and were incorporated primarily into the meteorites where they are observed today, and many have been mixed with local material and processed into chondrules.

There are potential implications for Al-Mg ages if there is mixing of other Al reservoirs, followed by remelting, in the chondrule forming region.

References:

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