TRACE ELEMENT DIVERSITY OF CHONDRULE MESOSTASIS IN CV AND CR CHONDRITES

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Introduction: The origin of the earliest solids in the solar system, preserved for 4.56 billion years in primitive meteorites, is poorly understood, in part because of the lack of detailed chemical data on individual phases within representative populations of these solids. We have measured trace element abundances in modally dominant mineral phases across the chondrule component population of carbonaceous Renazzo-group (CR) and Vigarano-group (CV) chondrites using laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). Here we present 153 trace element analyses of chondrule mesostasis across 7 meteorites from the CV (Allende, Vigarano, Axtell, Leoville) and CR (Renazzo, Gao-Guenie (b), Acfer 139) groups.

Trace elements, the rare earth elements (REEs) in particular, are utilized because of their ability to reveal precursor characteristics, formation conditions, and processing histories of chondrite constituents. They are particularly useful in assessing the origin of chondrules and chondrites because the REE patterns can survive the secondary processing (aqueous alteration, metamorphism, shock) that these rocks endure [1]. In determining the large-scale distribution of trace elements across two important carbonaceous chondrite groups, we have produced a statistically significant trace element dataset to complement existing major element and isotopic datasets [2-10]. This dataset may provide evidence for either a single or multiple reservoir origin for these chondrites, and result in key constraints on dynamical accretion mechanisms in astrophysical models of the early solar system.

Methods: Polished thick sections of the seven meteorites were prepared for X-ray element intensity mapping in order to locate targets for LA-ICPMS analysis. Multiple polished thick sections of Axtell (2), Vigarano (2), and Allende (3) were prepared to account for heterogeneity within the meteorites. Analyses were performed using the LA-ICPMS at Rutgers University. We measured 153 REE patterns across 7 chondrites and 70 individual chondrules (36 CV chondrules, 34 CR chondrules). We report REE abundance and pattern type for each.

Results: The CV chondrites have a demonstrably larger spread of REE abundance in chondrule mesostasis than the CR chondrites. Less than 10% of the CV analyses plot above 30x CI, and no CR analyses plot above 30x CI. There is no apparent correlation between REE abundance or pattern and chondrule petrologic type. The averages of the LA-ICPMS measurements for each group (Fig 1b) plot near 10x CI, with the mean CV chondrule mesostasis being slightly higher than that for the CRs, mimicking the bulk REE signatures of both groups, though at a higher enrichment. We observe a variety of individual REE patterns across all 70 chondrules (Figure 1a), but the average of those measurements (Fig 1b) shows a fairly 'flat' REE pattern for chondrule mesostasis, consistent with the bulk patterns. However, some chondrule mesostases exhibit markedly 'non-flat' REE patterns, such as group II patterns (triangles, Fig 1b). This pattern is widely thought to be a relic of fractionation during condensation of the first solar system solids, inherited from chondrule precursors [11].

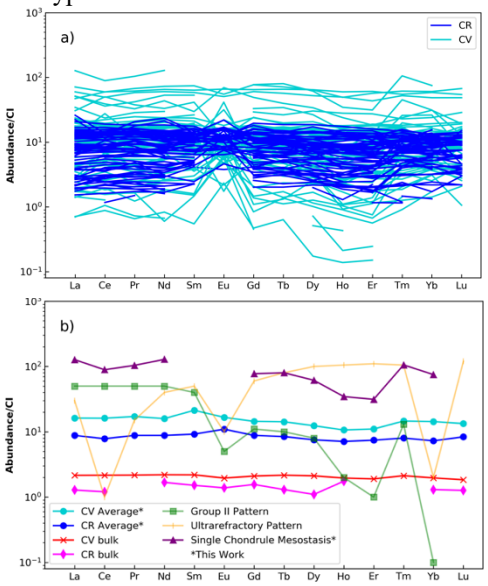

Figure 1. a) REE abundance pattern for 153 chondrule mesostasis analyses. b) REE abundance pattern for chondrule mesostasis (triangles) in a single Allende chondrule. This phase exhibits a subtle Group II REE pattern. Observed ultrarefractory (vertical ticks) and Group II (squares) patterns in CAIs are shown for comparison [4]. Bulk CV (x's) and CR (diamonds) REE abundances (flat within 10% of 2xCI) are also shown [7,12].

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