ON THE SEARCH FOR CHONDRULE PRECURSORS IN CV CHONDRITES.

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Introduction: In recent years it has become apparent that migration of sub-mm sized-particles occurred in the very early Solar System (e.g., [1–5]). The extent and direction(s) of grain migration throughout the protoplanetary disk is not yet known. Since the different chondrite groups have distinct chemical and isotopic characteristics (e.g., [6]) and are believed to have formed at different heliocentric distances and at slightly different times [7], they have the potential to record grain migration in the disk. In fact, some minimally altered chondrites have recently been shown to contain evidence for grain migration (e.g., [2–5]).

Partially melted chondrules retain unmelted precursor silicates, termed *relict* grains; the chemical and O-isotope compositions of which can be used to determine their origins. Relict grains may show similarities to material from other chondrite groups and thus imply potential grain migration in the protoplanetary disk (e.g., [3]). As part of our ongoing efforts to understand grain migration (e.g., [2–4]), we have undertaken a search for chondrule precursors in various different chondrite groups. We previously reported analyses of relict grains in unequilibrated ordinary chondrites (UOCs), and carbonaceous Renazzo-like (CR), Mighei-like (CM), and Ornans-like (CO) chondrites [2–4,8]. Here we present preliminary data for the carbonaceous Vigarano-like (CV) chondrites, which are believed to have formed in the outer Solar System, beyond the orbit of Jupiter, and slightly earlier then the other carbonaceous chondrites groups ([7] and references therein).

Sample selection: Since relict grains only remain in the least altered chondrites and CV3s are generally of higher petrographic type (i.e., more heated) than the CR, CM, and some CO chondrites, particular care will be taken to select CV3s of low petrographic types. To begin with, we studied polished sections of the type samples for each of the three CV subgroups; the oxidized CV_{OxA} Allende (ASU 818_132_L1a) and CV_{OxB} Bali (USNM 4839-1), and the reduced CV_{Red} Vigarano (ASU 590_C1) to provide benchmarks for comparison. We also studied two additional $CV3_{Red}$, Leoville (ASU 821) and NWA 12772 (ASU 2019). While Allende is known to be heated [9], we have analyzed it to compare with other CV_{OxA} chondrites and to test of limits of relict grain survival. Since the different CV subgroups experienced varied degrees and types of secondary processing, it is possible that relict grain abundances may differ.

Analytical techniques: Backscattered electron (BSE) images and X-ray element maps, which were used to identify mineral phases for quantitative analysis, were obtained on polished sections using the JEOL JXA-8530F Hyperprobe field emission electron probe microanalyzer (EPMA) at Arizona State University (ASU) (operating conditions: 20 kV and 15 nA). Quantitative compositional analyses of silicate phases were subsequently performed on the Cameca SX-100 EPMA at the University of Arizona using similar conditions to those reported in [10].

Results and discussion: We identified relict grains in all CV chondrites studied here, including FeO-poor relict grains in FeO-rich (type II) chondrules, and relict dusty-olivine grains in FeO-poor (type I) chondrules. Using Fe-Mn systematics, following the method described in [4], we also identified FeO-poor relict grains in FeO-poor chondrules and FeO-rich relict grains in FeO-rich chondrules, which would otherwise be difficult to identify (they are not apparent in BSE images). In the least altered chondrites (i.e., those with minimal or no detectable heating; types $\leq$3.2), linear regressions of Fe and Mn abundances in chondrule olivine that crystallized from a single melt have coefficient of determination (R^2) values of near 1 [4,11]. Deviations from an R^2 of 1 can identify relict grains in both FeO-poor and FeO-rich chondrules, by iteratively removing different grains or analyses within grains to yield an R^2 value of ~1.

We found that all chondrules in Allende have R^2 values below 0.9. Since Allende is a >3.6 petrologic type [9], this poorer correlation is likely due to Fe- and Mg-diffusion during heating. However, diffusion did not mask relict grains.

Summary: We identified relict grains in chondrules from all CV subgroups, even in high petrologic type 3s (i.e., Allende), and plan to survey more CV chondrites to identify low petrologic type 3s. We will undertake O-isotope analyses of relict-grain bearing chondrules from all CVs studied to investigate the origin(s) of these relict grains.

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