**PRESOLAR SILICATES AS TRACERS OF THE FORMATION OF FINE-GRAINED CHONDRULE RIMS IN CO3 CHONDRITES.** P. Haenecour[1,2,3], C. Floss[1,3,4], B. L. Jolliff [2,3], T. J. Zega[5], M. Bose[6] and P. Carpenter[2,3]. [1]Laboratory for Space Sciences, [2]Department of Earth and Planetary Sciences, [3]The McDonnell Center for the Space Sciences, [4]Physics Department, Washington University, St. Louis, MO 63130, USA. [5]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA. [6]Dept. of Chemistry and Biochemistry, Arizona State University, Tempe, AZ 85287-1604, USA. (haenecour@wustl.edu)

**Introduction:** Fine-grained material in carbonaceous chondrites occurs either as interchondrule matrix or as rims around chondrules/CAIs. Circumstellar grains have been identified in relatively high abundance in the matrices of CO3.0 chondrites [1, 2]. Recently, presolar grains have also been identified in fine-grained chondrule rims (FGCRs) [3-6]. While the presence of presolar grains in FGCRs excludes a formation of the rims from adjacent chondrule material (e.g., disaggregation or re-condensation), it is still unclear whether these rims formed by nebular [7] or parent body processes [8].

Here we report the first self-consistent data set of presolar grain abundances for individual FGCRs in three CO3.0 chondrites and use these data to discuss possible models of chondrule rim formation. Most studies of the formation of FGCRs are mainly based on meteorites which have experienced some heating and/or aqueous alteration [7, 8]. However, the meteorites in our study have only experienced minimal secondary processing and thus provide more direct information on the earliest processes responsible for the formation of FGCRs.

**Experimental methods:** FGCRs were identified by optical microscopy in thin sections of the CO3.0 chondrites LAP 031117, ALHA77307 and DOM 08006. We carried out oxygen and carbon NanoSIMS raster ion imaging using a focused $Cs^+$ primary beam of ~1 pA (~100 nm in diameter) that was rastered over fine-grained areas of 10×10 $\mu m^2$ ($256^2$ pixels). We also acquired X-ray elemental maps and determined the major-element concentrations in several matrix areas and FGCRs using a JEOL JXA-8200 electron microprobe. We also carried out FIB/TEM measurements as described in [9]. Presolar grain abundances are determined from the areas of the isotopically anomalous grains and the total area analyzed. Presolar oxides are present only in low abundance (≈ 10-20 ppm) in CO3 chondrites and the abundance of O-anomalous grains is, thus, dominated by presolar silicates [1–3].

**Presolar grain abundances:** We mapped a total area of 53,350 $\mu m^2$ (matrix = 30,650 $\mu m^2$; FGCRs = 23,700 $\mu m^2$) in LAP 031117. Based on the 112 O-anomalous grains identified, we calculate an O-anomalous grain abundance of 204 ± 24 ppm in the matrix and 88 ± 22 ppm and 120 ± 26 ppm, respectively in FGCR 1 and 2 (Fig. 1). The presolar SiC abundances are the same, within errors, in the matrix and two FGCRs, with an average of ~60 ppm.

We measured a total of 10,800 $\mu m^2$ in chondrule rim 1 (FGCR 1) of ALHA77307 and identified five O-anomalous grains, as well as two SiC grains. We calculated an O-anomalous presolar grain abundance of 54 ± 24 ppm for this FGCR. Bose et al. [2] reported a relatively high presolar silicate abundance in ALHA77307 (119 ± 14 ppm). They measured a total area of 27,300 $\mu m^2$, including 6100 $\mu m^2$ in a chondrule rim (FGCR 2), but did not differentiate between matrix and FGCRs. Based on their data, we re-estimated O-anomalous grain abundances of 192 ± 22 ppm in the

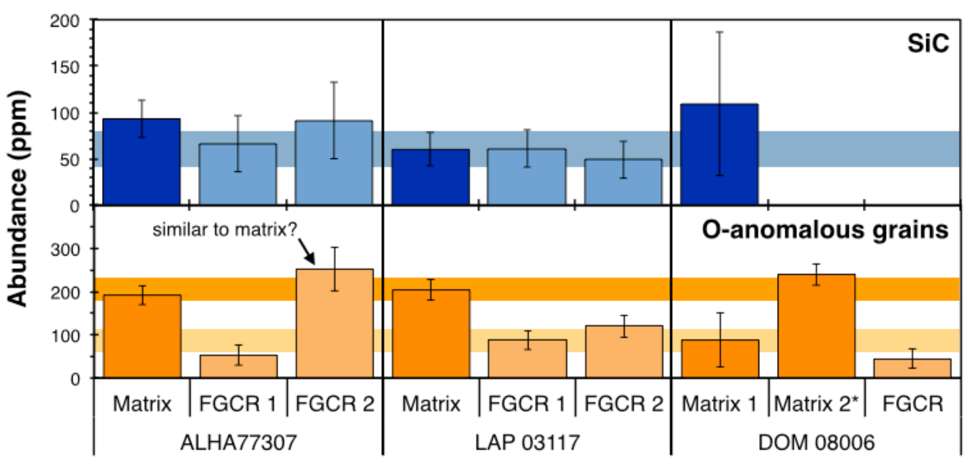


**Fig. 1:** Comparison of the presolar grain abundances in the matrix and fine-grained chondrule rims (FGCRs) in the CO3.0 chondrites ALHA77307, LAP 031117 and DOM 08006. *Data from [10].

matrix, and 253 ± 51 ppm in FGCR 2. The abundances of presolar SiC grains in the matrix and FGCRs are the same (Fig. 1).

Recently, Nittler et al. [10] reported a high presolar silicate abundance (240 ± 25 ppm) in the newly discovered CO3.0 chondrite, DOM 08006. To date, we have measured a total area of only 5,500 $\mu m^2$ (matrix = 1,100 $\mu m^2$; FGCR = 4,100 $\mu m^2$) and identified six O-anomalous grains in this meteorite. Our initial abundance estimates are 88 ± 62 ppm and 45 ± 25 ppm, respectively for the matrix and a FGCR. We also identified three SiC grains in the matrix, corresponding to an abundance of 109 ± 77 ppm.

**Identification of a chondrule within a larger chondrule rim:** The identification of microchondrules in some FGCRs has suggested that the formation of chondrules and rims were contemporaneous events [11]. In ALHA77307, we identified a small chondrule surrounded by its own distinct rim (~40 µm) within a larger chondrule rim (FGCR 2; ~200 µm). This observation is consistent with formation of FGCRs by dust accretion around freely-floating chondrules in the solar nebula. If FGCRs formed as a result of impacts on the parent-body asteroids, as suggested by [8], the rim around the smaller chondrule would not be distinguishable from the rim material that accreted around the larger chondrule. Moreover, the FGCR around the smaller chondrule clearly accreted first and was incorporated into the larger FGCR, which formed later.

**Uniform initial distribution of presolar grains in CO3.0 chondrites:** As shown in Fig. 1, the abundances of O-anomalous presolar grains in the matrices of the three meteorites are the same, within errors, and the abundances of presolar SiC grains are the same in both the matrix and FGCRs in these meteorites. These two observations are consistent with an origin of matrix and FGCR materials in CO3.0 chondrites from nebular reservoirs with similar presolar grain abundances. This interpretation is also supported by the fact that the EPMA and TEM data indicate that the matrix and FGCRs in LAP 031117 and ALHA77307 have similar chemical and mineralogical compositions.

**Implications for the formation of rims around chondrules in CO3.0 chondrites:** Based on the presolar grain abundances in LAP 031117, we previously suggested [5] that the lower abundance of presolar silicates in the FGCRs than in the matrix reflects the destruction or re-equilibration of the oxygen isotopic compositions of some presolar silicates due to heating. We proposed that this heating was either the result of dust accretion onto relatively hot chondrules [7], or due to low-intensity impacts (< 5 GPa) on the meteorite parent body [12]. Our new data for ALHA77307 and DOM08006 also show lower abundances of O-anomalous presolar grains in FGCRs than in the matrix (Fig. 1) and, thus, are also consistent with this conclusion. Unlike all the other FGCRs, the abundance of O-anomalous grains in FGCR 2 of ALHA77307 is the same as that in the matrix (Fig. 1). This observation is consistent with a formation of FGCR 2 later, when the chondrule was already cold.

Electron microprobe analyses of the matrix material and FGCRs in LAP 031117 and ALHA77307 give similar, low totals (by ~11%), due to unmeasured components such as water or carbon, and porosity present in the areas analyzed. The bulk of this missing 11 % likely reflects the porosity of these materials, given that CO3.0 chondrites are characterized by low water and carbon contents and have an average porosity of 10.8% [13]. The fact that the matrix and FGCRs in the CO3 chondrites we studied have similar porosities suggests that they experienced similar compaction histories on the parent-body asteroids. This raises questions about our previous suggestion that low intensity impacts on the meteorite parent body are responsible for the destruction of presolar silicates in FGCRs, as those impacts induce pressure/temperature excursions around the chondrules which might be expected to result in a lower porosity for the FGCRs than for matrix; however no difference is observed in our samples.

Models for chondrule formation in the solar nebula include shock wave or bipolar jet flow models [14, 15]. In the shock wave model, dust accretion is associated with the post-shock event, immediately after the shock front [14]. In the bipolar jet flow model, newly-formed chondrules are directly transported to the outer regions of the solar nebula where they impact at hypervelocity speeds with nebular dust [15]. Isotopic re-equilibration of some presolar grains in FGCRs by dust accretion onto relatively hot chondrules (900 – 1100 °C) [14-16] in the solar nebula is consistent with both models.

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