FORMATION OF CHONDRULE FINE-GRAINED RIMS FROM LOCAL NEBULAR RESERVOIRS.

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Introduction: Chondrules are frequently armored by fine-grained rims (FGRs), which are distinguished from the surrounding matrix (or "intercomponent matrix", ICM) by their texture, mineralogy, and/or presolar grain abundance [1,2,3]. Although numerous studies have focused on FGRs, their origin remains poorly constrained and no consensus has yet arisen. One hypothesis is that FGRs formed early in a nebular environment through the accretion of dust around free-floating chondrules [4,5]. Alternatively, FGRs may have formed during parent body evolution through compaction or secondary processes such as fluid and/or thermal alteration [6,7]. Deciphering the origin of FGRs thus requires that they be studied in detail, in particular within the least aqueously and thermally altered CO carbonaceous chondrites [8]. Here we report a systematic survey of FGRs in CO, CM, CV, and CR chondrites. We compared (i) the estimated sizes of FGRs to those of their host chondrules and (ii) the frequency of FGRs to the modal abundance of FGR+ICM in the respective host chondrite group.

Samples and methods: We studied four polished sections of CO3 chondrites collected in the dense collection areas of El Médano (EM 397, EM 463, and EM 216) and Los Vientos (LoV 123), provided by the Museo del Meteorito (Chile). We also surveyed sections of CM (Paris, section 4029sp1), CV (Vigarano, section Vigarano-P), and CR carbonaceous chondrites (Dar al Gani [DaG] 574, section 3681sp2; Renazzo, section719sp3) provided by the Muséum national d'Histoire naturelle of Paris. The petrography and mineralogy of chondrules and FGRs were determined by optical microscopy, backscattered electron (BSE) imaging, and X-ray compositional mapping. The modal abundances of coarse- and fine-grained components were determined by manual point counting using JMicrovision software (3000 random points) and the perimeter of all rimmed chondrules was traced by eye using the open-source software ImageJ.

Results and discussion: The estimated percentages of FGR-bearing chondrules in CO, CR, CV, and CM chondrites are positively correlated with the modal abundances of fine-grained materials in those chondrites. To explain this correlation solely through parent body processes would require that either (i) FGRs were derived from the ICM by compaction [e.g., 7] or (ii) the ICM was derived from FGRs by attrition [e.g., 9]. However, our petrography description of broken chondrules having rims interrupted where they were fragmented, provides strong evidence for FGR formation prior to accretion. Furthermore, FGR thickness is positively correlated with the host chondrule size. This correlation between FGR thickness and chondrule size has also been interpreted as evidence of FGR formation within the protoplanetary disk [4,5]. This scenario is supported by the observed correlation between the abundance of FGR-bearing chondrules and matrix, provided that ICM modal abundance is representative of dust abundances in the chondrite-formation regions. Since large-scale migration within the disk would have destroyed any correlation between the frequency of occurrence of FGRs and ICM abundance, chondrules and matrix incorporated in a given chondrite must have formed locally [e.g., 10].

Conclusion: Our data suggest that FGRs did not form during parent body evolution, but rather result from nebular processes, with the frequency and thickness of FGR being directly related to the abundance of available dust in their respective chondrule formation regions. Since large-scale migration within the disk would have destroyed the correlation between FGR and matrix abundances, our data support models of local chondrule formation with limited, if any, transport in the circumsolar disk.

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