FINE-GRAINED RIMS IN WATONGA (LL3.1 CHONDRITE): RECORDS OF PREACCRETIONARY PROCESSES.

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Introduction: The fine-grained chondrule rims (FGRs) in the least equilibrated ordinary chondrites (UOCs, e.g. LL3.0-3.1) record processes that predate final parent body assemblage and may have formed in the nebula or through asteroidal processes within an earlier generations of ephemeral planetesimals [e.g. 1-5]. Contending hypotheses, however, would have FGRs as products of aqueous alteration of matrix in the parent body [6,7]. Watonga (LL3.1) is a primitive UOC with numerous rimmed chondrules as well as other unusual features. We describe the petrology of Watonga (AMNH-1, -3) with special attention given to the FGRs (using SEM, Field Emission-SEM, and electron probe). Comparisons are then made with other minimally metamorphosed UOCs.

Results: Watonga is a highly primitive UOC containing both type I (magnesian) and type II (ferroan) chondrules, chondrule fragments, metallic (opaque) nodules, and, unusual for UOCs, amoeboid-olivine aggregates (AOAs) up to 500 µm in size. Watonga FGRs are recognizable in BSE images as bright gray features and in X-ray element maps as Fe-rich, Mg-poor material enveloping chondrules. They have sharp contacts with adjacent chondrules and matrix. FGRs in Watonga reach up to 90 µm (avg. 37 µm) in thickness. In comparison, FGRs from other UOCs, including Semarkona (LL3.0), NWA 5717 (Ung. 3.05), and Bishunpur (LL3.15), average 32, 36, and 28 µm, respectively. The FGRs are dominantly FeO-rich silicates with varying amounts of metal and sulfide grains, though one of their most compelling features are microchondrules. Microchondrules, a ubiquitous feature within the FGRs, are microspherules that range from 40 µm down to submicron sizes [3,8]. FGRs are abundant in Watonga (70 % all chondrules have rims). Many of the rimmed chondrules have irregular surfaces consisting of depressions, divots, and embayments filled with rim material. The abundance of chondrules with rims is similar to that in NWA 5717 (70 % all chondrules) and Semarkona FGRs (79 % of all chondrules), though Bishunpur has fewer (59 %) rimmed chondrules. Most FGRs are continuous, completely surrounding the host chondrule. Chondrule fragments also host FGRs, which can be continuous, covering the entire broken surfaces. However, some partially rimmed fragments have broken chondrule surfaces that lack FGRs, suggesting rim accretion prior to the fragmentation of the host chondrule and prior to final accretion of the meteorite. Additionally, an AOA in Watonga contains a partial FGR that fills divots and embayed surfaces around the object.

Watonga FGRs are most similar to those in NWA 5717. While small pockets of hydrated material, such as saponite, occur in submicron spaces of some FGRs in NWA 5717, FGRs from Semarkona are more abundant in hydrous minerals and have a more complex mineralogy (i.e. serpentine-saponite intergrowths) [9]. We have not yet determined the alteration phases in Watonga FGRs. However, we speculate they are similar to those in NWA 5717. Semarkona FGRs tend to have lower bulk composition totals (down to 85 wt.%) than FGRs from NWA 5717 and Watonga (range 90 – 100 wt.%), as determined by defocused EPMA, suggesting more water in Semarkona FGRs.

Discussion: Observation of FGRs on Watonga chondrules show the following: (1) chondrules experienced reheating of their surfaces prior to rim accretion, evident by irregular chondrule surfaces infilled by rim material and the formation of protuberances and microchondrules [cf. 3,8], (2) rims are dominated by submicron fayalitic olivine that is absent in the chondrules and compositionally different from the matrix olivine, (3) some rims contain hydrated minerals with assemblages sharply different from their host chondrules and adjacent matrix. These observations suggest a complex history of modification of chondrule surfaces followed by accretion of FGR components and finally alteration of those components, all prior to final accretion with the matrix. The alteration products within FGRs suggests accretion of ices mixed with dust onto chondrule surfaces. Heating of this icy-dust mixture led to oxidation of Fe and the alteration assemblage in the FGRs. Higher degrees of hydration in Semarkona FGRs indicate a separate pathway of processing than in other UOC FGRs, or that more ices accreted with adhering dust. The preaccretionary environment of rim formation may represent either: 1) a nebular setting within the accretionary disk, or 2) an earlier stage of fluid-assisisted alteration of fine-grained material with emphemeral planetesimals that were subsequently broken apart through collisional brecciation [e.g. 5].

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