

Formation mechanism of fine-grained rims surrounding chondrules, CAIs and forsterite aggregates in Tagish Lake

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Introduction: Tagish Lake carbonaceous chondrite consists of two major lithologies: carbonate-rich and carbonate-poor [1]. Most chondrules and coarse-grained aggregates in Tagish Lake are surrounded by fine-grained rims [1]. The origin of fine-grained chondrule rims has been controversial [e.g. 2-7]. Nakamura et al. [6] suggested that the rims in the carbonate-rich lithology were formed during brecciation on the parent body (or bodies). In contrast, by studying the carbonate-poor lithology, Greshake et al. [7] concluded that formation of the rims by dust accretion in the solar nebula most convincingly accounts for their observations. Here we present the results of our mineralogical and petrological study of fine-grained rims surrounding chondrules and coarse-grained aggregates in the carbonate-poor lithology of Tagish Lake.

Results and Discussion: We found 87 chondrules, 14 forsterite aggregates, and two CAIs in the two thin sections (~114 microns²). These coarse-grained components are embedded in the dominant matrix (84.1 vol.%) consisting mainly of phyllosilicates with minor amounts of Fe-Mg carbonate, magnetite, forsteritic olivine, Ca carbonate, and Fe-(Ni) sulfides. Most chondrules consist of irregularly shaped cores composed of forsterite and enstatite and phyllosilicate-rich outer zones (POZs) (5-100 microns in thickness). Also, characteristic round pseudomorphs of opaque nodules that consist largely of phyllosilicates were commonly found in both core and the POZs. The observation suggests that the POZs are altered zones which were formed by replacing the peripheries of chondrules.

96 % of the chondrules are surrounded by fine-grained rims which are significantly less porous than the matrix. The volume abundances of the minerals in the rims are significantly different from those of the matrix (e.g. Ca carbonate is totally absent). Most rims contain characteristic fractures that run radially from the core/altered zone boundaries, penetrate both altered zones and rims, and terminate at the rim/matrix boundaries. All of the CAIs and forsterite aggregates are also surrounded by fine-grained rims which are identical to those of the chondrules in texture, mineralogy and chemical compositions.

We found 55 clasts that consist of materials texturally and mineralogically identical to the fine-grained rims surrounding the coarse-grained components. We also found a large clast that contains three chondrules and three forsterite aggregates. The chondrules in this clast also have altered zones. The matrix of the clast exhibits fractures that run radially from the surfaces of the chondrules and forsterite aggregates and interconnect them. They always terminate at the clast/matrix boundary.

These observations suggest that the chondrules, CAIs, forsterite aggregates, and their rims and the clasts originated from a common precursor region in the meteorite parent body that was different from the location where the host meteorite was finally lithified. That is, the rims are remnants of matrix material of the precursor region. This model is essentially consistent with those previously proposed for the carbonate-rich lithology of Tagish Lake [6] and the hydrated clasts in the Vigarano and Mokoia CV3 chondrites [4, 8].

References:

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