MINERALOGY OF FINE-GRAINED RIMS AND INTER-CHONDRULE MATRIX IN THE PARIS CM CHONDRITE.

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Introdution : In primitive chondrites, chondrules and refractory inclusions are frequently surrounded by fine grained rims (FGRs) consisting of an unequilibrated mineral assemblage made of a groundmass of amorphous silicates and Mg-Fe rich phyllosilicates which embeds anhydrous silicates, sulfides, metal and organic compounds [1]. Although these FGRs present clear textural differences (grains size, compaction, porosity) in comparison to the matrix, previous studies [e.g., 2] show that they remain chemically and mineralogically nearly identical. Due to these similarities, origins of FGRs are difficult to discriminate and formation in both nebular and parent body settings have been proposed [3-5]. It is likely that the difficulty in identifying differences between FGRs and the adjacent matrix is due to: i) the fine granulometry (<3µm) of FGRs; ii) the fact that FGRs and matrices have experienced post-accretional secondary processing (aqueous alteration) under identical conditions. In order to compare the mineralogy of FGRs and the adjacent matrix in the case of limited secondary parent body processes, we studied the pristine Paris meteorite [6] with a new method that enables high resolution mineralogical classification.

Methods: To obtain a complete petrological comparison between the matrix and the FGR, we developed a methodology which couples low-voltage (6 keV) EDS mapping and electron probe micro-analysis (EPMA) quantification. We thus obtain modal abundances, grain size distributions, densities and bulk compositions of matrices and chondrule rims with a pixel size of 300 nm. This methology is described in detail in [7]. Seven electron transparent sections were then extracted from the different areas by the focused ion beam (FIB) technique. These samples were examined using a tranmission electron microscope (TEM) FEI TITAN Themis 300.

Results : *SEM:* In the Paris meteorite, FGRs are present around many chondrules, metal grains, and chondrule fragments. Several fresh chondrules display an internal rim enclosed by a distinct, external one. The internal rim is always fragmented and never completely surrounds the chondrules. Several differences are observed between FGRs and matrix. Similar phases are present but modal abundances differ significantly. Tochilinite is more abundant in the matrix (12% vol. %) than in the FGRs (2,5% in the internal rim and 5% in the external rim). The same is true for carbonates and sulfates (1 and 2% respectively in the matrix), which are almost absent from the rims (<1%). Anhydrous silicates are more abundant in the external rim (4%) compared to the internal one (3%) and to the matrix (2.5%). The external rim also exhibits a higher olivine/pyroxene ratio with a value of 0.95 (compared to 0.61 and 0.62 respectively). We find a mean density for the internal rim of 2.1g/cm^3 ± 0.6, and the same density is observed for the matrix, while the density of the external rim is much lower with a value of 1.7 g/cm^3 ± 0.5. Given that the mineralogy and composition of the internal and external rim are similar, it appears that despite the large errorbars, the difference between this two densities is significant and must be due to a higher porosity in the external rim.

TEM observations : TEM obsevations confirm these differences at a much finer scale. Both FGRs and matrix contain anhydrous silicates, sulfides and carbonaceous matter embedded in a silicate groundmass. However, FGRs are dominated by amorphous silicates [8], whereas inter-chondrule matrix exhibits more crystalline fibrous silicates with patches of tochilinite-cronstedtite intergrowth. In agreement with SEM density measurements, we observe a significant porosity (20 %) in the external rim, whereas the internal rim exhibits a compact texture (porosity 3%).

Discussion: Our methodology has enabled us to reveal differences between the matrix and FGRs, both at the SEM and the TEM scales. (1) The abundance of secondary phases at the SEM scale and the amount of amorphous silicates at the TEM scale show that the alteration is more advanced in the matrix than in FGRs; (2) the mineralogy and the composition of the internal and external rims are similar but the porosity is much higher in the external one; (3) the textural characteristics (porosity, connectivity) and the mineralogy of the external rim should make it sensitive to alteration but it appears less altered than the matrix; (4) matrix and FGRs must have sampled different reservoirs since the various olivine/pyroxene ratio cannot be explained by differential alteration.

We suggest that the FGRs are formed by the successive accretion of grains and aggregates in the nebula [9] where they could have sampled different reservoirs. The result is a various quantity of constituents (between the FGR and the adjacent matrix) including a less amount of water rich components which allowed a better preservation of FGRs during parent body alteration.

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