MULTI-LAYER FINE-GRAINED RIM AROUND CHONDRULE IN THE YAMATO 75273 LL3 CHONDRITE: NEBULAR AND PARENT-BODY PROCESSES.

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Introduction: Chondrules in primitive chondrites are commonly surrounded by fine-grained rims. The origin and formation process of the rims is controversial [e. g., 1–4]. Many studies have proposed that fine-grained rims were formed by accretion of pristine dust particles in the solar nebula [1]. However, recent studies showed that some fine-grained rims were formed by parent-body processes [2, 3]. Chondrule rim formation by the parent-body process requires desruption and reacceretion of an earlier-formed regolith material. To uncover the origin of fine-grained rims, we performed FE-SEM and FE-EPMA analyses of a primitive LL3 ordinary chondrite Y 75273.

Results : Most chondrules in Y 75273 are surrounded by fine-grained rims. Among them, we found one chondrule surrounded by a multi-layered fine-grained rim. The rim consists of five layers from innermost 1st to outermost 5th layer. Mineral combination is similar, but relative mineral abundance, grain size, and chemical composition of the minerals differ among the rims. The 1st layer contains abundant euhedral olivine (typically <5 μm but occasionally up to 10 μm in size), Al–Na rich mesostasis glass, and minor amounts of high–Ca pyroxene (typically <5 μm), Fe sulfide (typically <3 μm), and Fe–Ni metal (typically <3 μm). The 2nd layer is similar in mineral composition with 1st layer, but the abundance of the glass is much lower than the 1st layer. The 3rd layer is rich in sulfide and consists mainly of olivine and Fe sulfide (typically <15 μm) with minor amounts of high–Ca and low–Ca pyroxene (typically <15 μm), Fe–Ni metal (typically <15 μm), and mesostasis glass. The 4th layer is similar in mineral composition with 3rd layer, but the abundance of Fe–Ni metal and Fe–Ni–Si bearing minerals is much higher than the 3rd layer and that of glass is relatively low. Grain size of the 5th layer is much smaller (typically ~a few hundreds of nm in scale) than the other four layers. In the 1st–4th layer, Fe sulfide and Fe–Ni metal seem to have melted, but silicates are not melted completely. Metal and silicates in the 5th layer are not melted and the same feature is also observed in single rims around other chondurules. The boundaries between the central chondrule and the 1st layer, between the 1st and 2nd layer, between the 2nd and 3rd layer are not easily discernible, while the boundaries between the 3rd and 4th layer, between the 4th and 5th layer are distinct and smooth (no topographic depressions).

The chemical composition differs between the layers. Defocused (10μm diameter) electron beam analysis of each layer shows compositional variation in individual rims: in the Si–Mg–Fe ternary diagram, the 2nd- layer data distribute close to the solar abundance and the 1st- and 2nd- layer data make a trend from solar toward the Si-apex suggestive of addition of Si-rich material such as glass, while the 3rd- and 4th- layer data distribute from solar to the Fe-apex indicative of addition of Fe-rich material such as Fe Sulfide and Fe–Ni metal. On the other hand, the 5th- layer data fall on the different compositional field in Mg-poor areas relative to solar. The compositional field of the 5th layer overlaps those of the single rims on the other chondrules.

Discussion: Clear boundaries between the layers can not be explained by simple monotonous dust accretion. Rather, we suggest the following nebula and parent-body processes for the formation of the multi-layered rim: The 1st and 2nd layer was formed by accretion of fine dust with solar elemental abundance. The 3rd and 4th layer formed by accretion of Fe Sulfide-rich and Fe–Ni metal-rich fine-grained dust relative to solar abundance, respectively, in the solar nebula. After accretion of the 1st to 3rd layers, some heating process occurred and caused partial melting of the 1st to 3rd layers. The 1st and 2nd layer formed from the same dust reservoir, but melted mesostasis glass was supplied to only 1st layer from the center chondrule because the 1st layer is closer to the chondrule, which is verified by the enrichment of Si and Na in the 1st layer. Dust accretion on the surface of solidified 3rd layer resulted in the formation of the 4th layer. Probably, similar heating process could have occurred after the formation of the 4th layer. Similarities in the bulk chemical composition and texture between the 5th layer and single rims suggest that they have the same origin. Chondrules, including that with the 1st to 4th layers, in an earlier-formed parent body might have been excavated by an impact and re-accumlated to the present location with irregular-shaped fine-grained rims once constitutes matrix material between chondrules. Our observation indicates that the multi-layer fine-grained rim was formed by both nebular and parent-body processes.

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