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 disruption and reaccretion 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 1\textsuperscript{st} to outermost 5\textsuperscript{th} layer. Mineral combination is similar, but relative mineral abundance, grain size, and chemical composition of the minerals differ among the rims. The 1\textsuperscript{st} 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 2\textsuperscript{nd} layer is similar in mineral composition with 1\textsuperscript{st} layer, but the abundance of the glass is much lower than the 1\textsuperscript{st} layer. The 3\textsuperscript{rd} 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 4\textsuperscript{th} layer is similar in mineral composition with 3\textsuperscript{rd} layer, but the abundance of Fe–Ni metal and Fe–Ni–Si bearing minerals is much higher than the 3\textsuperscript{rd} layer and that of glass is relatively low. Grain size of the 5\textsuperscript{th} layer is much smaller (typically ~a few hundreds of nm in scale) than the other four layers. In the 1\textsuperscript{st}–2\textsuperscript{nd} layer, Fe sulfide and Fe–Ni metal seem to have melted, but silicates are not melted completely. Metal and silicates in the 5\textsuperscript{th} layer are not melted and the same feature is also observed in single rims around other chondrules. The boundaries between the central chondrule and the 1\textsuperscript{st} layer, between the 1\textsuperscript{st} and 2\textsuperscript{nd} layer, between the 2\textsuperscript{nd} and 3\textsuperscript{rd} layer are not easily discernible, while the boundaries between the 3\textsuperscript{rd} and 4\textsuperscript{th} layer, between the 4\textsuperscript{th} and 5\textsuperscript{th} 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 2\textsuperscript{nd} layer data distribute close to the solar abundance and the 1\textsuperscript{st} and 2\textsuperscript{nd} layer data make a trend from solar toward the Si-apex suggestive of addition of Si-rich material such as glass, while the 3\textsuperscript{rd} and 4\textsuperscript{th} 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 5\textsuperscript{th} layer data fall on the different compositional field in Mg-poor areas relative to solar. The compositional field of the 5\textsuperscript{th} 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 1\textsuperscript{st} and 2\textsuperscript{nd} layer was formed by accretion of fine dust with solar elemental abundance. The 3\textsuperscript{rd} and 4\textsuperscript{th} 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 1\textsuperscript{st} to 3\textsuperscript{rd} layers, some heating process occurred and caused partial melting of the 1\textsuperscript{st} to 3\textsuperscript{rd} layers. The 1\textsuperscript{st} and 2\textsuperscript{nd} layer formed from the same dust reservoir, but melted mesostasis glass was supplied to only 1\textsuperscript{st} layer from the center chondrule because the 1\textsuperscript{st} layer is closer to the chondrule, which is verified by the enrichment of Si and Na in the 1\textsuperscript{st} layer. Dust accretion on the surface of solidified 3\textsuperscript{rd} layer resulted in the formation of the 4\textsuperscript{th} layer. Probably, similar heating process could have occurred after the formation of the 4\textsuperscript{th} layer. Similarities in the bulk chemical composition and texture between the 5\textsuperscript{th} layer and single rims suggest that they have the same origin. Chondrules, including that with the 1\textsuperscript{st} to 4\textsuperscript{th} layers, in an earlier-formed parent body might have been excavated by an impact and re-accumulated 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.