Complex thermal and shock history of the Juvinas eucrites

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Introduction: Eucrites are a class of differentiated achondrites, and are considered to have originated from an asteroid 4 Vesta (~500 km in diameter). Eucrites are classified into basaltic (noncumulate) and cumulate eucrites. Eucrites make up the outermost crust of Vesta formed after global melting of the parent body. After the crystallization, most eucrites experienced secondary processes such as impact, brecciation, melting and thermal metamorphism on Vesta's surface. Juvinas has been considered a monomict eucrite [1]. However, Takeda and Yamaguchi (1991) [2] reported that the texture of Juvinas is heterogeneous. They suggested that the Juvinas records information on crustal evolution from magma process to metamorphism after its solidification. Hence, Juvinas is a suitable sample to reveal the early geologic history of the Vestan crust. In this study, we report the petrologic and mineralogical features of Juvinas and discussed the secondary processing to understand the formation history of the Vestan crust.

Samples and Methods: We examined polished thick and thin sections (PTSs) of Juvinas using an electron microprobe analyzer (EPMA) (JEOL JXA-8200), field emission scanning electron microscope (SEM) (JEOL JSM 7100) equipped with an energy dispersive detector (EDS) (Oxford AZtec Energy) and a cathodoluminescence (CL) system (Oxford Mono CL2) at NIPR. We also used a luminoscope (ELM-3) at OUS and a Raman spectroscope (JASCO NRS-1000) at NIPR to distinguish silica minerals.

Result: The PTSs of Juvinas display a heterogeneous texture, and are composed of coarse- to fine-grained crystalline clasts set in a clastic matrix. The coarse-grained portion in the clasts has a subophitic texture of low-Ca pyroxene and plagioclase (An_{80-96}). Accessory minerals include silica minerals (mainly quartz), olivine, chromite, troilite, ilmenite, Ca-rich ($An_{>95-97}$) plagioclase, phosphate and Fe-metal. The fine-grained portion is composed of anhedral pyroxene and needle shape plagioclase. The fine-grained portion is contacted with the coarse-grained portion with diffuse boundaries. In this portion, the abundances of the accessory minerals are lower except tridymite which occurs as large laths (~2-3 mm in length). Clastic matrix is composed of small lithic clasts and mineral fragments identical to the crystalline clasts with pore spaces. In the clastic matrix, fine mineral fragments and clasts have rounded outline and meet at 120° triple junctures, indicative of mild recrystallization.

Discussion: Our observations suggest that Juvinas experienced a multi-stage geologic process. Coarse-grained portion crystalized from a magma near the surface of Vesta as other noncumulate eucrites. The absence of Mg-Fe zoning in low-Ca pyroxenes indicates that coarse-grained portion experience thermal metamorphism after the crystallization (type 5). We suggest that fine-grained portion was made by localized shock melting of the coarse-grained portion and rapid cooling. The Mg# of low-Ca pyroxene in the fine-grained portion are similar to those of the coarse-grained area, indicating that this portion suffered thermal metamorphism after the shock event. The coarse- and fine-grained portions were brecciated by the second impact event to produce the clastic matrix. The high porosity of the Juvinas matrix suggests that Juvinas did not experience a compaction. Juvinas was located near the surface of Vesta. The presence of rounded outline and recrystallized texture in the clastic matrix implies that Juvinas experienced a low-degree of thermal metamorphism. Thus, Juvinas is a monomict breccia of coarse- to fine-grained clasts. We found secondary minerals such as Fe-rich olivine, Ca-rich plagioclase, and Ca-phosphates possibly related metasomatism [3]. However, it is not clear the timing of the metasomatism event. We continue a detailed petrologic study of the Juvinas eucrite.

References

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