Complex formation history of the Juvinas eucrite: Implications for multiple metamorphism and metasomatism on Vestan crust.

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After the initial crystallization, most of the eucrites experienced complex secondary processes such as impact, brecciation, melting, thermal metamorphism and metasomatism. Juvinas has been suggested to be a typical eucrite, and is classified into a monomict eucrite. In this study, we suggest that Juvinas experienced a complex formation history.
Juvinas is a breccia composed of crystalline clasts set in a porous clastic matrix (CM). The crystalline clasts are composed of coarse-grained portion (CG), fine-grained portion (FG), and granoblastic pyroxene (GP) with gradational boundaries. The CG displays a coarse-grained subophitic texture of pyroxene and plagioclase with minor minerals. Pyroxene grains in the CG generally show a cloudy appearance due to the presence of tiny opaque minerals. There are clear veins along rims and healed cracks in the pyroxene grains. The GP consists of fine-grained (<100 μm), polygonal pigeonite with augite lamellae, silica and opaque minerals. The FG is composed of acicular plagioclase (~200 μm), anhedral pyroxene and lathy tridymite. The CM is composed of lithic clasts of the crystalline portions described above, and mineral fragments. The lithic clasts and mineral fragments are joined smoothly indicating that this portion is mildly welded.
We observed several minor minerals likely formed by metasomatism. Fe-rich olivine (Fa_{67-77}), chromite and Ca-rich plagioclase (An_{-97}) occur as thin veins (<20 μm thick) in pyroxene grains in the CG and GP. In crystalline portions (CG, GP and FG), the troilite has a vein shape (~50 μm thick) that filled the fractures. In the CM, there are small silicate fragments bounded by irregular troilite grains.
The CG crystallized from an initial melt. The plagioclase in the CG shows a positive correlation between Na and K from a core to a rim. The CG crystallized near the surface of Vesta. Subsequently, the CG suffered from thermal metamorphism evidenced by homogeneous Mg# and cloudy texture of pyroxene grains.
The granoblastic texture indicates that the GP formed by shock metamorphism. We consider the FG crystallized from shock partial melting of the CG. The FG has greater amounts of silica minerals than those in the CG. The Mg# of low-Ca pyroxene in the FG has slightly lower than the CG. These are expected features of partial melt of basaltic eucrites. The fine-grained sizes imply that the FG cooled rapidly during crystallization. The FG suffered thermal metamorphism after the crystallization because of the lack of Fe/Mg variations in low-Ca pyroxene. The CM formed by brecciation of crystalline clasts of the CG, GP and FG by impact event(s). After brecciation, this portion suffered from mild thermal metamorphism evidenced by welded features. Minor Fe-rich olivine, Ca-rich plagioclase and chromite in pyroxene grains in the CG and GP may have been produced by Fe-metasomatism [1]. This process should have taken place before the formation of the FG since FG does not have these secondary minerals. We suggest that irregular troilite should have been added at the last stage formation history. In some cases, the boundaries between the troilite and exsolved pyroxene has a saw zigzagged shape. The fact implies that the troilite could have formed due to reaction of FeSiO3 components in pyroxene and sulfur-rich fluid [2].
In summary, we suggest that Juvinas formed by the following processes: (1) initial crystallization from a magma near the surface of Vesta (CG), (2) Fe-metasomatism, (3) thermal metamorphism, (4) shock melting and/or recrystallization by impact event(s) (FG and GP), (5) the homogenization by second thermal metamorphism, (6) second impact event (CM), (7) mild recrystallization of the boundaries of the

lithic clasts and mineral fragments by third thermal metamorphism and (8) S-rich fluid related metasomatism.

[1] Barrat J. A. et al. (2011) Geochimica et Cosmochimica Acta, 75, 3839-3852. [2] Zhang A. C. et al. (2013) Geochimica et Cosmochimica Acta, 109, 1-13.

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