Origin of silica minerals in basaltic eucrites

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Introduction: Eucrites grouped with diogenites and howardites, represent the largest group of differentiated meteorites. Eucrites are considered to have originated from an asteroid 4 Vesta. Eucrites are basalts or gabbros made up the outermost crust of Vesta formed after global melting. After the crust formation, eucrites experienced secondary processes such as shock metamorphism, brecciation, reheating, and metasomatism. Secondary minerals in eucrites provide us with valuable information about post-crystallization history of the eucritic crust. We have been studying the occurrences of silica minerals in basaltic eucrites for better understanding of the secondary processing. In this study, we described the textures of silica minerals in basaltic eucrites with different metamorphic grades [e.g., 1].

Samples and Methods: We studied five Antarctic eucrites (A-881747, EET 90020, Y-790266, Y-792510 and Y 983366) and six non-Antarctic eucrites (NWA 049, NWA 1466, NWA 5356, NWA 7188, Agoult and Juvinas). We examined these eucrites using an electron microprobe analyzer (EPMA JEOL JXA-8200), scanning electron microscope (SEM JEOL JSM 7100) equipped with an EDS (Oxford AZtec Energy) and CL system (Oxford Mono CL2). We used a luminoscope (ELM-3) and a Raman spectroscope (JASCO NRS-2100) to distinguish silica minerals.

Results: We estimated the degrees of thermal metamorphism (petrologic types) [1] for these eucrites. The presence of zoned pyroxene indicates that NWA 049 and Y-790266 are classified into petrologic type 2 and 3, respectively. These eucrites suffered from relatively low degrees of thermal metamorphism. A-881747, Y-792510, Y 983366, NWA 1466, NWA 7188 and Juvinas have low-Ca pyroxene with homogeneous Fe/Mg values indicating that they are classified into petrologic type 4 or 5. These eucrites suffered from moderated degrees of metamorphism. Agoult, EET 90020 and NWA 5356 are classified into petrologic types 5-6. Agoult and EET90020 have granulitic textures, indicative of strong metamorphism. These eucrites may have experienced stronger degrees of metamorphism than did normal type 5-6 eucrites. We classified silica minerals in the eucrites studied here into three groups. (A) Most silica phases in Agoult, EET 90020 and NWA 5356 (type 5-6) occur as tridymite. Tridymite in NWA 5356 contains tiny (< 10 μm) inclusions (anorthite, pyroxene and ilmenite). (B) In NWA 049 (type 2), A-881747, Y-792510, NWA 1466 and Juvinas (type 4 or 5), both tridymite and quartz occur. Tridymite occurs as large lath or rectangular crystals (<500 μm). Tiny grains (<30-50 μm) of quartz (quartz aggregates) occur along rims around and as veins in the tridymite grains. The quartz is in most cases associated with ilmenite and troilite. (C) In Y-790266 (type 3), Y 983366 (type 4) and NWA 7188 (type 4-5), most of the silica phases are quartz. Quartz portions in these eucrites show a fine-grained texture similar texture the (B) group.

Discussion: We could not find any relationship between the petrologic types estimated from pyroxenes and the occurrences of silica minerals except for the highly metamorphosed eucrites. This indicates that the fine-grained quartz formed by secondary processes. The vein-like textures indicate that the quartz aggregate formed after the crystallization of tridymite possibly due to metasomatism. On the other hand, the presence of large grains of tridymite and the absence of quartz is consistent with the fact that Agoult and EET 90020 experienced high-temperature metamorphism (>1000 ˚C).

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