CATHODOLUMINESCENCE STUDY OF SECONDARY MINERALS IN EUCRITES

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Introduction: HED meteorites (Howardites-Eucrites-Diogenites) are considered to have originated from an asteroid 4 Vesta. Eucrites are basalts or gabbros making up the outermost crust of Vesta formed after global melting. After the crust formation, eucrites experienced secondary processing such as metamorphism, brecciation, and metasomatism. Secondary minerals in eucrites provide us with a valuable information about post-magmatic processing of the eucritic crust. Recently, several secondary minerals formed by metasomatism were found in eucrites. Quartz in Serra de Magé (cumulate eucrite) has considered to derive from liquid water solution [1]. Fe-rich olivine and Ca-rich plagioclase are considered to have formed by Fe-metasomatism. [2]. Detail petrographic observations are required for understand about the metasomatism. In this study, we observed secondary minerals formed metasomatism in several eucrites using a cathodoluminescence (CL) method and optical and scanning microscopes. CL emissions can detect the presence of trace impurities and structural defects, which provides a crystal-chemical information about formation and alteration of the minerals. Furthermore, Color-CL imaging is an efficient tool to distinguish the minerals different in their origin closely related to an alteration mechanism on the parent body.

Samples and Methods: Seven eucrites of NWA 1466, NWA 5356, NWA 7188, Juvinas and Agoult were employed for CL measurement. CL color images were obtained using a luminoscope (ELM-3) with electron beams generated by an excitation voltage of 10 kV and a beam current of 0.5 mA. A scanning electron microscope (SEM JEOL JSM 7100) equipped with chroma CL also used for CL imaging at high magnifications. CL spectra were obtained using a system of CL-SEM which comprises a SEM (JEOL JSM-5400) combined with an integral grating monochromator (Oxford Mono CL2) over the wide wavelength range of 300 nm to 800 nm. The system was operated at 15 kV with 2 nA incident beam current in a scanning mode. All CL spectra were corrected for the total instrumental response. Mineral compositions determined using an electron microprobe analyzer (EPMA JEOL JXA-8200). Analysis of Ti in quartz was carried out performed using a 15 kV accelerating voltage and 20 nA beam current. Raman spectra were obtained by a laser Raman spectroscopy (JASCO NRS-2100) with an Ar laser of 514.5 nm wavelengths.

Results and Discussion: Juvinas is a brecciated equilibrated eucrite containing subophitic lithic fragments. Agoult is an unbrecciated granulitic eucrite. NWA 7188 is a polymict eucrite, containing two distinct fragments: The main with a gabbroic texture and the clasts with an ophitic to sub-ophitic texture. The CL in the eucrites studied here shows almost same feature for each mineral. CL colors of quartz, tridymite and plagioclase are red to purple, aqua-blue and yellow to orange, respectively. The color-CL imaging reveals that the most of silica phase in the eucrites are tridymite. Quartz in the eucrites except for Agoult occurs only in mesostasis associated with tridymite, and as porous aggregates. These quartz aggregates in many cases contains tiny grains of troilite, ilmenite, chromite, and apatite. Raman spectra analysis of quartz of Si-O band (typically 464 cm^{-1}) in Juvinas and NWA 1466 show a peak shift to lower wave numbers. These facts imply that the quartz retains the isotropic tensional stress derived from the inversion from the low dense phase or by a shock effect. CL spectral deconvolution analysis of the quartz in the eucrites gives emission centers of Fe^{3+} substitution, non-bridging oxygen hole center (NBOHC), Ti-impurity and $[Al^{3+}/M^{+}]$. Quartz in the eucrites has high NBOHC and low Ti-impurity as hydrothermal or rapid growth quartz in terrestrial. The Ti concentrations in quartz of Juvinas are slightly above or similar to the detection limit of our EPMA analysis (~120 ppm) indicating that the formation temperatures of quartz in Juvinas are <800℃ [3].

Plagioclase veins occur along cracks of pyroxene and/or around plagioclase grains in Juvinas and NWA 7188. The plagioclase veins show a bright blue CL emission. EPMA analysis reveals that the plagioclase is more Ca-rich ($An_{97\sim99}$) than large grains of igneous plagioclase ($An_{80\text{-}97}$). The Ca-rich plagioclase contains higher amount of FeO (0.7~1.7 wt%) than primary plagioclase (0.1~0.6 wt %). Chromite, Fe metal and troilite occur near the Ca-rich plagioclase vein. The occurrence of the Ca-rich plagioclase is consistent with the secondary phase reported by Barrat et al. [2]. These observations indicate that Juvinas and NWA 7188 also suffered from metasomatism.

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