Formation mechanism of spherulite in welded tuff: devitrification induced by volatile components

*Takuya Echigo[1], Yoichiro Saito[2], Mitsuyoshi Kimata[3], Masahiro Shimizu[3], Norimasa Nishida[4], Shigeru Takizawa[5]

1.Faculty of International Resource Sciences, Akita University, 2.Master's Program in Science and Engineering, University of Tsukuba, 3.Doctoral Program in Earth Evolution Sciences, Graduate School of Life and Environmental Sciences, University of Tsukuba, 4.Chemical Analysis Division, Research Facility Center for Science and Technology, University of Tsukuba, 5.National Research Institute for Earth Science and Disaster Prevention

This study reports detailed mineralogical and geochemical descriptions of the spherulite occurring in welded tuff from Aga town, Niigata prefecture, Japan, and also discussed its formation process. Powder X-ray diffraction showed that this spherulite mainly consists of cristobalite and Na-rich sanidine without any secondary minerals such as clay and zeolite minerals produced by hydrothermal alteration. Both bulk chemical analyses of spherulite and groundmass and microprobe analyses of plagioclase phenocrysts included in spherulite and groundmass revealed that the present spherulite crystallized from the same pyroclastic deposits as the host rock (strongly welded rhyolite tuff). The rare earth elements (REE) contents obtained by ICP-MS are slightly enriched in spherulite rather than in the host rock, indicating that the precursor of spherulite contained volatile components that induced the REE diffusing from the surrounding pyroclastic deposits into spherulite precursor. Textural observation using back-scattered electron image and micro-Raman spectroscopy showed that the present spherulite has three layers structure: rim (dense texture), mantle (porous texture) and core (fan-shaped aggregates of fibrous crystals). The distribution of elements within spherulite was examined using electron-microprobe analyzer with wave-dispersive spectrometer (EMPA-WDS). These results demonstrated that both Ca and Na are enriched in both the rim and core of spherulite, suggesting that Na-rich plagioclase is crystallized in these parts. In addition, detailed observation by secondary electron microscopy showed that fibrous microcrystals (~ 1 μm) of both feldspar minerals and cristobalite were intergrown to constitute fan-shaped aggregates in the core and porous aggregates of larger crystals (~ 5 um) in the mantle. These chemical and textual evidences suggested that the present spherulite is formed in a series of steps: (1) Non-crystalline precursors of spherulite were generated by local concentrations of volatile components in pyroclastic deposits. (2) Ca ion migrated to the boundary between the precursor of spherulite and the host rock and resulted in crystallization of plagioclase-rich rim. (3) Rapid intergrowth of cristobalite and plagioclase occurred in the core of spherulite and can be made up into the fan-shaped aggregate. (4) From the residual volatile-rich glass, fine crystals of Na-rich sanidine and cristobalite were intergrown and resulting volume shrinking generated pores in the mantle. (5) Euhedral crystabalite precipitated on the pore wall due to degassing of volatile components.

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