Thermal history of pyroclasts reflecting the structure of eruption clouds: Application of textural analysis of pyrrhotite oxidation

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Entrainment of air in eruption clouds causes rapid oxidation of pyroclasts due to an increase of oxygen fugacity at a high temperature. Oxidation texture of sulfide minerals (pyrrhotite) in pyroclasts can be an indicator for the process of air entrainment and temperature change in eruption clouds as it forms via interaction with air. To demonstrate the contrast of air entrainment and thermal disequilibrium processes of Plinian and Vulcanian eruption columns, oxidation texture of pyrrhotite in four andesitic pyroclastic eruptions of Asama and Sakurajima volcanoes was investigated. Although pyrrhotite and oxidized pyrrhotite crystals were commonly observed in the pumice clasts of these four eruptions, the component proportions and degree of oxidation of the pyrrhotite crystals were significantly different between Plinian and Vulcanian fall-deposits. Component proportions of oxidized pyrrhotite crystals were high for pumice deposits of the Asama 1783 and the Sakurajima 1914 Plinian eruptions than those of the Asama 2004 and the Sakurajima 2010 Vulcanian eruptions. These results indicate that the temperature of pumice clasts was kept above the closure temperature of pyrrhotite oxidation in the Plinian eruption clouds for a long time, while they dropped quickly in the Vulcanian one. The high temperature maintenance in Plinian clouds probably reflects (i) multiple mixing of an eruption cloud due to the continuous nature of Plinian flow and (ii) heat retainment in a pumice clast in the buoyant plume of the Plinian cloud. Thus, textural analysis of oxidized pyrrhotite can be a new approach for constraining the duration of high temperatures of an eruption cloud from fall-deposits, thereby reflecting the eruption dynamics.

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