Mechanism of volatile transport from mafic to silicic magma upon mixing

*Shumpei Yoshimura[1], Akiko Matsumoto[1], Mitsuhiro Nakagawa[1]

1. Department of Earth and Planetary Sciences, Hokkaido University

Introduction
Deep-derived, high-temperature mafic magma often injects into shallow-stored, low-temperature silicic magma, producing either well-mixed intermediate magma or mafic enclaves floating in host magma. Volatile transport from mafic to silicic magma accompanies magma mixing, and it may control volcanic activity (e.g., Roberge et al., 2009). However, the detailed mechanism of such volatile transport is unclear. In this study, we investigated how the gas was generated in mafic magma and transported to the silicic magma based on S and Cl analysis of Atchiyama rhyolitic lava that contains abundant basaltic enclaves.

Method
We observed Atchiyama biotite-rhyolite lava that erupted 1600 BP in Niijima Island (Isshiki, 1997), and analysed compositions of host rhyolite and basaltic enclaves. Cl mapping analysis was also performed on the area of enclave-host boundary to track the volatile transfer paths.

Results and discussion
Basaltic enclaves exhibited fine-grained groundmass composed of dendritic crystals, rhyolitic interstitial melt, and bubbles. The interstitial melt, which was compositionally distinguishable from the host rhyolite, was S-free (<50 ppm) and Cl-rich (1200 ppm). Melt inclusion analysis showed that the initial basaltic melt before mixing was S-rich (~4000 ppm) and Cl-poor (~430 ppm). These observations indicate that the basaltic magma cooled and crystallised rapidly upon injection, and the interstitial rhyolitic melt was produced as a result of crystallisation fractionation. Crystallisation-induced vesiculation (second boiling) occurred and S degassed completely, while Cl was concentrated in the interstitial melt.
Groundmass glass of host rhyolite was S-free and Cl-poor (~800 ppm). However, Cl mapping analysis revealed that the Cl content increased to 1200 ppm near the enclave margin. In addition, finger-like veins containing vapour-phase crystals developed from the enclave to far afield in host rhyolite, and the Cl content was also high near such veins. All these observations indicate that S- and Cl-rich gas was generated in crystallising enclave, and it was transported to the host rhyolitic magma via gas flow and diffusion.

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