Disequilibrium melting and assimilation of granitic xenoliths in andesitic magmas

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Crustal assimilation is one of the important magmatic processes especially for arc magmas. This process is well-illustrated at Mt. Tsukumo in NE Shikoku, SW Japan. Mt. Tsukumo is a small volcanic neck composed of Miocene andesites (Setouchi volcanic rocks), which locally contains partially melted granitic xenoliths (10–60 cm). By using the samples, we examined the petrological and geochemical evolution during xenolith assimilation on sub-meter scale.

A suite of rock samples indicates that xenolith assimilation proceeds through disequilibrium melting of granitic xenoliths and subsequent mixing of xenolith-derived porphyritic magmas with host andesitic magmas. Minerals in xenoliths are separated along phase boundary by melting, and further broken into smaller pieces by injection of partial melt into thin fractures. These minerals except for quartz progressively change their texture and composition through dissolution and precipitation. The partial melts in xenoliths, now observed as fresh glass, show diffusion-controlled compositional variations, and its heterogeneity is significant in Al_2O_3 and SiO_2. The heterogeneity of melt remains even under moderate degree of melting (~40%). Observation suggests that partially melted xenoliths behave as magma, not rigid material, when the melt proportion exceeds 50 vol%. Thus, the xenolith-derived magmas mix with host andesitic magmas to form a mixing zone surrounding xenoliths. This mixing event erases the diffusion-controlled compositional heterogeneity of partial melts. Consequently, compositions of assimilated magmas are approximated by binary mixing of the host andesitic magmas with the xenolith-derived magmas that experienced >50 % melting.

The Setouchi volcanic rocks, including high-Mg andesites, often contain quartz and feldspar xenocrysts, which are probably from Cretaceous granitic basement. This study suggests that the volume of granitic xenolith-derived melts cryptically mixed with host magmas is more than double of the observed xenocryst abundance. In addition, occurrence of quartz xenocryst should be investigated whether they were derived from partially-melted xenoliths or non-melted xenoliths. Quartz is easily separated from other granite-forming minerals at the early stage of partial melting. Thus, isolated quartz xenocrysts dispersed in host magmas could be derived from partially-melted xenoliths. If quartz form an aggregate with other mineral phases such as feldspar and biotite, these minerals would be entrained by mechanical breakoff of non-melted xenoliths.

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