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Time scale from mixing to eruption for historical lavas of Chokai volcano: Estimation by olivine residence times

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Chokai volcano is an active strato-volcano situated in the rear arc side of northeast Japan arc. The magmatic activity occurred at least three times between AD 871 and 1801. Based on petrologic data of the historical lavas, previous study deduced that the erupted products were formed by magma mixing. However, time intervals between mixing and eruption are not well determined. Here we estimate the time intervals based on Fe-Mg and NiO zoning of olivine phenocrysts in the historical lavas.

Samples for this study are lavas erupted during AD 871 to 1801. Lavas are divided into the Senjadani lower and upper lavas (AD871), the Kohjingatake lower and upper lavas, Kohjingatake agglutinate (some period between AD 871 and 1801) and Shinzan lava dome (AD1801). All lavas, except for Senjagadani upper lavas, possess mafic inclusions, and bulk compositions of lavas and inclusions are depicted on same linear trends in silica variation diagrams. Phenocryst assemblages are similar in all samples, and the phenocrysts are divided into mafic magma derived (An-rich plg and olv) and felsic magma derived ones (An-poor plg, opx, cpx, and hbl). Silica contents of host rocks and mafic inclusions are 56-58 and 51-55% in Senjadani lower lavas, ca. 51% in upper lavas, 59-60 and 52-57% in Kohjingatake lower lavas, 62-63 and 55-58% in Kohjingatake upper lavas, 66-69 and 56-58% Kohjingatake agglutinate, 61-62% and ca. 54% in Shinzan lava dome.

Olivine phenocrysts are subhedral in shape, and most olivine crystals have the reaction rim of orthopyroxene but some do not. These olivines have broad homogeneous cores and narrow, normally zoned rims. Fo content of core spans 74 to 79, and that of rim decreases to around 64. NiO content of core is ca. 0.02 wt% and that of rim decreases to ca. 0.002 wt%. We calculated residence times for the olivine crystals on the assumption that the zoning was produced by diffusion of the elements after the magma mixing event.

We used diffusion coefficients for Fe-Mg and Ni calculated by the equations of Costa et al. (2008) and Petry et al. (2004). We measured compositional profiles across these zoned olivine crystals by electron microprobe. We compared modeled diffusion profiles by the methods of Costa and Chakraborty (2004) with the observed ones, and determined the residence times required to produce the measured profiles. We obtained the residence times of one month to one year for the Senjadani lower lavas, one year to one year and a half for the Senjadani upper lavas and two months to eight months for the Kohjingatake lower lavas.

Keywords: Chokai volcano, olivine, diffusion, residence time, magma mixing