Olivine residence times for historical lavas of Chokai volcano, NE Japan: Estimation by Fe-Mg and Ni diffusions in olivine crystals

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Chokai volcano is an active strato-volcano situated in the rear arc side of northeast Japan arc. Chokai volcano erupted more than ten times in historic period. The magmatic activity occurred at least three times between AD 871 and 1801. Based on petrologic data of the historical lavas, it has been proposed that the erupted products were formed by magma mixing. However, little is known about time intervals between mixing and eruption. 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 from the Senjadani lower and upper lavas (AD871), the Kohjingatake lower lavas (some period between AD 871 and 1801). 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 the lavas are 56-58% and in the Senjadani lower lavas, ca. 51% in the upper lavas, 59-60% in the Kohjingatake lower lavas.

Olivine phenocrysts are less than 1.2 mm in size and subhedral in shape. 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 typically spans 74 to 79, and that of rim decreases to be around 64. In addition, NiO content of core is ca. 0.02 wt% and that of rim decreases to be 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 selected olivine crystals without reaction rim and whose crystal orientations are easily determinable in the thin section. We measured compositional profiles across these zoned olivine crystals by electron microprobe. Using the methods of Costa and Chakraborty (2004), we compared modeled diffusion profiles with the observed ones, and determined the times required to produce the measured profiles. The obtained olivine residence times were 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.