# Comparative petrological study of the 1792 and 1991-1995 effusive eruption of Unzen volcano

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Between the last two effusive eruptions (1792 and 1991-1995) of the Unzen volcano, the 1792 lava flow had slightly higher $SiO_2$ bulk rock composition (66-66.5wt%) compared with the 1991-1995 lava lobes (64.5-66wt%), nevertheless had lower viscosity estimated from apparent topography. The two eruptions have other different features related to the eruption processes, such as, lack of pyroclastic flows, higher effusion late, and shorter duration of the 1792 eruption. Both of these lavas show petrological evidence of magma mixing. In the present work, we estimated the mixing ratio and temperature of the end-member magmas, and intends to resolve the discrepancy of eruption features of the two eruptions.

The 1792 lava (Shin-yake lava flow) erupted from a vent on the northern slope of Unzen Fugendake, and flowed as lava flow for ca. 2.7 km down to the foot of the volcano with maximum thickness of ca. 80meters. The aspect ratio (H/L) is 0.03. The eruption of magma continued for about 50 days, total volume is 0.03km^3, so the average effusion late is 6.0*10^5m^3/day. This is ca. 4 times larger than the average effusion rate of the 1991-1995 eruption. Apparent viscosity of this lava has been estimated to be one order of magnitude lower compared with the 1991-1995 lava lobe. The 1792 lava contains plagioclase, hornblende, biotite, quartz, magnetite and ilmenite as phenocrysts, opx and cpx as micro-phenocrysts, and plagioclase, opx, cpx, magnetite, and ilmenite as groundmass. The 1792 lava has uniform bulk composition (66-66.5 wt.% $SiO_2$) for the whole of the lava flow, although it had suffered from magma mixing. Because almost all the phenocrysts of 1792 lava were derived from low-temperature magma alike the 1991-1995 lava, its end member bulk composition could be estimated from mass balance of phenocryst abundance (Nakamura 1995). Estimated mixing ratio of low-temperature magma vs. high-temperature magma is 1:2, and the bulk $SiO_2$ contents of both end-member magmas are almost equivalent.

The temperature of end-member magmas and mixed magma is estimated from two-oxide thermometry and pyroxene thermometry. The homogeneous cores of magnetite and ilmenite phenocrysts that preserved composition of low-temperature magma equilibration have respectively composition of Usp 14-17 and Ilm 79-80, yielding temperatures of 720-750oC at oxygen fugacity of NNO + 2. The condition of mixed magma and high temperature magma can be estimated by groundmass-microphenocryst size pyroxene thermometry. These pyroxene pair have bimodal value of Mg# composition, which is interpreted that high Mg# pyroxene pair which indicated temperature of 1100-1150oC derived from high temperature end-member magma, and low Mg# pair indicate 990-1050oC derived from the mixed magma. These temperatures is consistent with mixing ratio derived from phenocrysts mass balance.

The estimated temperature of the end-member magma of 1792 lava suggests that the mixed magma had a temperature of ca. 1030oC, about 130oC higher than the temperature of the 1991-1995 lava. This difference of magma temperature is consistent with the low viscosity, higher effusion late, lower bulk rock $H_2O$ contents, and lack of pyroclastic flow of the 1792 eruption.

We further obtained compositional profiles of magnetite phenocrysts in the 1792 lava, diffusion profiles caused by disequiliblium through magma mixing are observed. Larger phenocrysts (100 microns over) have rather uniform core (usp 15-17) with variable diffusion profiles at the rim. Smaller phenocrysts (under 50 microns) have high Usp composition, and some of them have entirely diffused core (Usp ca.30) which is approximately equal to the groundmass magnetite composition(usp 32-37). We inteprete that the magnetites suffered from extended annealing effect during cooling from the high temperature mixed magma in the 1792 eruption compared with rather limited annealing of magnetite phenocrysts in the 1991-1995 dacite demonstrated by Nakamura (1995).