Trace elements and Sr isotope microanalysis of plagioclase from Unzen volcano

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Chemical zoning within a phenocryst records geochemical evolution of a magma from which the phenocryst grew. We developed microanalytical techniques on trace elements and Sr isotope ratio in a plagioclase and applied it to the plagioclase extracted from Furuyake, Shinyake and Heisei lavas of Unzen volcano. The trace element abundances and Sr isotopic compositions were rather homogeneous among the samples. The results suggest a possibility that they may have precipitated from a single parent magma. In addition, since many of the samples show isotopic disequilibrium between their outer rims and their ground masses, they were xenocrysts. The similality in chemical and isotopic compositions in the plagioclases requires that they were formed from a magma before the Furuyake eruption.

Conventional geochemical studies on volcanic rocks mostly analyzed bulk rock samples and mineral separates. They can only obtain time integrated goechemical data. Chemical zoning within a phenocryst, to the contrary, records geochemical evolution of a magma from which the phenocryst grew. We developed microanalytical techniques on trace elements and Sr isotope ratio in a plagioclase. Plagioclase was chosen for this study since 1) the diffusion rates of trace elements in the mineral is slow, 2) the mineral is ubiquitous in volcanic rocks formed by subduction volcanisms. The micro analytical study were applied to the samples of plagioclase extracted from Furuyake (erupted at 1663), Shinyake (1792) and Heisei lavas (1991-1994) of Unzen volcano.

Trace elements in six samples of plagioclase were analyzed by a LA(laser ablation)-ICPMS. In all the samples Ba/Sr and La/Nd ratios were rather constant, 3.3-4.8 and 4.4-6.3, respectively. The degree of Eu anomaly appears also constant for all the samples. This chemical homogeneity is in contrast with the previously reported large variations within a single crystal of plagioclase from volcanic and plutonic rocks.

Eight samples of plagioclase was analyzed for Sr isotope ratios by a micro drilling sampling with MC-ICPMS (IsoProbe, Micromass). Two to four points were analyzed for each samples. Six samples showed isotopic disuquilibrium between their outer rims and their groundmasses. Sr isotope ratios varies between 0.70439-0.70454 within crystals. Three samples show gradual decrease in 87Sr/86Sr ratios from the cores to the rims. Others show homogeneous isotopic ratios with in the crystals. Samples of plagioclase with homogeneous in Sr isotope ratio can be divided into two groups, one with 87Sr/86Sr of around 0.70442 and the other with that of around 0.70454. In the three samples with isotopic variation, the cores has 0.70454 and rim 0.70442. 87Sr/86Sr ratios of groundmasses of Furuyak, Shunyake and Heisei lavas were 0.71417, 0.70467, 0.70447-0.70450, respectively.

The results indicate that the plagioclase in the last theree eruptions of Unzen formed from a magma with similar chemical compositions and suggest a possibility that they may have formed from a single parent magma. In addition, since many of the samples show isotopic disequilibrium between their outer rims and their ground masses, they were xenocrysts. The similality in chemical and isotopic compositions in the plagioclases in the last three eruptions requires that they were formed from a magma before the Furuyake eruption. The isotopic ratios of Furuyake groundmass, 0.71417, ruled out the possibility that it was the parent magma of the plagioclases. The lavas erupted four and five thousand years ago can be the parent magma in terms of their Sr istope ratios. Thus the results of the micro-analysis suggests that plagioclase can stay in a magma chamber or a conduit surviving several eruption events.