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Magmatic processes of Unzen volcano revealed by laser microprobe analyses of noble gases in zero-age plagioclase phenocrysts

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Using the laser-microprobe noble gas analytical method, we investigate and reveal the source and trapping site of excess argon in zero-age plagioclase phenocrysts extracted from the lavas erupted during 1990-1995 activity of the Unzen volcano, Kyushu, Japan. The majority of the excess argon is retained in melt inclusions in the dusty zone of the phenocrysts. We propose a model for the isotopic evolution of argon in the phenocryst-bearing lava from the Unzen volcano by taking into consideration the noble gas data from Unzen volcanic gases and the chemical composition of the melt inclusions in the phenocrysts. In our model, plagioclase phenocrysts crystallize from, or are captured by a low-temperature (T) rhyodacitic magma. This magma has a comparatively high $^{40}Ar/^{36}Ar$ ratio (> 970) for an arc magma due to assimilation of old Cretaceous granitic wall rock. Mantle-derived argon is replenished in the rhyodacitic magma over the life of the volcano when the magma chamber is recharged at intervals by high-T juvenile magma. The plagioclase phenocrysts crystallize rapidly, trapping magmatic argon during successive dissolution/crystallization events caused by intrusion of the high-T magma or water-rich fluids. The phenocryst-bearing mixed magma ascends at a relatively rapid rate following a final injection of the high-T magma, and interacts with shallow groundwater causing the $^{40}Ar/^{36}Ar$ ratio of the magma to decrease to the atmospheric ratio. The remnant magma has been continuously degassing for a decade since the recent eruptive activity, without significant change to $^{3}He/^{4}He$ and $^{40}Ar/^{36}Ar$ ratios.