Degassing process of Unzen Volcano, Heiseishinzan-eruption

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Unzen 1990-1995 eruption is a good example of the effusive eruption of dacitic magma whose composition was similar with that of plinian eruptions such as Pinatubo in 1991. Quantitative observation of eruption volume, SO_2 flux measurement, volcanic gas composition and melt inclusions analyses enabled us the quantitative evaluation of degassing process during the eruption (Nakada et al., 1999; Hirabayashi et al., 1995; Ohba et al., 1994; Yamaguchi, 1997). Detailed observation of magma and SO_2 flux shows a contemporaneous variation of these fluxes corresponding quantitative degassing of 150 ppm S (Fig. 1).

Although the vent of magma discharge shifted with the growth of the lava dome, major volcanic gas emission vents seem to locate at the same position of former Jigokuato crater, where the first lava lobe extrusion occurred. Although major plumes with pale-blue color rich in SO_2 were mainly originated from these vents, white plumes likely rich in steam were also occurred over the growing dome. There was no major changes observed at hot spring discharges nearby, indicating that gas emission caused by the eruption occurred only from the growing dome.

Comparing the degassed S content and volcanic gas composition, we can estimate composition of volatile components degassed from the magma. The composition of degassed volatile components can be also estimated as the difference between those in melt inclusions and matrix glasses. The low S content (50 ppm) in the melt inclusions derived from a silicic end-member magma cannot account for the SO_2 flux whereas the estimated H_2O and Cl amount degassed during the eruption were larger than those of the observed flux in the volcanic gases. In contrast, melt inclusions in pyroxenes, likely derived from a mafic end-member magma are rich in sulfur with maximum of 500 ppm S. Considering the 1:1 mixing ratio of the silicic and mafic components, we can estimate the average S content in the erupted magma to be 250 ppm S that is high enough to cause the observed sulfur degassing (Satoh et al. 2002).

In contrast, the small H_2O emission rate compared with the degassed amount cannot be explained by the magma mixing. Therefore it is likely that there is another sink of magmatic water. Although the volatile flux was estimated based on the volcanic gas composition emitted from the main vent, white plume that is likely rich in steam also emitted from large area of the dome. Fukui (2002) estimated variation of H_2O flux and found that the H_2O flux from the dome is several times larger than that estimated based on the volcanic gas composition.

The new data of the Unzen degassing activity 1991-1995 demonstrated that the volatile flux can be quantitatively explained by closed-system degassing processes. This example is in well agreement with the model proposed by Melnik and Sparks (1999). However, it is quite rare to find such agreement amongst the erupted magma volume, volatile content and volcanic gas fluxes. It is rather common to observe that the gas emission rate is much larger than expected from complete degassing of an erupting magma (excessive degassing). Examples of St. Helens, Redoubt and Montserrat show the excessive degassing activity. Magma mixing is commonly observed is such dacitic eruptions. Their mafic endmember, however, is not always well characterized in particular for its sulfur content causing underestimation of petrological estimate of the degassed S amount. This could partly explain the cause of the excessive degassing at these volcanoes. However the extensive degassing during post-eruption stage of Redoubt volcano and during repose period of Montserrat volcano cannot be caused by the difference in the S content in magmas but should be caused by S degassing from non-erupted magma. Therefore, the 1991-1995 Unzen eruption might be a rare model case of the simple dome-forming eruption.