Volatile composition of island arc magma: Estimation based on the volcanic plume composition

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Magma discharges most of their volatile components by ascent to the surface or crystallization underground. Therefore, composition of the discharged volatiles should reflect the original volatile composition in the magma. There have been various such estimates using composition of high-temperature fumarolic gases, however, the high-temperature fumarolic gases do not necessarily represent the bulk composition of the volatile emission from volcanoes, because of their small flux compared with gas emission through continuous plume degassing activity. During recent activity in Japan, the important volcanic gas discharges occurred at Miyakejima, Suwanosejima, Sakurajima, Satsuma-Iwojima, Aso, Asama and Tokachidake, which discharges more than 99% of volcanic SO_2 from Japan islands. Therefore, if we can estimate the average composition of the volcanic gases discharged from these volcanoes, we can estimate the average volatile composition of the magma supplied to the island arc. However, degassing at most of these volcanoes occurred from inaccessible vent, the conventional fumarolic gas sampling method could not be applicable for the study of these large scale degassing. Recently, Shinohara (2005) developed a new method to estimate the volcanic gas composition by measuring composition of volcanic plume by the use of portable multi-component gas analyzer system (Multi-GAS), and the volcanic gas compositions of most of these volcanoes were estimated by this new method.

Most important recent degassing activity in Japan occurred at Miyakejima volcano, which started the intense degassing activity in 2000 up to now discharging 21 Mt of SO_2 in total. The volcanic gas composition estimated by the plume measurement is almost constant during all the period at about H_2O/SO_2=50, CO_2/SO_2=1, SO_2/HCl=0.1 mol ratio. This composition is consistent with the volatile contents in melt inclusions, except for CO_2, indicating that the volcanic gases were discharged at low pressure from magma with similar volatile composition with the melt inclusion. CO_2 is likely oversaturated and existed in CO_2-rich bubbles at the time of the melt inclusion trapping. Assuming S=1200 ppm as measured in the melt inclusions, volatile content in the magma can be estimated as H_2O=3.4 wt.% and CO_2=1600ppm, and the amount of magma necessary to supply the 21 Mt SO_2 during these 7 years is calculated to be 8.8 Gt (3.3 km^3). As the volcanic gas composition discharged during these 7 years was almost constant, this large amount of magma was homogeneous with the constant volatile composition. As the melt inclusions can be experienced degassing before trapping, their composition does not necessarily represent the composition of the magma supplied to the crust. However, in order to change the volatile content of this large amount of magma by degassing, large scale degassing activity similar in the present activity should have occurred in the past. However, such a large degassing activity was not recorded at Miyakejima, suggesting that the measured volcanic composition represent the deep supplied composition.

Volcanic gas compositions of Suwanosejima, Aso, Asama were also measure by Multi-GAS. In spite of the various magma compositions ranging from basalt to andesite, their volcanic gas compositions were quite similar with that of Miyakejima. As the continous degassing requires a large amount of magma as the source, it is likely that the volcanic gas composition represent the volatile composition of the magma supplied to each volcano. Therefore, it is suggested that the volatile compositions in the island arc magmas are similar regardless of the magma-type. The volatile content, such as H_2O wt.%, however, cannot be evaluated only from the volcanic gas composition, and further investigations with melt inclusion analyses are necessary to evaluate the volatile content variation with magma types.