

Magmatic processes prior to the Vulcanian eruptions of Sakurajima volcano: A combined petrologic and geophysical approach

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We analyzed water contents of phenocryst melt inclusions (= MIs) in the erupted materials of Vulcanian explosions from Sakurajima volcano in a period from October 30, 1975 to February 18, 2015. The 11 typical and characteristic Vulcanian explosions were selected with respect to the seismic and geodetic behaviors prior to the explosions. The water contents of 153 MIs were analyzed with FT-IR micro-reflectance spectroscopy (Yasuda, 2014). We then observed the texture of MIs and analyzed the major chemical element compositions with EMPA.

Most of the MIs have dacitic to rhyolitic compositions. The MIs in lava-type pyroclasts have lower water contents (0–1.9 wt.%) than those in the scoria type (0–4.1 wt.%). This is consistent with a general view that the lava-type pyroclasts are derived from degassed and compacted magmas in a very shallow conduit. The MIs with high water contents were quenched and fragmented at deeper parts of the conduit or within short time insufficient for water re-equilibrium with surrounding melt in the shallow conduit.

The MIs in pyroclasts from the Minamidake crater have higher water contents than those from the Showa crater. The average water content of MIs in the samples from the Showa crater is 1.4 wt.%, while that from the Minamidake crater is 0.6 wt.%. This shows that the magma was ejected from the shallower part of conduit or their residence time in the shallow conduit was longer during the activity of the Showa crater, being consistent with the fact that Vulcanian explosions from the Minamidake crater were more vigorous than those from the Showa crater.

The water contents of MIs contained in the pyroclasts erupted on August 24, 1995 from the Minamidake crater were 1.9–4.3 wt.% (2.5 wt.% on average). This range of water contents is similar to those of the three historical Plinian eruptions of Sakurajima (Araya et al., 2019). This indicates that the magma ascended nearly as fast as in the Plinian eruptions, and that magma ascent rate does not solely determine the difference between Vulcanian and Plinian eruptions.

The eruption on August 24, 1995 occurred after approximately 3 months low-activity period. As a precursory phenomenon of the explosion, rapid and large intrusion of magma was detected through inflation of the volcanic edifice observed with an extensometer. Five hours after the expansion started (at the time the tiltmeter scaled-out), the eruption began concurrently with the beginning of the BL swarm. In the early stage, the eruption was not accompanied by air shocks, and a fire fountain 100–200 m in height was observed, then later the activity shifted to the Vulcanian explosions with repeated air shocks. The volume of magma intruded prior to the eruption was estimated from the amount of crustal inflation to be more than 5 times as much as that of the average value for the explosions at Minamidake crater. Such a sub-Plinian-like eruption sequence on August 24, 1995 seems to be consistent with the result that the magma ascent rate was close to those of the Plinian eruptions.

Keywords: Vulcanian explosion, Melt inclusion, Sakurajima volcano