Shallow and deep triggering of Plinian-type eruptions inferred from acoustic and seismic eruption tremors

Mie Ichihara, Minoru Takeo, Yuki Maehara, Jun Oikawa, Takao Ohminato

Earthquake Research Institute, University of Tokyo, Japan

E-mail: ichihara@eri.u-tokyo.ac.jp

Plinian-type eruptions are characterized by sustained emission of large amounts of magma fragments with gas, and may cause strong impacts, both regionally and globally. Fluid dynamics models for such eruptions assume the control of parameters within the flow (pressure or magma input below the conduit, magma properties, and multi-phase flow dynamics), while shock-tube models used in the laboratory and calculations assume rapid decompression of magma from the top. Direct triggering for Plinian-type eruptions has been identified in relatively few cases.

Monitoring seismic and acoustic eruption tremor is useful for evaluating volcanic activity. Recent advances in remote sensing and image transmission techniques have provided observations that directly compare temporal changes in eruption behaviors and seismic and acoustic wave fields, thereby confirming the importance of interpreting information included in eruption tremor. Here we analyze seismic and acoustic eruption tremor during three sub-Plinian eruptions of Shinmoe-dake, a volcano in Kyushu, Japan.

Ground shaking caused by infrasound is sometimes significant, especially during relatively weak sustained eruptions. To eliminate this effect from the seismic data, the local response function of the ground to infrasound must be determined. Observations at Shinmoe-dake are unique in that a good infrasound source is available to evaluate the response function: Sakurajima, about 42 km away, frequently transmits explosion infrasound. However, because of the distance, the associated seismic waves do not reach the stations at Shinmoe-dake, or if they do, they are well separated from the infrasound signals. The spectral relation between the vertical velocity and infrasound from Sakurajima was used to empirically obtain the local response function at stations.

Comparing the amplitudes of seismic and acoustic tremor with other observations, we distinguish the shallow and deep triggering for each of the three sub-Plinian events. The first and the third events are preceded by rapid decompression near the surface and can be viewed as a delayed fragmentation observed in laboratory experiments (Kameda et al., 2008). In contrast, the second event grew without qualitative change in deformation or oscillation of the volcano. It is thus suggested that the triggering of the second event, if any, was deep and probably with in the magma itself. Petrological studies of eruption products are expected to provide further evidence for the deep triggering of spontaneous-onset eruptions.

