

Volcanic process of the 2011 Shinmoedake eruption inferred from extensometer records

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The Shinmoe-dake, one of volcanic cones of Kirishima volcanic group in Japan, erupted in January 2011. The activity was characterized by three sub-Plinian eruptions and a subsequent lava effusion and accumulation at the summit crater, between 26 and 31 January, 2011. Ground deformation in association with these activities was monitored by GPS and tiltmeters by several institutions. The deformation source was estimated from analysis of GPS data to be located 7 km northwest of the volcano. In addition, it has been observed by vault-housed extensometers at Isa-Yoshimatsu Observatory (ISA) placed approximately 18 km away from the summit of the crater. We inspected the time series of strain data at ISA to clarify more detail process of the subsurface volcanic activity.

Significant changes of 10^{-7} in strain are recorded at the time of three sub-Plinian eruptions on 26 and 27 January, and during lava effusion from 28 through 31 January. We estimated locations and sizes of deformation sources by using strain data at ISA, assuming horizontal position of sources to coincide with that estimated from GPS. Estimated depths of volume changes corresponding to three sub-Plinian eruptions and following lava extrusion are 7.2, 7.0, 7.6 and 8.3 km, respectively. Estimated changes in volume corresponding to these events are 1.25, 1.59, 0.94 and 5.25×10^6 m³, respectively. The ratio of the sum of volume change due to three eruptions to that of lava effusion is 0.7 and total of volume change is 9.02×10^6 m³, which are smaller than those estimated by other means.

In addition, the extensometers recorded minute strain changes of the order of 1×10^{-9} several hours prior to each of sub-Plinian eruptions. The magnitudes of the pre-eruption strain changes are about 1% of the magnitudes of co-eruption changes in strain. Temporal changes in these pre-eruption changes suggest that a gradual expansion and following quick contraction occurred beneath Shinmoe-dake. Gas and ash emission was observed during contraction phase. Although accurate estimation of locations and sizes of these deformations is difficult, calculations considering reading errors indicate that the deformation source is approximately on the same direction to the magma chamber from the ISA, and its depth is shallower than the estimated depth of those associated with sub-plinian eruptions and lava effusion. Pre-eruption deformations are also recorded by a borehole tiltmeter of the Japan Meteorological Agency at 1.5 km away from the crater of Shinmoe-dake. Analysis of the tilt data also suggests that the depth of the pre-eruption deformation source is shallow. These results propose a hypothesis that a portion of magma stored in the chamber moved upward as a forerunner of main ejection of magma, and it is ejected from the surface of the ground before sub-Plinian eruptions.