Volcano deformation caused by magma recession during a vulcanian explosion at Showa-crater of Sakurajima, Japan

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It is necessary to investigate spatio-temporal changes of pressure source during the eruptions to understand the dynamics of magma in volcanic conduit. In this study, we present a simple moving pressure source during a vulcanian eruption and calculate volcano deformation. We compare the results with the observed data at Showa crater of Sakurajima to understand the spatio-temporal change of magma recession.

We simplify the vulcanian eruption as follows. The explosion is triggered by a removal of a "cap" that pressurizes magma in the conduit beforehand. The magma head propagates downward as volcanic ash ejects. During the magma head falls down, the normal stress that works on the conduit wall weaken. At the same time, the drag force generated by magma flow is applied on the conduit wall, and its reaction force works on the bottom of conduit.

We calculate volcano deformation by using a 3-D boundary element method. We duplicate topography of Sakurajima by 10 m meshed DEM (GSI) and make a cylindrical conduit with a radius of 15 m under Showa crater. Radial tilt and strain changes caused by the magma depression and drag force at the ground surfaces are calculated at Arimura and Harutayama stations which are located at distances of 2.1 km and 3.2 km, respectively, from the Showa crater. The initial position of the magma head is set at 650 m altitude. We firstly explain deformation at Arimura caused by the normal stress. The tilt does not change remarkably during the magma head is dropped from 650 m to 0 m. The tilt starts to subside toward the crater at about 0 m and turns to uplift at about -1300 m. The radial strain shows extension at the beginning and turns to contract when the magma head reaches at about -950 m. The tilt caused by the drag force and its reaction force shows uplift toward the crater, and then turns to subside when the magma head reaches at about -1300 m. The strain shows contraction at the beginning, and then turns to show extension at about -950 m. Similar changes are shown at Harutayama station. These calculations indicate that recession process of magma in the conduit can be quantified by the tilt and the strain data.

We compare the calculation results with observation records of a Showa crater eruption on Feb 6, 2008, which is reported in Iguchi (2008). The observed radial strain shows a change from extension to contraction about 10 min after the start of eruption. The calculation indicates that the magma head downs to -950 to -1150 m at that time.

When the magma head becomes deeper than -2000 m, the tilt caused by normal stress shows uplift toward the crater, while such a change is not observed. This fact suggests that the eruption stopped at the depth shallower than -2000 m or that another deep deflation source exist.

The observed uplift toward the recorded just after the start of the eruption may be explained by upward drag force due to magma ascent at shallower part of the conduit.