A study on the volcano deformation during Vulcanian eruptions

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Recent geodetic measurements show that volcanoes sometimes inflate during the Vulcanian eruption. This result seems to contradict the idea that volcano deflates by a removal of volcanic material from conduit and reservoir. Some previous studies discuss secondary sources for such volcano inflation with, for example, volume expansion caused by gas bubble growth and bubble nucleation or viscous drag force acting on the conduit wall that are driven by a rapid expansion of magma due to gas bubble growth. In this study, however, I examine simple magma ascent process without gas bubble behavior as a source of the volcano inflation.

Magma is assumed to be pressurized in the conduit before eruption. When it erupts, the magma is driven upward by the pressure gradient built up by a sudden depressurization at the top of magma in the conduit. Depressurization propagates from the top of magma to deeper parts in the conduit, which makes the volcano deflates. Magma flow is also triggered by the depressurization, and viscous drag force acts on the conduit wall. This drag force can inflate the volcano. I calculate the deformation field caused by these two sources using analytical solutions of deformation for an semi-infinite medium. The results show that the volcano inflates when the source is shallow because the drag force is dominant. On the other hand, the volcano deflates when the source becomes deep. These predictions can explain the observed results.

However, it is noted that most of the volcanoes deflate and do not inflate during eruptions. This is probably explained by including the effect of magma fragmentation which rapidly effuses volcanic materials from the top of magma in the conduit.