Study on local crustal deformation associated with volcanic activity by InSAR observation and simple numerical simulation

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Phreatic eruptions may be related to transient pressure changes in subsurface regions of hydrothermal systems attributing a heating of shallow aquifers from magma. It means that crustal deformation presumably proceeds with the pressure increase under the ground, which can be a kind of precursor if it would be detected. One of the most difficult points is that as the eruption size becomes smaller, the precursor signal should be more local, suggesting that it is rather hard to identify the anomaly using conventional ground-based observation tools. An effective proactive monitoring method for phreatic eruptions is desired, and one of the tools to overcome the drawbacks is SAR observation.

In previous studies, I have shown the detection of locally distributed ground inflation preceding a small phreatic eruption at the Hakone volcano, Japan, through the application of interferometric synthetic aperture radar analysis (InSAR). The results show that the local inflation can be identified in the early May in 2015, almost synchronized with anomalous volcanic activity observed since the end of April, with a spatial size of ˜200 m. The maximum displacement was positioned at the center of the deformed area in the initial stage, but the peak location shifted to the southwest starting in the middle of May. The ground deformation proceeded with a trapdoor-like shape. The eruption occurred nearby the most deformed part.

In this report, I will show the crustal deformation before the anomalous activity period. Here I investigated slowly-progressive deformation by applying InSAR time series analysis using RADARSAT-2 satellite. In general, it is difficult for C-band data to get good coherence in non-urban area through a standard analysis, thus I applied an elaborated phase optimization incorporating a phase linking method. I successfully detected significant inflational crustal deformation also before the anomalous activity period. The deformed area was roundish with a diameter of ˜200 m, and the displacement eventually reached ˜3 cm for six months in line-of-sight (LOS) component. The deformation proceeded at constant slow speed of ˜5 mm/month. The ground movement could be recognized as significant by the end of 2014 at the latest, although this was not so clear because there were no available data before September 2014. Next, I constructed a pressure source model to account for the slowly-progressive deformation. Here, I apply the penny-shaped crack model proposed by Fialko et al. (2001). The pressure source was eventually estimated to be located at a depth of ˜150 m from the ground surface with a pressure change of 0.7 MPa, which is equivalent to 1,330 m^3 in volume change. Further, I discuss the mechanism of the local ground deformation on the basis of the idea of mineralogical conduit sealing, which has been indicated to be one of several possible mechanisms for phreatic eruptions. Here I conducted numerical simulation for spatiotemporal evolution of hydrothermal system using a software HYDROTHERMAL which is developed and released by U. S. Geological Survey. I set low permeability medium onto the top of volcanic conduit with high permeability, leading to the Owaku-dani area, and supply volcanic fluid and heat from the depth. Under the condition, I computed the spatial distribution and the time evolution on pressure and temperature around the cap. The simulation result shows that high pressure can be locally produced just beneath the cap region.

Acknowledgements: ALOS-2 data were provided from the Volcano Working Group under a cooperative research contract with JAXA (Japan Aerospace Exploration Agency). The ownership of ALOS-2 data belongs to JAXA. RS2 data were provided from JAXA under a cooperative research contract between GSI and JAXA, and in addition, for RS2 under a contract between JAXA and CSA. The ownership of RS2 data belong to MDA. This study was supported by JSPS KAKENHI Grant Numbers JP16K1779.

Keywords: InSAR, crustal deformation, numerical simulation

