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Magma transfer process in volcanoes revealed by continuous gravity observations

Takahito Kazama[1*], Shuhei Okubo[1], Keigo Yamamoto[2], Masato Iguchi[2], Takayuki Sugano[1], Yoshiyuki Tanaka[1], Wenke Sun[1]

[1]ERI, Univ. Tokyo, [2]DPRI, Kyoto Univ.

Gravity observation is one of the most effective methods in monitoring magma transfer in volcanoes, because magma mass redistribution can be detected as time variations of gravity value. Although portable relative gravimeters have been used to observe gravity change at volcanoes, these gravimeters have poor gravity accuracy (about 10 micro-gal) and instrumental drifts, which have often led to poor understanding of mass distribution changes in volcanoes. We thus installed driftless absolute gravimeter FG5 (observation accuracy: about 2 micro-gal; Niebauer et al, 1995) to observe highly accurate and continuous gravity data at Asama and Sakurajima volcanoes in 20 04 and 2008, respectively.
The amplitudes of the observed gravity reached 25 and 20 micro-gal at Asama and Sakurajima, respectively. The observed gravity, however, increases during rainfalls, associated with groundwater flow, not magma transfer. We then corrected the gravity disturbance originating from groundwater flow with the hydrological modeling by Kazama and Okubo (2009). (Please see a presentation on the detail of the groundwater disturbance correction by Kazama et al. in the geodesy session.)
The amplitudes of the corrected gravity resulted in 5 and 10 micro-gal at Asama and Sakurajima volcanoes, respectively. In addition, the corrected gravity decreased during eruptions and increased in volcanically quiet periods, suggesting mass redistribution in volcanoes. However, these gravity variations cannot be explained by (1) emission of volcanic gas, (2) emission and deposition of volcanic ash, or (3) inflation/deflation of magma reservoirs.
We then assumed that the gravity changes were caused by magma transfers in the shallow part of volcanoes, and converted the gravity changes into magma head variations in volcanic vents (Okubo, 2005). In both cases of Asama and Sakurajima volcano, the estimated magma heads rose up to around the volcanic craters during eruptions, and declined in volcanically quiet periods. In addition, the magma head variations were consistent with several volcanic data such as volcanic earthquake, gas and ash. We thus succeeded in understanding magma transfer processes in the shallow part of volcanoes with continuous absolute gravity observations.
In the future, we would like to install several gravimeters around one volcano to monitor higher dimensional mass redistributions. At the same time, we would like to integrate gravity observations with other new observations (such as cosmic-ray muon radiography and continuous gas observation) to understand more detailed magma transfer processes.

Keywords: absolute gravity observation, magma transfer, volcanic vent, volcanic ash, volcanic gas, crustal deformation