Continuous relative gravity observation at Sakurajima Volcano: Tilt and gravity changes during the dike intrusion event

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At Sakurajima Volcano (Kagoshima Prefecture, Western Japan), rapid tilt changes due to the inflation of the mountain body were observed on 15 August 2015, along with the increase of volcanic earthquakes (Japan Meteorological Agency, 2015). Geodetic investigations also showed that the inflation was caused by the intrusion of a dike, whose strike direction was close to the north-south axis (Geospatial Information Authority of Japan, 2015). Ascending volcanic fluid may be related to the dike intrusion, but physical properties of the fluid such as density cannot be directly identified from the observations of earthquakes and crustal deformations because these observations only detect indirect deformations of the volcanic medium.
We thus utilize the minutely continuous data of relative gravity and tilts collected by a Scintrex CG-3M gravimeter at Arimura Observatory (2.1 km south-southeast of the Showa crater), in order to discuss the mass movement process during the dike intrusion event on 15 August 2015. Note that we already corrected several disturbances in the raw data of the gravity and tilts (such as the tidal effect and instrumental drift), which will be presented in the “Gravity and Geoid” session in detail.
Tilt change: The blue and green lines in the upper panel of the attached figure show the time variations in tilt for the N35E and N55W axes on 15 August 2015, respectively. Two tilt values increased rapidly around noon, suggesting that the ground uplifted at the north of Arimura Observatory (i.e., at the area of the volcanic craters). We estimated the time constant and amplitudes of the tilt variations by fitting the exponential functions of exp(x) for x<0 and 2 - exp(-x) for x>=0 through the trial-and-error approach. The peak-to-peak tilt amplitudes are +36 and +42 micro-rad for the N35E and N55W axes, respectively, so the absolute value of the tilt changes is calculated to be 56 micro-rad, which is about 65 % of that recorded in the Arimura tunnel (Japan Meteorological Agency, 2015). In addition, the time constant of the exponential functions is 1.0 hour, and the two tilt components varied most rapidly at 11:30 in JST.
Relative gravity change: The red lines in the lower panel of the attached figure show the relative gravity change in 15 August 2015, recorded by the CG-3M gravimeter. Although a part of the gravity data scatters due to the active seismicity, a gravity step can be identified in the instrumental drift with a period of a few days. By applying the regression of a fifth-order function and the above exponential function to the gravity time series, the peak-to-peak amplitude of the gravity step is calculated to be +9 micro-Gal. However, this gravity change is inconsistent with that observed by an absolute gravimeter at Arimura Observatory (-5 micro-Gal; Okubo et al., 2015) in terms of the sign and absolute amplitude. One of the possible reasons is that the relative gravity data was disturbed by apparent gravity changes due to the significant tilt changes. In our presentation, we will report the investigation results of the tilt-derived apparent gravity changes to discuss the mass movement process from the gravity signals associated with the dike intrusion.

Keywords: relative gravity, gravity change, tilt change, Sakurajima Volcano, dike, magma