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Spatio-temporal changes of GNSS strain field caused by 2013 earthquake swarm activity in Hakone Volcano

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During the past two decades, several intense swarm activities have occurred at the Hakone volcano: 2001, 2006, 2008-2009, 2011 and 2013 (e.g., Harada et al., 2013). Crustal deformations associated with an inflation of the volcanic body were observed during these activities (e.g., Daita et al., 2009; Harada et al., 2009), except for the 2011 activity that was triggered by the Tohoku earthquake. More than 1,800 earthquakes were observed in the 2013 swarm activity; the seismic activity was remarkably activated in the period from the beginning of January and the end of February, 2013.

Data of GNSS stations installed by Hot Springs Research Institute of Kanagawa Prefecture (HSRI) was not available before the 2013 swarm activity. Thus, in the 2013 activity, we could observe crustal deformation first time by dense GNSS observation with an average interval of approximately 5 km, including GEONET and HSRI stations. The crustal deformation data observed by the dense network give us an important opportunity to clarify the spatio-temporal changes of strain fields associated with the volcanic activity and to understand a generation process of the earthquake swarms.

Through the analysis of areal strain field, we found that the crustal expansion occurred from the middle of December 2012, before the initiation of the 2013 swarm activity. The crustal expansion continued until the end of the swarm activity. An accumulated areal strain during this period was about 1.7 micro-strain at the central cone of the Hakone Mountain. By adding the GNSS data observed by HSRI stations, the location of expansion region could be well constrained.

To explain the distribution of the areal strain field, we assumed spherical pressure source models. Horizontal position of the sources were set at the center of the expansion region (139.000E,35.215N), and depths of them were assumed two cases, 7 and 10 km. In each case, volume changes were estimated 1.5×10^6 and 4.0×10^6 m^3, respectively, to explain the areal strain distributions. As a result, we found that the spherical pressure source at a depth of 10 km was more plausible to explain the strain field. This result is consistent with a location of magma chamber beneath the Hakone Mountain estimated by the seismic tomography (Yukutake et al., 2014).

From the result of this study, we concluded that the volume change started in the magma chamber at a depth of 10 km, prior to the 2013 swarm activity, and continued for two months until the end of the swarm activity. In future studies, it is important to interpret the relationship between other phenomenon for clarify the process of the activity in more detail.

Keywords: Hakone Volcano, earthquake swarm activity, GNSS, strain field