Aseismic slip during the earthquake swarms in Hakone volcano on May 2019

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The occurrence of earthquake swarms has been related to crustal fluid migration (e.g., Parotidis et al., 2005) or an aseismic slip on fault planes (e.g., Lohman and McGuire, 2007). In Hakone volcano, central Japan, shallow intense swarm activities were often observed. Based on the dense seismic observation data, the hypocenters of the earthquake swarms show a diffusion like migration that follows a diffusion equation and gives hydraulic diffusivity between 0.5 and 1.0 m^2/s (Yukutake et al., 2011). The observation implies that the earthquake swarms were triggered by the high-pressure crustal fluids. On the other hand, we observed a precursor seismic activity, several repeating earthquakes and tilt changes before or during the swarm activity in the Hakone volcano, on May 2019, as well as the diffusion like migration of hypocenter. The hypocenter distribution relocated by the double-difference method (Waldhauser and Ellsworth, 2000) presents a plane-like distribution oriented to the E-W and vertical dipping angle. The detailed spatial distribution of seismicity estimated by the Matched filter method on the plane-like distribution shows that the precursive seismic activity occurred on the middle part of the plane in the period from 11 to 18 May, following the remarkable earthquake swarms. We observe a migration of precursive seismicity toward the starting point of the remarkable earthquake swarms at the speed of 70m/day, and also found that the remarkable earthquake swarms started from 18 May show a diffusion like migration of hypocenter that gives a hydraulic diffusivity of 3.0 m^2/sec. 56 groups of repeating earthquakes were identified during the seismic activity. Averaged slip histories estimated from the repeating earthquakes following the method of Uchida et al. (2003) indicate that a subtle aseismic slip of 0.5 mm occurred during the precursive seismic activity, while the aseismic slip accelerated during the earthquake swarms from 18 May up to the cumulative slip of 4 mm. We observed the tilt changes at several bore-hole stations near the source region, suggesting that a dextral strike-slip of 8 mm containing a normal slip component occurred on the fault plane that consistent with the plane-like hypocenter distribution. The slip amount and direction are consistent with that obtained by the analysis of repeating earthquakes and a rake angle in the focal mechanism of earthquake swarm. The observed tilt changes were not explained by the cumulative moment of all swarm events. These observations imply that the aseismic slip on the fault plane was related to the triggering the earthquake swarms, in addition to the reduction of fault strength due to the highly pressurized crustal fluid.

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