

Earthquake swarms and their relation to crustal fluid as revealed by dense seismic observation in Hakone volcano, central Japan

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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). This study aims to investigate the contribution of crustal fluid to the occurrence of earthquake swarms, based on the highly resolved hypocenter distribution and seismic tomography results in Hakone volcano, central Japan, where shallow intense swarm activities and crustal deformation associated with inflation of the pressure source were often observed. The hypocenter distribution of earthquake swarms reveals thin vertical plane-like zones, each with a thickness of several tens of meters. Moreover, hypocenters of the earthquake swarms migrate following a diffusion equation that gives hydraulic diffusivity between 0.5 and 1.0 m²/s (Yukutake et al., 2015). Low stress drop and high b-values are estimated for the earthquake swarms during the initial stage of activity. These observations imply that the earthquake swarms were triggered by the diffusion of high-pressure crustal fluids within the fault damage zones. Tomographic inversion reveals a region of low P-wave velocity (V_p), low S-wave velocity (V_s), and high V_p/V_s ratios at depths of 10–20 km beneath the volcano, corresponding to the locations of the pressure sources (Yukutake et al., 2015). The high V_p/V_s ratios represent a deep magma chamber with a high content of fluid and melt, according to the theoretical modeling by Takei (2002). Above the high V_p/V_s zone, a region of low V_p , low V_s , and low V_p/V_s ratios exists at depths of 3–10 km, suggesting the presence of crack-filled water or CO₂ supplied from the deep magma chamber. Most of the earthquake swarms occur in this low V_p/V_s zone. These results indicate that the crustal fluids from the magma source substantially contribute to the generation of the earthquake swarms, as well as the geothermal activity in Hakone volcano.

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