# Well-resolved hypocenter distribution of earthquake swarm in the caldera of Hakone Volcano

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Hakone volcano is located at the northern part of the Izu-Mariana volcanic arc in central Japan. There is tectonically and volcanically active area. Within the caldera of Hakone volcano, there has been fumarolic activity around the Owakidani area. Although there is no historical record of eruptive activity, Kobayashi et al. (2006) indicated that phreatomagmatic eruption might occur between the latter half of the 12th and 13th centuries. Within the caldera, many intense earthquake swarms have been reported since 1786. Recently, the earthquake swarms were remarkably activated in 2001 and 2006 (e.g. Tanada, 2002; Tanada, 2007). With these activities, the crustal deformation was detected surrounding the tiltmeters and GPS stations net-work (Geographical Survey Institute, 2002; Geographical Survey Institute, 2007; Daita et al., submitted). After the swarm activity in 2001, new fumarolic area emerged at the northern slope of the Owakidani area (Tanada, 2005). To determine highly resolved hypocenter and focal mechanism distribution in Hakone volcano is important to discuss mechanism of swarm earthquake, and to clarify its relationship to the crustal deformation and fumarolic activity.

We used 50 permanent online stations operated by HSRI, NIED Hi-net and the ERI of the University of Tokyo. We used 9073 events that occurred within the caldera of Hakone volcano, and period between April, 1995 and June, 2008. We estimated the one-dimensional velocity structure and station correction, applying the JHD method (Kissling et al., 1994). We determined the hypocenters of 9073 events by the modified Hypomh program (Hirata and Matsu'ura, 1987), which uses the station corrections and one-dimensional structures for P- and S-wave velocities (Kawanishi et al., 2008). The double-difference (DD) relocation method (Waldhauser and Ellsworth, 2000) was applied to the double-difference data using the initial hypocenters obtained by above procedures. We relocated the initial hypocenters with the DD relocation method, using the differential arrival time obtained by both manual picking and waveform cross-correlation analysis. Subsequently, we determined the focal mechanisms from the absolute P- and SH-wave amplitudes by adding the P-wave polarities.

From the relocated hypocenter distribution, we found that most of the swarm earthquake in Hakone volcano concentrated on the fault plane with the dimension from 100 m to several km scales. The directions of these fault planes are mainly oriented to the EW or NW-SE strike. These directions are broadly consistent with the nodal plane of focal mechanisms that are strike-slip and normal fault type. We estimated the stress field from the focal mechanisms using the stress inversion method developed by Michael (1987). We found that the fault structures associated with the swarm activity are developed to the parallel or oblique directions to the S1 axis. These results are consistent with the fault structure model by Sibson (1996), that the fault structures concerned with swarm activity are controlled by the stress field around them.

In Owakidani region, the swarm earthquakes in 2001 were aligned with the fault plane with NW-SE strike direction. On the other hand, the open crack model in 2001 estimated from the geodetic data (Daita et al., submitted) are oriented in the direction of WNW-ESE which is inconsistent with the hypocenter distribution of swarm earthquakes in 2001. This result might reflect the model by Hill (1977) in which shear fractures occur along oblique fault planes to the dike intruded fault.