

Mechanisms transition of LFEs beneath Zao volcano due to the stress change induced by the 2011 Tohoku earthquake

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Deep low-frequency earthquakes (LFEs) with dominant frequencies of 2–8 Hz occur at depths of 20–40 km, which is deeper than the depth of regular crustal earthquakes. Many previous studies indicated that focal mechanisms of LFEs have non-double-couple components such as CLVD (compensated linear vector dipole) and volumetric deformation. Therefore, LFEs are thought to be related to the magma or crustal fluid, but their physical mechanisms are still unknown. The focal mechanisms of LFEs are key information for understanding the physics underlying LFEs. Seismicity of LFEs in Zao has increased about two years after the Tohoku earthquake, so we are also interested in the potential variations of focal mechanisms in association with the seismicity change.

We analyze the mechanisms of 48 LFEs beneath Zao volcano by using the amplitude ratios of S-wave to P-wave. The site effect at each station is corrected using the radiation from regular earthquakes with known mechanisms. We assume four focal models (double-couple, CLVD, tensile-crack, and single-force) and determine an optimal model based on AIC (Akaike information criteria), to minimize the residuals between observed and theoretical S/P ratios with a penalty for the number of parameters.

We successfully determined focal mechanisms of 29 events. While the majorities are double couples (18 events; 62%), there are notable numbers of non-double-couple LFEs. The obtained mechanisms are classified into five groups, three types of double-couple (DC-A, DC-B, DC-C), a CLVD type (CLVD-D) and a single-force type (SF-E). Whereas the DC-A LFEs are observed only before the increase of LFE seismicity, most of the other types are generated after the increase of seismicity. The DC-A is consistent with the local stress field, and the symmetry axis of CLVD-D is sub-parallel to the P-axis of DC-A, so the CLVD-D is interpreted to be a shear-tensile-crack under the similar stress field. Considering that the transition of focal mechanisms was two years later than the Tohoku earthquake, we suggest that the lateral compressional stress field became less dominant near the source of LFEs two years after the Tohoku Earthquake, probably associated with afterslip and viscoelastic relaxation, and the change in local stress field altered the occurrence of LFEs.

Keywords: Low-frequency earthquake, The 2011 Tohoku earthquake, Focal Mechanisms