

Focal Mechanisms of Volcanic Deep Low Frequency Earthquakes in Northeast Japan

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Deep low-frequency earthquakes (LFEs) are small events ($M < 2$) with dominant frequencies of 2–8 Hz. LFEs in Northeast Japan mainly occur at depths of 20–40 km around active volcanoes. Many previous studies obtained various focal mechanisms including both double-couple and non-double-couple components. Therefore, physical models related to the movement of magma or crustal fluid have been proposed. However, we need further case studies to constrain their physical mechanisms. Thus, we determine the focal mechanisms of volcanic LFEs beneath 21 volcanic regions and examine the temporal variation of focal mechanisms in relationship to seismicity and large earthquakes.

To analyze the mechanisms of LFEs, we use the amplitude ratios of S-wave to P-wave (S/P ratios). First, the site effect at each station is corrected using the radiation from regular earthquakes with known focal mechanisms. Next, we carry out a grid search to estimate the moment tensor components which minimize the residuals between observed and theoretical S/P ratios. Finally, we select reliable solutions using the Bootstrap test.

We obtain various focal mechanisms of 155 events including significant non-double-couple component, while there are some events with similar focal mechanisms in each region. In order to evaluate the similarity of mechanisms, we perform clustering analysis using the density-based algorithm. Based on the results of clustering, we determine representative focal mechanisms for seven regions. We calculate induced stress tensors from the 2008 Iwate-Miyagi earthquake and the 2011 Tohoku earthquake to quantitatively evaluate the triggering potentials. As a result of this analysis, representative focal mechanisms in seven regions show good agreement with the LFE activity change associated with the 2011 Tohoku earthquake. This result indicates that seismicity of LFEs are controlled by the temporal stress change as well as shallow crustal earthquakes.

Keywords: low-frequency earthquake, the 2011 Tohoku Earthquake