The diversity of focal mechanisms of volcanic deep low frequency earthquakes in Northeast Japan caused by spatiotemporal stress pattern

*Genki Oikawa[1], Naofumi Aso[1], Junichi Nakajima[1]

1. Tokyo Institute of Technology

Deep low-frequency earthquakes (LFEs) in Northeast Japan occur actively beneath the active volcanoes at depths of 20–40 km. LFEs radiate low-frequency seismic waves, with most energy at 2–8 Hz, despite their small magnitudes (M < 2). Although many previous studies obtained various focal mechanisms with non-double-couple components and suggested physical process related to fluid movement, the universal physical process is poorly understood. Therefore, we comprehensively determine focal mechanisms of 264 LFEs for 26 volcanic regions in Northeast Japan using the S/P amplitude ratios. In addition, we investigate the relationship between the static stress change of large earthquakes and activity of LFEs by evaluating the similarity between stress tensors and moment tensors of LFEs. We calculate induced stress tensor orientations of both the 2008 Iwate-Miyagi earthquake and the 2011 Tohoku earthquake using “Coulomb 3.3” program (Toda et al., 2005; Lin et al., 2004).
Many of the obtained solutions have large double-couple component with small compensated linear vector dipole component. Considering that we determine focal mechanisms using the initial part of waveforms, this result suggests that the initial rupture process of LFEs is dominated by shear slip on the faults like ordinary earthquakes. Such source mechanisms can be explained by shear slip on the bending fault. We also find that plunge of the Null axis increases from 22º at 20 km depth to 41º at 40 km depth, which indicates that focal mechanisms change from dip-slip type to strike-slip type with depth. The differential stress change in the depth direction may be caused by the depth variation in physical properties such as Poisson’s ratio. In an extreme case of viscous fluid with high Poisson’s ratio, isotropic stress is produced, while in the other extreme case of elastic body with low Poisson’s ratio, the differential stress appears large, which results in the east-west compressional and vertically-tensional stress. With regard to the temporal stress change, we find that activity change and similarity between stress tensors and moment tensors of LFEs have some correlation. Their weak correlation suggests that the seismicity of LFEs is more or less sensitive to temporal stress change.

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