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Semi-Volcanic Low-Frequency Earthquakes and Stress Accumulation during Magma Cooling

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Deep low-frequency earthquakes (LFEs) are relatively small earthquakes that radiate low frequency seismic waves. While tectonic LFEs on plate boundaries are thought to be thrust events, the mechanisms of volcanic LFEs around the Moho beneath active volcanoes have not yet been firmly established. Recently, we examined a unique class of LFEs that occur far from active volcanoes but which are otherwise similar to volcanic LFEs [Aso et al., 2011; 2013]. Since these 'semi-volcanic' LFEs occur far from active volcanoes, they may provide clues to generally explaining why LFEs occur.

We used waveform inversion to estimate focal mechanisms of semi-volcanic LFEs in eastern Shimane, where the second-most frequent (semi-) volcanic LFEs occur in a quiet region. The focal mechanisms and moment rate functions were estimated by grid search and a linear inversion, respectively. The moment rate functions determined from our inversions oscillate between positive and negative values. The focal mechanisms for many LFEs are found to be dominated by a CLVD component, with their symmetry axes parallel to the lineation formed by the source distribution.

Based on these observations, we tried to develop a physical source model of semi-volcanic LFEs. We suggest that the fundamental driving force of these LFEs is due to the rapid density change caused in a cooling process of magma. Our model involves three steps: stress accumulation, stress release, and oscillation excitation. First, we calculate the expected amount of accumulated stress and compare the speed of accumulation and that of diffusion. Next, we explain the reason why the brittle deformation prefers CLVD type of deformation to simple faulting. Finally, we evaluate a basic frequency and an attenuation factor of the resulting oscillation.

Keywords: Semi-Volcanic Low-Frequency Earthquakes, CLVD, Cooling Magma