

Comprehensive analysis of deep low-frequency earthquakes in 52 regions all over Japan

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In the most volcanic regions all over Japan, deep low-frequency (DLF) earthquakes occur at depths of 10–50 km in which regular crustal earthquakes rarely occur. The dominant frequencies of DLF earthquakes are about 1–10 Hz, which is lower than those of regular earthquakes with similar magnitudes. DLF earthquakes near volcanoes are considered to be affected by fluid in the lower crust because they often occur in or around of low-velocity anomalies (e.g. Hasegawa et al., 2005). However, generating mechanism of DLF earthquakes and relationship with the surrounding structure are still unknown because hypocenters of DLF earthquakes do not have a good resolution due to their weak signals. Kurihara et al. (2019 SSJ) analyzed DLF earthquakes all over Japan based on relocation analysis using network correlation coefficient method (Ohta and Ide, 2011), classification using waveform correlation, and detection using matched filter technique. In results, for example in Hijiori, northeastern Japan, we showed that hypocenters of DLF earthquakes concentrate into some small isolated groups with separations of several kilometers in the vertical direction. Temporal activity patterns of DLF earthquakes are different in each group; in other words, there are both groups in which DLF earthquakes constantly occur and episodically occur. As like Hijiori, discrete distributions of groups of DLF earthquakes were also observed in many other volcanoes.

In this study, as for quantifying temporal activity patterns of DLF earthquakes, we defined an index “swarm ratio (SR)” for each group of all regions which show the ration of swarm DLF earthquakes and generally classified the activity patterns in 52 regions all over Japan. SR means the ratio of swarm DLF earthquakes out of all DLF earthquakes in the groups. Swarm DLF earthquakes were defined as the DLF earthquakes. Swarm DLF earthquakes are defined when 10 or more earthquakes occur with the shorter interval from the former earthquake than the expected interval time of the group.

In many regions especially in Tohoku district, only the groups of DLF earthquakes with SR lower than 0.7 in which DLF earthquakes constantly occur were observed. On the other hand, 12 regions, such as Yakedake and Ontake, included groups with high SR values over 0.7 that shows episodic occurrences of DLF earthquakes. In addition, magnitude-frequency distributions show that groups with episodic DLF earthquakes have high b-value in Gutenberg-Richter law compared to groups with constant DLF earthquakes. These results suggest that episodic DLF earthquakes may repeatedly occur in the concentrated same smaller-scale sources and constant DLF earthquakes may occur in some different sources.

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