

Magma supply from lower crust to surface volcano inferred from activities of deep low-frequency earthquakes

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In most volcanic regions, deep low-frequency (DLF) earthquakes 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. The relationship between activities of DLF earthquakes and surface volcanic activities such as eruptions was discussed so far because we have observed many DLF earthquakes beneath active volcanoes. For example, DLF earthquakes were observed before the 1986 eruptions of Izu-Oshima volcano and 1991 eruptions of Pinatubo volcano. Recent studies also showed increases of DLF earthquakes before the eruptions in Klyuchevskoy volcano in Russia and Hakone volcano in Japan. However, the number of observations of DLF earthquakes associated with volcanic activities is small and the relationship between DLF earthquakes and volcanic activities is still unknown in many volcanoes. To reveal detailed activities of DLF earthquakes, we analyzed DLF earthquakes occurring in 49 volcanic regions all over Japan based on relocation, classification, and detection analyses and we made catalog of DLF earthquakes from April 2004 to December 2018. Then, we newly found the relationship between activities of DLF earthquakes and volcanic activities in Kirishima, Meakan, Sakurajima, and Ontake.

In Kirishima, DLF earthquakes at depths of 25 km increased during the period of the 2011 eruption, and hypocenters of these DLF earthquakes were deeper than the those of DLF earthquakes in the other period. The waveforms of the DLF earthquakes during the period of the 2011 eruption have low dominant frequencies (Kurihara et al., 2019). In Meakan and Sakurajima, DLF earthquakes during the periods of eruptions and crustal deformation also have lower dominant frequencies than DLF earthquakes during other periods. On the other hand, in Ontake, Hakone and at the eruptions of Kirishima in 2018, DLF earthquakes with usual occurrence increased before and after the eruption. In Ontake and Hakone, DLF earthquakes in several groups increased, but the activation timing differs for each group. In many cases, the period of the increase of DLF earthquakes related to the period of the crustal deformation, which is thought to be related the expansion of shallow magma chambers.

These results suggest that DLF earthquakes may be associated with the supply of magma from the deep crust. In addition, the magma may pass only around a part of the source regions because the increase of DLF earthquakes may be limited in a part of the source region.

Keywords: Deep low-frequency earthquake, Kirishima volcano, Ontake volcano