

Seismic velocity structure beneath southern Hokkaido and its relation to crustal deep low-frequency earthquakes

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The crustal deep low-frequency earthquakes (CDLFE) are often occurred beneath active volcanoes in Japan (e.g., Takahashi and Miyamura, 2008). Additionally, some CDLFEs showing the similar characteristics for those observed beneath volcanoes are also detected in non-active volcanic areas, such as a fault zone (e.g., Ohmi and Obara, 2002). However, relations between the CDLFEs and volcanoes and regular earthquakes occurred in the arc crust have not been revealed in clearly.

In southern Hokkaido, the CDLFEs are observed beneath both of active volcanoes and non-active volcanic areas, which corresponds to shallow swarm-like activity of the regular crustal earthquakes. This indicates southern Hokkaido is an interesting region for understanding the relations between the CDLFE and near surface phenomena, including volcanoes and crustal earthquakes. In this study, therefore, we investigate seismic velocity structure beneath southern Hokkaido in detailed and then discuss the relations of them based on the obtained heterogeneous structure.

In order to estimate the seismic velocity, we applied the double-difference tomography technique (Zhang and Thurber, 2003; 2006). From the earthquake catalogue by Japan Meteorological Agency, we collected 15,645 earthquakes which occurred in the period from March 1st, 2003 to June 15th, 2016. A magnitude range of the earthquakes was 1.5-6.5. The number of travel time data is 306,335 for P wave and 242,093 for S wave.

In addition to characteristic structures as imaged in previous studies (e.g., Kita et al., 2010; Niu et al., 2016), the obtained results clearly show the low-velocity zones are distributed at depths of about 20-40 km beneath around the active volcanoes and generating regions of the CDLFEs. Correspondingly, high- V_p/V_s ratio is calculated at the depths. In contrast, high-velocity zones are widely determined at a depth of 10 km, while reductions of seismic velocity from surroundings are obtained near the active volcanoes. The crustal earthquakes which involves shallow seismic swarms occurred above the DLFEs seems to be located within the high-velocity zones. The obtained spatial variations of the seismic velocity demonstrate that the CDLFEs are posited at transition zones of velocity and V_p/V_s ratio, proposing that presence and migration of fluids or melts would attribute for their triggering (e.g., Ukawa and Ohtake, 1987). Additionally, heterogeneity that associate with the upper crust and correspond to the CDLFEs seem to closely link to the subsurface phenomena at above the CDLFEs: crustal earthquakes occurred in the upper crust are facilitated in the high-velocity zones and active volcanoes are located within the low-velocity area those compared from surroundings.

Keywords: seismic velocity, deep low-frequency earthquakes, seismic swarm, Hokkaido