Seismic activities of high- and low-frequency earthquakes around the Lake Towada

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The Towada volcano, which is located on the volcanic front in northern Japan, has repeated huge eruptions historically. Recent establishment of dense seismograph network enables us to obtain the spatiotemporal change of seismicity in detail. In this study, we summarize the recent activity of both high-frequency (HF) and low-frequency (LF) earthquakes around the Lake Towada. Also we discuss the relation between the crustal structure and the focal region of LF events.

Here we used waveform data of Aomori Pref. and Hi-net to estimate the hypocenters of ultramicroearthquakes. For the period from 2001 to 2002, the number of events with magnitude above -1.0 is 834 including 116 LF events. Our hypocenter catalog is almost complete above M=-0.5, judging from the fact that the magnitude-frequency relation is well approximated by the Gutenberg-Richter relation. Epicenters of HF events form several clusters with the depths ranging from 5 to 10 km especially around the inner caldera of the Towada volcano. The epicentral distribution of LF events, however, is concentrated to the south of the Lake Towada. The activity of LF events is separated in two depths; one is located in the mid-crust (~15 km), the other is in the deep crust (~25 km). Although such feature is also noticed beneath Mt. Iwate, seismicity of Towada is characterized by the adjacency of HF events in the shallow crust and the LF events in the mid-crust.

For the swarm beneath Nakanoumi on July 14, 2002, the largest event with magnitude 2.5 has normal-fault-type focal mechanism with the T-axis in NE-SW direction. For the swarm beneath the root of Ogura Peninsula on September 24, 2002 and January 19, 2003, the number of earthquake in one day rose up to 115 and 180, respectively. Normal-fault-type focal mechanism is also suggested for these events, though uniqueness of nodal planes is rather poor. Generally E-W trending compressional stress field governs the inland crust of Tohoku region. Thus the Towada volcano is unusual because of the existence of normal fault type activity.

After the first identification of LF event around the Lake Towada in the summer of 2001, LF events had become active until late 2001. Careful inspection of the time series revealed the following change of seismicity pattern. First, in late September 2001, 5 LF events occurred in the deep crust, followed by quiescence lasted about one month. Then, from mid-November to December, LF events in the mid-crust were activated. Moreover, swarms of HF events were also observed in the period corresponding to the quiescence of LF events. Also we observed the unique phenomena that the successive occurrence of LF events in the mid-crust forms low-frequency wave trains for three times in that period (Ohtani et al., 2002). These facts suggest some relation between the occurrence of HF and LF events.

To investigate the crustal structure of the focal region of LF events beneath the Towada volcano, we estimated the receiver functions based on the technique newly developed by Shiomi (2002). From the analysis of 37 teleseismic events observed from 2001 to 2002, the Moho depth was estimated to be about 35 km beneath the Towada volcano. Also the existence of low velocity layers in the mid-crust (~10 km) and the deep crust (~25 km) is in good agreement with the depths of LF events. The fact that the focal region of LF events in the deep crust corresponds to the low velocity zone near Moho is commonly observed for other active volcanoes, including Mt. Iwate. In Mt. Iwate area, however, LF events in the mid-crust occur in a high velocity layer, suggesting the difference of earthquake generation process between two volcanoes. Estimation of 3D seismic structure is indispensable to understand the nature of HF and LF events beneath the Towada volcano.

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