Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

U004-P16 Room: Convention Hall Time: May 24 17:15-18:45

Correlation of seismicity between deep low-frequency earthquakes and shallow earthquakes beneath Shimokita Peninsula

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1. Introduction
Deep low-frequency earthquakes (DLFEQs) that occur at depths from the lower crust to the uppermost mantle in the Japanese Islands attract great interest of earth scientists because they are located beyond the depth limit of brittle-ductile transition of rocks. Source mechanism of DLFEQs are thought to be related with magma or derived crustal fluids, however, the general conclusion has not yet obtained. Ten years passed since the Japan Meteorological Agency (JMA) started to set a flag of low-frequency earthquakes in the earthquake catalog by JMA. Because this catalog may provide useful information for seismicity of DLFEQs, I investigated the spatio-temporal variation of DLFEQs location beneath the Shimokita Peninsula in the northeastern Japan.
2. Hypocenter distribution of DLFEQs
The data set I used is (1) the JMA catalog, (2) hypocentral data relocated by using arrival time data of JMA catalog and different location method, and (3) the hypocentral data picked by myself. The hypocenter distributions from these data sets show no significant difference. I also compared with the relocated hypocenters by using the homogeneous station method. The hypocenter distributions are again similar, which suggest that the hypocenter location of DLFEQs beneath the Shimokita Peninsula depends strongly on neither the data set nor the location method.
One notable characteristics of hypocenter distribution is its elongation in the depth direction. There are two clusters in the shallow part (12-28 km) and the deeper part (30-45 km). This depth range over 30 km is far larger than the depth uncertainty of earthquake location. In addition, the waveforms of deeper DLFEQs show systematically longer S-P times than those of shallower DLFEQs. Thus the elongated hypocenter distribution is not due to artifact of mislocation. This pattern of double clusters is common to that of DLFEQs beneath the Towada volcano located about 100 km to the south of Shimokita Peninsula.
3. Spatio-temporal variation of seismicity
I investigated the spatio-temporal change in hypocenter location by using the JMA catalog. Generally the seismic activity is regular for shallower DLFEQs while that of deeper DLFEQs is intermittent. Seismicity of these clusters is complementary. During the active period of deep seismicity, 2000-2001 and 2005-2006, the depth of shallower DLFEQs were decreased. In a quiescent period of deeper seismicity from 2003 to 2004, the shallower DLFEQs were quite active. I found there is a correlation of seismicity between the shallower DLFEQs and ordinary earthquakes. An example of complementary activity is seen in a short quiescent period in mid 200 3, when the activity of ordinary earthquakes has increased. Other correlation is a synchronous change in focal depth of both clusters during the period from 2007-2009.
At present the cause of correlation is not clear, but a probable and likely mechanism is the stress change in the shallow crust resulted from the occurrence of DLFEQs. The generation mechanism of DLFEQs has been tackled by the viewpoint of source mechanisms through the analyses of seismic waves, however, the correlation of seismicity will provide an additional clue to clarify the generation mechanism.
Acknowledgement

I used waveform data from seismic stations of Tohoku university and Hokkaido University, Hi-net, and JMA. I also used the earthquake catalog by the JMA.

Keywords: low-frequency earthquakes, seismicity, hypocenter distribution, Shimokita Peninsula, correlation