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Spatial distribution of high- and low-frequency earthquakes among the aftershocks of the Iwate-Miyagi Nairiku Earthquake

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1. Introduction

Low-frequency earthquakes (LFEQs) have been attracted the interest of seismologists by their waveform characteristics that reflect the unusual source processes. Some LFEQs occur as the aftershocks of large earthquakes. Here we detect LFEQs from the aftershocks of the Iwate-Miyagi Nairiku Earthquake in 2008 and investigate their spatial distribution to get insight to their origin.

2. Data and method

We detect LFEQs by using the predominant frequency of Fourier spectral amplitude for both body wave and coda wave observed at 59 temporal stations operated by the group for the aftershock observations. The predominant frequency depends both hypocentral distance and earthquake magnitude. Thus we first estimate the zero-offset frequency for each earthquake by straight line fitting between the logarithm of predominant frequency and the hypocentral distance. Then we performed a linear regression between the logarithm of zero-offset frequencies and the earthquake magnitudes. We define the frequency deviation for each earthquake by the frequency difference from the regression line. On the scatter plot between the frequency deviation for body wave as the horizontal axis and those for coda wave as the vertical axis, there is a clear positive correlation. We define high-frequency earthquakes (HFEQs) and LFEQs as those in the first quadrant and third quadrant on the scatter plot, respectively, with larger frequency deviation than the standard deviation.

3. Spatial distribution of high- and low-frequency earthquakes

HFEQs are distributed preferentially in the source area of main shock, in particular, in a wide area to the north of mainshock and a linear zone to the SSE of mainshock. On the other hand the LFEQs are distributed complementarily to the HFEQs, in a wide area to the WNW and to the SWS of mainshock, and outside the source area both to the north and to the south. Compared with the geology, the LFEQs are located around the Kurikoma and Yakeishi volcanoes, and in the calderas formed from the Pliocene to the early Pleistocene in age. This suggests that these LFEQs occur in hotter areas where the ductile deformation occurs. Not a few LFEQs occur in a northern extension of seismogenic fault, where postseismic deformation was observed by GPS. This deformation is attributed to the aseismic slip on a fault that did not move coseismically. The LFEQs in the area are located along a deep boundary of aseismic fault. The HFEQs occur on the seismogenic fault that is located to a deeper extension of aseismic fault. This spatial pattern suggests the effect of both the increased pore pressure and the decreased normal stress on the faults as the location moves from the deeper part to the shallower part. Thus the distribution of LFEQs is a key parameter to interpret the role of crustal fluids to the seismogenic processes.

Keywords: low-frequency earthquakes, aftershocks, Iwate-Miyagi Nairiku Earthquake, geofluid