Spatial distribution of low-frequency earthquakes suggestive of geofluid among the aftershocks of the 2008 Iwate-Miyagi Nairiku Earthquake in northeastern Japan

Masahiro Kosuga
Hirosaki University, Hirosaki, Japan (mkos@hirosaki-u.ac.jp)

In northeastern Japan, low-frequency earthquakes (LFEQs) occur preferentially at depths from the lower crust to the uppermost mantle near the active volcanoes. Many researchers have suggested the contribution of geofluid to the occurrence of these unusually deep LFEQs. Recent observations show that relatively low-frequency earthquakes occur even in the upper crust as well. Investigation of the generation mechanism of shallow LFEQs is quite important because it is directly related to the mechanism of closely located high-frequency earthquakes in the brittle upper crust. One of the areas of enhanced shallow LFEQ seismicity is the aftershock zone of the 2008 Iwate-Miyagi Nairiku Earthquake (Mw 6.8) located to the west of the 2011 great Tohoku earthquake. We detected LFEQs by using the frequency index (FI) defined by the logarithm of a ratio of high- and low-frequency spectral amplitudes. We used 2–4 Hz and 10–20 Hz bands for low- and high-frequency ranges. We analyzed more than 4000 events observed by a dense temporary seismic network deployed just after the occurrence of the mainshock. Our detection revealed that there are five LFEQs dominant clusters in the aftershock zone trending NNE-SSW with a length of about 40 km: the northern and the southern edge of the aftershock zone, to the north of the mainshock epicenter, the eastern and western edge of the central aftershock zone. In the area near the mainshock epicenter, hypocenter distribution shows two planes: mainshock fault dipping to the west and a conjugate fault dipping to the east. The previous study has shown that the events with N-S trending largest principle stress axis are distributed along the conjugate plane. In contrast, the events along the mainshock fault have E-W trending largest principle axis that is consistent with the relative motion of the subducting Pacific plate beneath the Tohoku region. The former anomalous groups are interpreted to be caused by local stress change by the mainshock applied to a neutral stress field with high pore pressure suggested by high Vp/Vs ratio. An interesting feature is the preferential distribution of LFEQs along the conjugate plane. Also, the hypocenter of LFEQs migrated with time from deeper to the shallower part of the plane. These observations strongly suggest that the existence and movement of geofluid are responsible for both the unusual stress field and the occurrence and migration of LFEQs. The location of LFEQs at the northern and eastern edge of the aftershock zone is close to the areas of postseismic slip detected by GNSS observation, which is suggestive of the increased pore pressure in the area. The LFEQs at the southern and western edge of the aftershock zone occur in calderas, suggesting that these LFEQs occur in hotter and/or fluid-rich areas where the ductile deformation occurs. Thus, though
the interpretation of the cause of LFEQs is not unique, the distribution of LFEQs plays a crucial role in understanding the contribution of geofluids not only to the seismogenic processes of aftershocks but to the faulting mechanism in the upper crust.