Multi-planar structures in the aftershock distribution of the Mid Niigata prefecture Earthquake in 2004

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A shallow destructive inland earthquake of M6.8 occurred at 17:56, on Oct. 23, 2004 (JST) in the middle part of Niigata prefecture, Japan. This earthquake accompanied the prominent aftershock activity with four aftershocks of M6.0 or greater.The difference of the magnitude, 0.3, between the main and the largest aftershock of M6.5 occurred at 18:34, On Oct. 23 was smaller than the median of the difference, 1.6, for main shocks of M6.8. The main purpose of this study is to understand and confirm the complicated fault structures with high aftershock activity of this earthquake. We make precise hypocenter locations of seismic activity by adopting the double-difference earthquake location algorithm (Waldhauser and Ellsworth, 2000), and investigate the structure of the aftershock distribution in detail.

We analyze the events for the period from the occurrence time 17:56 on Oct. 23 of the main shock to 24:00, Nov. 30, 2004. For the original data set, we select the P- and S-wave arrival times observed at 19 regional stationary seismic stations from the integrated seismological bulletin.

We can summarize the characteristics of this activity as follows: (1) the distribution of the hypocenters has a double-planar structure with a distance 5km in parallel dipping in WNW about 50 degrees and a single-planar structure dipping in ESE about 15 degrees, (2) the formation of the upper and lower planes of the double plane began with the main shock and the largest aftershock of M6.5 which occurred in the respective planes, and finally that of the ESE dipping plane began with the 3rd largest aftershock of M6.1 occurred at 10:40, on Oct. 27 in the same plane, and (3) the areas of the planes are almost proportional to the magnitudes of these events.

From the above characteristics we can conclude that three dipping planes formed by the aftershocks represent the fault planes of the large events mentioned above. The fault of the main shock is nearly parallel to that of the largest aftershock. The fault of the 3rd largest aftershock seems to be a conjugate fault which is located on the upper edge of the fault of the largest aftershock.

The comparison of the focal mechanisms of the aftershocks estimated from initial motions with the fault plane structures suggests a close relationship of the stress re-distribution and the formation of the complicated fault structures. There are many aftershocks having the same focal mechanisms as the main shock on the fault planes of the main shock, the largest and the 3rd largest aftershocks. However, the aftershocks having different focal mechanisms seem to occur off these fault planes.

The whole aftershock activity of this earthquake was high as compared to those of the other shallow inland earthquakes in Japan, but the sequence of the aftershock activity forming each fault plane is very simple and the temporal variation of the cumulative number of events for each activity is normal. We can interpret the complicated fault structures with high aftershock activity of this earthquake as the superposition of the normal aftershock activity of the main shock and the normal secondary aftershock activities of the other proceeding large aftershocks.

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