O-01

Complicated fault geometries of shallow destructive inland earthquakes with high aftershock activity -the Mid Niigata Earthquake in 2004 and the Mikawa Earthquake in 1945-

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1. Introduction

The Mid Niigata Earthquake in 2004 (hereafter referred to as NEQ) of M_{JMA}6.8 was accompanied by a prominent aftershock activity with 26 aftershocks of M5.0 or greater. The activity was equivalent to that of the Mikawa Earthquake in 1945 (hereafter referred to as MEQ) of M_{JMA}6.8. Figure 1 shows the numbers of aftershocks of M5.0 or greater as a function of D_1, which denotes the magnitude difference between the main shock and the largest aftershock, for 30 shallow inland earthquakes of M6.5 or greater in Japan from 1925 to 2008. Eight out of 10 main shocks of D_1 1.0 or smaller were accompanied by five or more aftershocks of M5.0 or greater. This result suggests that D_1 is a reasonable indicator of the aftershock activity [e.g., Utsu (1999)]. The main purpose of this paper is to understand the reason of the high aftershock activities caused by shallow inland earthquakes such as the NEQ and the MEQ in relation with their fault geometries.

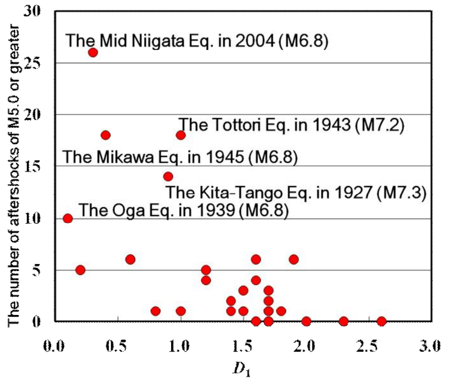

Fig. 1. The numbers of aftershocks of M5.0 or greater is plotted as a function of D_1 for 30 inland earthquakes of M6.5 or greater which occurred in Japan.

2. The Mid Niigata Earthquake in 2004 (2004/10/23 M_{JMA}6.8)

Figure 2 shows a relocated aftershock distribution of the NEQ [Aoki *et al.*, 2005]. We can summarize the characteristics of this distribution as: (1) the distribution of the hypocenters has a double-planar structure with a gap of 5km in parallel dipping with about 50 degrees in WNW and a single-planar structure dipping with about 15 degrees in ESE, (2) the formation of the upper of the double planes began with the main shock which occurred at 17:56 on Oct. 23 (JST), that of the lower plane began with the largest aftershock of M6.5 which occurred 38 minutes after the main shock, and finally that of the ESE dipping plane began with the 3rd largest aftershock of M6.1 which occurred at 10:40 on Oct. 27, and (3) the

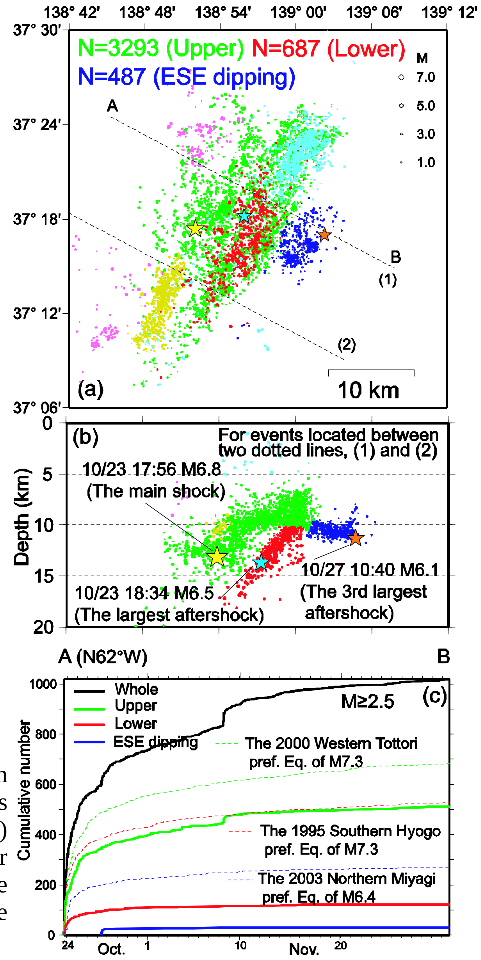

Fig. 2. Aftershock activity of the NEQ. The events which occurred from 17:56 on Oct. 23 to 24:00 on Nov. 30, 2004. Green, red and blue circles denote hypocenters of the upper plane, the lower plane and the ESE dipping plane, respectively. (a) Map viewing of hypocenter distribution. (b) Vertical cross section along A-B for events located between two dotted lines. (c) Temporal changes of cumulative number of M2.5 or greater events. Dotted lines denote the temporal changes of the other inland earthquakes.

areas of these planes are correlated with the magnitudes of three large events mentioned above.

3. The Mikawa Earthquake in 1945 (1945/1/13 M_{JMA}6.8)

There are discrepancies among the fault models of the MEQ presented previously [e.g., Ando (1974), Hamada (1987) and Kikuchi *et al.* (2003)]. One of the causes of these inconsistencies is the lack of accuracy in locating the aftershocks. The MEQ occurred 65 years ago during the World War II in Aichi prefecture. Aoki (2006) found a vestige of the aftershock activity of the MEQ in the present seismicity (Fig. 3). We can summarize the characteristics of this activity as: (1) the present seismicity in the aftershock area was distributed in the westward area of the surface fault [e.g., Sugito and Okada (2004)], (2) in the southern part of the aftershock area, recent events occurred on the WSW dipping plane with 30-60 degrees, and in the northern part, they occurred on the WNW dipping plane with 70-90 degrees, and (3) their rate of occurrence almost corresponds to the predicted value by the Omori-Utsu formula and the Gutenberg-Richter relation.

Additionally, Aoki (2006) searched the optimal faults model which satisfied both the coseismic crustal deformation [Geographical Survey Institute, 1960] and the geometries of two seismic planes mentioned above, and discovered the low-angle reverse fault (M_W6.6) related to the main shock and the right-lateral strike slip fault (M_W6.2) in northern part of the aftershock area where the largest aftershock of M6.4 occurred.

4. Conclusions

We can conclude that three dipping planes formed by the aftershocks of the NEQ represent the fault planes of the large events. As Fig. 2(c) indicates, 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. In addition, the MEQ had not only the main fault related to the main shock but also the sub-fault related to the large aftershocks. These results indicate that the high aftershock activity of an inland earthquake with a complicated fault structure (e.g., the NEQ and the MEQ) is interpreted as the superposition of the normal aftershock activity of the main shock and the normal secondary aftershock activities of the other following large aftershocks.

References Utsu, 1999, *Seismicity Studies: A comprehensive Review*. Aoki, *et al.*, 2005, *Earth Planets Space*, **57**, 411-416. Ando, 1974, *Tectonophysics*, **22**, 173-186. Hamada, 1987, *Pap. Met. Geophys.*, **38**, 77-156. Kikuchi *et al.*, 2003, *Earth Planets Space*, **55**, 159-172. Aoki, 2006, *Proc. Hokudan Symp. Active Faults 2006*, 63-66. Sugito & Okada, 2004, *Active Fault Research*, **24**, 103-127. Geographical Survey Institute, 1960, *Report on the 2nd & 3rd order re-triangulations in the Mikawa Earthquake Area*.

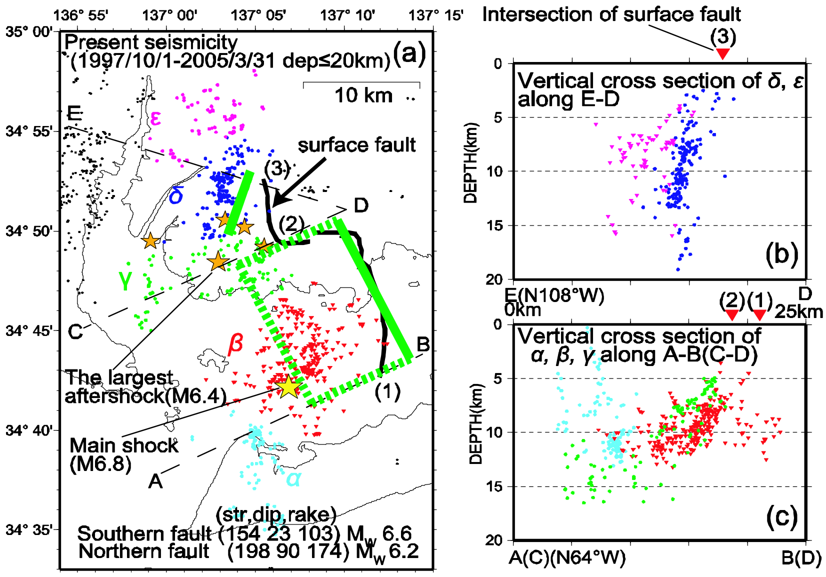

Fig. 3. The present seismicity in the aftershock area of the MEQ. Five clusters (α - ε) are distinguished. (a) Map viewing of hypocenter distribution of present seismicity. Big yellow, big orange and small orange starts denote epicenters of the main shock, the largest aftershock and the other aftershocks of M5.5 or greater, respectively. Green square and green thick line indicate the optimal faults which satisfied coseismic crustal deformation. Black thick line indicates the surface fault. (b)Vertical cross section along E-D for the clusters of δ and ε. (c) Vertical cross section along A-B for the clusters of α, β and γ.