Weak surface features of some large shallow crustal earthquakes and evolution of strain release system

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Some recent damaging earthquakes in Japan are associated with weak features of surface rupture and/or a short active fault. Weak surface features of rupture would make it difficult to restore the event by a trench excavation survey. Short active faults may cause underestimation of the size of earthquake taking place on the fault. These weak surface features, which are tend to be neglected when seismic hazard is estimated on the basis of geomorphological/geological data, must be incorporated in the hazard estimation. These features also represent the present stage of evolution of strain release system in Japan.

Estimated frequency of paleoseismic events on the basis of trench excavation results needs to be corrected. This is because about one-third of the previous damaging earthquakes with Japan Meteorological Agency magnitude (M) 7 and above is difficult to be detected by a trench excavation survey. The surface rupture of the M6.8 Niigata-Chuetsu earthquake of 2004 leaves 10cm vertical offset of the ground while trench excavation carried out there by Maruyama et al. (2007) revealed 2m vertical offset produced by a previous earthquake. A future trench excavation would not detect the weak feature left by the latest M6.8 event.

The active faults recognized on the surface often represent only a part of the underlying source faults. The lateral extent of subsurface weak zone accompanied by a short active fault needs to be evaluated to estimate a potential size of future earthquake on the basis of geophysical/geological surveys. The source fault of the 2008 Iwate-Miyagi earthquake with M7.2 was 30km or longer while the length of active fault was only 3 to 4km. Similar situation is found for the M7.3 Western Tottori earthquake of 2000. The length of a geological fault and/or a linear zone of large gradient of gravity anomaly give a better estimate of the size of earthquake.

A comparison of the frequency distribution of the length of observed active faults with an assumed power law distribution indicates a lack of active faults shorter than 40km, which corresponds to M7.5. I interpret this as evidence of a ‘short’ active fault whose source fault is much longer than the surface expression. Thus a ‘short’ active fault can be a site of earthquake with magnitude as large as 7.4. More important aspect of this distribution function lies in its slope. When we assume that the length of an active fault is independent on its activity, we obtain too high b-value of the G-R relationship. For a reasonable b-value, frequent occurrence of large earthquakes is necessary. Thus a tendency exists that the recurrence interval of earthquakes on a long active fault is shorter than that of a short fault, which can be confirmed by the survey results of the major active faults in Japan. This may imply an evolutionary elongation and smoothing of faults; adaptive faults are connected to produce a more adaptive fault to the surrounding stress regime.