An interpretation on seismogenic stresses in relation to tectonic stresses

Kiyohiko Yamamoto[1]

[1] none

The stress tensor inversion method has been proposed for estimating tectonic stresses from the seismogenc stresses or the stresses on fault surfaces that produce earthquakes. This method is valid on the following two conditions: I) Earthquakes occur in a uniform tectonic stress field. II) The slip occurs to the direction of the largest shear stress on a fault plane. Further, we can take one of the following two standpoints about the frictional strength or friction coefficient of the faults where earthquakes are generated: A) Every fault has the nearly same frictional strength. B) The frictional strength widely ranges. In the case of (A), the orientations of the fault planes are specific to the stress field and the strength is necessary to be known or determinable. In the case of (B), the orientations are expected to be random or uniform.

The followings have been found by in-situ stress measurements near faults: 1) Shear stress on a fault plane is extremely small. 2) There is a case that the principal directions of stress rotate in a fault damage zone (e.g. Sato et al., 2003). The article (1) allows the different stress orientations in the respective blocks on the both sides of a fault. The article (2) substantiates this inference. The articles (1) and (2) mean that earthquakes are not necessarily produced in a uniform stress field. Therefore, they conflict with the condition (I).

Yamamoto (2005) estimates the strength of cracks from the experimental data of the effect of specimen size on the fracture strength of intact rocks. His results suggest that 3) the shear strength of cracks decreases to about 0.1 in friction coefficient without pressurized pore-water, as the crack size increases to the order of 1 m. This suggests that the strength of faults can be small in general. Yamamoto et al. (2002) propose a model of fault damage zones. Using this model, they (2003) evaluate the released and spent energies in the zones at fracturing and show that 4) the asperity area occupies at most 5 per cent of the fault plane. This together with (3) strongly suggests that the strength of faults is small in general. The small strength of faults means that one of the principal stress axes is nearly perpendicular to the fault plane. This does not seem to be in favor of the condition (B).

From the data of in-situ stresses in the Kitakami Mountains and ODP site 794, Yamamoto et al. (2004) show as follows; 5) The tension axis is approximately parallel to the so-called absolute displacement velocity vector observed by GPS. Their interpretation for (5) is as follows; spatially non-uniform distribution of displacement velocity produces shear stress perturbations on the surfaces along the displacement vector. These perturbed stresses in a relatively uniform tectonic stress field are released on the weak faults, of which the friction coefficient is near zero. Although the number of samples is small, the earthquake source mechanisms in the region appear to support this interpretation. The article (5) suggests that earthquakes occur in order to relax not the accumulated tectonic stresses but the perturbed stresses produced in the tectonic process, even if the condition (I) is satisfied.

The above arguments are negative to the idea for estimating the tectonic stresses from the seismogenic stresses. They rather imply that the earthquake source mechanisms reflect not the stress field but the displacement field of tectonic process.

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