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Enhanced detectability of stress tensor inversion from heterogeneous fault-slip data with preferred orientations

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Fault planes occasionally have preferred orientations according to the slip tendency (e.g., Lisle and Srivastava, 2004), which is defined as the ratio between normal and shear stresses (Morris et al., 1996). In contrast, most stress tensor inversion methods calculate crustal stress states from fault-slip data on the assumption that faults slip along the resolved shear stress vectors on their surfaces. This assumption called Wallace-Bott (W-B) hypothesis allows low values of slip tendency on "misoriented" faults so as to consider faulting along pre-existing weak surfaces in rock masses. However, the weak assumption causes the loose constraint on stress. For example, when a set of conjugate faults is observed, one usually determines principal stress axes as bisectors of fault planes. On the contrary, W-B hypothesis permits only to constrain the axes within the angle between fault planes. Such a disadvantage severely lowers the detectability of multiple stress conditions from heterogeneous fault-slip data. To avoid this problem, this study proposes a new method of stress tensor inversion by combining the W-B hypothesis and the slip tendency.

This study employed a stress tensor inversion method called HIM (Yamaji et al., 2006; Sato 2006) which maximize the fitness between observed slip directions and shear stress vectors. The fitness value is modified to be the product of the conventional fitness and the slip tendency. Artificial fault-slip data are analyzed to examine the performance of the new method. The data set includes 200 faults compatible with N-S compressional stress and 50 faults compatible with E-W tensional stress. The former has random orientations of fault planes and the latter has a preferred orientation so that they have large values of slip tendency. As the result, the conventional HIM could not detect the latter stress, while the new method could detect both stresses.

The new method is applied to fault-slip data from Late Miocene Awa Group in eastern Boso Peninsula. Mesoscale faults in this area have at least two different origins; reverse-faulting stress and normal-faulting one (e.g., Angelier and Huchon, 1987). The new method successfully detected both stresses without a priori classification of faults into subsets.

References
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