Combined inversion technique to determine stress condition and friction coefficient from fault orientation

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Stress condition and friction coefficient of fault control the brittle deformation in earth's upper crust. Since shear zone materials cannot preserve their physical properties at the time of activation over the geological time scale, it is difficult to estimate the friction coefficients of ancient geological faults.
This study proposes to simultaneously estimate the friction coefficient of faults and the stress condition which activated them by the following procedure. Stress tensor inversion using fault-slip data can calculate principal stress axes and a stress ratio, which allows us to draw a normalized Mohr's circle. Assuming that the faults have a common value of friction coefficient, the frequency of fault orientation is expected to have a peak at the tangential point between the Mohr's circle and the friction envelope and to decrease according to the distance from the envelope. This model was combined with the Wallace-Bott hypothesis that a fault slips along the shear stress vector to compose the objective function of inversion to determine the stress condition and frictional coefficient.
The method was applied to some examples of natural outcrop-scale faults. The first example is from the Pleistocene Kazusa Group, central Japan, which filled a forearc basin of the Sagami Trough. Stress inversion analysis showed WNW-ENE trending tensional stress with a low stress ratio. The friction coefficient was calculated to be about 0.7, which is typical value for sandstone.
Another example is from an underplated tectonic mélange in the Cretaceous to Paleogene Shimanto accretionary complex in southwest Japan along the Nankai Trough. The stress condition was determined to be an axial compression perpendicular to the foliation of shale matrix. The friction coefficient ranges from 0.1 to 0.3, which is extremely low indicating a weak plate boundary under the accretionary wedge.

Keywords: stress tensor inversion, fault-slip analysis, friction coefficient, fault instability