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A method to estimate friction coefficient from orientation distribution of meso-scale faults

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Static friction coefficient controls the brittle strength of earth's crust of which deformation is recorded as faults. It is difficult to estimate the friction coefficient of ancient geological faults because fault gouge does not preserve its physical property. This paper proposes a method to determine friction coefficient from orientation distribution of fault planes.

Stress tensor inversion techniques have been applied to geological meso-scale faults to calculate a reduced stress tensor, which is composed of three principal stress orientations and a stress ratio. Angelier (1989) tried to determine all six independent components of stress tensor including magnitudes of principal stresses, assuming that the ratio of normal and shear stresses on observed fault surfaces exceeds the friction coefficient. The assumption allows us to estimate the friction coefficient of meso-scale faults as the slope of linear boundary of distribution of points representing normal and shear stresses on Mohr's diagram. However, there has been remained uncertainty in the estimation since the recognition of the line has been done manually on the diagram.

This study computerizes the estimation of friction coefficient as follows. Meso-scale faults are assumed to slip when they satisfy the cohesionless Coulomb's failure criterion represented by the linear friction envelope. The principal stress axes and stress ratio are presumed to be stable, while the changes in the magnitude of differential stress and the fluid pressure are taken into account. When the two parameters fluctuate to cause faulting, the Mohr's circle moves to leftward (negative direction of effective normal stress). Then, a upper left part of the Mohr's circle is cut off by the friction envelope and the faults corresponding to the part are activated. If such events are repeated with various values of differential stress and fluid pressure, the orientation distribution of activated faults should have concentration around the tangential point between the friction envelope and the Mohr's circle normalized to satisfy sigma_1=1 and sigma_3=0. According to the above-mentioned concept, the new method searches for the direction of linear gradation in the frequency of fault planes on the normalized Mohr's diagram. The slope of friction envelope is given by linear contour lines of frequency of faults.

The method was applied to natural fault-slip data gathered from the Pleistocene Kazusa Group, eastern Boso Peninsula. The strata are composed of sandstones and slitstones. Stress inversion analysis (Sato, 2006) gave a WNW-ENE trending tensional stress. The friction coefficient was determined to be 0.66 +0.05/-0.05, which is typical value for sandstone.

References

Angelier, J., 1989, Jour. Struct. Geol., 11, 37-50.
Sato, K., 2006, Tectonophys., 421, 319-330.

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