# Stress tensor inversion by using mixture probability distribution: Application to Quaternary meso-scale faults in Beppu area, southwest Japan

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Stress tensor inversion techniques from orientations of faults is widely used in structural geology and seismology. Among them, the Hough method (Yamaji et al., 2006) has two advantages. One is to detect mutiple stress states from a set of fault-slip data. The other is that incomplete fault-slip data which lacks information on slip orientations or shear senses can be utilized to constrain the stress states (Sato, 2006). However, the detection of optimal stress solutions has not been fully automated and there remains subjectivity in the result. This study aims at automating the detection of stress tensors.

The input data for stress tensor inversion is called fault-slip datum which carries fault plane orientation and slip direction. A reduced stress tensor, which has four degrees of freedom to be determined in the inversion analysis, corresponds to a point on five-dimensional (5-D) unit sphere (Sato and Yamaji, 2006). Assuming that a fault slips along the shear stress acting on the fault plane, a fault-slip datum constrains stress tensor to the corresponding points on a great semicircle on the 5-D unit sphere. The Hough method superimposes the semicircles specified by observed faults to obtain the distribution of objective function to be maximized. The peaks of the distribution give optimal reduced stress tensors. This study proposes to fit a mixture probability distribution to the distribution of objective function. The 5-D Kent distribution is employed as the component distribution in order to express the anisotropy caused by the shapes and the orientations of the great semicircles. The number of peaks is determined according to the Bayesian information criterion.

The new method was tested by the analysis of a synthetic fault-slip dataset, which consists of two groups of faults originated from different stress tensors. As the result, two given stress tensors are successfully detected. The new method was applied to meso-scale fault-slip data gathered from the Pleistocene Sekinan Group, Beppu area, southwest Japan. Two stress tensors were detected with NNE-SSW and NNW-SSE horizontal tension axes. Meso-scale faults cutting the Pleistocene Oita Group which overlies the Sekinan Group were also analyzed and only the NNE-SSW tensional stress was detected. These facts suggest that the tension orientation changed between 2.5 Ma and 1 Ma. The 68% confidence region of stress axes were also estimated by the bootstrap technique to be around 30 degrees.

References

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