Determination of optimal stress tensors without exhaustive grid search and fast multiple inversion

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Some methods of stress tensor inversion uses exhaustive grid search in determining optimal stress solution. Multiple inversion (Yamaji, 2000) among them has an advantage that plural solutions are detectable from a fault dataset which records spatial or temporal variation of stress. It can be applied to both geological fault-slip data and seismic focal mechanisms (Otsubo et al., 2008). A difficulty of the method is in the computational cost caused by its iterative resampling process. This study tried to reduce the cost by determining optimal solution without grid search.

Multiple inversion extracts subsets from a fault dataset, each of which includes four or five faults. A subset requires a grid search process to find an optimal stress solution. The present version of software uses 60,000 grid points for the search (Sato and Yamaji, 2006b). When we have N faults and a subset includes k faults, ${}_N C_k$ solutions will be determined in exchange for a long computation. Concentrations of solutions indicate optimal stress states for the whole dataset. Statistical techniques such as clustering have been proposed to detect the concentrations (Otsubo et al., 2006).

This study improved the process to find an optimal stress solution for a fault subset. Given four faults, the stress tensor inverse problem is even-determined and an analytical solution can be easily calculated without exhaustive grid search. In the five-dimensional deviatoric stress space (Sato and Yamaji, 2006a), four faults correspond to four unit vectors and the responsible stress is indicated by the direction normal to all the four vectors. Therefore, the analytical solution is given by a five-dimensional cross product of four vectors. The constraints from polarities of slip vectors, i.e. distinction between normal and reverse faults, are separately checked and unsatisfactory solutions are rejected.

New software based on the above-mentioned technique is about four times faster than conventional one. This improvement is effective, but is not so drastic since the new technique also uses the computational grid only to visualize the enormous solutions. Moreover, the computational cost increases factorially with number of faults. Further reduction is desired to analyze thousands of faults and focal mechanisms.

References
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