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Incremental fold test for paleostress analysis using the Hough transform inverse method

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We present a method of incremental fold test for paleostress inversion of fault-slip data set from folded sedimentary rock masses, which provides not only the orientations of three principal stress axes and stress ratio but also the relative age of folding and faulting. The point of our method is stepwise backtilting of strata associated with faults. On each step, rotated fault-slip data are analyzed by a stress inversion technique based on Hough transform. The inversion technique calculates the fitness of all possible stresses to the fault data and detects peaks of the fitness. The peak values of fitness are compared among backtilting steps to find a maximum. The stress and the backtilting step which give the maximum are the optimal solution of our analysis. In order to assess the validity of the method, we firstly applied it to artificial fault-slip data sets generated with hypothetical histories for folding and faulting with known paleostresses. The stresses were successfully detected and the correct timing of faulting relative to tilting were chosen. Secondly, we applied the test to natural fault-slip data set in an early Middle Eocene sedimentary strata of Kyushu, southwest Japan, which was folded with NE–SW trending fold axes in the Early Miocene. The result presented three significant paleostresses; a NE–SW tensional normal faulting stress, an oblique stress with maximum and minimum principal stress axes in directions around 311° / 050° and 168° / 034°, and a NW–SE compressional strike-slip faulting stress. It was also shown that faulting by the former stress preceded the folding and faulting by the other two stresses occurred during the folding. The experiments using artificial and natural fault-slip data sets validated the present method, and it is consequently worth applying to fault-slip data whose relative ages of folding and faulting are indeterminate at outcrops.