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Predicting stress in fault-bend fold by optimization

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The objective is to estimate the stress distribution in geometrical models of folds, as proposed by Suppe (1983). The methodology is an application of the internal approach of limit analysis, which provides the lower bound on the tectonic force. The optimum stress field satisfies equilibrium and boundary conditions, and lies within the convex strength domain at every point of the fold. This stress field is found by numerical means with a spatial discretisation with triangular elements allowing stress discontinuities at their boundaries (Krabbenhøft et al., 2005). The unknowns of the problem are the stresses at the nodes, the triangle apexes. They are found, as well as the lower bound, with an optimization code (Mosek, 2006).

This Equilibrium Elements Method (EEM) predicts that the force to thrust a rectangular domain over a flat décollement is equal to Hafner (1961)'s analytical solution, if the strength limit is not attained within the bulk. If that limit is reached, the predicted force is then less than Hafner's result, because the décollement is not activated. The first application is a fault-bend fold consisting of a block gliding over a flat décollement prior to the motion over a single pre-defined ramp. This ramp is not activated and another failure mechanism in a pop-up is triggered with partial sliding over the décollement, for large values of its friction angle. The pop-up is asymmetrical, as observed in sand boxes. For small friction angles, the whole décollement and the ramp are activated combined with a localized failure in the bulk, typical of a back-thrust rooted at the base of the ramp. The strength limit is also attained in the ramp hanging wall close to the surface, because of small horizontal stresses, indicating that tensile failure could occur there, as in the extrados of a fold.

In conclusion, it is noted that this EEM could provide the stress field in most geometrical models of fold-and-thrust belts, providing a valuable insight in their interpretation.