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Hanging-wall deformation above a normal fault: sequential limit analyses

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The deformation in the hanging wall above a segmented normal fault is analysed with the sequential limit analysis (SLA). The method combines some predictions on the dip and position of the active fault and axial surface, with geometrical evolution à la Suppe (Groshong, 1989). Two problems are considered. The first followed the prototype proposed by Patton (2005) with a pre-defined convex, segmented fault. The orientation of the upper segment of the normal fault is an unknown in the second problem. The loading in both problems consists of the retreat of the back wall and the sedimentation. This sedimentation starts from the lowest point of the topography and acts at the rate r_s relative to the wall retreat rate.

For the first problem, the normal fault either has a zero friction or a friction value set to 25^o or 30^o to fit the experimental results (Patton, 2005). In the zero friction case, a hanging wall anticline develops much like in the experiments. In the 25^o friction case, slip on the upper segment is accompanied by rotation of the axial plane producing a broad shear zone rooted at the fault bend. The same observation is made in the 30^o case, but without slip on the upper segment. Experimental outcomes show a behaviour in between these two latter cases.

For the second problem, mechanics predicts a concave fault bend with an upper segment dip decreasing during extension. The axial surface rooting at the normal fault bend sees its dips increasing during extension resulting in a curved roll-over. Softening on the normal fault leads to a stepwise rotation responsible for strain partitioning into small blocks in the hanging wall. The rotation is due to the subsidence of the topography above the hanging wall. Sedimentation in the lowest region thus reduces the rotations. Note that these rotations predicted by mechanics are not accounted for in most geometrical approaches (Xiao and Suppe, 1992) and are observed in sand box experiments (Egholm et al., 2007, referring to Dahl, 1987).

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