Numerical modelling of forced folding and faulting in multilayer sequences above a basement normal fault*

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Scaled analogue models focusing on deformation patterns in isotropic, homogeneous cover above a basement normal fault with varying dips have successfully assisted seismic interpretations and improved our knowledge of fault growth (e.g. Horsfield (1977); Withjack et al. (1990)). We perform 2-D numerical experiments using a discrete element code (*PFC*, Itasca Consulting Group) with similar boundary conditions as the studies cited above, but in contrast, focus on the growth of folds and faults in multilayer sequences on a metre scale, i.e. below the resolution of seismics. Competent rocks (e.g. limestone, sandstone) are modelled as coarse, bonded particles and incompetent rock (e.g. shale) as fine, non-bonded particles. The rheology of the two materials is investigated by means of biaxial compression tests with varying confining pressure. The incompetent material is nearly perfect plastic, i.e. the material flows at constant stress after yielding. The competent material deforms by localised shears, i.e. faults, at intermediate confining pressures. At high confining pressure deformation is less localised.

Figure 1 shows model results of a five layer cover sequence (two competent and three incompetent beds) above a 45° dipping basement normal fault (see figure caption for details). To our knowledge this is the first attempt to model numerically the localisation and growth of fault zones in multilayer sequences and our results can be summarised as follows: (i) A monocline develops in the competent layers. The wavelength of the monocline and the width of the fault zone increases with decreasing dip of the basement fault. Folding is accommodated by flow within the incompetent layers and by bedding parallel slip at the

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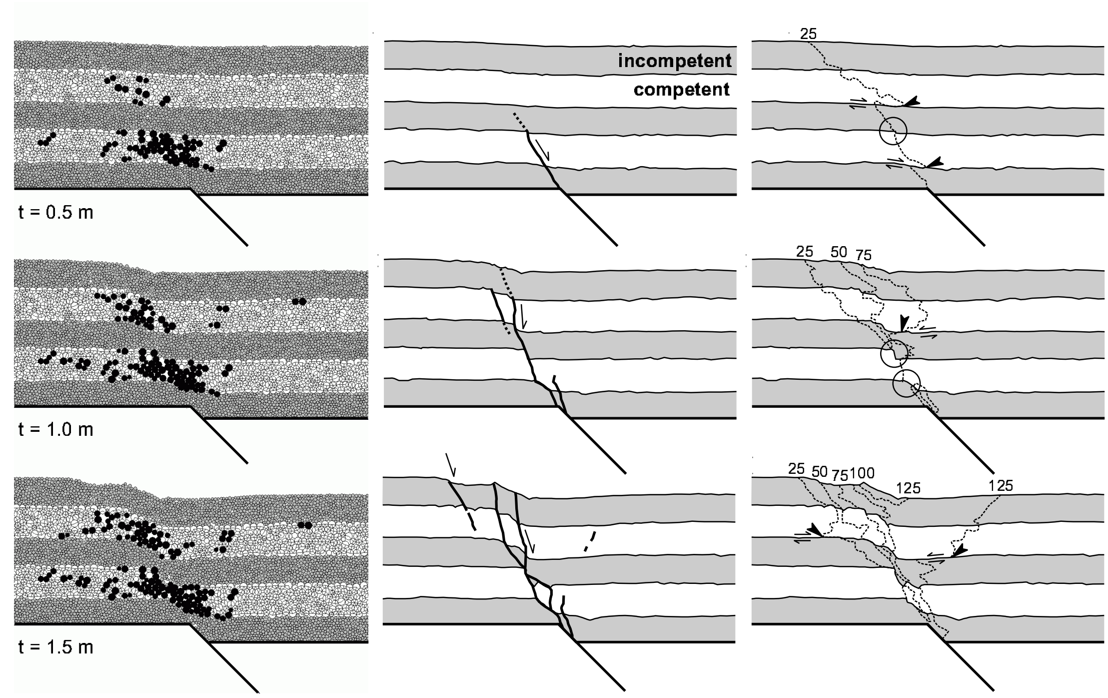

Figure 1: Numerical model results for a basement normal fault dipping 45° underneath a five layer cover composed of two competent (bonded particles, white) and three incompetent (non-bonded particles, grey) beds. Throw (t) is $0.5m$, $1.0m$ and $1.5m$. Black particles have broken bonds. Interpreted faults (middle) and horizontal displacement contours (centimetres, right hand side) illustrate the staircase geometry of faults and extensional oversteps across the competent layers. Arrows indicate evidence for bedding parallel slip and circles depict strain refraction.

base of the competent layers. (ii) Faults grow from bottom to top in a staircase geometry with contractional oversteps across the incompetent layers. (iii) The evolution of the fault zone depends on the dip of the basement fault. The space problem caused by the movement on a low angle basement fault (30° dip) is accommodated by antithetic faults.

References

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Withjack, M., J. Olson, and E. Peterson (1990). Experimental models of extensional forced folds. *American Association of Petroleum Geoscientists Bulletin 74*, 1038–1054.