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Quantitative comparisons of numerical models of brittle deformation

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Numerical modelling of brittle deformation in the uppermost crust can be challenging owing to the requirement of an accurate pressure calculation, the ability to achieve post-yield deformation and localisation, and the choice of rheology (plasticity law). One way to approach these issues is to conduct model comparisons that can evaluate the effects of different implementations of brittle behaviour in crustal deformation models. We present a comparison of three brittle shortening experiments for fourteen different numerical codes, which use finite element, finite difference, boundary element and distinct element techniques. Our aim is to constrain and quantify the variability among models in order to improve our understanding of causes leading to differences between model results.

Our first experiment of translation of a stable sand-like wedge serves as a reference that allows for testing against analytical solutions (e.g., taper angle, root-mean-square velocity and gravitational rate of work). The next two experiments investigate an unstable wedge in a sandbox-like setup which deforms by inward translation of a mobile wall. All models accommodate shortening by in-sequence formation of forward shear zones. We analyse the location, dip angle and spacing of thrusts in detail as previous comparisons have shown that these can be highly variable in numerical and analogue models of crustal shortening and extension. We find that an accurate implementation of boundary friction is important for our models.

Our results are encouraging in the overall agreement in their dynamic evolution, but show at the same time the effort that is needed to understand shear zone evolution.

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