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The Numerical Sandbox: Comparison of Numerical with Analogue Model Results for Shortening and Extension Experiments

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Numerical and analogue modelling techniques are widely used to investigate the evolution of geological structures as, for example, fold-and-thrust belts or sedimentary basins. In this study, we test the agreement between results obtained with both modelling methods by comparing results of numerical and analogue models directly. Two experimental set-ups were examined: (1) A brittle shortening experiment designed to investigate the influence of alternating strength layers on thrust wedge formation, and (2) An extensional experiment examining the effect of a weak, basal viscous layer on normal fault localisation and propagation in overlying brittle materials.

We first report results comparing numerical models of sandbox-type experiments. Seven different numerical codes, both commercial and academic, were tested against each other. Results show that the overall evolution of all numerical codes is broadly similar. Shortening is accommodated by in-sequence forward propagation of thrusts building a thrust wedge with a surface slope in the stable field for critical taper theory. Details of thrust timing, spacing and dip vary between different codes suggesting that there are limitations to the extent to which quantifiable measures may be compared. For the extensional experiment we find that the structural evolution of the large-deformation models is similar to a high degree. Differences in the number of shear zones that develop appear to reflect differences in mesh resolution and material

tracking techniques.

Comparison to equivalent analogue experiments shows that numerical models can reproduce the gross evolution and deformation of the analogue experiments and that the variability between numerical results is about the same as the degree of variability between different analogue models. Differences between numerical and analogue experiments are found in, for example, the dips of extensional shear zones, the degree of localisation onto faults and the development of backthrusts in the shortening experiment.

Our inter-comparison of numerical modelling results and the comparison to analogue experiments highlight the agreement in overall evolution and dynamics and, therefore, brings more credibility to both numerical and analogue studies. We hope that our comparisons also form a useful guide to help determine the degree to which features found in modelling experiments may be applied to natural systems.