Geophysical Research Abstracts
Vol. 19, EGU2017-717, 2017
EGU General Assembly 2017

Reverse fault growth and fault interaction with frictional interfaces: insights from analogue models

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The association of faulting and folding is a common feature in mountain chains, fold-and-thrust belts, and accretionary wedges. Kinematic models are developed and widely used to explain a range of relationships between faulting and folding. However, these models may result not to be completely appropriate to explain shortening in mechanically heterogeneous rock bodies. Weak layers, bedding surfaces, or pre-existing faults placed ahead of a propagating fault tip may influence the fault propagation rate itself and the associated fold shape. In this work, we employed clay analogue models to investigate how mechanical discontinuities affect the propagation rate and the associated fold shape during the growth of reverse master faults. The simulated master faults dip at 30° and 45°, recalling the range of the most frequent dip angles for active reverse faults that occurs in nature. The mechanical discontinuities are simulated by pre-cutting the clay pack. For both experimental setups (30° and 45° dipping faults) we analyzed three different configurations: 1) isotropic, i.e. without precuts; 2) with one precut in the middle of the clay pack; and 3) with two evenly-spaced precuts. To test the repeatability of the processes and to have a statistically valid dataset we replicate each configuration three times. The experiments were monitored by collecting successive snapshots with a high-resolution camera pointing at the side of the model. The pictures were then processed using the Digital Image Correlation method (D.I.C.), in order to extract the displacement and shear-rate fields. These two quantities effectively show both the on-fault and off-fault deformation, indicating the activity along the newly-formed faults and whether and at what stage the discontinuities (precuts) are reactivated. To study the fault propagation and fold shape variability we marked the position of the fault tips and the fold profiles for every successive step of deformation. Then we compared precut models with isotropic models to evaluate the trends of variability. Our results indicate that the discontinuities are reactivated especially when the tip of the newly-formed fault is either below or connected to them. During the stage of maximum activity along the precut, the faults slow down or even stop their propagation. The fault propagation systematically resumes when the angle between the fault and the precut is about 90° (critical angle); only during this stage the fault crosses the precut. The reactivation of the discontinuities induces an increase of the apical angle of the fault-related fold and produces wider limbs compared to the isotropic reference experiments.