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Slip partitioned faults have non-steady state slip rates under oblique convergence

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Scaled oblique convergence experiments in wet kaolin develop slip-partitioned fault systems rather than developing a single active oblique-slip fault. The development of two fault surfaces, which consumes greater work than a single fault, arises due to changes in the local stress state after development of the first fault. As one strain component is relieved by either the early strike-slip along a pre-existing weakness or oblique slip along a newly created reverse fault, the local stress field then favors development of the other fault type.

The suite of experiments in this study reveal three styles of slip partitioning development controlled by the convergence angle and presence of a pre-existing crustal weakness. The first style (Type 1) observed in the low convergent angle experiments (5°) grow strike-slip faults prior to reverse faults regardless of whether the fault is precut or not. This result suggests that the presence of a pre-existing weakness has a lesser effect on the development of slip partitioning in very low convergence systems than for more moderate angle convergent margins. For the more moderate convergence angle experiments (10°, 15°, 20° precut and uncut), the sequence of slip partitioning is dominantly controlled by the presence of a pre-existing crustal weakness. In all experiments, the primarily reverse fault forms first. Subsequent slip partitioning develops either with the initiation of strike-slip along the precut fault (Type 2) or growth of a secondary reverse fault where the first fault is steepest. Subsequently, this slip on the first fault transitions to strike-slip (Type 3). Here, the relative angle of convergence seems to play a subordinate role, controlling the timing of slip partitioning development (higher convergence angles partitioning earlier) but not the sequence of faulting leading up to slip partitioning.

The net slip rates on the slip partitioned faults fluctuate and are anti-correlated with each other through time so that when slip rates decrease on one fault, they increase on the other. The total fault slip rate of the system varies with the slip rate on the strike-slip fault because slip partitioning in these low-convergence experiments is strike-slip dominated. Consequently, the moment rate and kinematic efficiency of the faults also varies throughout slip partitioning. Additionally, the slip rates do not show indications of converging towards long-term steady-state rates. Non steady-state slip rates along the strike-slip and reverse faults for both precut and uncut experiments suggest that faults in slip-partitioned systems adjust to the conditions produced by deformation along other faults as shear and convergent strain are redistributed throughout the fault system's evolution.