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Erosion controls transpressional wedge kinematics

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High resolution digital image analysis of analogue tectonic models reveals that erosion strongly influences the kinematics of brittle transpressional wedges.

In the basally-driven experimental setup with low-angle transpression (convergence angle of 20 degrees) and a homogeneous brittle rheology, a doubly vergent wedge develops above the linear basal velocity discontinuity. In the erosive case, the experiment is interrupted and the wedge topography fully removed at displacement increments of ∼3/4 the model thickness. The experiments are observed by a stereo pair of high resolution CCD cameras and the incremental displacement field calculated by Digital Particle Image Velocimetry (DPIV). From this dataset, fault slip on individual fault segments - magnitude and angle on the horizontal plane relative to the fault trace - is extracted using the method of Leever et al. (2011).

In the non-erosive case, after an initial stage of strain localization, the wedge experiences two transient stages of (1) oblique slip and (2) localized strain partitioning. In the second stage, the fault slip angle on the pro-shear(s) rotates by some 30 degrees from oblique to near-orthogonal. Kinematic steady state is attained in the third stage when a through-going central strike-slip zone develops above the basal velocity discontinuity. In this stage, strain is localized on two main faults (or fault zones) and fully partitioned between plate boundary-parallel displacement on the central strike-slip zone and near-orthogonal reverse faulting at the front (pro-side) of the wedge. The fault slip angle on newly formed pro-shears in this stage is stable at 60-65 degrees (see also Leever et al., 2011).

In contrast, in the erosive case, slip remains more oblique on the pro-shears throughout the experiment and a separate central strike-slip zone does not form, i.e. strain partitioning does not fully develop. In addition, more faults are active simultaneously. Definition of stages is based on slip on the retro-side of the wedge. In the first stage, the slip angle on the retro-shear is 27 +/- 12 degrees. In a subsequent stage, slip on the retro-side is partitioned between strike-slip and oblique (∼35 degrees) faulting. In the third stage, the slip angle on the retro side stabilizes at ∼10 degrees. The pro-shears are characterized by very different kinematics. Two pro-shears tend to be active simultaneously, the extinction of the older fault shortly followed by the initiation of a new one in a forelandward breaking sequence. Throughout the experiment, the fault slip on the pro-shears is 40-60 degrees at their initiation, gradually decreasing to nearly strike-slip at the moment of fault extinction. This is a rotation of similar magnitude but in the reverse direction compared to the non-erosive case. The fault planes themselves do not rotate.

Leever, K. A., R. H. Gabrielsen, D. Sokoutis, and E. Willingshofer (2011), The effect of convergence angle on the kinematic evolution of strain partitioning in transpressional brittle wedges: Insight from analog modeling and high-resolution digital image analysis, Tectonics, 30(2), TC2013.