The structural and morphological evolution of transpressive systems: insights from analog modeling

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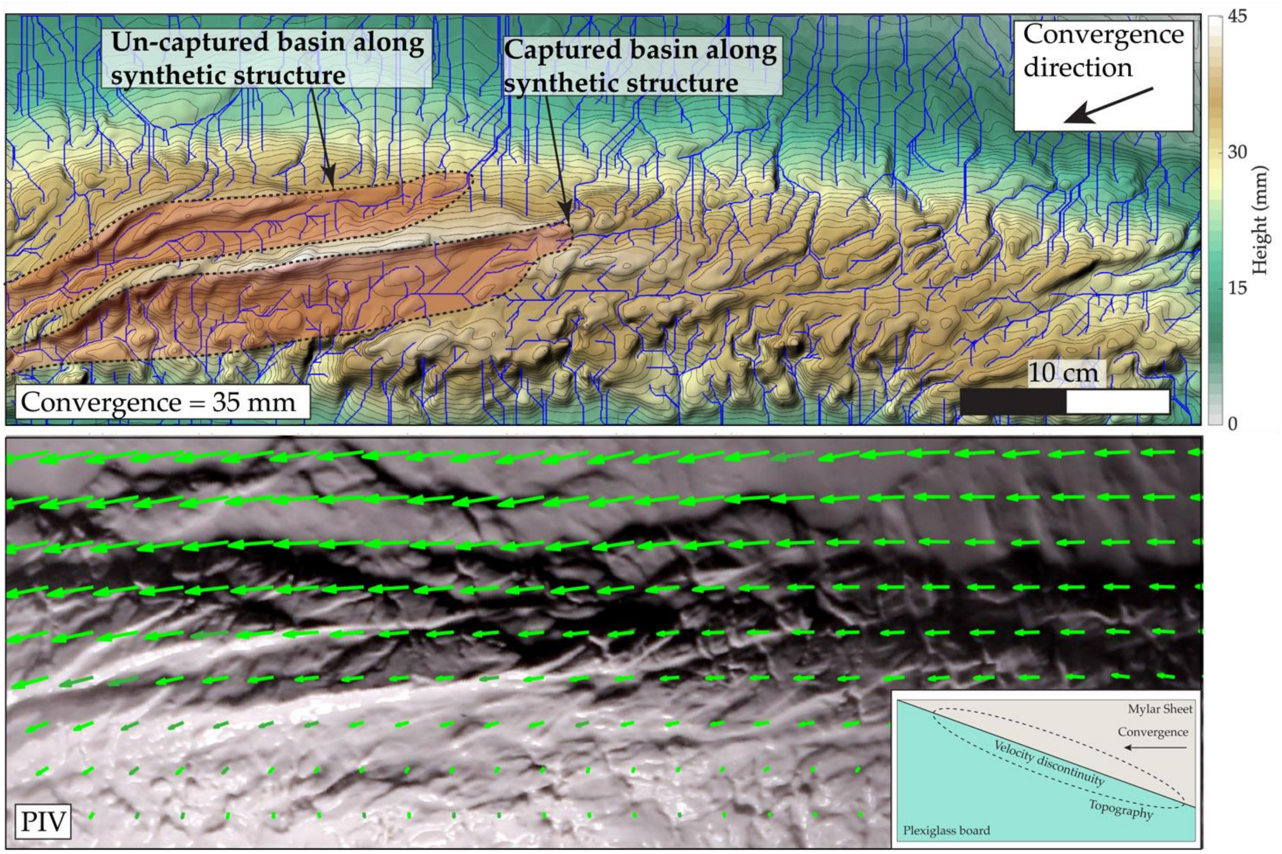
The relationships between deformation and erosion in transpressive systems are still poorly understood. Here, we present a new set of analog models to investigate how the tectonic and surface processes present at large-scale transpressive plate boundaries interact to shape topography. The experimental setup comprised a 2 x 1 x 0.5 m^3 plexiglass box fit with a plexiglass board cut to 20º obliquity. A motor pulled a mylar sheet beneath the board to generate a velocity discontinuity at the interface. We loaded a ~5 cm thick layer of a granular material onto the board and sheet composed of 40 wt. % silica powder, 40 wt. % glass microbeads, and 20 wt. % PVC powder (cf. CMII in Reitano et al., 2020, doi: 10.5194/esurf-8-973-2020). This setup allows deformation to nucleate at the velocity discontinuity and naturally form a transpressional wedge. The model was monitored with digital cameras and a laser scanner to conduct particle image velocimetry and digital elevation model analysis, respectively. To explore surface processes associated with mass transport and erosion, we used a sprinkler system that casts a uniform mist across the model surface. We allowed ~1 cm of relief (equivalent to ~10 cm of convergence) to form before misting began to ensure the formation of realistic drainage networks. Before misting, experiments evolved in 3 stages: 1) distributed strain, 2) strike-slip faulting along synthetic structures, and 3) uplift and formation of a wedge along bivergent thrust structures. After misting, strike-slip deformation was still fully partitioned to synthetic structures and thrust sheets propagated in the prowedge direction. As the experiment continued, sub-longitudinal drainage systems formed with their orientation controlled by synthetic structures. Strike-slip displacement along these structures interrupted transverse streams, which ultimately captured the sub longitudinal systems. On the retrowedge, a longitudinal basin formed along a coalesced extensional structure, which also was later captured by transverse channels. These and other interactions between fault structures and channel networks provide insight into erosion and mass transport in transpressional systems and the nature of the complex reorganization of stream networks in response to deformation.



Plain language summary:

Transpressive plate boundaries accommodate oblique convergence between tectonic plates. In these settings, the interactions between faults and climate-driven erosion are poorly understood. **Here, we present a set of laboratory-based landscape evolution experiments that combine tectonic deformation and surface erosion to build and shape topography.** We conduct experiments using a special apparatus designed to build a transpressional mountain range from granular materials and use a misting system to initiate surface processes. Experiments are recorded with digital cameras to analyze particle motion and a laser scanner to create a digital elevation model of the landscape at different stages. We analyze the evolution of fault and stream networks and interpret the potential linkages between the two. **These analyses provide insight into the evolution of transpressional systems, specifically, how mass is eroded and transported and how stream networks respond to faulting.**