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Temporal and spatial organisation of faulting in frictional wedges

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The spatial and temporal organization of thrusting in accretionary wedges and in fold-and-thrust belts results from the coupling between tectonics, erosion and the degradation of the rock strength along faults. A quantitative assessment of this coupling is presented, based on a simple approach which combines geometrical construction and evolution of developing thrust-related folds and optimization techniques based on limit analysis. We consider the simple prototype of a triangular wedge resting on a basal layer, the overall lying on a straight décollement, and consider large shortenings corresponding to several million years.

Our understanding of frictional wedges is based on the critical taper theory of Dahlen (1984) and the introduction of the critical topographic slope α_c function of the basal décollement dip β and of the material frictional properties. If the average topographic slope α is less than α_c , the relief builds-up until α_c is reached from a sequence of forward folds. This sequence is interrupted by the activation of out-of-sequence thrusts which are contributing to the modification of the average topographic slope. The recurrence time of this activation is function of the distance to the front and also of the thickness of the basal layer. This last parameter becomes inportant once the deformation reaches the front of the wedge. Once α_c is globally attained, a steady state is reached and the spatial organization of the deformation can be seen as two propagating "waves" of deformation, one spread from the rear, the second from the front. These two waves recurrently enter in spatial resonnance, but the global effect of this last point is not clear.

Damage along activated thrusts, reflected by a drop in the friction angle, perturbs the periodicities both in time and space. Erosion controls the direction of the major thrusts as well as preferential localization of the deformation. This can lead to the exhumation of basal material. Comparison with large shortening sandbox experiments with erosion (Malavieille, 2010) brings new insights on the mechanisms of rotation and exhumation of originally deep materials. A study of the strength evolution during deformation with erosion/sedimentation is also proposed. The main result of this study is the predominant role of the geometry, and subsequently of the topography, on the spatial and temporal organisation of the deformation.