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Analogue modeling of 3-D structural segmentation in fold-and-thrust belts: interactions between frictional and viscous provinces in foreland basins

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Accretionary wedges are generally segmented both across and along strike because of diverse factors including tectonic and stratigraphic inheritance. In fold-and-thrust belts, along-strike stratigraphic changes in the foreland sequence are classically observed and cause a curvature of the deformation front. Although the parameters controlling this curvature are well documented, the structural interactions and mutual influences between adjacent provinces are much less analyzed. To investigate this question, we deformed analogue models in a compressional box equipped with digital cameras and a topographic measurement apparatus. Models where shortened above a basal frictional detachment (glass microbeads) and segmentation was tested by having a region in which we added an interbedded viscous level (silicone polymer) within the sedimentary cover (dry sand). By changing the number (2 or 3) and the relative width of the purely frictional and viscous provinces, our goal was to characterize geometrically and kinematically the interactions between the viscous and the purely frictional provinces. We used a commercial geomodeller to generate 3-D geometrical models.

The results indicate that regardless of the relative width of the purely frictional vs. viscous provinces, the deformation style in the frictional province is not influenced by the presence of the adjacent viscous province. On the contrary, the structural style and the deformation kinematics in the viscous province is significantly impacted by the presence or absence of an adjacent purely frictional province. At first order, the deformation style in the viscous province depends on its width, and three structural styles can be defined along strike. Far from the frictional area, structures are primarily of salt-massif type, and they do not seem to be influenced by the frictional wedge province. Towards the frictional province, deformation changes gradually to a zone of purely forethrusts (foreland verging), and finally to a highly faulted zone with both fore- and backthrusts (hinterland verging).

In addition, a kinematic analysis indicates that narrow viscous provinces are strongly influenced by the presence of an adjacent frictional province. Indeed, propagation of shallow thrusts occurs in sequence and the deformation front reaches lately the external décollement pinchout. On the contrary, the deformation front of the wide viscous provinces propagates rapidly to the external décollement pinchout, then younger thrusts form out of sequence.

Along-strike segmentation also affects the deep structures (thrusts detaching on the basal frictional décollement). In the viscous province, the presence of an upper viscous décollement opposes the advance of the basal deformation front. There, the rear of the wedge is characterized by imbrications of thrusts sheets (antiformal stacks), and the deep deformation front is convex towards the hinterland.

Our experiments allow to better understand the dynamics of salt-controlled fold-and-thrust belts such as in the Huallaga (Peru) and Kuqa (China) basins or the Franklin Mountains (NW Canada).