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# Effect of single and multiple décollement layers on thrusting dynamics in fold-and-thrust belts

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Thin-skinned fold-and-thrust belts related to convergence tectonics develop by scraping off a rock sequence along a weaker basal décollement. Such décollements are often formed by water-saturated shale layers or low-viscosity salt horizons.
A two-dimensional finite element model with a visco-elasto-platic rheology is used to investigate the structural evolution of fold-and-thrust belts overlying different décollement horizons. In addition, the influence of several weak layers in the stratigraphic column is studied. The characteristics of the layered rock sequence are identical, applying an internal friction angle of 30°and a viscosity of $10^{25}$ Pa·s for all simulations. Model shale décollements are purely frictional, with friction angles ranging from 5°- 25°and the same viscosity as the layered overburden. Model salt layers have viscosities ranging from $10^{17} - 10^{20}$ Pa·s and same friction angle and cohesion as the layered sequence.

Results show that fold-and-thrust belts with a single frictional basal décollement generate thrust-systems ramping from the décollement to the surface. Spacing between thrust ramps depends on the thickness of the overlying sequence. If the “salt” décollement has low viscosity ($10^{18}$ Pa·s), isolated box-folds (detachment-folds) occur. Multiple viscous salt layers with the same viscosity ($10^{18}$ Pa·s) lead to long-wavelength folding. The structural evolution of simulations with an additional low-frictional layer strongly depends on the strength relationship between the basal and the additional, within-sequence décollement. If the within-sequence décollement is weaker, underplating occurs and leads to antiformal stacking at the rear of the fold-and-thrust belt. In the distal part, where deformation is restricted to the upper part of the rock pile, imbrication occurs with a wavelength depending on the depth of the intermediate weak layer.

**References**

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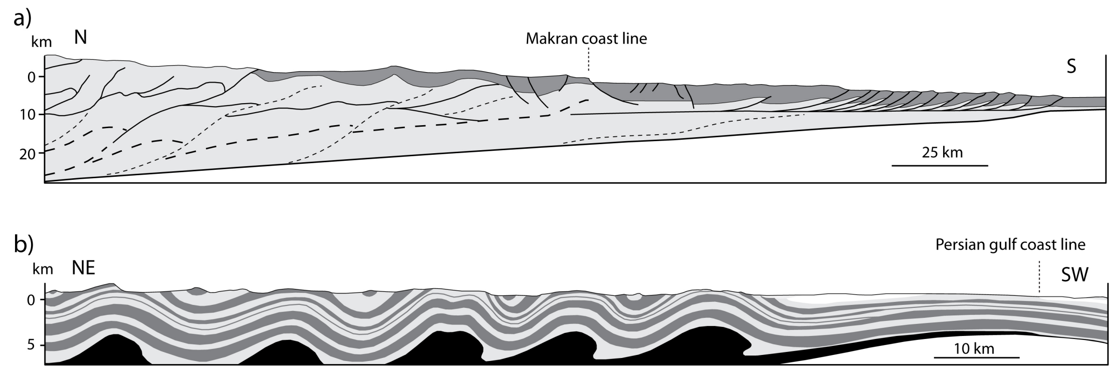


Figure 1: Profiles of selected fold-and-thrust belts comprising different detachment types. a) Cross-section through the Makran accretionary wedge, SE Iran (adapted from [1]). Detachments are frictional and consist of over-pressured shale. Additional detachments exist within the deformed sedimentary pile. b) Profile through the South-western part of the Simply Folded Zone in Zagros, SW Iran (adapted from [2]). The Zagros is an example of a fold belt related to thick salt layers acting as detachment. Several weak salt layers within the sedimentary pile were detected [3].

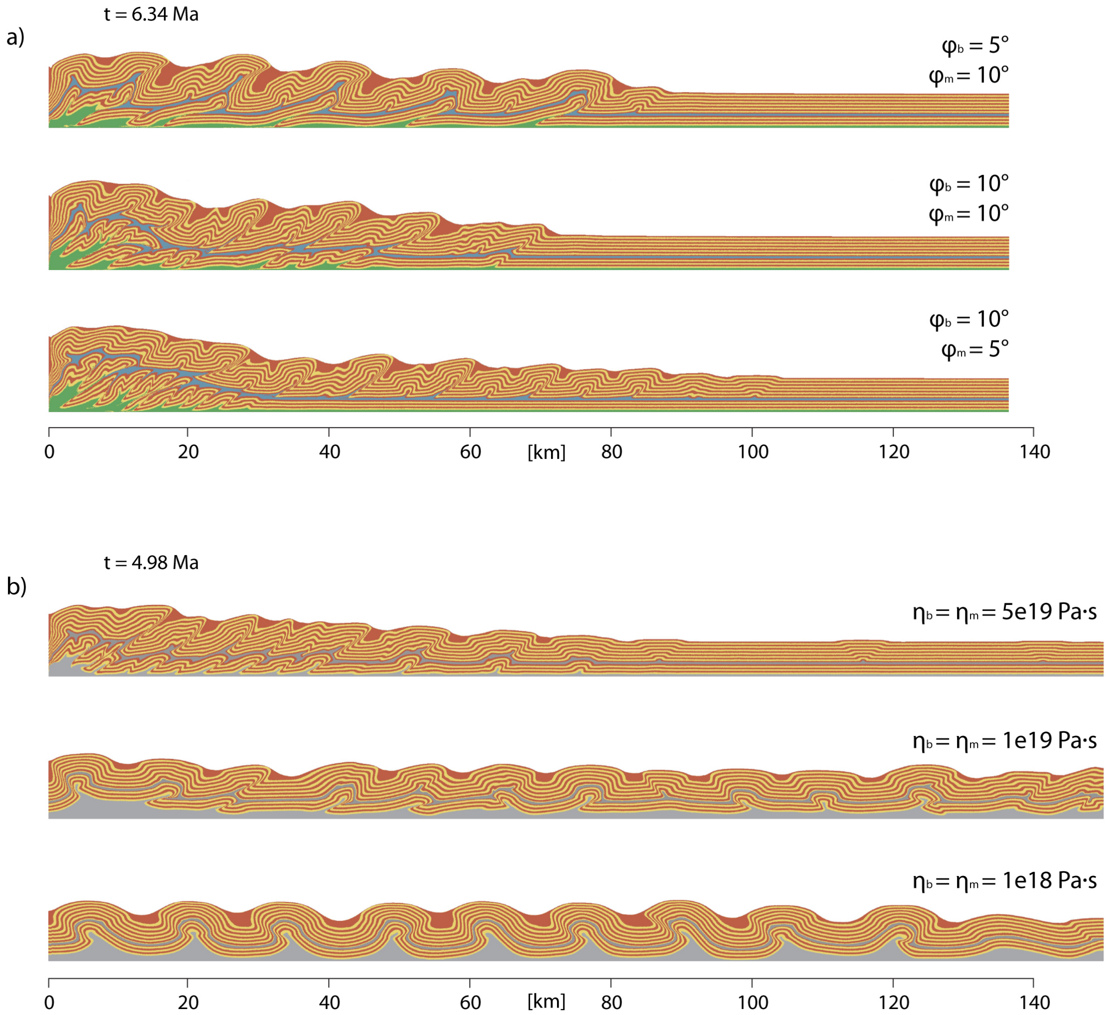


Figure 2: Simulations with multiple décollements. a) Base and intermediate décollement consist of shale (geen and blue). All shale related simulations are compressed for 6.34 Ma. Upper subfigure: Intermediate décollement stronger than basal décollement. Total wedge taper is dependent on strength of base décollement. Middle subfigure: Intermediate and base décollement have same strength. Lower subfigure: Basal décollement stronger than intermediate one. Underplating leads to antiformal stacking at the rear of the wedge. Imbrication at the toe of the rock pile with wavelength depending on depth of décollement. b) Simulations with two salt layers (grey scale) compressed during 4.98 Ma. Upper subfigure: High salt viscosity produces drag towards the backstop. Middle subfigure: Fault-propagation folds with no preferred vergence. Very low surface taper Lower subfigure: Low salt viscosity and increased salt thickness form open folds with long wavelengths.