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Importance of basement faulting and salt decoupling for the structural evolution of the Fars Arc (Zagros fold-and-thrust belt): a numerical modeling approach

Fatemeh Gomar et al.

Correspondence to: Fatemeh Gomar (fatemehgomar@iasbs.ac.ir) and Jonas B. Ruh (jruh@icm.csic.es)

Overview

This supplement presents additional GIFs related to the structural evolution of numerical experiments discussed in the main text.

Fig S1: Structural evolution of the reference model with listric faults and power-law rheology for the salt layer.

The reference model (Model 1) features a 2-km-thick salt horizon with power-law viscous rheology and three inherited listric faults in the basement, which are shortened at the same rate as the sedimentary cover during convergence. In the extensional phase, half-graben basins form along the listric faults, filled by syn-extensional deposits. Deformation is concentrated along weak zones and all faults are active without preference. During compression, reverse motion on the basement fault near the backstop alters the salt décollement geometry. Strain localizes along basement faults and decouples from the sedimentary cover due to the salt layer. Over time, inversion of basement faults causes ramp-flat-ramp structures and harpoon-like anticlines, with deformation amplified in the sedimentary cover. Strain transitions from brittle to ductile at deeper crust levels (~26 km).

Fig S2: Structural evolution of modeling within the test without a salt layer.

Without salt (Model 2), no mechanical decoupling occurs, and deformation follows pre-existing faults, creating basement-cored anticlines with little internal deformation in the sedimentary cover. Thrust faults propagate upward through the cover.

Fig S3: Structural evolution of modeling within the test of a 4 km salt layer.

With a 4-km-thick salt layer (Model 3), the extension phase remains similar to the reference model, but the thicker salt prevents faults from cutting through. During compression, the thicker salt enhances decoupling, reducing small-scale deformation and forming salt-cored folds and diapirs.

Fig S4: Structural evolution of modeling within the test of linear rheology for the salt layer (10^{18} Pa·s).

In Models 4 after 5 Myr of extension, symmetric ridges form, with deformation mostly accommodated by the salt layer and inherited faults. After 15 Myr of compression, folds in the sedimentary cover incline toward the hinterland. Strain rates show that deformation in Model 4 is interrupted.

Fig S5: Structural evolution of modeling within the test of linear rheology for the salt layer (10^{20} Pa·s).

In Models 5, the extension phase is similar to the reference model, but during compression, forethrusts develop without backthrusts. Strain rates show thatthe décollement remains connected.

Fig S6: Structural evolution of modeling within the test of planar faults.

In Model 6, with planar faults, constant-angle basement faults generate conjugate normal faults, with deformation concentrated above the salt horizon, particularly near the footwall. After 15 Myr of compression, overturned folds and backthrust faults develop due to the activation of basement thrusts. Strain concentrates in the salt layer, planar faults, and backthrusts.

Fig S7: Structural evolution of modeling within the test without inheritance faults.

In Model 7 (no basement faults), strain accumulates mainly along extension-induced fractures, and the basement is decoupled from the sedimentary cover. After 15 Myr of shortening, intense basement thrusting creates pop-up structures near the backstop. Forward-verging thrusts dominate toward the foreland, while the sedimentary cover shortens via décollement folding. A large pop-up structure forms without mechanical decoupling between the basement and cover.

Fig S8: Structural evolution of modeling with different basement velocity ($v_{x\_b} = 0.25 \cdot v_x$).

In Model 8 with 75% basement involvement, the two faults on the right become flat-ramp-flat structures. The sedimentary cover is thrust above the basement blocks, overthrusting the frontal fault zone by around 50 km.

Fig S9: Structural evolution of modeling with different basement velocity ($v_{x\_b} = 0.5 \cdot v_x$).

In Model 9, the faults on the right remain continuous and experience significant displacement, and the right-side fault partially exits the model. Most deformation localizes in the salt layer, pre-existing basement faults, and faults within the sedimentary cover.

Fig S10: Structural evolution of modeling with different basement velocity ($v_{x\_b} = 0.75 \cdot v_x$).

In Model 10 the cover sequence shortening, the right-side fault nearly exits the model, while the other two faults show about 100% tectonic inversion. Deformation in the sedimentary cover becomes more laterally distributed and less dependent on basement fault locations. Additionally, the salt layer remains connected, forming a nearly horizontal décollement horizon.

Fig S11: Structural evolution of modeling with different basement velocity ($v_{x\_b} = v_x$).

In Model 11, inherited basement faults remain inactive. As a result, the sedimentary cover deforms in a thin-skinned tectonic style, without the influence of underlying basement structures.