Structural relief across the NW segment of the Zagros Mountain Front Flexure in the Kurdistan Region of Iraq: implications for basement thrusting

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https://doi.org/10.5194/egusphere-egu2020-18993
Introduction

- Zagros Fold-Thrust Belt
- It is resulted from the closure of the Neotethys and the subsequent continent-continent collision between the Arabian and Eurasian plates in the Cenozoic.
- It consist of several NW-SE belt parallel morphotectonic zones separated by major faults.

(modified after de Lamotte and Leturmy, 2013)
Introduction

• Zagros Fold-Thrust Belt

• One of these boundaries is the Zagros Mountain Front Flexure or Fault (MFF).

• It separates folds of high amplitude and short wavelength of the High Folded Zone from the widely spaced low amplitude folds of the Foothill Zone.

• The structural style of the MFF at depth is not well constrained yet.
Several models for the deformation style of the MFF at depth have been proposed. This work aims to: 

i) estimate the structural relief (step) across the MFF in several transects, and 

ii) reconstruct the geometry of the MFF using balanced cross-sections and forward modeling.
• Sedimentary cover is 8-12 km thick.

• In the vicinity of the MFF, geological units of the Cretaceous and Jurassic ages crop out.

• Upper Triassic and older units rarely expose at surface.
Sedimentary cover is 8-12 km thick.

In the vicinity of the MFF, geological units of the Cretaceous and Jurassic ages crop out.

Upper Triassic and older units rarely expose at surface.

Field observation and seismic data shows parallel folding with maintenance of bed thickness down to the upper Triassic horizon.

There is no dominant detachment within the Jurassic & Cretaceous succession.
The structural relief across the MFF is calculated for Upper Triassic horizon along several transects crossing the belt.

The relief is in between 2 and 3 km and 2.55 km as average.

This makes an angle of more than 6° toward the foreland.
Cross-Section

- The structural style for the upper section in the Akre transect is well constrained from the field data and the structural step across the MFF is 2.35 km.
- Theoretically this step can be formed by both thin-skinned model and combination of both thin- and thick-skinned model, with different consequences (requirement) for the lower section.
- While the latest model is more acceptable, and is validated by balanced cross-sections and forward modeling.

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Forward Modeling

- Iterative kinematic forward modeling along the Akre transects suggests that a multi-stage evolution involving both:
  
  i. Thin-skinned deformation by early detachment folds in the Mesozoic to Neogene succession above the Triassic detachment, and,

  ii. Thick-skinned deformation overprinted by a NE-dipping basement-rooted thrust system with a cumulative displacement of 6.5 km.
Regional Cross-Section

• A regional balanced cross-section shows that the minimum horizontal shortening of the sedimentary cover is about 24.6 km (9.1%) for this part of belt.

• The calculated shortening for the topographically low part of the belt is about 17 km at rates of 2-3 mm/yr since the deformation has reached there in Late Miocene. These shortening rates are much lower than geodetically derived present-day convergence rates (5.4 mm/yr).

Fault slip rates (block model)

- Red: Fault normal component (positive = extension)
- Blue: Fault parallel component (positive = right-lateral)

Fault slip rates are from (Khorrami et al., 2019)
Conclusions

• The structural relief for the Upper Triassic horizon across the Zagros Mountain Front Flexure is 2-3 km on average.

• A balanced cross-section requires 6.5 km reverse displacement on a listric NE-dipping basement thrust.

• The shortening rates during Late Miocene-Quaternary in the topographically part of the Zagros were much lower than geodetically derived present-day convergence rates.
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