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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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JST Jena Structural Geology - Tectonics

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DFG Deutsche Forschungsgemeinschaft German Research Foundation

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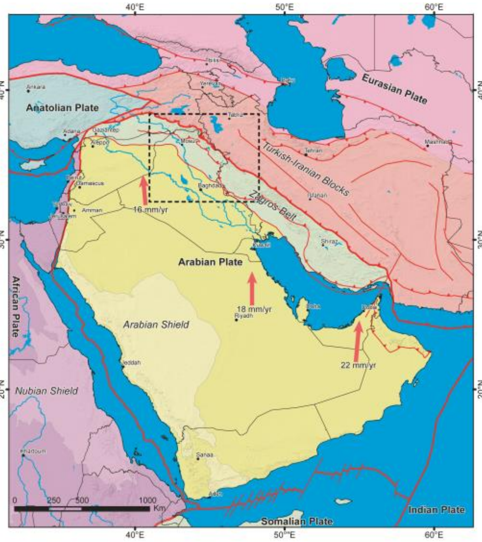
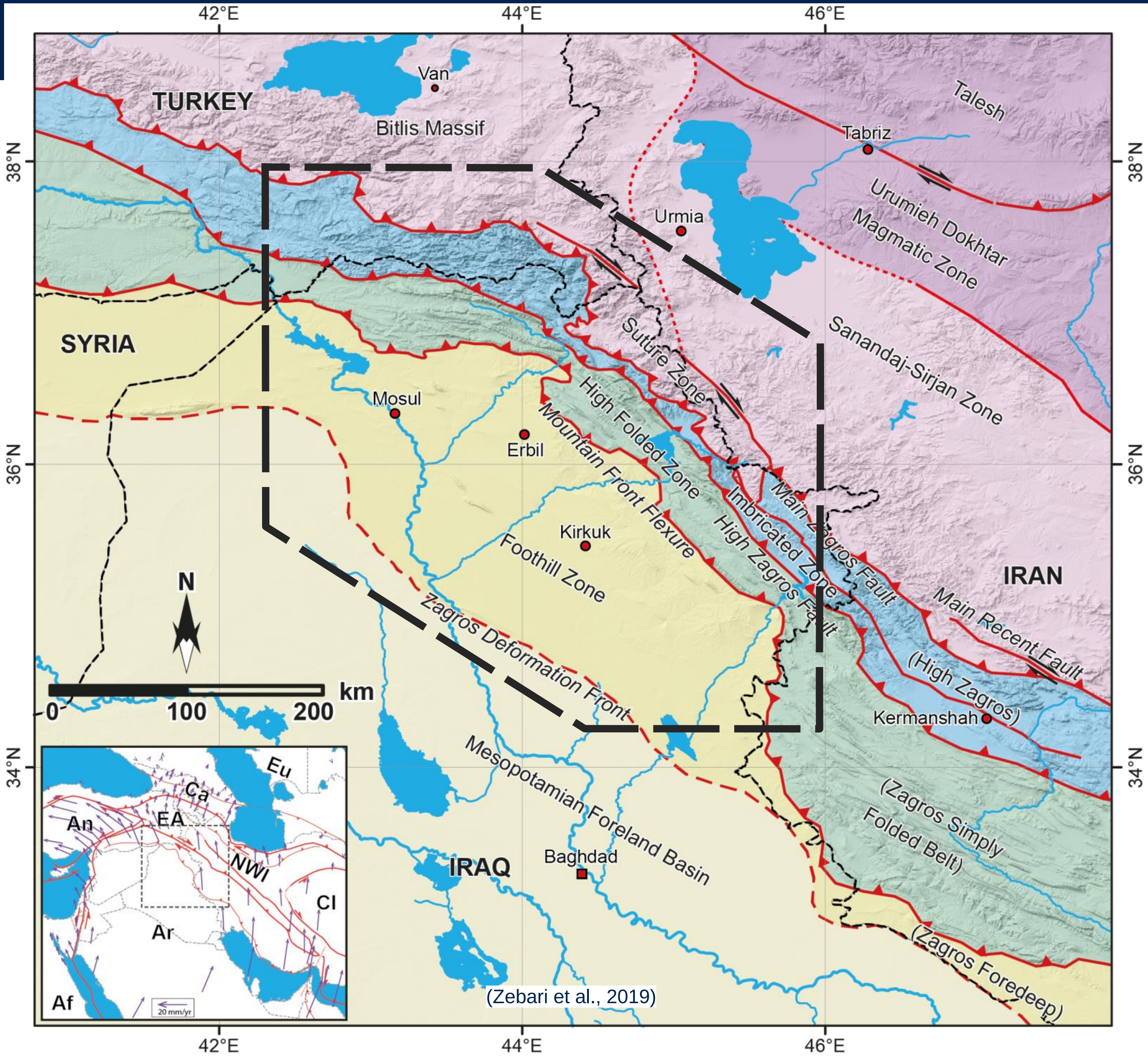
Introduction

- 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)

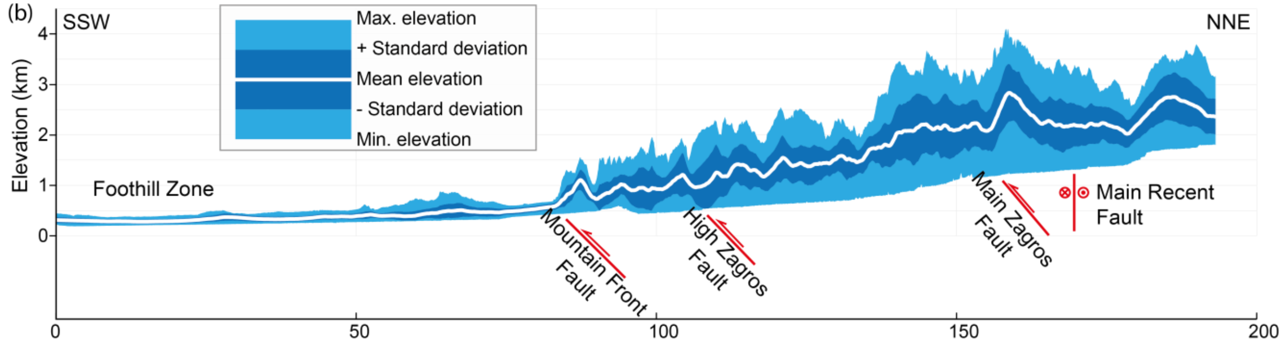


(Zebari et al., 2019)

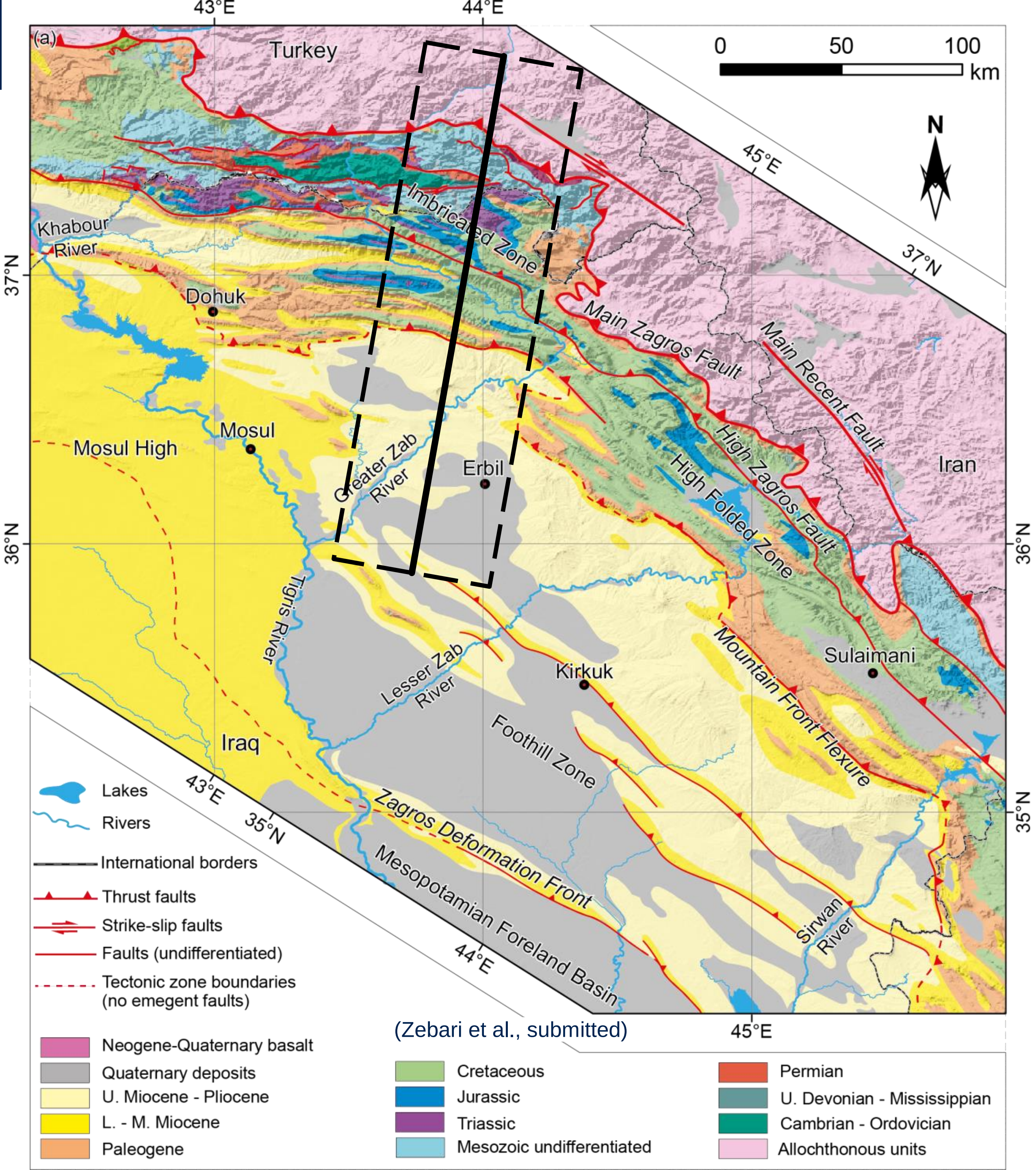
Introduction

- 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.

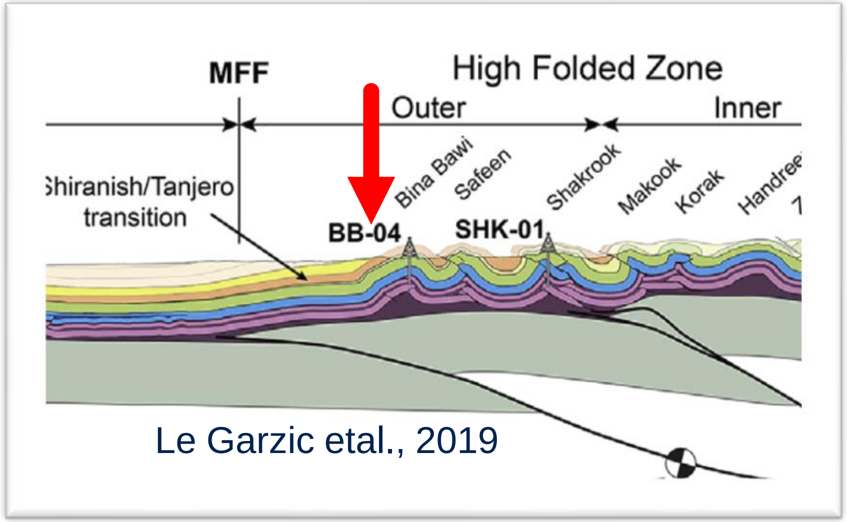


(Zebari et al., submitted)

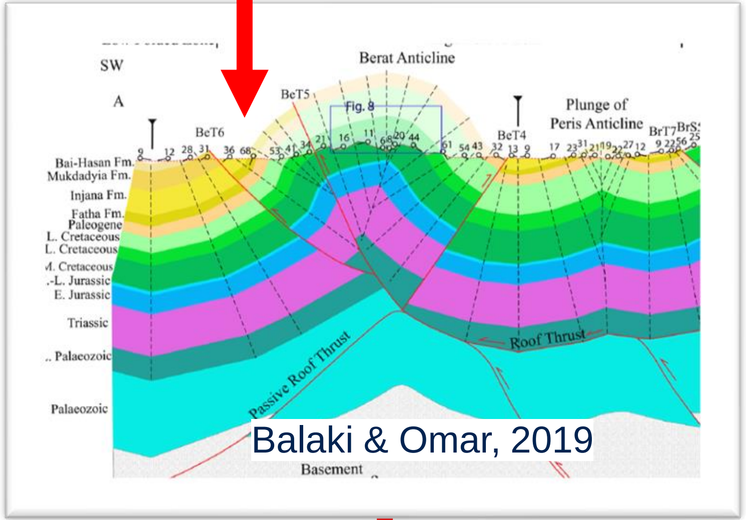


(Zebari et al., submitted)

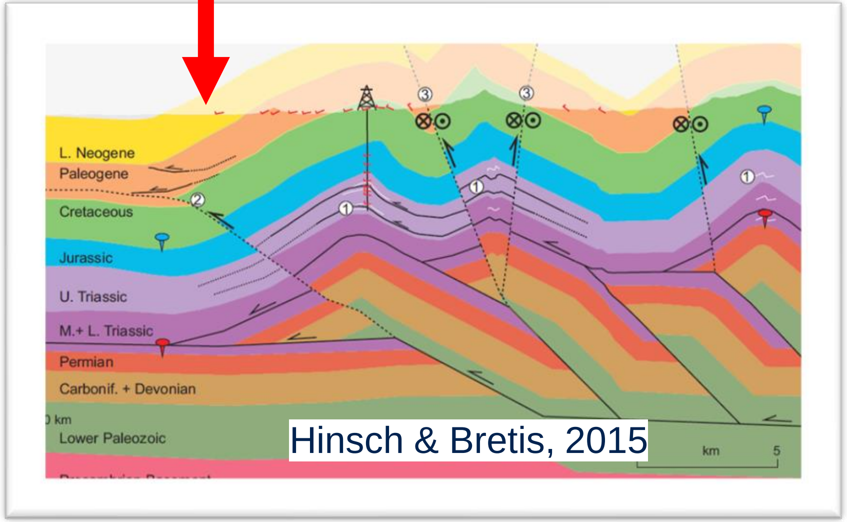
Mountain Front Flexure



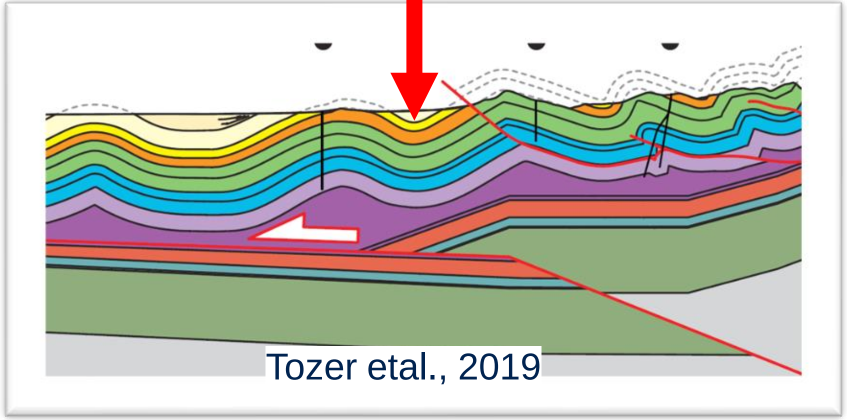
Le Garzic etal., 2019

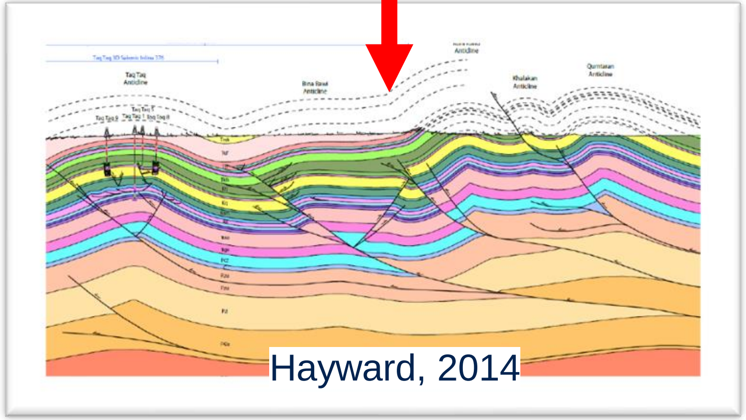


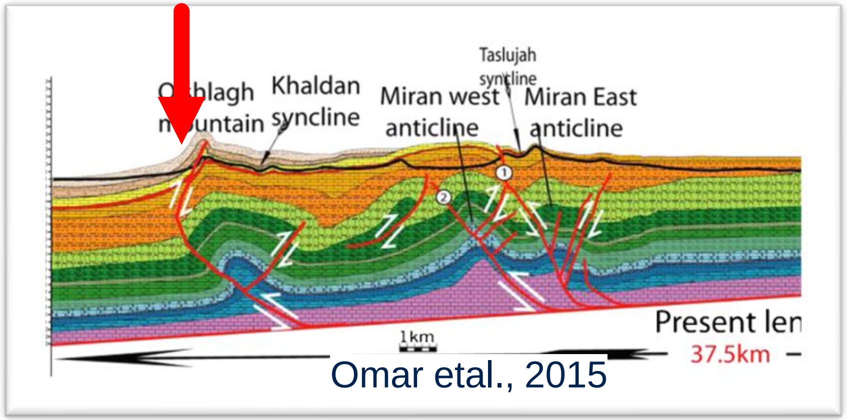
Balaki & Omar, 2019



Hinsch & Bretis, 2015


Tozer etal., 2019


Hayward, 2014



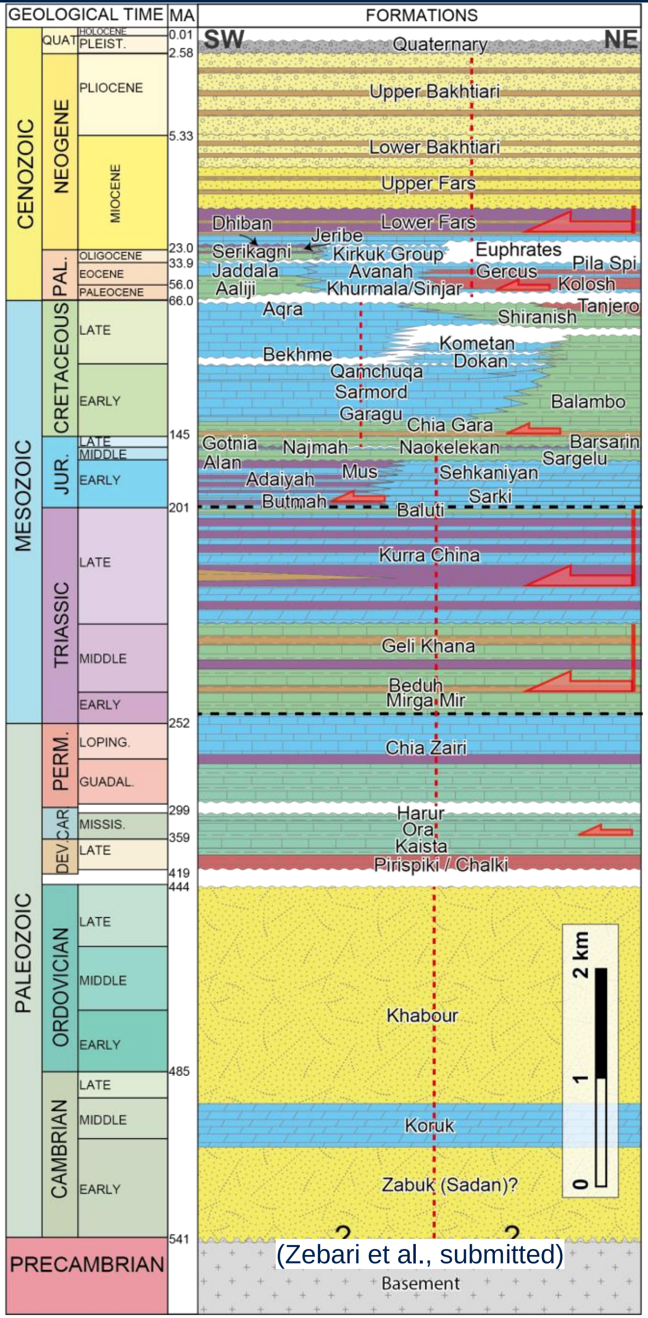
Omar etal., 2015

- 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

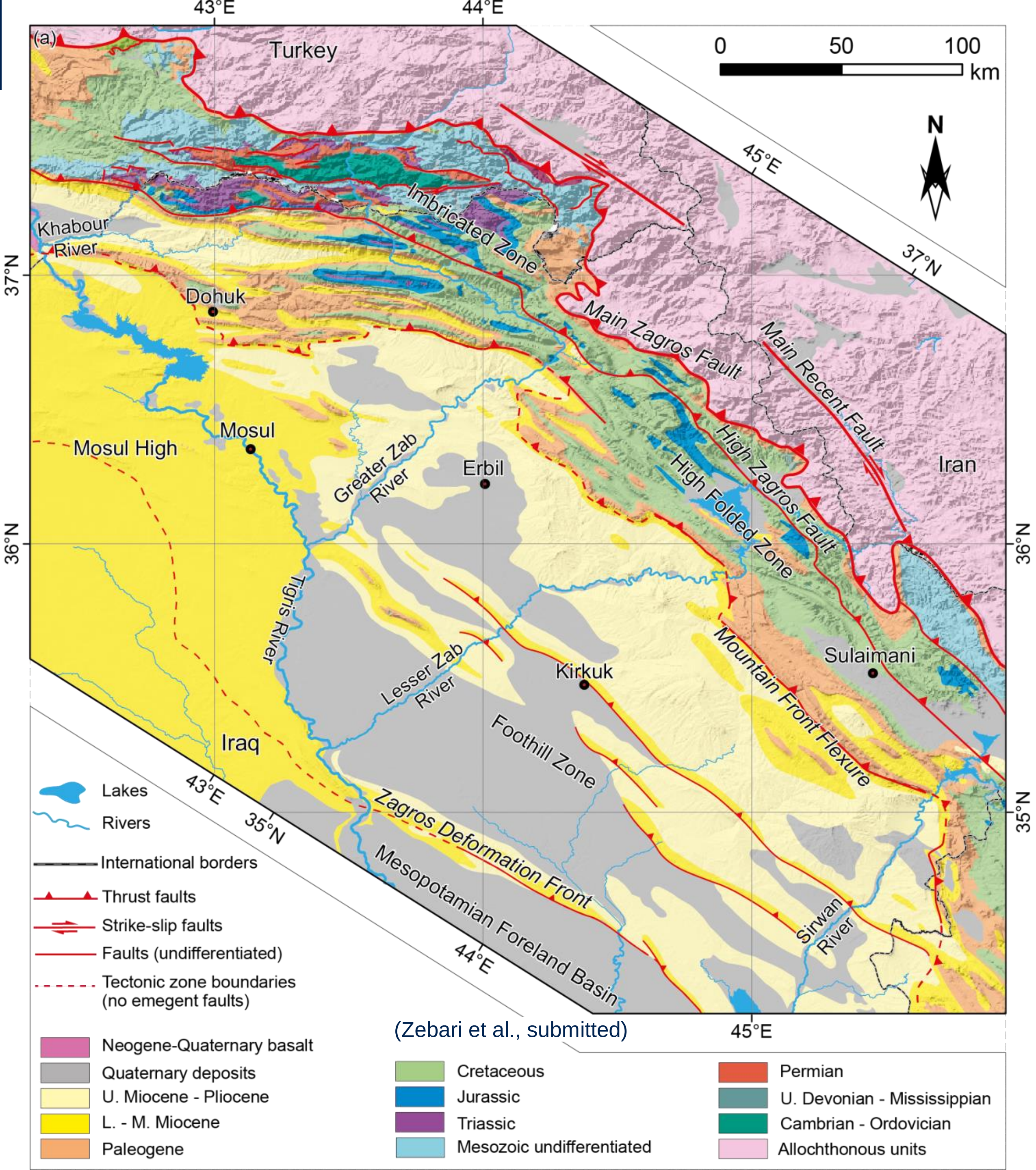
  ii) reconstruct the geometry of the MFF using balanced cross-sections and forward modeling.

Geological Column

- 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.



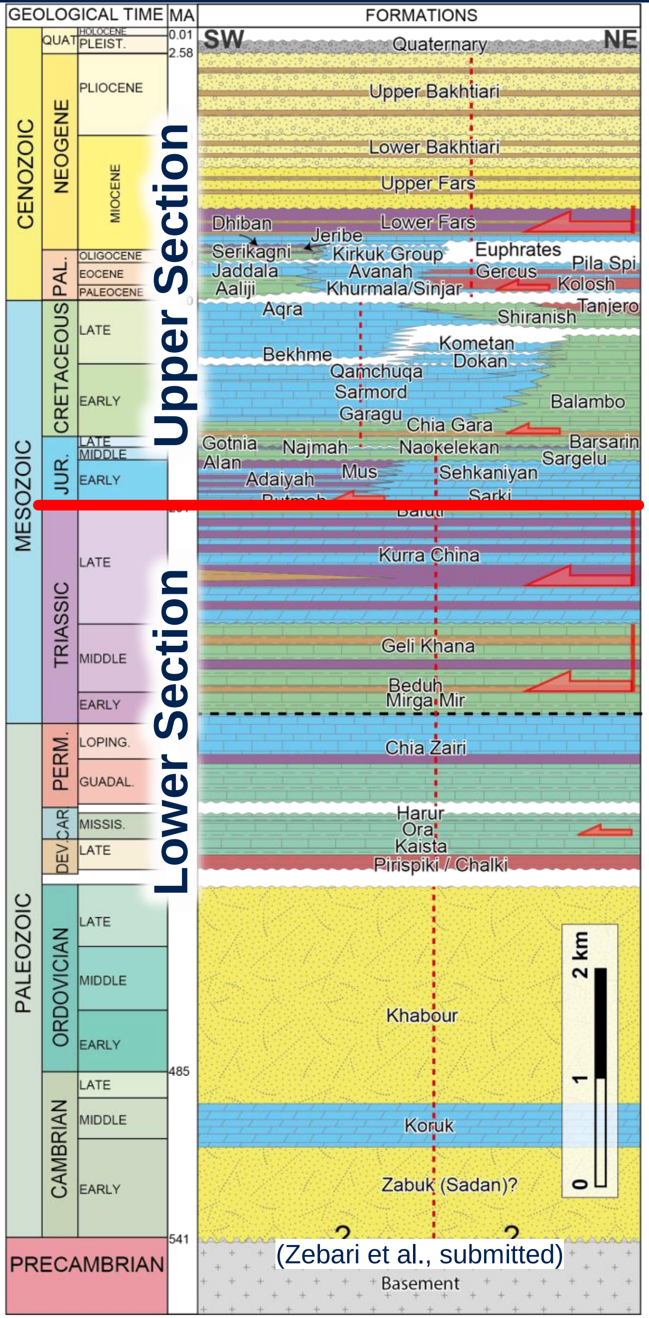
(Zebari et al., submitted)



(Zebari et al., submitted)

Deformation

- 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.



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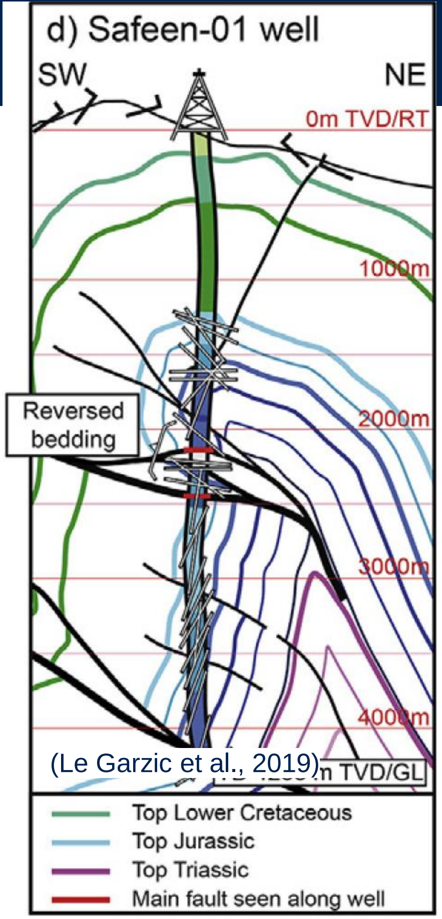
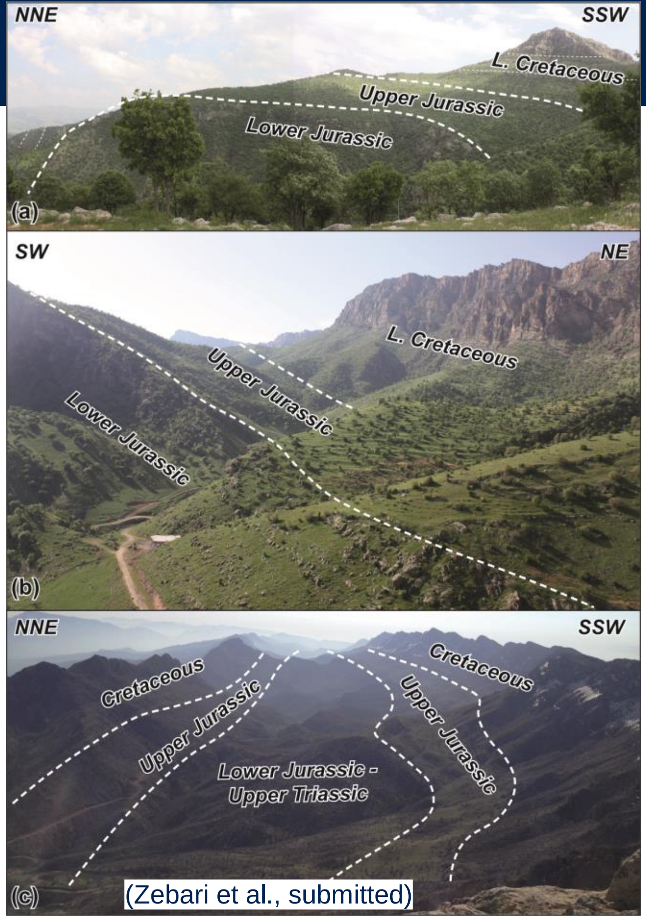


(Le Garzic et al., 2019)



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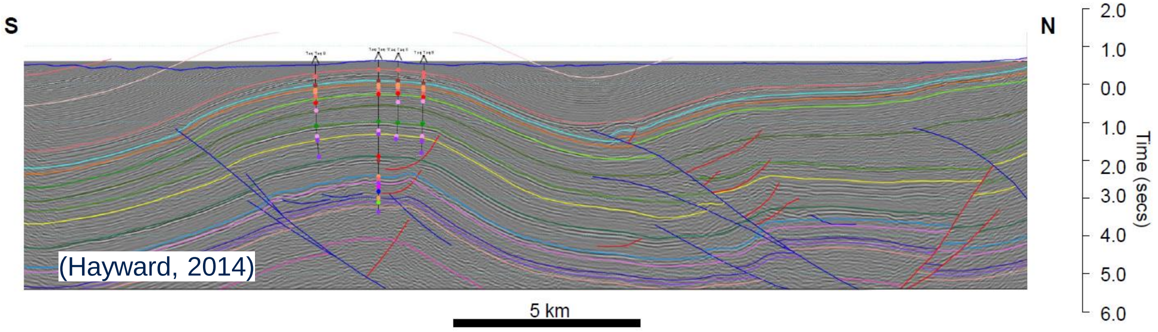
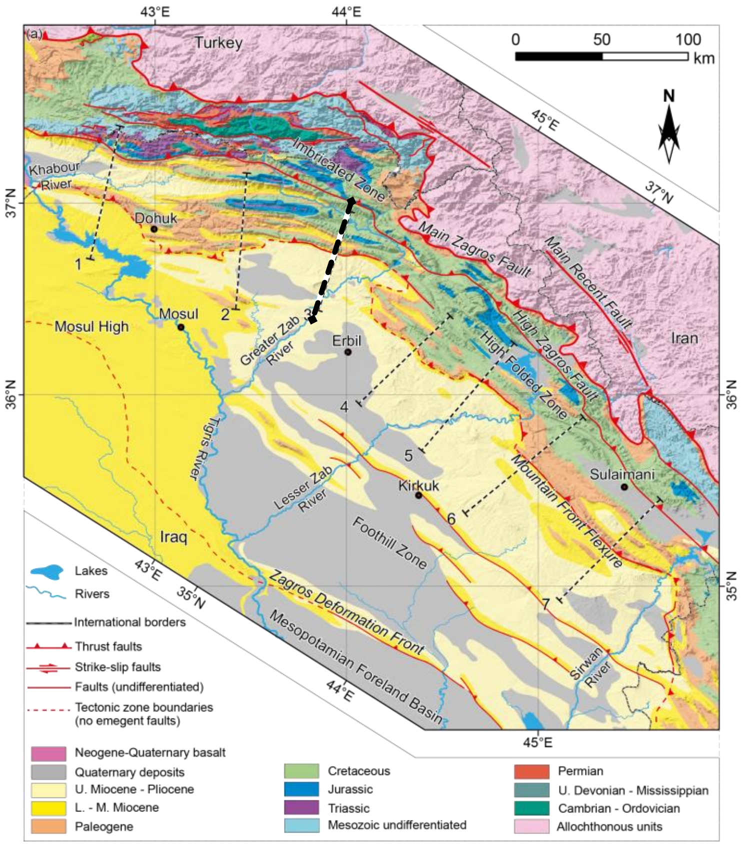


(Hayward, 2014)

(modified after de Lamotte and Leturmy, 2013)

Structural Relief

- 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.



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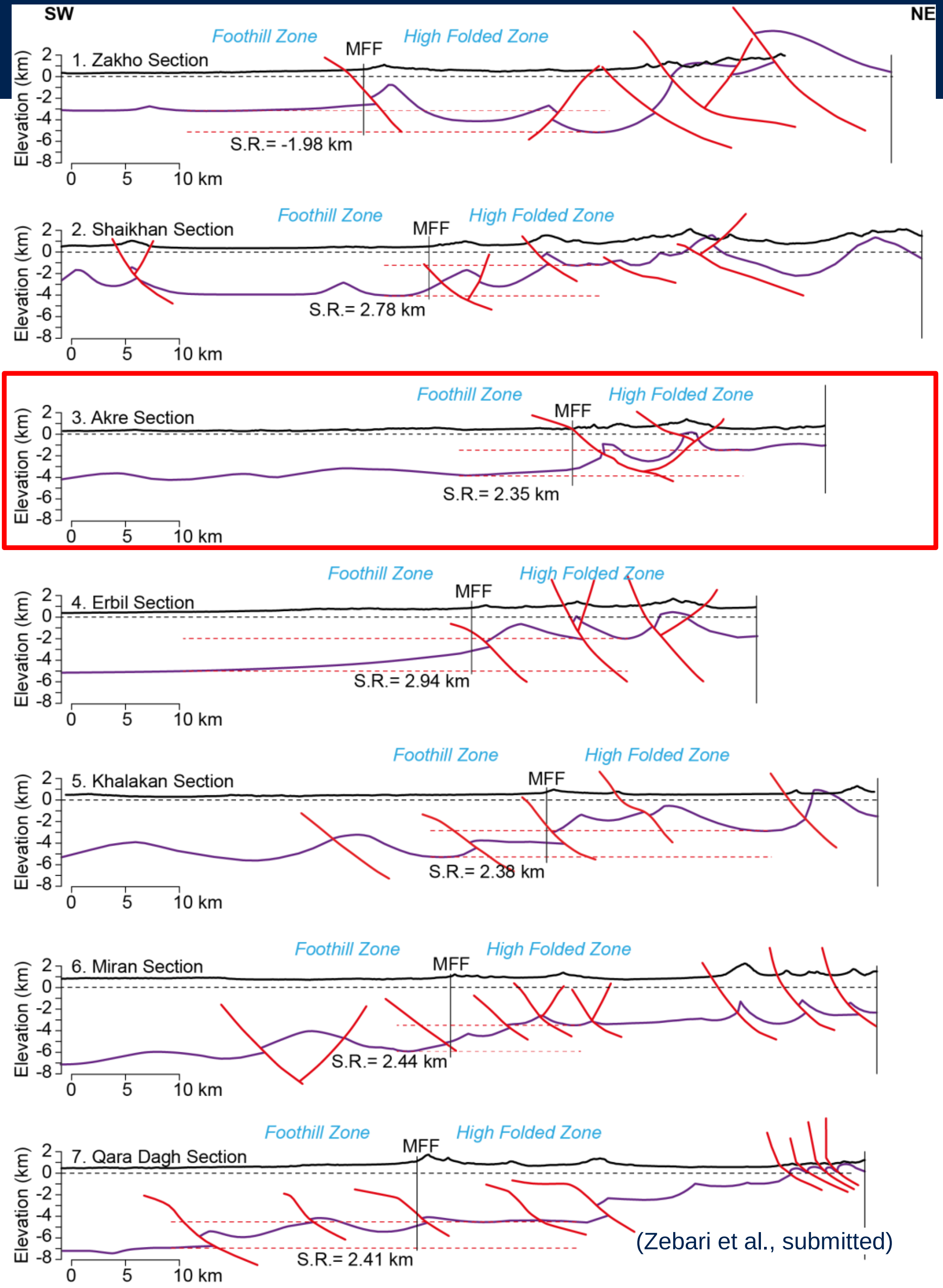
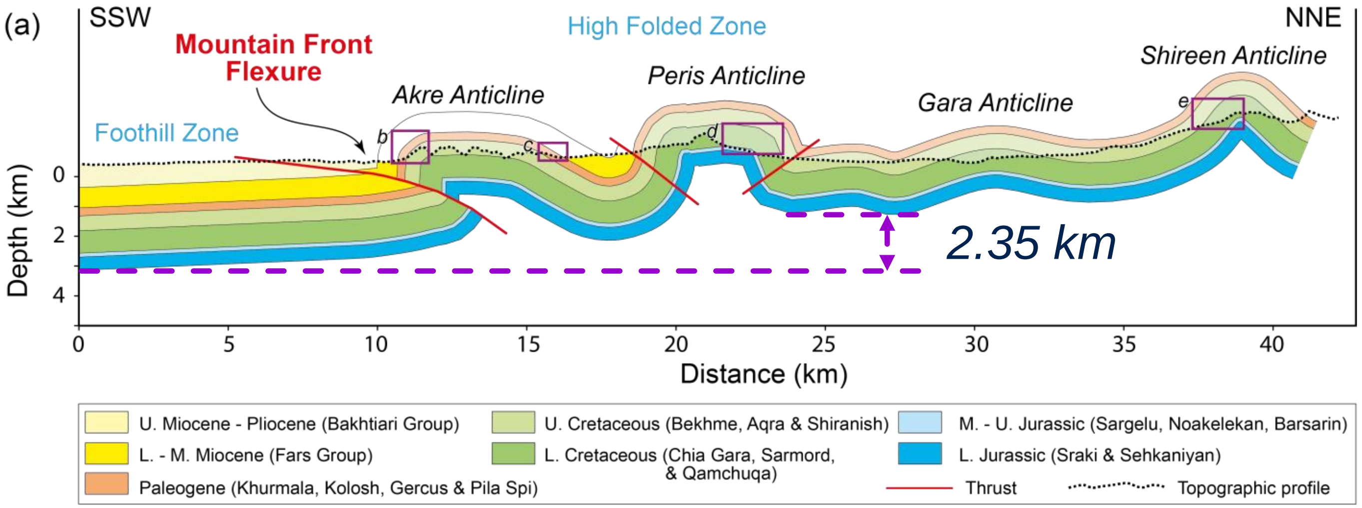


(Zebari et al., submitted)

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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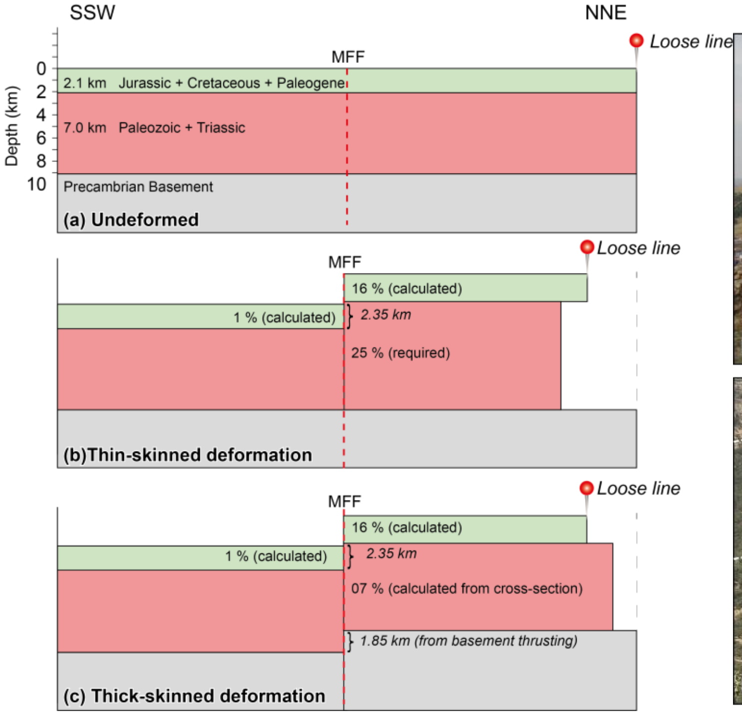

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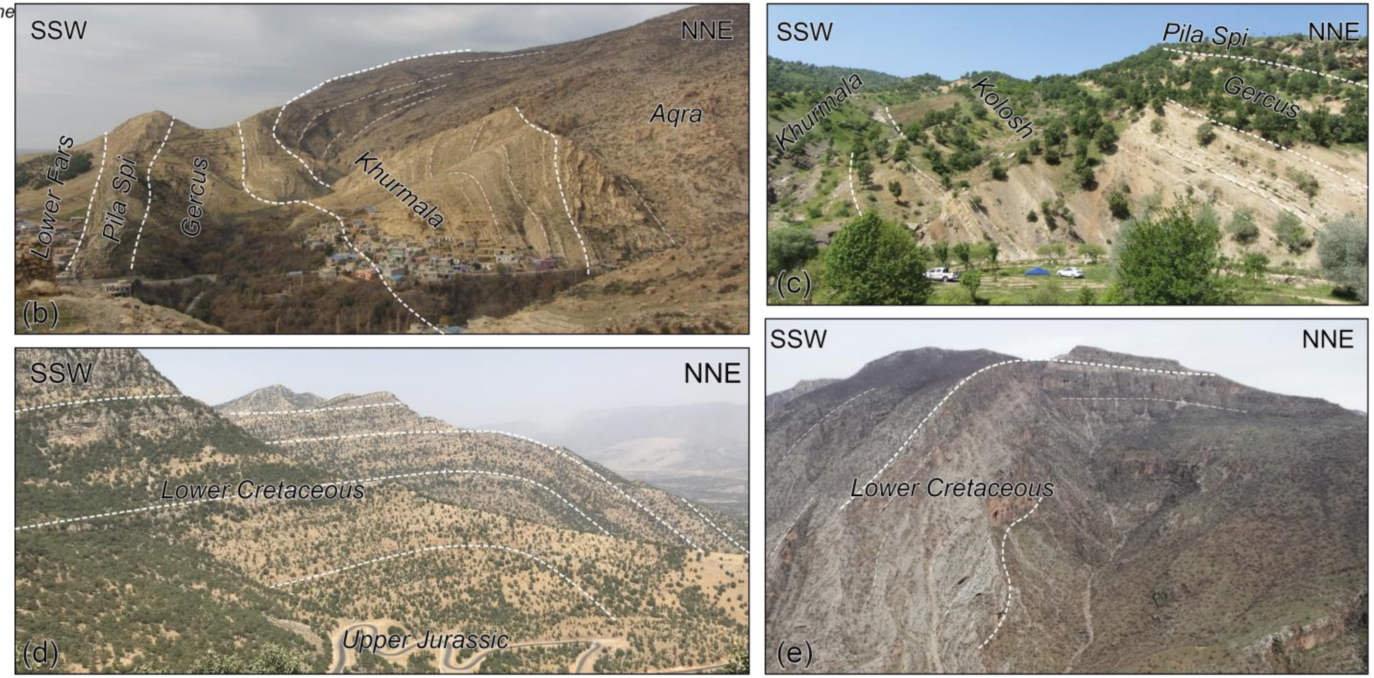
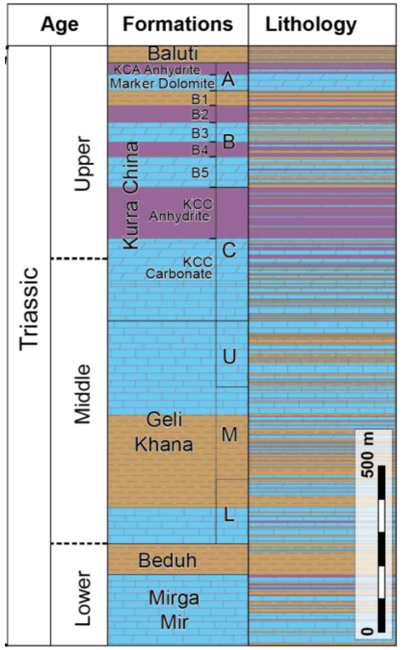
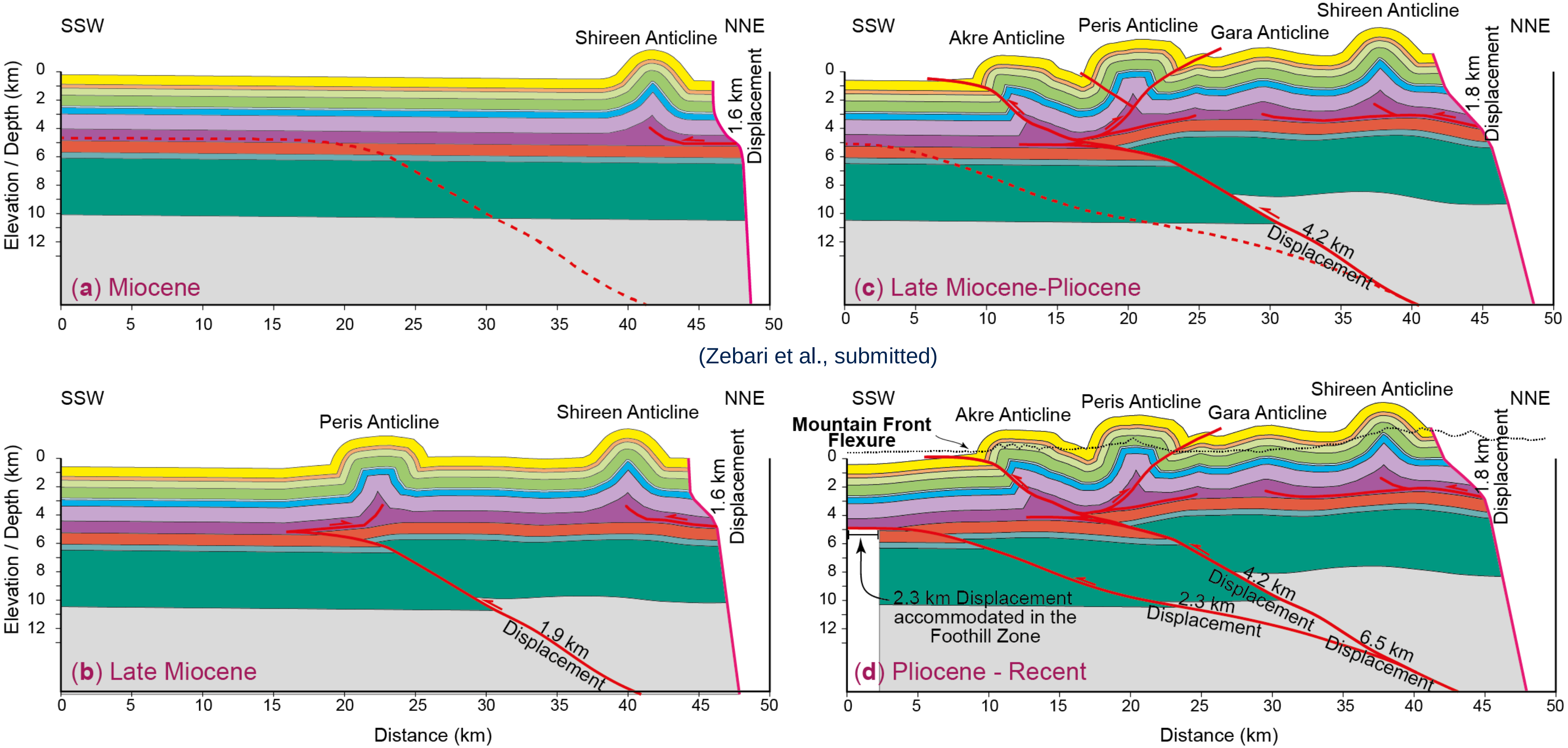


Forward Modeling

- 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.



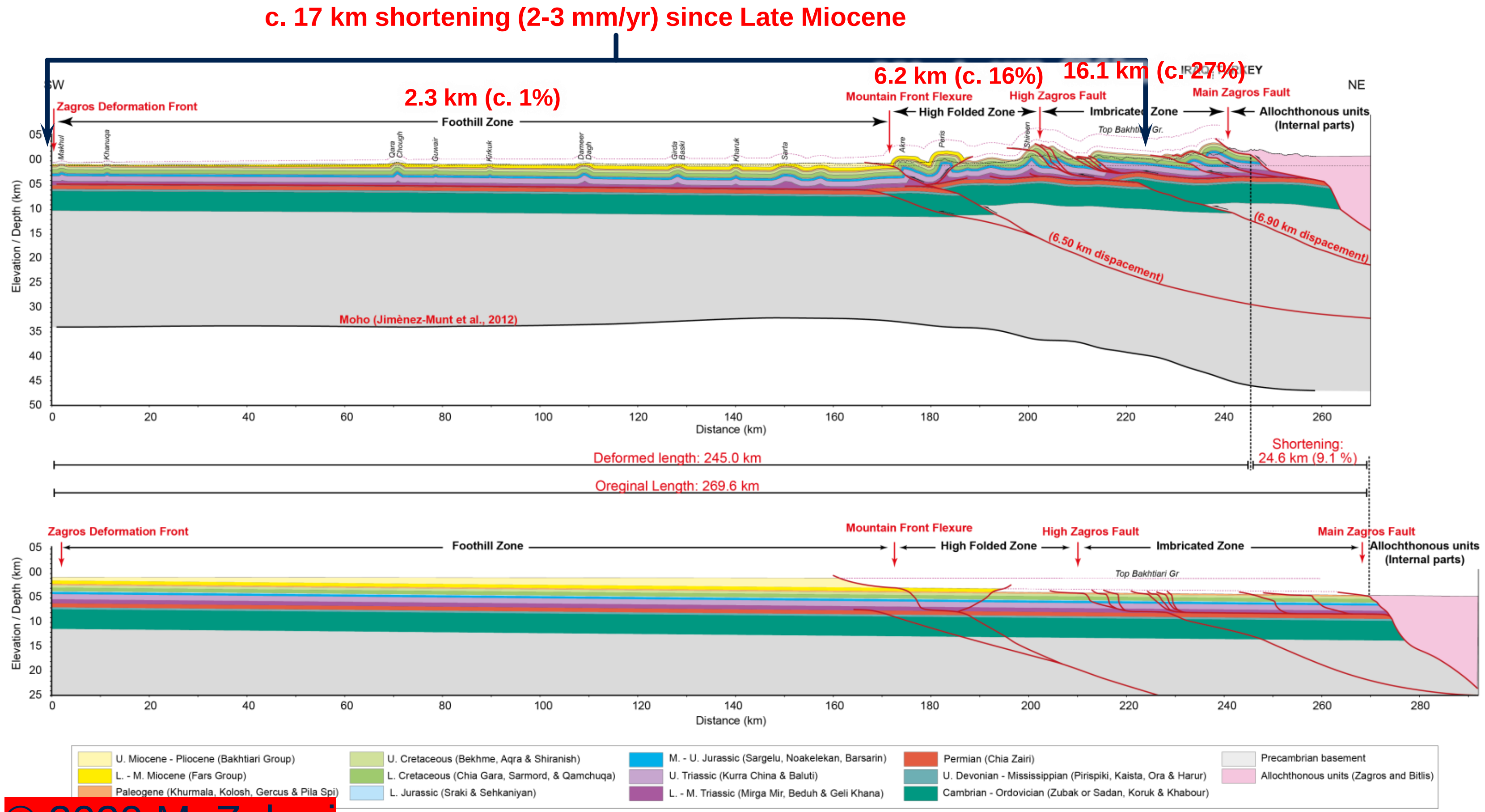


(Zebari et al., submitted)

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).



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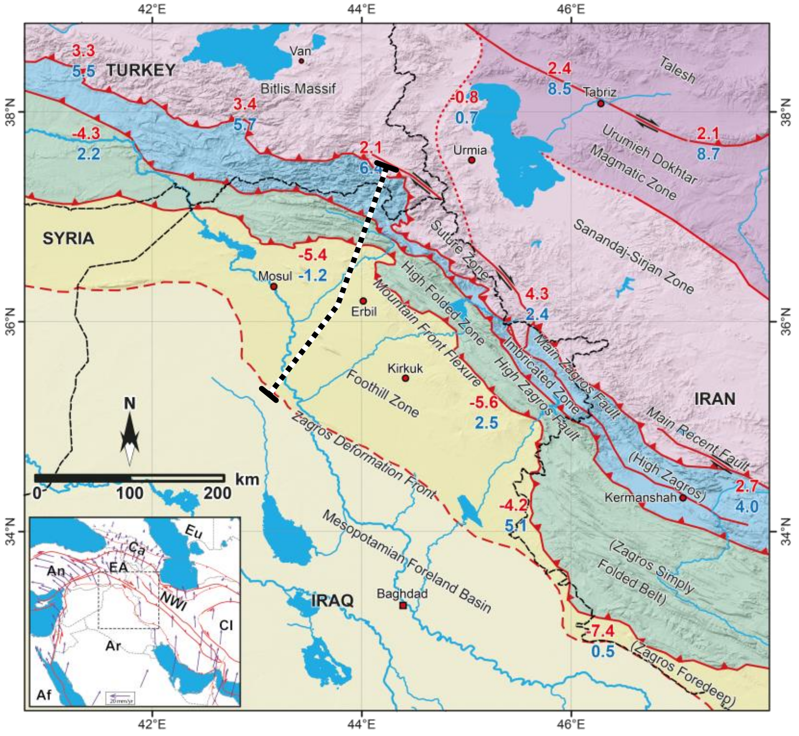

Fault slip rates (block model)

- **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.**

Cited References:

- **Balaki**, H.G.K., Omar, A.A., 2019. Structural assessment of the Bradost and Berat structures in Imbricate and High Folded zones—Iraqi Kurdistan Zagros belt. Arabian Journal of Geosciences 12, 1–21.
- **Frizon de Lamotte**, D., Leturmy, P., 2014. The structural map of the Arabian Plate and surrounding areas. Episodes, 37 , pp. 111-114.
- **Hayward**, T., 2014. The Opening of the Kurdistan Oil and Gas Province: The Making of a Nation. Search and Discovery Article #110204 (2014), AAPG International Conference and Exhibition.
- **Hinsch**, R., Bretis, B., 2015. A semi-balanced section in the northwestern Zagros region: Constraining the structural architecture of the Mountain Front Flexure in the Kirkuk Embayment, Iraq. GeoArabia 20, 41–62.
- **Khorrami**, F., Vernant, P., Masson, F., Nilfouroushan, F., Mousavi, Z., Nankali, H., Saadat, S.A., Walpersdorf, A., Hosseini, S., Tavakoli, P., Aghamohammadi, A., Alijanzade, M., 2019. An up-to-date crustal deformation map of Iran using integrated campaign-mode and permanent GPS velocities. Geophysical Journal International 217, 832–843.
- **Lunn**, G.A., Miller, S., Samarrai, A., 2019. DATING AND CORRELATION OF THE BALUTI FORMATION, KURDISTAN, IRAQ: Implications for the regional recognition of a Carnian “marker dolomite”, and a review of the Triassic to Early Jurassic sequence stratigraphy of the Arabian Plate. Journal of Petroleum Geology 42, 5–36.
- **Omar**, A.A., Lawa, F.A., Sulaiman, S.H., 2015. Tectonostratigraphic and structural imprints from balanced sections across the north-western Zagros fold-thrust belt, Kurdistan region, NE Iraq. Arabian Journal of Geosciences 8, 8107–8129.
- **Tozer**, R.S.J., Hertle, M., Petersen, H.I., Zinck-Jørgensen, K., 2019. Quantifying vertical movements in fold and thrust belts: subsidence, uplift and erosion in Kurdistan, northern Iraq. Geological Society, London, Special Publications SP490-2019–118.
- **Zebari,** M., Grützner, C., Navabpour, P., and Ustaszewski, K., 2019. Relative timing of uplift along the Zagros Mountain Front Flexure (Kurdistan Region of Iraq): Constrained by geomorphic indices and landscape evolution modeling, Solid Earth, 10, 663–682.
- **Zebari**, M., Balling, P., Grützner, C., Navabpour, P., Witte, J., and Ustaszewski, K.. Structural style of the NW Zagros Mountains and the role of basement thrusting for its Mountain Front Flexure, Kurdistan Region of Iraq. Submitted to the Journal of Structural Geology.

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