

From Ancient Suture to Active Fault Zones

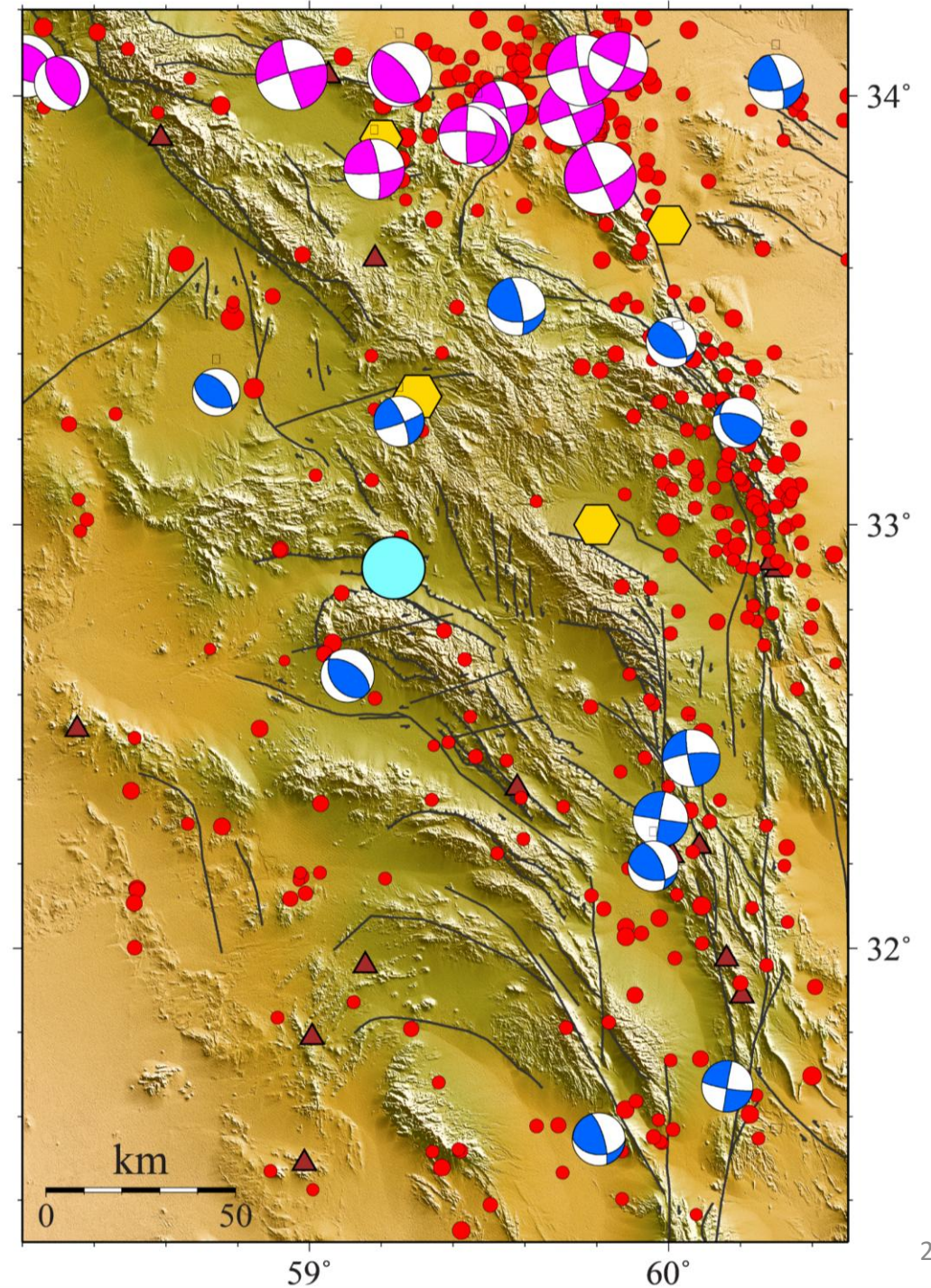
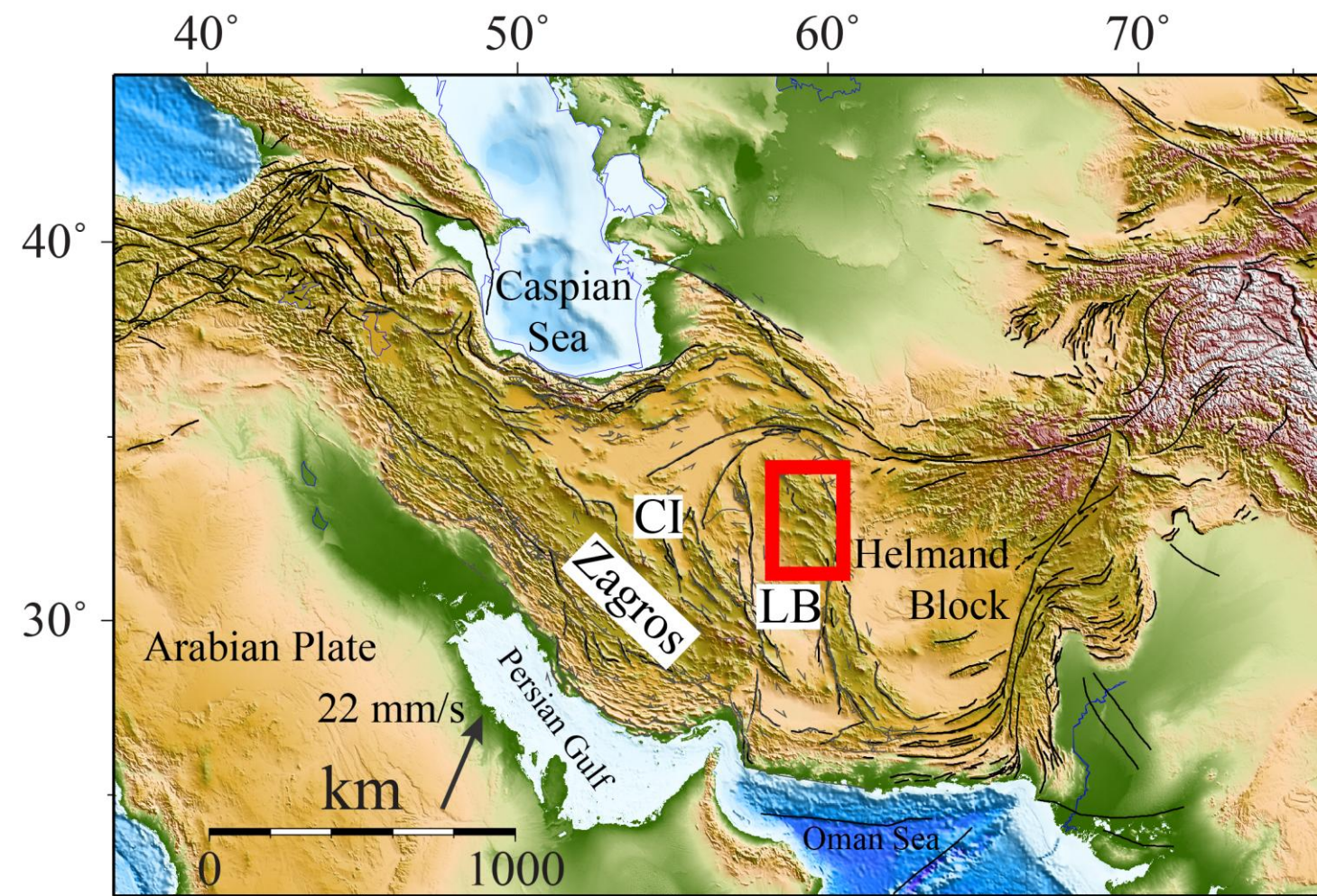


Seismic Imaging of the Tectonic and Seismogenic Architecture of Northern Sistan Stuture Zone

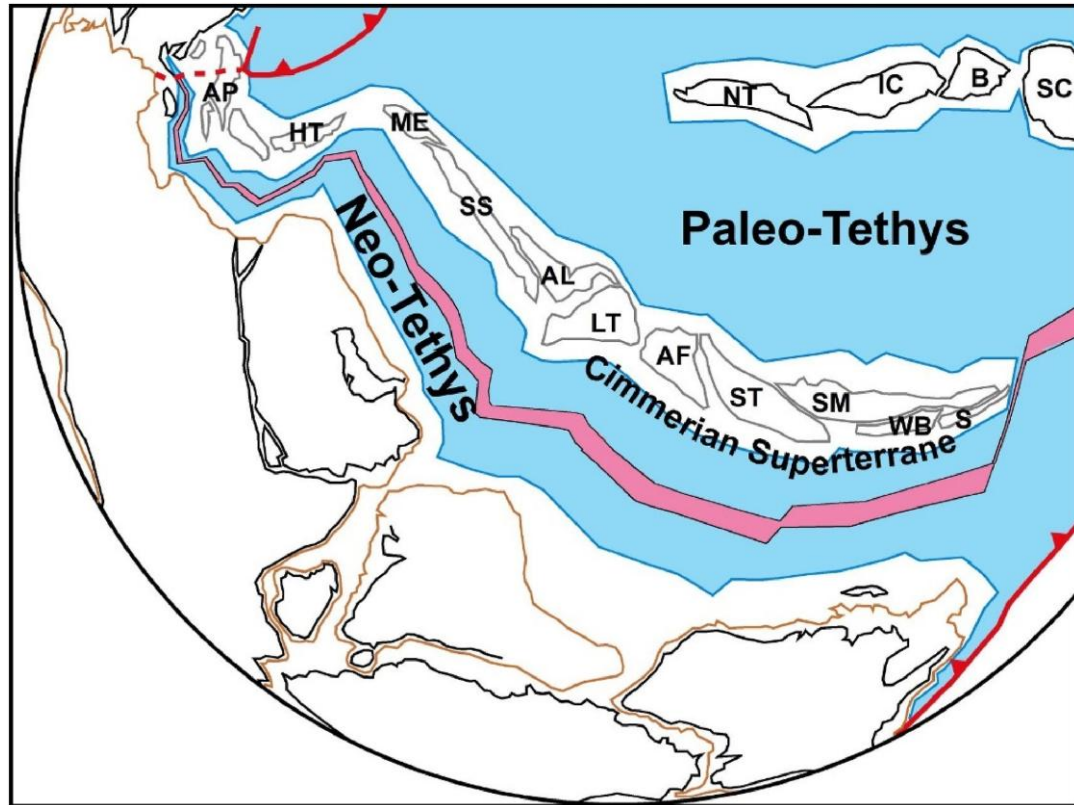
Meysam Mahmoodabadi
Seismological Research Center

19th October, 2026

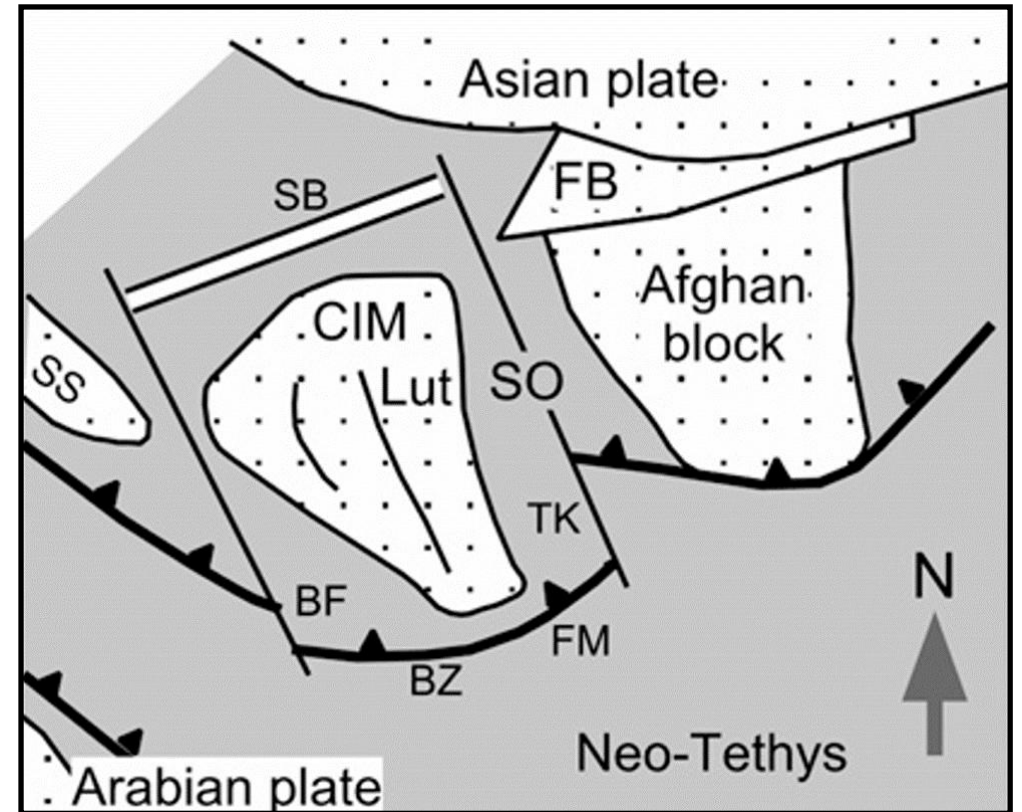
Tectonics and seismicity



Evolution history

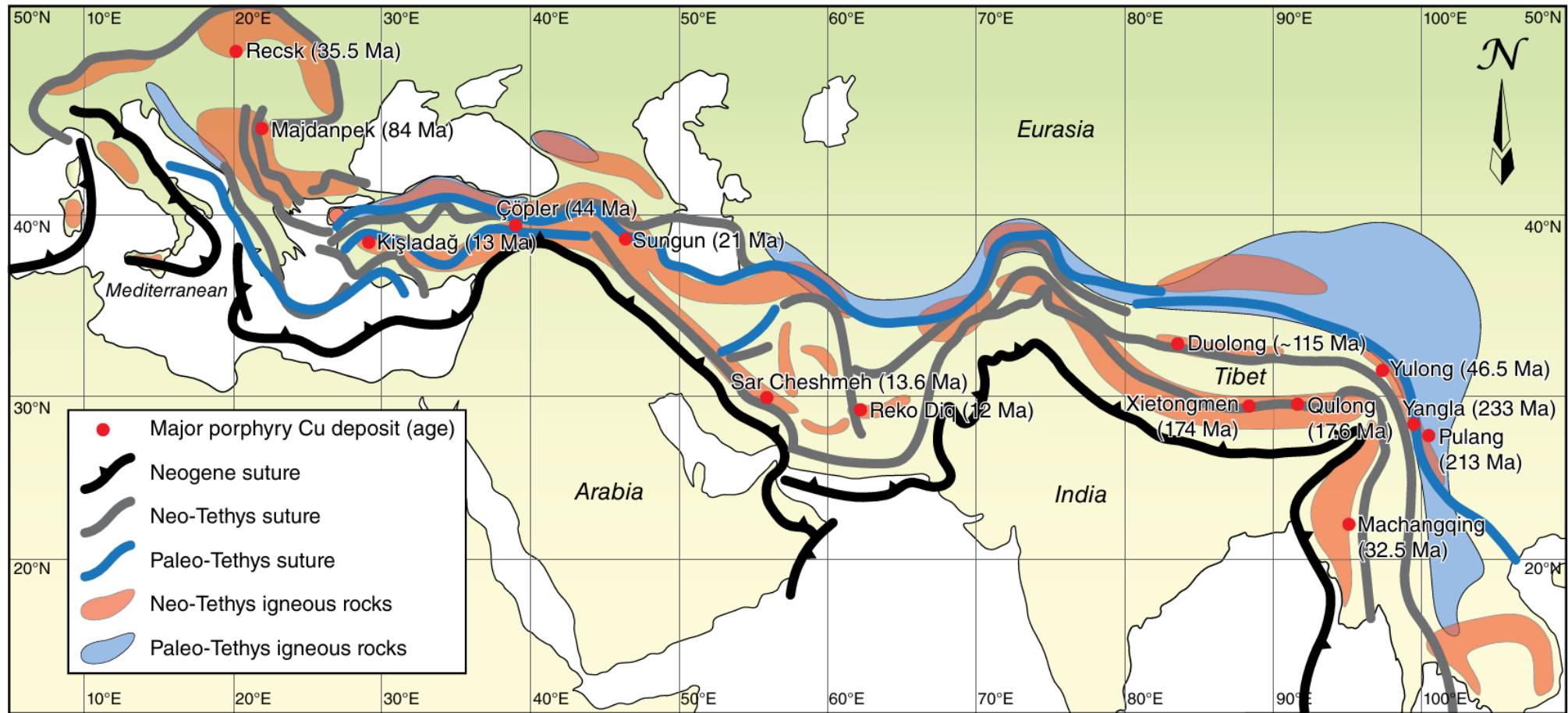


Khin et al. 2025; <https://doi.org/10.1016/j.eve.2025.100086>



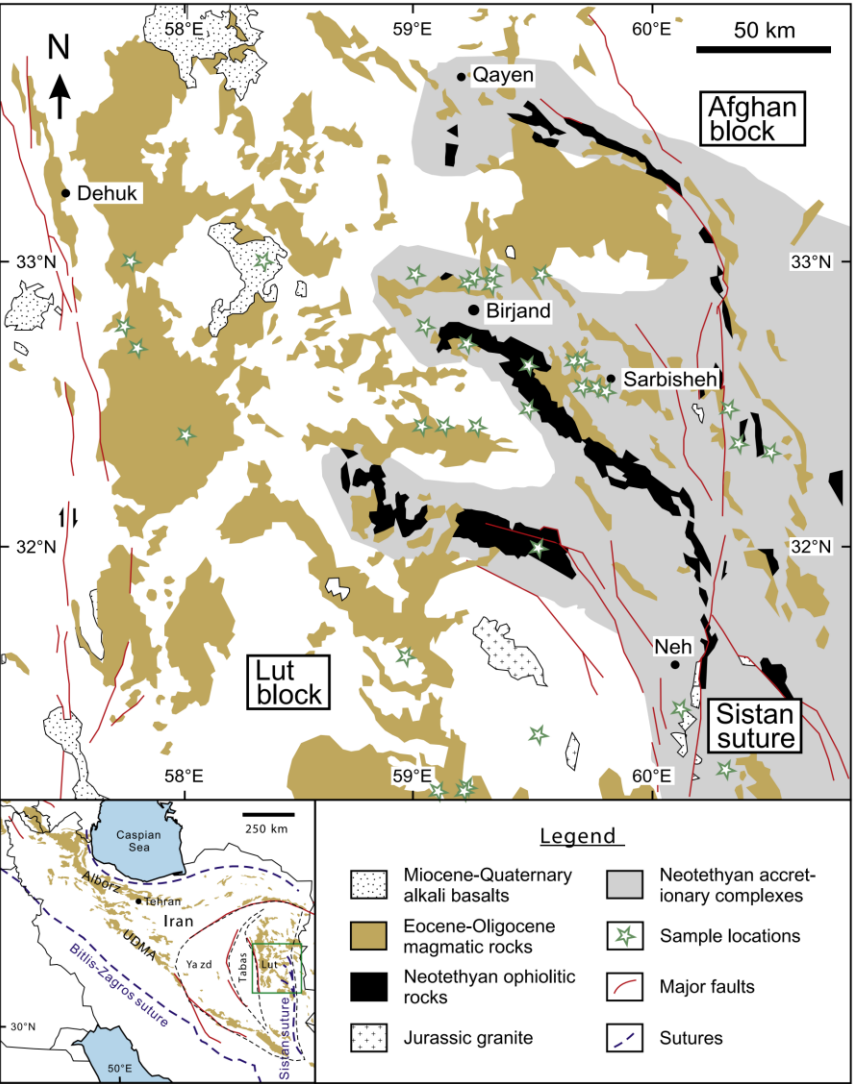
Saccani et al., 2010; <https://doi.org/10.1016/j.lithos.2010.02.016>

Evolution history

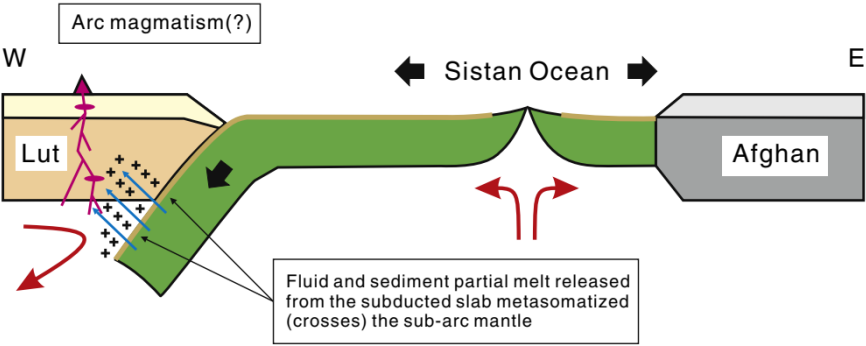


Richards & Sengör, 2017; <https://doi.org/10.1130/G38954.1>

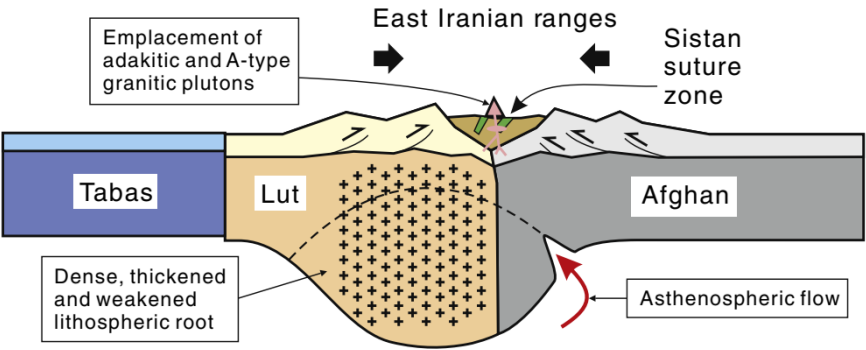
Petrological evidence



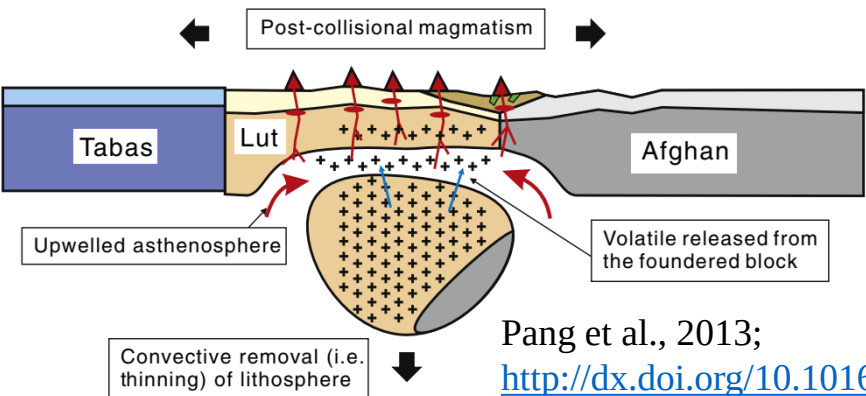
a) Early to Middle Cretaceous (pre-Aptian to ~86 Ma)



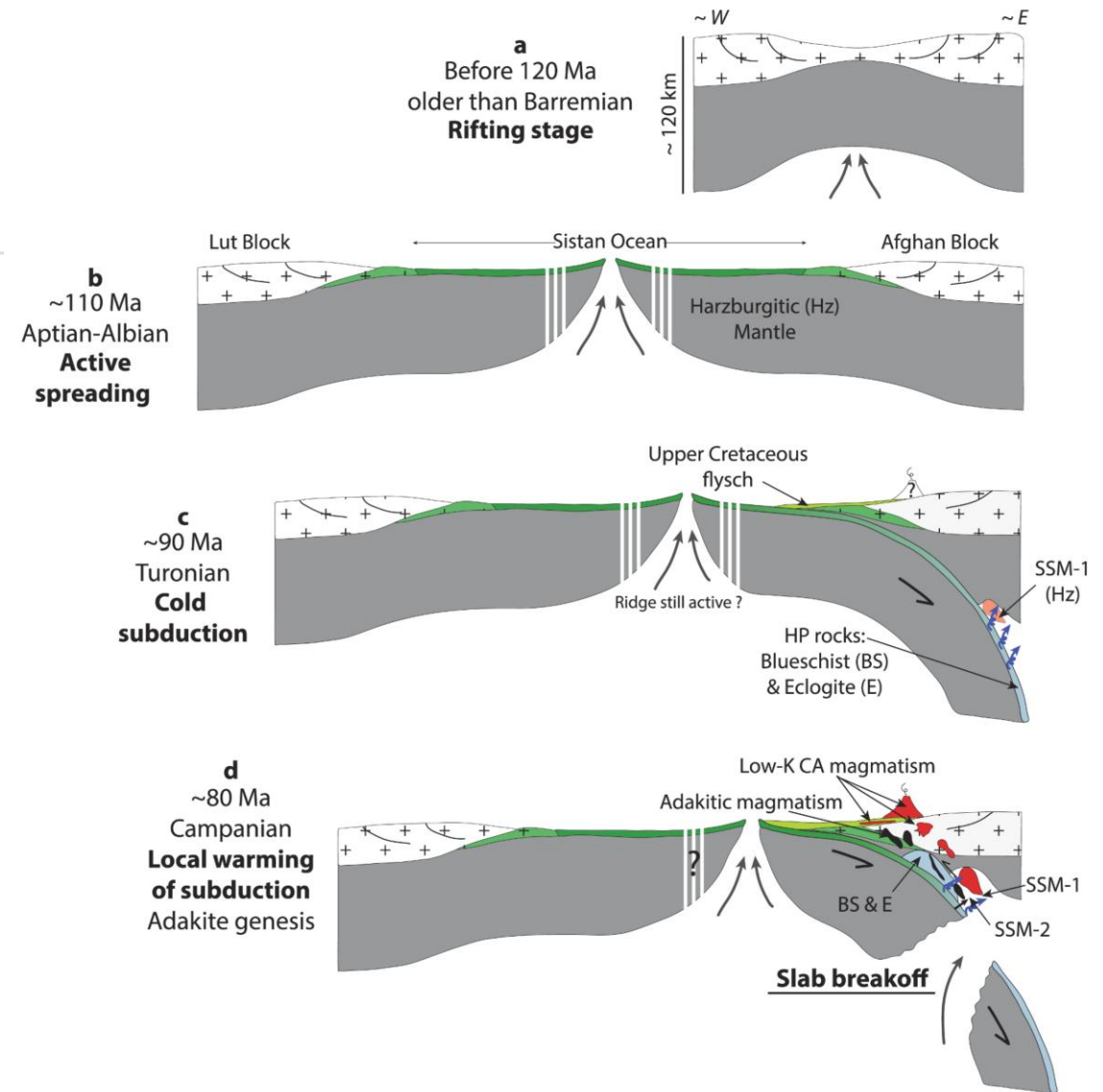
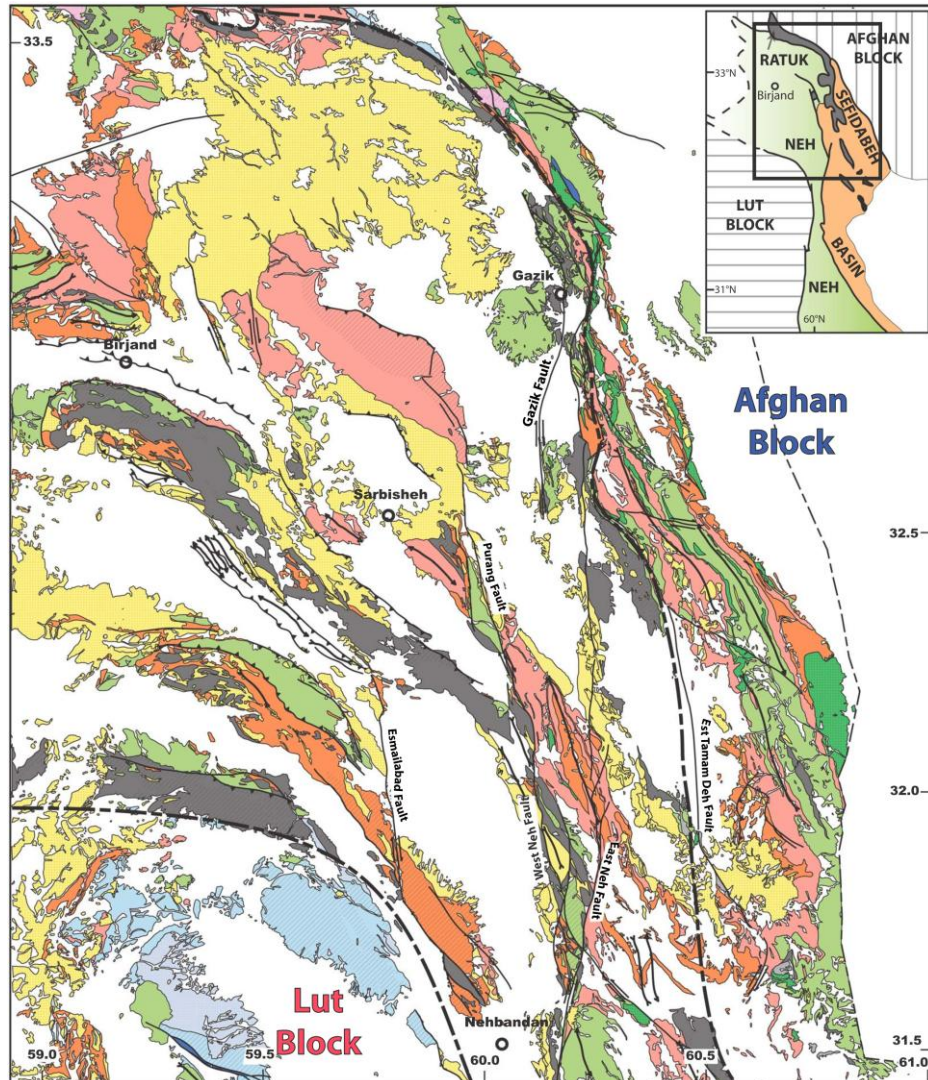
b) Late Cretaceous to Late Paleocene (~86-55 Ma)



c) Middle Eocene to Late Oligocene (~46-25 Ma)



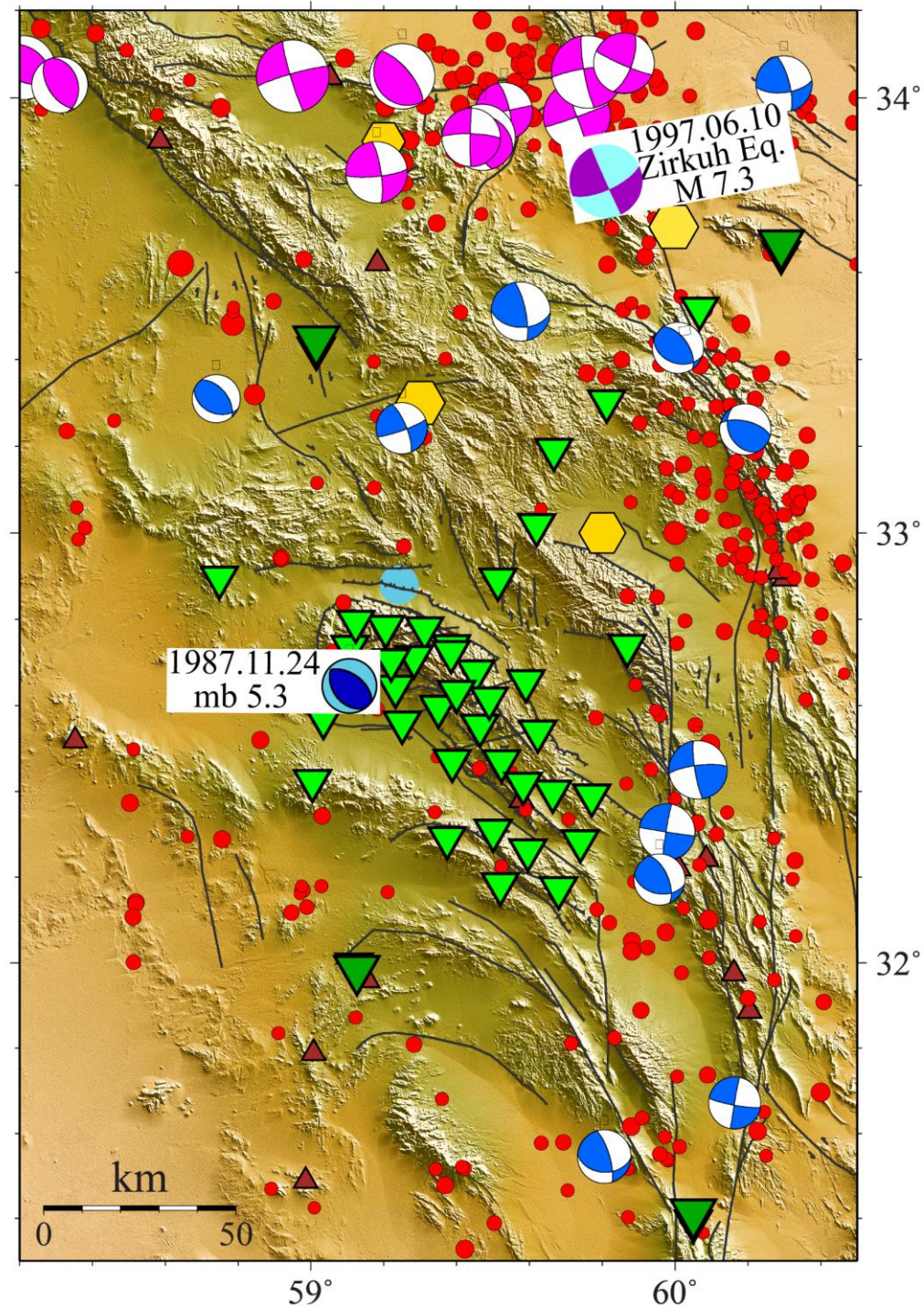
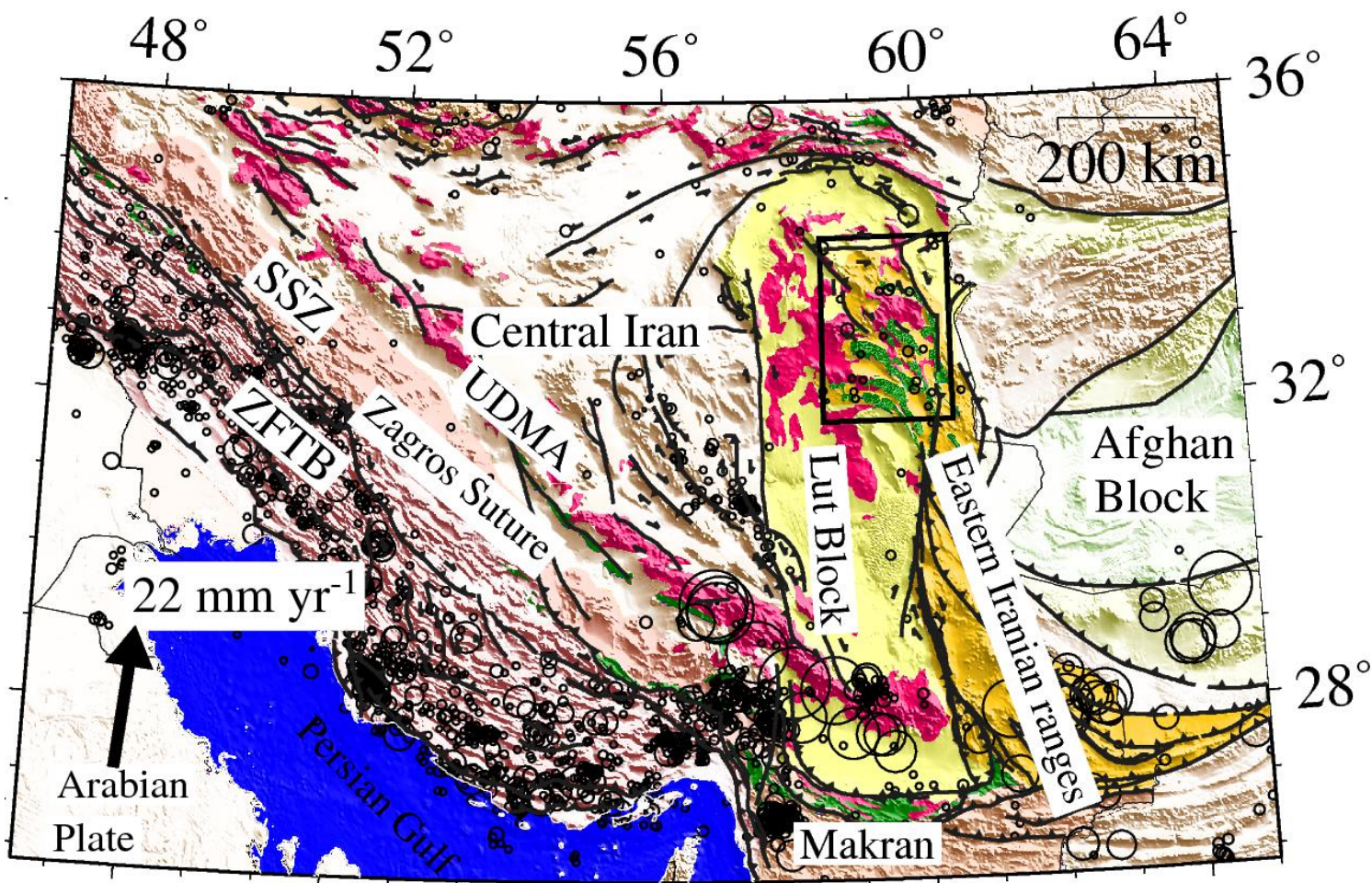
Petrological evidence



Jentzer et al., 2017; <https://doi.org/10.1002/2016TC004275>

Jentzer et al., 2020; <https://doi.org/10.1016/j.jseas.2020.104588>

IIEES seismic network





Contents lists available at [ScienceDirect](#)

Physics of the Earth and Planetary Interiors

journal homepage: www.elsevier.com/locate/pepi



<https://doi.org/10.1016/j.pepi.2024.107180>

Post-collisional lithospheric delamination in eastern Iran, revealed by non-linear teleseismic tomography and residual topography

Meysam Mahmoodabadi^{a,*}, Farzam Yamini-Fard^a, Mohammad Tatar^a, Ahmad Rashidi^b



Contents lists available at [ScienceDirect](#)

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto



<https://doi.org/10.1016/j.tecto.2026.231296>

Crustal imbrication and mountain building in the Eastern Iranian Ranges; Insights from receiver function and Rayleigh wave dispersion analysis

Meysam Mahmoodabadi^{a,*}, Farzam Yamini-Fard^a, Mohsen A. Irandoust^b, Mohammad Tatar^a, Azar Afshar-Savat^a, Saeed SoltaniMoghaddam^a



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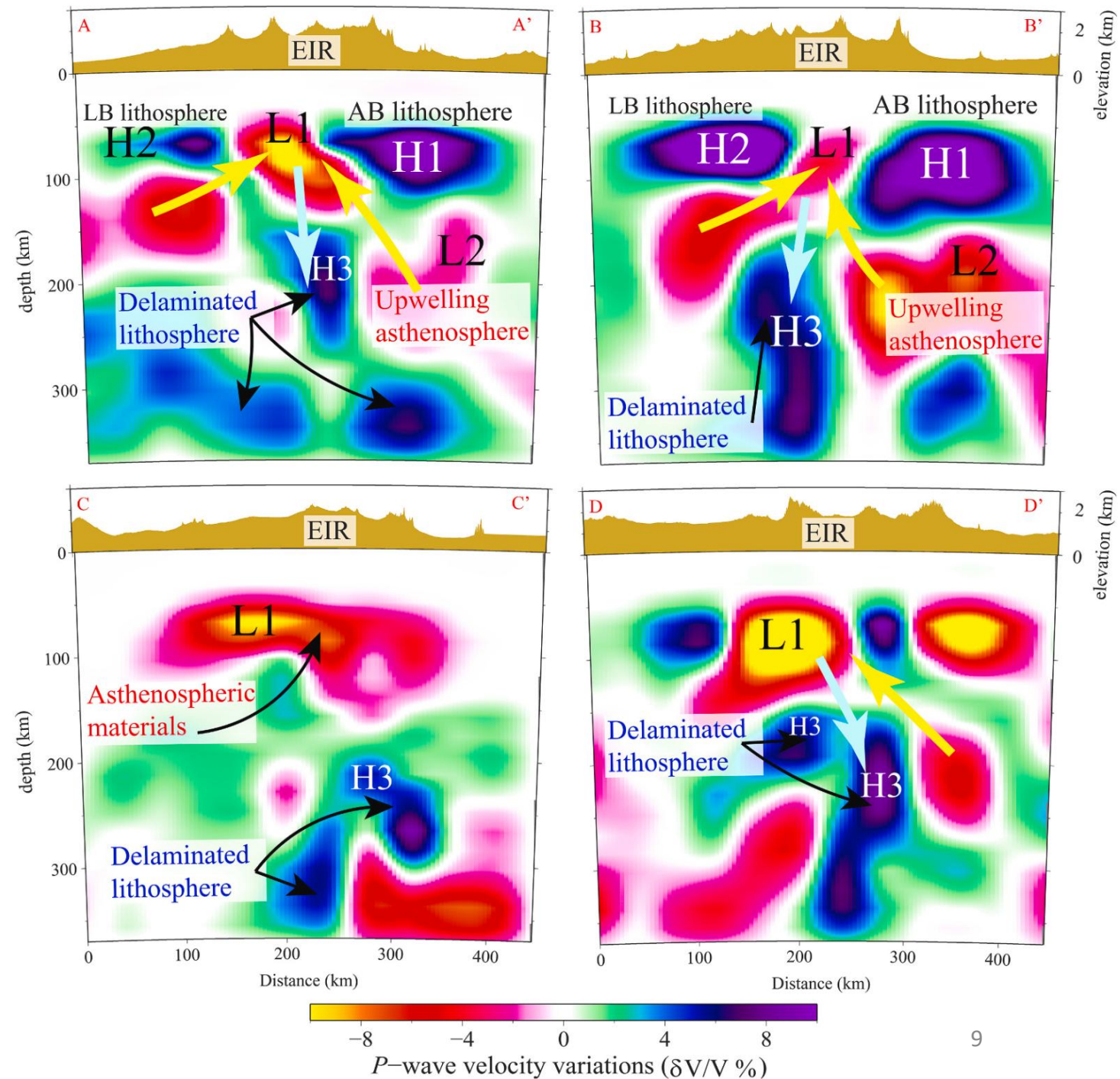
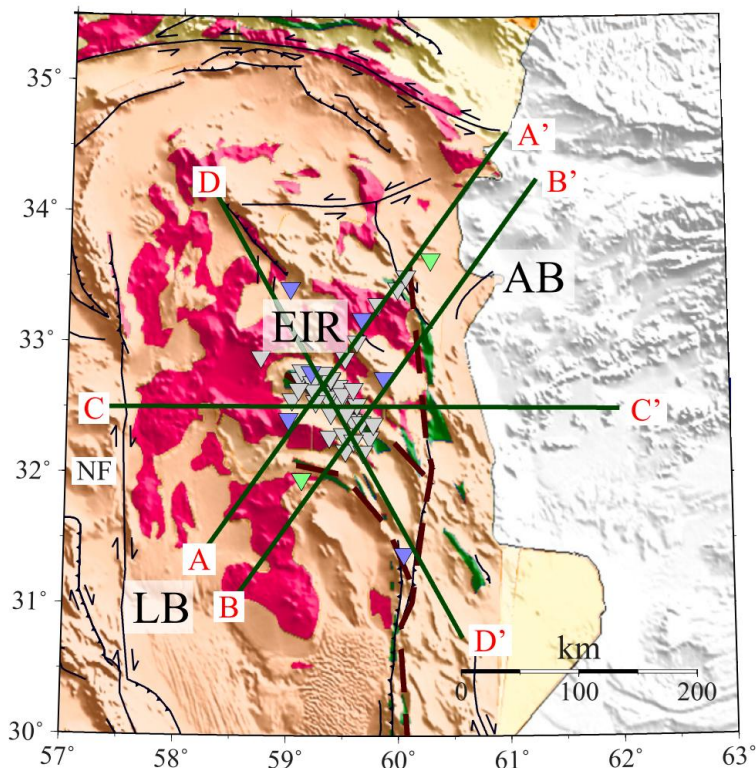


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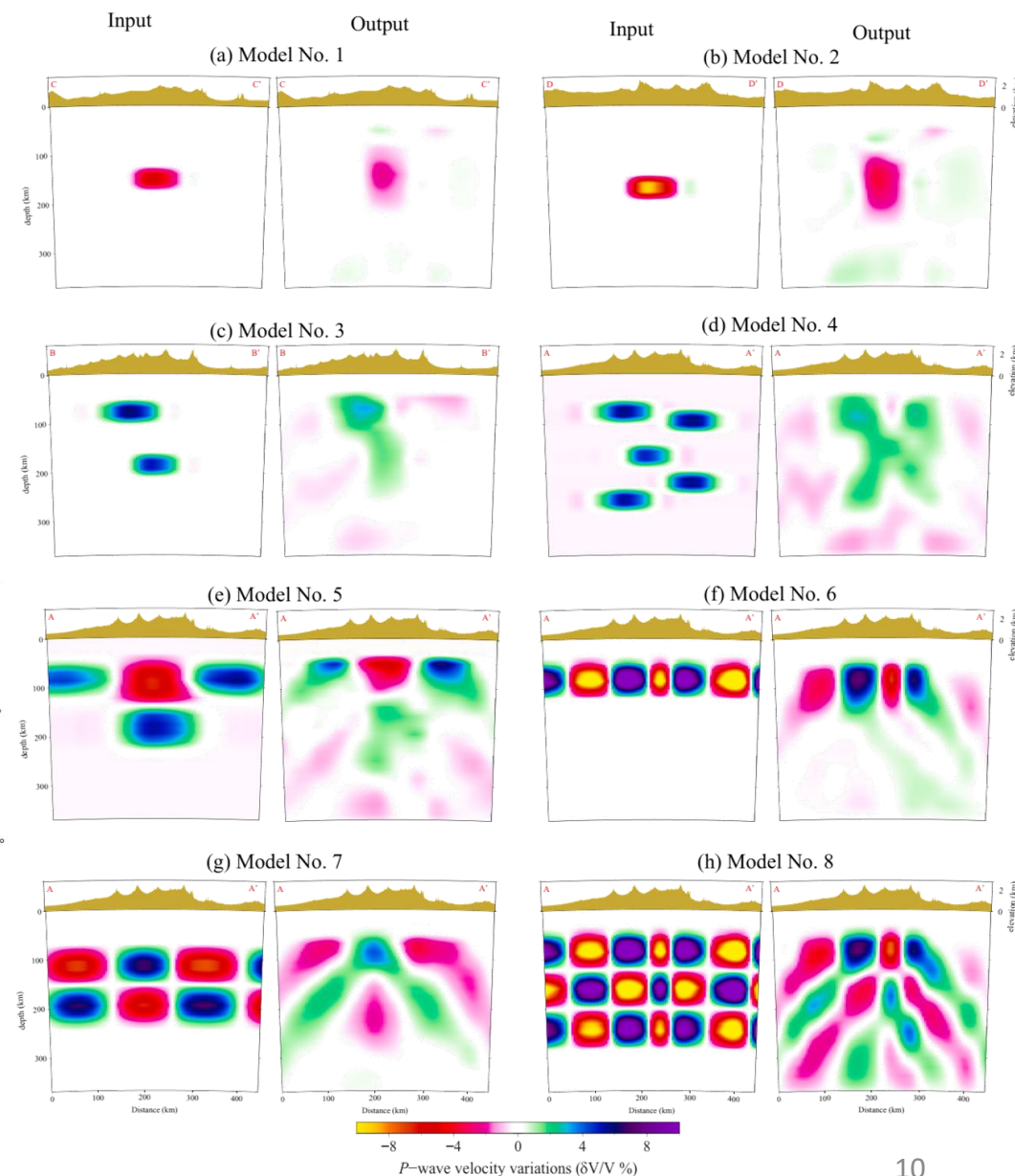
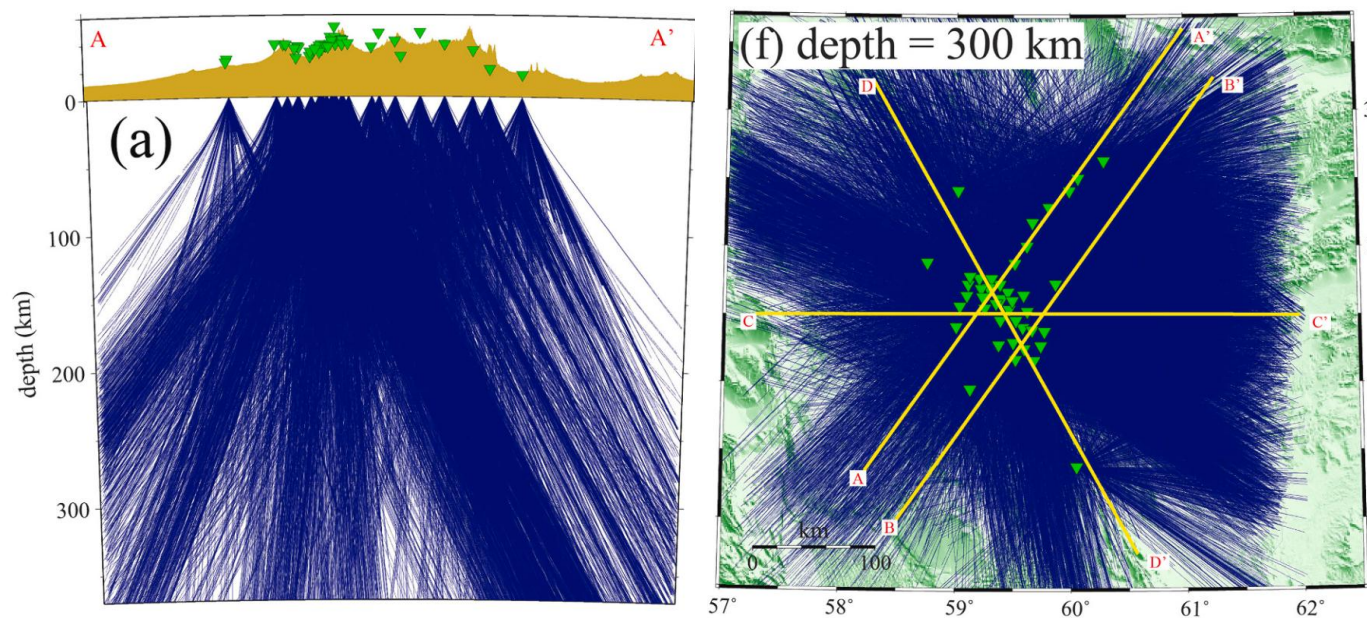
Wedge-confined deformation and strain partitioning in the northern Sistan suture zone (Eastern Iran) revealed by microseismicity

Meysam Mahmoodabadi^{a,*}, Ali Hashemi Gazar^b, Farzam Yaminifard^a, Mohammad Tatar^a, Hossein Kianimehr^b, Saeed SoltaniMoghaddam^a, Shahrokh Pourbeyranvand^a

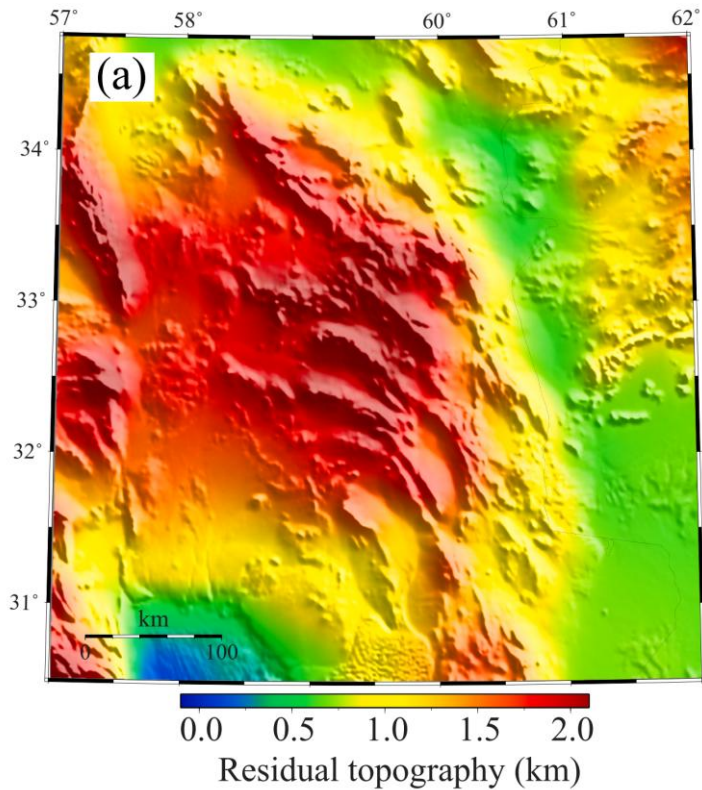
Delaminated lithosphere



Resolution of tomographic images

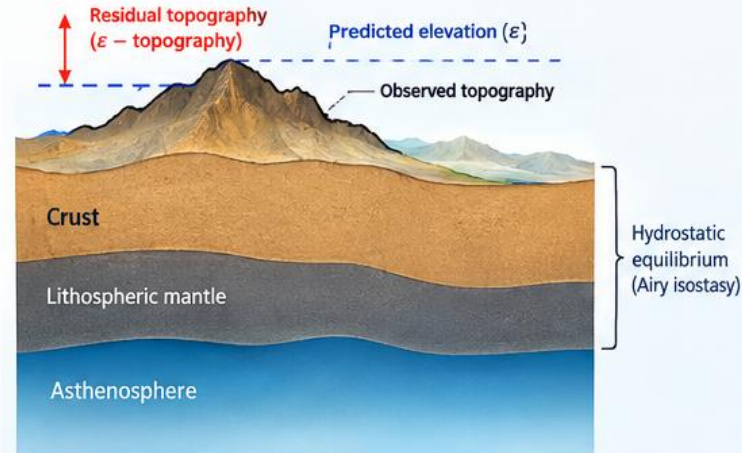


Analysis of topography



The difference between observed surface elevations and the elevations predicted from crustal buoyancy (Airy isostasy).

1. Concept



2. Calculation

$$\varepsilon = a (f_1 t_c + f_2 t_m - H) \quad (1)$$

$$a = \begin{cases} 1 & \text{for } \varepsilon \geq 0 \\ \frac{\rho_a}{\rho_a - \rho_w} & \text{for } \varepsilon < 0 \end{cases} \quad (2)$$

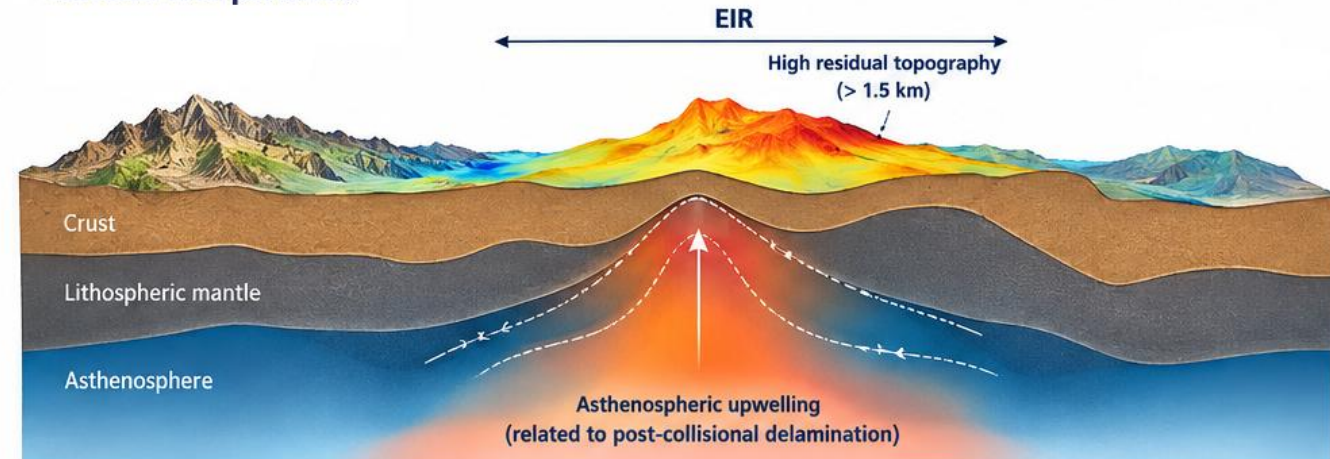
$$f_1 = \frac{\rho_a - \rho_c}{\rho_a} \quad (3)$$

$$f_2 = \frac{\rho_a - \rho_m}{\rho_a} \quad (4)$$

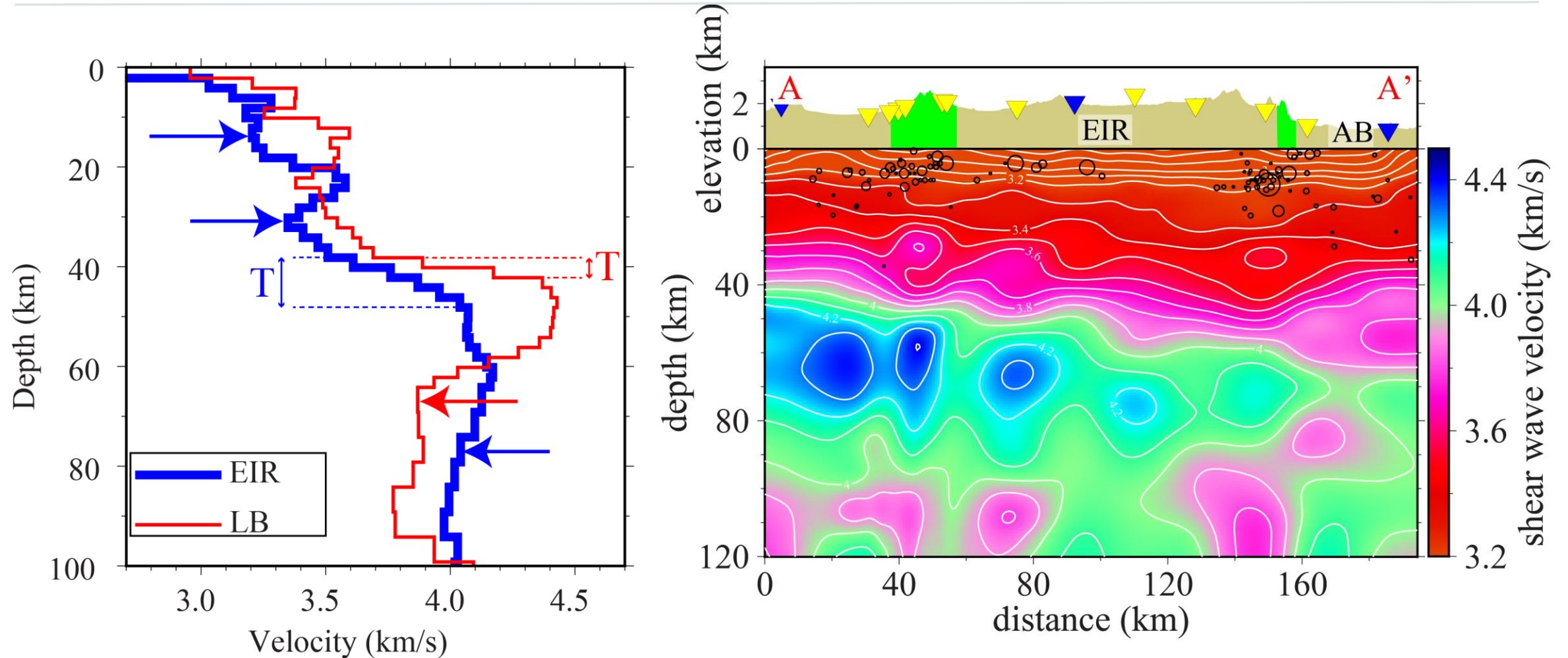
t_c : crustal thickness
 t_m : lithospheric thickness
 H : reference level (e.g., ridge or regional average)

Density values (kg/m^3):
 $\rho_a = 3260$ (asthenosphere)
 $\rho_m = 3300$ (mantle lithosphere)
 $\rho_c = 2835$ (crust)
 $\rho_w = 1000$ (water)

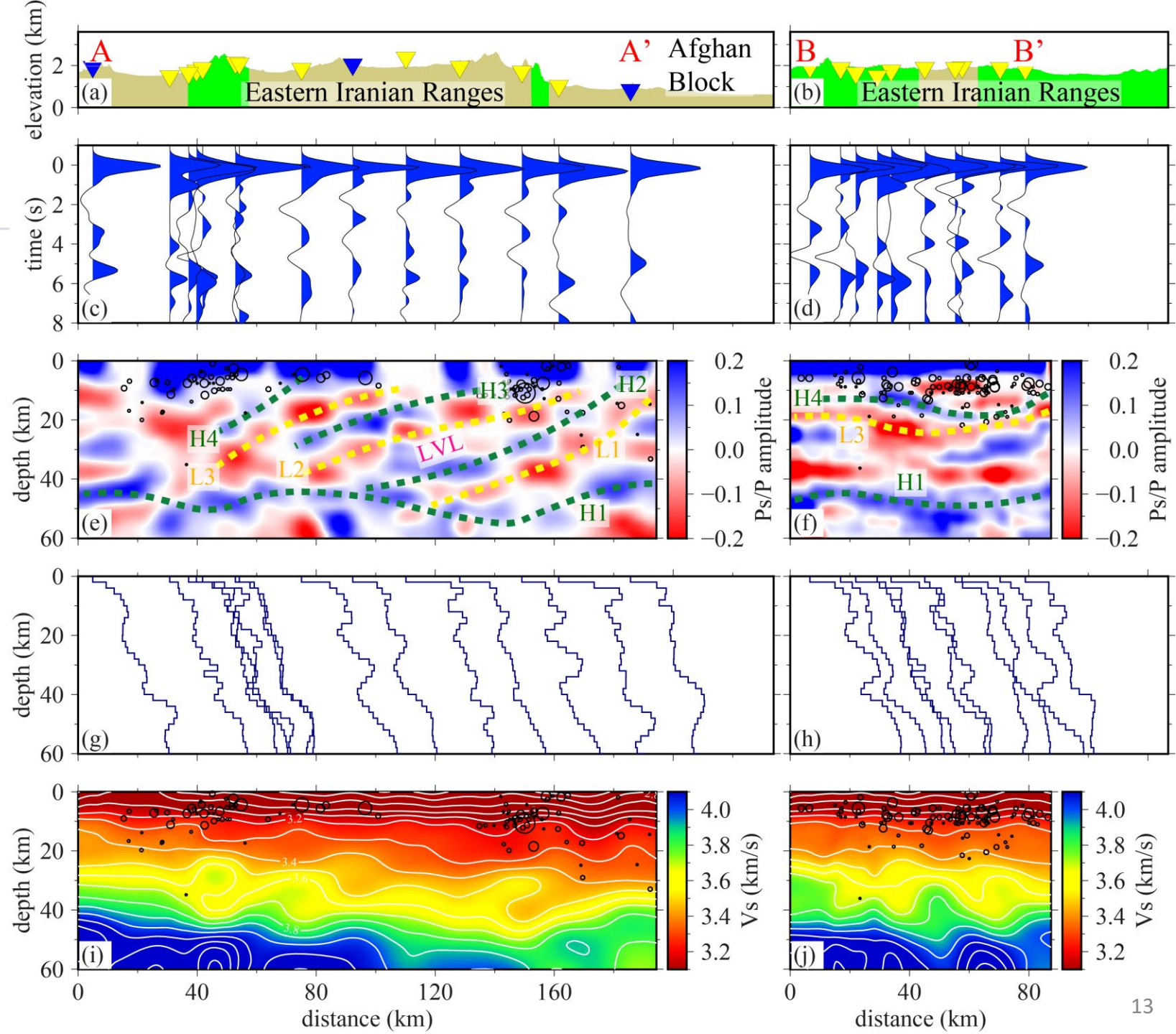
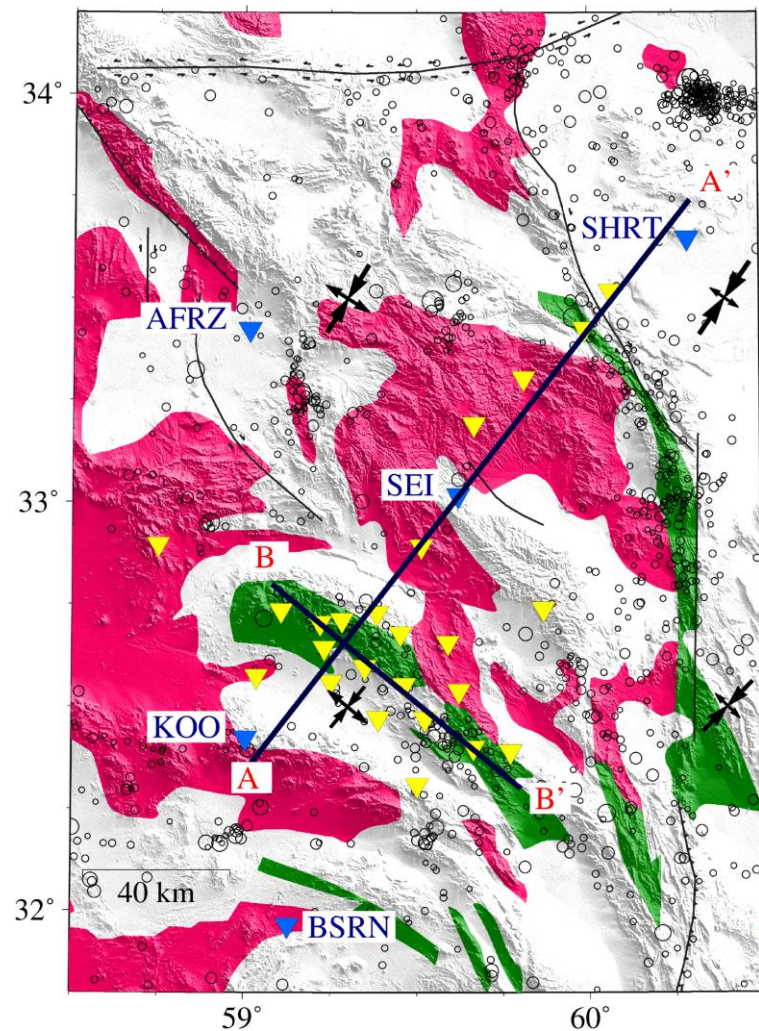
Tectonic Interpretation



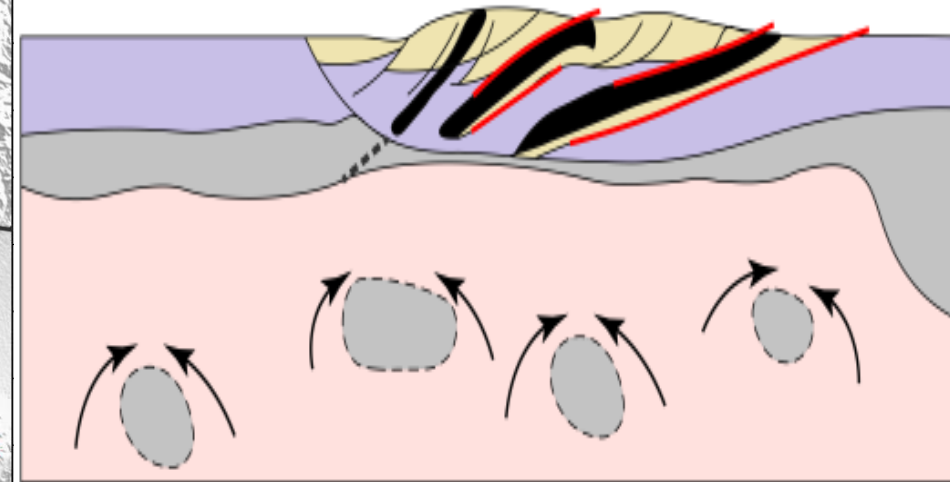
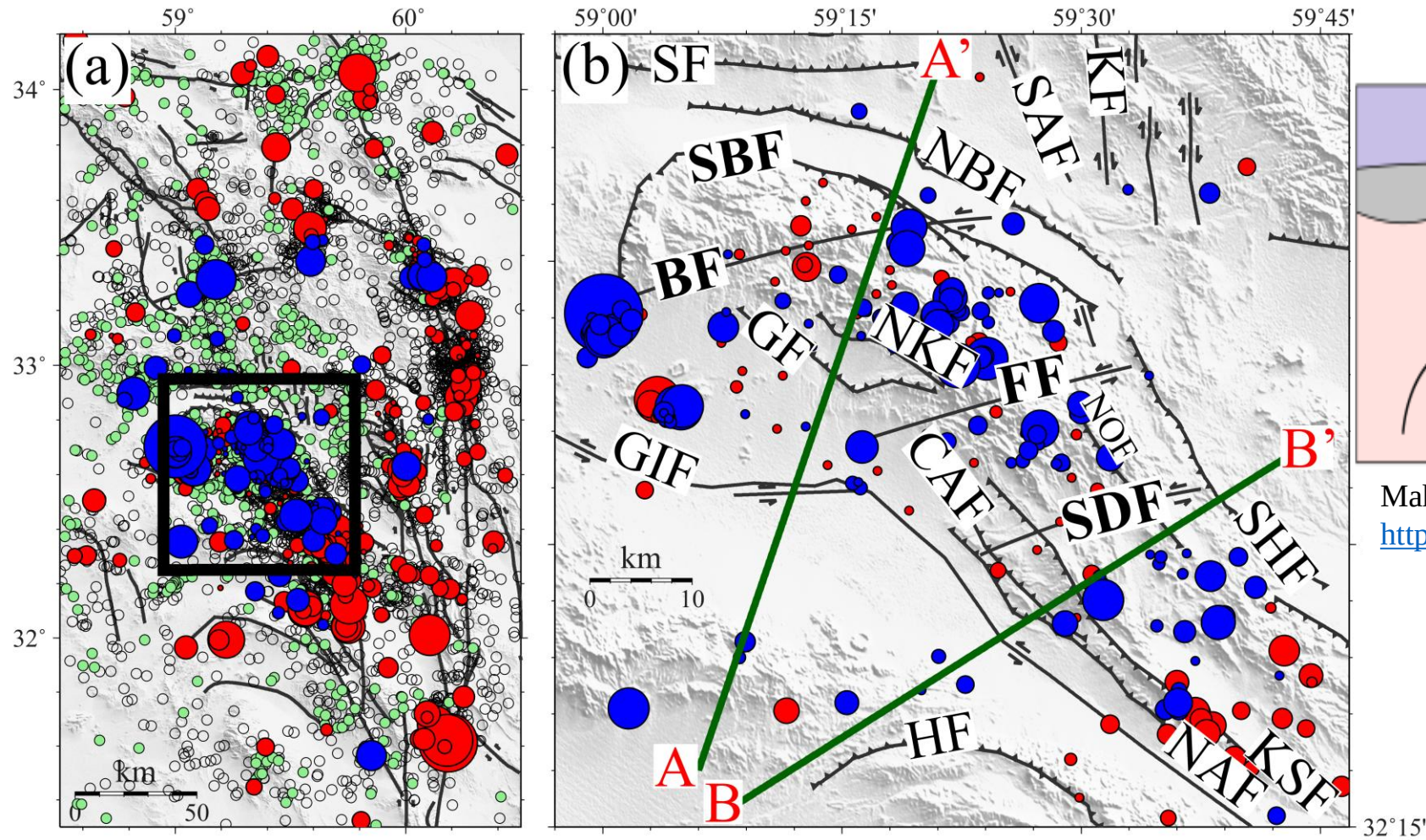
Low velocity crustal and lithospheric structures



The crust is layered



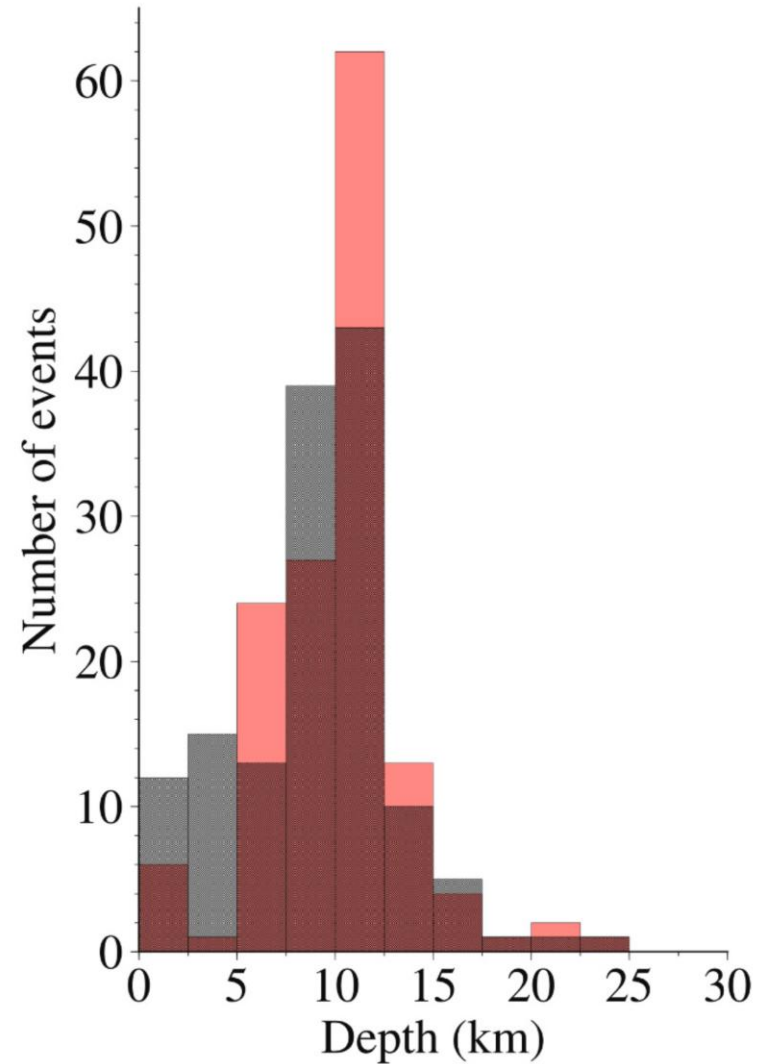
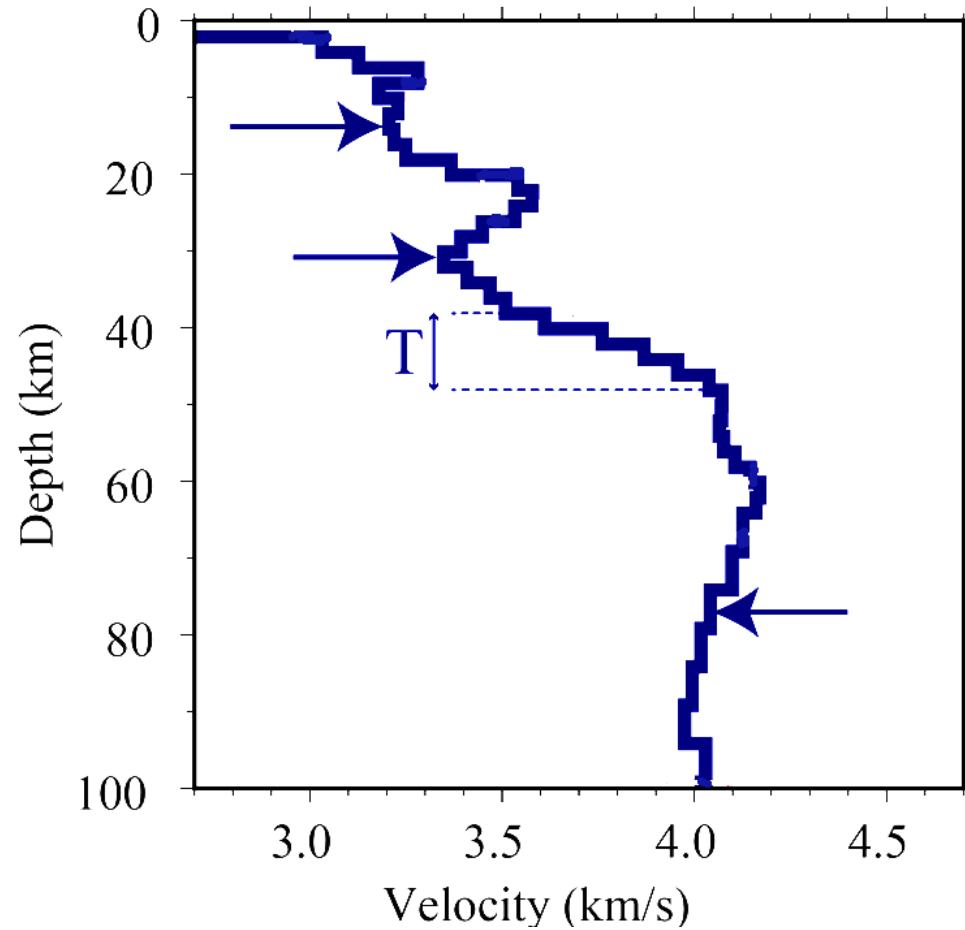
Where does present-day deformation occur?



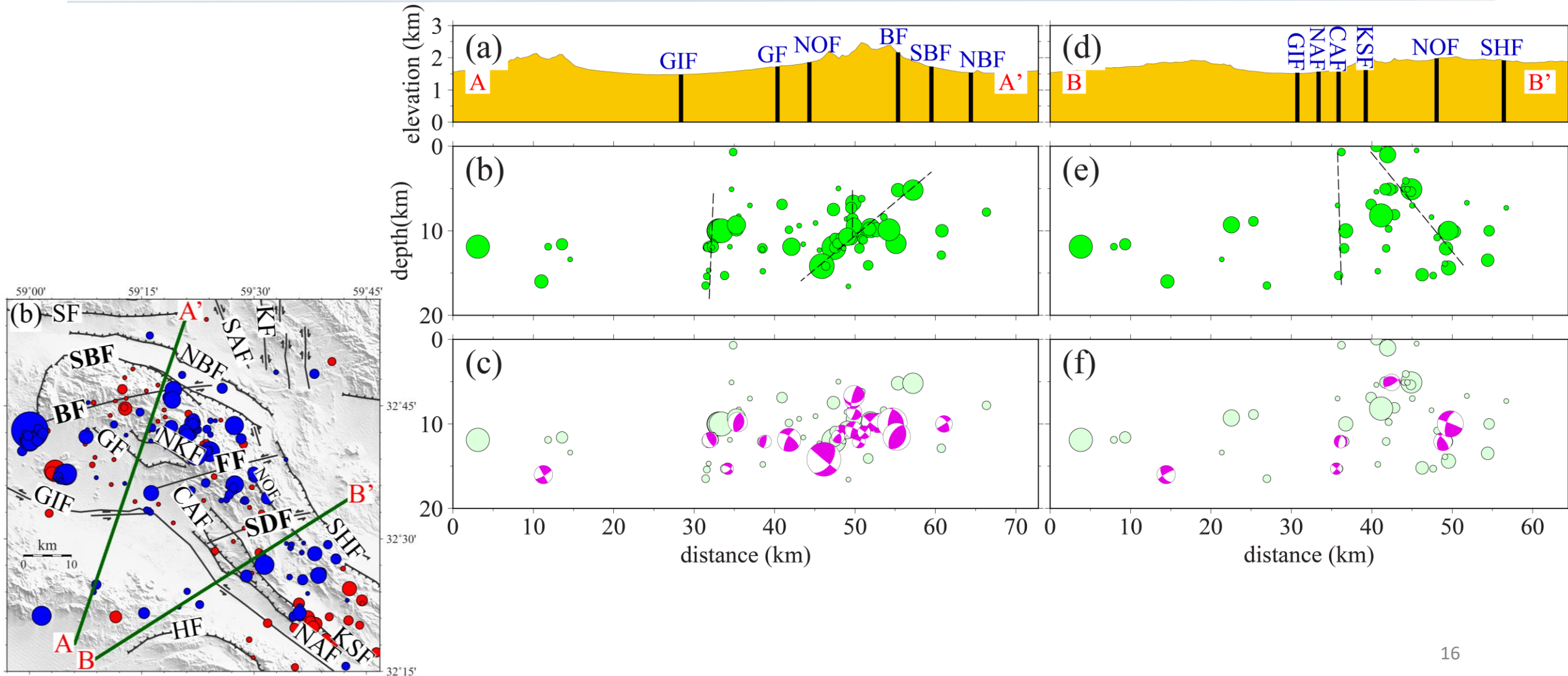
Mahmoodabadi, 2024;

<https://doi.org/10.22059/jesphys.2024.374683.1007598>

The Seismogenic zone is thin



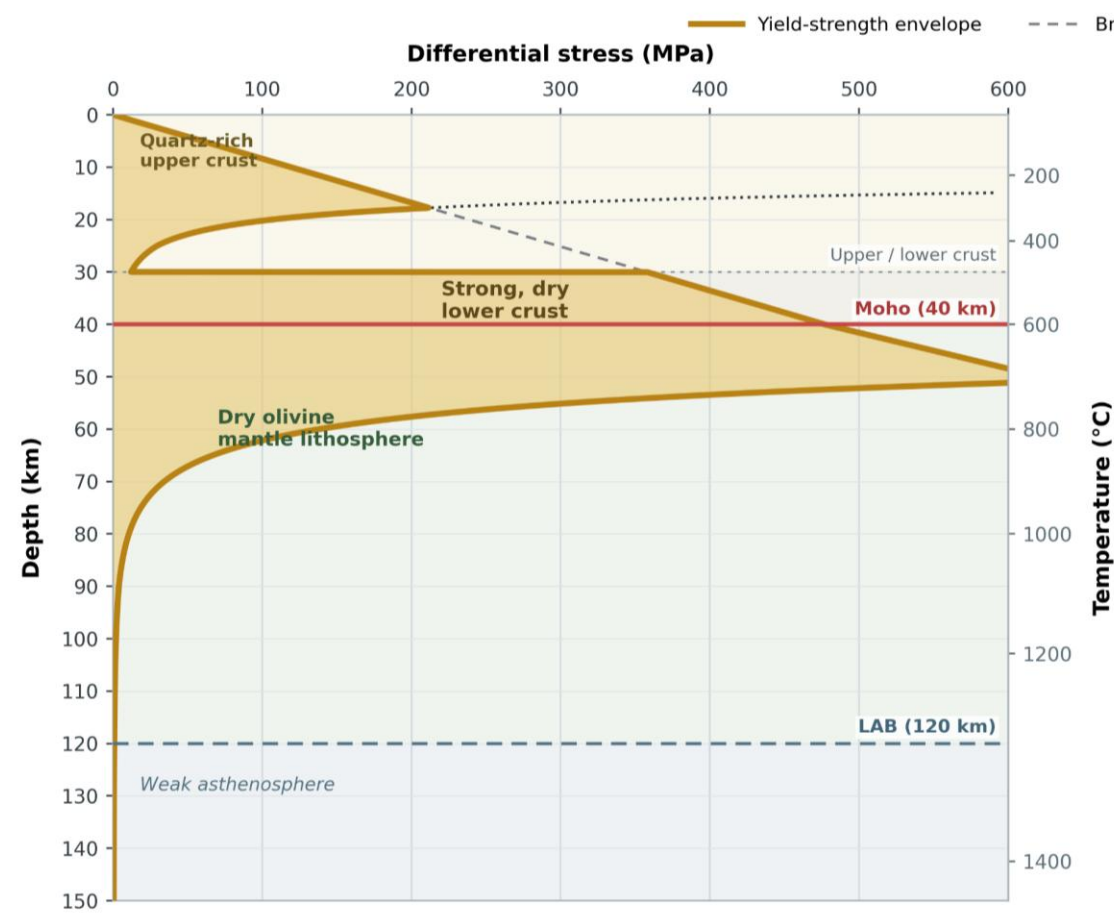
The Seismogenic zone is thin



Lithosphere strength profiles

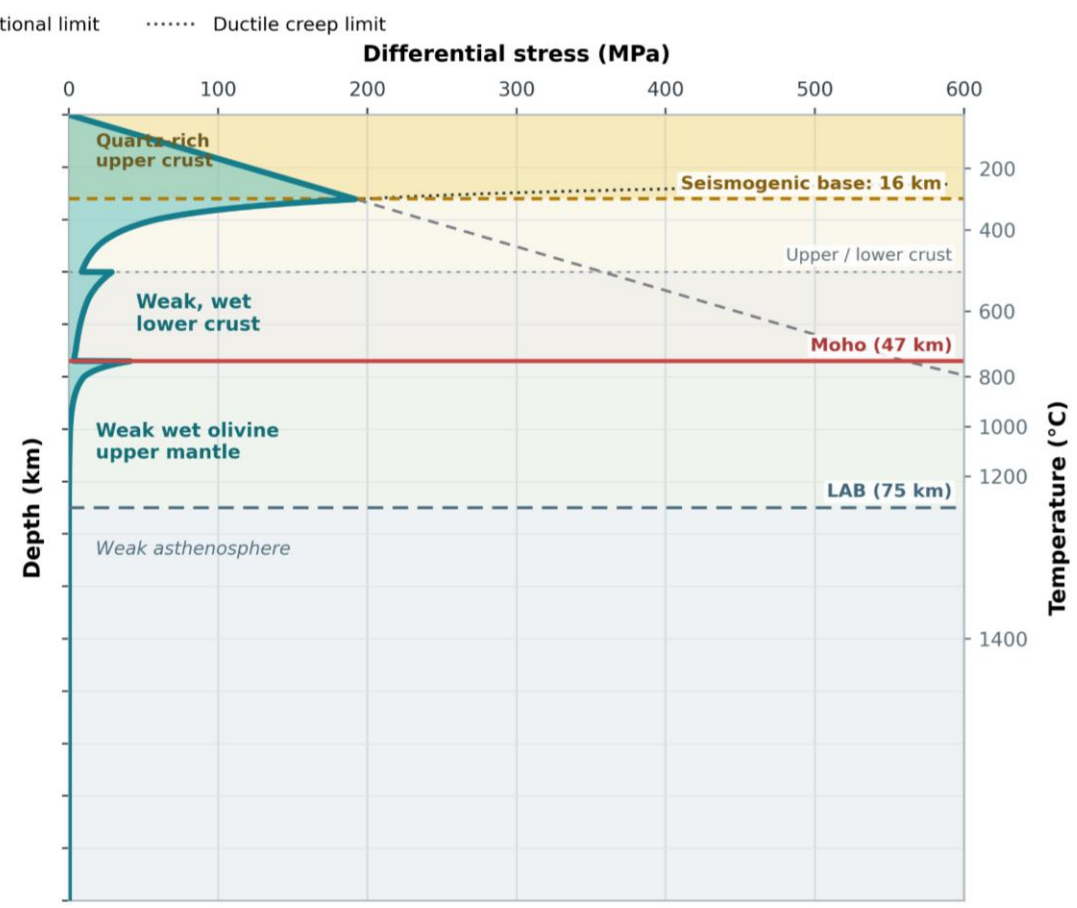
A | Reference continental lithosphere

Strong / dry lower crust and dry olivine mantle

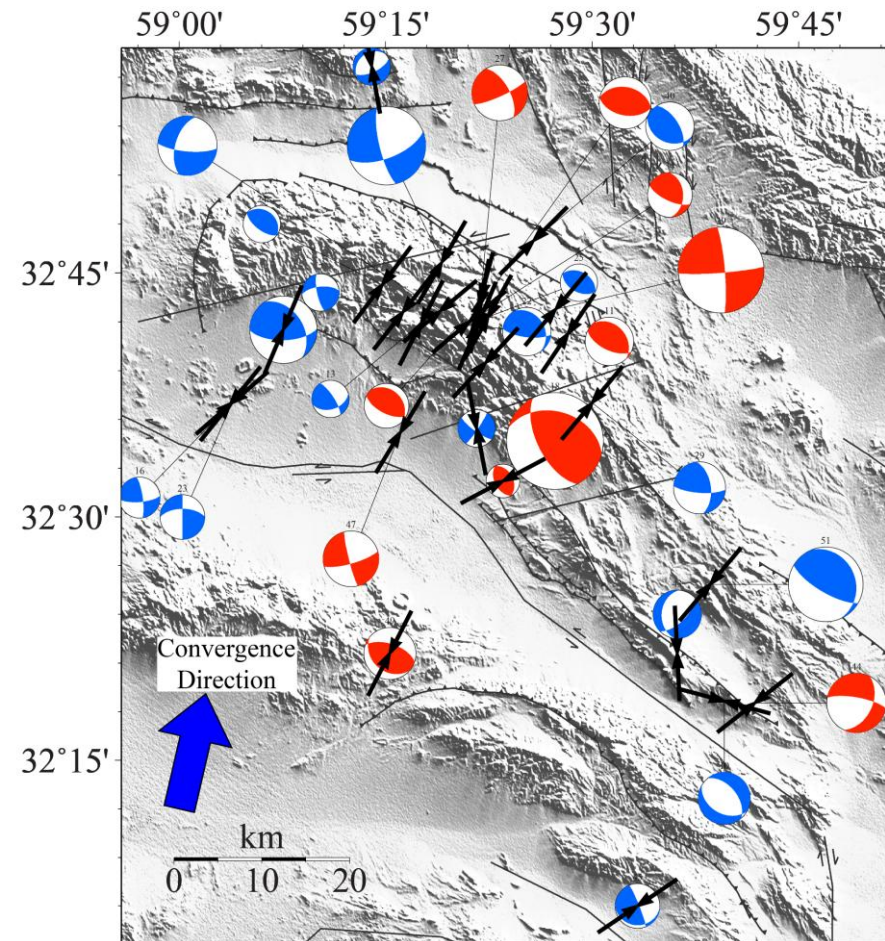
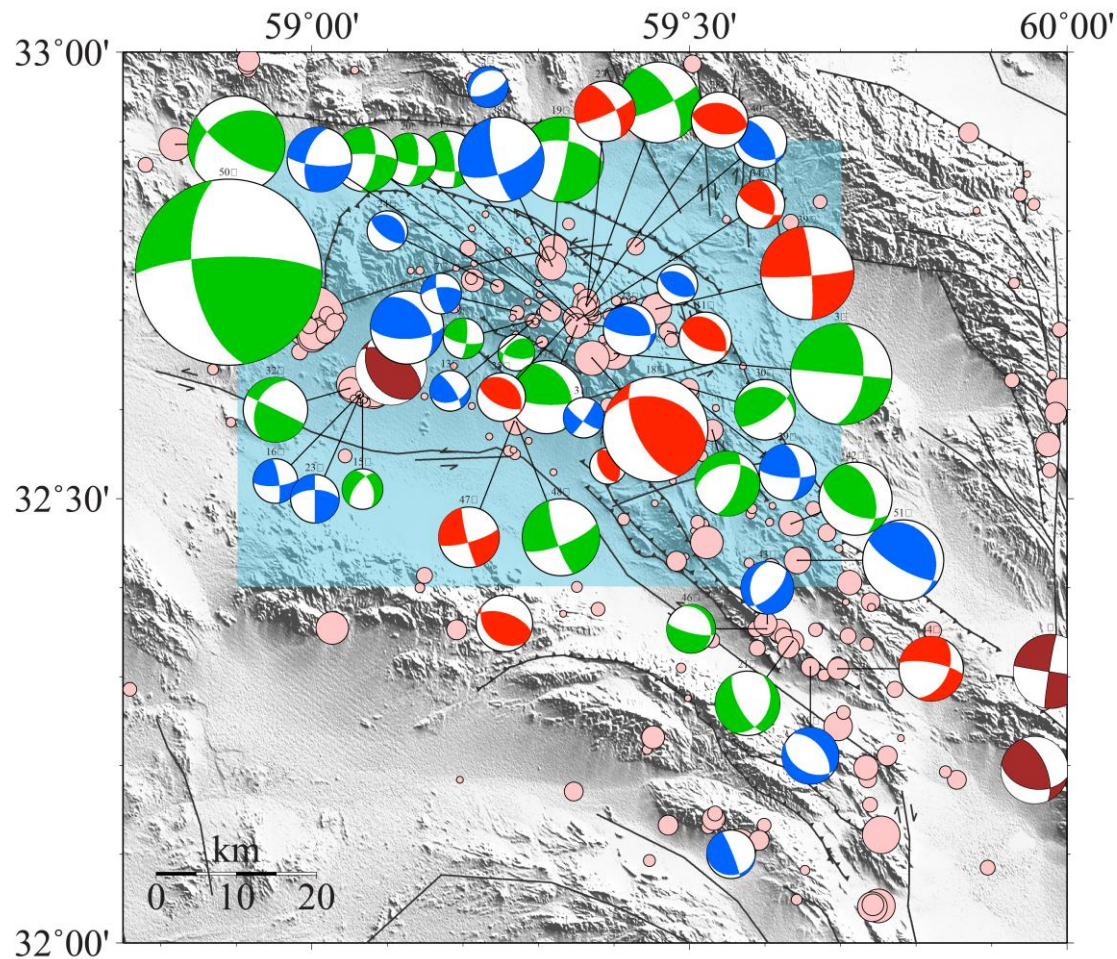


B | Eastern Iranian Ranges (EIR)

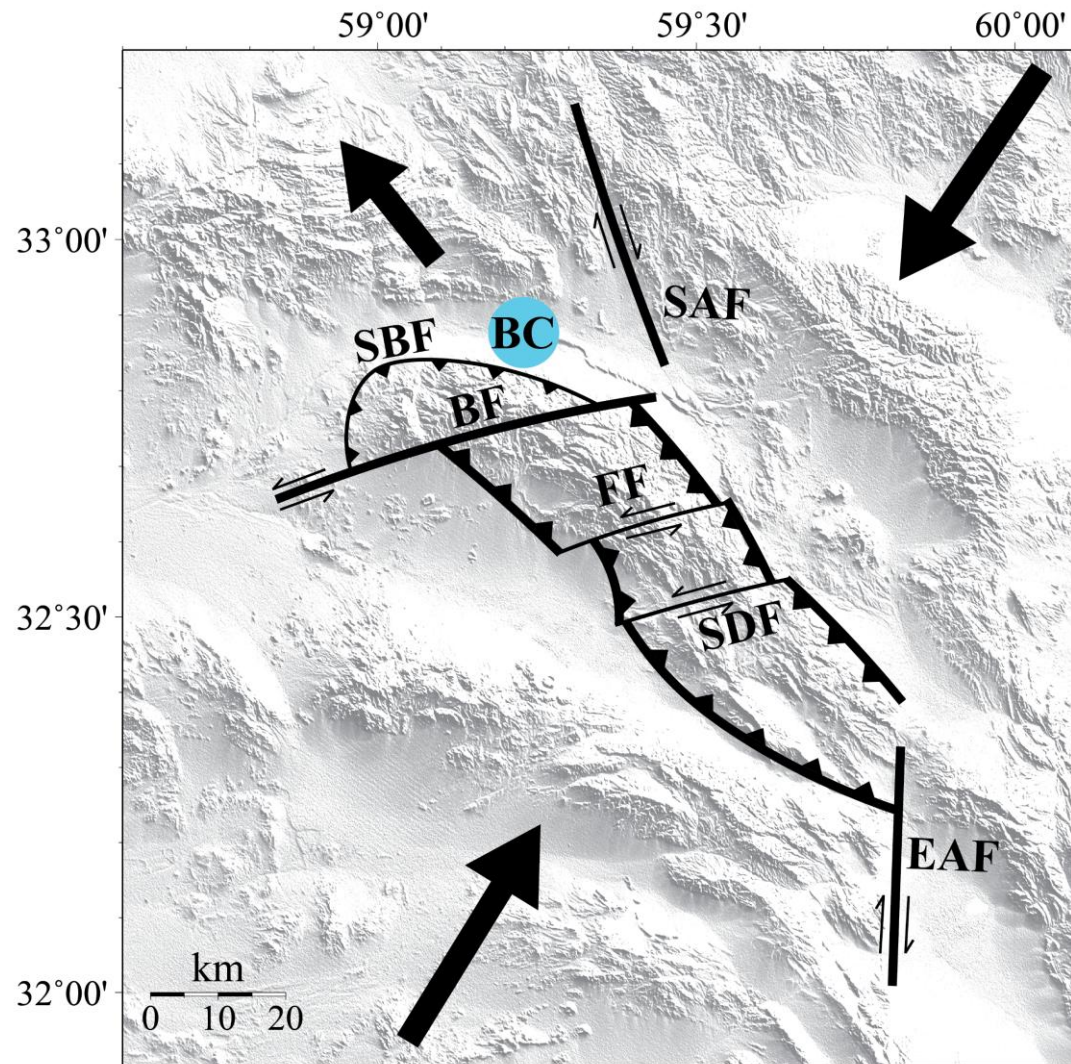
Hot / weak lower crust and wet olivine mantle



Strain is partitioned across multiple fault families



A wedge confined transpressional system south of Birjand



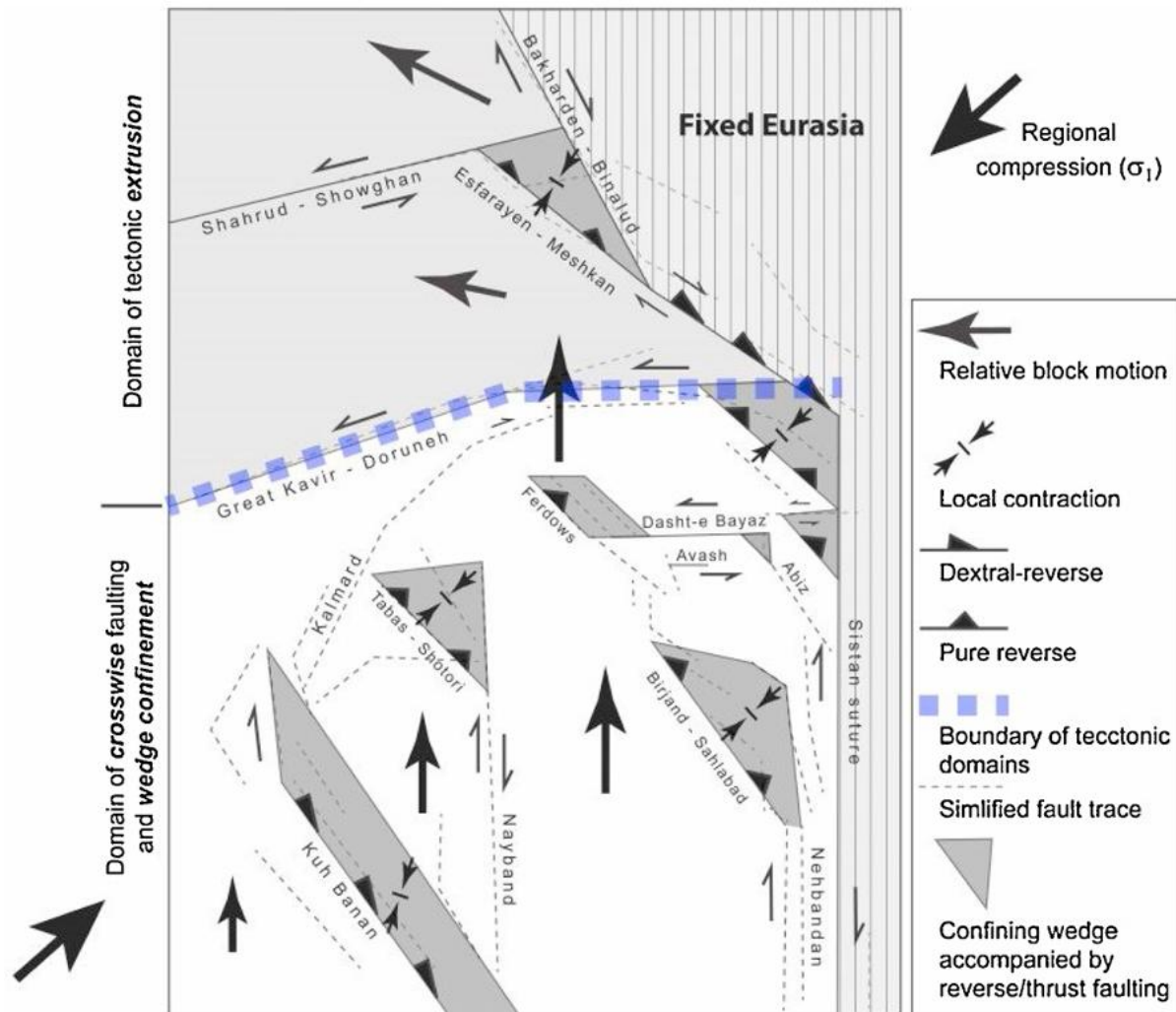
Shortening

NW-oriented reverse structures accommodate the component of oblique convergence perpendicular to the mountain belt.

Lateral shear

East-west, left-lateral shear zones distribute the strike-slip component through the upper crust.

Wedge confined deformation over the region



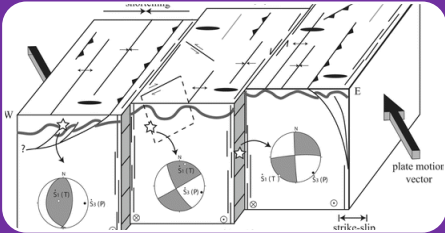
Deformation

The region is deformed through transverse faulting and wedge confinement.

Why wedge-confined?

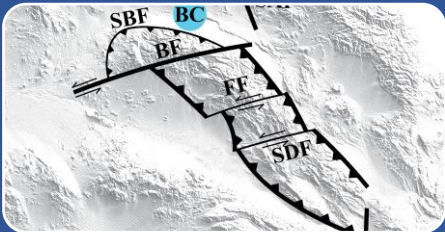
The interacting faults appear to distribute strain inside a bounded upper-crustal domain - without requiring rigid block rotation or one through-going master fault.

Broader implications



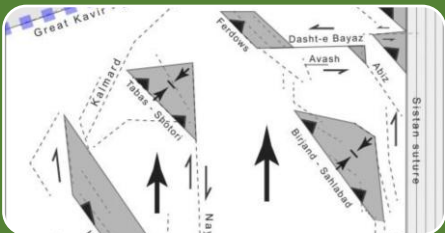
Strain Partitioning

- The mountains represent an obliquely convergent, wedge-confined suture zone.
- Convergence splits into reverse faulting and left-lateral shear.
- A long-lived fault network is created and controlled by the lithospheric fabric.



Seismic Hazard is Governed by the Fault Network

- Mechanical coupling and stress transfer can cause cascading, multi-segment ruptures.
- More complex, heterogeneous shaking and complicated recurrence patterns are expected.



Hazard Models

- Single-fault approaches can misrepresent earthquake hazard potential in such regions.
- Future models should incorporate interaction physics, time-dependent stress transfer, and probabilistic multi-fault rupture scenarios.

Integrated architecture

0 km

SEISMOGENIC WEDGE

~16 km ~3-16 km: brittle faulting

IMBRICATED CRUST + DECOUPLING

Moho locally >50 km; weak lower crust

50-60 km

THIN / WEAK LITHOSPHERE

~80 km scale lithosphere; thermally perturbed

~80 km

DELAMINATION + ASTHENOSPHERIC UPWELLING

Lithospheric fragments below + low-velocity mantle

320 km

Surface expression

A mountain belt with distributed strike-slip and reverse faulting.

Crustal architecture

Imbrication, west-dipping decoupling, localized thickening and a weak lower crust.

Mantle dynamics

Detached high-velocity lithosphere and low-velocity asthenospheric upwelling.

Sistan Ocean

- Rifting in Cretaceous

Accretion

- Subduction and Collision
- Convergence and Sistan orogen
- Crustal imbrication

Postcollisional Weakening

- Thickened lithosphere becomes unstable
- Asthenospheric upwelling and magmatism

Present Transpression

- The inherited structure is reactivated by oblique convergence
- Producing thin seismogenic wedge
- Strain partitioning

In such system, mechanical coupling and stress transfer can cause cascading, multi-segment ruptures.

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