Influence of structural inheritance along the Çardak fault on the Mw7.6 Elbistan earthquake rupture, southeastern Türkiye

Caden J. Howlett[1], Alexis K. Ault[1], Leslie Garcia[1], Dennis L. Newell[1], Musa Balkaya[2]

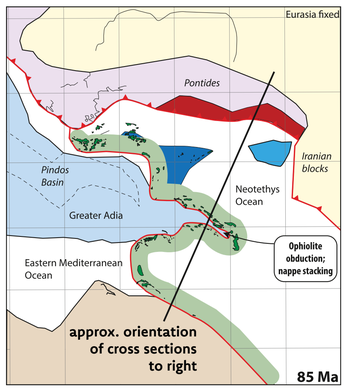
[1]Department of Geosciences, Utah State University, [2]Kahramanmaraş Sütçü İmam University, Kahramanmaraş, Türkiye

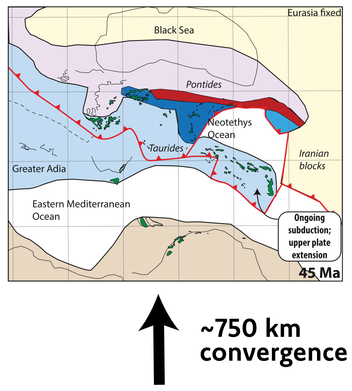
Introduction and motivation

Long-term (10-100 Myr) regional tectonic processes influence subsequent fault zone development and evolution. Preexisting structures, fabrics, and slip surfaces within basement can act as zones of weakness that facilitate strain localization over multiple earthquake cycles. Inversion and/or reactivation of ancient dip- and strike-slip faults is readily recognized in orogenic systems globally. However, the initiation, growth, and kinematics of most major active faults remain poorly understood in the context of their broader tectonic history.

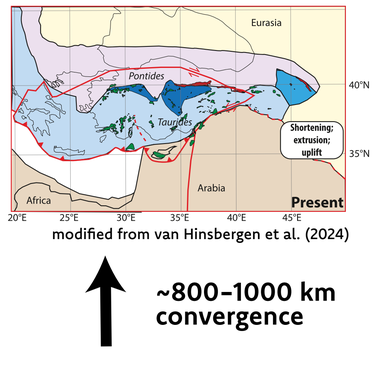
The conjunction of certain tectonic elements in Eastern Anatolia (southeastern Türkiye) and bedrock exposure surrounding the Çardak fault system provides an ideal setting to assess the influence of ancient structures on the modern behavior of large continental strike slip faults.

This poster integrates a simplified regional geologic map with preliminary field observations, helping us us evaluate if structural "inheritance" provides a control on the modern rupture location and behavior of the Çardak fault system.





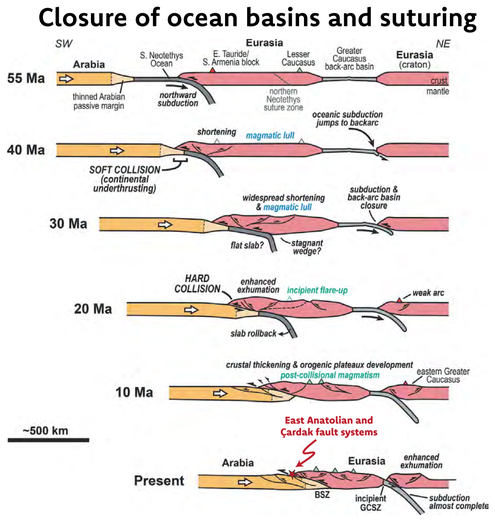
~750 km convergence



modified from van Hinsbergen et al. (2024)

~800-1000 km convergence

Closure of ocean basins and suturing

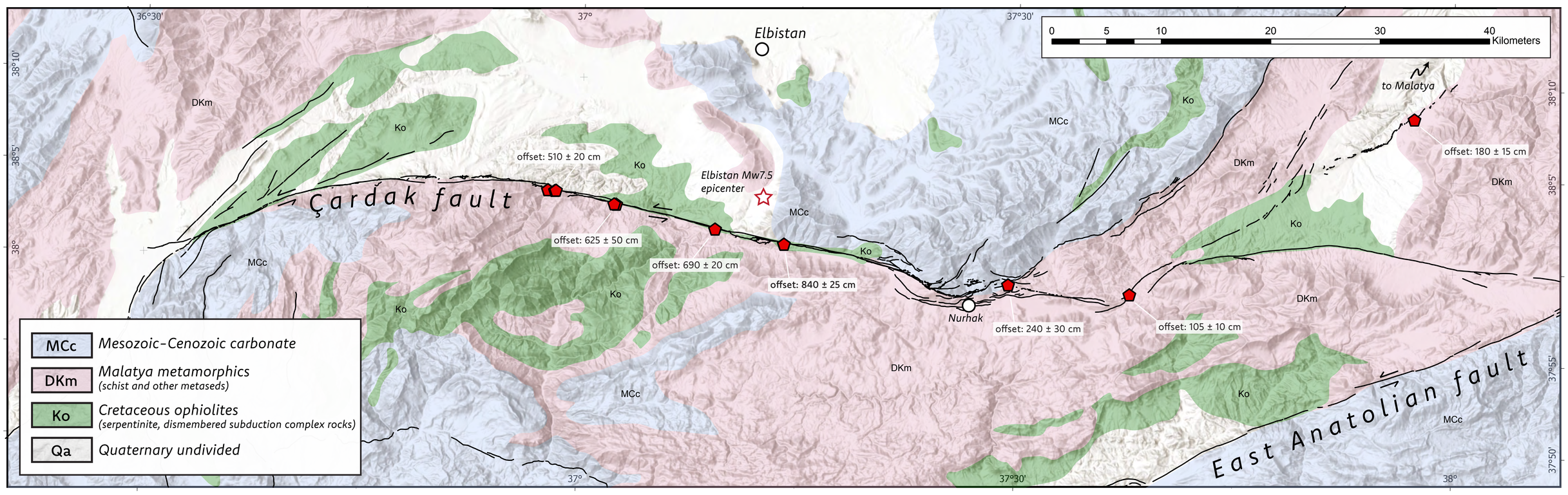


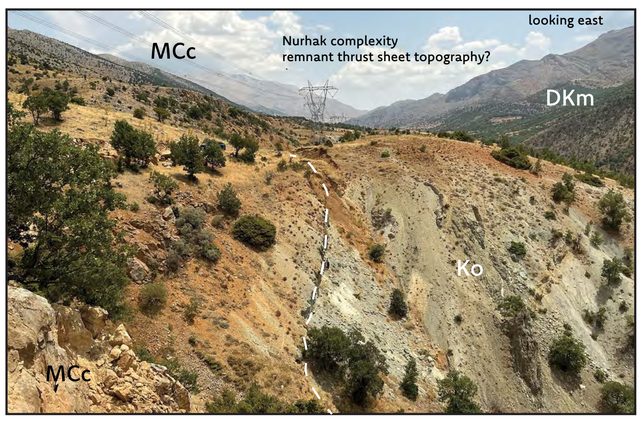
modified from Darin & Umhoefer (2022)

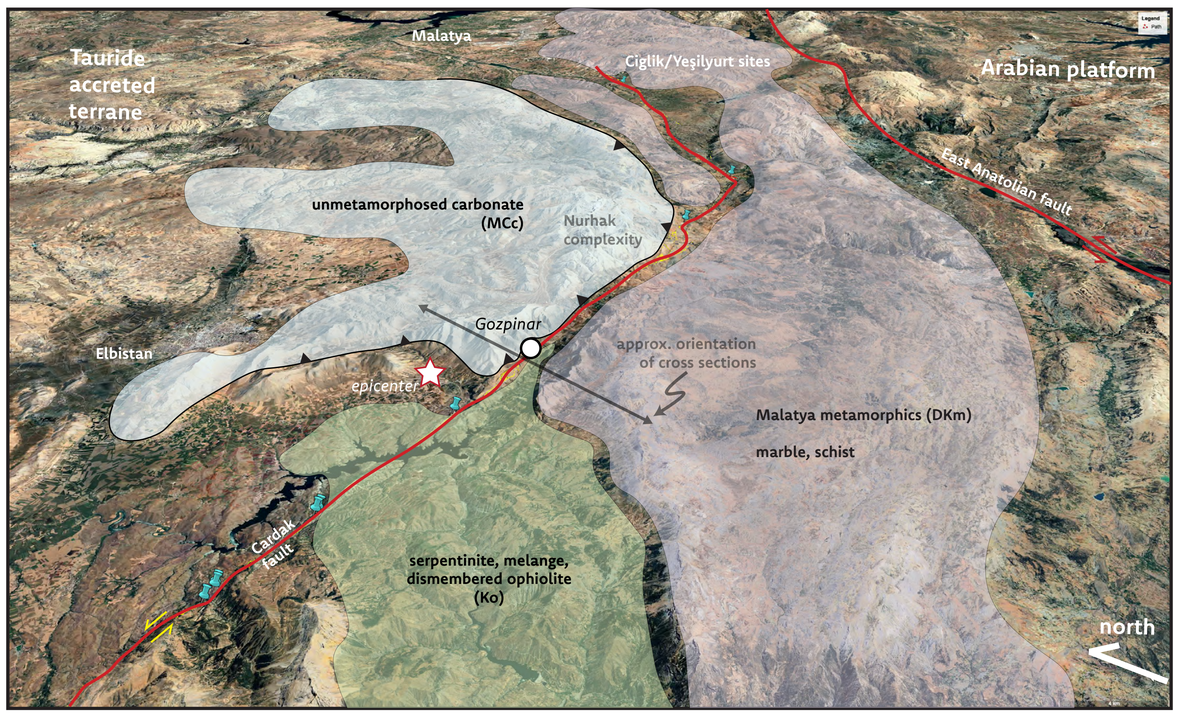
Tectonic history & geologic setting

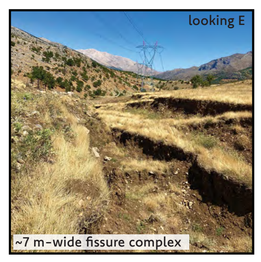
The region's tectonic history is characterized by the opening and closure of remnant oceanic basins via northward subduction, tightening sutures that were subsequently overridden by southward verging thrust sheets (***see above and right***). This process produced a regional field relationship of dismembered ophiolite sequences (primarily sheared serpentinite mélange) juxtaposed with massive, variably metamorphosed carbonate strata. To first order, the Çardak fault parallels this ancient structural contact (***see below***).

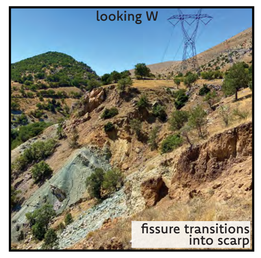
Regional geologic framework: ancient thrust systems and serpentinite influence the Çardak fault and 2023 Elbistan EQ rupture?

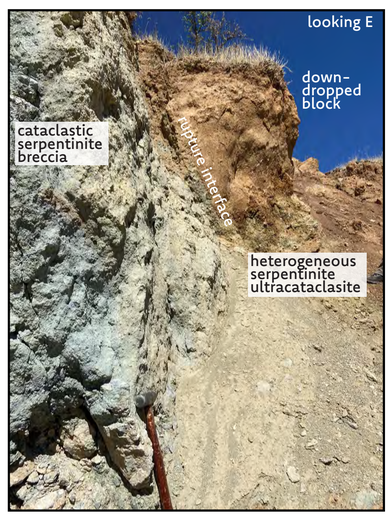


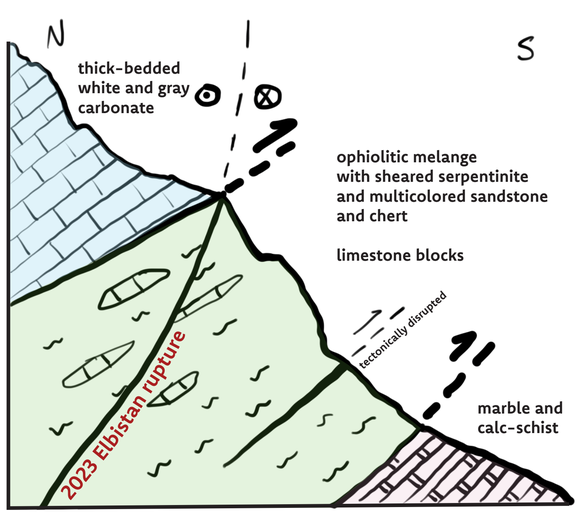




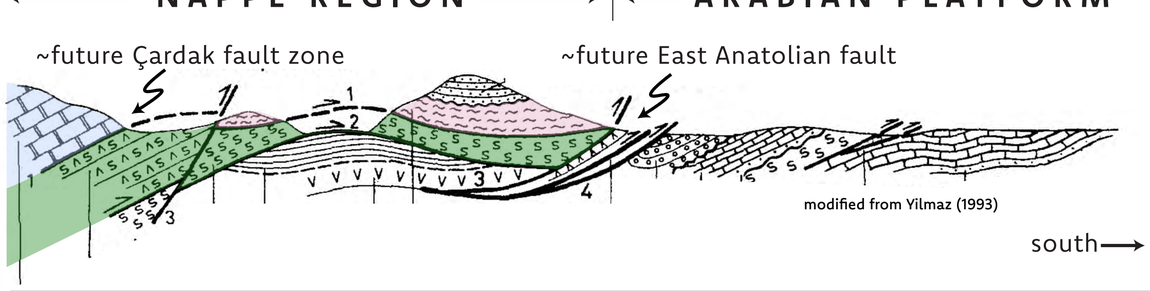








Simplified structural relationship near Gozpinar (see location on oblique map view above-right), with dismembered ophiolite sequence wedged between thrust sheets carrying Malatya metamorphics and unmetamorphosed carbonate. Relief near Nurhak is supported by the latter and likely represents remnant thrust belt topography. Additional field mapping and cross section construction will help better constrain pre-existing geometries adjacent to the 2023 rupture.



Geologic cross section modified from Yilmaz (1993). The section is generally representative of regional structural relationships along the Çardak fault west of the Nurhak complexity. The orogenic wedge was built by progressive southerly movement of nappes (thrust sheets) toward the Arabian plate during Late Cretaceous-Miocene time. This caused progressive accretion of the different tectonic units into the present nappe stack, which itself finally accreted to the Arabian continental margin.

Findings & future directions

- Elbistan rupture geometry and behavior are influenced by inherited basement structures, including a northward-dipping, strike-slip surface rupture.
- Field observations reveal a bi-material interface (serpentinite mélange against carbonate) and evidence for slip localization along preexisting fabrics (see Leslie Garcia Poster #144 for more!).
- Along-strike variations in rupture geometry (northward dip near epicenter vs. vertical, linear fault farther west) may reflect the role of ancient tectonic architecture.

- Cross-section construction and magnetite (U-Th)/He thermochronology will constrain the subsurface orientation and thermal history of rocks adjacent to the rupture.
- Comparative analysis with the San Andreas system will assess broader implications for structural inheritance in active strike-slip faults. **Ideas and possible analogs appreciated!**

References:

Darin, M. H., & Umhoefer, P. J. (2022). Diachronous initiation of Arabia–Eurasia collision from eastern Anatolia to the southeastern Zagros Mountains since middle Eocene time. International Geology Review, 64(18), 2653–2681.

Robertson, A. H. F., Parlak, O., Ustaömer, T., Taslı, K., & Dumitrica, P. (2021). Late Palaeozoic-Neogene sedimentary and tectonic development of the Tauride continent and adjacent Tethyan ocean basins in eastern Turkey: New data and integrated interpretation. Journal of Asian Earth Sciences, 220, 104859.

Trikhunkov, Ya. I., Celik, H., Lomov, V. S., Trifonov, V. G., Bachmanov, D. M., Karginoglu, Y., & Sokolov, S. Yu. (2024). Geological Position, Structural Manifestations of the Elbistan Earthquake and Tectonic Comparison of Two Strongest 06.02.2023 Seismic Events in Eastern Turkiye. Geotectonics, 58(3), 368–383.

Van Hinsbergen, D. J. J., Gürer, D., Koç, A., & Lom, N. (2024). Shortening and extrusion in the East Anatolian Plateau: How was Neogene Arabia–Eurasia convergence tectonically accommodated? Earth and Planetary Science Letters, 641, 118827.

Yilmaz, Y. (1993). New evidence and model on the evolution of the southeast Anatolian orogen. GSAB, 105(2), 251–271.

Acknowledgements: *Funding for this research from U.S. NSF Frontier Research in Earth Science grant EAR2420543. We express gratitude to Alba M. Rodriguez Padilla and Kelian Dascher-Cousineau for helpful discussions.*