EGU26 GENERAL ASSEMBLY

EGU26-11516

Numerical Simulation Study on Seismic Hazard of the Malatya Fault

Hui Li[1,2] ,Wei Tao[1,2] ,Peng Su[1,2],Yixuan Yang[1,2],Chi Zhang[1,2] ,Shimiao Qi[1,2] ,Xuhang Yang[1,2]

1.State Key Laboratory of Earthquake Dynamics and Forecasting, Institute of Geology, China Earthquake Administration, Beijing 100029, China

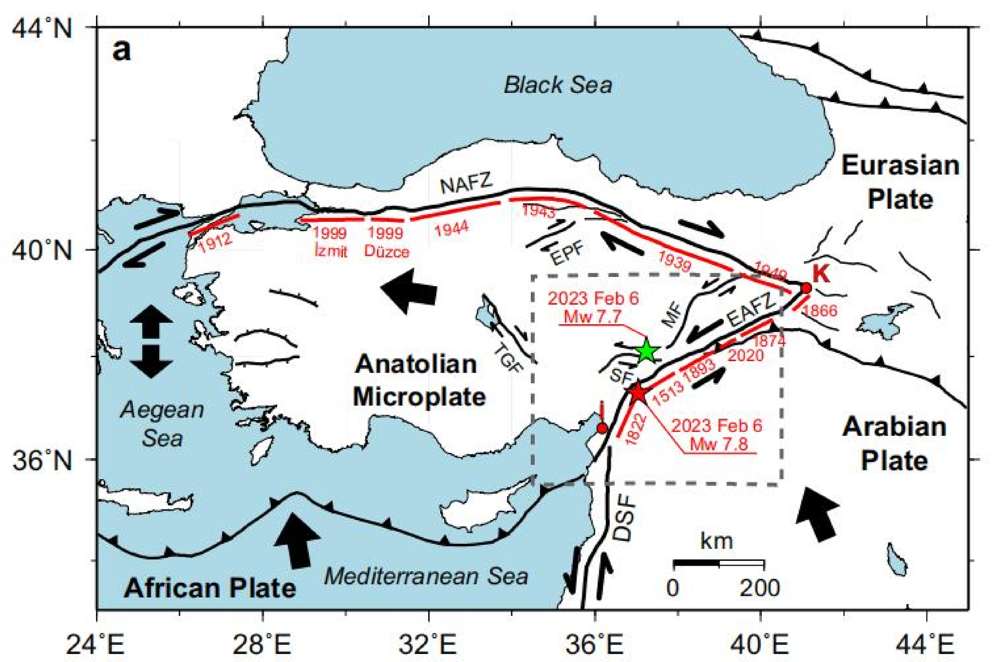
2.Sichuan-Chongqing Earthquake Science Research Center, Sichuan 646000, China

taowei@ies.ac.cn;15898148116@163.com

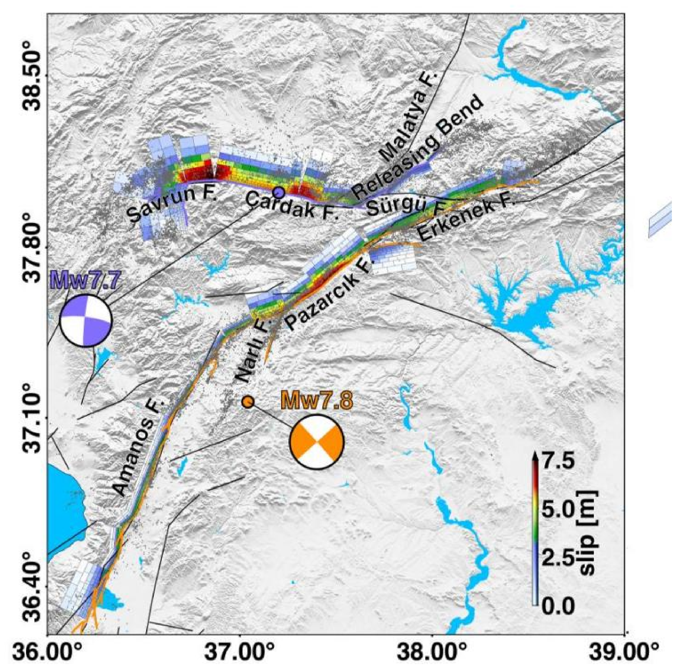
Abstract

The Mw 7.8/7.5 twin earthquakes in eastern Turkey on February 6, 2023, caused heavy losses and altered the regional stress field. The Malatya Fault has not ruptured for ~2,500 years and faces high seismic hazard. Using aftershock and geophysical data, we constructed its 3D fault geometry and built a 3D viscoelastic finite element model with geodetic constraints. Simulations quantify Coulomb stress loading from coseismic and postseismic relaxation, reveal stress distribution, and evaluate seismic hazard. Results support fault interaction analysis and earthquake mitigation.

Geological Setting



(Liu et al.,.2023)

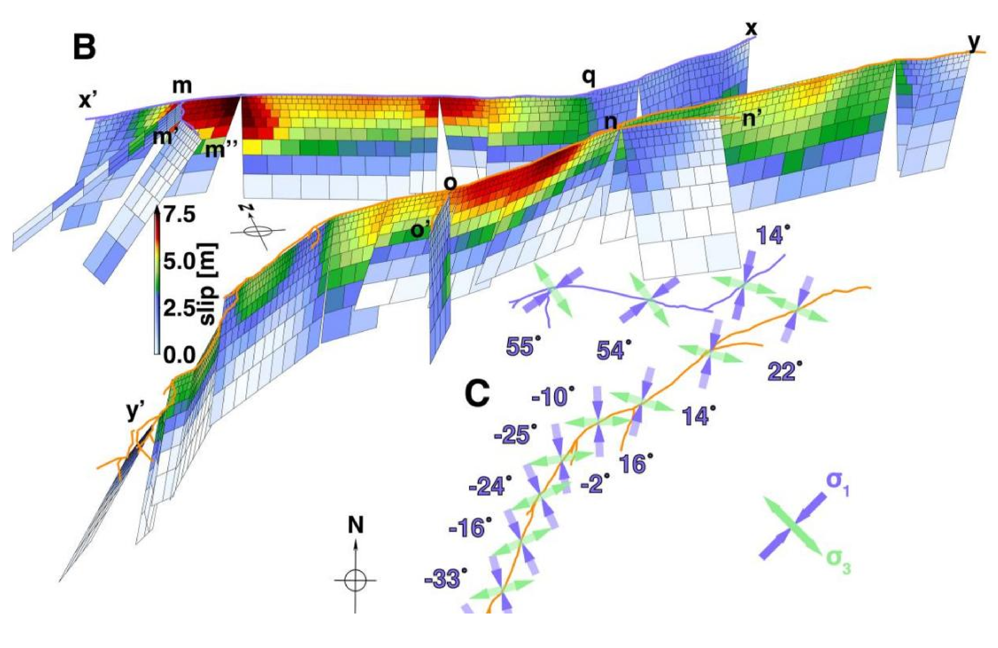


(Ma et al.,2024)

The twin large earthquakes that struck eastern Turkey on February 6, 2023 caused heavy casualties and economic losses. Coulomb stress analysis indicates that these earthquakes resulted in rapid Coulomb stress loading in the adjacent Malatya region. The Malatya Fault is the most critical active fault in the area; it has not experienced a large surface rupturing earthquake for approximately 2,500 years, implying an extremely high risk of large earthquakes in the near future.

Data

◆ In-situ stress field

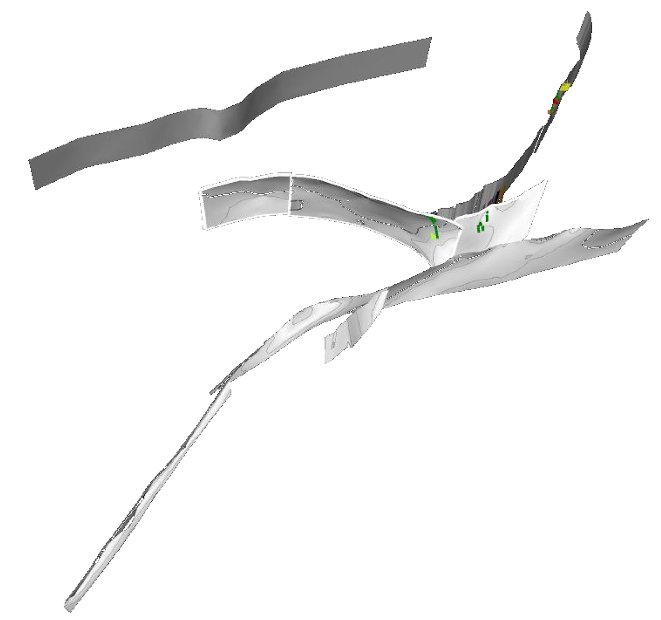


(Ma et al.,2024)

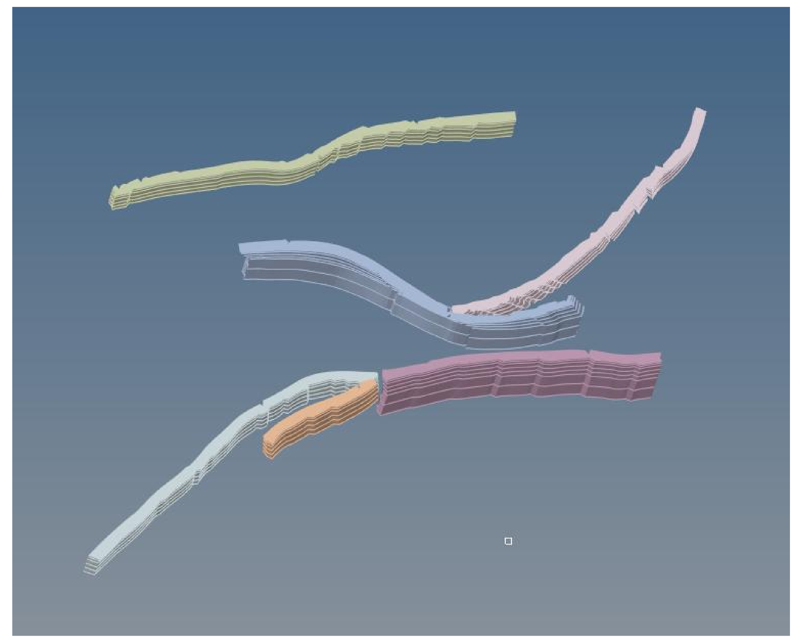
- ➢ 3D fault geometry data (Malatya Fault & East Anatolian Fault)
- ➢ Deep crustal stratigraphic structure
- ➢ Stratigraphic medium parameters (elastic modulus, Poisson’s ratio, viscosity, density, etc.)
- ➢ Coseismic slip distribution of the 2023 twin earthquakes

Methods

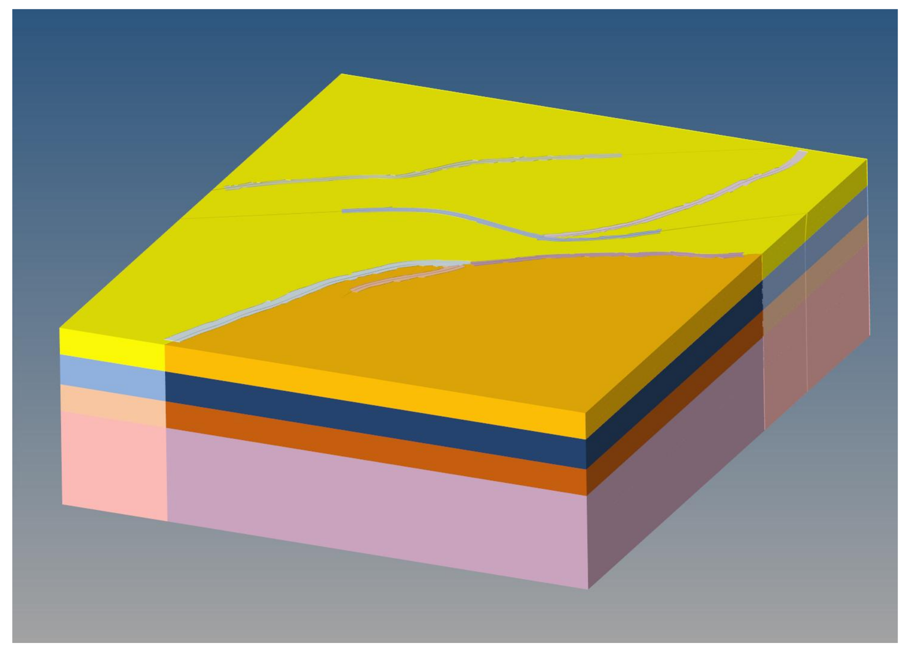
◆ Three-dimensional tomographic model



(Su et al.,2026)



◆ Viscoelastic finite element model



➢ **Coseismic slip data processing**

Collect and interpolate coseismic slip distribution of the 2023 Turkey twin earthquakes to provide initial deformation conditions.

➢ **Viscoelastic finite element numerical simulation**

Establish a 3D geomechanical finite element model covering the East Anatolian Fault and Malatya Fault, considering viscoelastic rheology of the crustal medium.

➢ **Boundary condition constraints**

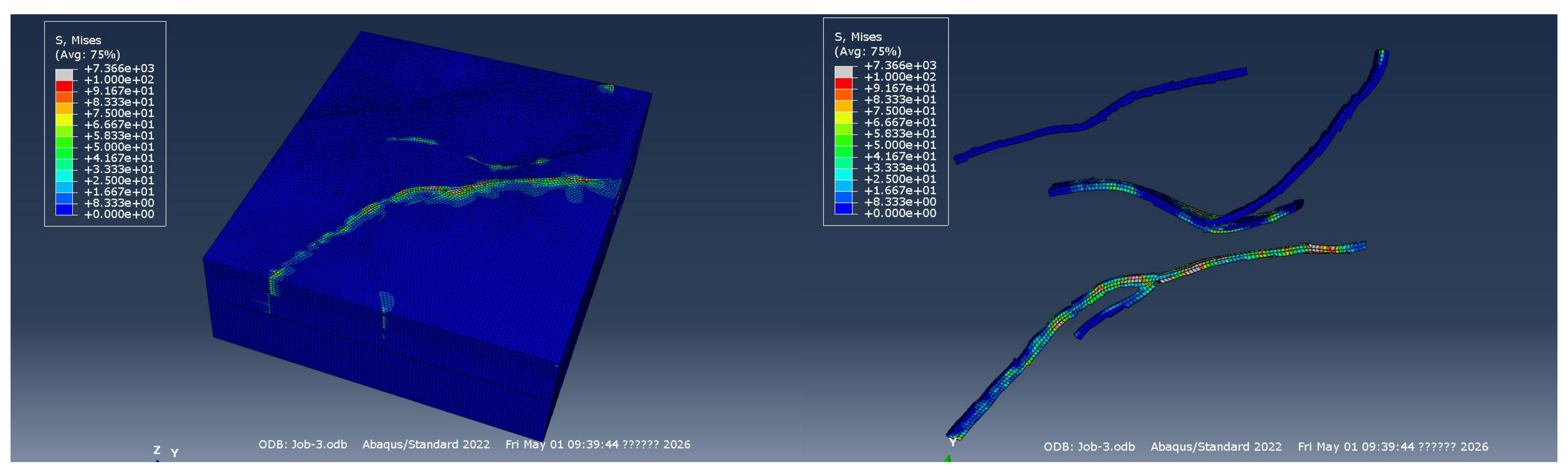
Apply velocity boundary, stress boundary, and bottom constraint conditions consistent with regional tectonic movement.

➢ **Stress loading analysis**

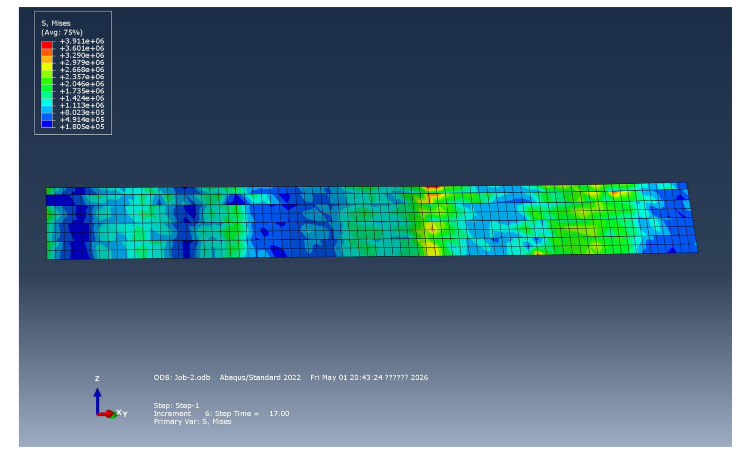
$$\Delta CFS = \Delta\tau + \mu^{'}\Delta\sigma_N$$

Results

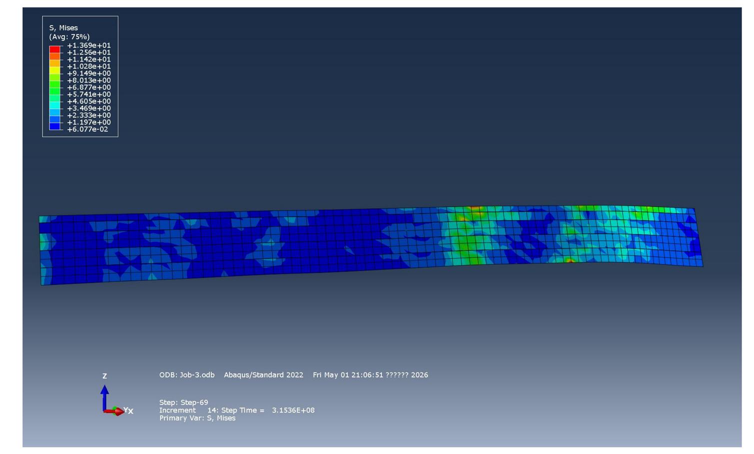
◆ Results of the viscoelastic finite element model



◆ Results of the viscoelastic finite element model

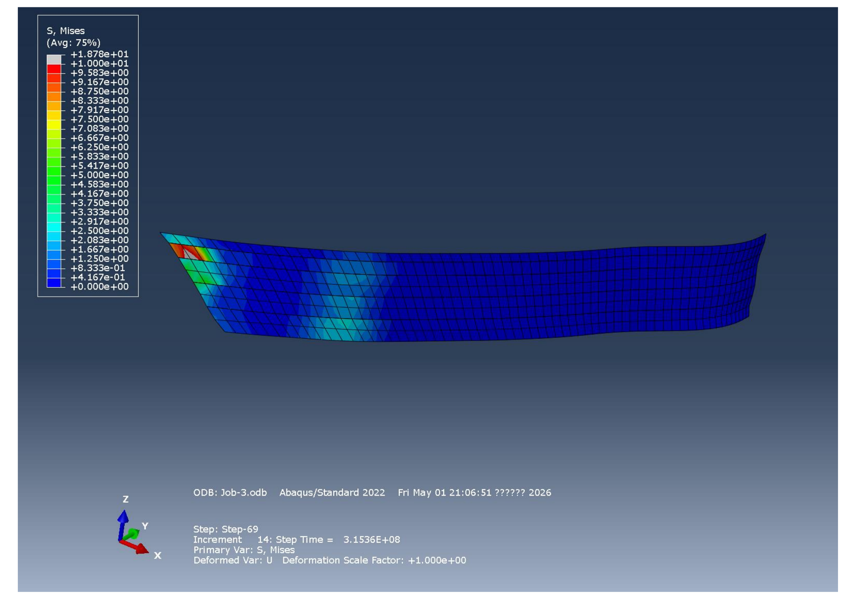


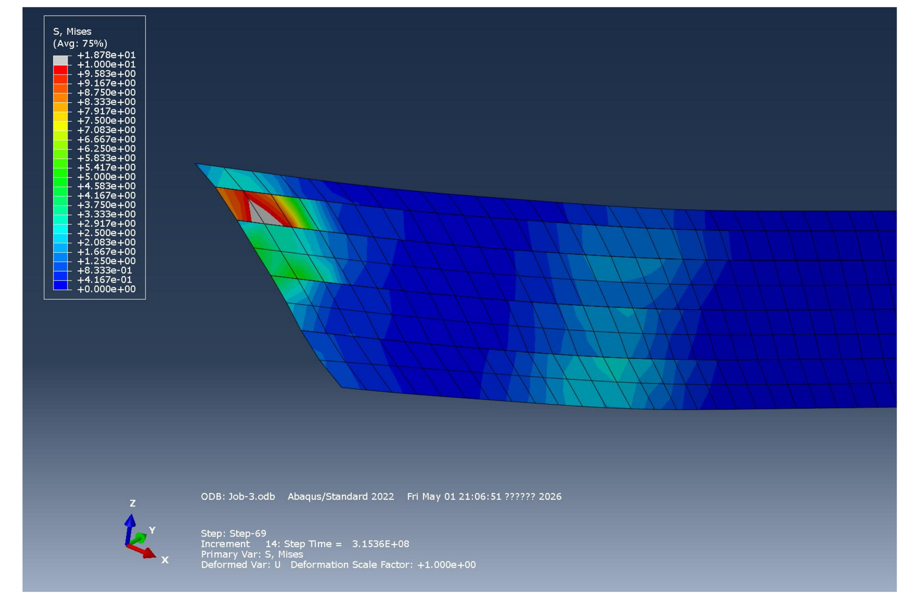
EAFZ



➢ The stress distribution in the EAFZ during the double earthquake in Turkey, as well as the stress distribution at various depths decades after the earthquake.

◆ Stress distribution at different depths along the Malatiya Fault





MF

The stress distribution of the Malatiya Fault 50 years after the double earthquake.

◆ The risk associated with the Malatiya Fault

- ➢Within 50 years after the earthquake, stress on the Malatiya Fault increased, with the most significant rise occurring near the site of the dual earthquakes in Turkey. (The southwestern end of the Maratia Fault connects with the northern end of the East Anatolian Fault.)
- ➢Stress concentration is also present at a distance of 35 kilometers.
- ➢Over time, and under the influence of viscoelasticity, the stress on the Marathya Fault gradually increases, making the seismic risk a matter of serious concern.

Conclusions

- ➢The 2023 Turkey twin earthquakes have produced stress loading on the Malatya Fault, enhancing its seismic hazard.
- ➢The Malatya Fault is in a higher-risk state after the 2023 earthquakes, and continuous monitoring is recommended.
- ➢The follow-up work is still ongoing.