2019 Mw5.8 Silivri Earthquake Reveals the Complexity of the Main Marmara Shear Zone

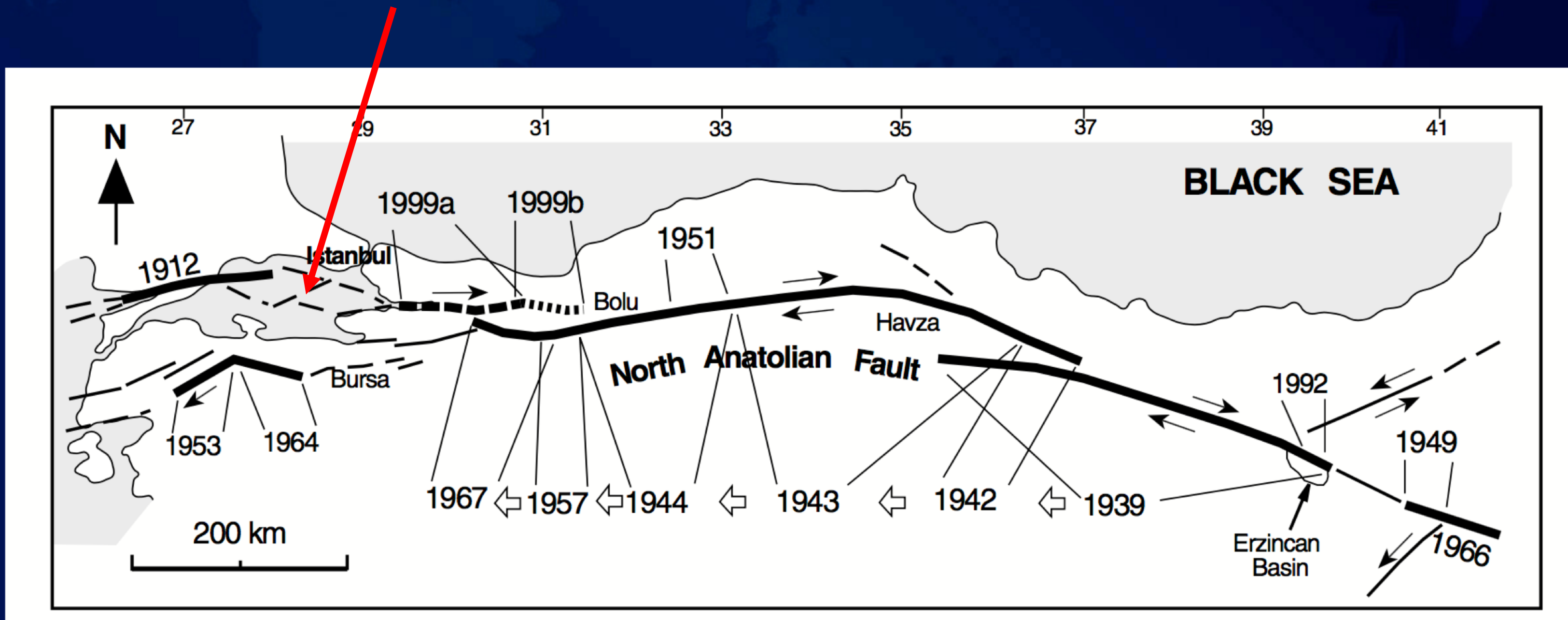
A. Ozgun Konca, Sezim Ezgi Guvercin, Hayrullah Karabulut,

Figen Eskikoy, and Semih Ergintav

North Anatolian Fault and the Sea of Marmara

- While most of the North Anatolian Fault (NAF) has ruptured since the beginning of the 20th century, the part of NAF beneath the Sea of Marmara remains unbroken.

Sea of Marmara seismic gap

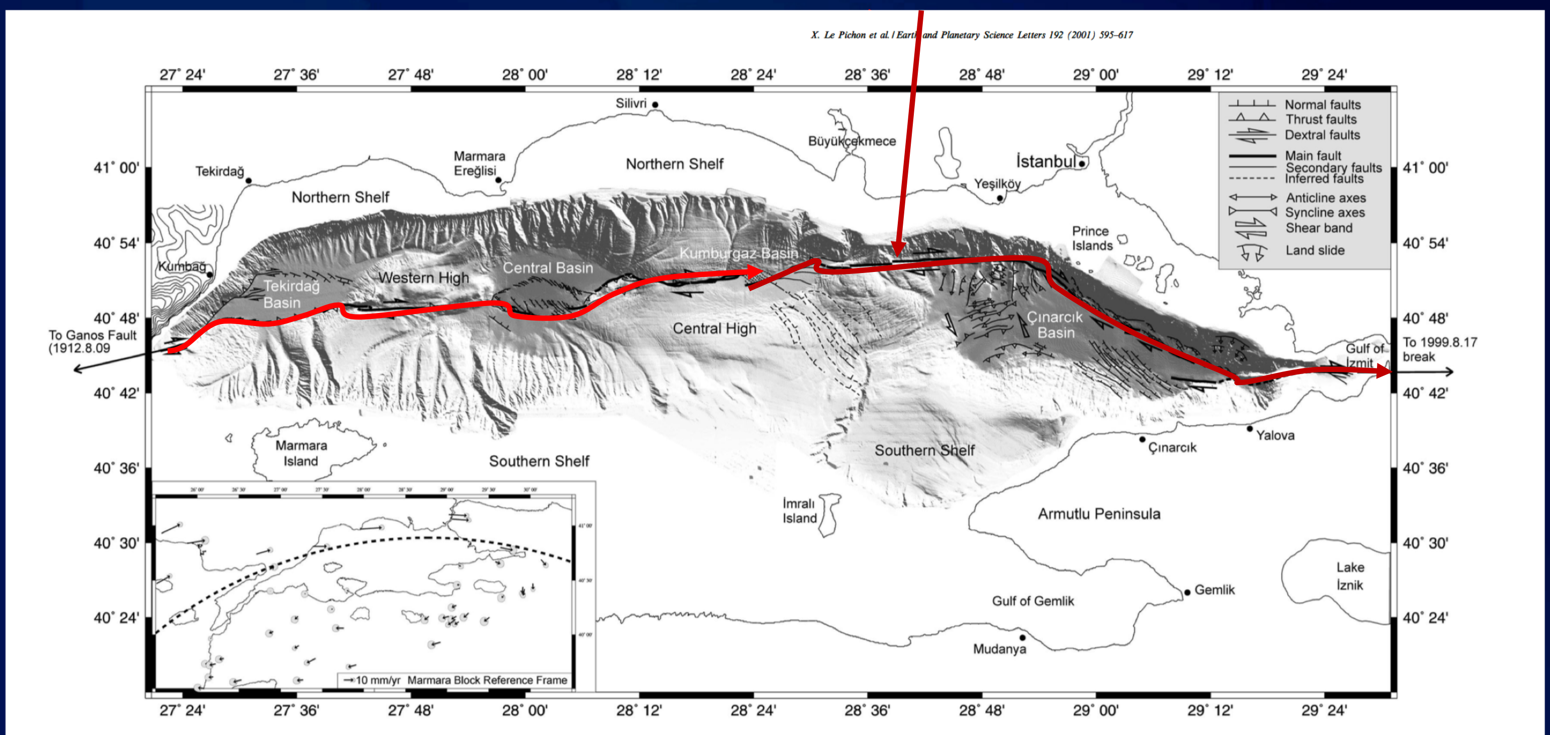


(Barka et al, 2002)

Main Marmara Fault

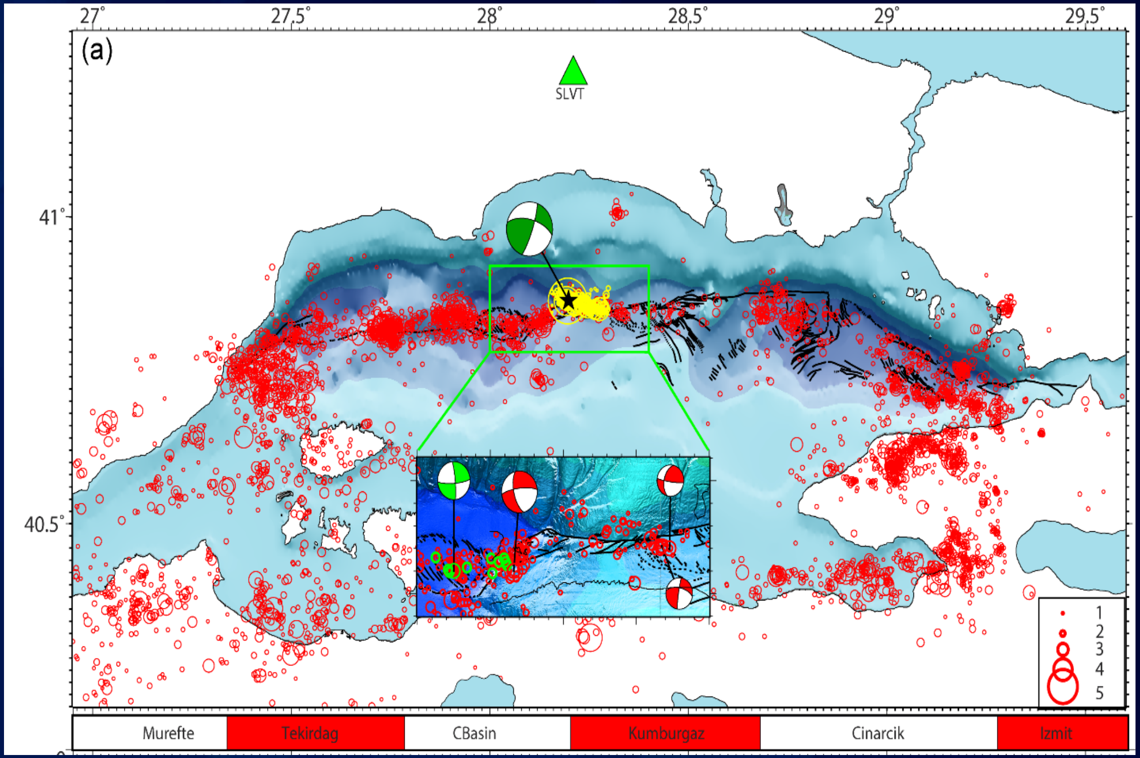
- One reason for more complex earthquake history along Marmara Sea might be that the shear zone is much wider than most of the rest of NAF
- Although the fault structure in Marmara Sea is quite complex, with several branches proposed, the deformation is localized to a segmented fault zone called the Main Marmara Fault (MMF) (Le Pichon et al, 2001).
- MMF covers several segments characterized by basins and thick (~6-8 km) cover of sediments.

MMF



2019 September Silivri Earthquake Sequence

- In September 24, an Mw4.7 earthquake struck followed by several earthquakes larger than 4.0.
- On September 26, 5.7 mainshock occurred, largest earthquake in the Sea of Marmara since 1963.
- The sequence lasted until the end of September
- It was not clear whether the earthquakes broke some part of NAF or not.
- The sequence has a potential to give more information about the shear zone.



Background seismicity (red) and the 2019 September sequence (yellow). Green beach ball shows the mainshock mechanism

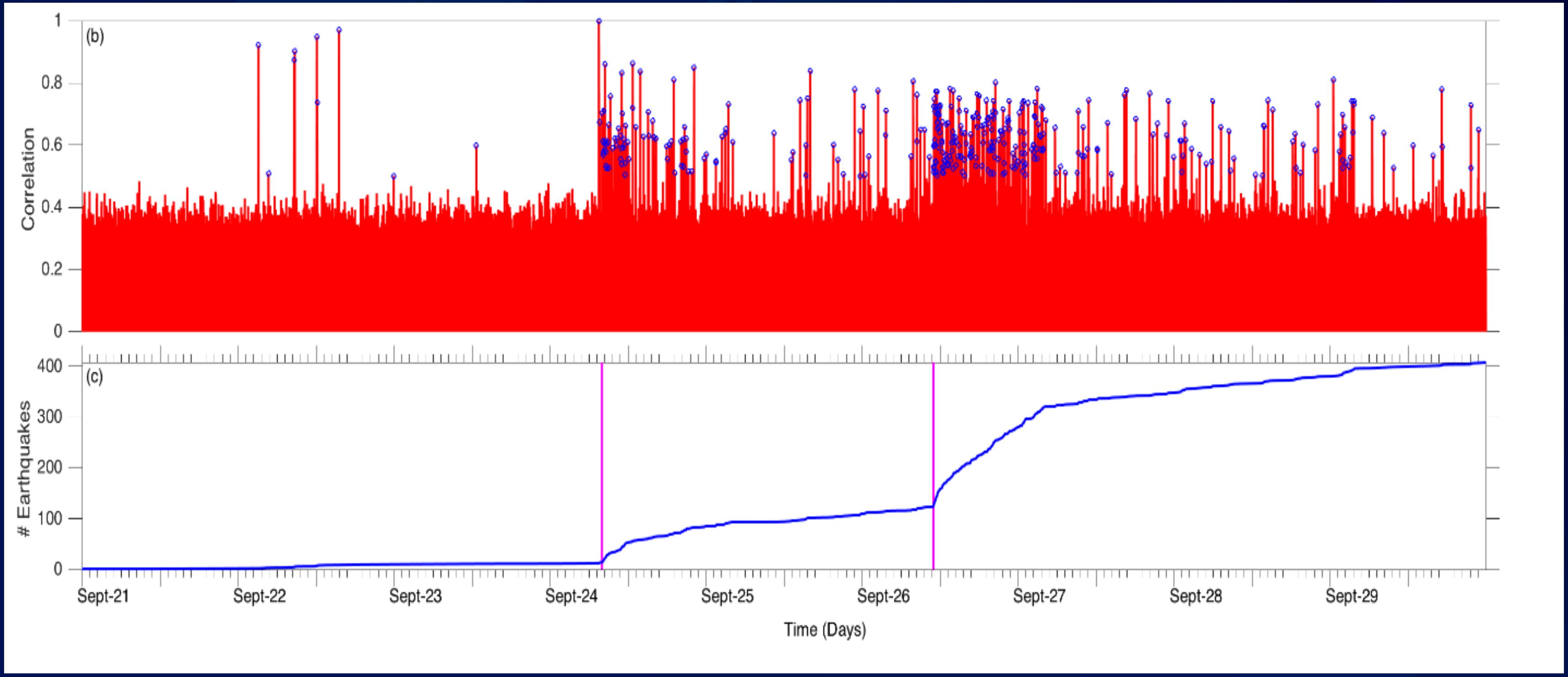
Summary of This Study

In this study

- In order to understand whether the earthquake occurred along the main fault or another fault
  - We relocated the events in the sequence by manually picking arrival times and optimizing for the best fitting velocity model.
  - obtained the mechanism of events that are larger than M3.5.
- We obtained a finite-fault solution of the sequence
- We calculated Coulomb stress changes to see the affect of the earthquake on the MMF.

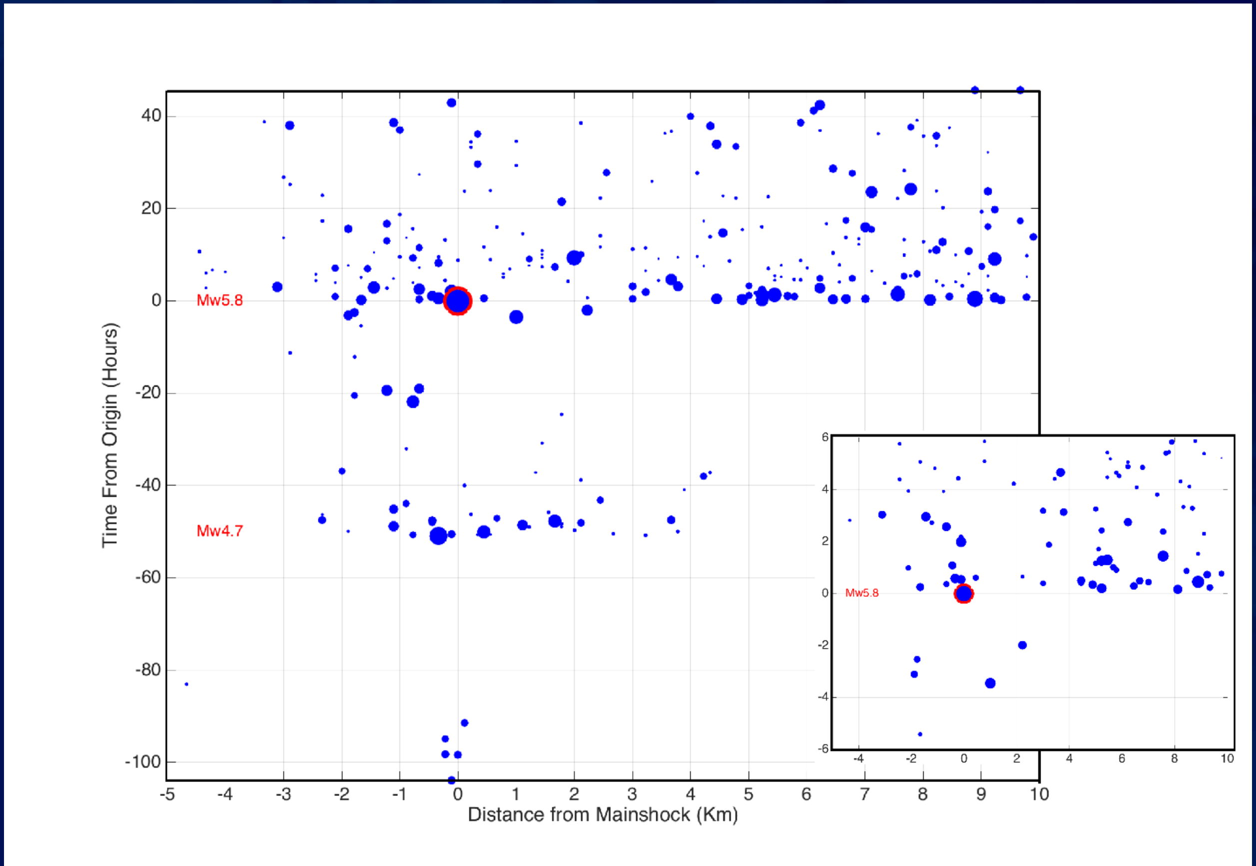
Template Search and Detection

- We used one of the foreshocks as template for deciphering the temporal character of the seismic activity.
- The activity started several days before the Mw4.7 September 24 earthquake.



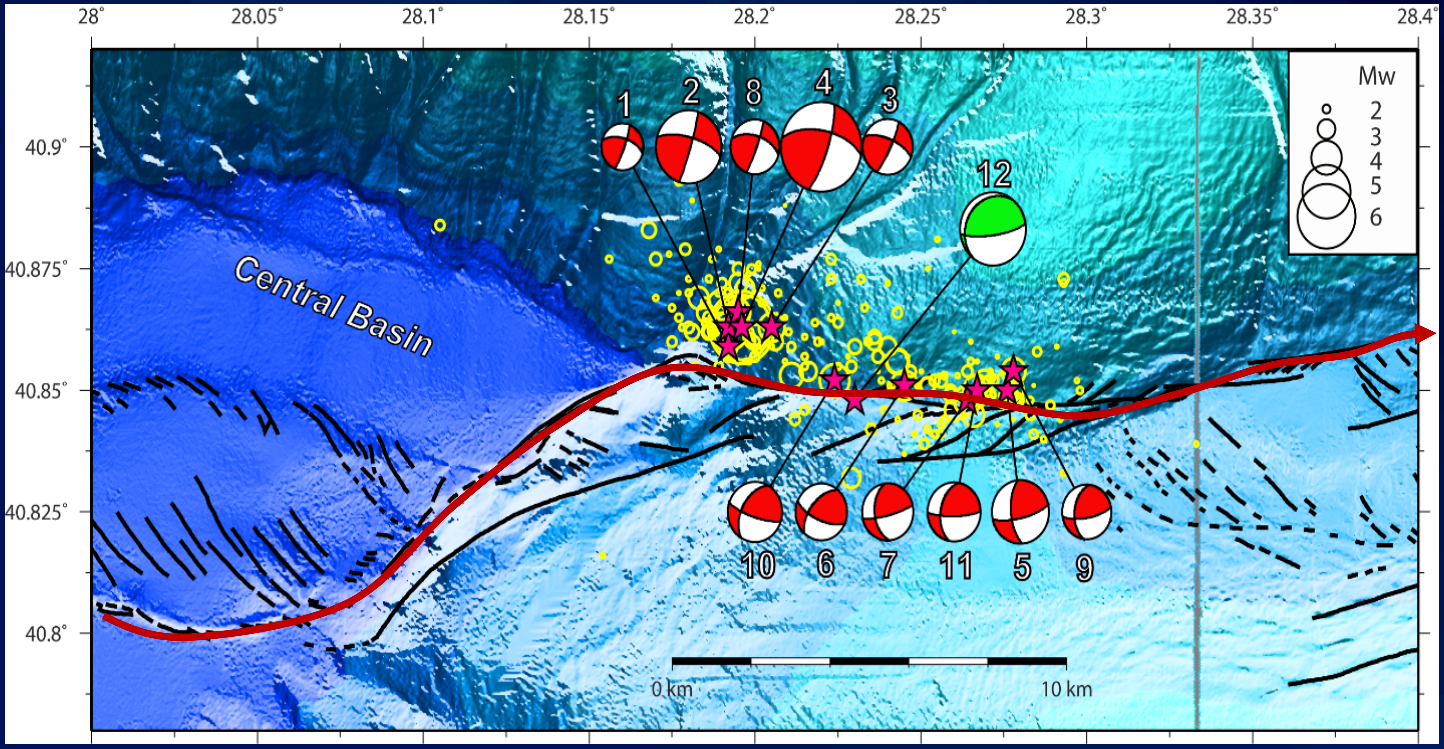
Spatiotemporal Evolution of the Seismic Activity

- Relocations and sliding window cross-correlations show that the activity initiated in a very narrow zone (~100 m) and spread out to 7-8 km following the Mw4.7 earthquake.



Relocated Aftershocks and Mechanisms

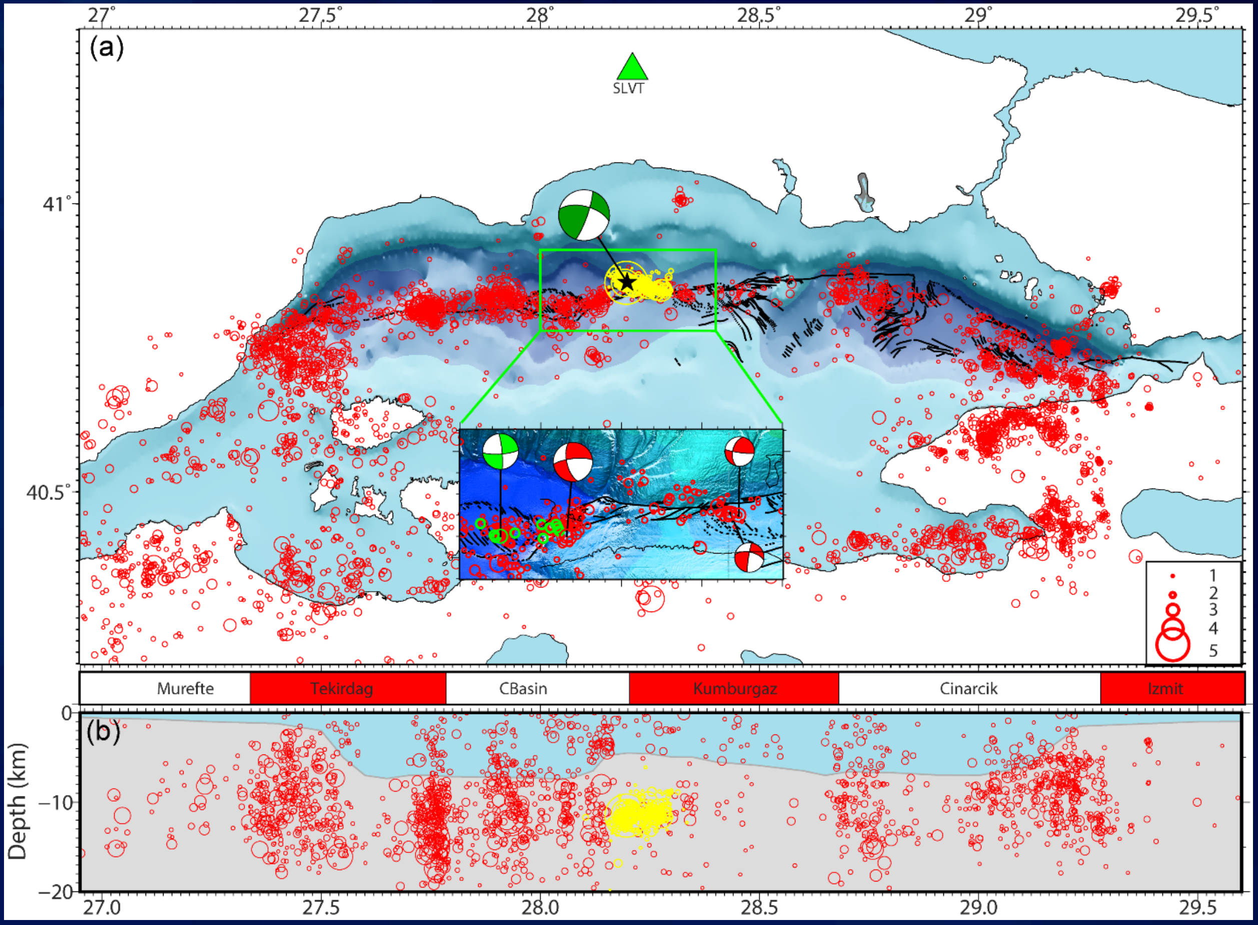
- The relocations show that the initial activity including the Mw5.7 mainshock has occurred to the north of the MMF.
- Remarkably, all earthquakes have strike-slip mechanism with significant thrust component. The strike direction is slightly oblique to the MMF for the events to the west.



The Depth Profile and Faulting Related to the Silivri Activity

- The depth profile of the seismicity shows that all of activity is confined to a narrow depth range below the sedimentary cover.

- Based on mechanisms, locations and depth distribution we infer that the Mw5.8 mainshock occurred on a secondary fault structure below the sedimentary layers in the shear zone north of MMF.

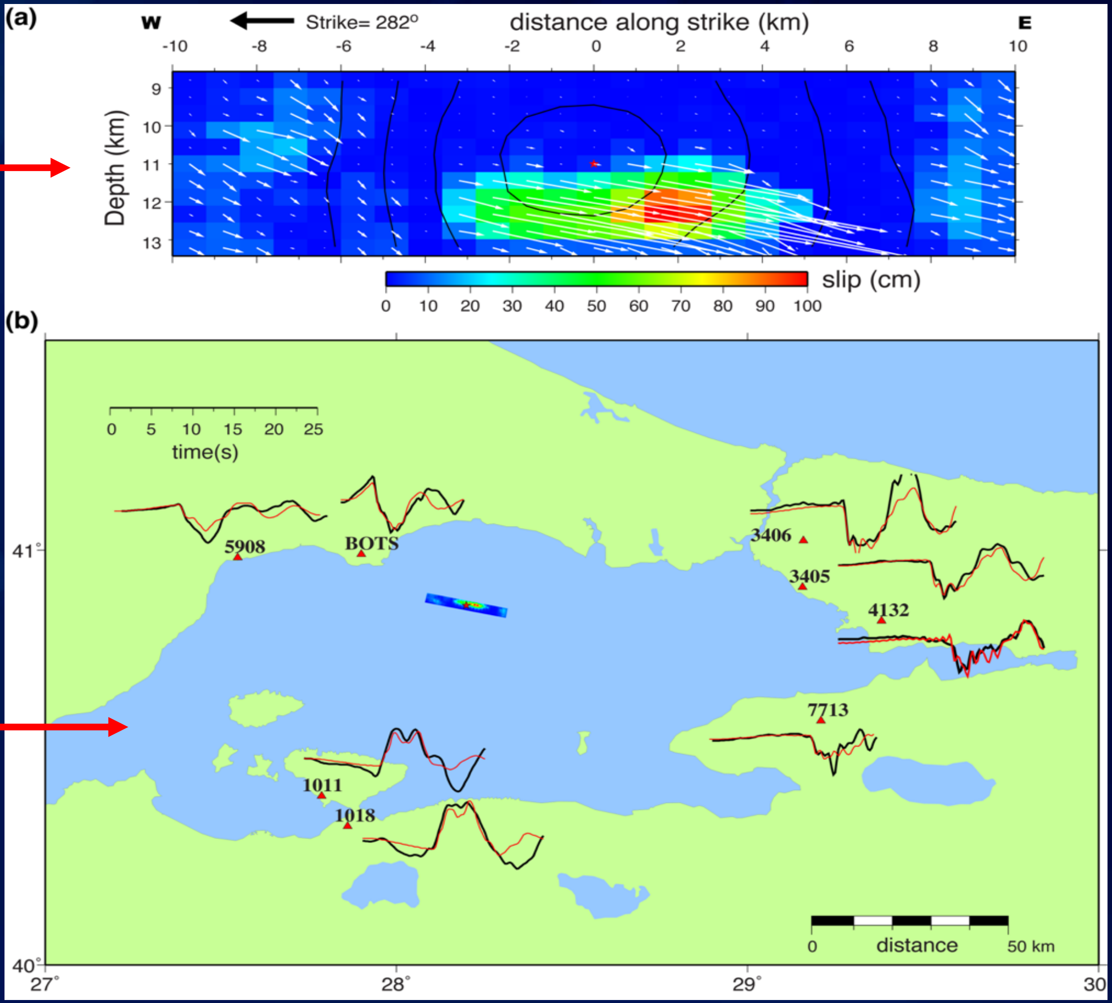


Finite-Fault Model of the Mainshock

- We obtained a finite-fault model of the Mw5.8 mainshock by using the SH waveforms of the strong-motion stations showing down-dip propagation.

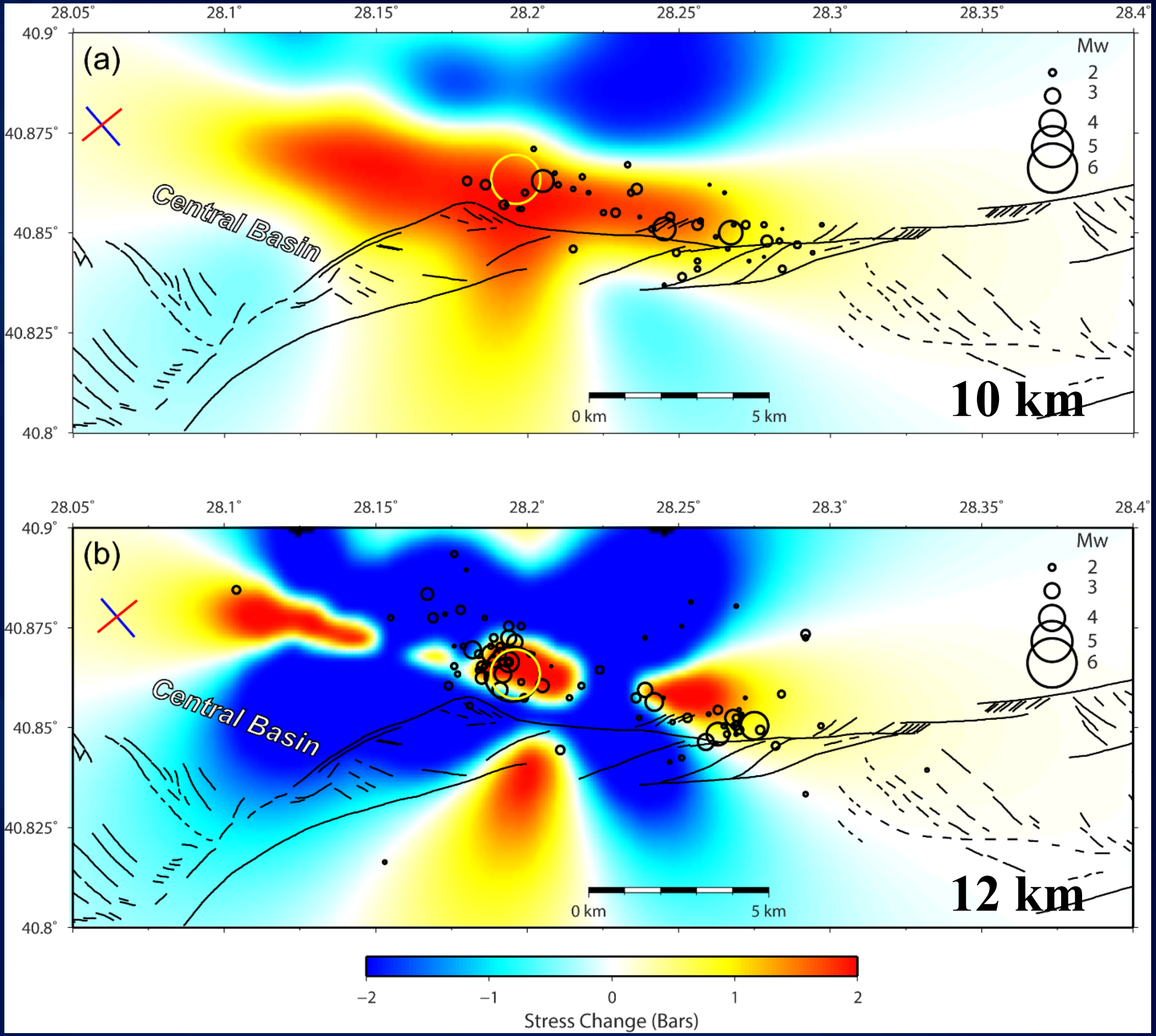
Fault plane view of the slip distribution

Transverse component waveforms (black) and model fits (red).



Coulomb Stress Changes and Aftershocks

- The Coulomb stress change along two depth sections show that aftershock locations are consistent with positive stress change.
- While the Mw5.8 event released some stress on MMF, and clamped the fault due to thrust component, it also loaded the shallower part of the fault and the eastern tip.



Conclusions

- The September sequence shows that while the initial nucleation was very small, the 4.7 stress perturbation was sufficient to spread the activity to 7-8 km distance eventually triggering the mainshock
- The activity started on a deep secondary structure to the north of MMF but propagated to the MMF.
- While the activity released some of the accumulated stress, it also loaded the upper section of the MMF in addition to the eastern tip of the rupture zone.

THANK YOU FOR YOUR ATTENTION