The 2 earthquakes of February 6th 2023 in Turkey

Preliminary Report

by **Evangelia GARINI** and **George GAZETAS**

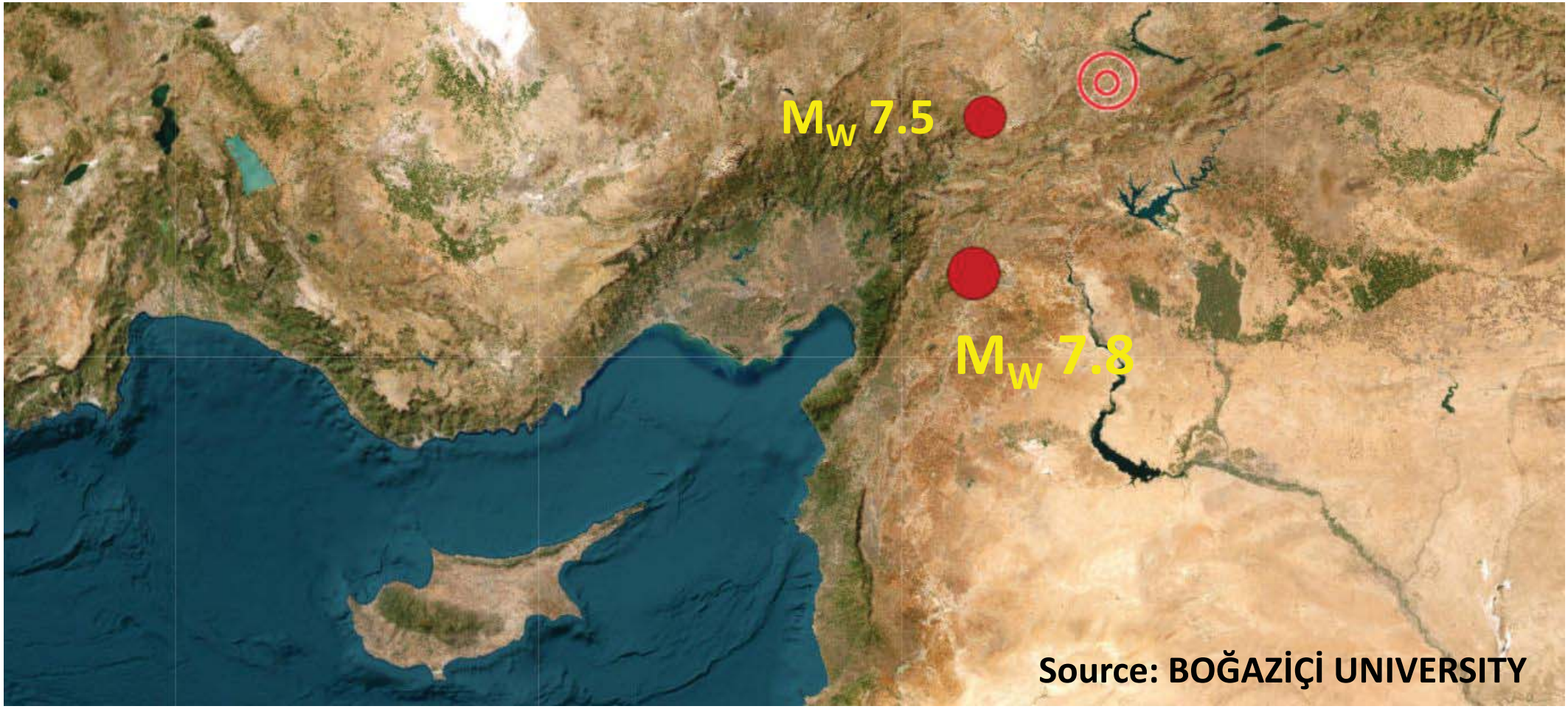
NTUA, Greece

PART A

Seismological Data of the M 7.8 and M 7.5 earthquakes

Tectonic setting-Intensity maps

7 February 2023



- Magnitude **Mw 7.8**
- Region **CENTRAL TURKEY**
- Date time **2023-02-06 01:17:36.1 UTC**
- Location **37.17 N ; 37.08 E**
- Depth **20 km**

- Magnitude **Mw 7.5**
- Region **CENTRAL TURKEY**
- Date time **2023-02-06 10:24:49.6 UTC**
- Location **38.11 N ; 37.24 E**
- Depth **10 km**

Map of seismic epicenters

Source: https://www.emsc-csem.org/Earthquake/Map/gmap.php

Map of seismic epicenters

Source: https://www.emsc-csem.org/Earthquake/Map/gmap.php

The M 7.8 earthquake resulted from strike-slip faulting at shallow depth.

The event ruptured either a near-vertical left-lateral fault striking northeast-southwest, or a right-lateral fault striking southeast-northwest.

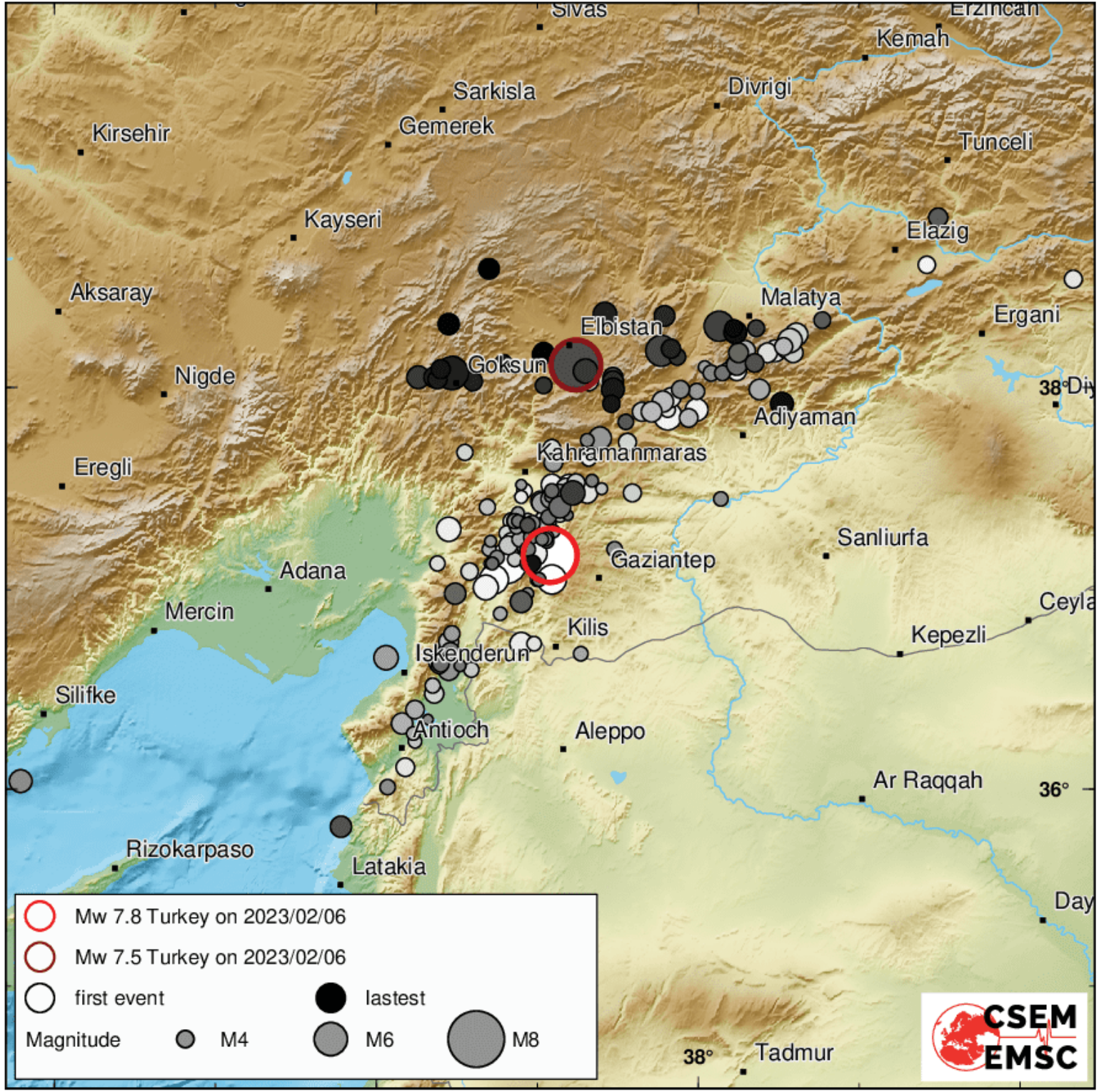
The preliminary location of the earthquake places it within the vicinity of a triple-junction between the Anatolia, Africa and Arabian tectonic plates. **A magnitude 7.8 strike slip earthquake is associated with a rectangular fault rupture of ~240 km long and ~20 km wide.**

Nine hours after the first earthquake of M 7.8

a second earthquake of M 7.5 occurred

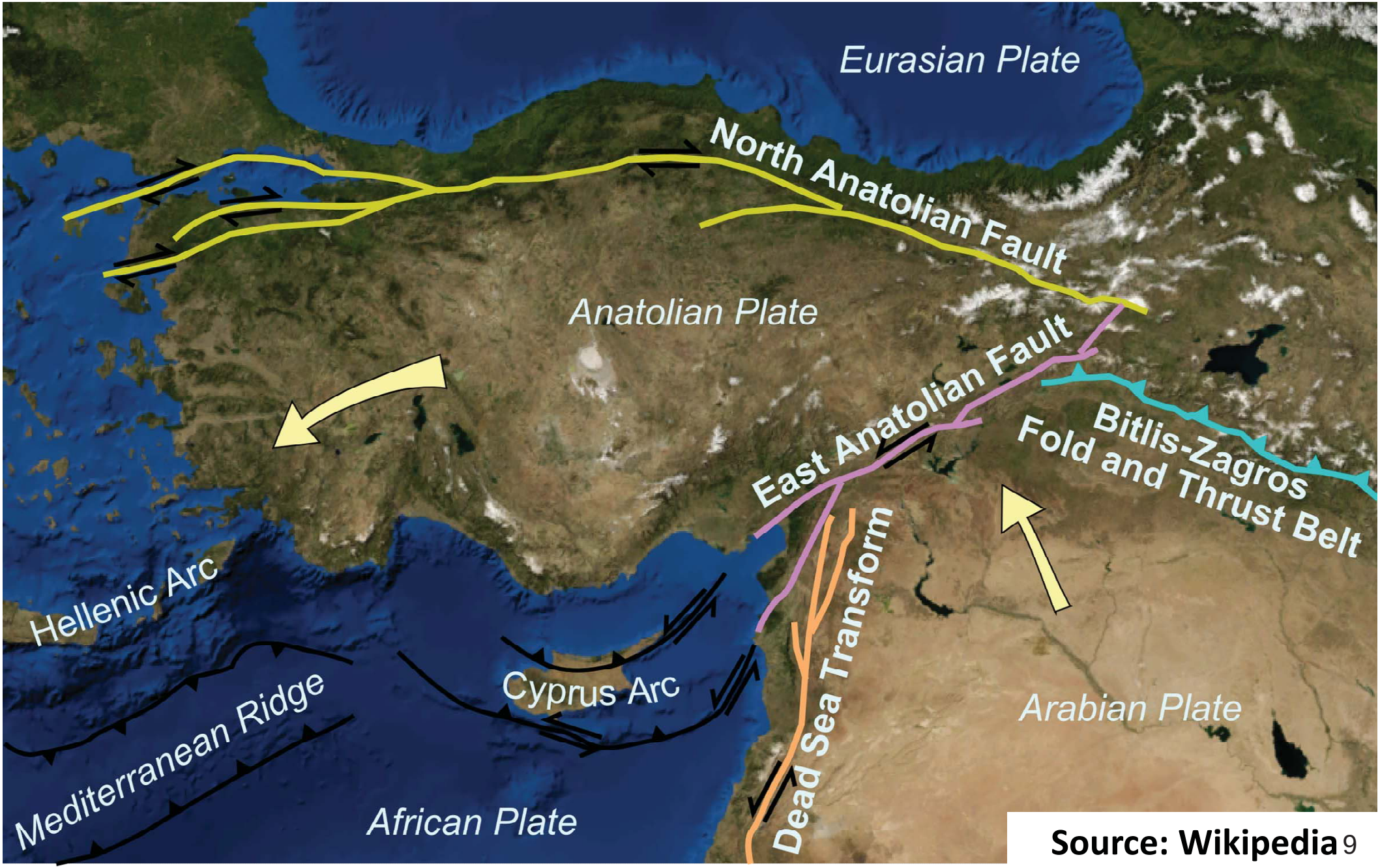
100 km to the north


TURKEY
SYRIA
TURKEY
Second quake
7.5 magnitude
Malatya
Diyarbakir
Ekinözü
Adiyaman
Kahramanmaras
First quake
7.8 magnitude
Osmaniye
Adana
Gaziantep
Kilis
Hatay
Aleppo
SYRIA
Latakia
CYPRUS
Hama
Tartus
100km
100 miles
Google
Source: INGV
BBC


Sivas
Erzincan
Kemah
Sarkisla
Divrigi
Gemerek
Kirsehir
Tunceli
Kayseri
Elazig
Aksaray
Malatya
Ergani
Elbistan
Goksun
Nigde
38°
Adiyaman
Kahramanmaras
Eregli
Sanliurfa
Gaziantep
Adana
Ceyla
Mercin
Kilis
Kepezli
Iskenderun
Silifke
Antioch
Aleppo
Ar Raqqah
36°
Rizokarpaso
Latakia
Day
Mw 7.8 Turkey on 2023/02/06
Mw 7.5 Turkey on 2023/02/06
first event
lastest
Magnitude
M4
M6
M8
38°
Tadmur
CSEM
EMSC
178 earthquakes on this map
100 km
Updated on 06/02/2023 at 13:15 UTC

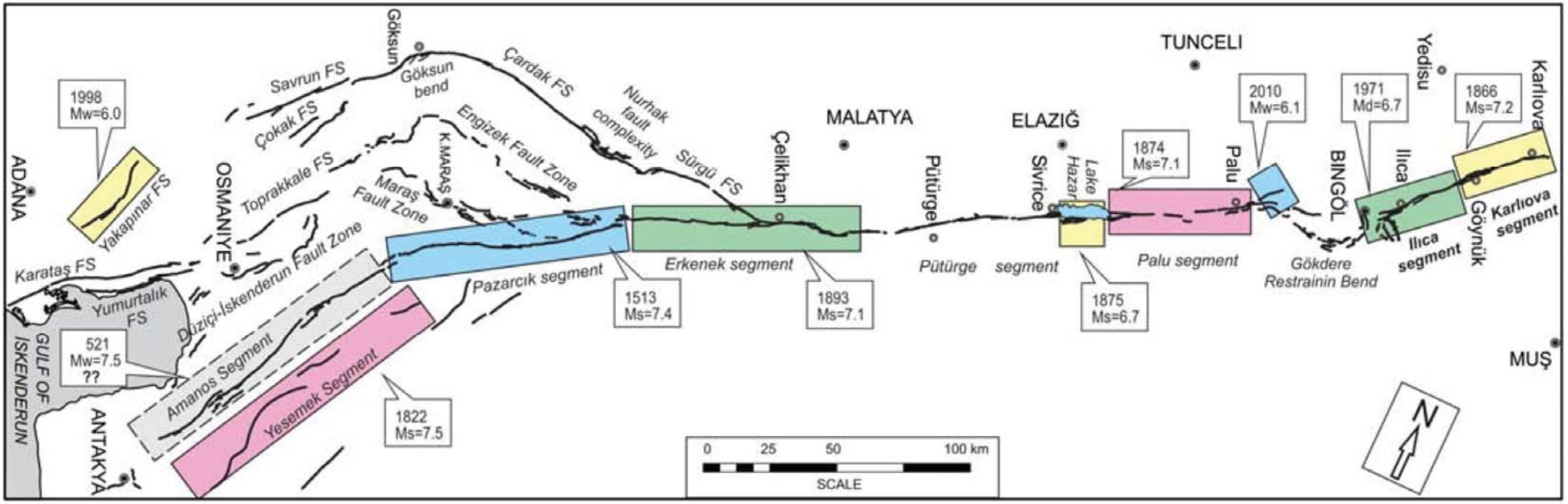
SEISMOLOGICAL INFO

Map showing main tectonic structures around the Anatolian Plate.
The arrows show displacement vectors of the Anatolian and Arabian Plates relative to the Eurasian Plate

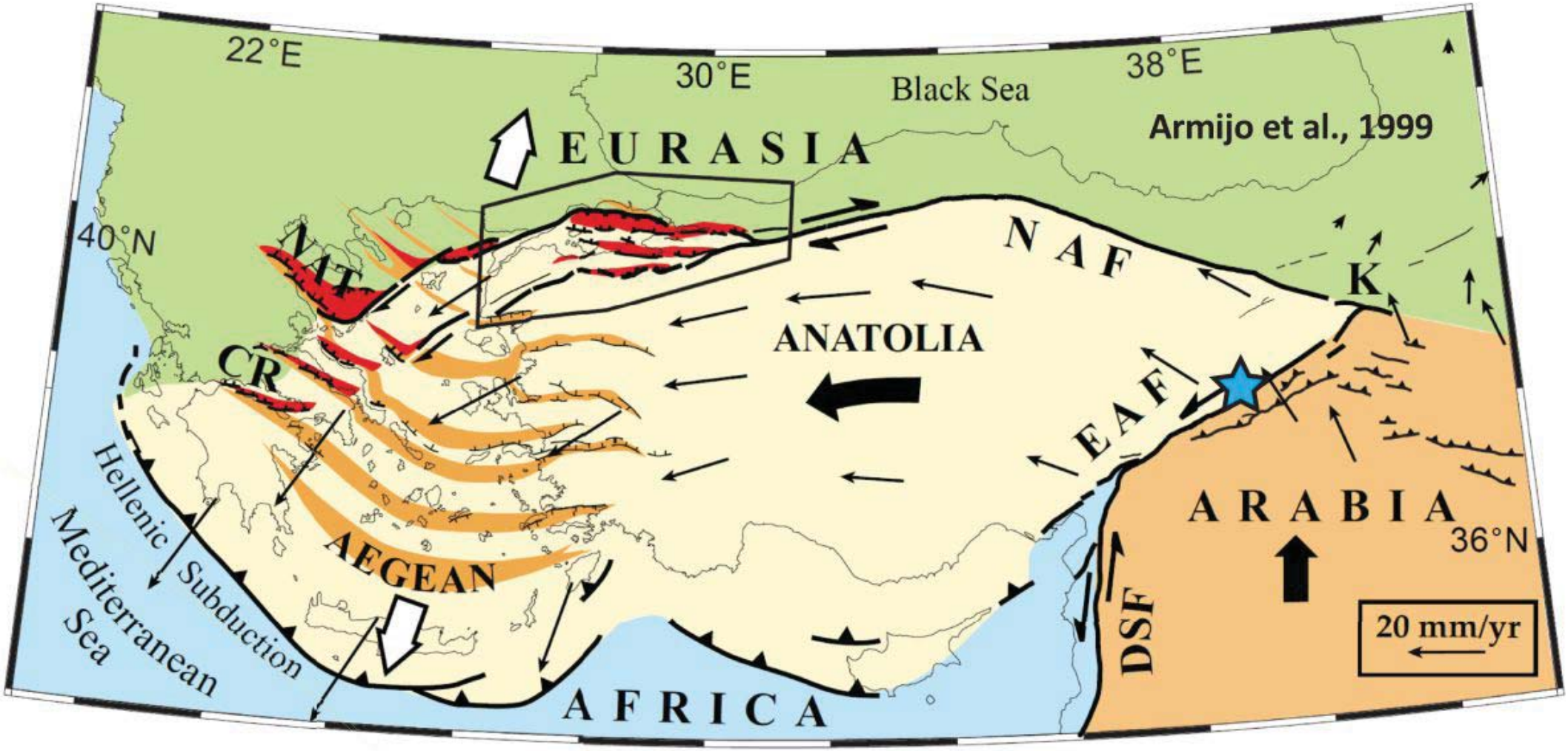


Source: Wikipedia

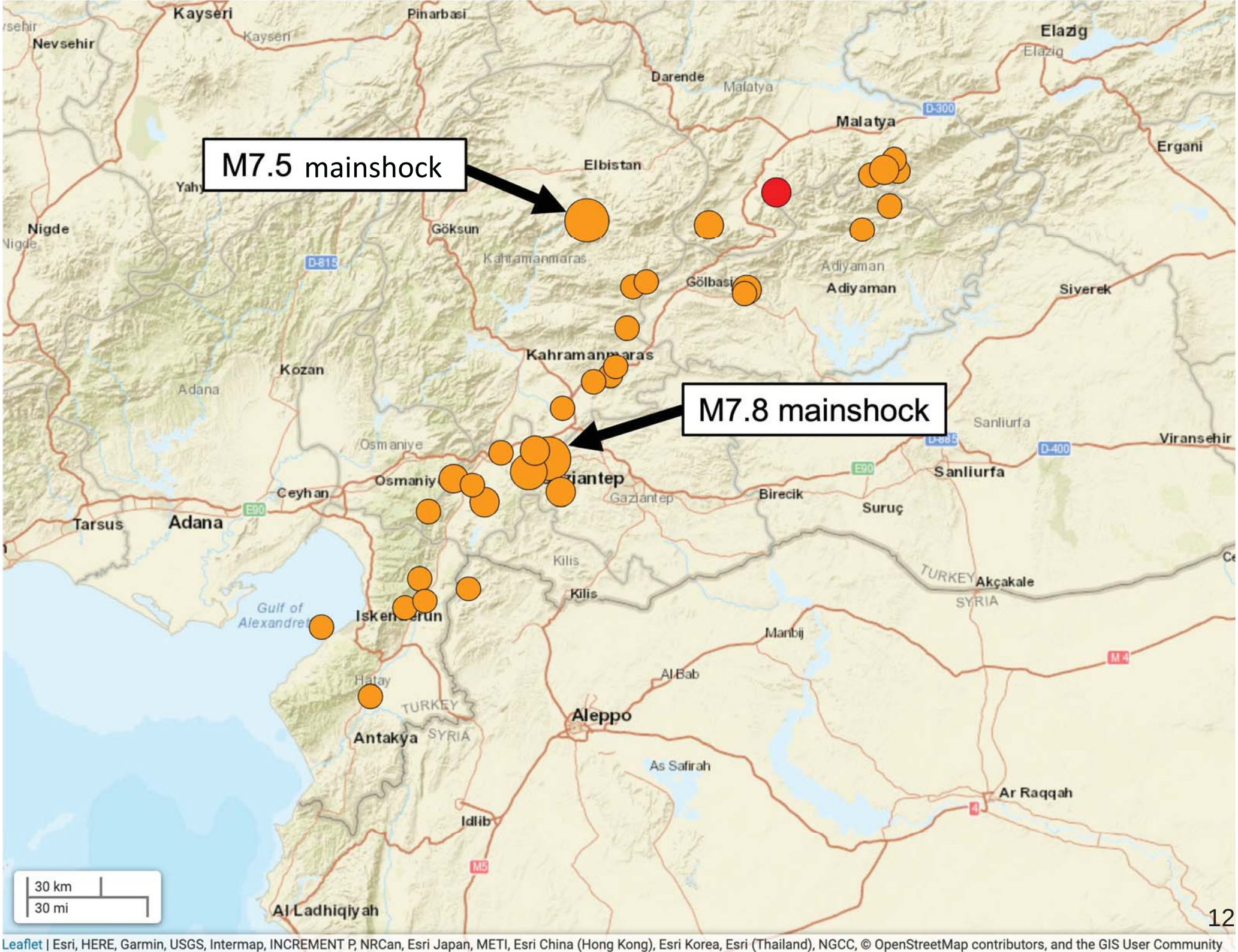
Tectonics and fault system Map of the East Anatolian Fault

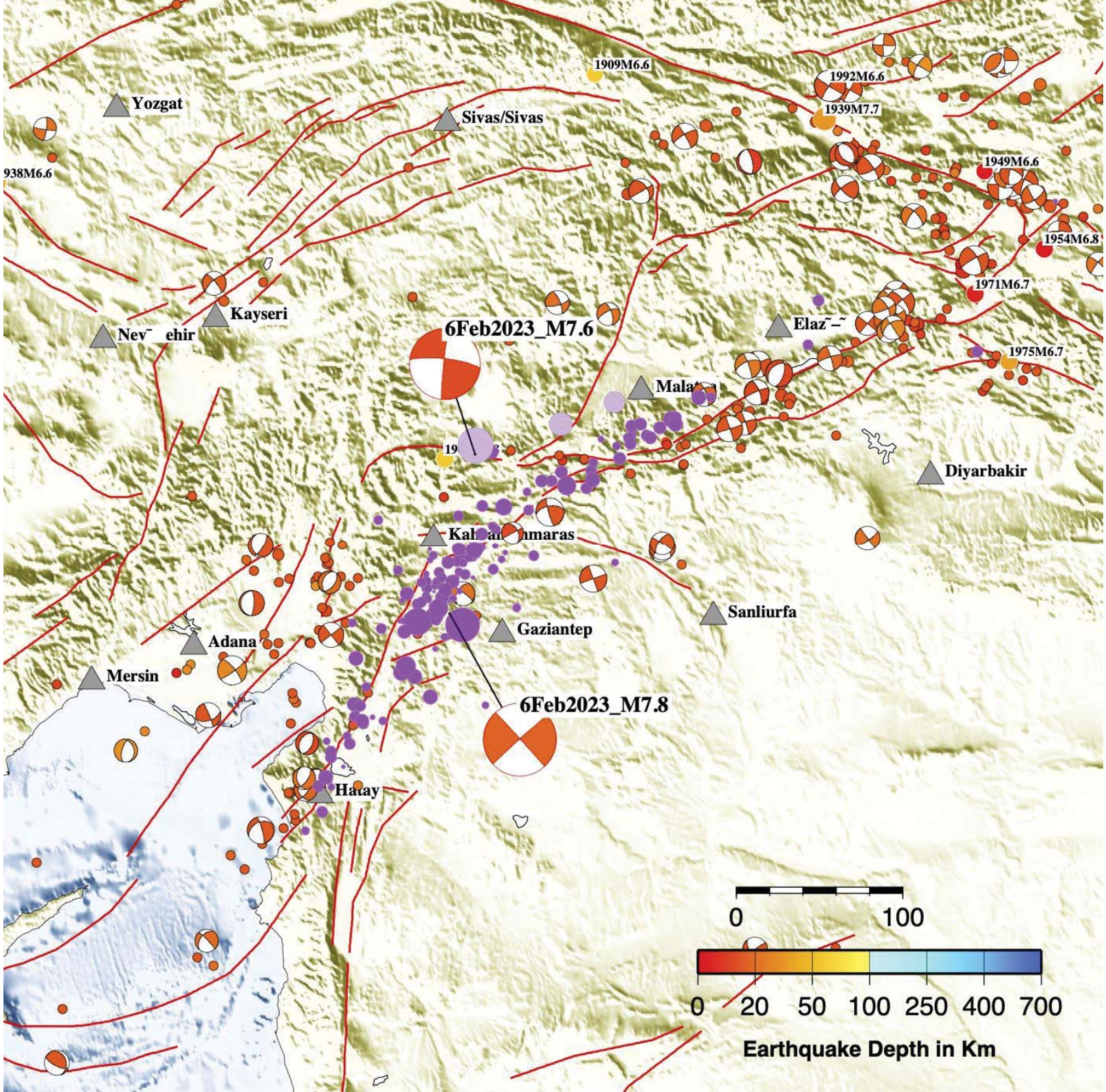


Source: Duman and Emre (2013)

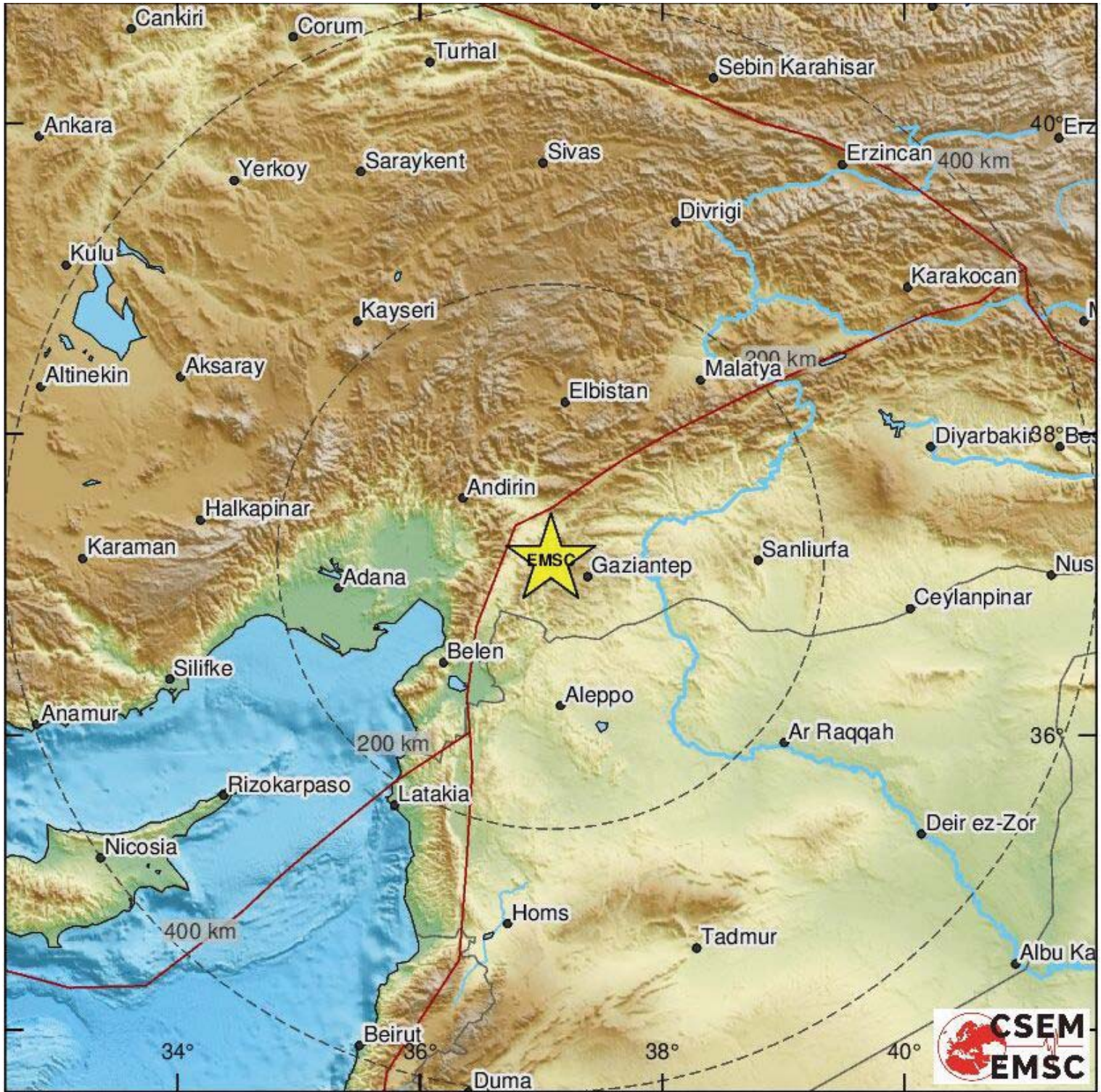


Source: **CSEM-EMSC + GEM + USGS + Jason R. Patton**


M7.5 mainshock
M7.8 mainshock
Kayseri
Pinarbasi
Nevsehir
Elazig
Darende
Malatya
Ergani
Elbistan
Göksun
Kahramanmaras
Gölbasi
Adiyaman
Siverek
Nigde
Kozan
Adana
Osmaniye
Gaziantep
Sanliurfa
Viransehir
Birecik
Suruç
Ceyhan
Tarsus
Kilis
TURKEY
SYRIA
Akçakale
Gulf of Alexandretta
Iskenderun
Manbij
Al Bab
Hatay
Antakya
Aleppo
As Safirah
Ar Raqqah
Idlib
Al Ladhiqiyah
30 km
30 mi
Leaflet | Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community



Source: Jascha Polet



The 1st mainshock of M7.8

100 km

Political boundaries

Tectonic plates boundaries

Depth

- 0 - 40 km
- 40 - 80 km
- 80 - 150 km
- 150 - 300 km
- > 300 km

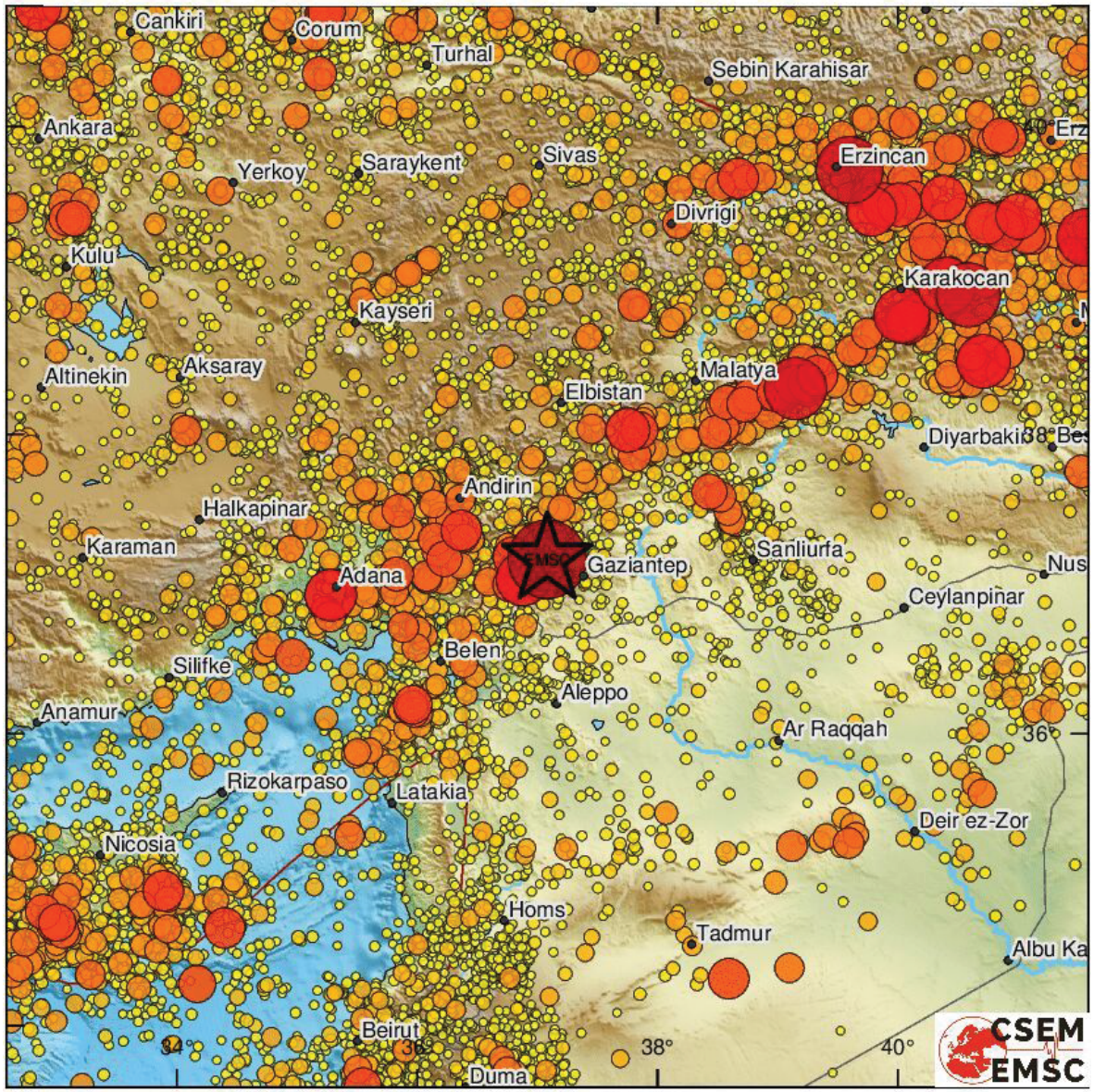
EMSC manual location

M:7.8 2023/02/06 - 01:17:36 UTC

Lat: 37.17 Lon: 37.08 Depth: 20 km

Background data: ISC + EMSC catalogues from 1960 to 06/02/2023 01:00

(Total number of events with M>3: 18778



Magnitude

2 3 4 5 6 7 8 9

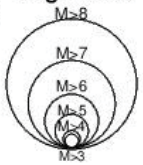
100 km

Political boundaries

Tectonic plates boundaries (Bird, P. [2003])

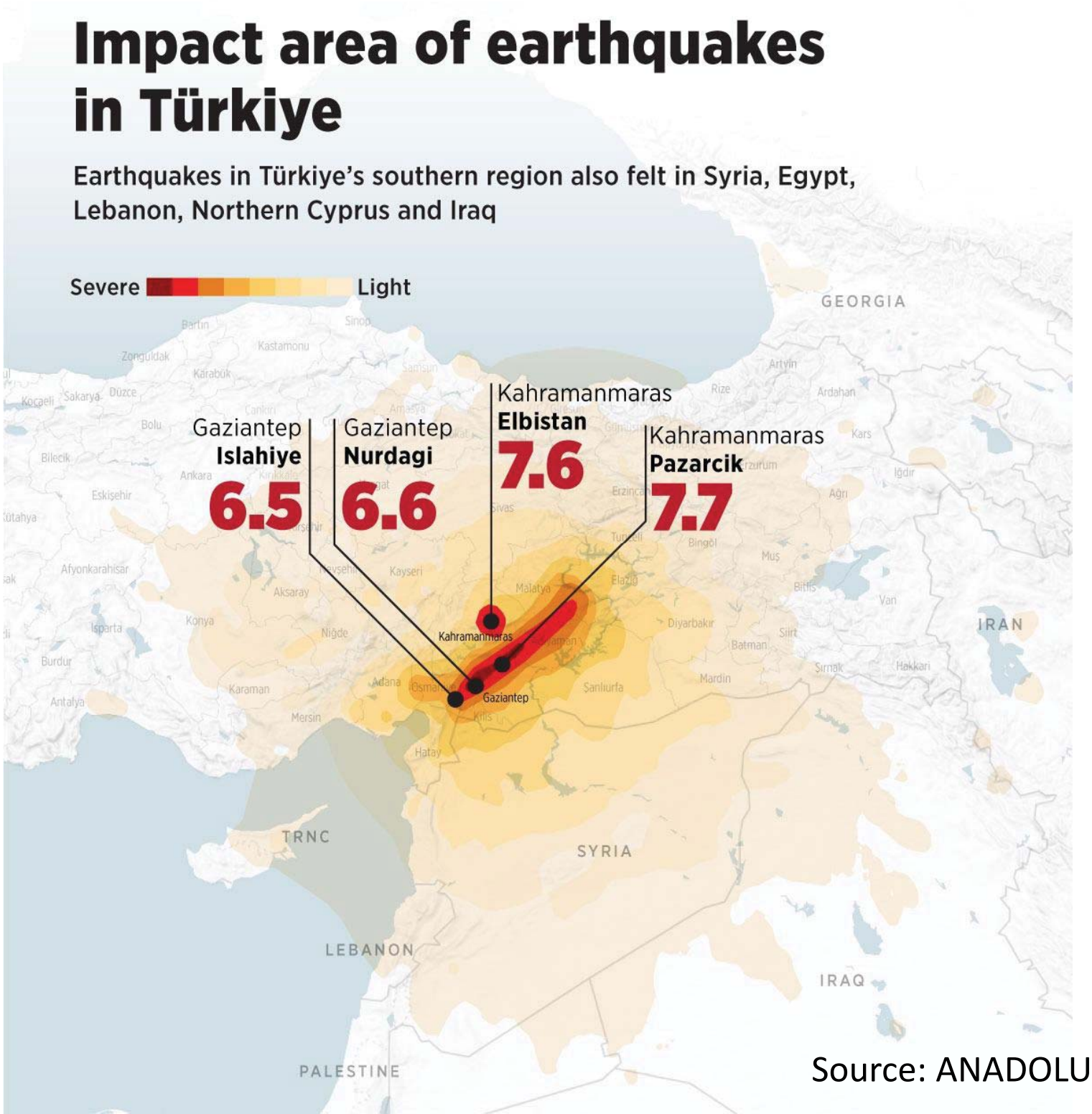
Last updated: 2023-02-06 at 08:21 UTC

Magnitude



Impact area of earthquakes in Türkiye

Earthquakes in Türkiye's southern region also felt in Syria, Egypt, Lebanon, Northern Cyprus and Iraq

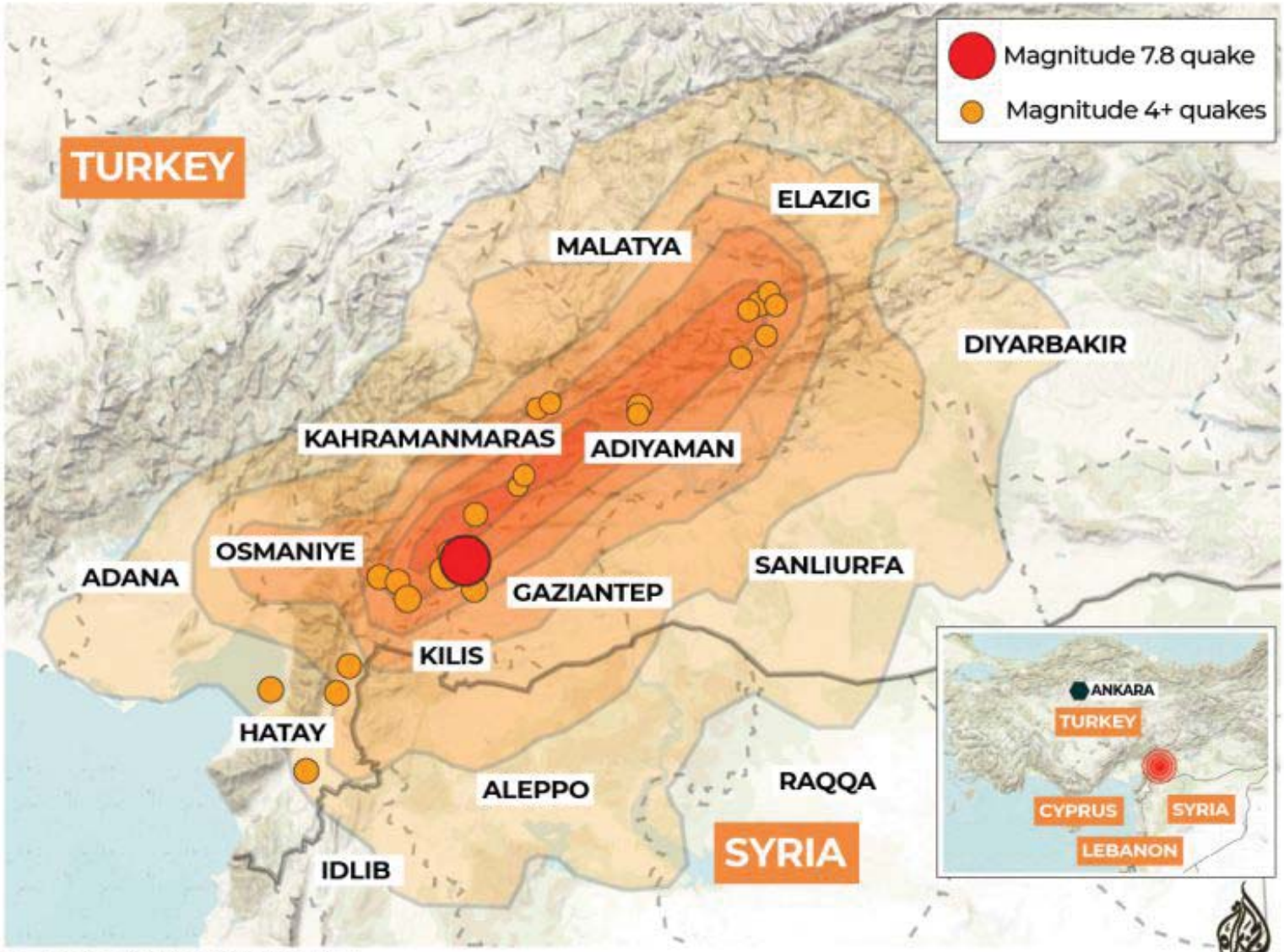


Source: ANADOLU AGENCY

EARTHQUAKE

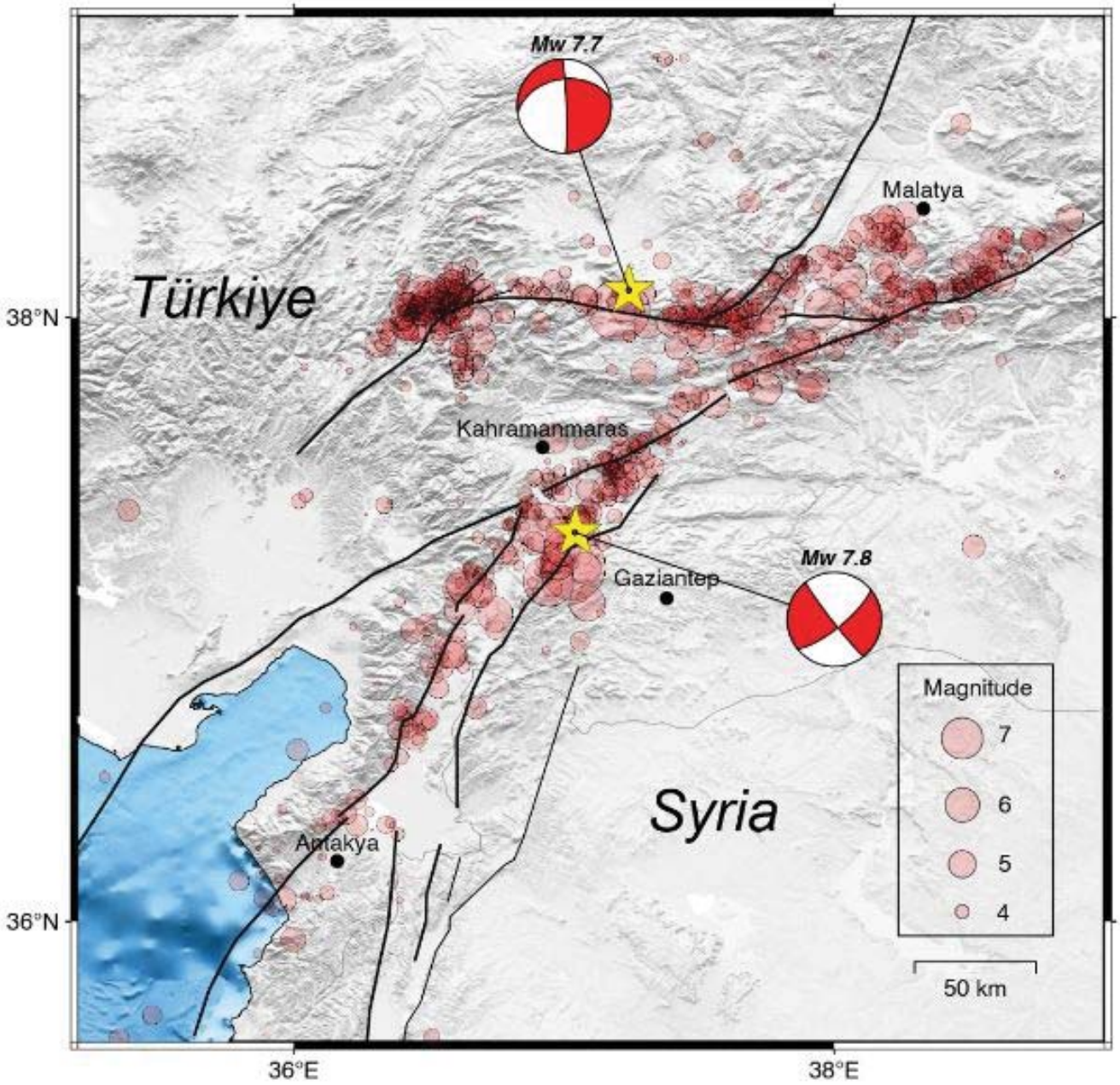
Hundreds dead in Turkey, Syria earthquake

Hundreds of people are dead and more than 1,700 buildings have collapsed after a magnitude 7.8 earthquake struck the southeastern region of Turkey along the border with Syria. Tremors were also felt across Lebanon and Cyprus.



Source: Al Jazeera | Updated: February 6, 2023

@AJLabs ALJAZEERA

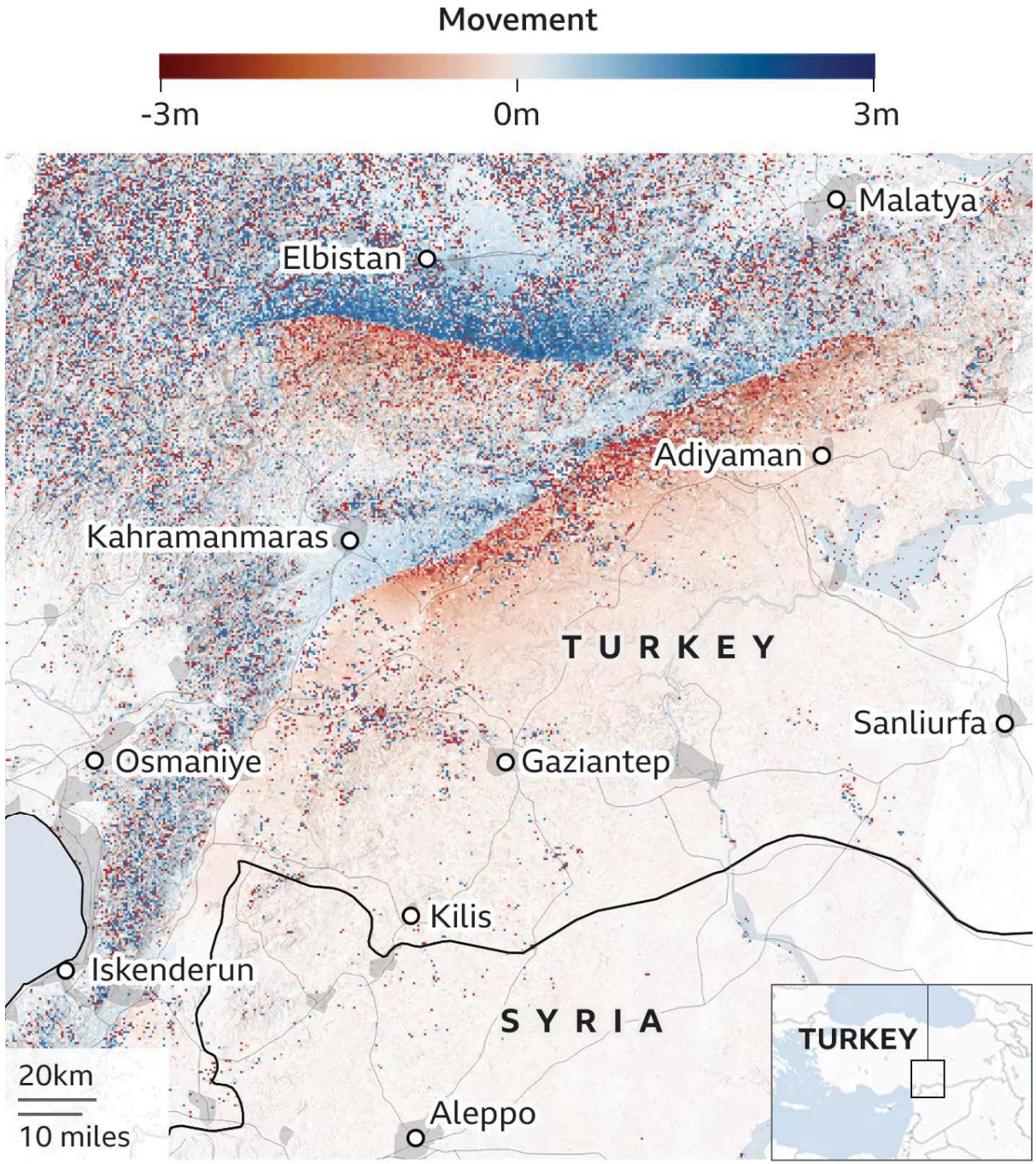


Map of the seismic activity of February 6, 2023, near the Türkiye–Syria border. Fault lines are shown in black. The first magnitude 7.8 mainshock (yellow star) occurred at 01:17 AM (UTC) on the East Anatolian Fault system. The second magnitude 7.7 mainshock (01:24 PM UTC; yellow star) occurred about 100 km north of the first event on a distinctly separate fault.

The first mainshock broke along an ~350 km long stretch of the EAF, while the 2nd mainshock was ~170 km long.

Graphic courtesy of **P. Martin Mai and Sigurjon Jonsson, Earth Science and Engineering, KAUST.**

EU satellite precisely maps earthquake faults



Ground movement measured closer to or further away from passing satellite

Source: Copernicus data, Esa, Comet 2023

BBC

PRELIMINARY REPORT

Failures of Multistorey Buildings
in Turkey and Syria
Due to the M 7.8 and M 7.5 Earthquakes

PART B: Structural Collapse and Interpretation

PART C: Recorded Accelerograms, Response Spectra

Evangelia GARINI and George GAZETAS

8 February 2023

School of Civil Engineering,

National Technical University of Athens

PART B

Some Remarks on the

STRUCTURAL * Collapse of Multistorey Buildings

* and one purely GEOTECHNICAL Failure

Based on the following photos, and our experience from the Kocaeli (1999) earthquake, we draw some conclusions regarding the unprecedented extent of damage.

In addition to the very strong seismic shaking, with PGAs in the order of at least 0.7 g – 1 g, the following structural deficiencies (that are clearly identified in these photos and are evident in perhaps all the collapsed buildings) were truly fatal:

1. **Very thin columns, but rather thick slabs**
2. **Very inadequate steel reinforcement (in size and number of longitudinal bars)**
3. **Transverse reinforcing bars of inadequate density and improperly tied**
4. **NO beams !! Slabs constracted directly on columns, without continuity of the longitudinal Rebars, and no proper joints**
5. **Nowhere to be seen Shear Walls, even in > 10 story buildings**

(For comparison, a typical 2-story building in Cephalonia, Greece, is shown — from an area of similar seismicity as the region inflicted by the 7.8 earthquake.)

See next slide for details

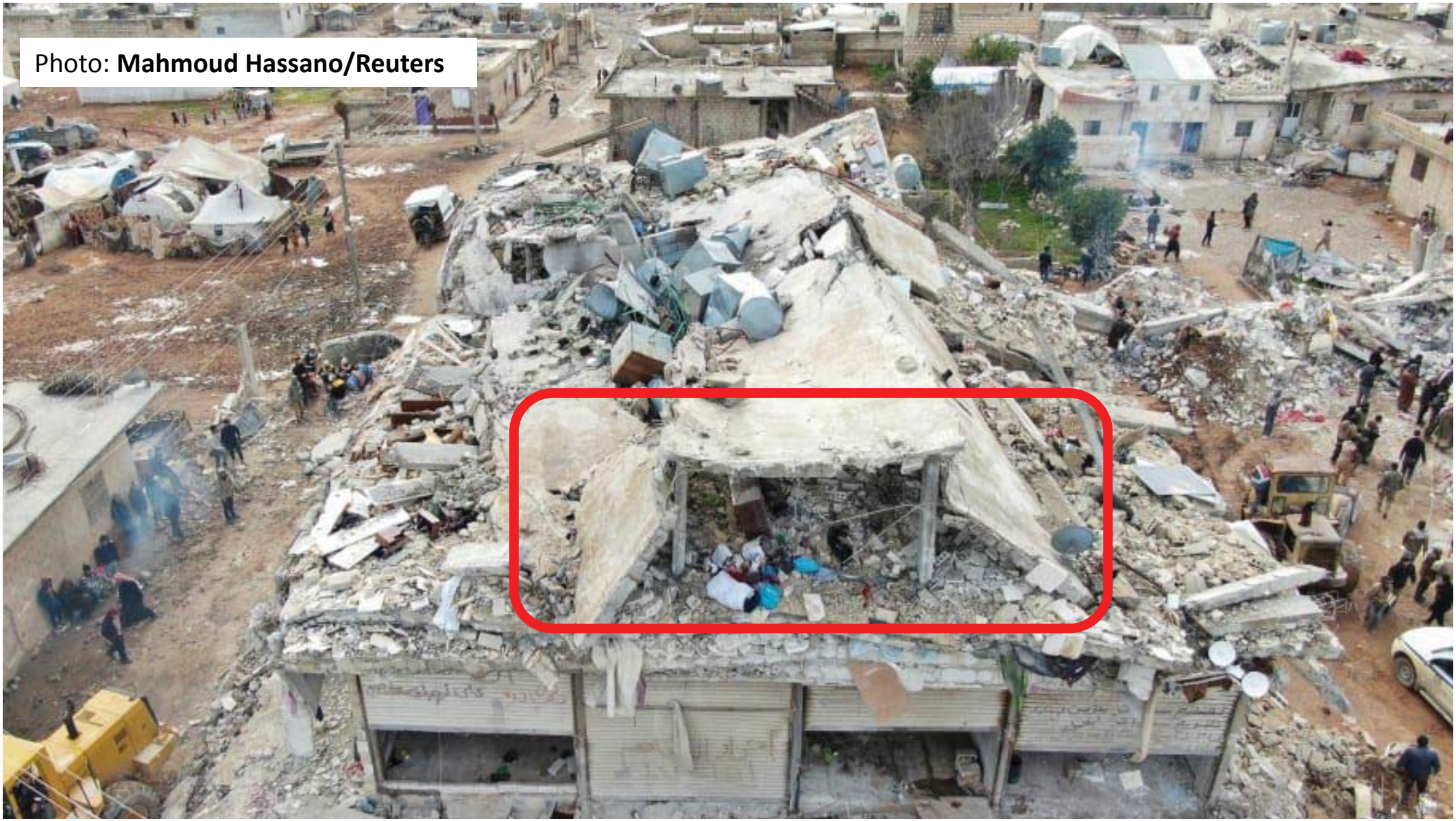
Numerous buildings without any beam, with small size columns (inappropriate even for 1-story buildings in a region of moderate seismicity).

See next slide for details

NO BEAMS

NO SHEAR WALLS

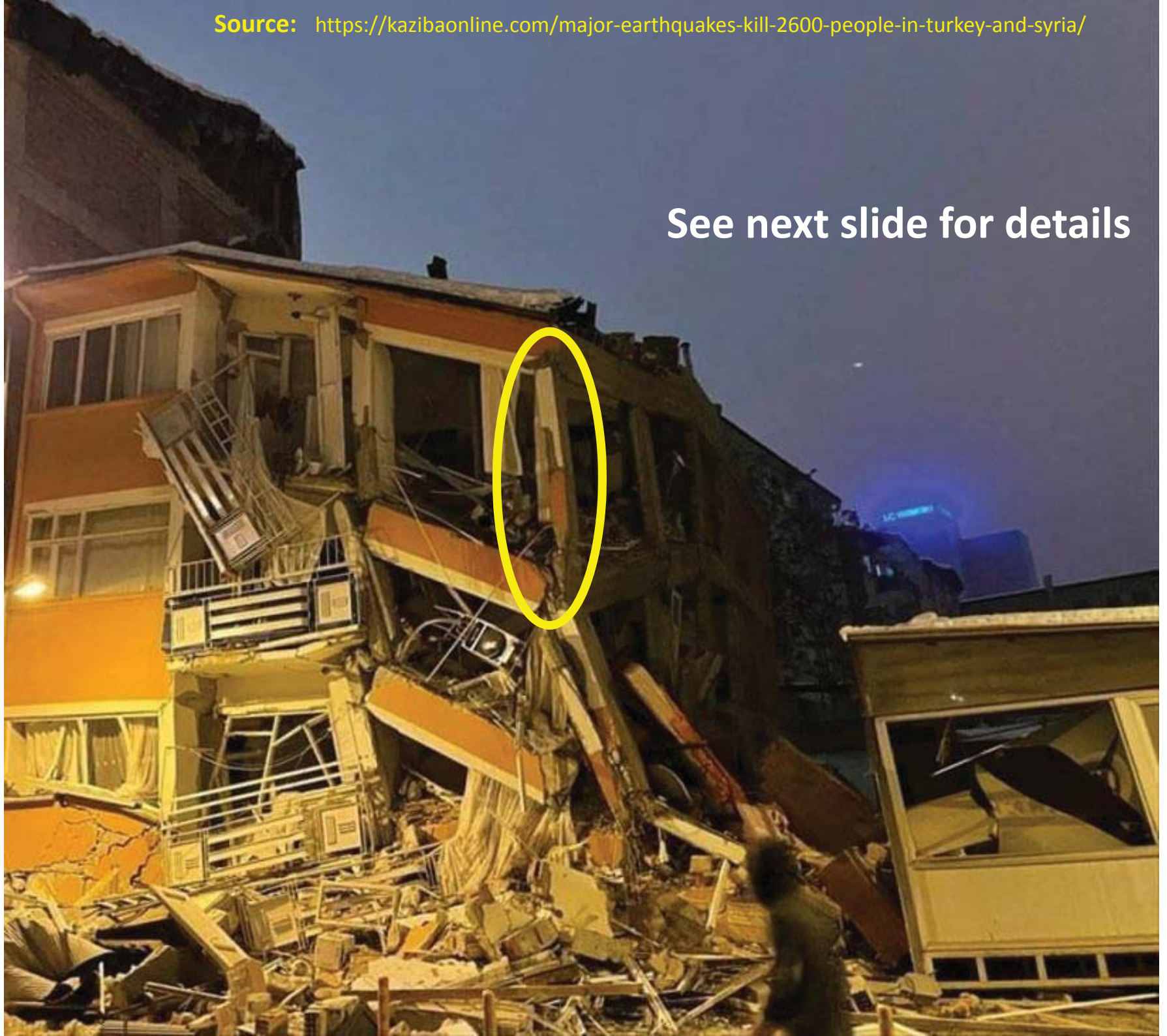
POOR JOINT,
COLUMN
PENETRATES
THE SLAB



See next slide for details


The slab is effectively SIMPLY-SUPPORTED, as just resting on top of the thin columns !
VERY THIN COLUMNS
NO Slab–Column JOINT

Source: https://kazibaonline.com/major-earthquakes-kill-2600-people-in-turkey-and-syria/



See next slide for details


Joints fail, as if there is no continuity of the longitudinal reinforcement (REBARS).
Essentially, NO Slab–Column JOINT

Source: https://en.as.com/latest_news/turkey-and-syria-earthquakes-live-updates-death-toll-nears-100000-earthquake-map-video-of-magnitude-78-quake-n/

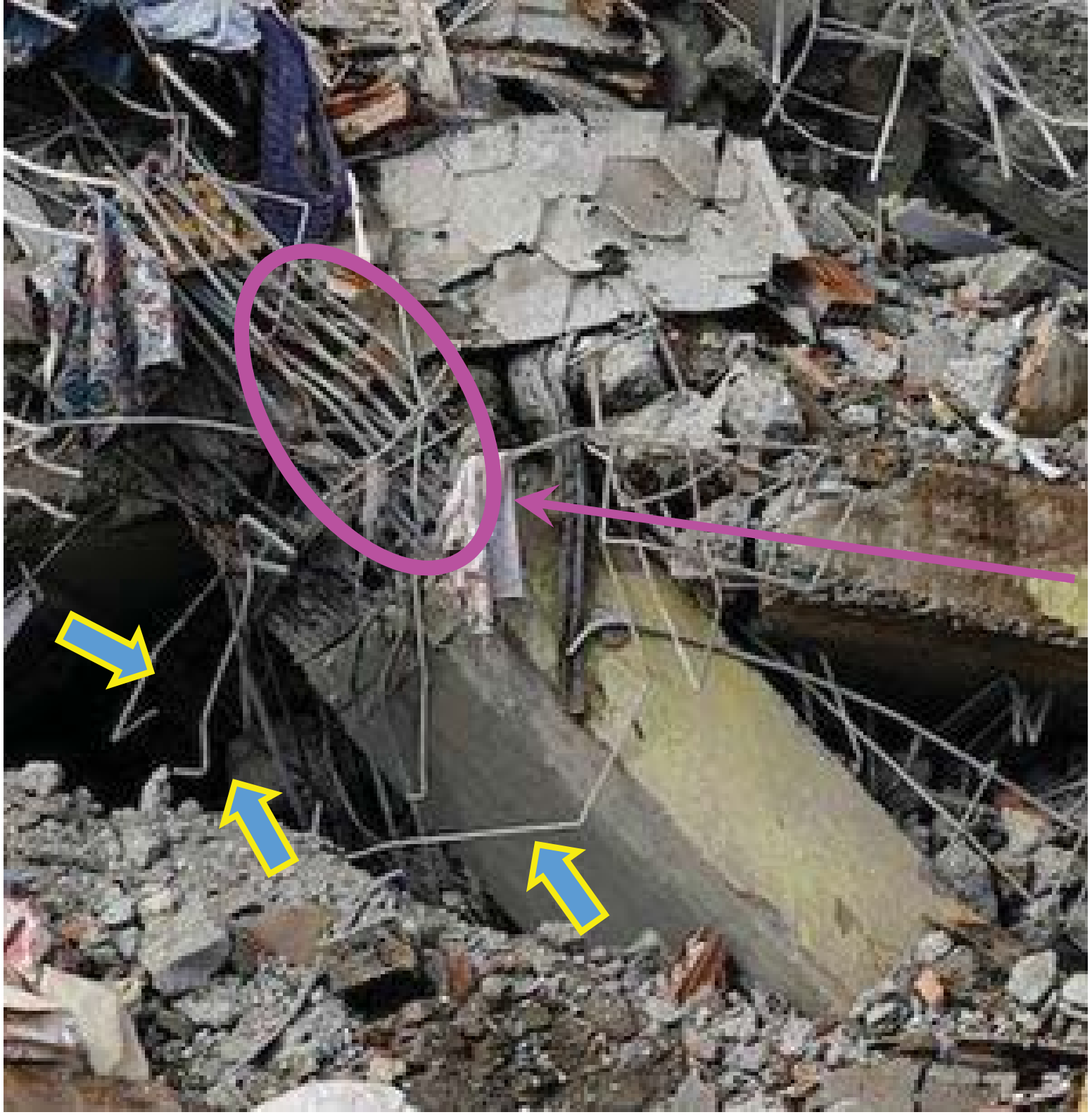
VERY FEW REBARS, OF VERY SMALL DIAMETER

Photo: ymphotos/Shutterstock

See next slide for details

Transverse reinforcement almost effectively non-existing… it was untied, leading the inadequate longitudinal rebars to buckle.

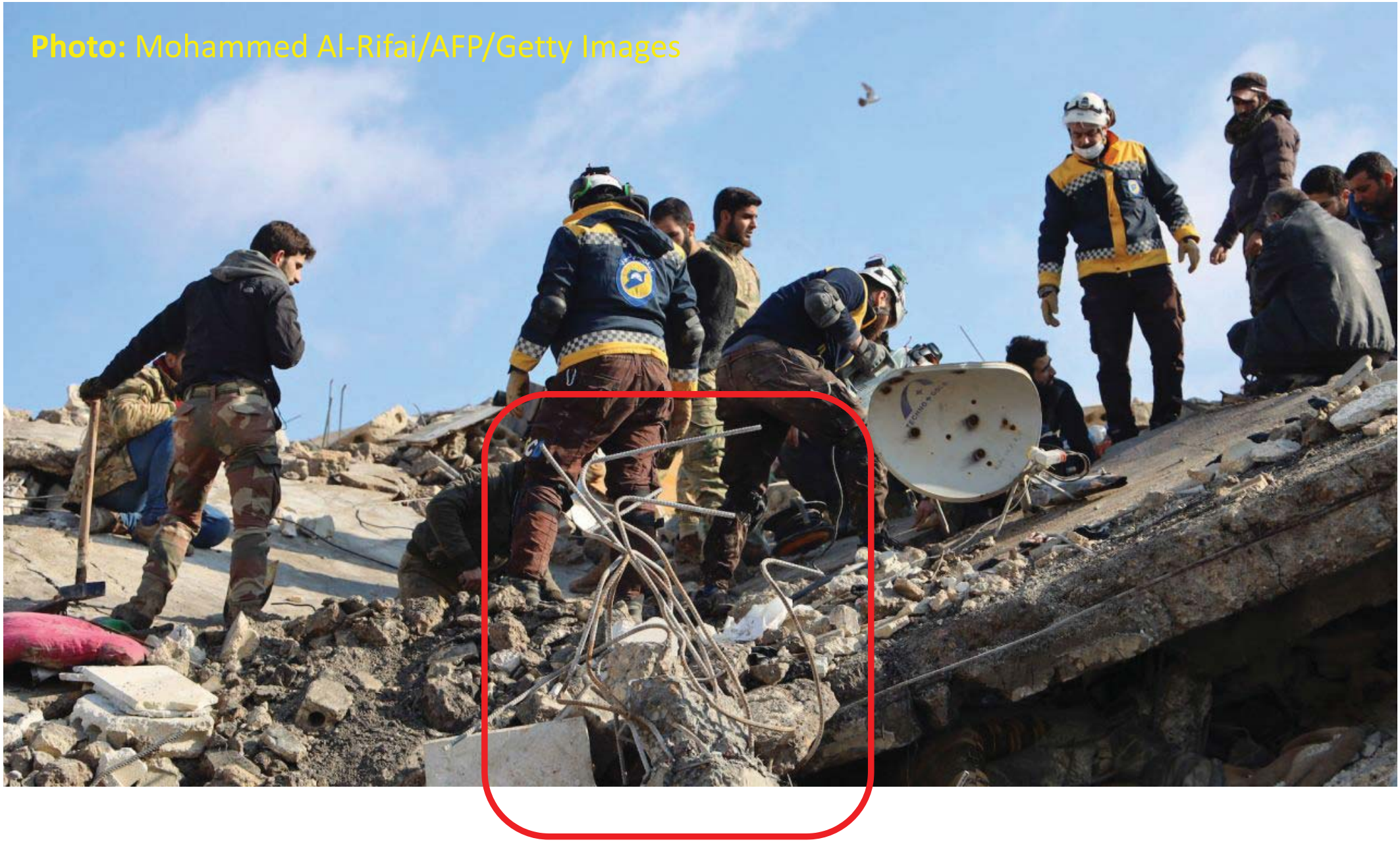
See next slide for details



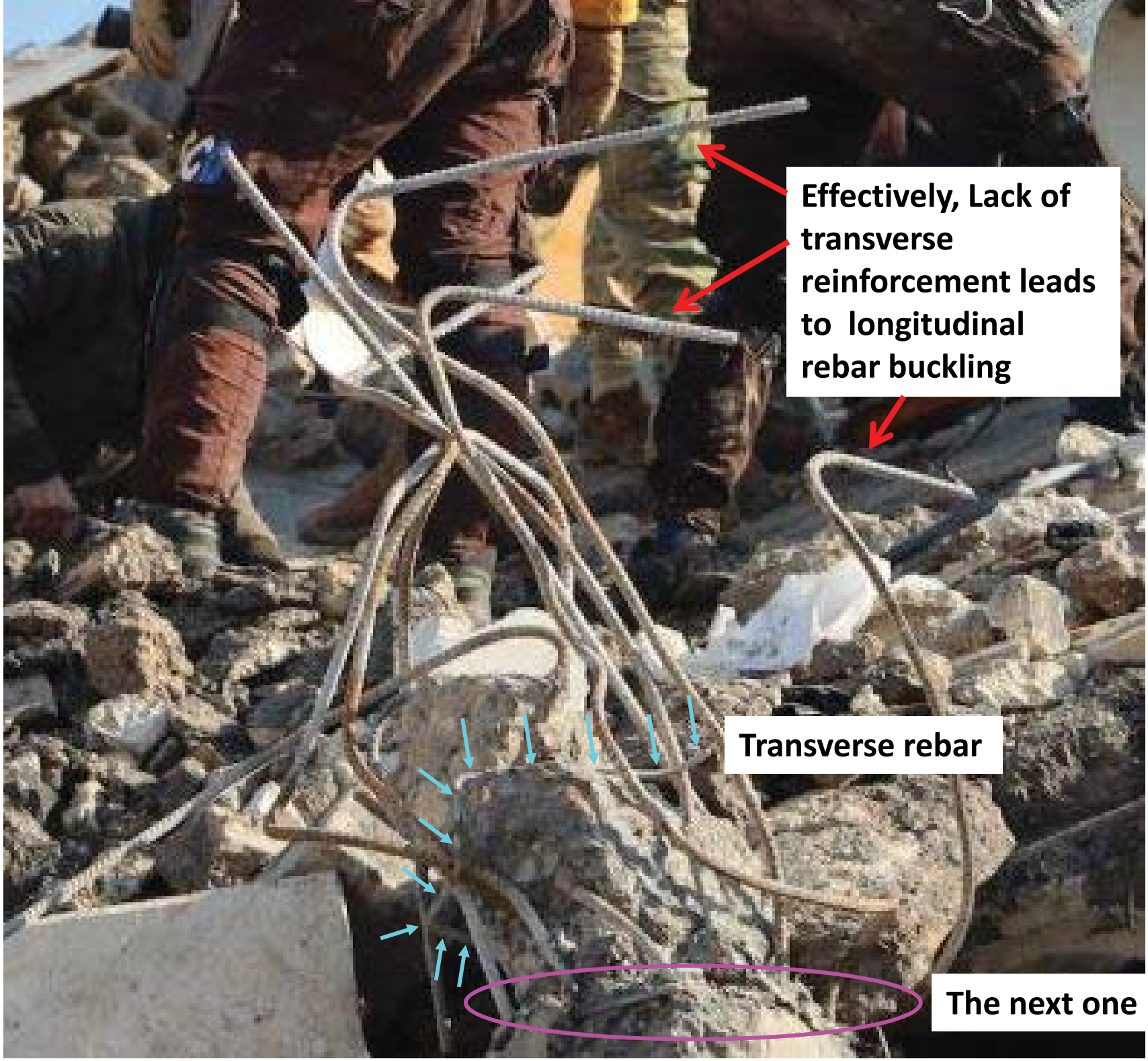
Transverse bars were un-tied.

Longitudinal REBARS are of VERY SMALL DIAMETER


NO BEAMS, POOR (or rather No)
JOINTS !



See next slide for details


Effectively, Lack of transverse reinforcement leads to longitudinal rebar buckling
Transverse rebar
The next one

See next slide for details

Same building seen from a different angle


NO BEAMS, POOR JOINTS !
VERY FEW
REBARS OF
VERY SMALL
DIAMETER

Source: https://www.rescue.org/article/earthquakes-near-turkish-syrian-border-deepen-crisis

See next slide for details

VERY THIN COLUMNS
NO BEAMS
POOR JOINTS

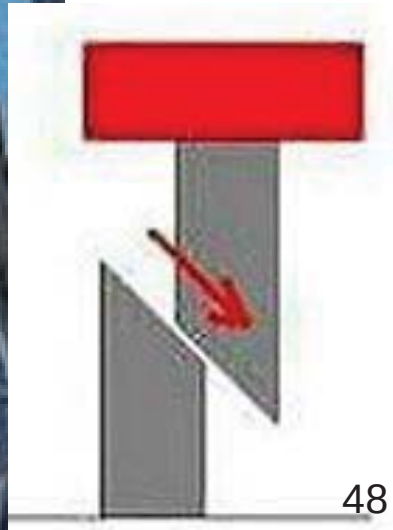
See next slide for details

Longitudinal REBARS have penetrated the supported slab !!

Aerial photo shows the destruction in Kahramanmaras, southern Turkey, Wednesday, Feb. 8, 2023. (**Photo | AP**)

See next slide for details

Un-connected parts of a column !! Failed in SLIDING or SHEAR (??)



NO BEAMS, NO JOINTS, NO SHEAR WALLS

Photo: Twitter/@PAOK_FC

See next slide for details

An aerial photo from Kahramanmaras, Turkey **CREDIT: Ahmet Akpolat/DIA via AP**

Inadequate columns cannot "follow" the above building on its lateral movement

See next slide for details

FEW LONGITUDINAL REBARS, OF VERY SMALL DIAMETER

Transverse reinforcement ??


NO BEAMS !
NO transverse reinforcement ??
NO transverse reinforcement
VERY FEW Longitudinal REBARS, OF VERY SMALL DIAMETER