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t-rupt

January 25th, 2024 Malatya Earthquake

Earthquake Information Report

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1. Introduction

An earthquake of magnitude M5.2 occurred on January 25th, 2024, at 16:04 local time (13:04 UTC) in Battalgazi (Malatya, Turkey). The earthquake parameters reported by KOERI, AFAD, and USGS are given in Table 1. The earthquake was felt in the Malatya region with a macro-seismic intensity of MMI VII (reported by USGS). Table 2 shows the densely populated urban settlements near the earthquake epicenter. The location of the event is shown in Figure 1 and Figure 2.

Table 1. Important indicators of the Battalgazi (Malatya) earthquake (source: AFAD)

Magnitude	Mw5.2
Location	Battalgazi (Malatya)
Date time	25/01/2024 13:04:04
Epicenter	38.1989 N, 38.4589 E,
Depth**	13.88 km

* USGS reported the magnitude as mb5.0, KOERI reported the magnitude as M_L5.3

** EMSC-CSEM and USGS reported the depth as 10 km.

Table 2. The nearest urban settlements and their populations to the epicenter of the January 25th M5.0 event (source: EMSC)

Nearby Settlements and Their Populations
Sincik, Adıyaman, 24 km, population: 7,152
Çelikhan, Adıyaman, 27 km, population: 12,961
Malatya, 21 km, population: 441,805
Kâhta, Adıyaman, 49 km, population: 73,105

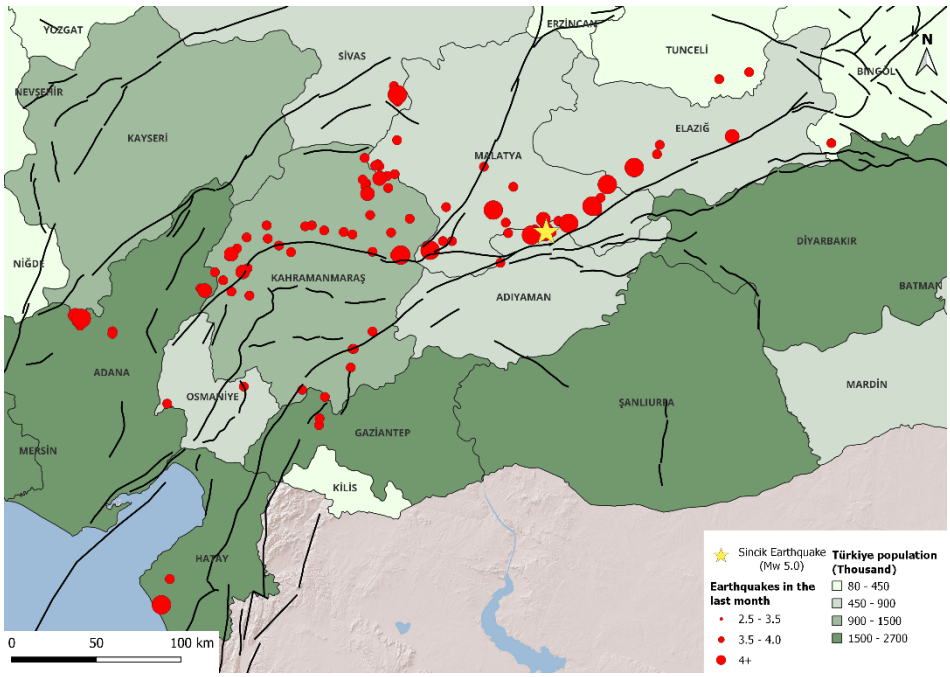


Figure 1. Epicentral location of the M5.2 earthquake (yellow star) and the aftershocks associated during the last 30 days (red circles).

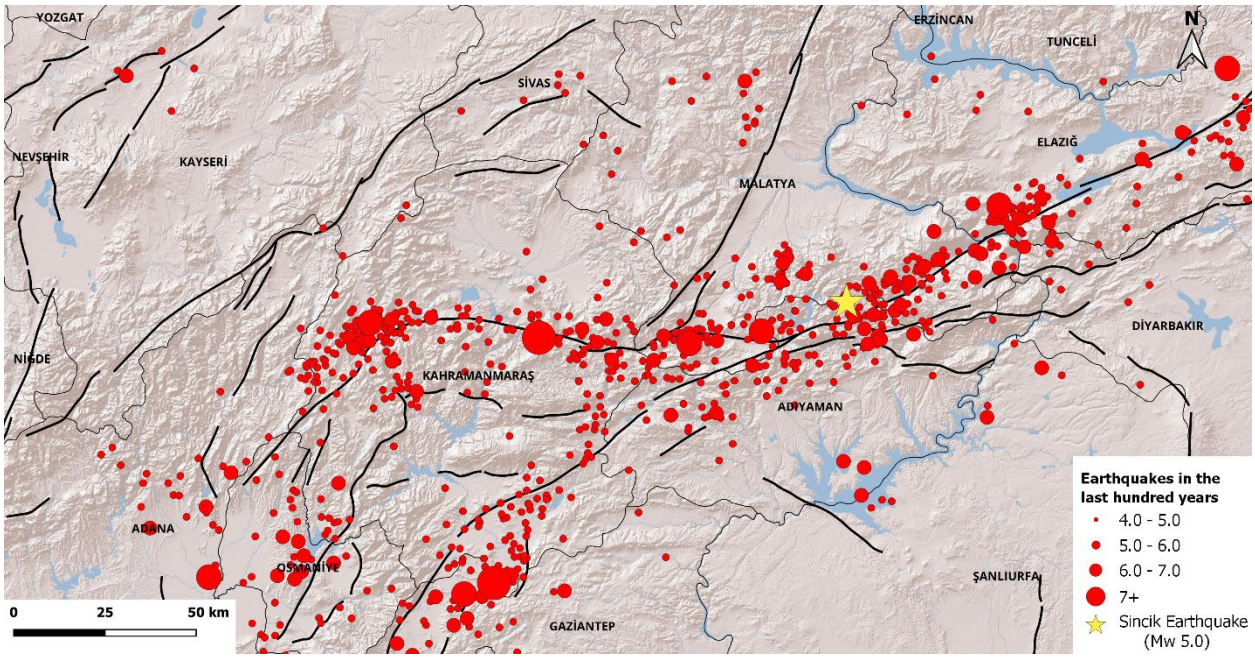


Figure 2. The seismic activity of the region during the last 100 years. (source: EMSC and USGS).

2. Seismotectonic features of the region

Two large earthquakes of moment magnitudes M7.8 and M7.7 occurred almost one year ago on February 6, 2023, at 04:17 and 13:24 (local time, +3 GMT) located at Pazarcık and Ekinözü districts of Kahramanmaraş respectively. These ruptured 300km long fault segments along the NE-SW trending East Anatolian Fault Zone (EAFZ) and its 100km long E-W trending fault segment. Yesterday's earthquake of magnitude M5.2 also occurred on the EAFZ, its epicenter being located at 167 km NE of Pazarcık and 113 km E of Ekinözü earthquakes on February 6, 2023.

The maximum observed offset along the ruptured fault segments on February 6, 2023 earthquakes was close to 8-10m at some locations, pointing out a long-lasting strain accumulation along the plate boundaries. In the following paragraphs, the main seismotectonic features of the major fault systems are outlined from a T-Rupt internal report on the February 6, 2023 events.

The tectonic interaction between the Arabian, African, and Eurasian plates forces the Anatolian Block to move westward (Figure 3). The westward movement of the Anatolian Block mainly takes place along the North Anatolian Fault Zone (NAFZ) in the north and the EAFZ in the southeast. The EAFZ is a left-lateral strike-slip fault and it accommodates the relative motion between the Anatolian Block and the Arabian Plate. The total length of the EAFZ is about 550 km and extends from Karlıova in the northeast to the Mediterranean Sea in the southwest. Although there is an agreement regarding the main trace of the fault zone between Karlıova in the northeast and Türkoğlu in the southwest (Figure 3), the southwestern continuation further southwest of Türkoğlu is under debate.

Moderate and large earthquakes have occurred during the pre-instrumental and instrumental periods along the plate boundaries between the three plates. Several surface rupturing events reportedly took place on the EAFZ in the 19th century (e.g. 1866 M = 6.8, 1874 M ≥ 7.1, 1875 M = 6.7, 1893 M = 7.1 earthquakes). Earthquakes in 1114 and 1513 most probably occurred in the southwestern part of the EAFZ and caused significant damage in northern Syria and eastern Anatolia. Based on paleoseismological

studies the 1513 (M = 7.4) and 1114 earthquakes occurred on the Türkoğlu-Pazarcık and Pazarcık-Gölbaşı segments of the EAFZ, respectively. The 1544 (M = 6.7) earthquake took place on the Çardak-Sürgü Fault (Figure 3).

The 1408 earthquake (M = 7.5) took place at the northern end of the DSFZ and is associated with ~20 km long surface rupture. The 13 August 1822 (M = 7.4) event occurred in the Karasu Valley. The 1872 April 3 earthquake (M = 7.2) occurred in the Amik Basin and generated heavy damage around the former Amik Lake.

Some moderate-size earthquakes (e.g. 1905, M = 6.8 Malatya; 1971, Ms = 6.7 Bingöl; 1986, Ms = 6.0 Sürgü; 2003, Ms = 6.4 Bingöl; 2010, M = 6.0 Karakoçan–Elazığ; 2020, M = 6.8 Elazığ) occurred on the main trace of the EAFZ during the instrumental period but no surface rupture was reported. It is noteworthy to note that the northeastern part of the EAFZ reactivated with moderate-size earthquakes during the instrumental period (Figure 3).

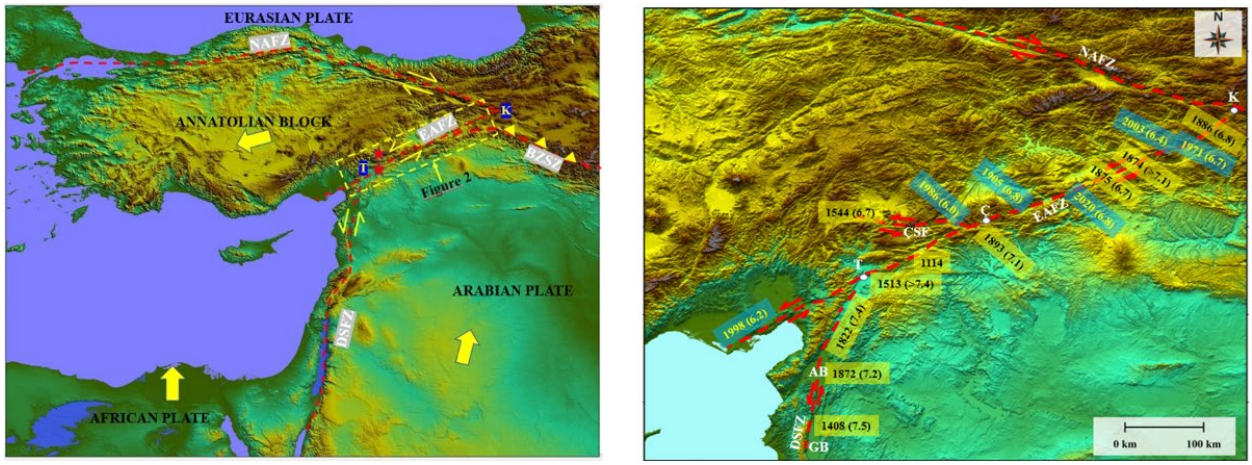


Figure 3. (Left panel) Simplified map of the Eastern Mediterranean showing relative plate motions (solid yellow arrows) and major active fault zones (dashed red lines). NAFZ: North Anatolian Fault Zone, EAFZ: East Anatolian Fault Zone, DSFZ: Dead Sea Fault Zone (yellow half arrows show sense of motion on the fault zone). BZSZ: Bitlis-Zagros Sture Zone (yellow triangles are on the thrusting site). K: Karlıova, T: Türkoğlu. Map produced from SRTM Worldwide Elevation Data (1-arc-second resolution). (Right panel) Instrumental (blue boxes with yellow numbers) and pre-instrumental (yellow boxes with black numbers) earthquake activity of the main trace of the EAFZ and northern DSFZ.

3. Aftershock Activity of the February 6, 2023 Events

The 7.7 and 7.6 magnitude Kahramanmaraş earthquakes, which occurred nine hours apart at 04:17 and 13:24 on February 6, 2023, local time, were caused by the rupture of several large and small fault segments. The total length of the ruptured faults exceeded 400 km. Intense aftershock activity delineated the rupture fault segments (Figure 4). Aftershocks extended to Samandağ Hatay in the south, Göksun Kahramanmaraş in the west, Pütürge, Yeşilyurt, and Malatya in the north. The magnitudes of several aftershocks reached 5 and above. The MTA Active Fault Map is shown with red lines (Figure 4). The distribution of aftershocks mostly coincides with active faults. However, there is intense aftershock activity in some regions, where there are no known active faults. It appears that there is no fault associated with the intense aftershock activity that occurred between Doğanşehir and Yeşilyurt. Several earth scientists claimed that a new fault is forming in the Yeşilyurt direction. The most recent M5 aftershocks in that region are the 5.2 magnitude aftershock occurred on August 10, 2023, at 20:48 and January 25, 2024 M5.2 aftershock (Table 3 and Figure 5).

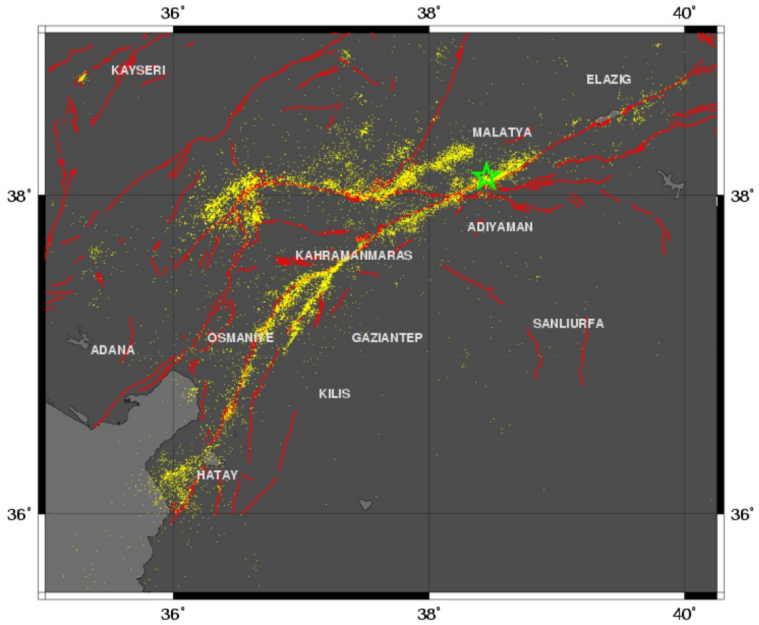


Figure 4. The aftershock distributions of the February 6, 2023 earthquakes were relocated by Antony Lomax.

Table 3. Moderate-size aftershocks in the proximity of Malatya

No	*Tarih*	*Saat*	*Enlem*	*Boylam*	*Derinlik*	*Magnitüd*
1	*06.02.2023*	*05:03:37*	*37.86*	*37.81*	*5*	*5.5*
2	*06.02.2023*	*06:18:46*	*38.23*	*38.57*	*10*	*5.0*
3	*06.02.2023*	*13:26:48*	*38.03*	*37.96*	*20*	*6.0*
4	*06.02.2023*	*13:51:32*	*38.30*	*38.13*	*8*	*5.7*
5	*06.02.2023*	*18:33:34*	*38.27*	*38.15*	*10*	*5.4*
6	*06.02.2023*	*23:53:24*	*38.21*	*38.28*	*10*	*5.0*
7	*07.02.2023*	*10:11:15*	*38.18*	*38.63*	*10*	*5.4*
8	*07.02.2023*	*13:18:15*	*38.14*	*38.52*	*10*	*5.4*
9	*27.02.2023*	*12:04:51*	*38.25*	*38.29*	*5*	*5.2*
10	*10.08.2023*	*20:48:00*	*38.27*	*38.265*	*11*	*5.2*
11	*25.01.2024*	*16:04:04*	*38.20*	*38.46*	14	*5.2*

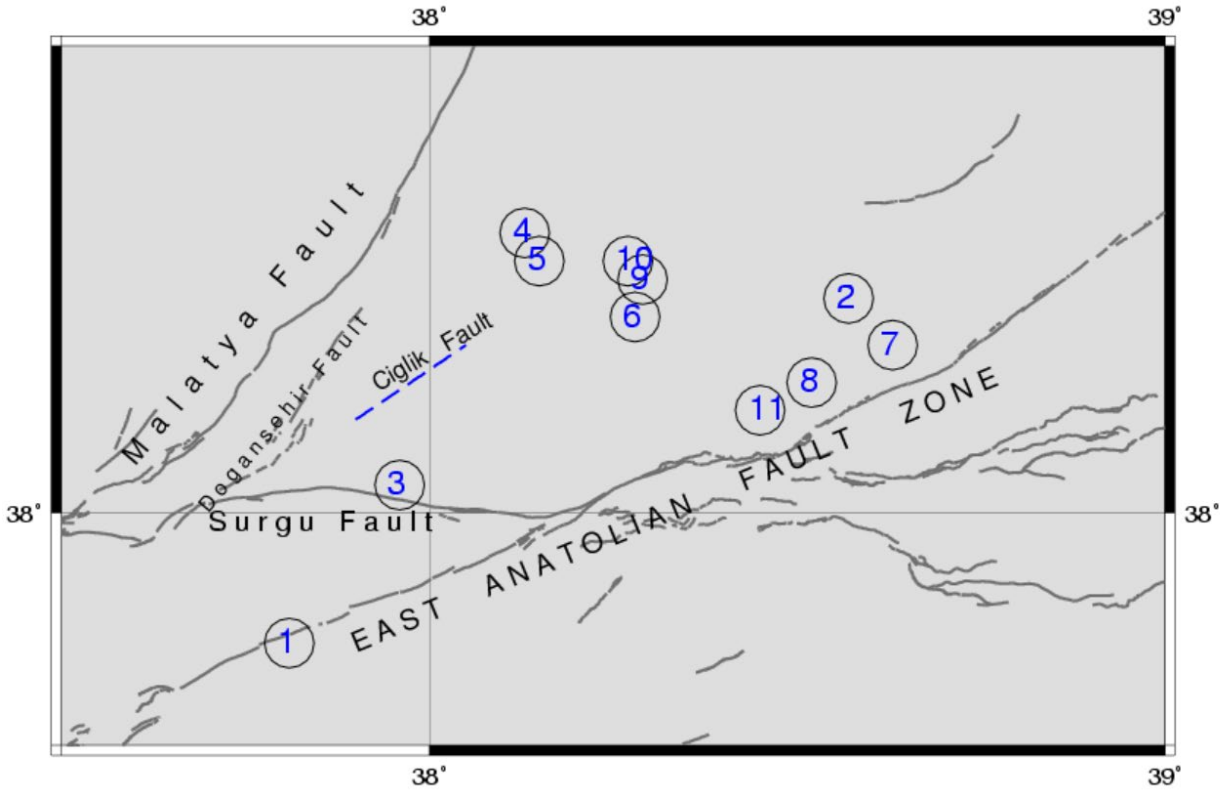


Figure 5. Locations of the aftershocks are in Table 3.

4. The Jan. 25, 2024, Event as an Aftershock of the February 6, 2023, Events

Almost a year has passed since the devastating major shocks. The January 25, 2024 event took place in the region where the fault rupture terminated on Feb. 6, 2023. That is to say, it is located on a fault segment ruptured by the major earthquakes. The ruptured fault segments and the Jan. 25 earthquake (green star) are shown in Figure 4 . Considering the location and the origin time since the major events, it could be a debatable subject to consider the Jan. 25 event as an aftershock or as an independent earthquake. There are several definitions used in classifying earthquakes as dependent (foreshock or aftershock) or as independent (mainshock). The most widely used one is the Gardner and Knopoff (1974).

Table 4. Aftershock identification windows (Gardner and Knopoff, 1974)

M	L(km)	T(days)
2.5	19.5	6
3.0	22.5	11.5
3.5	26	22
4.0	30	42
4.5	35	83
5.0	40	155
5.5	47	290
6.0	54	510
6.5	61	790
7.0	70	915
7.5	81	960
8.0	94.0	985

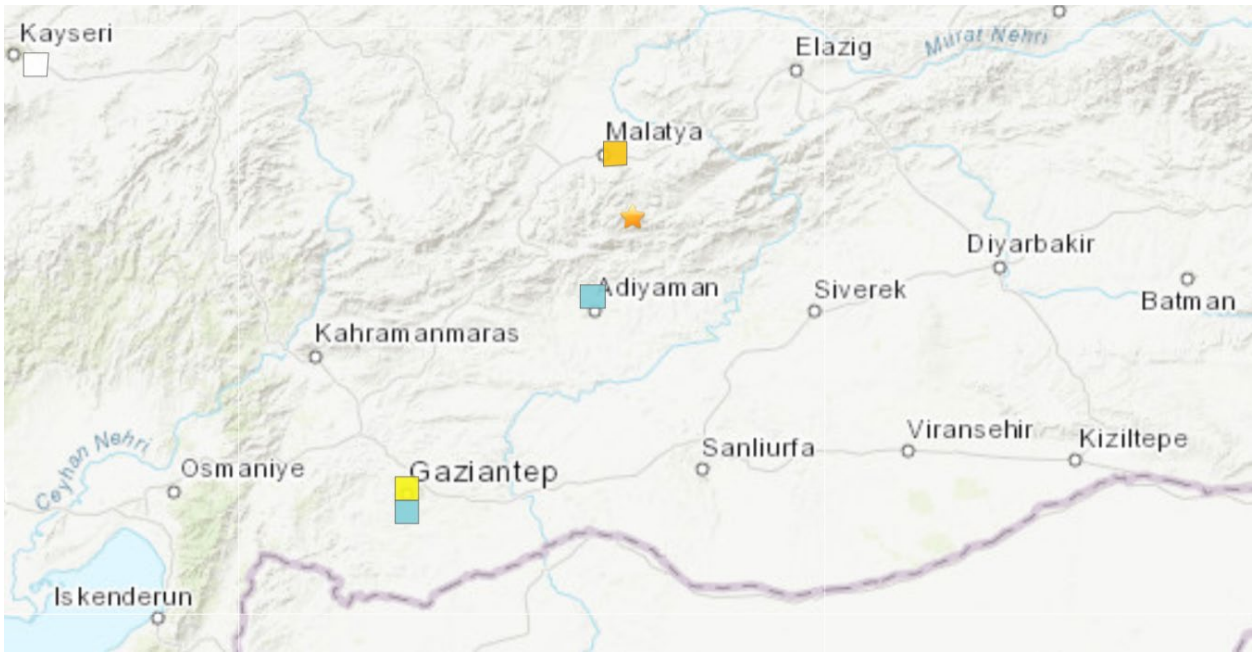
The space and time windows of Gardner and Knopoff (1974) used for characterizing the earthquakes as dependent and independent are given in Table 4. Considering the magnitude M7.8 of the mainshock, the distance from the ruptured fault plane, and the time since the mainshock then it is obvious that the January 25 event is an aftershock, as it is located in the proximity of the ruptured fault segment and the days passed since the mainshock is less than one year.

5. Seismic Intensities Associated with the Jan. 25, 2024 Event

Yet another interesting point that needs elaboration is the asymmetric distribution of the felt intensities reported by EMSC (Figure 6). Although there are just a few reports from the regions north of the source regions beyond 200km there are plenty of felt reports south of the source region within 600km circular area centered at the epicenter. The topography illustrated in Figure 6 could be a plausible explanation. The relation between the topography and the near-surface seismic velocities is a well-known fact. The higher the elevation the higher the seismic velocities (Wald and Allen, 2007). The lower seismic velocity regions are prone to stronger shaking.

Figure 6. Felts reports associated with January 25, 2024 earthquake

Similar results are observed in the USGS intensity map based on felt reports of the January 25 events. Although the distance from the epicenter to Malatya and Adıyaman locations are close to each other there is a remarkable difference between the two intensities (Figure 7).



SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 7. Felt reports and the corresponding intensity map results by USGS

6. References

USGS, United States Geological Survey, (last accessed on Jan. 25th, 2024)
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EMSC, European Mediterranean Seismological Centre, (last accessed on Jan. 25th, 2024)
https://www.emsc-csem.org/Earthquake_information/earthquake.php?id=1610815

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