Precursors of Pazarcik and Elbistan earthquakes 2023

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Abstract

The paper explains origin of Pazarcik-Elbistan earthquake 2023 and seeks for precursors which could be helpful for earthquake prediction. Detailed tectonic study and correct direction of plates movement by tides revealed that the extreme quick Earth's rotation speed, after last 60 years, triggered this earthquake. Group of 5 low magnitude earthquakes before Pazarcik-Elbistan 2023 and 2 before Elazig 2020 earthquakes can be used as indicator preceding large earthquake. Maximum Moon and Sun declinations and coincidence with Full Moon indicated large tidal torques responsible for earthquake triggering. Nevertheless, there is following consequence: maximum Moon declination, Full or New Moon and then earthquake. Similar consequence has low magnitude precursors, occurring 2 or 3 days after ±minimum time deviation from 86400 s day standard.

Introduction

To find origin of earthquake from area of Kahramanmaraş Province of 7.8 magnitude and huge devastating consequences, in site where for many decades no stronger earthquake has been found, is not an easy task. It is generally accepted that large earthquakes were created during Full or New Moon, but not all of them. It depends on it whether Moon tidal torque and Sun's tidal torques are summarized or subtracted. I recommend to reader to study Appendix where formulas indicate values of tidal torques dependent on Moon and Sun declinations and Earth's rotation, which creates bulging facilitating action of torques. Author in many papers (Ostřihanský 1991, 1997, 2015, 2022) indicated the action of tides on plate movement and earthquakes triggering. Similarly, as variations of the Earth's rotation are caused by tides, they can be used as indicators of plates movement and earthquakes origin. Earth's rotation variations can trigger earthquakes has been proven by Varga et al 2005, calculating Earth's rotational energy, sufficient to trigger earthquakes. Statistically, relation of Earth's rotation and earthquakes has been proven by Li and Chen 2020. Let us mention that in case of Io, tidal heating gains energy from deceleration of orbit. (Goldstein and Jacobs 1985). Causes of Earth rotation acceleration are not known (Zotov et al 2022)

Earth's rotation variations and earthquakes

The first precursor of Pazarck-Elbistan earthquake is the quickest Earth rotation in past 60 years, evident in LOD (length of day) graph, which activated seismicity on South Anatolian Fault. Figure 1 shows distribution of earthquakes in Kahramanmaras

Pprovince from 1962 to 2023 together with LOD variations, reflecting the speed of Earth's rotation. Decisive for Earth's rotation speed and consequent earthquakes triggering is the 0th standard of Earth rotation (marked by blue line), which separate less numerous (above) and more numerous (below) earthquakes occurrence. More numerous earthquakes are evident below minimum 2005-2007 and with the deepest minimum at the end of figure, where the largest earthquake M 7.8 Pazarcik is situated. This observation entitles to claim. that the Earth's speed influences earthquakes triggering.

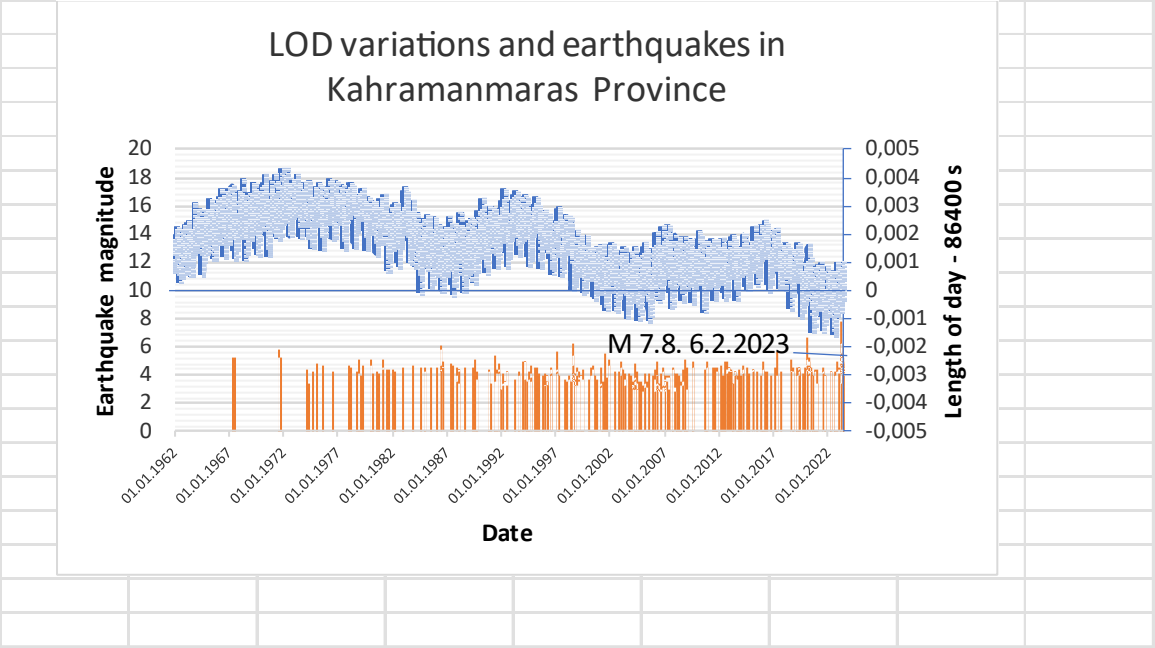

Figure 1. depicts all earthquakes in Kahramanmaras Province from 1962 to present. At the end of earthquakes record, the earthquake M 7.8 is marked but also earthquake M 6.7 24.1.2020 not signed by arrow, which marks the beginning of the shortest length of days.

Figure 2 presents detailed investigation. For earthquake prediction the shorter time before event is recommended and for this reason the figure presents the earthquakes occurrence from 1. 8. 2022 to 25. 5. 2023. Whereas earthquakes before December 2022 correlate with LOD minimums or maximums, reflecting actions of north-southward or west-eastward action of tidal forces, earthquakes since 20.10.2022 are triggered always shortly after minimum LOD variations (in one or two days later), marked on Figure 2 by red points. These points are the most important

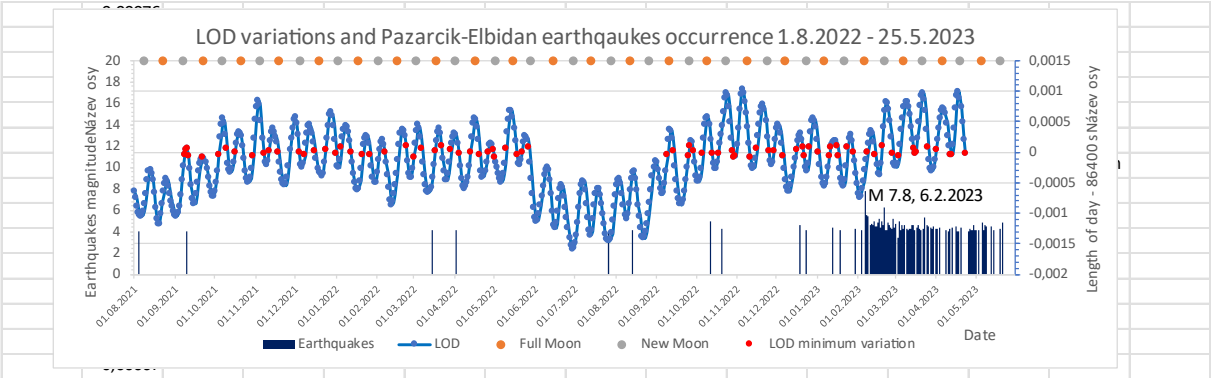

Fig. 2. Detailed figure of LOD variations showing earthquakes and M 7.8 and M 7.5 aftershocks. 5 precursors of these earthquakes, starting 18.12,2022, precede these earthquakes by ±minimums from 86400 s standard, marked by red points.

precursors for earthquakes triggering. Hardly can be imagined that length of day standard, derived from the mean solar day of a reference meridian, had any effect in earthquakes triggering in any deviation from this standard. As Fig 1 shows, length of days, equal to 86400 s standard of atomic clock, are from 2020 shorter (Bizouard 2023)

Tectonic consequences of increment of Earth rotation.

Figure 3 shows real plate movements of African plate with westward and important northward components and also westward movement of Eurasian plate.

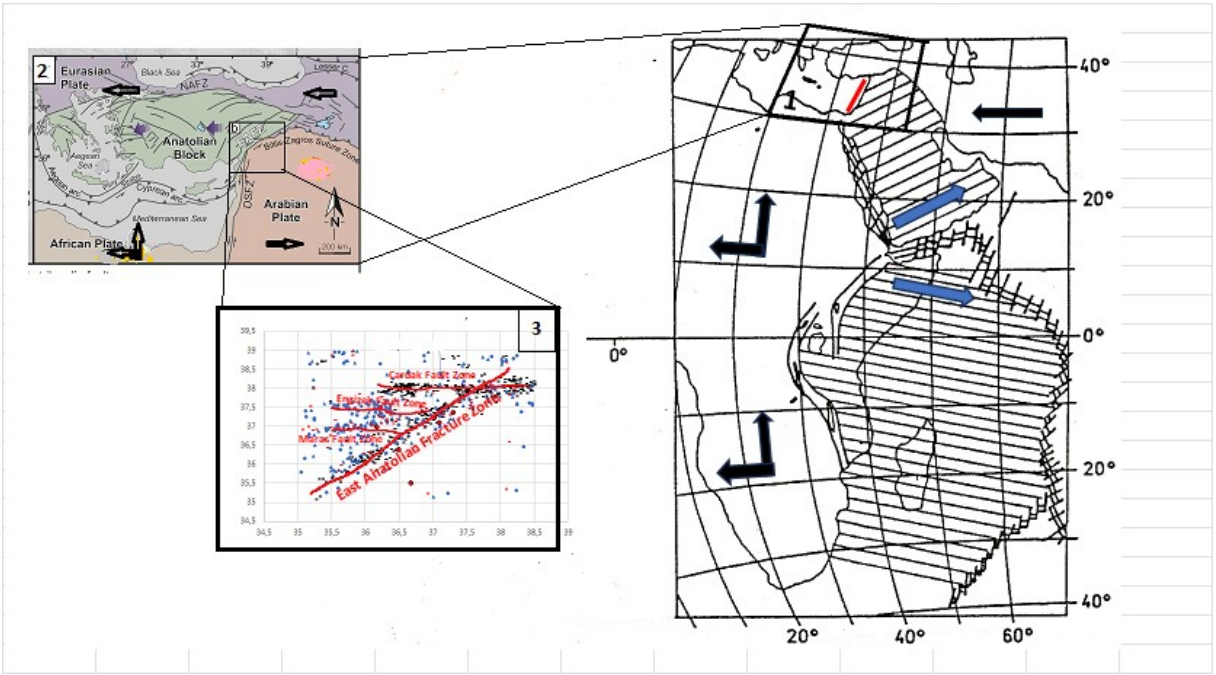

Figure 3. Insert 1 depicts, in two enlargements 2 and 3, tectonic faults in Kahramanmaras Province, comprising Red Sea-East African Rift Tripple Junction (Ostřihanský 2015), Anatolian and Arabic Blocks with plate movement modification of Emre et al 2018 (insert 2) and tectonic faults of Daman and Emre 2013 (insert 3). Blue arrows mark shift of hatched blocks eastward by Earth rotation increment. Red line marks South Anatolian Fault.

(Most authors consider this plate incorrectly as stable). Westward movement of Eurasian plate is confirmed by back arc basins on its eastern side and almost everyday earthquakes in Hindu Kush (Ostřihanský 2022). Similarly enormous earthquakes are triggered in Anatolian Block owing to balance of pressure from North Anatolian Fault and African Plate, whose subduction zones, namely Cyprus subduction, brake and decelerate northward movement of Anatolian plate (see inset 2 of Fig. 3. As Fig. 3 shows: rotating mantle drifts from African plate in Red Sea-East African Rift Triple Junction hatched areas and by rotation of Arabian Block the East Anatolian Fault is created (marked by red line on Fig. 3). Extreme Earth quick rotation drifted Arabian Block eastward and by its rotation under simultaneous westward drift of Eurasian plate on its northern part of Block, the large Pazarcik-Elbistan earthquake has been created

Next precursors of Kahramanmaras and Elazig earthquakes

Therefore, it is not possible to derive any effect of time standard of length of day equal to 86400 s on earthquakes triggering. Any possibilities of Earth's bound rotation are excluded. One solution remains: Fig. 2 shows that earthquakes are triggered either in LOD variation minimum, corresponding to positive or negative Moon's declination exerting maximum tidal torque (see Appendix) directing in north southward direction or in LOD maximum, under 0º declination directing westward. Earthquakes, as important large earthquakes precursors (marked in Fig. 2 by red points) are always outside maximum or minimum LOD variation. Solution is offered that such earthquakes are triggered under cumulative action of both north-south and westward acting tidal torques specifically for given tectonics. Fig. 2 shows 5 such earthquakes before main shock M 7.8, 6.2.2023.

Earthquakes M 7.8, 6.2.2023 Pazarcik and Elbistan.

The last precursor has been triggered 29.1.2023, M 4.2 after 28.1.2023 on LOD red point with -0.00000 s deviation from 86400 s standard. Then followed earthquake M 4.2, 2.2.2023 coinciding with LOD minimum and extremely high declination 27.4º. Full Moon has occurred 5.2.2023 with Moon's declination +21.6º and Sun's declination -15.9º. Corresponding tidal torques (see Appendix) are sufficient to trigger earthquakes, which has occurred 6.2.2023 at 01:17:34 UT. 9 hours later at 10:24:48, the M 7.5 at Elbistan, has occurred, not on South Anatolian Fault but on Cardak FZ (see Fig. 3, Insert 3), parallel with North Anatolian Fault. This is not aftershock of previous earthquake, but earthquake triggered not by rotation of Arabian Block, but earthquake triggered by westward tidal torque on Anatolian Block, which is a mediator between westward movement of Eurasian plate and African plate, being braked by firmly anchored subduction zones in Mediterranean Sea (see Insert 2 in Fig. 3). Fig. 4 shows positions of both earthquakes in Kahramanmaras Provinces with corresponding aftershocks and red points of precursor earthquakes.

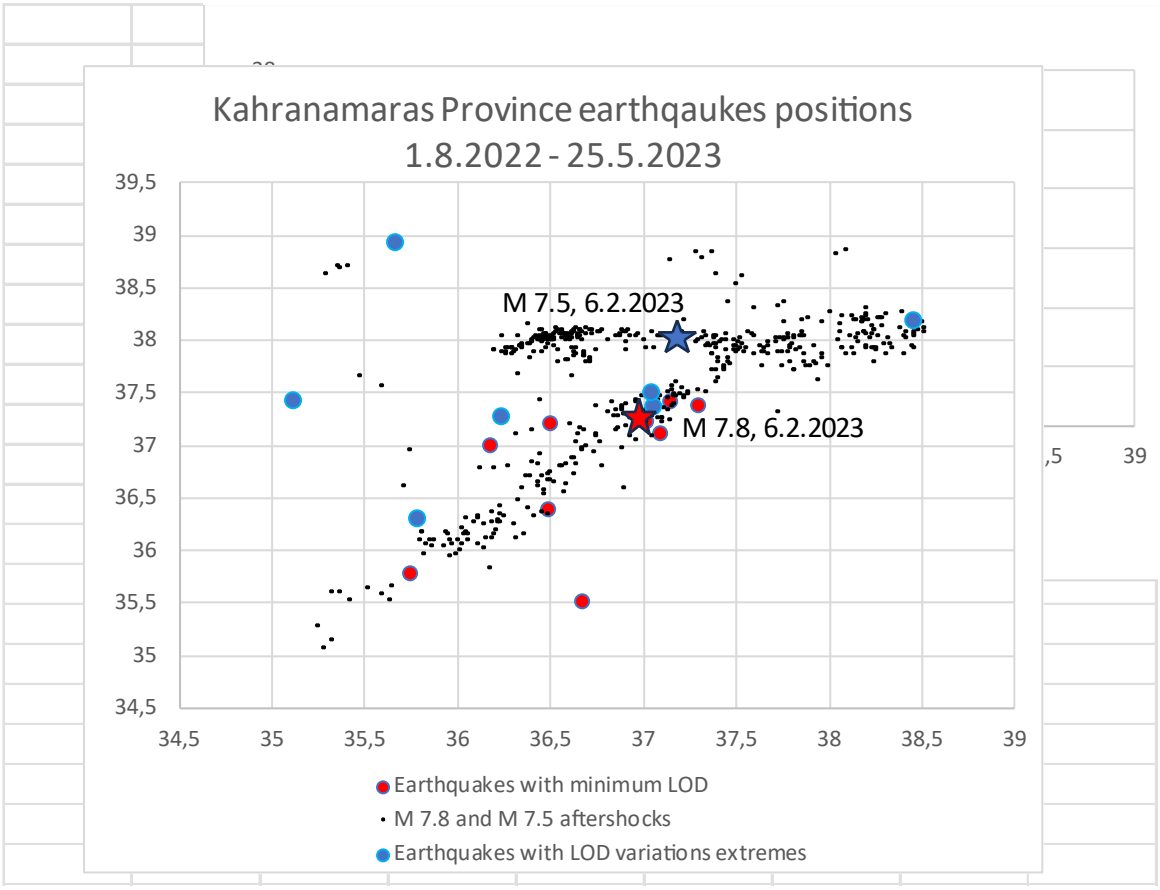

Figure 4. Positions of Earthquakes M 7.8 6.2.2023 Pazarcik and M 7.5 Elbistan with their aftershocks and precursor earthquakes marked by red points.

Figure 4 shows quite different earthquakes distribution on Arabian Block, right side of South Anatolian Fault and Anatolian Block, left side from it. Better distribution shows Fig. 5, compiled from all earthquakes occurring 1962-2023, the same as in Fig. 1. Minimum, earthquakes are evident on Arabian Blocks, which rotates and triggers earthquakes only on South Anatolian Fault, which shifts owing to rotation. Most of earthquakes are evident on Anatolian block, where next two faults are situated, parallel with North Anatolian Fault: the Engizek and Maras Fault Zones (see Fig. 3, Insert 3). These zones are even curved (not evident on Insert 3) what convinces rotation and shift of South Anatolian Fault. This confirms the contemporary action of both tides, the north-south and westward drift. No wander thar only 9 hours after M 7.8 Pazarcik on South Anatolian Fault, the earthquake M 7.5 Elazig on Cardak Fracture Zone were triggered.

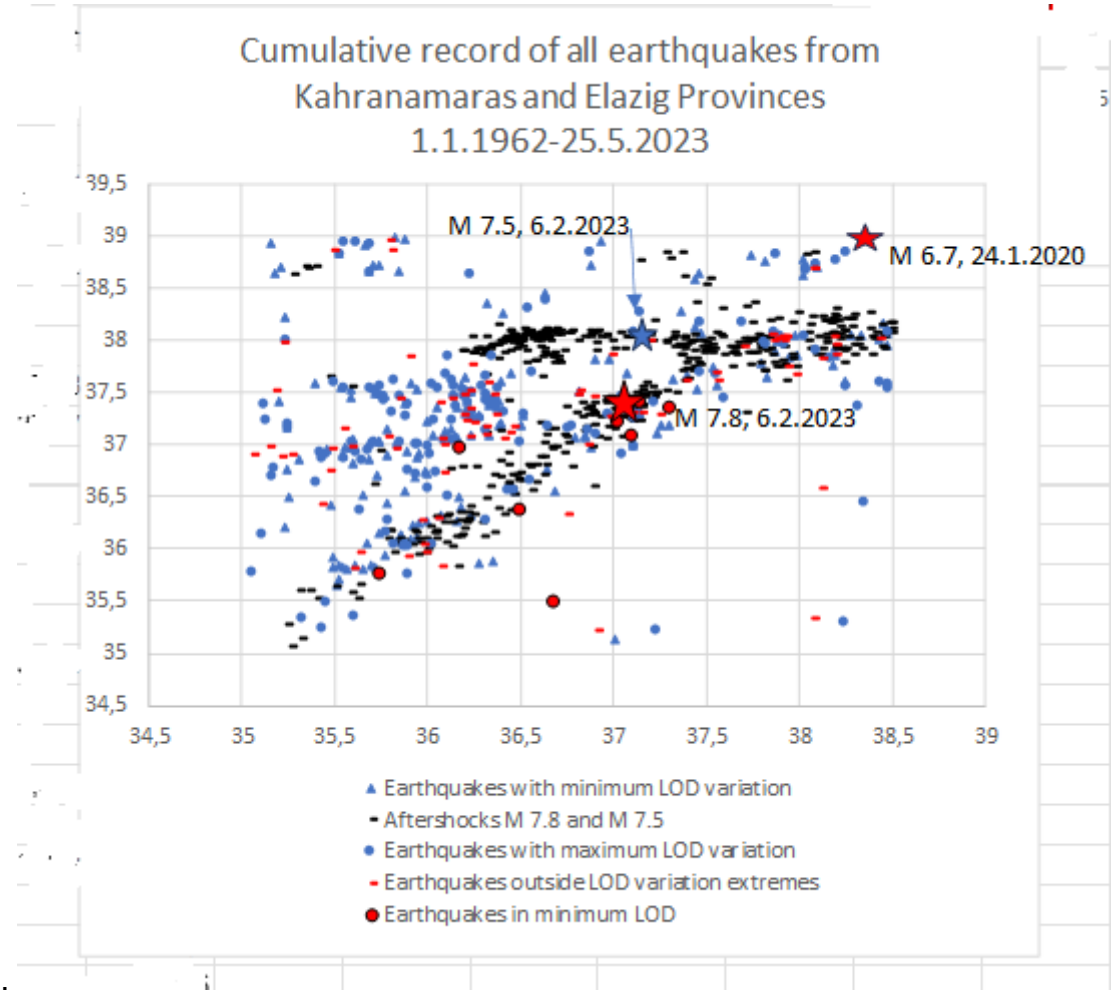

Figure 5. Distribution of all earthquakes from Kahramanmaras Province and earthquake M 6.7 24.1. 2020.from. Elazig Province.

Earthquake M 6.7 24.1.2020 Elazig.

This earthquake, mentioned as the last, could however be the first to inform about approaching catastrophe. This earthquake has occurred 24.1.2020 in Elazig Province, at the north end of South Anatolian Fault (see Fig. 5). The distribution of earthquakes depicts Fig. 6 and comparison with LOD graph Fig. 7, which shows only

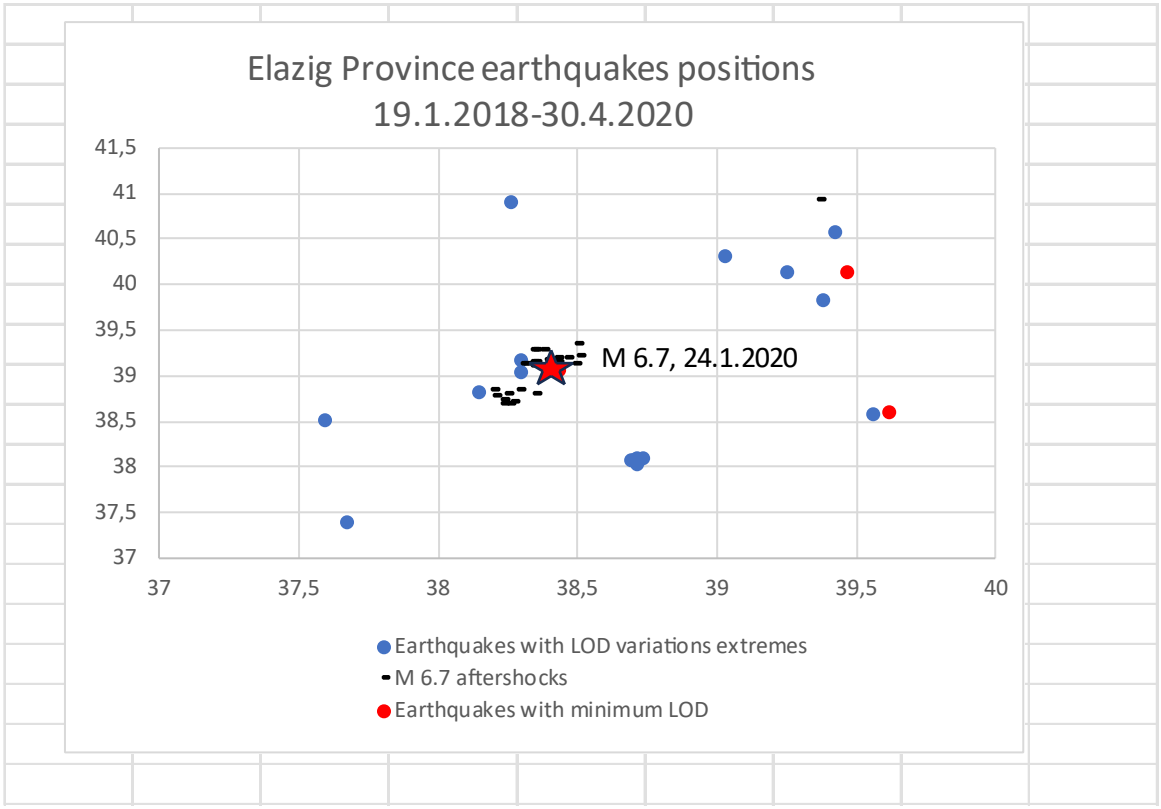

Figure 6. Positions of Earthquake M 6.7, 24.1.2020 Elazig with aftershocks and precursor earthquakes marked by red points.

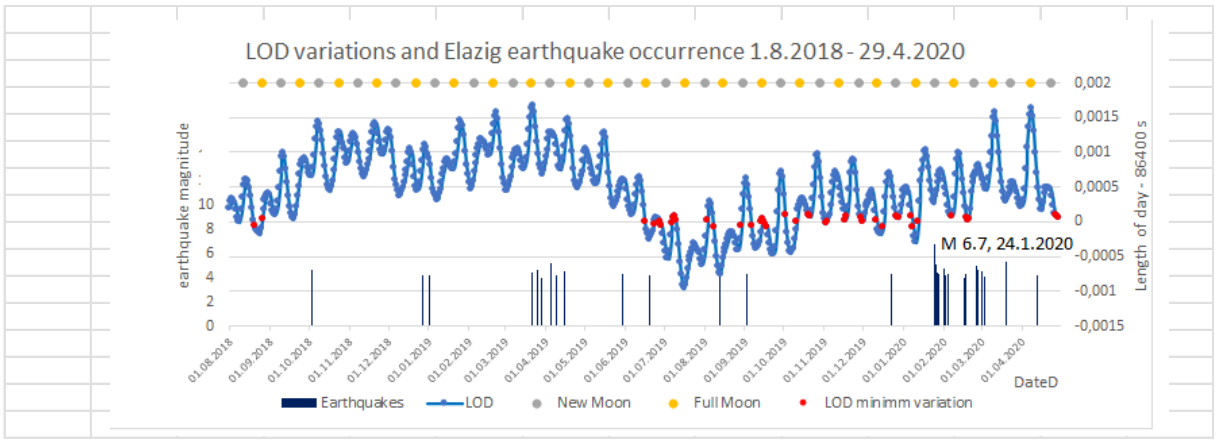

Fig. 7. LOD record and earthquakes from Elazig Province showing only 2 precursors before earthquake M 6.7, 24.1.2020 Elazig: 2.9.2019 and 22.12.2019, preceded by red points on LOD graph.

two precursors of earthquakes. Earthquake itself coincides with LOD minimum 24.1.2020 under Moon's declination -22.8º and Sun's declination -19.4º. The New Moon has occurred also in 24.1.2020 and because both declinations have the same signs, they are summarized in resulting torque capable to trigger earthquake (see Appendix). Nevertheless, the Moon's tidal torque is not so high as with Pazarcik and Elbistan earthquakes where Moon's declination has reached +27.4º. Similar high declination had 26.12.2004 the Great Sumatra earthquake during Full Moon +27.8º

Ostřihanský 2015, 2023) and since that time, just in 2023, the 18.61 years of lunar-nodal period have passed. So, the Pazarcik-Elbistan earthquake is also influenced by this period, but specifically, with maximum declination 4 days before Full Moon

Conclusion

The cause of devastating earthquake M 7.8 Pazarcik and Elbistan has been quick Earth rotation, which drifted Arabian Block and part of African Pate eastward, causing Arabian Block rotation under simultaneous westward drift of its northern part. It is evident that such Earth's accelerations have occurred in the past, as large earthquakes from Ancient and Medieval Ages convince (Karabacak et al 2023). Large number of earthquake one year before large earthquake at the end of January or beginning of February during Full or New Moon could be used for prediction. Nevertheless, no large earthquakes have occurred in 2021 and 2022, what requires detailed investigation. It is probable that owing to the Earth's deceleration, as probably increment of LOD record shows, no large earthquake will occur.

Appendix (Calculation of tidal forces)

Tidal forces acting on plates are following:
1. Forces, which try to align the Earth's flattening to the level of acting tidal forces, i.e. to the planes of Moon and Sun orbits.
2. Force, which brakes the Earth's rotation, i.e., the tidal friction.

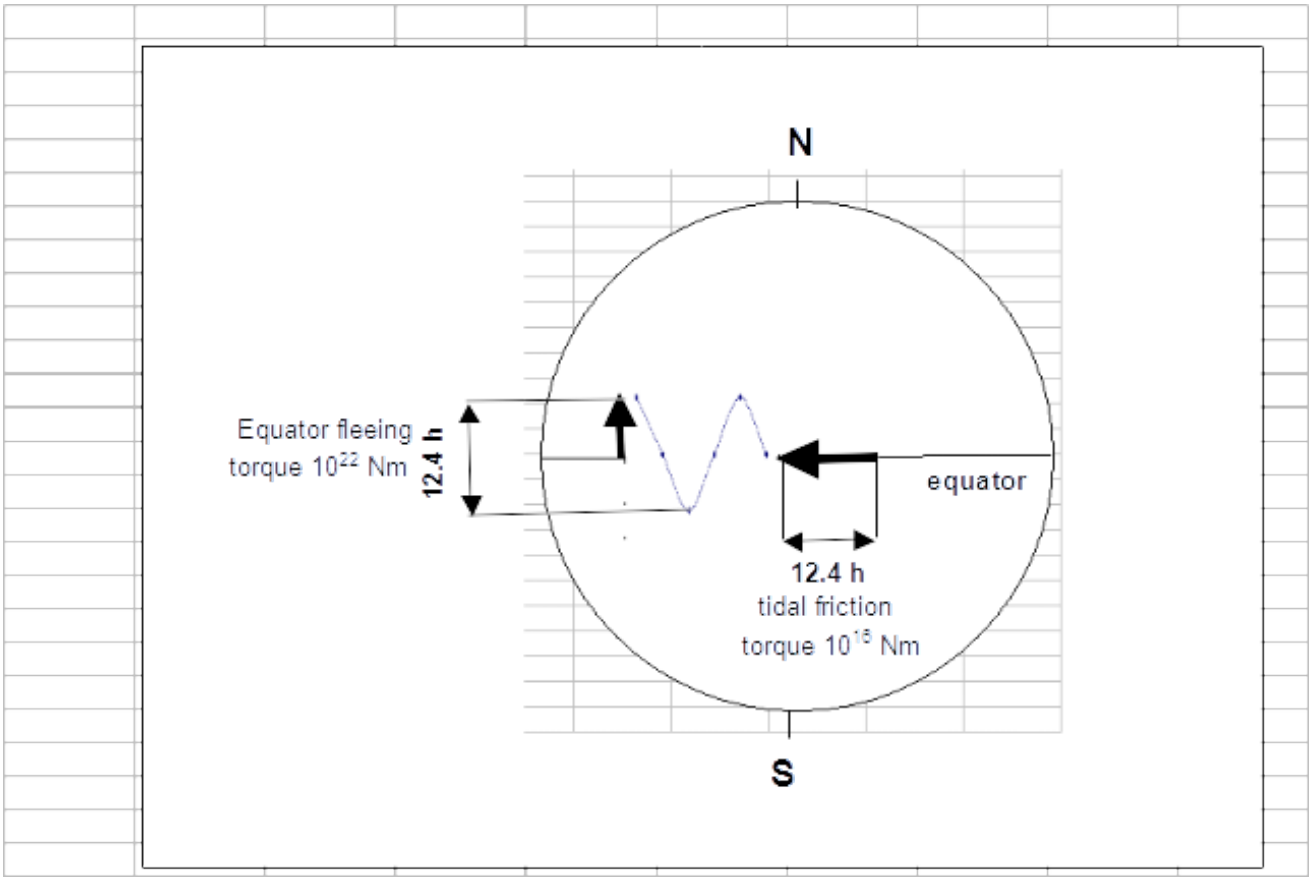

Figure A1 shows action of tidal forces on lithosphere

1. Figure A1 shows the action of the tidal force in their maximum value and their daily variation given by Earth's rotation. For better understanding in presented paper, the equator fleeing torque is called north-south tidal torque and tidal friction as the westward tidal torque. Arrow divided on half marks that force moves the plate only northward because southward force is damped directing against mid-ocean ridge. The torque acting on the plate can be calculated in following steps (Brož et al 2012):

Earth's angular velocity ω = 7.29 10^{-5} rad/sec, Earth's moment of inertia I = 8.036× 10^{37} kg m^2 (Stacey 2007). Earth's angular momentum L = I×ω = 5.89 ×10^{33} kg $m^2 s^{-1}$. Mass of the lithospheric bulge is

$$m_{bulge} = \frac{1}{2}\left(\frac{4}{3}\pi abc - \frac{4}{3}\pi c^3\right)\rho_{crust} ,$$

where we insert a = b = R_e ≈ 6378 km, c = R – 21 km, ρ_{crust} ≈ 2700 kg m^{-3} and we get m_{bulge} ≈ 9.6 ×10^{21} kg ≈ 1/624 m_e . (Earth's mass m_e = 5.97 x 10^{24} kg). The torque of force couple acting on the Earth is then: in case of the Sun (m_s, r_s Sun's mass and distance, G gravitational constant)

$$M_s = 2 \times \frac{2Gm_{bulge}m_s}{r_s^3} R_e \cos\varepsilon . R_e \sin\varepsilon , \qquad (1)$$

where ε = 23.45° is the obliquity of ecliptic to equator. This is valid only in case if the mass of bulge were concentrated in one point on equator and the Sun were just in highest point above equator. In reality we should integrate over the bulge because some its parts are closer to the axis of rotation and to center over the Earth's rotation because the instant angle of the Sun above equator varies. We would get:

$$\overline{M}_s = \frac{1}{4} M_s \approx 5.7 \times 10^{21} \text{ N m}$$

The same calculation is for the Moon:

$$M_m = 2 \times \frac{2Gm_{bulge}m_m}{r_m^3} R_e \cos\iota . R_e \sin\iota , \qquad (2)$$

where i is the Moon's declination (insert 23.45°). The result is $\overline{M}_m = \frac{1}{4} M_m \approx 1.2 \times 10^{22}$ N m. The torques simply summarize $\overline{M} = \overline{M}_s + \overline{M}_m = 1.8 \times 10^{22}$ N m.

This important result calculates that the torque 1.8×10^{22} N m is able to move the plate in north-south direction. The seismic moment of the Sumatra earthquake is 3.5×10^{22} N m (Varga and Denis 2010; Lay et al 2005; Stein and Okal, 2005). Because the torque exerted by tidal force acting on Earth's flattening represents the kinetic energy and also the seismic moment represents energy according to definition $M_0 = \mu AD$, where μ is the shear modulus N/m^2, D is displacement on area A, this quantity of N m dimension represents also energy, both quantities can be compared.

2. The torques of tidal friction were calculated by Burša (1987a), (1987b) on the basis of angular momentum balance in the Earth – Moon – Sun system.
$N_m = 4.2 \times 10^{35}$ kg m^2 cy^{-2} = 4.2×10^{16} kg m^2 s^{-2} = 4.2×10^{16} Nm

$N_s = 8.9 \times 10^{34}$ kg m^2 cy^{-2} = 8.9×10^{15} kg m^2 s^{-2} = 8.9×10^{15} Nm

The ratio of tidal torques of Moon and Sun therefore is
$N_m/N_s = 4.7$

According to Jeffreys this ratio is 4.9 (Jeffreys 1975). The Sun's share in tidal friction is only 21%.

The tidal fiction decelerates the Earth's rotation (Lambeck, 1977) and therefore it can be also considered as the force causing the westward movement of plates (Ostřihanský 2012a, 2012b). The torque exerted by the tidal friction is relative low 10^{16} N m. (Burša 1987a) and considering the mantle viscosity only 2 orders of magnitude lower than the lithosphere (Cathles 1975), this force is considered as insufficient for the plate movement. But considering variable force (ad 1), acting on Earth's flattening, and tidal friction (ad 2) acting semidiurnally, then the westward movement is possible, owing to the north-south varying force ad 1, acting on it perpendicularly.

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