On the Erroneous Correlation between Earthquakes and Eclipses

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Abstract. A long-lasting belief is that the gravitational stress by the moon would be responsible for earthquakes because of causing a tidal deformation of Earth’s crust. Even worse, earthquakes are sometimes said to be correlated with eclipses. We review the origin of this wrong statement and show that the idea is owed to a fallacious perception of coincidence. In ancient times the two catastrophes were linked interpreting the announcement of Doomsday, while in modern times a quasi-scientific essay disseminated such an interrelation shortly before the theory of tectonics.

Keywords: Eclipses, Earthquakes, Tides, Tectonics, Moon.

1 Introduction

Eclipses of the sun and moon come about as an interplay of light and shadow. Nevertheless, one stumbles upon some neo-scientific views in books and internet that there would exist a relation between this optical phenomenon and earthquakes. The argument is based on the position of the moon in space: at the syzygy, which is the only time for an eclipse to occur, the tidal forces on the earth’s crust are strongest, and, therefore, tensions discharge in a quake. Our attempt is to trace down the origin of this idea. We briefly clarify the geophysical effects accountable for earthquakes at next section, then we elucidate the historical roots of the statement that eclipses and quakes would happen concurrently. Finally, we give an explanation why this non-existent relation is still believed in.

2 Tides and Tectonics

The earth is considered a rigid body, but it is also exposed to drag forces that make it deform like a plastic body. The physical deformation is caused by both sun and moon exerting a stronger force on the facing side than on the averted side. In principle, the tensions on the thin crust could trigger an earthquake. However, one should distinguish two processes: tectonics and tides.

Tectonic activity is the primary impetus for land- and sequeakes. The continental shelves float on the viscous upper mantle and are driven by subjacent convection streams. They change their position on timescales of millions of years. The plates collide and get stuck, while moving past each other, and they are subject to a bent, compression, and stretching. At the contact boundaries tensions build up. Once the local tensions get too high, they discharge in a sudden rupture releasing large amounts of energy. The basics of this theory were elaborated in the late 19th century and promoted by Alfred Wegener in 1912 [16].

A completely different effect is the tidal force from celestial objects. The moon generates gravitational tides on the earth’s surface creating two tidal bulges. It pulls the terrestrial water masses from the fringes to its facing side, while on the far side the centrifugal force due to Earth’s rotation becomes preponderant. The range of the tidal uplift is between 50 to 100 cm for the open ocean. The effect applies to the crust as well. For example, Central Europe elevates and sinks by some 45 to 50 cm [10].

The sun exerts principally the same force on the earth, but its share is smaller, amounting for ≈40% of the total force. At new or full moon, the forces of the sun and moon reinforce each other, and the deformation unfolds stronger than at the quadratures. Actually, the earth is in a state of constant seismic tremor, but we take only cognisance of the more violent incidents. Small distortions could eventually induce a crack, and the subsequent wave lets the continental plate carry out a re-adjustment: the earth endures a quake. One might think that the phase of the moon has an effect on that, which would also be reflected in the occasion of eclipses.

3 Historical Background

The first one to mention the coincidence of an eclipse with an earthquake was the Greek historian Thucydides in the 4th century BCE. He was primarily concerned with the Peloponnesian War between Athens and Sparta, but he incidentally told that there were ten days between the solar eclipse of 21 March 424 BCE, that was seen partial in Athens (mag = 0.705), and an earthquake. It is not quite clear whether the historian wished to insinuate a connection between the two phenomena [1].

The naturalist Aristotle discussed in his book Meteorologica the reasons for earthquakes a century later. He refuted three hypotheses of forerunners circulating at his time and alluded to a lunar eclipse stating that both phenomena would coincide sometimes [11]. His own concept rested on winds produced by “exhalations” in the earth’s interior. The
The total solar eclipse of 29 CE was accompanied by an earthquake in temporal proximity [4].

Explanation reads somewhat muddled incorporating “missing heat drift” from the moon during the time of the eclipse. From our present-day view Aristotle’s idea is wrong, either.

The next scholar was Phlegon of Tralleis, a chronicler of the early 2nd century CE living in Asia Minor. He covered various aspects of the Roman history in his book Olympiades that closes with 137 CE. There, he took up an issue among the early Christians. Phlegon wrote [6]:

In the fourth year of the 202nd Olympiad (32–33 CE) an eclipse of the Sun took place greater than any previously known, and night came on at the sixth hour of the day, so that stars actually appeared in the sky; and a great earthquake took place in Bithynia and overthrew the greater part of Nicaea.

Because of a scribal error the message must read: first year of that Olympiad. The eclipse refers to 24 November 29 CE, and it was widely seen in the Near East (Figure 1). His link to the earthquake emerges pivotal, as it slipped into the biblical account of Crucifixion. In fact, there was no eclipse on the day of Crucifixion visible from Palestine, even less an eclipse of the sun.

A widespread 6.3 magnitude earthquake has been confirmed to have taken place on the western shore of the Dead Sea in Palestine at any time between 26–36 CE, as varved sediments indicate [17]. The magnitude was probably sufficient energetic to cause local deformations in the sediment layers but not energetic enough to enter a widespread historical record. This event does not need to be the same as in Bithynia off the coast of the Black Sea reported by Phlegon. Both the eclipse and the earthquake were “borrowed” by the authors of that biblical chapter making the two phenomena a type of allegory to enhance the fate send out by God. After having entered the Bible, eclipses and quakes coalesced and were consolidated as portents. Similar accounts refer to the years 968 and 1133 CE [12].

Apart from the Euro-Asian peoples, a completely different culture has also drawn a connection between earthquakes and eclipses: the Aztecs. They exhibited great fear from tremors from below. There is the legend of “Five Suns” which is conveyed in a dozen sources and probably depicted on the famous calendar stone. It is interpreted as the creation myth of various peoples of central Mexico before the Conquest. The tenet comprises that there have been four worlds (or “suns” or “eras”) before our present sun. The previous ones were destroyed by actions of deity figures: a knock-out, hurricane, fire, and an immense flood [14]. Living under the fifth sun now, it will also perish some day. This destruction will be brought about by earthquakes. The Aztecs were convinced that the sun is under permanent threat and condemned to a cosmic catastrophe. Humankind could put off this evil day by keeping it supplied with sacrifices. Thus, an extinguishing sun, like in the case of an ongoing eclipse, was always feared as the end of the world. We gleaned in our study of eclipses a good number of years in the Aztec chronicles harbouring both an eclipse and earthquake [13]. Unfortunately, it is difficult to extract how the two effects are enmeshed in the mind-set of the natives, because many original documents were destroyed by the Conquistadores. Notwithstanding such myths, it might turn out that the geographical location in Central America is predestined to fear earthquakes, while the sudden loss of daylight has always been a reason for panic in every culture worldwide.

Finally, some sort of “scientific” basis was laid in the 19th century by a populariser of natural history, Rudolf Falb (1838–1903). He developed a concept of extraterrestrial influences on geophysical phenomena mingling floods, earthquakes, meteorology, and astronomy. In a once successful family magazine he enumerated some examples of synchronised occurrences [5]. There he linked up with a thesis of a seismologist, Alexis Perrey (1807–1882), who pioneered this field of geophysical research. The latter suspected a correlation between earthquakes and the position of the moon. At that time the theory of continental tectonics was not born still. In absence of knowledge of a potential terrestrial origin, it was only natural to look for a cause in the tidal stresses from outside. Falb, however, expanded Perrey’s views into the idea of predicting earthquakes by the aid of eclipses. The academic community vehemently rejected such assignments straight away. Nevertheless, Falb attained considerable popularity through apparently correct “predictions” of some few events.

4 Modern Reanalysis

One of the first who criticised the catenation of the two phenomena was the astronomer Friedrich Karl Ginzel (1850–1926). He analysed the seismological data from Califor-
nia, one of the most active regions on Earth [7]. He found that there were 153 eclipses (solar and lunar) between 1850 and 1888, and examined the positions of the moon with regard to perigee, apogee, and the lateral distance to the Earth’s equator, i.e. its declination. (Remember that the cycle of perigee/apogee, the anomalistic month, is not related to lunar phases.) Ginzel arrived at the conclusion that all tremors were statistically at random. They did not show any relation to the position of the moon, not even at the syzygies. But the most serious critique concerned the manner how Falb obtained his result: he only quoted examples supporting his theory without paying attention to the total quantity.

Even today many studies reveal unsteady despite technological advances. An unnamed survey, appearing credible though, is presented in Figure 2. It is based on a collection of earthquakes with magnitudes >7.0 of the Richter Scale between 1990 and 2005 [2]. The magnitudes are plotted against the angle Sun–Earth–Moon. If the alleged correlation would be correct, then the most severe events should occur at lunation phases near 0° (vertical line) or 180°, when the forces of the sun and moon sum up. But the data do not exhibit that. They show even the contrary: there was a quake here and there, but the quantity of events turned out less than at other lunar phases. When including weaker events, the distribution becomes even more arbitrary.

Two recent studies yield contradicting results. Satoshi Ide et al. state that for more than 10,000 earthquakes at approximate magnitude 5.5 the incident began during the time of high tidal stress and was more likely to grow to magnitude 8 or higher [9]. The authors refer to Sumatra in 2004, Chile in 2010, and Japan in 2011. On the other side, Susan Hough looked at both the date of the year and the lunar phase for 204 large earthquakes [8]. To avoid “clusters” of incidents within the data that might be aftershocks of a previous one, she chose to compare the dates as far back as 1600 CE. Her analysis did unveil some clustering, but on randomising the data there was no statistical significance: no correlation between earthquakes and tides.

The literature on this issue seems non-exhaustive. An overview of studies until the 1990s was undertaken by Dieter Emter [3]. He found almost a direct split between researchers who find such a connection, and those who do not. Sometimes the outcome depends on the method of investigation. Applying statistics to the datasets can actually cause all sorts of headaches that have more to do with mathematical treatment than science. Many re-analyses prove not representative, again. Surprisingly, a multitude of published diagrams on the internet come from astrologers and doom prognosticators. Days without a quake are actually very rare. It is estimated that around 500,000 earthquakes with a magnitude larger than 2.0 occur each year, detectable with current instrumentation [15]. About 100,000 of these are strong enough to be felt, and 100 cause damage. So, someone could choose almost any calendric date and his “prophecy” will be right.

Predictions of earthquakes are still not possible today. In particular, a reproducible prediction cannot be made for a specific day or month. All attempts are no more than a random guess. Researchers can only give a probability for an interval of time.

The gravitational attraction of the moon is rather small on terrestrial rocks, and the correlation between earthquakes and tides remains unproven. Such arguments will hold for the Galilean satellites of Jupiter and Enceladus of Saturn, but not for the Earth. Aside from tides, the hy-
hypothesis about a correlation of eclipses and earthquakes persists to this day. If the position of our moon should ever turn out significant, then the connection with an eclipse would be irrelevant, meaning: the earthquake will happen without the obscuration of celestial bodies.

5 Conclusions

We tried to reproduce the statement of an interrelation between earthquakes and eclipses. We believe that the answer goes back to rather quasi-religious illusions than to hard facts.

In old times, eclipses were considered as dreadful events. When the most important luminary in the sky suddenly failed to shine, dramatic turmoils were going on and a whole society became upset [12]. The scene of unexpected darkness remained in memory for many years. An earthquake, however, costs many people their lives and destroyed entire villages. If both calamities were to take place in temporal proximity, the tragedy was associated with a “punishment announced by the gods”. The fate from celestial prophecies became manifested hereinafter. For astrologers this was a welcome sign of validation of their doctrine. They cling more than ever to the putative connection. The scribes would transmit that with some decoration to raise the effect or to make their account more important.

Thus, many reports on the proximity of both disasters pile up because of psychological selection effects than reality. Sooner or later there will be another earthquake close to an eclipse, and the self-proclaimed prophets will have their joy.

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