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Mid-8th Century CE Seismic Sequences Along the Dead Sea Transform

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Abstract

A comprehensive examination of textual, archaeoseismic, paleoseismic, tsunamogenic, and paleo-landslide evidence was used to characterize and construct a timeline for a series of earthquakes which struck the vicinity of the Dead Sea Transform in the middle of the 8th century CE. Particular attention was paid to nearly coincidental dates reported in Byzantine, Coptic and Judaic sources along with the time of day reported in three different textual accounts: Pseudo-Dionysius of Tell-Mahre, an apparently local and contemporaneous source, along with Severus Ibn al-Muqaffa' and Mujir al-Din both of whom sourced earlier accounts which were written in the first person and purport to reproduce eye-witness testimony. The timeline, supported by archaeoseismic evidence in Bet She'an and Pella, suggests that the Sabbatical Year Earthquakes likely struck within 17 hours of each other, the first one at night and the next one the following morning, between the Julian calendar dates of 16 and 19 January in 749 CE rather than being separated by 3 years. Insight from historical scholarship was used in conjunction with other observations to propose reasons why the disparate earthquake accounts present seemingly incompatible reports of earthquake timing. While the conclusions of this article provide a hypothetical rather than a definitive solution to the Sabbatical Year Earthquakes conundrum, it does appear that some sort of seismic unzipping[1] occurred within a short amount of time and a number of destructive earthquakes, perhaps as many as six, impacted the Dead Sea Transform in the middle of the 8th century CE leading to widespread devastation from South to North and points in between.

Keywords: Historical Earthquakes; The Sabbatical Year Earthquakes; The By No Means Mild Earthquake; Dead Sea Transform; Seismicity, Al Aqsa Mosque

1. Introduction

In the middle of the 8th century CE, a series of earthquakes struck the Levant causing widespread devastation. Contradictory reports from a host of different sources using a host of different calendars have produced a seemingly impenetrable conundrum if one wishes to determine the exact dates when the earthquakes struck. The most well

1 The Dead Sea Transform occasionally experiences ruptures in sequence along its length, where segments suffer earthquakes in response to activity in other segments – e.g. the unzipping from north to south between 1114 and 1212 CE [Ambraseys, 2004].

documented earthquakes form a couplet known as the Sabbatical Year Earthquakes[2]. One or both of these two earthquakes have been variously dated to 746 [Ambraseys, 2009:230-238], 747 [Schreiner, 1979], 748 [Russell, 1985], and 749 [Tsafrir and Foerster, 1992] and have been widely thought to have struck about 3 years apart. This article makes the case that they likely struck within 17 hours of each other in January of 749 CE and were accompanied by several other earthquakes which may represent a seismic unzipping of the Dead Sea Transform that unfolded over up to half a century.

Mid-8th century CE earthquakes will initially be discussed in the order listed below.

- By No Means Mild Earthquake(s) – March 756 CE
- The Sabbatical Year Earthquakes – January 749 CE
- Two 8th century CE earthquakes identified in a paleoseismic trench in the southern Araba.
- The two earthquakes that damaged Al Aqsa Mosque; the first of which was one of the Sabbatical Year Earthquakes.

Notes

- Attenuation in the main article and the Supplemental Appendices is calculated using the transform of Hough and Avni [2009].

Abbreviations

A.M.$_a$ – Alexandrian version of the Anno Mundi Calendar used by some of the Byzantine Authors.
A.G. – Anno Graecorum – Seleucid Era Calendar used by some of the Syriac Authors.
A.H. – Anno Hegirae – Islamic Calendar used by the Muslim Authors and two of the Syriac Writers.

2. The By No Means Mild Earthquake(s) (March 756 CE)

This earthquake gets its name because in some translations of Theophanes[3], he describes it as an earthquake that was "by no means mild". Pseudo-Dionysius of Tell-Mahre[4], who appears to be a local and contemporaneous source [Harrak, 1999], describes the earthquake but provides more details than Theophanes – stating that three villages on the north Mesopotamian Khabur River collapsed and many other places in Jazira (Northern Mesopotamia) were destroyed [Harrak, 1999:197]. Theophanes merely specifies that the earthquake struck Syria and Palestine [Mango et al., 1997:594]. The geographic spread of these accounts may suggest a seismic sequence rather than one powerful earthquake.

The earthquake struck in March 756 CE. Although calendric inconsistencies in Theophanes' report indicate it could have struck in the years 756, 757, 758, or, less likely, 759 CE, Halley's comet appeared in 760 CE and was described by Pseudo-Dionysius of Tell-Mahre and Theophanes 4 years after their earthquake accounts – thus fixing the date of this earthquake to 756 CE (see Appendix A for details). There is a slight disagreement between Pseudo-Dionysius and Theophanes on the exact day of the earthquake. Pseudo-Dionysius says it struck on the 3rd of March while Theophanes says it struck on the 9th. Pseudo-Dionysius also says that it struck on a Tuesday in the middle of the night. An uncited Arabic source in Le Strange (1905:130-131) and Kemal al-Din (aka Ibn al-Adim) as cited by Blochet (1895: 46 n. 3) speak of an earthquake which struck Al-Massisah (Mopsuestia) in A.H. 139 (5 June 756 to 24 May 757 CE) or A.H. 140 (25 May 757 to 13 May 758 CE). The earthquake reports from Al-Massisah

2 Although older literature may list a single Sabbatical Year earthquake, the author accepts the conclusions of Karcz [2004] and Ambraseys [2005, 2009] that there was more than one earthquake for the reasons stated therein.

3 Theophanes wrote "The Chronicle" in the vicinity of Constantinople in Greek between 810 and 814 CE as a continuation of his colleague George Syncellos' Chronicle. Syncellos may have lived in Palestine for a number of years before moving to Constantinople. [Mango et al., 1997]

4 Not to be confused with Dionysius of Tell-Mahre whose work is largely lost but was a source for later Syriac Chroniclers such as Michael the Syrian [Hoyland, 2011: Figure 1, Brock, 1976:21] and Chronicon Ad Annum 1234 [Hoyland, 2011: Figure 1, Brock, 1976:22]. Pseudo-Dionysius gained his cognomen because his Chronicle was confused as being the largely lost Chronicle of the real Dionysius of Tell-Mahre. For example, Chabot's 1895 translation into French mistakenly titled the work as Annals by Denys of Tell-Mahre – Denys being a French version for Dionysius – when it was in fact Annals by Pseudo Dionysius of Tell-Mahre – a work that is sometimes less confusingly titled the Chronicle of Zuqnin. The identity of Pseudo-Dionysius is a mystery. Some have suggested he was Joshua the Stylite. Whoever he was, he lived and wrote at the Monastery of Zuqnin [Harrak, 1997] in what is now SE Turkey. It should also be noted that there appears to be some confusion in at least some of Ambraseys' publications regarding Pseudo Dionysius vs. Dionysius possibly because he did not fully understand the distinction between the two and that the real Dionysius of Tell-Mahre's work is largely lost. No such confusion exists in the catalog of Guidoboni et al. [1994].

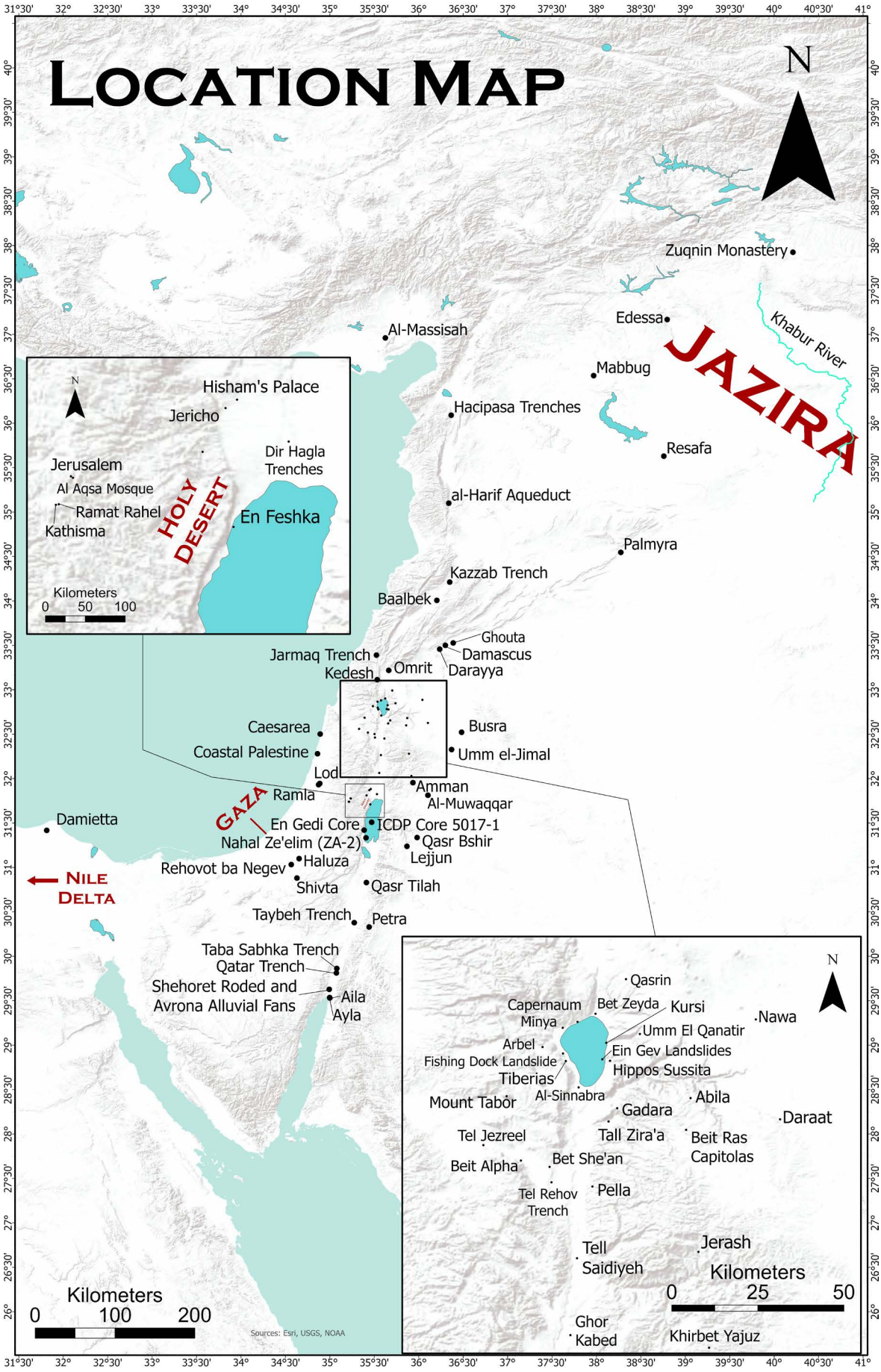
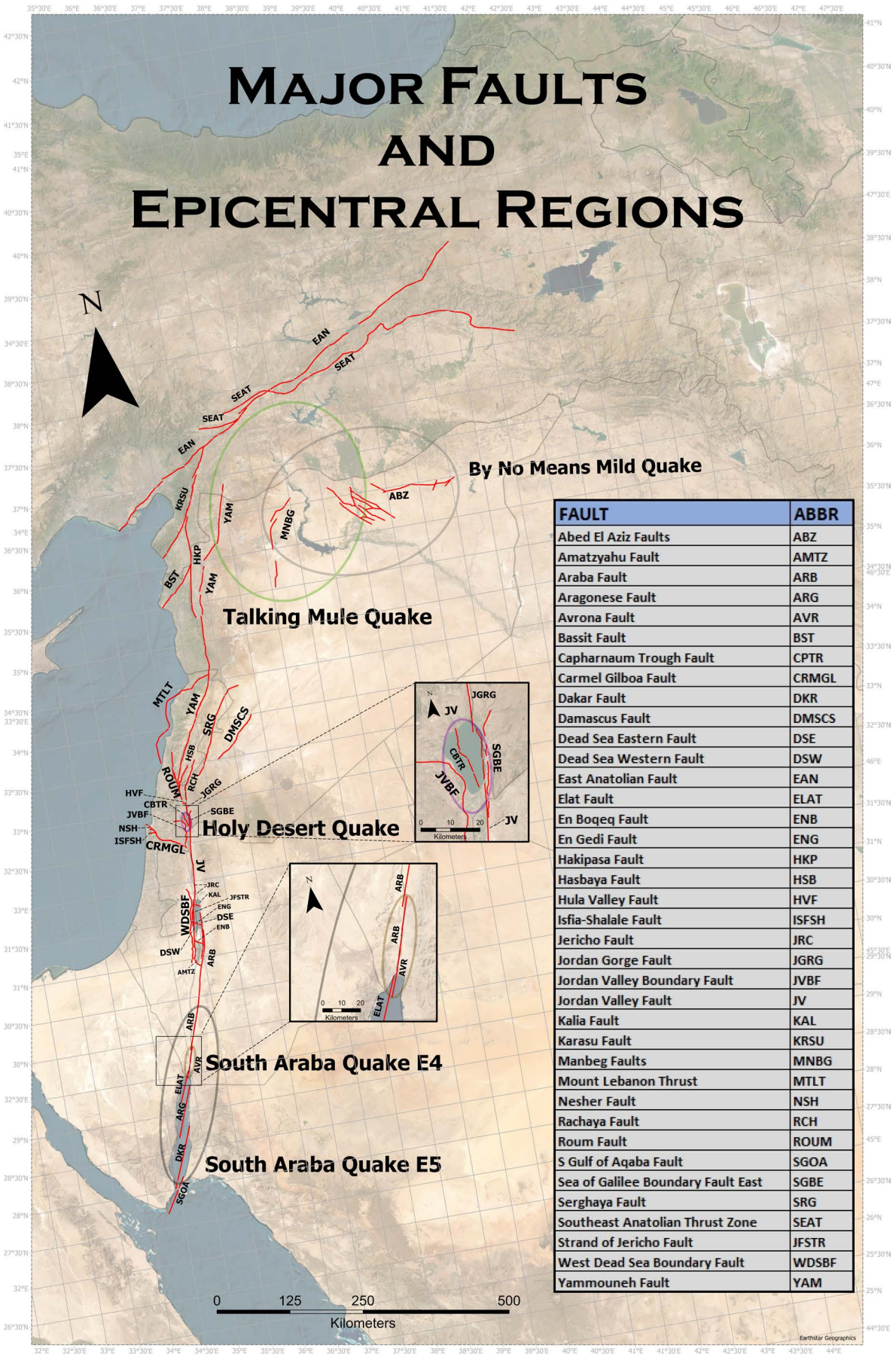


Figure 1a. Location Map.



FAULT	ABBR
Abed El Aziz Faults	ABZ
Amatzyahu Fault	AMTZ
Araba Fault	ARB
Aragonese Fault	ARG
Avrona Fault	AVR
Bassit Fault	BST
Capharnaum Trough Fault	CPTR
Carmel Gilboa Fault	CRMGL
Dakar Fault	DKR
Damascus Fault	DMSCS
Dead Sea Eastern Fault	DSE
Dead Sea Western Fault	DSW
East Anatolian Fault	EAN
Elat Fault	ELAT
En Boqeq Fault	ENB
En Gedi Fault	ENG
Hakipasa Fault	HKP
Hasbaya Fault	HSB
Hula Valley Fault	HVF
Isfia-Shalale Fault	ISFSH
Jericho Fault	JRC
Jordan Gorge Fault	JGRG
Jordan Valley Boundary Fault	JVBF
Jordan Valley Fault	JV
Kalia Fault	KAL
Karasu Fault	KRSU
Manbeg Faults	MNBG
Mount Lebanon Thrust	MTLT
Nesher Fault	NSH
Rachaya Fault	RCH
Roum Fault	ROUM
S Gulf of Aqaba Fault	SGOA
Sea of Galilee Boundary Fault East	SGBE
Serghaya Fault	SRG
Southeast Anatolian Thrust Zone	SEAT
Strand of Jericho Fault	JFSTR
West Dead Sea Boundary Fault	WDSBF
Yammouneh Fault	YAM

Figure 1b. Fault segments and hypothetical epicentral regions. The size of the epicentral regions in this preliminary map are a product of uncertainty rather than Magnitude. Sources of fault segments can be found in Appendix C.

(Mopsuestia) could be misdated and therefore identical to the earthquake described by Pseudo-Dionysius and they could reflect reports of a sizeable aftershock[5].

3. The Sabbatical Year Earthquakes (January 749 CE)

3.1 Introduction

The Sabbatical Year earthquakes are described by a wide array of authors of which only one (Pseudo-Dionysius of Tell Mahre) appears to be local and contemporaneous[6]. One or more earthquakes are recounted in Byzantine Greek, Byzantine Latin, Christian Syriac, Christian Arabic, Coptic Arabic, Jewish, Samaritan, Armenian, and Muslim Arabic sources. Textual transmission led to an amalgamation of events along with chronological inconsistencies. The accounts are not all in agreement particularly when it comes to defining the year the earthquakes occurred. However, attention to dates and the time of day[7] that the earthquakes struck along with some precise archaeoseismic data from Bet She'an allows one to reconstruct a timeline that reconciles a number of chronological inconsistencies.

3.2 Egyptian Sources describe a massive nighttime earthquake that could not have been due to a single fault break

The Coptic Egyptian source Severus Ibn al-Muqaffa' described an earthquake on the night of the 21st of *Tuba*[8] (16 January 749 CE[9]) which "happened all over the East – from the city of Gaza to the furthest extremity in Persia" [al-Muqqafa' in Evetts, 1910:139-140]. Also reporting from Egypt, George al-Makin described the same nighttime 21st of Tuba earthquake as "affecting all countries, out to the far east"[10] [Ambraseys, 2009:237]. From what we know of the Dead Sea Transform, none of its segmented faults are capable of producing an earthquake that would lead to damage over such a large area [Meghraoui, 2015:9-10, Wesnousky, 2006]. Thus, there must have been more than one earthquake. An earthquake struck, relieved stress on the fault, and transferred that stress to other segments. The added stress caused another segment(s) to break. This pattern of triggered earthquakes or couplets is not unusual for the Dead Sea Transform which has produced several known couplets (Table 1). The fact that these two Coptic sources described multiple earthquakes as one earthquake further suggests that they struck within a short time of each other[11].

5 Al-Massisah and the Khabur River are roughly 420 km apart. It is conceivable that an earthquake on a fault between the two sites of a reasonable magnitude (i.e. 7.5 or below) could produce local intensities of VII at both locations. A simple calculation using the attenuation relationship of Hough and Avni [2009] reveals that an Intensity of 7.3 would be experienced 210 km from the epicenter of a M = 7.5 earthquake.

6 Pseudo-Dionysius of Tell Mahre lived and wrote at the Zuqnin monastery (see Location Map in Figure 1a). Harrak [1999:10-17] provides a host of reasons why the final composition of the Chronicle of Zuqnin by Pseudo-Dionysius of Tell-Mahre is thought to have occurred in 775/776 CE.

7 Time of day is important because during traumatic events such as earthquakes which lead to death and destruction, this timing can be seared into the memory of eyewitnesses and persist in later retellings/public narratives. While dates and years may have been altered by the ancient authors due to chronological confusion in their sources and/or the conscious or unconscious temptation to force synchronicities which fit the theological, political, and/or other agendas of the author, there is no obvious reason or temptation to alter the time of day.

8 *Tuba* is a month in the Coptic Calendar. Although the 21st of *Tuba* normally falls on 16 January, during Coptic Leap Years, such as was the case in 748 CE, the 21st of *Tuba* falls on 17 January.

9 Probable year based on the discussion which follows. Al-Muqaffa's translation did not specify a year and chronological inconsistencies in his account make it impossible to determine a reliable year from his textual account alone.

10 Al-Makin wrote later than al-Muqaffa' and may not be a fully independent source.

11 Other late writing sources such as Michael the Syrian (Syriac), Chronicon Ad Annum 1234 (Syriac), and Abu l'Fath (Samaritan) also described a "universal" earthquake. This could be thought of as an echo of two closely timed earthquakes which were perceived as one event or reflect corruption via oral and textual transmission which amalgamated two (or more) earthquakes into one.

Date	Time Between Events	References
~750 BCE	1-2 decades	Kagan et al. [2011: Appendix C]
~150 BCE	1-2 decades or less	Ellenblum et al. [2015]; Wechsler et al. [2014]; Klinger et al. [2015:323]; Kagan et al. [2011: Tables 3 and 4]; Geographica by Strabo: Book XVI Chapter 2 Paragraph 26 [Strabo of Amaseia, 2016]
363 CE	6 hours	Ambraseys [2009:148-151], Brock [1977]
1202 and 1212 CE	~10 years	Ambraseys [2009:327-338]
1759 CE	26 days	Ambraseys [2009:583-586]

Table 1. Known couplets along the Dead Sea Transform.

3.3 Byzantine Accounts and the 'eastern source'

The three earliest Byzantine sources (Paul the Deacon, Anastasius Bibliothecarius, and Theophanes in that order[12]) speak of two earthquakes separated by 3 years. The similarity of the ten Byzantine accounts, dates of composition, and the distance of the authors from the region (e.g., writing in the vicinity of Constantinople or Italy) suggests that the accounts are derived from a shared local source(s) and each other. None of the three earliest Byzantine authors could have experienced the earthquakes firsthand. As none of the Byzantine authors cite a source, the shared source – often referred to as the 'eastern source' – is a matter of conjecture[13]. Several scholars [e.g., Brooks, 1906] have suggested that the 'eastern source' was cobbled together by a Melkite[14] monk who wrote around 780 CE. After civil unrest led to the dissolution of Melkite monasteries in Palestine and Syria, a number of Melkite Monks ended up in Constantinople in 813 CE [Brooks, 1906:587]. One of the monks may have brought this text with him – a text that would eventually find its way into the hands of Theophanes. How this source was cobbled together is also a matter of conjecture. Two authors whose works are now lost have been proposed as promising candidates in providing source material – John son of Samuel of whom nothing is known beyond that he lived in Western Syria and Theophilus of Edessa. Theophilus, who wrote in Greek, Syriac, and Arabic, was in his 50's and living in the region when the earthquakes struck[15]. John's Chronicle is thought to have ended in 746 CE (supposedly[16]) and the unknown editor of ~780 CE may have been a continuator – meaning he added his own version of events from ~746 to ~780 CE. He may have also incorporated Theophilus' text, simply used Theophilus alone, or used other texts and information. Further, he may have been a redactor meaning that he modified John and/or Theophilus' original text in addition to adding his own events. Some hypothetical possibilities are shown in Figure 2. However this 'eastern source' came to be, since the Byzantine accounts write about earthquakes which

12 Although Anastasius Bibliothecarius wrote after Theophanes, Neil [1998:46] points out that Anastasius likely based his account on an earlier non-extant and perhaps 'unfinished' version of Theophanes thus making his account effectively older than the extant copies of Theophanes we currently have access to.

13 Brooks [1906:587] was one of the first scholars to hypothesize about who wrote the 'eastern source'. Subsequent work on the subject is discussed in multiple publications including but not limited to Proudfoot [1974], Mango et al. [1997: lxxxii-lxxxiv], Conrad [1992, 2004], Hoyland, [2011:10], and Conterno [2014].

14 Melkites were supporters of the Council of Chalcedon (i.e., Chalcedonians) who resided in Egypt, Palestine, and Syria. In the church schisms of the time, Chalcedonians were allied with the same faction as Byzantine writers such as Theophanes and wrote in Greek and Syriac thus producing texts which could have been read by the Greek reading Byzantine authors.

15 Theophilus' Lost Chronicle is known to have directly informed Arabic writer Agapius of Menbig and indirectly informed later Syriac authors such as Michael the Syrian and Chronicon Ad Annum 1234 [Hoyland, 2011:11-15]. All three of these authors wrote about the Sabbatical Year Quakes.

16 The dates of the Sabbatical Year Earthquakes may suggest that it ended in 749 CE.

affected Palestine, Syria, and Jazira (northern Mesopotamia), it would appear that the original report(s) of these earthquakes came from these territories.

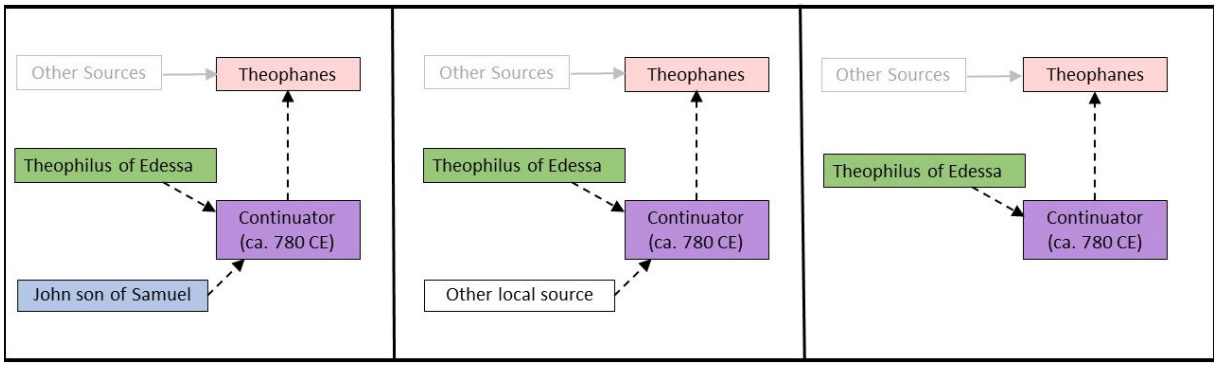


Figure 2. Three hypothetical source dependencies for Theophanes. Dashed arrows indicate uncertain textual transmission. Solid lines are certain. Other Sources refers to some of the many sources thought to have informed Theophanes Chronicle. Mango et al. [1997: lxxiv-lxxxviii], for example, list 20 possible sources for different time periods and subjects. Other local source refers to unknown sources of information for the Continuator. Alternative source dependencies are also possible.

3.4 The Holy Desert and Talking Mule Earthquakes as reported by the Byzantine authors

The details of the Byzantine earthquake accounts appear to suffer from inaccuracies due to the original source(s), the process of redaction[17], and/or mistakes made by the Byzantine authors themselves. As is often the case, chronology appears to have been one of the victims. Some details are accurate. Others are not. To avoid chronological confusion, I label the two Byzantine earthquakes by name rather than by date.

The Holy Desert Quake is described as striking first. Anastasius Bibliothecarius described it as follows[18]

> Anno Mundi 6238, divine incarnation year 738. In the 6th year of Constantine there was a powerful earthquake in Palestine, by the Jordan, and in all of Syria in January, at the 4th hour. Thousands died, an innumerable multitude perished, churches and monasteries collapsed, and it was worst in the desert of the Holy City. [Anastasius Bibliothecarius in Niebhur,1828:225]

Theophanes provided a similar account:

> In this year there was a great earthquake in Palestine, by the Jordan and in all of Syria on 18 January, in the 4th hour. Numberless multitudes perished, churches and monasteries collapsed, especially those in the desert of the Holy City. [Mango et al., 1997:585-586]

The Talking Mule Quake struck next in Syria and Jazira. Anastasius Bibliothecarius provided a description that is remarkably similar to Theophanes and Paul the Deacon.

17 Mango et al. [1997: lxxxii] note that divergent pointers in Theophanes' account point to a place of origin in Edessa (Sanliurfa, Turkey), Antioch, Emesa (Homs), and/or Palestine. This suggests that the 'eastern source' used by the Byzantine authors was redacted (i.e., edited) – perhaps from more than one source.

18 Translations from Latin, French, German, and Aragonese were made by Jefferson Williams with ample assistance from machine translators such as Quick Latin and Google.

> That year there was an earthquake in Syria, a terrible calamity. Many died. A spring [moved?]. In another place in the mountains, a village moved with its walls and homes intact for six roman miles. Finally in Mesopotamia, the earth split two thousand feet and out of the chasm came a white sandy soil and a spotless mule which spoke in a human voice and prophesied that the Arab lands would be invaded by a foreign army. And this prophecy came true.[19] [Anastasius Bibliothecarius in Niebhur,1828:228]

All accounts of the Talking Mule Quake end with a Talking Mule – something which provides insight into the mindset and gullibility of the authors.

3.5 Bet She'an shows that the years in the Byzantine accounts for the Holy Desert Quake are wrong

Although Theophanes and other Byzantine authors appear to place the year of the Holy Desert Quake in 745 or 746 CE (A.M.$_a$ 6238), a rare find of chronologically precise archaeoseismic evidence allows us to establish a *terminus post quem* for the Holy Desert earthquake. In Bet She'an, a coin hoard was found beneath mid-8th century earthquake induced rubble[20] [Tsafrir and Foerster, 1992]. The latest coin was in near mint condition and dates to A.H. 131 (31 August 748 – 19 August 749 CE). This provides a *terminus post quem* (after A.H. 130) and its near mint condition suggests that the earthquake struck soon after the coin was issued. The year provided by Theophanes and other Byzantine authors for the Holy Desert Quake is incorrect.

3.6 Archaeoseismic Evidence from Pella suggests that the Holy Desert Quake struck at night

Well-dated archaeoseismic evidence accompanied by human and animal skeletons from Pella suggests a nighttime earthquake which killed sleeping humans and domiciled animals. Walmsley and Smith [1982:127] noted that one of the human skeletons in Area IX "was found lying, as if sleeping". Walmsley and Smith [1982:185] also reported on the discovery of two human skeletons (male and female) in Area IV that had fallen through the house from the main living area in the second story and were covered in textiles. Walmsley [1992:185] interpreted this unfortunate couple as the owners of the house. Walmsley [2013] suggested that the domiciling of costly animals (e.g., donkeys and cows) at locations such as Area IV suggests that the earthquake struck in the winter which also suggests that the animals may have been taken in for the night. To reconcile skeletal evidence in Area IV (why were the animals and herdsman indoors?) with a ~10 am earthquake report from Theophanes, Walmsley and Smith [1982:139] speculated that it may have been so cold that the herdsman kept the animals indoors and perhaps even stayed in bed himself. However, if one considers that the Holy Desert Earthquake likely struck at night, a more efficacious argument is that the humans and animals were indoors because they were in for the night.

3.7 Other Chronological Clues – Date and Time

The Byzantine authors provided other chronological clues. Theophanes specified the date and time of the Holy Desert Quake – 10 am on 18 January – as did Cedrenus. Paul the Deacon and Anastasius Bibliothecarius also specify a 10 am earthquake that struck in January without providing a specific day. Agapius of Menbij, a Christian Arabic source, also dated the earthquake to January. By combining chronological evidence from Bet She'an, archaeoseismic evidence for a nighttime Holy Desert earthquake from Pella, textual evidence supporting a nighttime Holy Desert earthquake, and Coptic, Jewish, Syriac, and Byzantine accounts, we can say that the Holy Desert earthquake likely struck on the night of the 16th or 17th of January in 749 CE and the Talking Mule Quake struck soon after: probably on the following day at around 10 am. The reasons for this conclusion will be explained in the next few sections.

19 This reported prophecy may allude to the victory of the multi-ethnic Abbasids over the Arab Umayyads. Written about *ex eventu*, it may suggest a *terminus ante quem* of 750 CE.

20 Because it was a hoard, it is unlikely that it was intrusive.

3.8 al-Muqaffa' describes the Holy Desert Earthquake from Egypt

Severus ibn al-Muqaffa' provides us with what appears to be eyewitness testimony as his account is an Arabic translation of an earlier Coptic language account of Coptic Pope and Patriarch Michael I[21] as told by one of his travelling companions. Al-Muqaffa's account describes an earthquake which was experienced in the Nile Delta during the night of the 21st of *Tuba*. Geographic considerations indicate that this account described the Holy Desert Quake of the Byzantine authors[22]. The epicenter of the Talking Mule Quake in northern Syria or Jazira was too far away (~800-900 km)[23] to have caused severe shaking in the Nile Delta. In most years, the 21st of *Tuba* falls on the 16th of January but during years associated with a Julian leap year it falls on the 17th. 749 CE was normal year and the 21st of *Tuba* corresponds to 16 January[24].

3.9 Judaic sources specify a date and, by extension, the year (749 CE) for the Holy Desert Quake

In a book of Jewish prayers found in the Cairo Geniza, a fast is described for the 23rd of *Shevat* based on a description of seismic destruction. A year is not explicitly specified. Karcz [2004] provided an excerpt.

> On 23 *Shevat* a fast to the Land of Israel, since the land trembled and many cities fell and sages and pious and the just and the [etc.] ... died under the ruins. And it is referred to in texts 'in wrath the earth will pace ahead' and since destruction of Jerusalem to the date it happened in Land of Israel the count of in wrath.

The last Hebrew word of this account ('in wrath') has been interpreted via Gematria[25] as indicating that this earthquake struck in 749 CE. Stronger evidence comes from the date of 23 *Shevat* itself. In 749 CE, according to modern Hebrew calendar rules, the 23rd of *Shevat* lasted from sundown 17 January – sundown 18 January. It did not fall on this date during other years (Table 2)[26] [27]. Although there is a discrepancy of a day with the Coptic accounts,

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21 Michael I (aka Kha ʿil I) ruled from 743-767 CE.

22 The approximate geographical center of the Nile Delta is ~860 km distant from Mabbug (Menbij) where collapses are described for the Talking Mule Quake and is ~460 km form the southern part of the presumed epicentral region of the Holy Desert Quake in the Sea of Galilee/Northern Jordan Valley. Using the attenuation relationship of Hough and Avni [2009] and assuming M = 7.2 for both earthquakes, this results in an MMI Scale Intensity of ~V in the Nile Delta due to the Holy Desert Quake and ~III for the Talking Mule Quake. This in turn indicates that the Holy Desert Quake would have been universally felt in the Nile Delta and the Talking Mule Quake would have only been felt by a few people. Al-Muqaffa's account indicates that the earthquake was universally felt in the Nile Delta.

23 This assumes that the epicenter was reasonably close to Mabbug (Menbij) where damage was attested by four Syriac sources (Pseudo Dionysius of Tell-Mahre, Elias of Nisibis, Michael the Syrian and Chronicon Ad Annum 1234). Pseudo Dionysius of Tell-Mahre is thought to be independent from the other 3 sources, Elias of Nisibis cites his source as "Kuwarazmi'. – Daniel the Jacobite" and Michael the Syrian and Chronicon Ad Annum 1234 likely got much of their information from Theophilus of Edessa through the intermediary of the real Dionysius of Tell-Mahre. In addition, several Byzantine sources mention seismic damage in Mesopotamia which likely means in Jazira. Coptic source al-Makin mentions damage "as far as the East" and Coptic source al-Muqaffa' mentions damage "to the furthest extremity of Persia".

24 As the Julian day starts at midnight and the Coptic day starts at sunrise in the civil calendar and at sunset in the liturgical calendar, 21st of *Tuba* encompasses parts of two Julian days.

25 Gematria is the practice of using a cipher to assign a numerical value to a Hebrew letter, adding up the values of the various letters in a word or phrase, and then assigning the summation to the word or expression giving it an added or coded meaning. Margalioth [1960] proposed that an interpretation of the text through one of the more common ciphers indicated that a year which equates to 749 CE was coded into the prayer from the Cairo Geniza. Although such practice is commonplace in Hebrew literature, the analysis rested on an assumption that Sabbatical Years were counted differently in the 8th century CE than they are counted today. As noted by Karcz [2004], there is uncertainty associated with how Sabbatical Years were calculated in the 8th century CE. As noted by Stern [2001, 2012], there is also uncertainty as to how the Hebrew Calendar was reckoned during this time.

26 Although Table 2 indicates that 23 *Shevat* is close to 18 January in 746 CE, 746 CE can be eliminated due to the coin evidence from Bet She'an.

27 Tsafrir and Foerster [1992:234] note that Fried [1976:384] would date 23 *Shevat* from sundown 16 January – sundown 17 January in 749 CE. This produces a date that is compatible with the Coptic accounts and incompatible with Theophanes' date. Lunar observations lead to the same date as is derived from modern Hebrew calendar rules. The new moon crescent in the coordinates of Palestine should have been clearly visible for the first time on 26 December 748 CE [Sascha Stern, personal communication, 2022] which leads to 23 *Shevat* spanning from sundown 17 January – sundown 18 January. The only uncertainty for this observational calendar date is if, for whatever reason, the crescent was sighted a day late. If this happened, the Palestinian Jewish community would have experienced 23 *Shevat* from sundown 18 January – sundown 19 January. If all possibilities are combined, 23 *Shevat* is constrained from sundown 16 January – sundown 19 January in 749 CE.

the coincidence of this date in two independent traditions (Jewish and Byzantine/Theophanes) is compelling and the Holy Desert Quake appears to have struck within a day of a modern understanding of 23 *Shevat* (~5 pm 17 January – ~5 pm 18 January) in 749 CE (Fig. 3).

Hebrew Year	Julian Date	Julian Year
4506	Sundown 19 January – Sundown 20 January	746
4507	Sundown 7 February – Sundown 8 February	747
4508	Sundown 28 January – Sundown 29 January	748
4509	Sundown 17 January – Sundown 18 January	749
4510	Sundown 5 February – Sundown 6 February	750
4511	Sundown 24 January – Sundown 25 January	751
4512	Sundown 13 February – Sundown 14 February	752

Table 2. Julian Dates for 23 *Shevat* from 746 – 752 CE.
(Calculated using fourmilab's calendar converter – https:// www.fourmilab.ch/documents/calendar/).

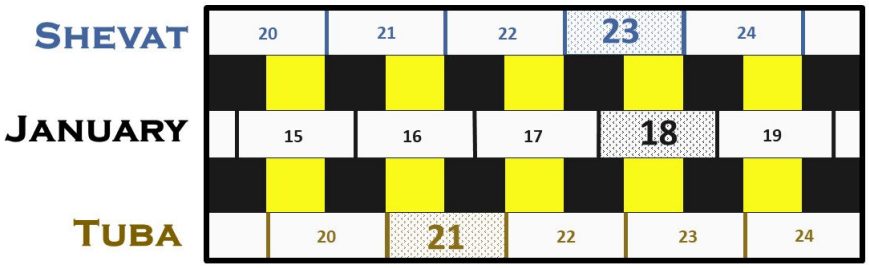

Figure 3. Dates of the Holy Desert Quake in 749 CE as reported in the months of three different calendars – Shevat from the Hebrew Calendar, January from the Julian Calendar, and Tuba from the Coptic Civil Calendar. Black squares represent nighttime and yellow squares represent daytime.

This same earthquake also appears to have been discussed in the Jewish *Piyyut Ra 'ash shvi'it* (רעש שביעית), a liturgical piece of poetry which gives the earthquakes their name – the Sabbatical Year Earthquake(s). Karcz [2004] describes the *piyyut* as lamenting "an earthquake that caused a widespread destruction and extensive casualties in Tiberias and a catastrophic flooding in the plain of Sharon." From archaeoseismic studies [e.g., Marco et al., 2003 and Ferrario et al., 2020] and textual sources [Agapius of Menbij, Michael the Syrian, and Chronicon Ad Annum 1234] we know that Tiberias, a prominent Jewish town at the time, was devastated by the same Holy Desert earthquake which struck nearby Bet She 'an. Death and destruction in Tiberias is sufficient to have generated a lasting memory in the form of a fast.

3.10 Pseudo Dionysius – The Holy Desert Quake struck at night and the Talking Mule Quake struck the next morning

Another source may add chronological information on the timing of the Talking Mule Quake relative to the Holy Desert Quake as well as hint to where at least one of the Byzantine author's source(s) was residing when the

earthquakes struck. Pseudo-Dionysius of Tell Mahre, who appears to be the only local and contemporaneous source for these accounts [Harrak, 1999], is believed to have lived in the monastery of Zuqnin in what is now southeastern Turkey. He recounted two tremors (earthquakes) which were felt in the northern Syrian town of Mabbug (Menbij)[28]

> A tremor took place during the night, and something like the noise of a roaring bull was heard from a great distance. When the morning came, the bishop emphatically ordered that all must gather and go out for prayer, saying that this happened because of sins. When everyone came to the prayer, they went out of the city altogether to a shrine called Church of the Mother of God, which was located outside the city of Mabbug in the West. Those people were also Chalcedonians and their bishop marched before them. When they arrived, they all went inside the shrine like goats inside the fold. As they cried out together in prayer, a tremor suddenly occurred. The church collapsed on them, crushing them to death, along with their bishop. None came out alive; all were abruptly crushed in fatal and horrifying fashion, as if in a wine-press. The righteous perished alongside the sinner. [Harrak, 1999:177-178]

The tremor from the night before was the likely the Holy Desert Quake[29]. The tremor that caused the church to collapse was the more northerly Talking Mule Quake. Since Theophanes specifies that the Holy Desert Quake struck at ~10 am (the 4th hour) and archaeoseismic evidence at Pella along with Coptic sources al-Muqaffa' and al-Makin[30] and Muslim source Mujir al-Din[31] all indicate that the Holy Desert earthquake struck at night, this suggests that the Byzantine author's ultimate source for the time of day was reporting from northern Syria or Jazira where they would have experienced the Talking Mule earthquake – in the morning around 10 am. In Pseudo-Dionysius' account, the time it took to assemble the townsfolk, walk to the church, and initiate a prayer service[32] suggests an earthquake which struck in the mid-morning which is compatible with an earthquake striking at 10 am. Seismic effects for the Talking Mule Quake are also richer in details in the Byzantine accounts than for the Holy Desert Quake.

3.11 The 'eastern source' muddled Byzantine chronology

Although previous authors have speculated that one of the reasons for chronological inconsistencies in the Byzantine accounts could have been partly due to calendric conversion from an A.G. calendar in the 'eastern source'

28 While a multiplicity of archaeoseismic and textual clues are being used here to determine the year, it may be worth noting the years provided by the Syriac writing authors while making reference to Fig. 4. Pseudo-Dionysius supplied a year of A.G. 1059 for these earthquakes which equates to 1 Oct. 747 CE to 30 Sept. 748 CE in Macedonian reckoning and 2 April 748 CE to 1 April 749 CE in Babylonian Reckoning. Macedonian reckoning utilizes a calendar start date of 1 Oct. 312 BCE while the Babylonian reckoning uses a calendar start date of 1, 2, or 3 April 311 BCE (approximating 1 Nisan). Macedonian Reckoning was the more standard usage for Syriac writing authors of this time [Sebastian Brock, personal communication 2021]. Neuhauser et al. [2021:5] note that Pseudo-Dionysius systematically used Macedonian reckoning for the part of the Chronicle composed during his lifetime – e.g in 749 CE. Elias of Nisibis dated the earthquake(s) to A.H. 131 (31 Aug. 748 CE – 19 Aug. 749 CE) while using A.G. 1059 as a reference to define the start date of A.H. 131 (i.e., he did not date it to A.G. 1059 – he dated it to A.H. 131). Michael the Syrian did not supply a date or year and Chronicon Ad Annum 1234 provided inconsistent years by stating that the earthquake(s) struck in A.G. 1060 (1 Oct. 748 CE to 30 Sept. 749 CE using Macedonian reckoning and 2 April 749 CE to 1 April 750 CE using Babylonian reckoning) as well as A. H. 134 (30 July 751 CE to 17 July 752 CE).

29 Using the transform of Tosi et al. [2012], one can calculate that ~21% of the population of Mabbug (Manbij) would have heard or perceived the rumble from the Holy Desert Earthquake whose epicenter was roughly 450 km away. Since Tosi et al. [2012]'s transform was fitted for local magnitudes between 5.0 and 5.5 and widespread destruction documented from archaeologic and paleoseismic studies suggest that the Holy Desert Quake had a magnitude of 7.0 or higher, 21% is likely a significant underestimate. In any case, the transform suggests that it is plausible that the rumble experienced the night before was due to the distant Holy Desert earthquake.

30 A third Coptic source, Chronicon Orientale written in the 13th century, also specifies that the earthquake struck at night (see Supplemental Appendix D– Textual accounts – Sabbatical Year Earthquake – Chronicon Orientale).

31 Although writing late, native Jerusalemite Mujir al-Din presents multiple accounts sourced through a chain of witnesses some of which purports to be eye-witness testimony.

32 Although later Syriac Authors (e.g., Elias of Nisibis and Chronicon Ad Annum 1234) recounted this same story and placed it on a Sunday, the contemporaneous account of Pseudo-Dionysius did not specify that it was a Sunday Mass and implies that it was an impromptu prayer service initiated by the local Priest due to the tremor experienced the night before. As explicitly stated by the bishop in Pseudo-Dionysius' account, it appears to have been common thought among Christian authors of the time that earthquakes were a direct result of man's sins hence an impromptu prayer service to ask for forgiveness would not be unusual. 18 January 749 CE fell on a Saturday.

to the A.M. calendar used by the Byzantine authors[33] (see Figure 4), it seems more likely that the 'eastern source(s)' did not supply chronological precision in terms of the exact year(s) and/or created chronological confusion that the Byzantine authors had to grapple with. For example, Hoyland [2011:19] notes that evidence suggests that the Lost Chronicle of Theophilus of Edessa, one of the hypothesized sources for the 'eastern source', was not annalistic (year by year) and was "rather sparing with dates". Theophilus' Chronicle, or another hypothesized chronicle, may have been composed in a narrative form where events were arranged, "as far as possible", in chronological order peppered by the occasional synchronism (e.g., "in the year 34/35/37 of the Arabs"). Theophanes and others whose work was annalistic would have had to place the events they read about in their source(s) "where [they] thought best."

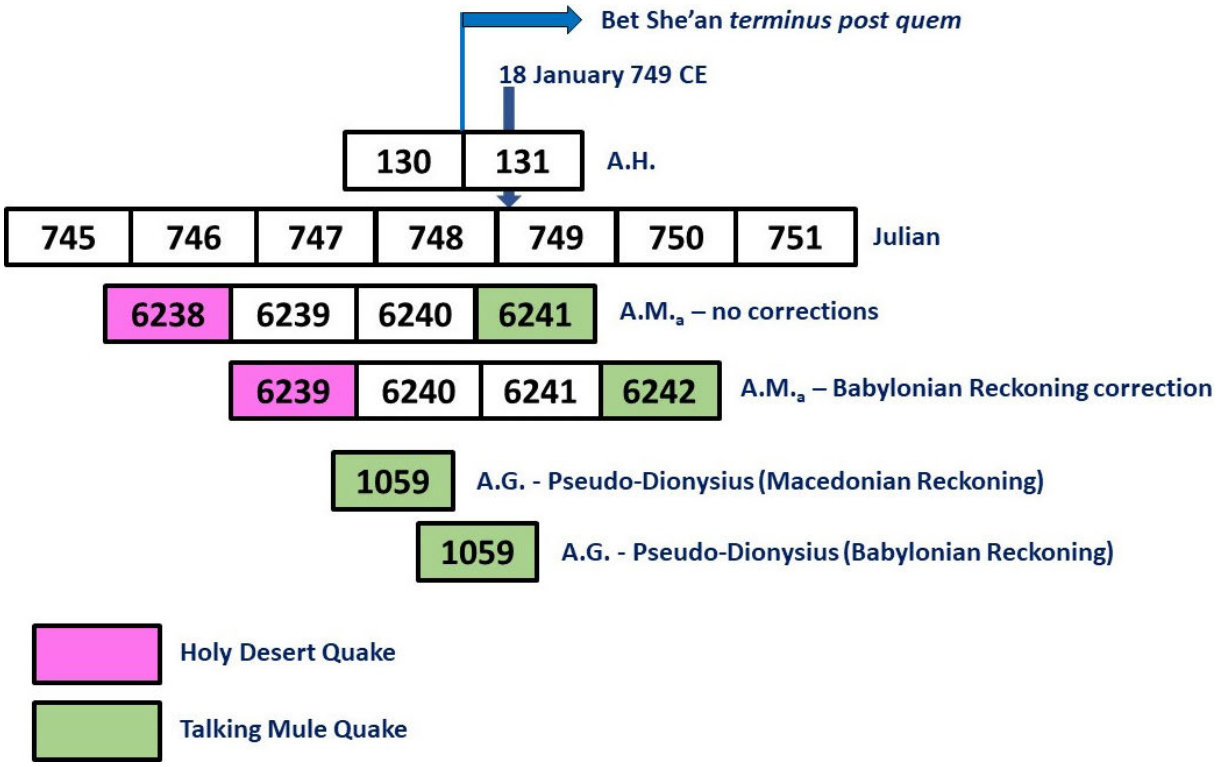

Figure 4. Some of the years for the Sabbatical Year earthquakes as reported in different calendars. The Babylonian Reckoning correction for $A.M._a$ assumes that the original source of the Byzantine authors reported a year in the A.G. Calendar using Babylonian reckoning which was converted by the Byzantine authors to $A.M._a$ using Macedonian reckoning. This adds one year but does not reconcile discrepancies. Grumel's (1934:398-402) synchronism MB was used to define a September start date of Theophanes' $A.M._a$ calendar during this time period. See footnote 33 for more details.

3.12 Initial Summary

Archaeoseismic evidence from Bet She'an combined with the coincidence or near coincidence of 23 *Shevat* with 18 January specifies 749 CE as the year of the Sabbatical Year Earthquakes. Five textual sources[34], one which is local

33 This line of inquiry presented the possibility that the original year of the Holy Desert Quake was reported using the Babylonian reckoning for the A.G. calendar but was converted to the A.M. calendar using a Macedonian reckoning. Such a mistake would result in the year of the earthquake being reported a year too low ($A.M._a$ 6238 instead of $A.M._a$ 6239) which is still incompatible with the coin evidence from Bet She'an. Although the Babylonian to Macedonian reckoning mistake is a possibility, it is not a probability as it was standard practice at the time for Syriac authors to use the Macedonian reckoning [Sebastian Brock – personal communication, 2021]. This correction is illustrated in Fig. 4. Macedonian reckoning utilizes a calendar start date of 1 Oct. 312 BCE while the Babylonian reckoning uses a calendar start date of 1, 2, or 3 April 311 BCE (approximating 1 Nisan).

34 Pseudo Dionysius of Tell Mahre, Al-Muqaffa', Al-Makin, Chronicon Orientale, and Mujir al-Din.

and contemporaneous and two of which are written in the first person, along with archaeoseismic evidence from Pella (Section 3.6), indicate that the Holy Desert Quake struck at night – likely on the 16th or 17th of January. The Talking Mule Quake likely struck the next morning around 10 am. Although four Byzantine accounts[35] relying on at least one shared source and/or each other state that the Holy Desert earthquake struck at 10 am, the local and contemporaneous account of Pseudo Dionysius of Tell Mahre indicates that this was the time when the Talking Mule Quake struck. This confusion is likely because the 'eastern source' of the Byzantine authors relied at least partially on a report from someone who experienced the Talking Mule Quake in Jazira or northern Syria and this timing somehow got transposed into the Holy Desert Quake account – possibly due to the temporal proximity of the two different earthquakes and possibly because the 'eastern source(s)' of the Byzantine authors was informed by more than one account – e.g. one from Palestine and one from Jazira/northern Syria[36]. The combined and possibly redacted account(s) that the Byzantine authors relied upon could have been chronologically inconsistent and confusing. The temporal proximity of the earthquakes and the nature of communication at the time appears to be why Egyptian authors at the periphery of the felt area reported a belief that there was one great "cosmic"[37] earthquake which struck the entire region. Two temporally proximal earthquakes, in turn, likely contributed to the amalgamation of two earthquakes into one that shows up in the later Syriac accounts of Michael the Syrian and Chronicon Ad Annum 1234 both of which reconciled events into chronologically flawed and overly expansive narratives which, nonetheless, are rich in their description of seismic effects.

3.13 Muslim Sources

There is a Muslim tradition recounted by a number of late writing authors which discuss an earthquake which caused damage in Damascus and Jerusalem in the years A.H. 130 (11 September 747 – 30 August 748) and/or A.H. 131 where A.H. 131 (31 August 748 –19 August 749) is compatible with earthquake(s) in 749 and A.H. 130 suggests an earthquake in 748. Tsafrir and Foerster [1992:232] noted that while Ibn Tagri Birdi dates the earthquake to A.H. 130, in the same section he "adds that there existed another, less common, tradition according to which the earthquake occurred in A.H. 131." As these authors were writing late (ca. 985 – ca. 1495 CE) with the bulk of reports composed between the 13th and 15th centuries CE, it would seem that textual transmission muddled their chronology. Geographic considerations suggest that reported damage to Al Aqsa Mosque in Jerusalem would have been caused by the Holy Desert Quake[38] which we know from Bet She'an could not have struck in A.H. 130. A.H. 131, compatible with an earthquake in January 749 CE, is the more likely date. That said, when one considers that Elias of Nisibis says that A.H. 131 was "a year in which there were many earthquakes", it is possible that the dual date tradition of the Muslim writers speaks to a more thinly reported earthquake in this seismic sequence.

3.14 Mujir al-Din

Jerusalemite Mujir al-Din supplied three different accounts of the Holy Desert Quake striking Jerusalem, each sourced through different chains of witnesses (*isnad*). The accounts are mostly consistent and contain elements evocative of eye-witness testimony. Although Mujir al-Din wrote late (ca. 1495 CE), Elad [1995] suggests that Mujir al-Din copied from what was in its genesis a type of literature known as "literature in praise of Jerusalem". Because this was considered to be a type of *hadith* literature where faithful copying is incentivized and because the subject

35 Paul the Deacon, Anastasius Bibliothecarius, Theophanes, and Cedrenus.

36 Hoyland [2011:270 n. 817] suggested that the same earthquake was repeated twice in Theophanes because he was drawing on two separate sources. Although Hoyland made a mistake in saying that Theophanes dated *both* earthquakes to January (a month wasn't supplied for the Talking Mule Quake) and, citing Tsafrir and Foerster [1992], assumed that there was only one earthquake, the supposition that Theophanes drew on two separate sources for two earthquakes is compelling and whether Theophanes drew on separate sources or Theophanes' source drew on separate sources, this helps explain chronological discrepancies.

37 e.g., George al-Makin called it "a cosmic earthquake affecting all regions out to the Far East" and al-Muqaffa' stated that seismic damage "happened all over the east, from the city of Gaza to the furthest extremity of Persia."

38 Extensive archaeoseismic evidence in and around the Sea of Galilee and paleoseismic evidence in Bet Zeyda suggests that the Holy Desert Quake was at least of M = 7 and had an epicenter in the Sea of Galilee or the northern part of the Jordan River Valley placing it ~90-120 km away from Al Aqsa Mosque in Jerusalem. Using the attenuation relationship of Hough and Avni [2009], one could expect intensities of 7.25-7.6; sufficient to cause collapse or damage to structures.

matter, time period, and general compatibility with other accounts make it unlikely that this represents a forgery (as is the case with some *hadith* literature), Mujir al-Din's three accounts likely capture at least some elements of original testimony. There are observations in Mujir al-Din's accounts of the Holy Desert Quake which, though not entirely consistent and possibly embellished, appear to contain the types of observations witnesses would remember such as a nighttime earthquake (sometimes expressed as seeing the stars after part of the roof of Al Aqsa Mosque was breached) and, in one account, noting that it was a cold and black night full of wind and rain[39]. Two of the accounts are written in the first person and all of the accounts specify an earthquake which struck at night. One account describes two earlier foreshocks preceding the main shock. Geographic considerations tie the main nighttime shock to the Holy Desert Quake[38]. One could speculate that one of the foreshocks could have been due to one of the seismic events observed in the southern Araba.

3.15 Final Summary (with some caveats removed for clarity)

- A massive nighttime earthquake was reported by Coptic sources from the Nile Delta. Damage was reported from Gaza to Persia. One of the Coptic sources is written in the first person and purports to present eyewitness testimony.
- The Dead Sea Transform is segmented and cannot produce such a large earthquake from one fault break alone. There had to have been more than one earthquake.
- The Byzantine accounts are a chronological mess. They relied on a report from the region which historical and textual scholars call the 'eastern source'. This hypothetical document is used to explain how the Byzantine authors sourced their information.
- The Byzantines accounts speak of two earthquakes. They are given names below
  - The Holy Desert Quake in the south
  - The Talking Mule Quake in the north
- A coin found beneath seismic rubble in Bet She'an dates the Holy Desert Quake to A.H. 131 (31 August 748 – 19 August 749 CE) or later – probably in A.H. 131. The coin was in near mint condition indicating that it had barely circulated.
- There are other chronological clues in the texts – e.g., dates
  - 16 January from Coptic accounts
  - 17/18 January from Jewish accounts – but only for the year 749 CE
  - 18 January from the Byzantine accounts
  - The Byzantine accounts also say that the Holy Desert Quake struck at 10 am
- The date from the Jewish sources and the coin from Bet She'an tell us that the Holy Desert Quake struck in 749 CE.
- Pseudo-Dionysius of Tell-Mahre, our only contemporaneous source, records that two earthquakes were experienced in Menbig in Northern Syria – a nighttime earthquake which was so far away it did no damage (the Holy Desert Quake) and a mid-morning earthquake that collapsed buildings and killed people (the Talking Mule Quake).
- Although the Byzantine accounts said that the Holy Desert Quake struck at 10 am, it struck at night. We know this from our Coptic sources in Egypt and a Muslim source (Mujir al-Din) which presents what is purported to be eyewitness testimony from Jerusalem. It is the Talking Mule Quake which struck at 10 am.
- A possible reason why the Byzantine accounts transposed the time of the Talking Mule Quake into the time of the Holy Desert Quake will be explained using a hypothetical scenario below
  - The Byzantine accounts relied on a source from the region – the 'eastern source'.
  - The first author of the 'eastern source' was a Monk living in the vicinity of Palestine. He wrote about the Holy Desert Quake. Then he died.
  - Many years later, another monk took this book, added events to it for ~30 years after the first Monk died, and edited the original text. He added an earthquake account from Theophilus of Edessa. This left two earthquake

39 It should be noted, however, that a cold and black night full of rain may be inconsistent with seeing the stars after the earthquake breached the Dome of Al Aqsa Mosque (see Supplemental Appendix D – Textual Accounts – Sabbatical Year Quake Sequence – Mujir al-Din).

accounts in the book – the Holy Desert Quake originally written by the ~Palestinian author and the Talking Mule Quake written by Theophilus.
  - Theophilus, like everyone else at the time, thought that there was one big earthquake. Since Theophilus experienced the Talking Mule Quake in the north he reported that the earthquake struck at 10 am.
  - Because Theophilus included reports of seismic damage in Palestine, the editor of the 'eastern source' rewrote the original passage of the Holy Desert Quake to say that it struck on January 18 at 10 am. He may have also created confusion in his editing.
  - Theophanes got ahold of the 'eastern source' in 813 CE when it arrived in Constantinople. He incorporated this book into the Chronicle he was writing at the time
- In summary, the Holy Desert Quake struck first – at night. The Talking Mule Quake struck the next morning. In Egypt they thought it was one big nighttime earthquake. In Northern Syria, they (e.g., Theophilus) thought it was one big day time earthquake.
- Later accounts in Michael the Syrian and Chronicon Ad Annum 1234 got much of their information from Theophilus and wrote about one big earthquake. They did not specify whether it struck in the daytime or the nighttime.
- Muslim sources wrote about earthquakes which struck Jerusalem and Damascus in A.H. 130 or A.H. 131. A.H. 131 is the correct date. The A.H. 130 date may reflect a less well reported earthquake in this sequence. After all, Elias of Nisibis and Cedrenus both said it was a time of many earthquakes.

4. Paleoseismic and Archaeoseismic Evidence from the Southern Araba

In Aila, dating provided by Thomas et al. [2007] for earthquakes III and IV suggests that earthquake III struck in the mid-8th century CE. Whitcomb [1994], Al-Tarazi and Korjenkov [2007], Damgaard [2008, 2011], and Damgaard and Jennings [2013] also dated earthquake damage in nearby Ayla to the mid-8th century CE. About 38 km to the NNE in the Qatar Trench, Klinger et al. [2015] observed paleoseismic evidence for two earthquakes (E4 and E5) which "had to happen very close in time as cracks associated with each event end within a very short distance in our trench." Klinger et al. [2015:323] added:

> The existence of the distinct unit D [] prevents any ambiguity about the fact that two distinct events are recorded here. Based on our age distribution, the time bracket that includes the two earthquakes is 671 C.E.– 845 C.E.. Event E4, the latter of the two earthquakes, produced more ground disruption than Event E5.

This would suggest that the latter event E4 is the same as the Earthquake III event observed in Aila by Thomas et al. [2017] and the mid-8th century earthquake observed in Ayla by Whitcomb [1994], Al-Tarazi and Korjenkov [2007], Damgaard [2008, 2011], and Damgaard and Jennings [2013]. The earlier event E5 may have struck the Gulf of Aqaba perhaps up to a few decades earlier[40].

5. Al Aqsa Mosque in Jerusalem

Several Muslim authors reported seismic damage in Jerusalem and to Al Aqsa Mosque on Haram esh-Sharif (aka Temple Mount). Although some chronological inconsistencies are present in the accounts of these late writing authors, taken together, the reports suggest that Al Aqsa was partially damaged by the 749 CE Holy Desert Quake, repaired, destroyed after the repair, and then entirely rebuilt. Except for Damascene Al-Dhahabi, all of the authors who described damage to Al-Aqsa were native Jerusalemites and Al-Dhahabi is reported to have studied in Jerusalem. The earliest writing author, al-Maqdisi, wrote in ca. 985 CE and dated earthquakes (plural) to the Abbasid Caliphate – i.e., on or after 25 January 750 CE. Al-Maqdisi stated that "earthquakes threw down most of the main building" which led to an order of repair by the Caliph "of the day".

40 Byzantine and Arabic sources describe an earthquake in 717 CE as striking Syria and Jazira which seems too far to have left a mark in the Araba unless it was mislocated [see Ambraseys, 2009:225-226].

Other Muslim sources who describe damage to Al Aqsa include Al-Dhahabi, Jamal ad Din Ahmad, and Mujir al-Din. Al-Dhahabi, writing in early part of the 14th century CE, reported that a violent earthquake in Jerusalem damaged the eastern and western parts of Al-Aqsa Mosque in A.H. 130 (11 September 747 CE – 30 August 748 CE) after which it was repaired while al-Mansur, the second Abbasid Caliph, ruled (754 – 775 CE). Al-Dhahabi referred to this as the first earthquake indicating that another earthquake struck the building. Jamal ad Din Ahmad, writing in 1351 CE, also reports damage to the eastern and western parts of Al Aqsa in A.H. 130 and a subsequent repair during the reign of al-Mansur. Jamal reports that after the repair was completed, a second undated earthquake struck Al-Aqsa and caused it to "fall to the ground". This is said to have led to an entire rebuild during the reign of the 3rd Abbasid Caliph Al-Mahdi who ruled from 775-785 CE. Mujir al-Din, writing in 1495 CE, provided additional chronological details in recounting that Al Aqsa was partially damaged by an earthquake in A.H. 130, repaired during the reign of Al Mansur, destroyed ("overturned") by a subsequent earthquake, and then rebuilt entirely during the reign of Al-Mahdi.

Geographic considerations (see footnote 38) and archaeoseismic evidence from Bet She'an indicate that initial damage to Al-Aqsa occurred in January 749 CE (A.H. 131). Although damage or destruction to Al Aqsa due to the second earthquake has been attributed to the By No Means Mild earthquake of 756 CE, the date for the second earthquake in the Muslim sources is not well constrained. The report by Pseudo-Dionysius of the By No Means Mild earthquake in Jazira is not a plausible candidate. It was too far away[41] and possibly too early (756 CE). It is possible Theophanes' version of the By No Means Mild Quake striking Syria and Palestine in 756 CE could speak to another earthquake in a By No Means Mild sequence which damaged Al Aqsa. It is also possible that that the second earthquake occurred later – sometime before 785 CE.

Other Muslim sources who mentioned seismic damage in Jerusalem due to the first earthquake include Baghdad native and longtime Damascus resident Sibt Ibn al-Jawzi and Cairene Ibn Tagri Birdi who wrote in the 13th and 15th centuries respectively. The history of seismic damage to Al Aqsa Mosque and its location on the southern edge of Haram esh-Sharif suggests that it is subject to seismic amplification due to a slope effect and/or underlying fill placed there in Herodian times [see, for example, Salamon et al., 2010; Frydman, 1997].

6. "A year in which there were many earthquakes"

Syriac author Elias of Nisibis described A.H. 131 (31 August 748 – 19 August 749 CE) as "a year in which there were many earthquakes". This is in general agreement with four Byzantine authors (Paul the Deacon, Anastasius Bibliothecarius, Theophanes, and Cedrenus) who specify two earthquakes rather than one and Cedrenus who stated that "there were many earthquakes in various places". Since paleoseismic evidence from the southern Araba suggests two more earthquakes and destruction to Al Aqsa Mosque after seismic repairs were made speaks to the possibility of yet another earthquake, it might be best to characterize the mid to late 8th century CE as a time of multiple earthquakes of which only three are well attested textually – The Holy Desert and Talking Mule earthquakes of the Sabbatical Year sequence and the By No Means Mild earthquake(s). More than three sizeable earthquakes appear to have struck in the vicinity of the Dead Sea Transform in the mid-8th century CE almost certainly accompanied by numerous aftershocks and possibly foreshocks[42].

7. Empirical and Textual Data Combined

In addition to the textual reports, mid-8th century seismic events have been observed in archaeoseismic, paleoseismic, paleo-landslide, and paleo-tsunamogenic investigations. This data along with the textual evidence

41 Reports of damage on the Khabur River during the By No Means Mild Quake place the epicenter ~700 (± 100) km away from Jerusalem which for a M = 7.0 earthquake and using the attenuation relationship of Hough and Avni [2009] results in Intensities between 2.8 and 4.0 (MMI Scale) in Jerusalem which is insufficient under normal circumstances to destroy Al Aqsa Mosque entirely.

42 See Supplemental Appendix D – Master Seismic Effects Table – Holy Desert Quake Textual Accounts – Various Places – Foreshocks and Aftershocks for textual sources which appear to describe aftershocks – particularly in Damascus and Jerusalem.

will now be integrated and discussed in a largely qualitative sense – sorted by event(s) in a different order than sections 2-6. The order will be

- Holy Desert Earthquake
- Talking Mule Earthquake
- South Araba Earthquake
- By No Means Mild Earthquake(s)

A quantitative analysis of the epicentral regions accompanied by hypothetical Intensity Maps will be presented in a forthcoming publication. Further details and supporting citations can be found in the Supplemental Appendices which are summarized in Table 3.

Appendix	Data	Subdivisions
A	Archaeoseismic Evidence	none
B	Paleoseismic Evidence	none
C	Paleo-landslide Evidence	none
D	Textual Evidence Sabbatical Year Sequence	Master Seismic Effects Table – Holy Desert Quake Textual Accounts Master Seismic Effects Table – Talking Mule Quake Textual Accounts Textual Accounts – Sabbatical Year Quake Sequence
E	Textual Evidence By No Means Mild Earthquake(s)	Master Seismic Effects Table – By No Means Mild Earthquake(s) Textual Accounts – By No Means Mild Earthquake(s)
F	Calendars	subdivided by calendar system
G	Intensity Estimates from Dead Sea Seismites	Method of Heifetz and Wetzler Modified Method of Williams
H	Information on the authors	none
n/a	Bibliography	Includes a subdivision on Ancient Texts

Table 3. Supplemental Appendices.

7.1 Notes about Intensity Estimates

Archaeoseismic Intensity estimates, which comprise most of the Intensity estimates shown in the maps, make use of the Earthquake Archeological Effects (EAE) Chart of Rodriguez-Pascua et al. [2013] which uses the ESI07 scale [Michetti et al., 2007]. Intensity estimates from Textual reports make use of the same EAE chart except for the report of sand boils in Mesopotamia (likely Jazira) during the Talking Mule Quake. In this case, a range of PGA estimates was derived from a chart in Obermeier [1996, Figure 9] and converted to Intensity on an MMI (Modified Mercalli Intensity) scale using the transform of Wald et al. [1999]. Estimated Intensities from paleoseismic sites in the Dead Sea are also on the MMI scale and are averaged from the two methods detailed in Supplemental Appendix G. Deformations in other paleoseismic sites are based on the assumption that a minimum Intensity of 7 (MMI Scale) is required to break the sediments in these trenches and outcrops [Mcalpin, 2009:312]. Intensity estimates from paleo-landslide sites were converted from PGA to Intensity on an MMI (Modified Mercalli Intensity) scale using the transform of Wald et al. [1999]. Intensity values on the map with a plus after the number (e.g. 8+) indicate that Intensity could be higher (e.g. 8+ is equivalent to ≥ 8).

7.2 The Holy Desert Quake

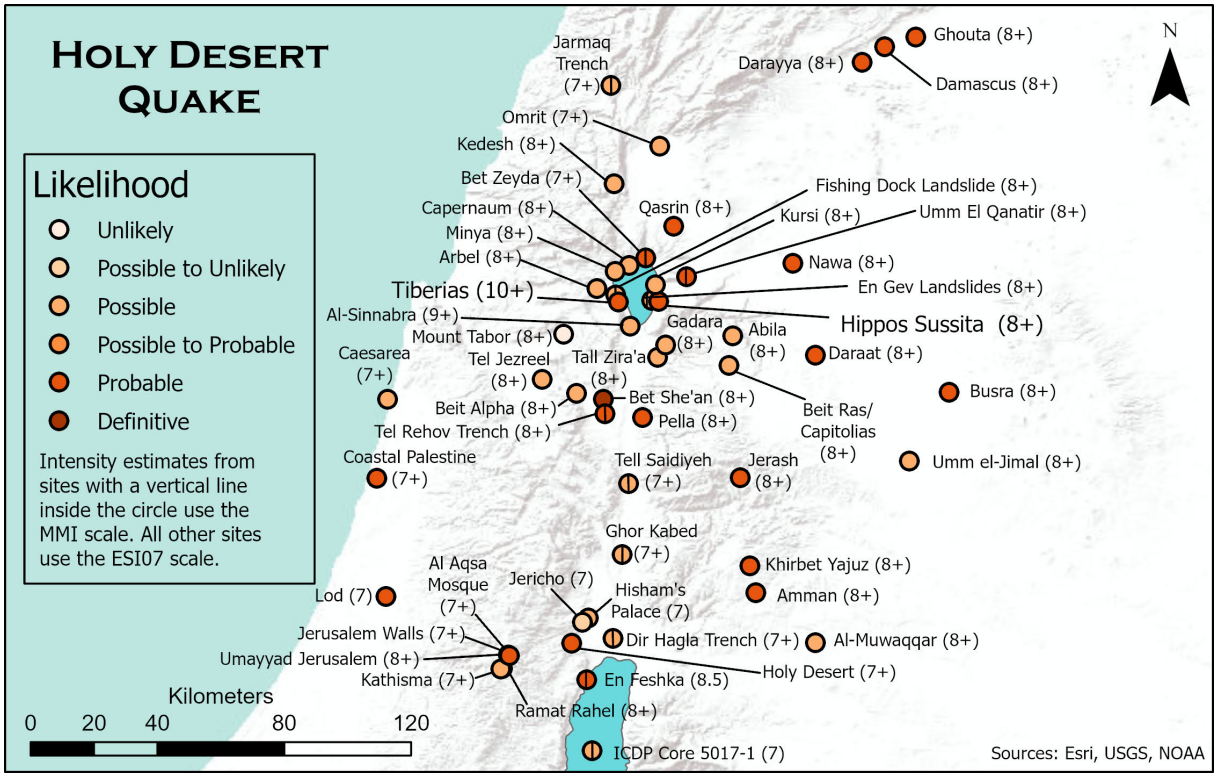

Figure 5. Damage Area for the Holy Desert Quake. Locations are labeled by name followed by an estimated Intensity in parentheses. Locations are color coded for likelihood that observed seismic damage is due to one of the mid-8th century earthquakes. Intensities are estimated from Archaeoseismic, Paleoseismic, Paleo-Landslide, and Paleo-Tsunami evidence as well as textual reports.

The Holy Desert Quake (Figure 5) is the best characterized event so it will be discussed first. Studies in Tiberias [Marco et al., 2003, Hazan et al., 2004, and Ferrario et al., 2020] and archaeoseismic, paleoseismic[43], and paleo-landslide studies (see Supplemental Appendices A-C) indicate that this earthquake devastated villages around the Sea of Galilee and was likely a result of both normal and strike-slip fault motion. Well-dated sites east of the Dead Sea Transform (e.g., Pella, Jerash, the Umayyad Palace on the Citadel in Amman, and Khirbet Yajuz) experienced high levels of seismic Intensity which, combined with textual reports from Southern Syria (e.g., Busra, Daraat, Nawa, Darayya, Damascus, Ghouta), indicates that seismic energy may have focused to the east. To the west, well dated archaeoseismic evidence in Lod (and probably Ramla) appear to corroborate the report by Agapius of Menbig that there was seismic destruction in Coastal Palestine. Tsunamogenic Evidence from Caesarea was also probably a result of this earthquake (see Appendix B). This tsunamogenic evidence appears to be corroborated by reports by Coptic authors al-Muqaffa', al-Makin, and Chronicon Orientale that many ships sank at sea on the night of the earthquake. These ships could be presumed to be sailing or anchored close to shore where they would have been subject to tsunamogenic damage. The fairly well dated landslide at Umm Qanatir [Wechsler et al., 2009] and up to 100 cm of dip slip displacement [Marco et al., 2003] observed on land in Tiberias suggests that subsea displacements and/or submarine landslides in the Sea of Galilee led to a sizeable seiche which may have been described in *Ra'ash Shvi'it*[44], Michael the Syrian, and Chronicon Ad Annum 1234.

43 Particularly Event CH2-E1 from Bet Zeyda close to the northern shore of the Sea of Galilee and dated to between 675 and 801 CE [Wechsler et al., 2018a].

44 Karcz [2004:785] and Ambraseys [2005:118] noted that while flooding specified in the plain of Sharon in *Ra'ash Shvi'it* would specify Israel's coastal plain in the modern lexicon, this geographic designation could have, at the time of composition, referred to parts of the Jordan and Yizrael (aka Esdraelon) Valleys (e.g., by Eusebius in the 4th century CE).

Whether there was a significant seiche in the Dead Sea is difficult to ascertain. A turbidite deposit from the ICDP 5017-1 core was radiocarbon dated (1σ) to 658-746 CE [Lu et al., 2020a] indicating that it could have been caused by either the Jordan Valley Quake of 659/660 CE or the Holy Desert Quake of 749 CE. Textual reports by Michael the Syrian and Chronicon Ad Annum 1234 describe the effects of a seismic sea wave on a fortress described as being "in the land of Balqa, that is to say Moab". Moab, which seems to be the specified location, would locate this seiche on the eastern shores of the Dead Sea however Balqa is traditionally understood as being further to the north[45]. As no corroborating archaeoseismic or paleoseismic evidence has yet been discovered for this sea wave destruction, the possibility that a destructive seiche was experienced in the Dead Sea in ~749 CE remains a mystery.

Reports by the Byzantine authors of seismic damage in the Holy Desert east of Jerusalem appears to be corroborated by seismic damage observed in Jerusalem [Mazar and Avi-Yonah, 1969, Magness, 1991, and Weksler-Bdolah in Galor and Avni, 2011:421] and just outside of Jericho [Whitcomb, 1988:83]. The Moment Magnitude of the Holy Desert Quake was likely between 7.0 and 7.5.

7.3 The Talking Mule Quake

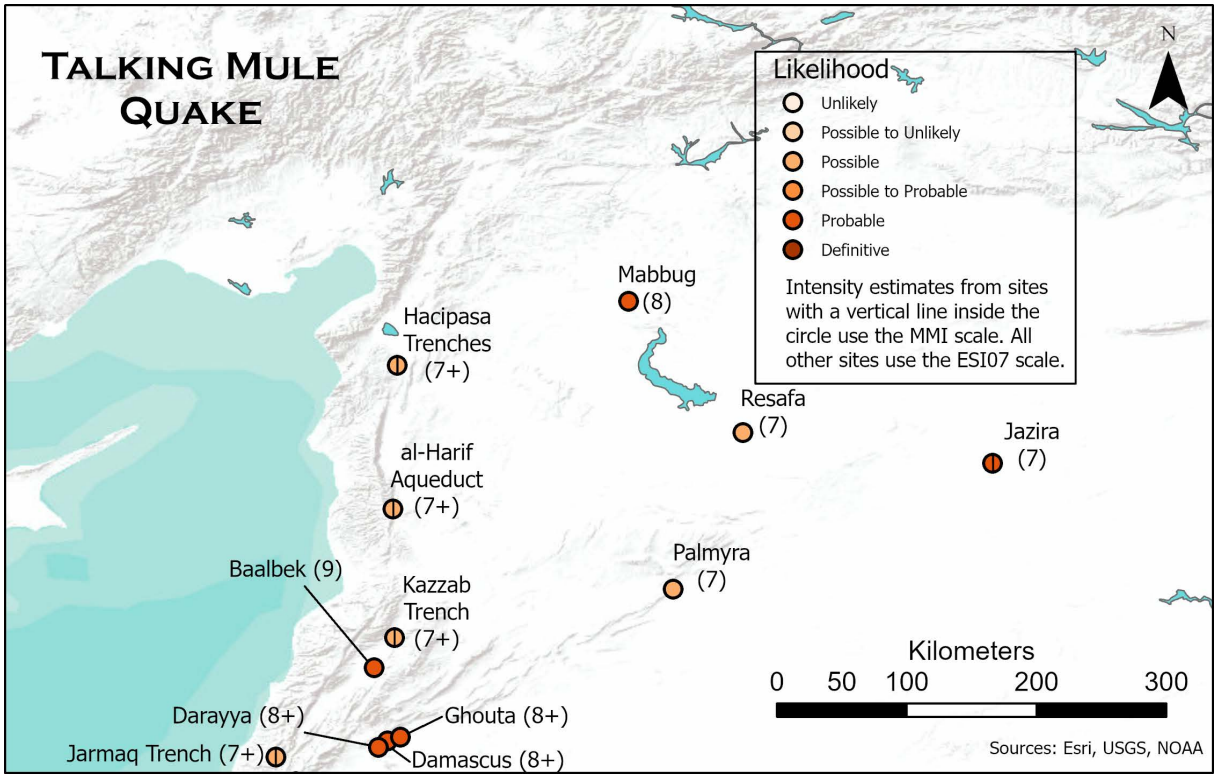

Figure 6. Potential Damage Area for the Talking Mule Quake. Locations are labeled by name followed by estimated Intensity in parentheses. Locations are color coded for likelihood that observed seismic damage is due to one of the mid-8th century earthquakes. Intensities are estimated from Textual Reports, Archaeoseismic, and Paleoseismic evidence.

The damage area for the Talking Mule Quake (Figure 6) was further north. Unfortunately, archaeoseismic evidence is limited and ambiguous. The best evidence may come from Palmyra where water pipes laid in Umayyad times were destroyed by an earthquake and replaced in Abbasid times [Intagliata, 2018:27; sources therein) and seismic damage to an abandoned Basilica was dated to around 800 CE [Gawlikowski, 1994:141]. Potential corroborating paleoseismic evidence from the northern part of the Dead Sea Transform suffers from dating inaccuracy in the

45 Hoyland [2011:270-273 n. 824] describes Balqa as corresponding to "modern north and central west Jordan" with "Amman as its capital." Moab contains the eastern shores of the Dead Sea.

Hacipasa Trenches[46] and event ambiguity in the Kazzab Trench[47]. Event Y from the combined paleoseismic and archaeoseismic investigation of the al-Harif aqueduct in Syria by Sbeinati et al. [2010] is bracketed to between 540 and 780 CE[48]. The best evidence may come from textual reports of seismic damage in Mabbug (aka Manbij). This damage is described in what may be independent sources – Pseudo-Dionysius of Tell-Mahre vs. Elias of Nisibis vs. Michael the Syrian and Chronicon Ad Annum 1234. Seismic reports by several Byzantine authors of earth fissures and sand boils in Jazira (N Mesopotamia) leads to an estimated Intensity (MMI Scale) between 6.7 and 8.2[49]. Taken together, all these data points suggest a large earthquake whose epicentral region was in Northern Syria and/or Jazira.

Whether textual reports by Michael the Syrian and Chronicon Ad Annum 1234 of devastation in Baalbek is due to the Holy Desert Quake or the Talking Mule Quake is difficult to ascertain qualitatively as Baalbek may be midway between the epicentral regions for the two events. Likewise, reports of seismic damage in the vicinity of Damascus could be due to the Talking Mule Quake[50] and/or the Holy Desert Quake. Although Syriac authors recount a translational landslide on Mount Tabor which would associate it with the Holy Desert Quake, the Byzantine authors did not locate this landslide on Mount Tabor and described it as a seismic effect of the Talking Mule Quake. This would appear to locate it in Syria – likely northern Syria. Mount Tabor was and still is the traditional pilgrimage site for the influential New Testament stories of the transfiguration, where Jesus reveals his divine nature and parts of his mission to his closest followers. It can be assumed that there was a theological temptation to re-locate this landslide to Mount Tabor to make a point that these earthquakes demonstrated the earth's reaction to man's sin's[51] even at a site of such supposed sacred geography – a theme that appears to be present in the Syriac author's accounts. Pseudo-Dionysius of Tell-Mahre, for example, states "Where can we show the causes of the earthquakes if these were not brought on by the sins of people?" Absent dated paleo landslide evidence from Mount Tabor, it may be best to assume that this landslide occurred in Northern Syria.

46 The oldest event in the Ziyaret Trench (of the Hacipasa Trenches) was dated by Akyuz et al. [2006] to before 983 CE with no lower bound.

47 Ambiguous paleoseismic event ?S2 was dated (2σ) by Daeron et al. [2007] to between 405 and 945 CE but may have been a "mole-track" feature caused by a later earthquake (S1 – 926-1381 CE).

48 Although Sbeinati et al. [2010] dated Event Y to 625-690 CE in Fig. 13 of their paper, the widest time constraint from all their dating methods brackets Event Y to between 540 and 780 CE.

49 For details on how this Intensity was estimated see Supplemental Appendix D – Master Seismic Effects Table – Talking Mule Quake Textual Accounts – Jazira (N Mesopotamia) – Earth Fissure and Sand Boils.

50 As-Suyuti describes the A.H. 131 earthquake in Damascus as breaching a mosque such that the sky was visible. He does not say that the stars were seen. This could indicate that this was a daytime earthquake – perhaps associated with the Talking Mule Quake.

51 Church schisms appear to be one of the "sins" which troubled the Syriac writing authors.

7.4 South Araba Quakes

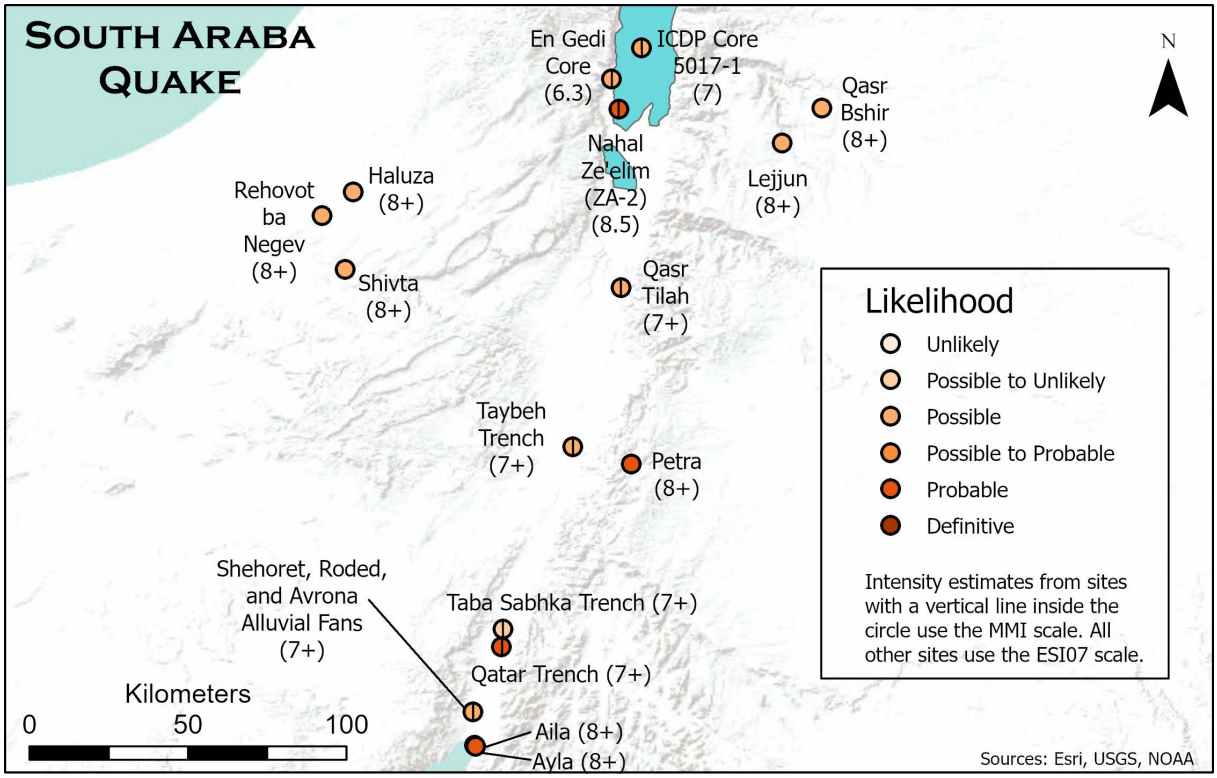

Figure 7. Potential Damage Area for the South Araba Quake [E4 of Klinger et al., 2015]. Locations are labeled by name followed by estimated Intensity in parentheses. Locations are color coded for likelihood that observed seismic damage is due to one of the mid-8th century earthquakes. Intensities are estimated from Archaeoseismic or Paleoseismic evidence.

Klinger et al. [2015] identified two seismic events in the Qatar Trench which happened within a relatively short time of each other and were dated to between 671 and 845 CE. The more locally energetic latter earthquake (E4) likely correlates with archaeoseismic damage observed 39 km to the south in Aila [Event III – Thomas et al., 2007] and Ayla [Whitcomb, 1994; Damgaard, 2008; Damgaard, 2011: Appendices 12; and Damgaard and Jennings, 2013]. Al-Tarazi and Khorjenkov [2007] estimated an Intensity of IX in Ayla indicating that this too was a sizeable earthquake. Whether archaeoseismic evidence from the Negev sites of Shivta, Haluza, and Rehovot ba Negev is related to this South Araba earthquake is difficult to ascertain as these three sites lack a reliable *terminus ante quem*. Petra may have been damaged by one of the South Araba earthquakes. The Phase 8 earthquake at Jabal Harun (~5 km SW of the Cardo in Petra) was dated to the mid-8th century after iconoclastic defacing which could provide a *terminus post quem* of ~725 CE; when the first iconoclasm began [Martin, 1930:16-36]. Mikkola et al. [2008] report extensive seismic damage in the Phase 8 earthquake including tilted walls, collapsed vaults and arches, and fallen columns. Perry in Bikai et al. [2020] likewise dates a seismic destruction to the Blue Chapel in Petra to the mid-8th century CE[52]. It is possible that one of the foreshocks described by Mujir al-Din a few hours before the Holy Desert Quake struck may have been due to the stronger and later South Araba Quake (E4). However, this must be viewed as speculation due to an inability to precisely date these South Araba earthquakes.

Klinger et al. [2015] described the earlier south Araba Quake (E5) as distant to the Qatar site. Where the epicenter for this earlier earthquake was located is matter of conjecture but it may have been to the south in the Gulf of Aqaba suggesting a pattern of seismic unzipping from south to north in the mid-8th century CE.

52 See Supplemental Appendix A – Petra – The Ridge Church and the Blue Chapel.

7.5 By No Means Mild Quake(s)

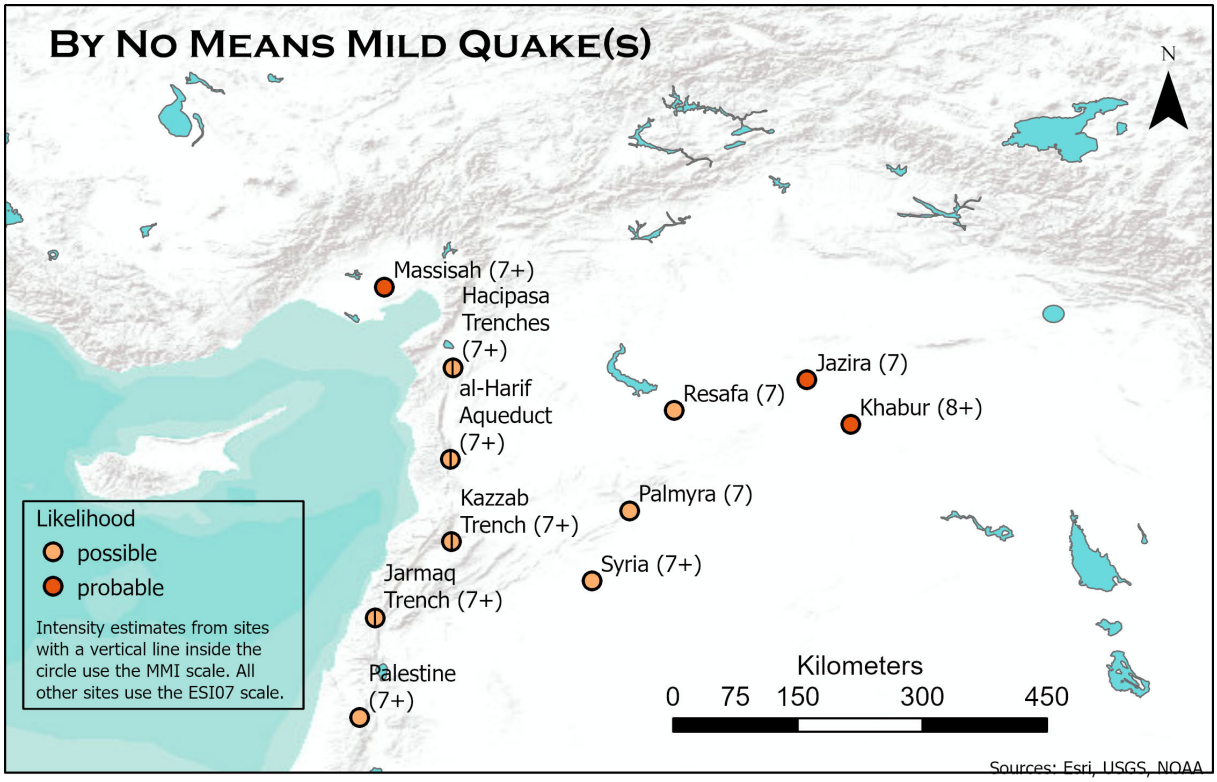

Figure 8. Potential Damage Area for the By No Means Mild Quake(s). Locations are labeled by name followed by estimated Intensity in parentheses. Locations are color coded for likelihood that observed seismic damage is due to one of the mid-8th century earthquakes. Intensities are estimated from Textual Reports, Archaeoseismic, and Paleoseismic evidence.

Corroborating archaeoseismic and paleoseismic evidence for this earthquake(s) (Figure 8) is similar to the Talking Mule Quake (e.g., Palmyra, Resafa, Hacipasa Trenches, al-Harif Aqueduct, the Kazzab Trench, and possibly also the Jarmaq Trench). This is because dating resolution is insufficiently precise to distinguish seismic damage due to an earthquake in 749 CE (Talking Mule Quake) vs. an earthquake in 756 CE (By No Means Mild Quake(s)). Figure 8 includes locations from textual reports by Pseudo-Dionysius (Khabur and Jazira), Theophanes (Syria and Palestine), and Al-Massisah (Mopsuestia) as cited by Le Strange [1905:130-131] and Blochet [1895: 46 n. 3]. The areal extent of these disparate reports indicates that if all the authors accurately reported seismic damage, more than one earthquake had to have been at play.

8. Conclusions

- Archaeoseismic and Paleoseismic evidence indicate that two earthquakes struck the southern Araba in the mid-8th century CE.
  - The earlier earthquake was distant to Ayla, Aila, and the Qatar Trench. Its epicentral region may have been in the Gulf of Aqaba.
  - The latter earthquake struck closer to these locations and, based on Intensity estimates of IX in Ayla [Al-Tarazi and Khorjenkov, 2007], would have been of a significant Magnitude.
- The Sabbatical Year earthquakes appear to have struck within 17 hours of each other in January 749 CE.
  - The Holy Desert Quake likely had a magnitude between 7.0 and 7.5 and an epicentral region around the Sea of Galilee and the northern Jordan Valley. This earthquake appears to have struck on the night of the 16th or 17th of January in 749 CE.

  - The Holy Desert Quake likely generated a destructive seiche in the Sea of Galilee and a destructive tsunami on the Palestinian littoral (see Appendix B). Whether it generated a destructive seiche in the Dead Sea is indeterminate.
  - The Talking Mule Quake appears to have struck on the following morning around 10 am and its epicentral region was likely in northern Syria or Jazira. The areal extent of textual accounts suggest that it was also of a significant Magnitude.
  - Two authors (Elias of Nisibis and Cedrenus) spoke of ~749 CE as being a year in which there were many earthquakes in various places indicating that, at a minimum, the Sabbatical Year Earthquakes were accompanied by significant foreshocks and/or aftershocks and at a maximum other less well documented earthquakes may have struck around this time.
- The By No Means Mild Earthquake struck northern Syria and Jazira in March of 756 CE. It may have induced another earthquake in Syria and Palestine which, based on reports of seismic destruction to Al Aqsa Mosque in Jerusalem, could have occurred up to three decades later.
- The sequence of seismic events in the mid-8th century CE suggests the possibility that an unzipping of much of the Dead Sea Transform occurred within roughly half a century with a significant amount of seismic activity concentrated in the ~7-year period from 749-756 CE. This unzipping may have unfolded from south to north. Such an unzipping has been documented in the opposite direction (north to south) between 1114 and 1212 CE [Ambraseys, 2004].

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A more extensive bibliography can be found in the Supplementary data.

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Appendix A. Halley's Comet of 760 CE

Pseudo-Dionysius of Tell-Mahre described and drew a picture of a comet which appeared in 760 CE which assists in multiple ways

- It dates the By No Means Mild Earthquake to 756 CE.
- It adds further support to Harrak [1999]'s assertion that Pseudo-Dionysius of Tell-Mahre is a contemporaneous source.

In Pseudo-Dionysius' entry for A.G. 1071 (1 October 759 – 30 September 760 CE), we can read in Harrak [1999:198]'s translation:

> The year one thousand and seventy-one: In the month of Adar (March), a shining sign was seen in the sky before dawn on the northeast side which is called Ram in the Zodiac, to the north of the three most shining stars. Its shape resembled a broom. On the twenty-second day of the month, it was still in the Ram at its head, in the first degree (of the Zodiac circle), the second after the wandering stars Kronos and Ares, somehow slightly to the south. The sign remained for fifteen nights, to the eve of the Pentecost feast. At one of its ends, which was narrow and more shining a star was seen and was turning toward the North. The other side, which was large and darker, was turning toward the South. The sign was moving little by little toward the Northeast. This was its form (Fig. A-1):

Figure A-1. Artist's rendition of part of page 136v of the Chronicle of Zuqnin (*Codex Zuqninensis* Vat. sir. 162). Because only one manuscript has been found, this may be the autograph (i.e., the original copy penned by the author). Note that all of page 136v is intact. Digitized Manuscript can be viewed at https://digi.vatlib.it/view/MSS_Vat.sir.162 (navigate to 137r-136v). Illustration painted by the artist Gladys Carolina Williams in 2022.

> On the eve of the third day after Pentecost, the sign was seen again in the evening in the Northwest, and it remained for twenty five evenings. It moved little by little to the South and then it disappeared. Then it reappeared in the southwest, where it in this way for many days. During this time, many schisms took place in the church because of leadership. [Harrak, 1999:198].

Neuhauser et al. [2021] used this description along with Chinese texts describing the same comet to fit a Keplerian orbital solution and showed that this was a description of Halley's Comet (1P/Halley). They obtained a perihelion time of 760 May 19.1 ± 1.7 (UT[1]) and dated the inferior conjunction between the comet and the sun to 760 June 1.8

1 UT = Universal Time – i.e. at 0° longitude (Greenwich, UK). The Zuqnin Monastery would have been about 2.5 hours ahead of UT.

(on a Sunday, UT). During and around the date of the inferior conjunction, the comet would not have been visible in the night sky due to its conjunction with the sun.

A discrepancy in the name of the month when the comet was first observed was discussed by Neuhauser et al. [2021], Hayakawa et al. [2017:11], and others. Pseudo-Dionysius of Tell-Mahre reports that the comet was seen on the 22nd of *ādār* (March), remained visible in the sky for 15 nights until the dawn of the Pentecost, disappeared and then reappeared on the third day after the Pentecost, and then remained visible for another 25 days. Pentecost in Pseudo-Dionysius' Jacobite Church fell on Sunday 1 June in 760 CE [Neuhauser et al., 2021:7] which is 71 days after 22 March; far more than 15. Hayakawa et al. [2017:11] and Neuhauser et al. [2021] suggested that Pseudo-Dionysius of Tell-Mahre (or, less likely, his copyist) made a scribal error miswriting May (*eyar*) as March (*ādār*) as there is only a one letter difference between these months in Syriac (ܐܝܪ vs. ܐܕܪ). If this explanation is accepted, it would appear that Pseudo-Dionysius' observations are compatible with Chinese Records, Neuhauser et al. [2021]'s orbital solution, and Michael the Syrian who also described the comet and placed it in Iyyar (May).

Pseudo-Dionysius dates the By No Means Mild Quake to 3 *Adar* A.G. 1067 which is ~4 years earlier than A.G. 1071 (760 CE). This dates the earthquake to the 3rd of *Adar* in 756 CE – according to Pseudo-Dionysius. Theophanes also mentions the comet in his $A.M._a$ 6252 entry which is also 4 years after his earthquake account in $A.M._a$ 6248. In Mango et al.'s [1997:596-597] translation, we can read Theophanes› description of the comet

> [A.M. 6252, AD 759/60]
>
> – Constantine, 20th year
> – Abdelas, 6th year
> – Paul, 6th year
> – Constantine, 7th year
>
> … In the same year a very bright comet appeared for ten days in the east and another twenty-one days in the west. [Mango et al., 1997:596-597].

Theophanes' regnal years (Constantine, Abdelas, Paul, and Constantine) and his $A.M._a$ date for the By No Means Mild Earthquake entry are all consistently 4 years apart from the comet of 760 CE[2]. Thus, it would appear that Halley's comet of 760 CE also fixes Theophanes earthquake date to 756 CE.

2 Typically, one can come up with a spread of years from any entry from Theophanes if one looks at his dates for $A.M._a$, regnal years, and reported historical events. However, with the comet as a chronological anchor, the spread in dates collapses for the By No Means Mild earthquake to (March) 756 CE.

Appendix B. Coastal Tsunami

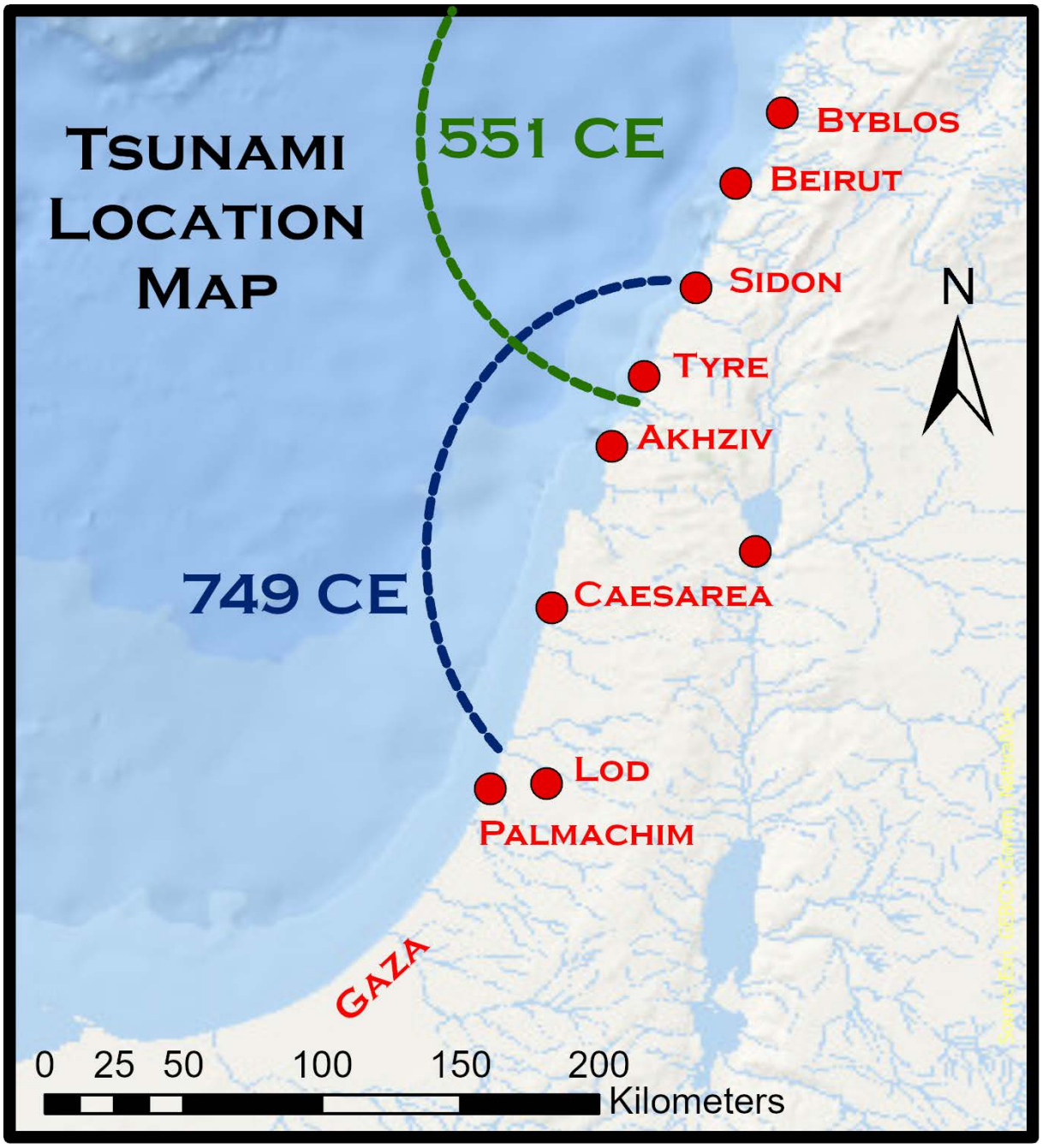

Figure B-1. Tsunami Location Map. The green dotted line marks a boundary 100 km away from the presumed epicenter of the 551 CE Beirut Earthquake [Epicenter from Elias et al., 2007]. The blue dotted line marks the 100 km boundary from the epicentral region of the 749 CE Holy Desert Earthquake using a point location near Al-Sinnabra where the Jordan River intersects the Sea of Galilee (see lower right inset of Fig. 1a for location). A forthcoming publication should refine the epicentral region and magnitude range for the Holy Desert Quake. These boundary lines encase a "sweet spot" for tsunamis generated by offshore slope failures (i.e., underwater landslides).

Goodman-Tchernov et al. [2009] identified tsunamites in cores taken immediately offshore of the harbor of Caesarea which Goodman-Tchernov and Austin [2015] dated to the ~5th-~8th century CE and associated with tsunamis generated by the Beirut Quake of 551 CE and one of the Sabbatical Year Quakes of 749 CE. Tyuleneva et al. [2018] identified what appears to be the same tsunamite in a core (Jisr al-Zarka 6) taken offshore of nearby Jisr al-Zakra. This core was located ~1.5-4.5 km north of the Caesarea cores. The tsunamite deposit from Jisr al-Zarka was more

tightly dated to 658-781 CE (1292-1169 Cal BP) – within the time window for the Holy Desert Quake. Although earlier publications assigned the 5th-8th century tsunamite deposit from Caesarea solely to the Beirut Quake of 551 CE, later revisions assigned this offshore deposit to one of the Sabbatical Year Quakes with the suggestion that the Sabbatical Year Quake tsunami deposit may contain some reworked tsunamites from the 551 CE Beirut Quake. The chronology of the cores was determined using an assemblage of ceramic finds, radiocarbon, and optically stimulated luminescence (OSL) dating. Multiple indicators were used to distinguish tsunami deposits from storm deposits. Particle size distributions were shown to be particularly helpful. Tsunami horizons were characterized by a wider range of grain sizes and poorer sorting. Goodman-Tchernov and Austin [2015] also discovered a potential tsunami deposit in the shallow intermediate harbor of Caesarea[3] and Dey et al. [2014] reassessed archeologic evidence from previous excavations and found what may be to be a landward tsunami deposit in Caesarea which dated to between ca. 500 CE and 870 CE while ʻAd et al. [2018] and Everhardt et al. [2023] identified what appears to be a tsunamite deposit in a then abandoned "warehouse" (area LL) located just north of Caesarea's inner harbor. This well dated deposit[4] was associated with burn evidence and a collapse where the "original order of the courses of the wall or vault could be clearly identified [see Fig. 8 in ʻAd et al., 2018]" adding confidence that an earthquake and tsunami successively struck the site betwixt which a seismically induced fire ravaged the warehouse before it was extinguished by the incoming wave.

A number of sources[5] stated or implied that a tsunami struck Beirut and parts of the Phoenician littoral in 551 CE and apparent tsunamigenic deposits from the 551 CE earthquake were found in Beirut [Marriner et al., 2008]. Such deposits were not found in Tyre[6] [Marriner et al., 2005], Sidon[6] [Marriner et al., 2006 and Carayon and Marriner, 2011], and Byblos [Carayon and Marriner, 2011]. This, along with reports in half a dozen sources[7] that the sea withdrew before striking Beirut, suggests that the 551 CE Beirut Tsunami was generated by shelf collapse – i.e., an underwater landslide. Landslide tsunamis can be very destructive in the near field but do not typically create a wide geography of destruction. Thus, it seems unlikely that the 551 CE Beirut tsunami struck Caesarea – ~198 km to the south. However, it is possible that shaking from the 551 CE Beirut earthquake generated a tsunami in Caesarea via localized offshore shelf collapse.

Whether a seismic break on land will generate an offshore slope failure that produces a coastal tsunami is affected by a wide array of factors, but one requirement is that a slope capable of failure must be present. This requirement appears to be satisfied. Dey et al. [2014] noted the presence of continuous offshore slope breaks from Akhziv to Gaza. Dey et al. [2014] also noted that underwater slumps have been identified off the coast of Akhziv and Palmachim. Salamon and di Manna [2019] curated a dataset to produce a bounding envelope which allows one to estimate if a seismogenically generated tsunami is within the realm of possibility for a given earthquake. Figure B-2 shows such bounding envelopes where points that plot to the right and below the curved blue lines represent Magnitudes and Distances of known earthquakes which generated tsunamis and points that plot above and to the left of the bounding lines represent Magnitude-Distance combinations where seismogenically generated tsunamis have not been observed to occur. Superimposed on the plot is a green line representing the distance from the presumed epicenter of the 551 CE Beirut Earthquake to Caesarea [according to Elias et al., 2007]. The blue rectangle on the plot represents a range of likely distances from Caesarea to either the nearest postulated fault break (~65-75 km) or the epicenter of the Holy Desert Quake (~85 km)[8].

3 Goodman-Tchernov and Austin [2015:452] report that excavations in the shallow intermediate harbor (TN area, Fig. 1C; Reinhardt and Raban, 2008:155-182) uncovered an extensive deposit of Byzantine-Early Islamic (4th-8th century CE) refuse that they suggested, due to its contents (domestic, commercial and religious including high value personal items along with broad harbor refuse) and the varying state and exposure of the items, was a result of a non-deliberate rapid burial such as would be expected from a tsunami event. They noted that no distinctive stratigraphy separates what could have been two distinct tsunami events and that the ceramics ranged in age from late Byzantine to Early Islamic (6th-8th century CE).

4 Ceramics dated the collapse as coming from the last half of the Umayyad period and before an Abbasid construction [ʻAd et al., 2018]. Radiocarbon dates from the top centimeters of the destruction debris dated to between 605 and 779 CE [Everhardt et al., 2023].

5 Theophanes, Malalas, Cedrenus, John of Ephesus, Pseudo-Dionysius of Tell-Mahre, Michael the Syrian, Bar Hebraeus, and a Hagiography of Symeon.

6 Age-Depth anomalies in the cores taken from the harbors of Tyre and Sidon may indicate that subsequent dredging operations removed potential tsunamogenic evidence [Marriner et al., 2006:1521].

7 Theophanes, Malalas, Cedrenus, John of Ephesus, Pseudo-Dionysius of Tell-Mahre, Michael the Syrian, and a Hagiography of Symeon.

8 Distances were estimated based on an epicenter near Al-Sinnabra and a fault distance measured from the Jordan Valley Boundary Fault.

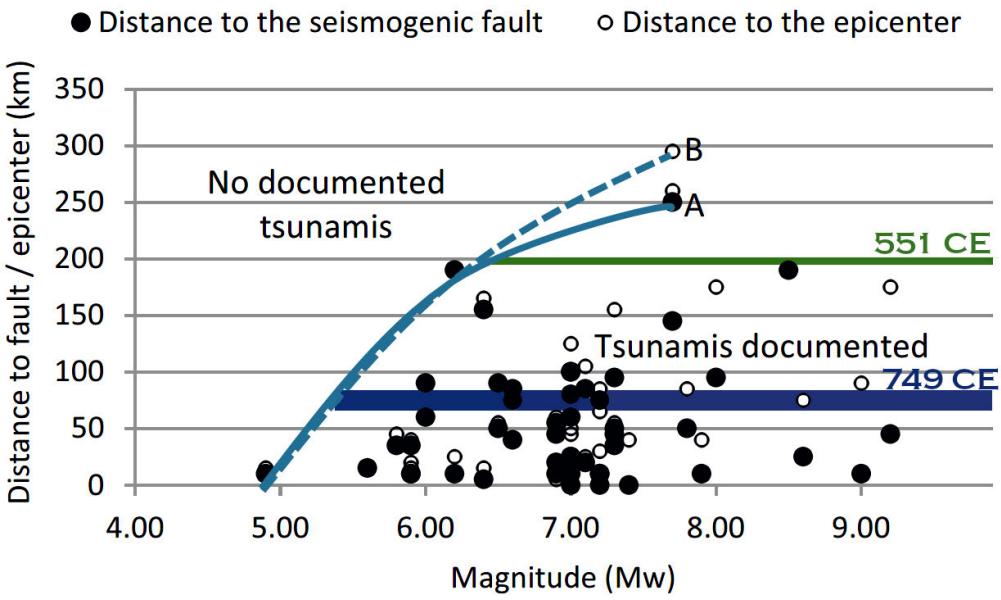

Figure B-2. Empirical 'Magnitude-Distance' bounding envelopes for tsunamis generated by seismogenic submarine landslides. Line A is the bounding envelope for fault distance – the maximum distance between the seismogenic fault and the subsea landslide scar. The dashed line is the bounding envelope for epicentral distance – the maximum distance between the seismogenic epicenter and the subsea landslide scar. Circles represent earthquakes which generated seismogenic tsunamis where the magnitude is known as well as the epicentral distance or fault distance. Filled circles represent fault distance and empty circles represent epicentral distance. The green line represents epicentral distance from Caesarea to the 551 CE Beirut Quake epicenter as postulated by Elias et al. [2007]. The horizontal blue rectangle represents a range of distances from Caesarea for either the fault distance or an epicentral distance postulated for the Holy Desert Quake. Modified from Salamon and di Manna [2019].

The plot indicates that a seismogenic submarine landslide due to the 749 CE Holy Desert Earthquake is within the realm of possibility for the estimated magnitude of this event – M_w between 7.0 and 7.5. The plot indicates that a seismogenic submarine landslide due to the 551 CE Beirut Earthquake Quake is also within the realm of possibility for the estimated Magnitude of that event – M_w between 7.4 and 7. 6 [Elias et al., 2007]. However, it is notable that the blue 749 CE rectangle is accompanied by many more documented Magnitude-Distance combinations than the green 551 CE line. The Holy Desert Quake appears to be in a "sweet spot" where tsunamis are more likely. Since this sweet spot appears to be defined by distances of ~100 km or less, 100 km boundaries for each respective earthquake were drawn on the Tsunami Location Map in Fig. B-1.

There is a significant amount of supporting evidence that suggests that the Holy Desert Quake generated a coastal tsunami. Well dated archaeoseismic evidence from Lod [Gorzalczany, 2009b and Gorzalczany and Salamon, 2018] indicates strong bedrock shaking (I = 7) and liquefaction was experienced on the coast during the Holy Desert Quake – shaking that appears to have been sufficiently energetic to have initiated a submarine landslide. This is corroborated by Agapius of Menbij who reported a violent earthquake was experienced in coastal Palestine. Coptic sources al-Muqaffa', al-Makin, and Chronicon Orientale, reporting from the Nile Delta, all stated that many ships sank during the Holy Desert Quake. This would likely refer to ships near the coastline (some anchored) which would have been affected by a tsunami. The Piyyut *Ra'ash Shvi'it* mentions women and children drowning; possibly in coastal areas and possibly in the Sea of Galilee[9]. Michael the Syrian described a "storm in the Sea" which is repeated in Chronicon Ad Annum 1234. Neither of these last two accounts specify a location and their accounts could suggest

9 Karcz [2004:785] and Ambraseys [2005:118] noted that while flooding specified in the plain of Sharon in *Ra'ash Shvi'it* would specify Israel's coastal plain in the modern lexicon, this geographic designation could, at the time of composition, have referred to parts of the Jordan and Yizrael (aka Esdraelon) Valleys (e.g., by Eusebius in the 4th century CE).

seiches in the Sea of Galilee and/or the Dead Sea. When all the evidence is combined, it appears that a destructive tsunami struck the coast due to shaking from the Holy Desert Quake in 749 CE.

Notes

– Theophanes reports a sizeable volcanic eruption in Indiction 9 and A.M.$_a$ 6218 (726 CE) between the islands of Thera and Therasia in the Aegean which could have generated a tsunami that impacted Caesarea.

Appendix C. Faults of the Dead Sea Transform

Fault	Abbr	Sources
Abed El Aziz Faults	ABZ	Abdul-Wahed and Al-Tahhan [2010] – simplified – locations are approximate
Amatzyahu Fault	AMTZ	Sharon et al. [2020]
Araba Fault	ARB	Klinger et al. [2015] after Le Beon et al. [2011] – some parts inferred
Aragonese Fault	ARG	Hartman et al. [2014] and Sharon et al. [2020]
Avrona Fault	AVR	Sharon et al. [2020] and Klinger et al. [2015] after Le Beon et al. [2011] – inferred in the Gulf of Aqaba according to Sharon et al. [2020]
Bassit Fault	BST	Sbeinati et al. [2010] – inferred to the SW and NE
Capharnaum Trough Fault	CPTR	Gasperini et al. [2020]
Carmel Gilboa Fault	CRMGL	Ferrario et al. [2020] and Gasperini et al. [2020] – inferred to the E and in the middle
Dakar Fault	DKR	Hartman et al. [2014] and Sharon et al. [2020]
Damascus Fault	DMSCS	Nemer et al. [2008] modified from McBride et al. [1990] – some parts inferred
Dead Sea Eastern Fault	DSE	Sharon et al. [2020] inferred
Dead Sea Western Fault	DSW	Sharon et al. [2020] inferred
East Anatolian Fault	EAN	Sbeinati et al. [2010] and Meghraoui [2015] – aka Karatas-Osmaniye Fault W of Karasu Fault
Elat Fault	ELAT	Sharon et al. [2020] and Hartman et al. [2014]
En Boqeq Fault	ENB	Ginzburg et al. [2007] inferred
En Gedi Fault	ENG	modified from Ben-Avraham et al. [2012]
Hakipasa Fault	HKP	Sbeinati et al. [2010] and Akyuz et al. [2006] – inferred N or former Lake Amik

Fault	Abbr	Sources
Hasbaya Fault	HSB	Sharon et al. [2020]
Hula Valley Fault	HVF	Wechsler et al. [2018] – named by Jefferson Williams
Isfia-Shalale Fault	ISFSH	Sharon et al. [2020]
Jericho Fault	JRC	Ferry et al. [2011]
Jordan Gorge Fault	JGRG	Wechsler et al. [2018] – south part of fault in Sea of Galilee is inferred
Jordan Valley Boundary Fault	JVBF	Ferrario et al. [2020]
Jordan Valley Fault	JV	Ferry et al. [2011] and Gasperini et al. [2020]
Kalia Fault	KAL	modified from Ben-Avraham et al. [2008]
Karasu Fault	KRSU	Sbeinati et al. [2010] – some parts inferred – southernmost segment also known as the Antakya Fault
Manbeg Faults	MNBG	Brew et al. [2000]
Mount Lebanon Thrust	MTLT	Elias et al. [2007] and Daeron et al. [2007] – simplification of multiple thrust faults
Nesher Fault	NSH	Sharon et al. [2020]
Rachaya Fault	RCH	Wechsler et al. [2018], Sharon et al. [2020], and Daeron et al. [2007]
Roum Fault	ROUM	Nemer and Meghraoui [2006] and Nemer et al. [2008] modified from McBride et al. [1990] – some parts inferred
S Gulf of Aqaba Fault	SGOA	Hartman et al. [2014] – extension south of Tiran Island speculated
Sea of Galilee Boundary Fault East	SGBE	Wechsler et al. [2018]
Serghaya Fault	SRG	Sharon et al. [2020]. Daeron et al. [2007] for north part
Southeast Anatolian Thrust Zone	SEAT	Meghraoui [2015] – aka Bitlis Suture
Strand of Jericho Fault	JFSTR	modified from Ben-Avraham et al. [2008]
West Dead Sea Boundary Fault	WDSBF	Salamon [2004] – potentially Active Faults on the W side of the Dead Sea
Yammouneh Fault	YAM	Sharon et al. [2020], Daeron et al. [2007], and Sbeinati et al. [2010] – some parts inferred – includes Missyaf segment