Natural Hazards
https://doi.org/10.1007/s11069-022-05736-7

ORIGINAL PAPER

Historical earthquakes, tsunamis, volcanic eruptions and comets in the eastern Mediterranean and the Sinai sub-plate: evidence from two little-known Greek documents

Ioanna Triantafyllou[1,3] · **Athanassios C. Katsiyannis**[2] · **Gerassimos A. Papadopoulos**[3]

Received: 7 April 2022 / Accepted: 22 November 2022

Abstract
The eastern Mediterranean region is characterized by high seismicity which has been documented by instrumental data and historical reporting. Strong submarine or coastal earthquakes often are associated by tsunami waves. We improve the earthquake and tsunami historical documentation in the eastern Mediterranean, including the Sinai sub-plate, with the study of two Greek documents that remained little-known to the seismological community. The first document is the *Historia chronike* written by the Byzantine chronicler John (Ioannis) of Antioch during the AD seventh century. The second is the book *Epitome of Holly and Secular History of Sinai*, written by Patriarch Nektarios during the seventeenth century. Both documents provide new information about earthquakes, tsunamis, one volcanic eruption and comets observed in the eastern Mediterranean region in various time periods. New evidence is presented about the puzzling earthquake and tsunami that caused destruction in Phoenicia in 138/135 BC, the AD 634 Palestine damaging earthquake, the tephra fall which was associated with a small volcanic eruption in NW Arabia in AD 639/640, the AD mid-eighth century destructive earthquakes in Palestine and Jordan and an associated destructive tsunami in the coast of Phoenicia. New information is revealed about the very little-known earthquakes of AD 1091 and the damaging seismic sequence of AD 1212 (or 1312) in St. Catherine's Monastery in Sinai. The synchronization of some earthquake events with astronomical phenomena, like the apparition of comets and sun eclipses, supported dating the events more precisely.

Keywords Comets · Eastern Mediterranean · Historical earthquakes · Sinai sub-plate · Tsunamis · Volcanic eruptions

✉ Ioanna Triantafyllou
ioannatriantafyllou@yahoo.gr

[1] Department of Geology and Geoenvironment, National and Kapodistrian University of Athens, 15772 Athens, Greece

[2] Royal Observatory of Belgium, Solar-Terrestrial Center of Excellence, Avenue Circulaire 3, 1180 Ukkel, Belgium

[3] International Society for the Prevention & Mitigation of Natural Hazards, 10681 Athens, Greece

Published online: 03 December 2022

1 Introduction

The eastern Mediterranean region (Fig. 1) is characterized by complex plate tectonics which is dominated by (1) the active subduction of the Mediterranean lithosphere beneath the Hellenic and the Cyprian Arcs from about SSW to NNE, (2) the northwards motion of the Arabian plate, which is taken up along the ~ N-S trending sinistral strike-slip Dead Sea Transform Fault (DSTF) and (3) the subsequent westward extrusion of the Anatolia continental block along the dextral strike-slip North Anatolian Fault (NAF) (e.g. McKenzie 1972; Dewey and Şengör 1979; Le Pichon and Angelier 1979; Le Pichon et al. 1982; Rotstein and Kafka 1982; Mascle and Martin 1990; Jackson 1992; Meijer and Wortel 1997; Garfunkel 1998; Robertson 1998; McClusky et al. 2000; Jolivet 2001; Kreemer and Chamot-Rooke 2004; Reilinger et al. 2006, 2010; Bocchini et al. 2018; Mantovani et al. 2022). The main geotectonic structures of the Hellenic Arc, the Cyprian Arc, the DSTF and the NAF, all are of high seismicity, which is reflected not only in the instrumental records and the historical documentation but also in archaeological and palaeoseismological evidence (e.g. Ben-Menahem et al. 1977; Ben-Menahem 1979, 1991; Poirier and Taher 1980; Ambraseys and Melville 1989; Ambraseys et al. 1994; Amiran et al. 1994; Guidoboni et al. 1994; Marco et al. 1996; Galli 1997; Papazachos and Papazachou 1997; Nur and Cline 2000; Hartleb et al. 2003; Riad et al. 2004; Guidoboni and Comastri 2005; Abdel-Rahman et al. 2009; Ambraseys 2009; Kagan et al. 2011; Papadopoulos 2011; Grünthal and Wahlström 2012; Stucchi et al. 2013; Agnon 2014; El-Isa et al. 2015; Zohar et al. 2017). The tsunami activity is also considerable in the basin of the eastern Mediterranean (e.g. Galanopoulos 1960; Ambraseys 1962; Antonopoulos 1979; Papadopoulos and Chalkis 1984;

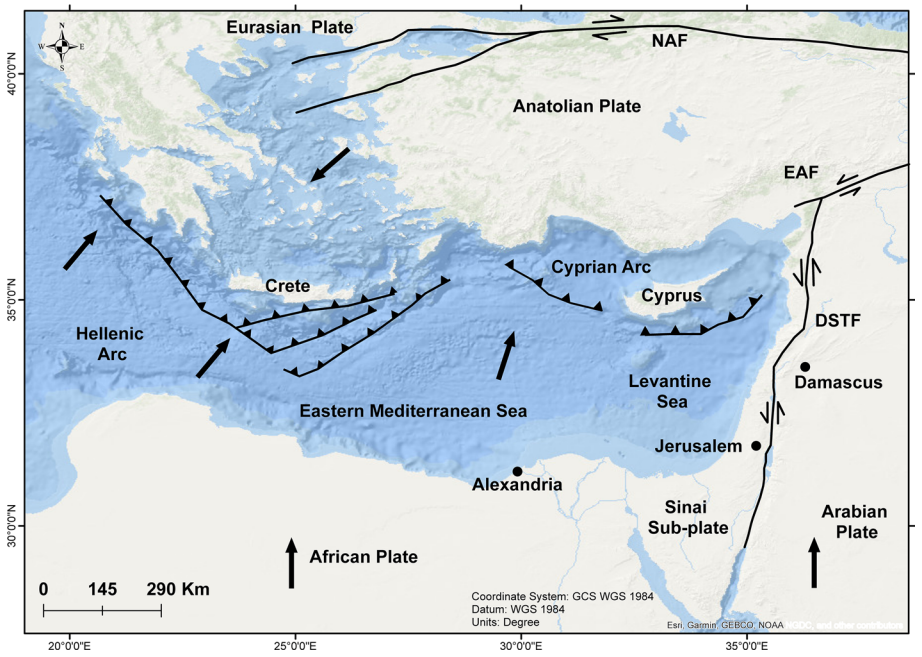

Fig. 1 Seismotectonics of the eastern Mediterranean region. Key; NAF = North Anatolian Fault; EAF = East Anatolian Fault; DSTF = Dead Sea Transform Fault; arrows show plate motions

Soloviev et al. 2000; Fokaefs and Papadopoulos 2007; Papadopoulos et al. 2007, 2012, 2014; Yolsal et al. 2007; Papadopoulos 2009, 2011, 2016; Maramai et al. 2014).

A distinct element of the eastern Mediterranean plate tectonics is the Sinai sub-plate, which is situated at the juncture of the African, Arabian and Anatolian plates (Fig. 1) (e.g., McKenzie 1970; Le Pichon and Francheteau 1978; Salamon et al. 1996, 2003) and has been considered as a splinter of Africa (Ben-Menahem et al. 1976). The Sinai sub-plate, however, is hardly distinguished, since its seismicity, volcanism and topography are only of secondary magnitude (Salamon et al. 2003). Historical evidence for geodynamic phenomena, such as earthquakes, occurring in Sinai is very scarce. From this point of view, documents providing new evidence regarding geodynamic phenomena in the Sinai peninsula is of particular interest. This is the case of a little-known Greek book written in Sinai during the AD seventeenth century under the title *Επιτομή Ιεροκοσμικής Ιστορίας (Epitome of Holly and Secular History,* Nektarios, last edition 1990). The book contains new information for various geodynamic phenomena, i.e., earthquakes, tsunamis and volcanic eruptions, occurring not only in the Sinai area but also in the entire eastern Mediterranean region from the AD seventh to 16th centuries. In addition, this book is also referring to phenomena of astronomical interest, such as comets observed from the eastern Mediterranean and the Middle East region often in synchronization with earthquakes.

Another little-known Greek document is the *Historia chronike,* which was written during the AD seventh century by the Byzantine chronicler John (Ioannis) of Antioch. An excerpt of this document, published by the eminent Greek historian Lampros (1904), refers to a mid-second century BC destructive and tsunamigenic earthquake that occurred in the Levantine Sea area, as well as to a comet which was visible close to the earthquake time. However, this document remained unknown to the seismological tradition.

In this paper the *Historia chronike* and *Epitome* are first presented as for their content and reliability. Then, extracts referring to geodynamic and astronomical phenomena are compiled in chronological order, cross-checked with other relevant documentary sources and discussed critically. This collection enhances the historical documentation of the relevant phenomena in Sinai and in the rest part of the eastern Mediterranean. Afterwards the two documents will be called *Historia chronike* and *Epitome*, respectively, for reasons of brevity.

2 The documents and their sources

2.1 Historia chronike

Historia chronike is an universal history for the time period extending from Adam to the death of the Byzantine Emperor Phocas (AD 547–610). The sources used by John of Antioch included, among others, Sextus Julius Africanus, Eusebius, Ammianus Marcellinus, Malalas and Flavius Eutropius. By the end of the 19th century, S. Lampros performed an investigation in the Iviron Monastery, Mt. Athos, and discovered fragments of the *Historia chronike,* which were not included in the classical collection *Fragmenta Historicorum Graecorum* (1841–1873) compiled by Müller (1883). The new fragments of *Historia chronike* were published in Greek by Lampros himself (1904). The extract, which is of interest here, comes from book 4. Although two editions of *Historia chronike* fragments appeared more recently (Roberto 2005; Mariev 2006) both diverge so profoundly in their

treatment of the fragments (van Nuffelen 2012). Therefore, we used the fragment published by Lampros (1904), which is considered as authentic anyway.

2.2 Epitome

Epitome is a rare title in the Greek literature written by the Bishop of Jerusalem Nektarios originated from Crete Isl., Greece. The book was first published in Venice in AD 1677 and got another six republications until 1900. This book contains plenty of information about the religious and cosmic (secular) history of Sinai and of the eastern Mediterranean. The copy used in our paper was published in 1990 and constitutes an anastatic (resurrection) publication of the 1900 edition. The *Epitome* and the documentary sources used by Nektarios are reviewed in a valuable article authored by the historian Manousakas (1947). In the next lines of this section the main points of the Manousakas' (1947) review are summarized since they are useful to better understand the author Nektarios, the documentary sources he used as well as the structure and content of *Epitome*.

Nektarios (AD 1602–1676), Bishop of Jerusalem (AD 1661–1669), has been one of the most eminent theologians of the Orthodox Eastern Church. *Epitome* was written after AD 1651 when Nektarios returned from Moldovlachia to get monastic life in the St. Catherine's Monastery in Sinai. Writing of *Epitome* terminated between AD 1659 and 1660 before the enthronement of Nektarios as Bishop of Jerusalem. The first edition, however, appeared in AD 1677, that is after Nektarios passed away.

Epitome is structured in five Parts. Part A is about the life of Moses, while Parts B and Γ are devoted to the main theme, which is the history of Mt. Sinai and St. Catherine's Monastery situated at the southern side of the peninsula (Fig. 2). The history of Egypt from the antiquity up to the era of Sultan Selim the 1st is the content of Part Δ, while the conquest of Egypt by Selim in AD 1517 is examined in Part E. It is evident that the first three Parts are about the religious history (*Hiero-Ιερό*), while the rest two are devoted to the secular (*Cosmic-Κοσμική)* history.

Information sources used by Nektarios were retrieved from the rich library maintained in Sinai Monastery. In Particular, in Part B Nektarios used, among other sources, a document called *Arabic Chronographer*, which according to Manousakas (1947) is the chronicle of the Arab historian Georgios al-Makin. The full name of Georgios al-Makin was Girgis ibn Abi ΄l-Jâsir ibn Abi ΄l-Makârim al Makin ibn al Amîd. Georgios was born in Cairo either in a.H. 605/AD 1208 or in a.H. 625/AD 1228 and passed away in Damascus in AD 1273. The *Arabic Chronographer* was extensively used in Part Δ too. In Part Γ of special interest is the description of an earthquake which according to Nektarios occurred in Sinai in 1312. Information source is a document called *Αραβικός Συναξαριστής* (*Arabic Synaxarium, i.e. Legend Book*) found in the Monastery's library. The main source for Part E is the Italian historian Paolo Giovio (AD 1483–1552), one of the most important historians of the Renaissance.

Regarding the style of the Greek language selected by Nektarios to use in *Epitome*, Manousakas (1947) attracted the reader's attention to a note that can be found in the Headline of Part A, where Nektarios explained that *Epitome* is composed by a "*common language*" with the purpose to make *Epitome* understandable "*by every Greek human being*". For event dates Nektarios used either Greek or Arabic characters but the chronology style varies in the several parts of *Epitome*. Nektarios used either Anno Domini (AD) calendar or Hegira calendar (a.H.).

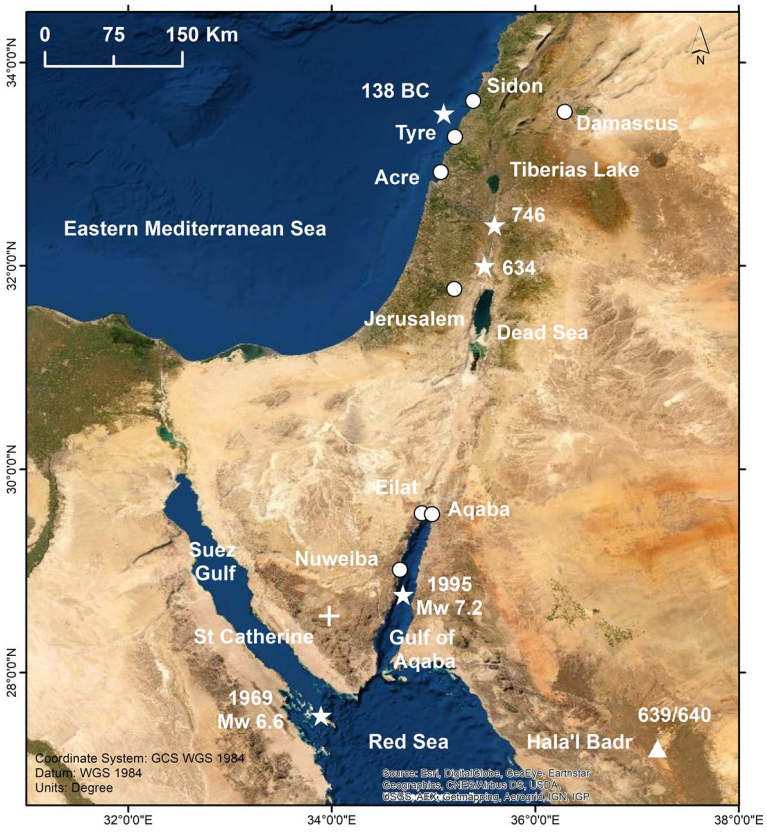

Fig. 2 Epicenters (stars) of the main earthquakes and places (white circles) reported in the text. Key: triangle shows position of volcanic eruption; years of earthquake occurrences and of eruption are in AD unless otherwise indicated; cross shows the St. Catherine's monastery

In the next section, the examination of the natural phenomena described in *Historia chronike* and in *Epitome* follows a chronological order. Quotations from these two documents are given in italics. Our short notes, when needed, are inserted in brackets; e.g., in the statement "*After the death of Mohammed [AD 8 June 632] a great fire appeared…"* the note in brackets has been inserted by us.

3 Natural phenomena in *Historia chronike*

3.1 c.138 BC: earthquake, tsunami and a comet in Phoenicia

3.1.1 Earthquake and tsunami event

Dispute prevails among researchers (Table 1) as regards the occurrence of an earthquake and tsunami event in the Levantine Sea in about the mid-second century BC (e.g., see reviews in Fokaefs and Papadopoulos 2007; Salamon et al. 2007; Ambraseys 2009). In the historical earthquake book by Guidoboni et al. (1994), which gets wide recognition, the

Table 1 Data about the mid-second century BC earthquake and tsunami in the Levantine Sea

Year (BC)	Area	R	I_m	k	K	Note	Ref
138	Levantine Sea			4		Tsunami	An
138	Levantine Sea					Tsunami	So
~140	Levantine Sea						K
140±2	Levantine Sea	2		?	?	Tsunami	FP
143/2	Akko, Tyre					Tsunami	Sa
139(?)	Ptolemais (Acre or Akko)					Sea flood, no evidence for earthquake	Am
138						No tsunami	Ma
141	Levantine Sea	2		4		Tsunami	Ma
Between summer 138 and September 135	South Syria and Phoenicia	3	9±1		8±1	Earthquake (south Syria, Sidon, Tyre) and tsunami (Tyre, Ptolemais)	Pp

Symbol key: R = reliability score in a 4-degree scale, where R = 1 and R = 4 stand for unlike and certain event, respectively; I_m = maximum seismic intensity in MMI scale; k = tsunami intensity in Sieberg's (1927) 6-degree scale; K = tsunami intensity in the 12-degree scale by Papadopoulos and Imamura (2001). References key: An = Antonopoulos (1979), So = Soloviev et al. (2000), K = Karcz (2004), FP = Fokaefs and Papadopoulos (2007), Sa = Salamon et al. (2007), Am = Ambraseys (2009), Ma = Maramai et al. (2014), Pp = Present paper

event is not listed. The dating of the event is a puzzling issue (Table 1) as it ranges from 143 to 138 BC depending on the interpretations given by various authors. Besides, Ambraseys (2009) doubts about the physical connection of the tsunami-like sea flood with an earthquake. As a contribution to dissolve the dispute we utilize for the first time a relevant passage from the *Historia chronike* and compares it with descriptions which are provided by other classical sources.

From *Historia chronike* we learn that *"Antiochus, the so-called Cyzicenus, was sovereign of Syria. During his reign, because of the occurrence of a great earthquake that happened towards the east, many myriads of Syrians killed and the seaside of Tyre inundated by the sea; and a comet that glowed for a few days foretold his death*".

Lampros (1904) wondered if the earthquake described in *Historia chronike* is the one reported by Posidonius who lived from c.135 BC to c.51 BC. Posidonius' fragments have been survived through Strabo (63 BC–AD 23) who in his Geography (A, III, 16) copied Posidonius as follows: "*In Phoenicia an earthquake happened that swallowed up a city built beyond Sidon [possibly Tyre or Ptolemais]; and the two thirds of Sidon itself fell but not at once and, therefore, not so many people killed. The disaster reached up to Syria but with less intensity"*.

The Posidonius' story does not provide evidence for dating the event. However, such an evidence comes from an independent account by Strabo (Geography, Δ, XVI, 2): "*A very rare and paradox suffering is reported in the seaside between Tyre and Ptolemais. The Ptolemeans, after having a battle with Sarpedon the general, were left in this place, in the aftermath of a brilliant rout. Then, a flood-like wave from the sea inundated the fugitives, while others were carried off and lost into the open sea; others left dead in hollow places. When the flood was succeeded by the ebb, dead bodies of men mix with dead fish were revealed"*. A similar description can be found in book 8 of Deipnosophistae (Scholars at the Dinner Table), an early AD 3rd-century Greek work written by Athenaeus of Naucratis (AD end 2nd-early 3rd century): "*Nor do I ignore the account given by Posidonius*

the Stoic…Tryphon of Apamea, who had taken possession of the kingdom of Syria, was attacked, general of Demetrius, close to Ptolemais. Sarpedon defeated was retreating to the center of the land, while Tryphon, with his victorious troop, was following the edge of the sea, when suddenly the wave rose and precipitated on earth an enormous wave which covered the whole troop, causing it to perish, submerged, and leaves in withdrawing a considerable heap of fish, with the corpses".

To unlock the possible interrelation between the different descriptions provided by different authors who wrote in different time periods we will first examine the sequence of the natural phenomena and then the issue of their dating.

Classical sources provide a puzzling picture as regards the occurrence of an earthquake and tsunami in the coastal zone of Phoenicia around mid-second century BC. Strabo and Athinaios, referred to a strong tsunami that inundated the coastal stretch between Ptolemais (Acre or Akko) and Tyre (Sur). In another account of Strabo, however, only an earthquake is reported in the same area. Modern authors, e.g., Antonopoulos (1973) and Ben-Menahem (1979), noted that the classical sources did not associate the tsunami with a causative earthquake and, therefore, suggested that a possible explanation might be the occurrence of a distant earthquake, e.g., in the Hellenic Arc, that passed unnoticed in Phoenicia. Ambraseys (2009) wondered if an earthquake occurred at all, thus leaving unexplained the tsunami-like sea flood in the area. Under these circumstances the Phoenicia earthquake and tsunami event was assigned reliability of only 2 in a scale ranging from 1 to 4 (Table 1). However, *Historia chronike* provides a more complete picture since it refers to both the earthquake and the ensuing tsunami. Consequently, we upgraded the reliability of that event to at least 3. We also considered that the most likely scenario should include a destructive earthquake, that ruptured possibly offshore but close to the Phoenician coastal zone, and a tsunami that inundated the same area with destructive effects.

The occurrence of a strong seismic tsunami in the Phoenician coast is not unlike, although this area is considered as of relatively low tsunami potential (Fokaefs and Papadopoulos 2007). As a matter of fact, on AD 9 July 551 a large submarine earthquake (Darawcheh et al. 2000), very likely caused by thrust faulting (Elias et al. 2007), set-up a powerful tsunami along the coastal segment that was hit by the mid-second century BC tsunami. Another example is the AD mid-eighth century seismic tsunami examined later.

Taking the documentary sources in a chronological order, we realize that according to Posidonius' description the earthquake caused destruction with effects increasing from north to south, namely from Syria to Sidon and to Tyre or Ptolemais, if one of the last two was the city "beyond Sidon" (Fig. 2). In the accounts by Strabo and Athenaeus, however, no earthquake is reported, only a severe sequence of sea inundation and ebb that caused the death of many people. But again, this event occurred along the Phoenician coast, particularly in the seaside segment extended from Tyre to the north up to Ptolemais in the south. The description of flood and ebb and their catastrophic consequences contain features that fit quite well to a tsunami attack.

It is noteworthy that the geographical area of the tsunami attack is coincident with the meizoseismal area of the earthquake, i.e., the area that suffered the main earthquake impact. This implies that there should be a physical connection between the earthquake and the tsunami, thus minimizing the possibility to interpret the tsunami generation by an aseismic mechanism, e.g., coastal or submarine landslide. This issue is illuminated by the *Historia chronike,* a document referring to both the destructive earthquake and the subsequent tsunami attack in the same area that was reported by the earlier documents. A reasonable interpretation is that a large magnitude earthquake ruptured along the Phoenician coastal zone and triggered a powerful tsunami.

3.2 A comet and the dating issue

The issue of dating the earthquake and tsunami event is puzzling. Strabo narrates that the event happened just after the battle of Ptolemeans under Diodotus Tryphon against general Sarpedon. From historiographic analysis it has been suggested that the battle may have taken place between 138 and 125 BC (Ambraseys 2009), although another analysis puts the battle in July/August 138 BC (see about Diodotus Tryphon in https://www.livius.org/category/hellenistic/, access on 6 Apr. 2022). On the other hand, the comet's apparition reported by *Historia chronike* constitutes a *terminus ante quem* for the earthquake and tsunami event. The so-called Mithridates' comet, observed in the SE Asia as well as in the Mediterranean region during September 135 BC (Yoke 1962; Seargent 2008), is possibly the comet reported in *Historia chronike* since it has been the closest in time. The so-called 2nd Mithridates' comet, recorded in Greco-Roman sources (Ramsey 2007) appeared in 119 BC but it is not close in time.

An issue that needs further examination is that in *Historia chronike* it is reported that the earthquake event occurred during the reign (129–96 BC) of Antiochus Cyzicenus. If it is true then the *terminus ante quem* is shifted much later, thus contradicting the dating implied by the account of Strabo. The contradiction is resolved if John of Antioch, when writing *Historia chronike* had in mind Antiochus VII Euergetes, nicknamed Sidetes, who was father of Antiochus Cyzicenus. Antiochus VII Sidetes was ruler of the Hellenistic Seleucid Empire and reigned from July/August 138 to 129 BC. Under these circumstances we arrive at the conclusion that the earthquake and tsunami event likely occurred between the Ptolemais battle in the summer of 138 BC and the comet's apparition in September 135 BC.

4 Natural phenomena in *Epitome*

4.1 AD 634 earthquake in Palestine synchronized with astronomical phenomena

In Part Δ of *Epitome*, Nektarios narrates the appearance of a comet: "*After the death of Mohammed [AD 8 June 632] a great fire appeared in the south side of the sky. It was a Star Comet, the so-called dokitis [beam-shaped], extending from south to north; and it was standing there for thirty days*". Very likely Nektarios copied the Byzantine chronographer Theophanes (AD 758/760–817/818; volume B), who reported that a comet was observed in a.M. (Anno Mundi) 6124, that is on the 23rd year of the reign of the Byzantine emperor Heraclius that extended from AD September 633 to August 634 (Guidoboni et al. 1994; Ambraseys 2009): "*In that same year an earthquake happened in Palestine, and a sign, called dokitis, appeared in the southern sky, foretelling Arab domination; it lasted for thirty days, and stretched from south to north, having the shape of a sword*". It is clear that Theophanes related the comet's appearance with an earthquake in Palestine. It should be noted, however, that Theophanes does not quote his information source(s).

The earthquake has been dated in AD 634 not only by Theophanes but also on the basis of an earthquake record provided by Michael the Syrian (AD 1126–1199). This record reads as follows in the reproduction by Guidoboni et al. (1994): "*There was a severe earthquake at that time, and at the moment of the tremor, the sun grew dark. The church of the Resurrection and that of the Golgotha and many places collapsed in the earthquake; and*

they were rebuilt by Modestus, the Chalcedonian bishop (AD 633–AD 634)". It is obvious that Michael's narration synchronizes the earthquake with the darkness of the sun.

In a second record of Michael the Syrian the earthquake was correlated with a sign in the sky. This second record is nearly identical with the one by Theophanes, which implies that very likely Michael copied Theophanes: "*In the year a.S. 945 of Greeks there was a violent earthquake, in the month of ilul (September), and after the earthquake there was a sign in the sky; it appeared in the form of a sword stretching from south to north, and remained for thirty days. To many it seemed to signify the coming of the Taiyayz (Arabs)"* (Ambraseys 2009). Michael's account was interpreted by Ambraseys (2009) as an earthquake occurring in the Greek (Seleucide) year a.S. 946, that is from AD September 633 to August 634. It is noteworthy that in two short statements of al-Makin, reproduced by Guidoboni et al. (1994) and Ambraseys (2009), the strong earthquake was consistently dated in the year 13 after Hegira (a.H. 13). Since Hegira's date equates to 16 July, 622 in the Julian calendar, a.H. 13 corresponds to an interval from AD 7 March 634 to 24 February 635, but it has not been related to a comet.

In a chapter about Mohammed's successors, Nektarios' (Part *Δ*) narration reads as follows: "*In the year a.H.13 [AD 7 March 634-February 635], A'bobeker [successor of Mohammed] prepared strong army in Medin and arrived in Damascus with the aim to fight…And the first land that A'bobeker took was Patra, in the borders of Damascus and Syria, and at the same year he died…And in the same year a great earthquake happened in Palestine, which lasted for thirty days; and a great plague occurred after the earthquake"*. The information regarding the earthquake and its dating is identical with the one given by al-Makin. It is very likely that the aftershock period following the main shock lasted for at least 30 days (Salamon 2009).

The documentary sources examined earlier leave no doubt that the Palestine earthquake happened within the year AD 634. The sources imply also that the months March and August should be considered as the *terminus post quem* and *terminus ante quem*, respectively, for the occurrence of that earthquake.

The possibility of limiting further the time interval for estimating the earthquake date is investigated in the next lines on the basis of astronomical phenomena reported in documentary sources. The account that at the moment of the earthquake the sun grew dark is interpreted as a sun eclipse that perhaps took place around the earthquake date. This is a very significant finding since eclipses of that period can be calculated with an accuracy of a few kilometers in position and a couple of minutes in time (Morrison and Stephenson 2004, Espenak and Meeus 2004 and references therein). Hence the Palestine earthquake must had occurred near the location and around the time of the annular solar eclipse of AD 1 July 634 (Espenak and Meeus 2006, catalog no 06276). The AD 634 Palestine earthquake has been also correlated to a comet seen from the eastern Mediterranean region. The comet was observed moving from south to north after the earthquake time, very likely in late September of AD 634 and later. Examination of Chinese historical records verifies that a comet was observed from southeast Asia in that time period (Yoke 1962; Yeomans 1991). Dating of the comet's apparition has been considered as an additional evidence for dating the Palestine earthquake in the year AD 634 (Guidoboni et al. 1994; Ambraseys 2009 and references therein). El-Isa et al. (2015) suggested magnitude 6.8 for an earthquake occurring in AD 634. On the contrary, Zohar et al. (2016) estimated magnitude as low as 5.5 for an earthquake placed in September AD 634.

Based on the very good concurrence between the calculations of the eclipse of AD 1 July 634 and the description of the same event by Nektarios as well as the agreement

between the Chinese historical records and the *Epitome*, it is apparent that a far more likely date for the earthquake is between July and September of AD 634.

4.2 639/640: tephra fall

In Part Δ of *Epitome* Nektartios narrates: *Then, Omar arrived in Missiri [Egypt] at the year a.H.18, and took it in the year a.H.19… During the same year he arrived in Alexandria, and while he was fighting against it, burning hot tephra fell from the Sky, and many animals burned…And in the year a.H.20, they took Alexandria"*. This event, which occurred in AD 639/640, very likely signifies the effects of a volcanic eruption the tephra of which arrived and fell in Egypt and possibly in the peninsula of Sinai.

In the volcanic eruptions chronology only one candidate eruptive episode was found. This is the eruption, which according to a native legend, took place likely in the year AD 640 in the volcanic center Hala'l Badr, in the area of northern Hejaz, northwest Arabia (Simkin et al. 1981) (Fig. 2). Ambraseys and Melville (1989) dated the event in AD 641. The eruption was assigned Volcanic Explosivity Index VEI = 2, which corresponds to moderate, explosive activity, usually of Vulcanian type with pyroclastic flows and moderate tropospheric injection (Simkin et al. 1981). Another volcanic event reported in the year AD 640 in the volcanic center Hala'l Ishqua, near to Hala'l Badr, was of VEI as low as 0, which implies only very little lava flow. An eruption of such a very low VEI was incapable to produce tephra falls in Egypt. An eruption of VEI = 2(?) occurring in Etna in AD 644 is unlikely the one described in *Epitome* due to the distance in space and time.

4.3 Mid-eighth century: earthquakes and tsunami in Palestine

4.3.1 Information sources

According to *Epitome* (Part Δ, p. 289), A'sam became the 17th successor of Mohammed in the year a.H.105 (AD 723/724) but he was extremely heartless against the Orthodox Higher Priests: "*And due to all these bad things the wrath of God arrived, and a great, terrible earthquake happened; because of the great seismic turmoil at sea many ships sank, while in the land many animals died due to the excessive motion of the Earth. In the East six hundred cities destroyed. It is said that the ruination of the East started at that time"*. This account implies that the earthquake was of large magnitude and caused several effects, which are described later in light of more information sources.

Several Byzantine, Arabic, Syrian and Jewish documentary sources make reference to a series of strong, disastrous earthquakes that shook eastern Mediterranean around the mid-eighth century. The relevant sources were reviewed and examined by many modern authors, including Ben-Menahem (1979), Guidoboni et al. (1994), Karcz (2004), Ambraseys (2005, 2009), Sbeinati et al. (2005) and Salamon et al. (2007). The earthquake reported in *Epitome* perhaps is one of those earthquakes. The most important event has been a great earthquake that affected Palestine, Jordan and Syria. However, in modern seismological and historiographic literature no general consensus exists neither regarding the number of single seismic events that occurred in that period nor about the events dating. Nevertheless, starting from the little information that *Epitome* provides we investigated the most candidate earthquake event(s). This effort has been based on the comparison of Nektarios' narration with the accounts existing in other sources regarding earthquakes that may have occurred in that period of time.

4.3.2 The dating issue

Starting with the chronology issue, from *Epitome* we learn that the great earthquake happened after AD 723/724 but certainly before the death of A'sam (AD 742/743) as it derived from another passage: "*A'sam understood that this great calamity was due to the wrath of God and let the Higher Priests alone causing them no further harm"*. No large earthquakes were dated in the eastern Mediterranean in the early period of that time interval. On the contrary, it is likely that more than one earthquakes occurred in the late period of that interval and beyond up to around AD 757. However, the many different dating systems used in the various documentary sources complicates the earthquake dating issue, thus the date of the great earthquake falls in the range from AD 737/738 up to 757/758. From detailed historiographic analysis, Guidoboni et al. (1994) suggested that the great earthquake of that period occurred in the morning of AD 18 January 749, which was also supported by Nur and Burgess (2008), on the basis of archaeoseismological interpretation, and adopted by Papadopoulos et al. (2014) and Papadopoulos (2016). An important archaeological discovery is the clear evidence of a powerful earthquake that affected the city of Ramla, to the west of Jerusalem, and dated by firm ceramic evidence around AD 749 (Gorzalczany and Salamon 2018). On the other hand, Karcz (2004), Ambraseys (2005, 2009) and Salamon et al. (2007), based mainly on the Chronography by the Byzantine Theophanes, which is the source nearest to the events, preferred AD 18 January 746 or 747. Other important earthquake events were dated in AD 749 or in AD 750 as well as on AD 9 March 757 (Karcz 2004; Ambraseys 2009).

Of interest is that the geometry, kinematics, and activity of the faults crossing the town of Tiberias, studied through an integrated structural, archaeoseismological and geophysical approach, revealed that this fault segment was activated in the AD mid-eighth century (Ferrario et al. 2020). Based on macroseismic information for an earthquake dated in AD 746, Riad et al. (2004) estimated maximum intensity as high as XI in Balqa, Jordan, and magnitude 7.7, which was adopted by Sawires et al. (2016) too. El-Isa et al. (2015) suggested two major earthquakes occurring in AD 746/747 and in AD 748/749 with estimated magnitudes 7.4 and 7.2, respectively. Zohar et al. (2017) placed the earthquake in 749/750 and suggested average magnitude of 7.2 as calculated from several previous estimates.

4.3.3 Tsunami

The Nektarios' narration that "*because of the great seismic turmoil at sea many ships sank"* is an evidence of a destructive tsunami that possibly associated the earthquake. However, the tsunami place is not provided. This account looks like similar to the accounts provided by earlier texts, which in a chronological order are those by Sawirus (Severus) ibn-al Muqaffa (AD tenth century), a Coptic Orthodox Bishop of the AD tenth century, Michael the Syrian (AD 1126–1199), al-Makin (AD 1208–1273) and Chronikon (1234), a post-AD 1234 anonymous West Syriac universal history (see a collection of accounts in Antonopoulos 1973, 1979; Guidoboni et al. 1994 and Ambraseys 2009). These sources make also reference to an extraordinary storm in the sea that destroyed many towns and villages. However, it is not clear to which earthquake the tsunami was associated with. According to al-Makin and Sawirus Muqaffa, as analyzed by modern authors (Antonopoulos 1973, 1979; Guidoboni et al. 1994; Karcz 2004; Ambraseys 2009), the great tsunamigenic earthquake was dated in a.H.120 (AD 737/738). Chronikon (1234) as well as Michael the Syrian dated the great earthquake in a.S. 1059, i.e. from AD October 747 to

AD September 748 according to the Seleucid (Greek) dating system. It is noteworthy, however, that in his earthquake accounts for that period, Theophanes does not make reference to an extraordinary storm in the sea or to similar phenomena.

On the other hand, the similarity between the above accounts indicates that one or more authors likely copied previous one(s). As Manousakas (1947) noted, al-Makin was in fact the main source for Nektarios as regards the Parts B and Δ of *Epitome*. The detailed historiographic analysis by Ambraseys (2009) showed that at least three strong earthquakes may have occurred causing destruction from Egypt to northern Syria in the time interval from AD 746 up to AD 757. The largest has been the one of 18 January 746 that caused extensive destruction and various ground failures, like landslides and soil liquefaction, in many places of Palestine and Jordan. We tentatively suggest that this is the tsunamigenic earthquake described by the various sources examined earlier.

4.3.4 Earthquake effects

The *Epitome's* account that "*In the East six hundred cities were destroyed"* may reflect the large extent of the destruction and the many human victims caused by the great earthquake in several settlements (see review in Guidobini et al. 1994; Ambraseys 2009). However, the statement "*while in the land many animals died due to the excessive motion of the Earth",* or a similar one, has not been found in other documentary sources available. To interpret this point there is a need to understand the ground shaking mechanism that may have caused massive animal death. The strong ground motion alone certainly is not enough to explain such an effect. What Nektarios possibly meant is that animals were buried by large scale landslides and/or rock falls triggered by the great earthquake. Such phenomena are clearly described by Theophanes in his account for the year 748/749 in association to the specific earthquake. Animals sacrificed by falling buildings, as a result of the earth shaking, sounds reasonable as well. In fact, Michael the Syrian (466–467) reported that in Mabbug, Mesopotamia, human beings and animals were sacrificed when during the oblation a strong earthquake occurred, which likely was the one of AD 749 or AD 750. This episode was also mentioned by Theophanes as happening in the year 748/749 and by al-Makin although these two authors provide different dates (see relevant quotations in Guidoboni et al. 1994 and Ambraseys 2009).

4.4 AD 12 February 1091: earthquakes in Sinai

In Part Γ of *Epitome* the attack of an Egyptian troop against the Sinai Monastery is narrated. This event happened in the year AD 1091. The Archbishop of the Monastery *Ιωάννης Αθηναῖος* (*Ioannis Athinaeos*) tortured by the Egyptians until he died on AD 12 February 1091. In *Epitome* one may find a short account regarding a series of earthquakes felt in the Sinai Monastery on the same date: "*But at that evening seven great and terrible earthquakes happened, and the Barbarians got in fear and left, and after that they asked nothing more"*.

This earthquake activity is also referred to by Anonymous (1817) who either had access to the source(s) used by the writer of *Epitome* or just copied *Epitome*. Guidoboni and Comastri (2005) do not list this earthquake episode. Badawy (1999) and Ambraseys (2009), who do not cite *Epitome*, included that seismic episode in their earthquake catalogues based only on to Anonymous (1817).

4.5 AD 1 May 1312 or 1212: Sinai seismic sequence

In Part Γ of *Epitome* there is a chapter titled "*About the great earthquakes that happened in the same Monastery"*. Then, the earthquakes and the significant damage caused are narrated as follows: "*On Monday [AD] 30 April of 1312 at sunset a small earthquake happened, and another one at midnight; at dawn of Tuesday 1 May another great and terrible earthquake occurred; and because of the rumble and the shaking of the Mountains and of the rocks throwing down from the Mountains, it looked like that the entire World would submerge. The northern and eastern walls as well as two towers of the Monastery pulled down; and some of the cells collapsed completely but in others only the roofs collapsed. The earthquakes did not finish, on the contrary they were coming one after the other. Then, the Monks got in fear and with cries and lamentations left to the wine-arbor, where the Cemetery is situated, for they were afraid of the complete ruination of the Monastery, since the walls were so much damaged as it was possible for a loaded animal to pass through"*. From Nektarios' narration we also learn that six days after the earthquake a group of seven Christian builders arrived and repaired the Monastery walls and towers "*in the situation they can be found today"*. The builders happened to arrive there for another reason, i.e., to renovate the Church at the Holly Summit of the Mountain since it suffered damage from past earthquakes. However, no further information is provided for those earthquakes.

The earthquake activity of AD 1312 is a puzzling episode from the dating point of view. Ben-Menahem (1979), based only "*upon private communication with Dr D. Neev, Israel Geological Survey",* listed an earthquake event that occurred either in AD 1312 or AD 1608, but without quoting relevant documentary source(s). Amiran et al. (1994) just copied Ben-Menahem (1979). The earthquake catalogues by Poirier and Taher (1980), Guidoboni and Comastri (2005) and Ambraseys (2009) do not list an earthquake on 1 May 1312. However, Guidoboni and Comastri (2005), who did not include *Epitome* in their sources, report on an earthquake that occurred in the Gulf of Aqaba on 1 May 1212 and caused significant damage in Eilat and as far as Cairo. However, the sources used by Guidoboni and Comastri (2005) did not mention the Sinai Monastery as one of the places damaged by the earthquake. Muslim sources used by Ambraseys (2009) dated the AD 1212 earthquake on 2 May. Ambraseys (2009), however, was based on an earlier version of *Epitome* and supported that Nektarios gives the date as AD 1312 or AD 1212, which is not correct since Nektarios gives only AD 1312. By considering the days mentioned by Nektarios, i.e., Monday for 30 April and Tuesday for 1 May, we found that they correspond to the year AD 1212. This implies that Nektarios was writing 1312 instead of 1212, which likely is the correct date of the earthquake given that for AD 1212 the 30th April was Monday.

It is noteworthy that Kagan et al. (2011) correlated historical records of large earthquakes with dates of seismites sedimentary layers deposited at the Ein Feshkha Nature Reserve outcrop located at the northern part of the Dead Sea basin. One of the seismites was dated around AD 1312 and correlated with several candidate earthquakes, all having occurred to the north of the basin with the exception of the AD 1312 one, for the historical documentation of which Kagan et al. (2011) quoted Amiran et al. (1994). However, the southward diminishing abundance of seismites may reflect the observation that the historic earthquakes from the 12th and 14th centuries, including the AD 1312 one, ruptured north of the Jordan Valley (Agnon 2014). This observation removes the Sinai AD 1312 earthquake from the list of candidate earthquakes.

It is noticeable that according to Tsolakidis (2001) an earthquake dated on 1 May 1201 is reported to have caused damage in St. Catherine's Monastery, which look like the

damage caused by the AD 1212 or 1312 earthquake: "*The memory of this event comes from the Sinai Codex 1097, and it is said that it happened on [AD] 1201 when many cells and towers were perished"*. Although we do not rule out that an earthquake in fact damaged the Monastery in 1201, one possibility is that the 1201 earthquake was mentioned with erroneous date in the calendars of Orthodox Church events. An alternative is the erroneous reading of AD 1212 in the Sinai Codex 1097 or by Tsolakidis (2001).

Summarizing, what we learn from *Epitome* is that at the sunset and again at midnight of AD 30 April 1212, Monday, foreshocks were felt in the Sinai Monastery. At the dawn of AD 1 May 1212, Tuesday, a very strong main shock occurred. The earth shaking was powerful enough and caused rock falls from the Mountain. The Monastery building was seriously damaged given that the walls at the eastern and northern sides collapsed. The same happened in two of the Monastery's towers. Moreover, some cells collapsed in total, while in others only the roofs fell. Many aftershocks followed the next days. The Monastery was repaired by a team of builders who happened to arrive there six days later.

4.6 AD 10 September 1509: earthquake in Constantinople (Istanbul), Marmara Sea

In Part E of *Epitome* Nektarios narrates that because of the war of Sultan Bayiazid against his sons, the Kingdom of Ottomans run a serious danger to disappear: "*And a foreshadow of this danger was given by some signs that happened in Constantinople. A terrible earthquake [took place], with no similar ones having occurred in the past; afterwards a terrible plague [happened], for which the [persons] being still alive were not enough to bury the deads. Because of these [events], Sultan Bayiazid got in fear and removed to the mountain of Rhodope, near Andrianople"*. Although Nektarios does not date the earthquake, no doubt remains that it was the large, lethal and tsunamigenic earthquake that struck Constantinople (Istanbul) on AD 10 September 1509. This event is well-known from a long number of sources (see review in Ambraseys 2009 and references therein). A strong tsunami that followed the earthquake (Yalçiner et al. 2002) was assigned intensity 5 (Papadopoulos and Fokeafs 2005) in the 12-grade tsunami intensity scale by Papadopoulos and Imamura (2001).

5 Discussion

Epitome is a source which provides important information about earthquakes occurring in several time periods in the eastern Mediterranean region. However, some of these earthquakes need further discussion. From historical, archaeological and palaeoseismological data little doubt remains that by the AD mid-eighth century more than one strong earthquakes occurred in the Palestine-Jordan-Syria region. According to *Epitome*, the great earthquake in Palestine happened after a.H.105 (AD 723/724) but certainly before the death of Mohammed's successor A'sam in a.H.125 (AD 742/743). From other sources, however, the earthquake activity is placed in the time interval extending from AD 746 to AD 750. A plausible explanation for this time discrepancy is that Nektarios, the *Epitome's* writer, followed the al-Makin's dating system, which shifted the Anno Domini calendar dates earlier by about three to six years (e.g., Karcz, 2005). Alternatively, but less likely, one should not rule out that Nektarios placed by purpose the earthquake activity earlier with the aim to make it coincident with the heartless behavior of A'sam against Orthodox priests, thus proving that the earthquakes came as the wrath of God.

The accounts about the occurrence of a great seismic turmoil at sea and the subsequent shipwreck of many ships may imply tsunami occurrence. Although *Epitome* attributes the turmoil at sea to a great earthquake, possibly the AD 746 or 749 one, we may not exclude that the event was due to stormy weather that accidentally happened at the earthquake time. If a tsunami really occurred, then it complicates the possible earthquake scenarios. An inland earthquake rupture explains quite well the extensive destruction caused in many places of the region but leaves the tsunami generation doubtful. In this case the only possibility is the co-seismic landslide offshore or along the coast. On the other hand, an offshore earthquake hardly provides explanation for the very extensive area of the seismic destruction reported. Such issues certainly worth further examination since they are important for better understanding both the seismotectonics and the tsunami potential of the region.

According to *Epitome* an earthquake sequence caused significant damage in the St. Catherine's Monastery at Sinai on AD 30 April and 1 May of 1212 or less likely in 1312. However, the macroseismic information available does not allow estimation of the magnitude and the epicentral coordinates of the AD 1 May 1212 main shock. This is also the case of the series of strong earthquakes that according to *Epitome* were felt in the same Monastery on AD 12 February 1091. One possibility is the activation of local seismic sources. However, we do not exclude the activation of distant sources.

Historiographic evidence (Guidoboni and Comastri 2005; Ambraseys 2009) indicates that the Gulf of Aqaba was the epicentral area of that earthquake. The instrumental seismicity in the area is mainly distributed along the Gulf of Aqaba-Dead Sea transform zone and in the Gulf of Suez rift zone (Fig. 2) but local earthquake sources are situated in the southern side of the Sinai sub-plate close to Mt. Sinai (Abdel-Rahman et al. 2009).

As regards the AD 1212 earthquake, one way to control the maximum epicentral distance of the Monastery from candidate causative seismic sources is to investigate the maximum distance, R_e, from the seismic source, at which earthquake-triggered rock falls and landslides may occur. From Greek data, Papadopoulos and Plessa (2000) proposed the empirical relationship (1), which fits limiting distance curves for worldwide data too; where R_e is measured in km and M_s is surface-wave magnitude:

$$\log\left(R_e\right) = -2.98 + 0.75M_s \tag{1}$$

A modern earthquake, which caused damage in the Monastery of St. Catherine, was that of 31 March 1969 measuring moment-magnitude M_w6.60 (ISC-GEM 2022). The epicenter of this earthquake (latitude 27.575° N, longitude 33.895° E) falls in the northern Red Sea (Fig. 2). The earthquake was associated with oblique-slip faulting (Ben-Menahem and Aboodi 1971; Ben-Menahem 1979). Assuming $M_s \approx M_w$, for M_w6.6 we get R = 93 km, which according to (1) places the St. Catherine's Monastery at marginal epicentral distance from the 1969 seismic source. Of interest is also another strike-slip earthquake (M_w7.2; ISC-GEM 2022) that ruptured the Gulf of Aqaba, at the south side of the Dead Sea transform zone, on 22 November 1995 (Klinger et al. 1999) (Fig. 2). This earthquake caused damage in the cities of Aqaba (Jordan) and Eilat (Israel) situated at epicentral distances of ~ 60 km. Extensive destruction was caused in the Nuweyba city, west Sinai coast, at epicentral distance of only ~ 20 km (Fig. 2). On the contrary, there is no evidence that the Monastery of St. Catherine, situated at distance of ~ 70 km, was damaged by that earthquake.

This discussion implies that apart from local seismic sources, the 1969 and 1995 epicentral areas are also candidates for possible modern repeats of the AD 1091 and AD 1212 seismic activities. However, the hypothesis that either of these two seismic sources was

activated in AD 1091 or in AD 1212 (alternatively in AD 1312) and caused damage in the Monastery is weakened by the large epicentral distance. As a matter of fact, it is doubtful if a series of foreshocks and aftershocks could be perceptible at epicentral distance exceeding 70 km or even 90 km.

6 Conclusions

The earthquake and tsunami documentation in the region of eastern Mediterranean and in the peninsula of Sinai has been improved from the study of two little-known Greek documents and their cross-checking with other historical sources. The first document is *Historia chronike* written in AD seventh century by the Byzantine chronicler John of Antioch. The second, *Epitome of Holly and Secular History*, was written in Sinai much later (17th century) by the Patriarch Nektarios. The description of astronomical phenomena, like comets and a sun eclipse, helped to date more precisely some of the earthquake events. Our conclusions about the geodynamic and astronomical phenomena examined in this paper are analyzed in the next lines and summarized in Table 2.

The information contained in *Historia chronice* and its comparison with other sources helped us to solve the dispute in the opinions of scholars, based on classical sources, about the occurrence of a tsunami and its physical connection to an earthquake in the Phoenician coast, Levantine Sea, around the mid-second century BC. We concluded that the earthquake caused destruction and many fatalities in southern Syria, in Sidon, in Tyre and possibly in Ptolemais, with the seismic intensity increasing from north to south. We suggested an earthquake epicenter offshore between Sidon and Tyre (Fig. 2) (Table 2). In the coast of Ptolemais, a powerful tsunami wave sacrificed many people, while dead fishes were left behind. From the extensive destruction and the many fatalities that reportedly caused by the earthquake and the tsunami we suggested macroseismic intensity of 9 ± 1 in MMI scale and tsunami intensity of 8 ± 1 in the Papadopoulos and Imamura (2001) scale.

Previous authors, ignoring *Historia chronike*, placed the earthquake in a time interval ranging from 143 to 138 BC. However, the Ptolemais battle, that very likely occurred during the summer of 138 BC, makes a *terminus post quem* for the Phoenician earthquake and tsunami event. On the other hand, *Historia chronike* reports on the apparition of a comet, which at all evidence was the so-called Mithridates' comet. The comet was observed in the SE Asia as well as in the eastern Mediterranean region in September 135 BC, which should be considered as the *terminus ante quem* for the earthquake and tsunami event.

The *Epitome of Hierocosmic (Holly and Secular) History* is a valuable document providing information about various geodynamic events, which happened in the Sinai subplate and other places of the eastern Mediterranean region. In chronological order the first event reported is an earthquake, which is known from other sources too (e.g., Guidoboni et al. 1994; Ambraseys 2009) and very likely occurred between March and August of AD 634. An independent *terminus ante quem* for the occurrence of this earthquake is based on the appearance of a comet after the earthquake during mid-September 634. On the other hand, a sun eclipse was historically reported to have been seen from Middle East near the time of the earthquake occurrence. We found that such an eclipse is indeed astronomically expected to have occurred on AD 1 July 634, a date which is a good approximation to the earthquake *terminus post quem*. The earthquake damaged several buildings in Jerusalem. We tentatively assigned macroseismic intensity 8 ± 1 (MMI) and epicenter on the Dead Sea Fault Zone northeast from Jerusalem.

Table 2 Summary of the natural phenomena referred to in the documentary sources examined

Year	m	d	Phenomena	φ°N	λ° E	M	I_o	K
Between summer 138 and Sept. 135 BC			*Earthquake* in Phoenicia: many fatalities; a city swallowed up; two thirds of Sidon fell. *Tsunami:* sea inundation in Tyre and Ptolemais; many fatalities; dead fish left in the coast	33.47	35.10	>6	9±1	8±1
135 BC	9		*Comet* seen from SE Asia and Middle East					
AD 634	7–9		*Earthquake* in Palestine: Buildings collapsed in Jerusalem and in other places	32.00	35.50		8±1	
634	7	1	*Sun eclipse* seen from Middle East					
634	9		*Comet* seen from SE Asia and Middle East					
639/640			*Volcanic eruption* in NW Arabia: Tephra fall in Alexandria	27.25	37.20	2*		
746 or 749	1	18	*Earthquake* in Palestine: 600 cities destroyed. Many animals died. *Tsunami(?)*: Many ships sunk	32.40	35.60		9±1	7±1
1091	1	12	*Seven "great and terrible" earthquakes:* felt in Sinai Monastery	28.556	33.976			
1212	4	30	*Foreshocks:* felt in Sinai Monastery at the evening	28.556	33.976			
1212	5	1	*"Great and terrible" main shock* felt in Sinai Monastery at dawn: rock falls; cells, towers and roofs collapsed; walls damaged. *Aftershocks* followed	28.556	33.976			
1509	9	10	*"Terrible" earthquake* in Constantinople (Istanbul)	41.02	28.79	7.14	10	5

Key: m = month, d = day, φ°N and λ°E = geographic latitude and longitude, M = earthquake magnitude, *Io* = epicentral seismic intensity (12-degree MMI scale), K = tsunami intensity (12-degree scale by Papadopoulos and Imamura 2001); * means Volcanic Explosivity Index. For the 1509 earthquake parameters are taken from SHEEC catalog (Stucchi et al. 2013), while tsunami intensity is from Papadopoulos and Fokaefs (2005). All earthquake and tsunami events assigned reliability 4

Burning volcanic tephra fall was reported in the area of Alexandria, Egypt, during AD 639/640. A candidate episode of volcanic eruption is the one, which according to a native legend, took place possibly in the year AD 640 in the volcanic center Hala'l Badr, in the area of northern Hejaz, northwest Arabia. Volcanic Explosivity Index as low as 2 has been assigned to that eruption (Simkin et al. 1981). The *Epitome* account about the tephra fall is the only relevant document found so far.

Epitome reports on a great earthquake in Palestine after AD 723/724 but before AD 742/743. Because of the strong seismic turmoil in the sea many ships sunk, which may imply a strong tsunami attack. However, stormy weather should not be ruled out as the cause of shipwrecks. The earthquake and tsunami-like event, as well as other earthquakes occurring in the period from AD 737/738 up to AD 757/758, are known from various modern authors who reviewed several documentary sources (Ben-Menahem 1979; Guidoboni et al. 1994; Karcz 2004; Ambraseys 2005, 2009; Sbeinati et al. 2005; Salamon et al. 2007). These authors placed the great and possibly tsunamigenic earthquake either in AD 746 or in AD 749/750, i.e., some years later than the time interval given in the *Epitome*. This time discrepancy is possibly due to the different calendar systems used in the different sources. Based on the destructive effects of the great Palestine earthquake we tentatively assigned macroseismic intensity 9 ± 1 (MMI) and placed the epicenter in the Dead Sea Fault Zone between the Dead Sea and Tiberias Lake (Fig. 2). However, several issues remain open for further examination, such as the number of earthquake events that occurred in that period, their rupture either onshore or offshore and their associations with tsunami-like sea disturbance.

A series of strong earthquakes occurred in Sinai on AD 12 February 1091. In the relevant passage of *Epitome*, however, it is not clear if damage was caused or not. According to *Epitome*, Sinai was again shaken by an earthquake sequence comprising foreshocks in the evening of AD 30 April 1312, a strong main shock occurring the dawn of next morning (1st May) and several aftershocks. The main shock caused significant damage in buildings of the St. Catherine's Monastery. Rock falls rolled down from the nearby Mountain. The damage caused was repaired some days later. Other sources indicate that this earthquake likely occurred on AD 30 April 1212.

Epitome narrates that during the reign of Sultan Bayiazid a terrible earthquake took place in AD 1509. Although Nektarios did not provide explicitly the date and place of the earthquake, no doubt remains that it was the well-known (e.g., Ambraseys 2009) destructive and tsunamigenic earthquake that struck Constantinople (Istanbul) on AD 10 September 1509.

Acknowledgements IT and GP contributed to the European Cooperation in Science and Technology COST project (2018-2023) "AGITHAR-Accelerating Global science In Tsunami HAzard and Risk analysis". Eclipse Predictions by Fred Espenak, NASA/GSFC Emeritus. ACK acknowledges funding from the Solar-Terrestrial Centre of Excellence (STCE), a collaborative framework funded by the Belgian Science Policy Office (BELSPO). We are grateful to two anonymous reviewers for their constructive comments and corrections which contributed to improving the initial submission. Figures 1 and 2 were created using the ArcGIS® software, version 10.8 by Esri.

Authors' contributions All authors contributed to the study conception and design. IT and GP collected historical documents; AK performed astronomical correlations; IT prepared figures and performed writing-original draft; all authors performed writing-review and editing.

Funding The authors declare that no funds, grants, or other support were received during the preparation of this manuscript, other than staff costs payed by the Royal Observatory of Belgium to ACK.

Declarations

Conflict of interest The authors declare no conflicts of interest.

References

Abdel-Rahman K, Al-Amri AMS, Enayat Abdel-Moneim E (2009) Seismicity of Sinai Peninsula. Egypt Arab J Geosci 2:103–118. https://doi.org/10.1007/s12517-008-0014-0

Agnon A (2014) Pre-Instrumental earthquakes along the Dead Sea Rift. In: Garfunkel Z et al (eds) Dead sea transform fault system: reviews modern approaches in solid earth sciences, vol 6. Springer, Dordrecht

Ambraseys NN (1962) Data for the investigation of the seismic sea-waves in the Eastern Mediterranean. Bull Seismol Soc Am 52:895–913

Ambraseys NN (2005) The seismic activity in Syria and Palestine during the middle of the 8th century; an amalgamation of historical earthquakes. J Seismol 9:115–125

Ambraseys NN (2009) Earthquakes in the Mediterranean and Middle East-A multidisciplinary study of seismicity up to 1900. Cambridge Univ. Press, UK, p 947

Ambraseys NN, Melville CP (1989) Evidence for intraplate earthquakes in Northwest Arabia. Bull Seismol Soc Am 79(4):1279–1281

Ambraseys NN, Melville CP, Adams RD (1994) The seismicity of Egypt, Arabia and the Red Sea: a historical review. Cambridge Univ. Press, UK, p 181

Amiran DHK, Arieh E, Turcotte T (1994) Earthquakes in Israel and Adjacent Areas: macroseismic observations since 100 B.C.E. Israel Explor J 44:260–306

Anonymous (1817) Perigrafi Iera Orous Sina (A Holly Description of Mt Sina). In: Glykas N (ed), p 219 (**in Greek**)

Antonopoulos J (1973) Tsunamis of the Eastern Mediterranean from Antiquity to present time, Athens, p 168 (**in Greek**)

Antonopoulos J (1979) Catalogue of tsunamis in the Eastern Mediterranean from Antiquity to present times. Ann Geof 32:113–130

Badawy A (1999) Historical seismicity of Egypt. Acta Geod Geoph Hung 34(1–2):119–135

Ben-Menahem A (1979) Earthquake catalogue for the Middle East (92 B.C.-1980 A.D.). Boll Geofis Teor Appl 21(84):245–310

Ben-Menahem A (1991) Four thousand years of seismicity along the Dead Sea Rift. J Geophys Res 96:20195–20216

Ben-Menahem A, Aboodi E (1971) Tectonic patterns in the Red Sea region. J Geophys Res 76:2674–2689

Ben-Menahem A, Aboodi E, Vered M, Kovach RL (1977) Rate of seismicity of the Red Sea region over the past 4000 years. Phys Earth Planet Inter 14:P17–P27

Ben-Menahem A, Nur A, Vered M (1976) Tectonics, seismicity and structure of the Afro-Euroasian junction: the breaking of an incoherent plate. Phys Earth Planet Inter 12:1–50

Bocchini GM, Brüstle A, Becker D, Meier T, van Keken PE, Ruscic M, Papadopoulos GA, Rische M, Friederich W (2018) Tearing, segmentation, and backstepping of subduction in the Aegean: new insights from seismicity. Tectonophysics 734–735:96–118

Darawcheh R, Sbeinati MR, Margottini C, Paolini S (2000) The 9 July 551 AD Beirut earthquake, eastern Mediterranean region. J Earthq Engin 4(4):403–414

Dewey JF, Şengör AMC (1979) Aegean and surrounding regions: complex multiplate and continuum tectonics in a convergent zone. Geol Soc Am Bull 90:84–92

Elias A, Tapponnie P, Singh SC, King GCP, Briais A, Daëron M, Carton H, Sursock A, Jacques E, Jomaa R, Klinger Y (2007) Active thrusting offshore Mount Lebanon: source of the tsunamigenic AD 551 Beirut-Tripoli earthquake. Geology 35:755–758. https://doi.org/10.1130/G23631A.1

El-Isa ZH, McKnight S, Eaton D (2015) Historical seismicity of the Jordan Dead Sea Transform region and seismotectonic implications. Arab J Geosci 8:4039–4055. https://doi.org/10.1007/s12517-014-1483-y

Espenak F, Meeus J (2006) Five millennium canon of solar eclipses: − 1999 to + 3000 (2000 BCE to 3000 CE). National Aeronautics and Space Flight Administration, Washington, DC. https://eclipse.gsfc.nasa.gov/SEpubs/5MKSE.html

Ferrario MF, Katz O, Hillman A, Livio F, Amit R, Michetti AM (2020) The mid-eighth century CE surface faulting along the Dead Sea Fault at Tiberias (Sea of Galilee, Israel). Tectonics 39:e2020TC006186. https://doi.org/10.1029/2020TC006186

Fokaefs A, Papadopoulos GA (2007) Tsunami hazard in the Eastern Mediterranean: strong earthquakes and tsunamis in Cyprus and the Levantine Sea. Nat Haz 40(3):503–526

Galanopoulos AG (1960) Tsunamis observed on the coasts of Greece from Antiquity to present time. Ann Geof 13:369–386
Galli P (1997) Archaeoseismological evidence of historical activity of the Wadi Araba-Jordan Valley transform fault. Il Quat Ital J Quat Sci 10:399–404
Garfunkel Z (1998) Constrains on the origin and history of the Eastern Mediterranean basin. Tectonophysics 298:5–35
Gorzalczany A, Salamon A (2018) Archaeological evidence of a powerful earthquake in Ramla, Israel, during the early Islamic Period. In: Horejs B et al. (eds) Proc 10th international congress on the archaeology of the ancient near east, vol 1. Harrassowitz Verlag, Wiesbaden, pp 601-614. 10.2307/j.ctvcm4f86.49
Grünthal G, Wahlström R (2012) The European-Mediterranean Earthquake Catalogue (EMEC) for the last millennium. J Seismol 16:535–570. https://doi.org/10.1007/s10950-012-9302-y
Guidoboni E, Comastri A (2005) Catalogue of earthquakes and tsunamis in the Mediterranean area from the 11th to the 15th century. INGV-SGA, Rome-Bologna, Italy, p 1037
Guidoboni E, Comastri A, Traina G (1994) Catalogue of ancient earthquakes in the Mediterranean area up to the 10th century. ING-SGA, Rome-Bologna, Italy, p 504
Hartleb D, Dolan JF, Akyüz HS, Yerlİ B (2003) A 2000-year-long paleoseismological record of earthquakes along the central North Anatolian Fault, from trenches at Alayurt, Turkey. Bull Seismol Soc Am 93:1935–1954
Jackson J (1992) Partitioning of strike slip and convergent motion between Eurasia and Arabia in Turkey and the Caucasus. J Geophys Res 97:12471–12479
Jolivet L (2001) A comparison of geodetic and finite strain in the Aegean: geodynamic implications. Earth Planet Sci Lett 187:95–104
ISC-GEM (2022) Global instrumental earthquake catalogue for the period 1904–2018. Version 9.0- released on 2022-03-15
Kagan E, Stein M, Agnon A, Neumann F (2011) Intrabasin paleoearthquake and quiescence correlation of the late Holocene Dead Sea. J Geophys Res 116:B04311. https://doi.org/10.1029/2010JB007452
Karcz I (2004) Implications of some early Jewish sources for estimates of earthquake hazard in the Holy Land. Ann Geophys 47:759–792
Klinger Y, Rivera L, Haessler H, Maurin J-C (1999) Active faulting in the Gulf of Aqaba: new knowledge from the M_W7.3 earthquake of 22 November 1995. Bull Seismol Soc Am 89(4):1025–1036. https://doi.org/10.1785/BSSA0890041025
Kreemer C, Chamot-Rooke N (2004) Contemporary kinematics of the southern Aegean and the Mediterranean Ridge. Geophys J Int 157:1377–1392. https://doi.org/10.1111/j.1365-246X.2004.02270.x
Lampros P (1904) Anekdoton apospasma Ioannou tou Antiocheos (Unpublished excerpt of John of Antioch). In: Brill EJ (ed) Neos Ellinomnimon, vol 1. Leide, pp 7–31 (**in Greek**)
Le Pichon X, Francheteau J (1978) A plate-tectonic analysis of the Red Sea-Gulf of Aden area. Tectonophysics 46(369):406
Le Pichon X, Lyberis N, Angelier J, Renard V (1982) Strain distribution over the east Mediterranean ridge: a synthesis incorporating new Sea-Beam data. Tectonophysics 86:243–274
Le Pichon X, Angelier J (1979) The Hellenic arc and trench system: a key to the neotectonic evolution of the eastern Mediterranean area. Tectonophysics 60(1–2):1–42
Manousakas M (1947) I "Epitomi tis Ierokosmikis Istorias" tou Nektariou kai ai pigai autis (The "Epitome of Holly and Secural History" by Nektarios and its sources). Kritika Chronika A:291–332 (**in Greek**)
Mantovani E, Babbucci D, Tamburelli C, Viti M (2022) Late Cenozoic evolution and present tectonic setting of the Aegean-Hellenic Arc. Geosciences 12(3):104. https://doi.org/10.3390/geosciences12030104
Maramai A, Brizuela B, Graziani L (2014) The Euro-Mediterranean tsunami catalogue. Ann Geophys 57:S0435. https://doi.org/10.4401/ag-6437
Marco S, Stein M, Agno A, Ron H (1996) Long term earthquake clustering: a 50,000 year paleoseismic record in the Dead Sea Graben. J Geophys Res 101(B3):6179–6192
Mariev S (2006) Neues zu Johannes von Antiochien? Byz Zeit 99:535–549
Mascle J, Martin L (1990) Shallow structure and recent evolution of the Aegean Sea: a synthesis based on continuous reflection profiles. Mar Geol 94:271–299
McClusky S, Balassanian S, Barka A et al (2000) Global Positioning System constraints on plate kinematics and dynamics in the eastern Mediterranean and Caucasus. J Geophys Res Solid Earth 105(B3):5695–5719
McKenzie DP (1970) Plate tectonics of the Mediterranean region. Nature 226:239–243
McKenzie DP (1972) Active tectonics of the Mediterranean region. Geophys J Int 30(2):109–185

Meijer PT, Wortel MJR (1997) Present-day dynamics of the Aegean region: a model analysis of the horizontal pattern of stress and deformation. Tectonics 16(6):879–895
Morrison L, Stephenson FR (2004) Historical values of the earth's clock error ΔT and the calculation of eclipses. Hist Astron 35(120):327–336
Müller K (1883) Fragmenta historicorum graecorum: I-V (1841–1873). Ambroise Firmin-Didot, Paris
Nektarios P (1990) Epitomi Ierokosmikis Istorias (Epitome of Holly and Secural History), vol 4. Edition of the Holy Monastery of the Goddess Sinai, Athens, p 499 (**in Greek**)
Nur A, Burgess D (2008) Apocalypse: earthquakes, archaeology and the wrath of God. Princeton Univ. Press, p 309
Nur A, Cline E (2000) Poseidon's horses: plate tectonics and earthquake storms in the late bronze age Aegean and Eastern Mediterranean. J Archaeol Sci 27(1):43–63. https://doi.org/10.1006/jasc.1999.0431
Papadopoulos GA (2009) Tsunamis-chapter 17. In: Woodward J (ed) Physical geography of the Mediterranean. Oxford University Press, pp 493–512
Papadopoulos GA (2011) A seismic history of Crete: earthquakes and tsunamis, 2000 B.C.-A.D. 2010. Ocelotos Publications, Athens, p 415
Papadopoulos GA (2016) Tsunamis in the European-Mediterranean region: from historical record to risk mitigation. Elsevier, Amsterdam, p 271
Papadopoulos GA, Chalkis B (1984) Tsunamis observed in Greece and the surrounding area from antiquity up to the present times. Mar Geol 56:309–317
Papadopoulos GA, Fokaefs A (2005) Strong tsunamis in the Mediterranean Sea: a re-evaluation. ISET J Earthq Technol 42:159–170
Papadopoulos GA, Minoura K, Imamura F, Kuran U, Yalçiner CA, Fokaefs A, Takahashi T (2012) Strong earthquakes and tsunamis in the East Hellenic Arc. Res Geophys 2(e12):90–99. https://doi.org/10.4081/rg.2012.e12
Papadopoulos GA, Gràcia E, Urgeles R et al (2014) Historical and pre-historical tsunamis in the Mediterranean and its connected seas: geological signatures, generation mechanisms and coastal impacts. Mar Geol 354:81–109. https://doi.org/10.1016/j.margeo.2014.04.014
Papadopoulos GA, Daskalaki E, Fokaefs A, Giraleas N (2007) Tsunami hazard in the Eastern Mediterranean: Strong earthquakes and tsunamis in the east Hellenic arc and trench system. Nat Haz Earth System Sci 7:57–64
Papadopoulos GA, Imamura F (2001) A proposal for a new tsunami intensity scale. Proc Internat Tsunami Symp, 7–10 Aug, 2001. Seattle, pp 569–577
Papadopoulos GA, Plessa A (2000) Magnitude-distance relations for earthquake-induced landslides in Greece. Eng Geol 58:377–386
Papazachos BC, Papazacho CB (1997) The earthquakes of Greece. Ziti Publications, Thessaloniki, p 304
Poirier JP, Taher MA (1980) Historical seismicity in the near and middle east, north Africa, and Spain from Arabic documents (VIIth-XVIIIth century). Bull Seism Soc Am 70:2185–2201
Ramsey JT (2007) A catalogue of Greco-Roman comets from 500 B.C. to A.D. 400. J Hist Astron 38:175–197. https://doi.org/10.1177/002182860703800203
Reilinger R, McClusky S, Paradissis D, Ergintav S, Vernant P (2010) Geodetic constraints on the tectonic evolution of the Aegean region and strain accumulation along the Hellenic subduction zone. Tectonophysics 488:22–30
Reilinger R, McClusky S, Vernant P et al (2006) GPS constraints on continental deformation in the Africa-Arabia-Eurasia continental collision zone and implications for the dynamics of plate interactions. J Geophys Res 111:B004051
Riad S, Taeleb AA, El Hadidy S, Basta Z., Abou Elel AM, Mohamed AA, Khalil HA (2004) Ancient earthquakes from some Arabic sources and catalogue of Middle East historical earthquakes. National Research Institute of Astronomy and Geophysics, Egypt, p 105
Roberto U (2005) Ioannis Antiocheni Fragmenta ex Historia chronica. Texte und Untersuchungen zur Geschichte der altchristlichen Literatur. Walter de Gruyter, Bd. 154, ccxi, Berlin, p 661
Robertson AHF (1998) Tectonic significance of the Eratosthenes Seamount: a continental fragment in the process of collision with a subduction zone in the eastern Mediterranean (Ocean Drilling Program Leg 160). Tectonophysics 298:63–82
Rotstein Y, Kafka AL (1982) Seismotectonics of the southern boundary of Anatolia, Eastern Mediterranean region: subduction, collision and arc jumping. J Geophys Res 87:7694–7706
Salamon A (2009) Patterns of seismic sequences in the Levant—Interpretation of historical seismicity. J Seismol 14(2):339–367
Salamon A, Hofstetter A, Garfunkel Z, Ron H (1996) Seismicity of the eastern Mediterranean region: perspective from the Sinai subplate. Tectonophysics 263:293–305

Salamon A, Hofstetter A, Garfunkel Z, Ron H (2003) Seismotectonics of the Sinai subplate-the eastern Mediterranean region. Geophys J Int 155:149–173
Salamon A, Rockwell Th, Ward S, Guidoboni E, Comastri A (2007) Tsunami hazard evaluation of the eastern Mediterranean: historical analysis and selected modeling. Bull Seism Soc Am 97:705–724. https://doi.org/10.1785/0120060147
Sawires R, Peláe JA, Fat-Helbary E, Ibrahim HA (2016) An earthquake catalogue (2200 BC to 2013) for seismotectonic and seismic hazard assessment studies in Egypt. In: D'Amico S et al (eds) Earthquakes and their impact on society. Springer
Sbeinati MP, Darawcheh P, Mouty M (2005) The historical earthquakes of Syria: an analysis of large and moderate earthquakes from 1365 B.C. to 1900 A.D. Ann Geophys 48(3):347–435
Seargent D (2008) The greatest comets in history, broom stars and celestial scimitars. Springer. https://doi.org/10.1007/978-0-387-09513-4_4
Sieberg A (1927) Geologische einführung in die Geophysik. Verlag von G. Fischer, p 374
Simkin T, Siebert L, McClellan L, Bridge D, Newhall C, Latter JH (1981) Volcanoes of the world. Hutchinson and Ross, Stroudsburg
Soloviev SL, Solovieva ON, Go CN, Kim KS, Shchetnikov NA (2000) Tsunamis in the Mediterranean Sea, 2000 B.C.-2000 A.D. Advances in natural and technological hazards research. Kluwer Academic Publichers, London, p 237
Stucchi M, Rovida A, Gomez Capera AA et al (2013) The SHARE European earthquake catalogue (SHEEC) 1000–1899. J Seismol 17:523–544. https://doi.org/10.1007/s10950-012-9335-2
Tsolakidis CH (2001) Agiologio tis orthdoxias (Hagiology of Orthodoxy). Athens ISBN-13:9789607841001 (**in Greek**)
Yalçiner AC, Alpar B, Altinok Y, Özbay I, Imamura F (2002) Tsunamis in the Sea of Marmara: historical documents for the past, models for the future. Mar Geol 190(1–2):445–463. https://doi.org/10.1016/S0025-3227(02)00358-4
Yeomans DK (1991) Comets: a chronological history of observation, science, myth, and folklore. Wiley
Yoke HP (1962) Ancient and mediaeval observations of comets and novae in Chinese sources. Vistas Astron 5:127–225
Yolsal S, Taymaz T, Yalçiner AC (2007) Understanding tsunamis, potential source regions and the tsunami-prone mechanisms in the Eastern Mediterranean. In: Taymaz T et al (eds) The geodynamics of the Aegean and Anatolia, vol 291. Geol Soc London, Special Publications, pp 201–230
van Nuffelen P (2012) John of Antioch, inflated and deflated. Or: how (not) to collect fragments of early Byzantine historians. Byzantion 82:437–450
Zohar M, Salamon A, Rubin R (2016) Reappraised list of historical earthquakes that affected Israel and its close surroundings. J Seismol 20:971–985. https://doi.org/10.1007/s10950-016-9575-7
Zohar M, Salamon A, Rubin R (2017) Earthquake damage history in Israel and its close surrounding- evaluation of spatial and temporal patterns. Tectonophysics 696–697:1–13. https://doi.org/10.1016/j.tecto.2016.12.015

Classical sources

Strabo (63 BC-AD 23) (1914-1916) Geography, Loeb Classical Library, Harvard University Press
Athenaeus of Naucratis (AD end 2nd-early 3rd century) (1927-1941) The Deipnosophistae (Scholars at the Dinner Table), book 8, Loeb Classical Library, Harvard University Press

Chronographies

Theophanes (AD 758/760–817/818) (1883-1885) Chronographia, Carolus de Boor (ed.), Leipzig, repr. Hildesheim 1963; C. Mango and R. Scott, 1997. The Chronicle of Theophanes Confessor. Byzantine and Near Eastern History AD 284–813, Oxford
Chronikon (1234) Anonymi auctoris chronicon ad a.c. 1234 pertinens, vol. II, trans. by Albert Abouna, Corpus scriptorum christianorum orientalium, Scriptores syri, tomus 154, vol. 354, Louvain, 1974