Two Inferred Antique Earthquake Phases Recorded in the Roman Theater of Beit-Ras/Capitolias (Jordan)

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Abstract

A Roman theater is recently being excavated at Beit-Ras/Capitolias in Jordan, which is one of the Decapolis cities, founded before A.D. 97/98. This is an archaeoseismological study that aims to investigate the temporal and intensity impacts of past earthquakes on the theater’s existing structure. A rich set of earthquake archaeological effects were identified, including deformed arches, tilted and collapsed walls, chipped corners of masonry blocks, and extensional gaps, indicating a seismic intensity of VIII–IX. The study identified at least two significant destruction phases that took part in the damage of the theater, which may have contributed to the abandonment of its major use as a theater at different periods. This is based on field observations of construction stratigraphy and damage features, the assessment of the observed destruction, and literature reports. The date of the first phase is bracketed between the establishment of the city (before A.D. 97/98) and the date of an inscription found in the walled-up orchestra gate (A.D. 261). The most likely candidate earthquake(s) for this immense destruction are the A.D. 233 and/or 245 events. Other moderate and less damaging events may have also occurred within the region but are not mentioned in available catalogs. After a major restoration, another earthquake phase occurred between A.D. 261 and Late Roman–Early Byzantine times, when the scena wall tilted and collapsed, rendering the building useless and beyond repair. Subsequently, the theater was then filled with debris and was abandoned. The most probable causative earthquake of the second phase of destruction is an event in A.D. 363. The article provides a rich discussion of potential causative earthquakes, based on archaeoseismological, construction stratigraphy observations, and calibrated intensity of historical earthquake-based attenuation modeling. It identifies the potential phases and types of destruction and reuse.

Introduction

The Dead Sea Transform (DST) fault is the main tectonic element in the Middle East. It is a left-lateral transform fault, defining the boundary between the Sinai and the Arabia subplates (Garfunkel and Ben-Avraham, 1996; Fig. 1). Several instrumental and historical catalogs describe the seismicity of the region in detail (Guidoboni et al., 1994; Guidoboni and Comastri, 2005; Ambraseys, 2009; Zohar et al., 2016). However, both documentary and archaeological records of historical earthquakes (see Marco, 2008; Schweppe et al., 2017, with abundant references) are mainly concentrated on events that are located between the DST fault and the Mediterranean Sea; although, there is very little information available on historical seismicity effects east of the DST fault, especially across Jordan. This is either due to the lack of earthquakes, which is not plausible, or to a paucity of historical sources (Niemi, 2007). Seismic hazard assessment studies require accurate and complete information about historical seismicity. Thus, it is...
imperative to increase the number of archaeoseismologically investigated archaeological sites, east of the DST fault.

Archaeoseismology is the study of historical earthquakes based on understanding the physical, social, and cultural effects and changes of ancient places (Stiros, 1996). It contributes to close gaps in the historical earthquake record (Kázmér and Györi, 2020), enriches the knowledge of the temporal and spatial distribution of earthquake damage (Marco, 2008), and presents data of more than a thousand years into the past (Kázmér and Major, 2015). Within the Middle East, there is a multitude of well-preserved masonry buildings that are ideal for archaeoseismological studies (e.g., Harding, 1959; Segal, 1981; Retzleff, 2003; Kázmér, 2014), along the DST fault (Marco et al., 1997; Ellenblum et al., 1998, 2015; Meghraoui et al., 2003; Haynes et al., 2006), and in the vicinity of the DST fault (Korjenkov and Erickson-Gini, 2003; Marco et al., 2003; Al-Tarazi and Korjenkov, 2007; Thomas et al., 2007; Marco, 2008; Wechsler et al., 2009; Kázmér and Major, 2010, 2015; Al-Azzam, 2012; Alfonsi et al., 2013; Korjenkov and Mazor, 2014; Hinzen et al., 2016; Schwepppe et al., 2017; Al-Tawalbeh et al., 2019; Jaradat et al., 2019). These studies indicate a rising interest in archaeoseismology, as a research topic around the DST fault.

This research presents the results of a detailed archaeoseismological study of a recently excavated theater at Beit-Ras/Capitolia, located 23 km east of the DST fault in northern Jordan. The study is based on understanding construction stratigraphy from the time of theater’s construction until its abandonment, and the correlation of existing observations with direct and indirect existing earthquake evidences. This correlation allows clarification of potential earthquake damage scenarios within the site and the surrounding area, with an emphasis on the Roman and Byzantine era.

Beit-Ras/Capitolia Theater

Capitolia (Beit-Ras) was one of the Decapolis cities of the Levant, extending from Damascus in the north to...
Philadelphia (today Amman) in the south. It is located 70 km north of Amman (Fig. 1), at an elevation of about 600 m above sea level. It was founded before A.D. 97/98, and the city flourished during the Roman and Byzantine time, until the Early Islamic (Umayyad) period (Lenzen and Knauf, 1987).

Descriptions of nineteenth-century travelers (Seetzen, 1810; Buckingham, 1821; Schumacher, 1890) and twentieth-century archaeological excavations (Glueck, 1951; Mittmann, 1970; Al-Shami, 2005; Młynarczyk, 2017; Młynarczyk, 2018) yielded sufficient information for understanding the history and the general plan of the city (Fig. 2).

A medium-size theater was found buried underneath rubble landfill. It was localized and excavated in the years, since 1999 (Al-Shami, 2003, 2004, 2005; Fayyad and Karasneh, 2004; Karasneh and Fayyad, 2005; Lucke et al., 2012). It is located on a hill north of the city of Beit-Ras/Capitolas (Figs. 2 and 3) (32° 35’ 56.4″ N, 35° 51’ 32.2″ E). The foundations of the theater are erected on hill slope outcrops of the Umm Rijam Chert Formation that was described by Powell (1989) as light-colored limestone (Eocene), bearing chert nodules, and of deep marine origin.

Roman theaters—developed from the Greek theaters—usually have recognizable and well-defined architecture built after the traditions, as described by Vitruvius (Dodge, 2009). The Beit-Ras/Capitolas theater is very similar in the overall structure and in the small details to other Greek and Roman theaters.

Greek and Roman theaters have developed names for their structural parts. Likewise, if we follow the Roman naming of the theater parts, this theater’s major parts are: the cavea (the semicircular rows of seats for the audience of common people), the orchestra (where high-ranking citizens were seated), the stage (where actors performed), the aditus maximus (the main side passageways into the orchestra), the scena (a high, decorated backstage wall, which provided the acoustic quality for everyone in the theater), and ambulatorium, an external annular passageway surrounding the upper seat rows. Common people used to enter the cavea from this annular passage via six radial corridors called vomitoria, with horizontal floors and inclined barrel vaults. These radial vomitoria passages lead people to the praeccinctio—a semicircular narrow floor all around the cavea about halfway in elevation between the lowest and highest seat rows (Fig. 4; Sear, 2006).

Methodology
The adopted methodology is based on the following main steps:

1. Identifying and documenting various damage anomalies within the building that can be described as earthquake anomalies.
4. Correlating the stratigraphy sequences of the theater and phases with identified damage evidences to constrain damage to a given time interval(s).

5. Defining potential seismic intensities based on the earthquake archaeological effect (EAE) scale (Rodríguez-Pascua et al., 2013).

6. Discussing and proposing the most probable sequences of historical event(s), which could produce the observed damages and those which could not. This is based on historical documentation and the main historical earthquake catalogs of the DST fault region, and estimating plausible seismic intensities (modified Mercalli intensity [MMI]). For these events, seismic intensities (MMI) were estimated based on a new attenuation equation developed for the Dead Sea region (Hough and Avni, 2009), taking into consideration site amplification conditions (Darvasi and Agnon, 2019).

Results
Earthquake-related damage features

Careful investigation indicated several observed damage features across the theater structure that can be attributed to seismic origin, including, displaced arches, chipped corners and edges of masonry blocks, tilted and collapsed scaena, extensional gaps, and broken stairs (Fig. 5).

Displaced arches. Three different styles of arches are seen in the theater: semicircular or arcuated, segmental, and flat. They were built out of wedge-shaped stones, arranged in the various shapes of an arch. Two arcuate arches are seen above the eastern gates (aditus maximus), although the adjoining vault is damaged and partly collapsed. The flat arches are seen as the lintel arches above stage gates (versurae), trending north–south, has a flat arch and a stress-releasing segmental arch above, where two stones of the flat arch dropped down almost 3 cm (Fig. 6b). The keystone of the segmental arch above is also dropped down ~4 cm (Fig. 6d). The flat arches of most vomitoria to the cavea also are dropped down (Fig. 6c).
Masonry arches are common above openings in walls, spanning wall openings by diverting vertical loads from above to compressive stress laterally (Dym and Williams, 2010). Dropped arches in a masonry building indicate an EAE having an earthquake intensity of VII or higher (Rodríguez-Pascua et al., 2013).

**Chipped corners and edges of ashlars.** Chipping of stone corners can occur during ground motion at any structure, especially the ones with well-cut and sharp-edged blocks. This is because a large pressure is applied more on the corners than other parts (Marco, 2008). The orchestra gates display spectacular examples (Fig. 7), suggesting seismic intensity of VII or more (Rodríguez-Pascua et al., 2013).

**Tilted and collapsed walls.** Figure 8 shows a deviation of the scena wall from the vertical toward the north by 8°. Also, a vertical buttress wall (portion of the city wall) was erected behind the tilted scena wall (Figs. 5 and 8). The normal elevation of the scena is presumed to be the same as the colonnade on top of the cavea or even higher (i.e., almost 13 m). Today, only the lower 5.2 m of the scena is preserved. Tilted and collapsed archaeological walls suggested an EAE seismic intensity range of IX and higher (Rodríguez-Pascua et al., 2013).

**Shifted blocks and extensional gaps.** A number of out-of-plane extruded and shifted blocks are observed and developed across single or multiple masonry courses (Fig. 8b,c). Such features are typically associated with intervening gaps produced due to shaking directed at high angle to the wall (Kázmér, 2014), suggesting an intensity range of IX–XII (Rodríguez-Pascua et al., 2013).

**Discussion**

Relative succession of events and phases

The foundation of Capitolias and the construction of the theater. The Roman domination over the region extended from 63 B.C. until A.D. 324 (Stager et al., 2000). According to Lenzen and Knauf (1987), based on numismatic and epigraphic evidence, the city reached its peak of prosperity in the latter half of the second century and the first half of the third century A.D., and the evidence of the coins suggests that...
The city certainly existed when coins were minted at Capitoiasin A.D. 97/98 (Spijkerman, 1978). The good economic position of the city promoted the construction of a theater—usually a project of decadal duration—possibly as early as the coins were minted (i.e., at the end of the first century A.D.). The theater was built against a hill slope, a typical engineering solution until the end of the second century A.D. (Sear, 2006). According to Frézouls (1959), many theaters were built in the region throughout the first to third centuries.

The first damage and reconstruction phase. In situ observations indicate that the eastern orchestra gate displays a complex construction and reconstruction history. This is concluded based on existing differences in construction material, practice, and observed masonry structures (Fig. 9). The eastern arched gate (aditus maximus) was made of well-cut and good-quality compact phosphatic limestone courses. Normally, it is open for its entire height and opens into the ambulacrum—the perimeter corridor connecting all entrances (vomitoria) to the theater (Sear, 2006). This corridor is now missing, as can be seen right above the gate where the lower two rows of the ashlars forming the barrel vault are preserved right above the gate (Fig. 9a). The gate is walled up to the top by locally extracted marly–chalky limestone ashlars, which is a lower quality material (i.e., highly weathered and soft) compared with the phosphatic limestone ashlars of the original wall and arch.

The infill wall contained a significant inscribed stone, bearing the year A.D. 261 (Fig. 9c). The inscription is Greek written in seven lines and is now in a vandalized state. It translates as follows: “In honor of the victory of our lord, Gallienus Augustus, at a time when Numerius Severus was governor and Aurelius Andromachos, excellent man and administrator was responsible for the works of this building in the year of 163” (translated from the French manuscript of Bader and Yon, 2018). The year 163 of the Greek calendar corresponds to a date between A.D. 259 and 261 of the Julian calendar. The sole rule of Emperor Gallienus (without co-emperor Valerius) started in A.D. 260. Therefore, the inscription was erected in A.D. 260 or 261. It marks the completion of a restoration process after, at least, one pronounced damaging event, probably an earthquake, which included the rebuilding of the scena with staircases and of the stage gate. The ambulacrum was not rebuilt; instead, the orchestra gate and four of six vomitoria were walled up. Another case where the marly–chalky limestone of poorer quality was used to build the wall, to the right of the eastern gate, where the original wall is joined by irregular suture (Fig. 9d). However, the edges of some blocks of the original arch are cracked and spalled off (Fig. 7d). Spalled-off edges are held in place by blocks of the infill wall, indicating that spalling occurred after its construction. According to these observations, it is strongly believed that the theater was originally built of a well-cut and good-quality compact phosphatic limestone that was probably derived from distant quarries, whereas, for an unknown reason, subsequent reconstruction and restoration were carried out using marly–chalky limestone that was extracted locally from strata outcropping within the theater and its vicinity.

The basalt masonry in the upper left (Fig. 9f) suggests a later local collapse and repair phase, where the basalt courses are overlaying the marly–chalky limestone to the left of the walled arched eastern gate.

It can be understood that the original theater was heavily damaged by an earthquake, where the perimeter corridor, the ambulacrum, the staircases, and the scena were damaged beyond repair, whereas the lateral portions of the cavea survived, including the eastern arched gate of the aditus maximus.

Figure 6. Damage features within displaced arches: (a) dropped blocks of the flat arch, east door in scena, (b) dropped blocks of the flat arch of the eastern stage gate (versura), (c) dropped blocks of the flat arch of vomitorium, small spaces between the stones formed due to the ground shaking, and (d) dropped keystone of the stress-releasing segmental arch above eastern stage gate (versura). Figure 5 shows positions of the damaged element. The color version of this figure is available only in the electronic edition.
Subsequent restoration was made using stones of inferior quality for the scena. The staircases and the eastern stage gate were rebuilt (still visible today), whereas the ambulacrum was not. Instead, the gate to the aditus maximus was walled up and marked with a dedicatory inscription. All these were built before A.D. 261—the date of the inscription. A subsequent earthquake cracked the ashlars of the gate, causing stone spalling and breaking off. Finally, the basalt stone portion of the wall is evidence for a later local damage and repair at an unknown time (Fig. 9f).

As mentioned by Russell (1980), during reconstruction, the archaeological evidence of earthquake destruction may consist solely of extensive rebuilding features postdating the time of the collapse. The evidence of which event (or events) caused the damage to the theater structure is not exactly clear, but it caused a substantial reconstruction that is still present. It is important to note that the scena and the staircases are the most vulnerable parts of any theater, and are built of relatively thin walls, bordered by vertical planes inside and outside. The lack of a postscenium (the dressing rooms for actors) in Capitolias adds to the structural vulnerability. The cavea, however, is a robust structure, bordered by an external vertical wall and internal slope. It provides stability like that of a pyramid. The ambulacrum and the scena walls are vulnerable to seismic shaking, as both had thin wall structures. It is a well-founded hypothesis that an earthquake destroyed these walls. The ambulacrum was never restored, while the scena was rebuilt, but from stones of inferior quality. The idea that the ambulacrum collapsed previously is further evidenced by the walling up with chalk limestone masonry on four of the six vomitoria. This was probably done at the same time as when the eastern gate was walled up.

The conversion of use phase (i.e., conversion into an amphitheater).

Observations strongly indicate that after the first collapse and subsequent reconstruction as a theater, the building was transformed into an amphitheater. As different forms of theater entertainment vanished, gladiatorial games and animal displays became the norm in the eastern Mediterranean (Segal, 1981; Retzleff, 2003; Sear, 2006; Dodge, 2009). These changes rendered the proscenium, the stage, and the scena obsolete. In Beit-Ras/Capitolias theater, the orchestra’s floor was then deepened to 3 m below the level of the former stage to contain the danger of the wild animals. In addition, the diameter of the orchestra semicircle was increased at the expense of the lowest rows of seats. Three refuges were carved into the face of the new wall of raw rock, which was plastered and color-painted. The proscenium—the frontal side of the stage—was removed as was the stage, and the remaining space was outlined by a wall of recycled stones arranged to form an oval arena (the orchestra foreground) (Fig. 10). The relative age of this substantial conversion is established by the deepening of the floor of the eastern aditus maximus by about 1.5 m, as far as the A.D. 261 walled-up gate, making it essentially useless. A canal was carved into...
The floor of the arena, possibly to allow the introduction of caged animals (Fig. 10).

Converting an existing theater into an amphitheater was quite common. For example, the Myrtusa Theater in Cyrene (Libya) has seen the removal of some rows of seats. The scena was demolished to give place to rows of seats, essentially creating a pseudo-amphitheater. At Stobi, Macedonia, the scenaefrons was preserved during transformation into a pseudo-amphitheater at the end of the third century A.D. Instead of deepening the orchestra, a thick masonry wall was added to the podium to increase its height to 3.60 m (Sear, 2006). Similar modifications were frequent in the eastern Mediterranean, as seen at the theaters of Ephesus, Pergamum in Anatolia, Corinth, Dodona, Philippi, and Athens in Greece (Dodge, 2009).

The second collapse and abandonment phase. It is likely that after the conversion into an amphitheater, at least one other earthquake was responsible for deformation seen in the scena wall (i.e., tilting, shifted stones, dropped keystones, stones rotations). The scena itself is strongly tilted toward the north, so much so that two-thirds of the original height collapsed and is missing, and leaving behind only a 3–5-meter-high truncated wall. This seismic event definitely contributed to the theater’s abandonment, when all damage remained unrepaired (Karasneh et al., 2002). Later, a buttress wall was built to support the tilted scena, making it a part of the city wall, in Late Roman–Early Byzantine.

The second collapse of the theater certainly occurred, after the conversion into an amphitheater and just before buttressing the scena wall system. This succession of events is proven by the severely damaged vomitoria arches, which were left unrepaired. It can be suggested that this final collapse led to a final abandonment of the theater.

The second restoration phase (i.e., conversion into a fortification). The unused theater structure was kept standing by a buttress wall, 1.5 m thick, joining the 1-meter-thick tilted scena. This wall encircled both staircases, providing support to the damaged northern facade. Also, there are two walls (part of the city wall) adjacent to the eastern side of the theater (trend northwest–southeast) (Figs. 3 and 5).

According to Lenzen (1990), the city wall was constructed during Roman times. It was found that it connects with the buttress wall all around the scena and the two staircases, and blocks all doors (Fayyad and Karasneh, 2004). This part of the city wall (buttress wall) includes stones from parts of the theater. It could have been constructed during Late Roman–Early Byzantine time to strengthen the defense of the northern part of the city (Fayyad and Karasneh, 2004).

Figure 8. Deformation of scena: (a) scena tilted toward the viewer and is supported by the buttress vertical wall (city wall), (b) out-of-plane shift of blocks of scena, (c) blocks sequentially shifted to the right, in direction of tilting, and (d) extreme tilt of scena, segment supported by buttress vertical wall (city wall). Figure 5 shows position of photos. The color version of this figure is available only in the electronic edition.
Młynarczyk (2017) dated a portion of the city wall that has a width of 2.5 m and is located 140 m west of the theater to not later than second century A.D., based on ceramics embedded in abutting floor levels. We think that this dating is not valid for the portion of the city walls adjacent to the theater, where the buttress wall is 1.5 m thick. At this time, the building was still functioning as designed, as a theater or amphitheater, as proven by the inscription dated A.D. 261 (Bader and Yon, 2018). The original city wall was probably somewhere to the south of the theater at that time. The city wall, which blocks most entrances of the theater, was built later, most likely after the second damaging earthquake. Młynarczyk’s doubts can be accepted on “tentatively dated” and “not easy to be dated” ceramics from the lower two stratigraphic levels (i.e., phases) abutting the wall. However, we agree with her assignment of

Figure 9. External view of the eastern orchestra gate leading from the outside into the aditus maximus. (a) Above the gate arch, there are two rows of ashlars of the former vault of the ambulatorium. (b) Upon the collapse of the passage, the gate was walled up, allowing access to the theater via a smaller stone door below (in the lower part). (c) A carved inscription from A.D. 261 dates the wailing up event. (d) About a meter to the right, there is a different wall, made of chalky limestone of lighter color, and has irregular contact with the original wall. (e) The wall suture clearly indicates that the lighter chalk wall was attached to the darker limestone wall later, as a repair structure. (f) Repair on the left by basalt cubes was carried out after the wall with the inscription was built. The color version of this figure is available only in the electronic edition.

Figure 10. (a) Photo of the orchestra from south shows the removed front part of the stage proscenium, remnants of the two curved walls outlining the arena of the amphitheater, and a median north–south canal (L-shape) across the floor. (b) Photo from north, orchestra’s depth is 3 m with three refuges. (c) Plaster and paint remains between refugia. The color version of this figure is available only in the electronic edition.
the upper phase (fifth phase) of the wall as Late Roman (fourth–fifth centuries), and consider this period as terminus ante quem when the wall was constructed.

The landfill (burying phase). Following the final abandonment, the empty space above the cavea, orchestra, and stage was filled up naturally and/or deliberately with sand and debris (Fig. 11), composed of sand-sized to boulder-sized clasts and containing fragments of ceramics and thin charcoal layers. It was interpreted by Lucke et al. (2012) as fluvial sediment, indicating an Early Medieval wet period. The lack of any sizeable natural drainage in the city makes this suggestion untenable. Several meters of thickly packaged and steeply dipping, parallel, decimeter-thick layers makes the succession similar to a man-made landfill used as a dump of quarry and construction garbage, where materials were dumped up to the entire volume contained by the theater walls, and they even buried the retaining wall in the north. However, the idea that the theater was used, as water cistern cannot be overlooked, a suggestion that was mentioned by Karasneh and Fayyad (2004).

It is most likely that the sediment burying the theater can roughly be dated as Late Roman, Byzantine, and Umayyad, because it contained a chaotic mixture of ceramics from these ages, including stamped Late Roman pottery (Karasneh and Fayyad, 2004). According to Lucke et al. (2012), four ash bands were identified across the fill material. The C14 dating of these bands indicated that the major part of the sediment was deposited, approximately, between A.D. 521 and 667 (Lucke et al., 2012). This is the period before and during the early years of the Umayyad caliphate (A.D. 661–750). Considering the error of radiocarbon dates measured on old timber (Schiffer, 1986), it is difficult to know exactly how old the living tree and age of dead wood was, when carbonized. This is a terminus post quem for the deposition of the landfill.

How many earthquakes?

Most archaeoseismological studies provide documentation of observed damage features, attempting to attribute these to a known earthquake, based on historical data and architectural styles. There are very few studies where a site allows the distinguishing of more than one earthquake event, for example, Selinunte in Sicily (Guidoboni et al., 2002), Al-Marqab (Kázmér and Major, 2010), Avdat (Korjenkov and Mazor, 1998), Mamshit (Korjenkov and Mazor, 2003), Haluza (Korjenkov and Mazor, 2005), Rehovot (four events: Korjenkov and Mazor, 2014), and Beit-Ras/Capitolias (this article) in the Levant.

The theater in Beit-Ras displays at least two phases of damage or earthquake activity separated by a reconstruction events, as indicated by an inscription dated A.D. 261 and by the methods used for reconstruction. Another evidence, for more than one earthquake, is the variation of damage seen within the dropped arch stones. Usually, an arch stone drop occurs when ground motion is parallel to the trend of the arches (Hinzen et al., 2016; Martín-González, 2018) or if it is ±45° to their strike (Rodríguez-Pascua et al., 2011). The arches in the theater have different trends, and the fact that their stones were dropped down along these arches (Fig. 5) suggests that Capitolias was hit by more than one earthquake. Figure 12 illustrates a timeline of the successions and major phases of the theaters and two major collapse events at the theater.

The first major proposed earthquake may be responsible for the destruction of the annular passageway (ambulatorium), which was followed by a reconstruction that was marked by a A.D. 261 inscription. However, a definitive judgment on the time separating the first earthquake occurrence from its subsequent reconstruction, which was evidently concluded in a documentary or celebrational activity, is difficult to support.

The second earthquake activity resulted in tilting of the rebuilt scaena wall. As a result, the upper two-thirds collapsed, and the vaulted corridors were totally demolished, which were never to be restored again.

Attribution to causative earthquakes

The DST fault has been the source of several large historical earthquakes (Ambraseys and Jackson, 1998; Guidoboni and Comastri, 2005; Ambraseys, 2009), which are capable of producing large earthquakes with magnitudes of up to 7.5. According to Zohar et al. (2016), there were 71 known historical earthquakes along the DST fault, during the period from 2000 B.C. until 1927. The Levant was hit 32 times during this time, of which 21 earthquakes occurred after the first and into the second millennium. The last major earthquake was in 1995 with $M_w$ 7.2, located about 80 km to the south of Aqaba (Ambraseys and Jackson, 1998; Al-Tarazi, 2000), and was too far from Beit-Ras to cause any significant damage.
Several Middle East historical earthquake catalogs were consulted to identify the major damaging earthquakes (i.e., Ben-Menahem, 1979, 1991; Russell, 1985; Abu Karaki, 1987; Guidoboni et al., 1994; Sbeinati et al., 2005; Ambraseys, 2009). The major damaging earthquakes belonging to the period between the first and eighth centuries are listed in Table 1, and the towns affected by these earthquakes are marked in Figure 1.

During the lifetime of Beit-Ras/Capitoliias theater, there were at least 13 significant events (Table 1). Five were probably coastal earthquakes (A.D. 233, 303/306, 347, 502, and 551), whereas eight were produced by displacement along the DST fault (A.D. 110/114, 127/130, 245, 363, 419, 634, 657, and 749). Two of these were too weak, poorly documented, and too low in magnitude to cause any damage (A.D. 127/130 and 347). We are aware that other major or moderately damaging earthquakes might not be listed in existing catalogs of historical earthquakes of the region. Further in-depth historical studies are needed to recover information about them.

To discuss potential causative relationships to candidate earthquakes, where observed EAEs produced a minimum seismic intensity of VIII–IX in the theater, an attempt was made to constrain the candidate events, based on expected earthquake MMI intensities using a calibrated intensity-based attenuation model of the Dead Sea, as proposed by Hough and Avni (2009), and recently developed by Darvasi and Agnon (2019) to incorporate site-specific conditions (equation 1). The model includes information related to site-specific conditions (i.e., shear-wave velocity), local magnitude, and epicentral distances:

\[
\text{MMI} = -0.64 + 1.7M_L - 0.00448d - 1.67\log(d) - 2.1\ln V_{S30}/655,
\]

in which MMI is the modified Mercalli intensity, \(M_L\) is the local magnitude, \(d\) is the distance from the epicenter, and \(V_{S30}\) represents the average shear-wave velocity from the surface to a depth of 30 m.

In this study, we reported a range of intensities assuming \(V_{S30}\) of 360 and 800 m/s, assuming soft rock and very dense soil material (according to the Eurocode 8 standard). The reported earthquake magnitudes were transformed into local magnitude \(M_L\), based on the model proposed by Al-Tarazi (2005). The results of the investigation are given in Table 2, and Figure 13 shows the epicentral locations, based on Table 2.

The earthquakes considered as potential sources of damage to the theater of Beit-Ras/Capitoliias are likely not all the earthquakes that have occurred there. Reading the Zohar (2017) catalog, there are 10 earthquakes known with some reliability in the first millennium and other 21 events in the second millennium. Therefore, one can safely assume that as many major damaging earthquakes occurred in the first millennium as in the second.

The review of the causative earthquakes can be divided into two phases. The first potential event, which belongs to the first phase of destruction of the theater, can be bracketed between the establishment of the city in A.D. 97/98 and 261. The second potential candidate event(s) belongs to the second phase of destruction that caused the collapse and tilting of the Scaena, followed by the abandonment of the theater, can be traced to the events of A.D. 303–306, 347, 363, and 419. Other later earthquakes that occurred post-abandonment are also covered in the discussion.

**Post the establishment of the city events**

Four candidate events occurred during the 1st phase of destruction, which are A.D. 110–114, 130, 233, and 245.

**A.D. 110–114 earthquake.** Because of the wide time span between the occurrence of this event and the date of subsequent reconstruction, we strongly believe that the A.D. 110–114 earthquake is not the responsible event that caused
the considerable damage in the theater resulted in the major reconstruction of A.D. 261. Definitely it is not conceivable that the wealthy society of Capitolias would wait so long, from A.D. 114 to 261, to put their favorite and only theater (i.e., excavated so far)—the place for public entertainment, social life, and display of wealth and power—to good use again.

**A.D. 130 earthquake.** Ambraseys (2009) doubted the certainty of the sources of the A.D. 130 event. It is not certain whether they refer to the damage of Neocaesarea and Nicopolis in the Pontus (Niksar and Enderes, respectively) or Caesarea Maritima and Nicopolis (Emmaus) in Palestine, whilst the former position, at northeastern Anatolia, is most likely. His doubts have arisen because there were at least three towns in the Roman Empire called Nicopolis, and many called Caesarea. He mentioned that Nicopolis is very close to Jerusalem, and, he questioned the integrity of this event, asking why no damage was reported from Jerusalem, although a less significant Nicopolis was expressly mentioned? Besides, there is another pair of cities called Caesarea and Nicopolis, 110 km apart along the North Anatolian fault. Accordingly, our suggestion is that the A.D. 130 event cannot be considered as a potential earthquake causing any damages to Capitolias.

**A.D. 233 earthquake.** The earthquake A.D. 233 has few historical source references (Sieberg, 1932; Ben-Menahem, 1979; Sbeinati et al., 2005), but its epicenter was reported along the

---

### TABLE 1

<table>
<thead>
<tr>
<th>Date (A.D.)</th>
<th>Sites That Were Damaged by or Felt the Earthquake</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>110–114</td>
<td>Caesarea, Hesban, Jerash and Petra, Advat (partly damage)</td>
<td>Russell (1985); Ambraseys (2009)</td>
</tr>
<tr>
<td>127/130*</td>
<td>Caesarea (severe damage)</td>
<td>Amiran et al. (1994); Ambraseys (2009)</td>
</tr>
<tr>
<td></td>
<td>Lod (strong earthquake)</td>
<td>Amiran et al. (1994)</td>
</tr>
<tr>
<td></td>
<td>Nicopolis (Emmaus) (strong earthquake)</td>
<td>Amiran et al. (1994); Ambraseys (2009)</td>
</tr>
<tr>
<td>233</td>
<td>Damascus (destructive)</td>
<td>Ben-Menahem (1979)</td>
</tr>
<tr>
<td>245</td>
<td>Occurred near Antioch ($M_l = 7.5$)</td>
<td>Ben-Menahem (1979); Öztekin et al. (2000); Sbeinati et al. (2005)</td>
</tr>
<tr>
<td>303/306</td>
<td>Tyre and Sidon (destructive)</td>
<td>Russell (1985); Amiran et al. (1994); Ambraseys (2009)</td>
</tr>
<tr>
<td></td>
<td>Gush Halav (destructive)</td>
<td>Amiran et al. (1994)</td>
</tr>
<tr>
<td></td>
<td>Byblos (may have affected), Caesarea (felt)</td>
<td>Ambraseys (2009)</td>
</tr>
<tr>
<td>347*</td>
<td>Beirut (affected)</td>
<td>Guidoboni et al. (1994); Ambraseys (2009)</td>
</tr>
<tr>
<td>363 May 19</td>
<td>Sebastia, Japho, Caesarea, Tiberias, Beit-Gubrin, Jerusalem, and Petra (severe damage)</td>
<td>Amiran et al. (1994); Guidoboni et al. (1994); Ambraseys (2009)</td>
</tr>
<tr>
<td></td>
<td>Haifa, Gerasa, and Lod (severe damage)</td>
<td>Ambraseys (2009)</td>
</tr>
<tr>
<td>419</td>
<td>Jerusalem (felt)</td>
<td>Russell (1985); Ambraseys (2009); Guidoboni et al. (1994)</td>
</tr>
<tr>
<td>502</td>
<td>Akko, Tyre, and Sidon (severe damage), Beirut (less damage)</td>
<td>Guidoboni et al. (1994); Ambraseys (2009)</td>
</tr>
<tr>
<td>551</td>
<td>Tyre, Beirut, Sidon, and Tripoli (worse damage)</td>
<td>Russell (1985); Amiran et al. (1994); Ambraseys (2009)</td>
</tr>
<tr>
<td></td>
<td>Jerash (much damage)</td>
<td>Amiran et al. (1994)</td>
</tr>
<tr>
<td></td>
<td>Sarafand, Galilee, and Samaria (some damage)</td>
<td>Ambraseys (2009)</td>
</tr>
<tr>
<td>634</td>
<td>Beit-She’an, Pella (affected)</td>
<td>Guidoboni et al. (1994); Ambraseys (2009)</td>
</tr>
<tr>
<td></td>
<td>Advat</td>
<td>Korjenkov and Mazor (1998)</td>
</tr>
<tr>
<td>659</td>
<td>Jericho (great damage)</td>
<td>Russell (1985); Guidoboni et al. (1994); Ambraseys (2009); Russell (1985)</td>
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<tr>
<td></td>
<td>Jordan Valley, Beth Shean, and Khan el Ahmer (strong effect)</td>
<td>Amiran et al. (1994)</td>
</tr>
<tr>
<td>749</td>
<td>Powerful event in Palestine</td>
<td>Guidoboni et al. (1994); Ambraseys (2009); Zohar (2017)</td>
</tr>
</tbody>
</table>

* Poorly constrained.
### TABLE 2
A List of Major Earthquakes of the DST Fault from the Roman to Late Byzantine Time and Estimated Potential Intensities

<table>
<thead>
<tr>
<th>Date (A.D.)</th>
<th>Latitude ('')</th>
<th>Longitude ('')</th>
<th>Reference</th>
<th>Reported Magnitude</th>
<th>Distance (km)</th>
<th>Estimated Intensity</th>
<th>MMI Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>110–114</td>
<td>30.70</td>
<td>35.30</td>
<td>Ambraseys (2009)</td>
<td>$M_L = 6$</td>
<td>217.63</td>
<td>4.26*</td>
<td>V†</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$M_L = 6$</td>
<td></td>
<td>5.93†</td>
<td>VI‡</td>
</tr>
<tr>
<td>127/130</td>
<td></td>
<td>Poorly documented</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>233</td>
<td>34.4</td>
<td>35.5</td>
<td>El-Isa et al. (2015)</td>
<td>$M_L = 6.2$</td>
<td>200</td>
<td>4.7</td>
<td>V</td>
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<td>245</td>
<td>36.25</td>
<td>36.10</td>
<td>Öztemir et al. (2000)</td>
<td>$M_L = 7.5$</td>
<td>405</td>
<td>5.5</td>
<td>VI</td>
</tr>
<tr>
<td>303/306</td>
<td>a 33.20</td>
<td>35.50</td>
<td>Ambraseys (2009)</td>
<td>$M_L = 6$</td>
<td>74.78</td>
<td>5.67</td>
<td>VI</td>
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<td></td>
<td></td>
<td></td>
<td>$M_L = 6$</td>
<td></td>
<td>7.35</td>
<td>VII</td>
</tr>
<tr>
<td></td>
<td>b 33.50</td>
<td>35.00</td>
<td>Abu Karaki (1987)</td>
<td>$M_L = 6.5 \pm 0.5$</td>
<td>128.25</td>
<td>5.55–6.23</td>
<td>VI</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$M_L = 6.3 \pm 0.4$</td>
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<td>7.23–7.91</td>
<td>VII–VIII</td>
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<tr>
<td></td>
<td>c 33.80</td>
<td>34.30</td>
<td>Sbeinati et al. (2005)</td>
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<td>197.16</td>
<td>5.61</td>
<td>VI</td>
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<td></td>
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<td>$M_L = 6.7$</td>
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<td>7.2</td>
<td>VII</td>
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<td>34.00</td>
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<td>Abu Karaki (1987)</td>
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<td>5.25–5.93</td>
<td>V–VI</td>
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<td>$M_L = 6.3 \pm 0.4$</td>
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<td>6.93–7.61</td>
<td>VII–VIII</td>
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<tr>
<td>May 19, 363</td>
<td>a 31.30</td>
<td>35.60</td>
<td>Ben-Menahem (1979, 1991)</td>
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<td>146.44</td>
<td>4.87–6.57</td>
<td>V–VII</td>
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<td>6.54–8.24</td>
<td>VII–VIII</td>
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<td>b 31.30</td>
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<td>Ambraseys (2009)</td>
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<td>150.73</td>
<td>6.01</td>
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<td>$M_L = 6.7$</td>
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<td>7.69</td>
<td>VIII</td>
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<tr>
<td></td>
<td>c 31.50</td>
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<td>129.57</td>
<td>6.22</td>
<td>VI</td>
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<td>7.89</td>
<td>VIII</td>
</tr>
<tr>
<td>419</td>
<td>a 33.00</td>
<td>35.50</td>
<td>Ben-Menahem (1979)</td>
<td>$M_L = 6.2$</td>
<td>55.81</td>
<td>5.79</td>
<td>VI</td>
</tr>
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<td></td>
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<td></td>
<td>7.47</td>
<td>VII</td>
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<tr>
<td></td>
<td>b 33.00</td>
<td>35.50</td>
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<td>55.81</td>
<td>5.97–6.48</td>
<td>VI</td>
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<td>$M_L = 6 \pm 0.3$</td>
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<td>7.64–8.15</td>
<td>VIII</td>
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<tr>
<td>502</td>
<td>a 33.00</td>
<td>35.00</td>
<td>Abu Karaki (1987)</td>
<td>$M_L = 6.5$</td>
<td>91.81</td>
<td>5.96</td>
<td>VI</td>
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<td>$M_L = 6.3$</td>
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<td>7.63</td>
<td>VIII</td>
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<tr>
<td></td>
<td>b 33.00</td>
<td>34.80</td>
<td>Sbeinati et al. (2005)</td>
<td>$M_L = 7.2$</td>
<td>108.53</td>
<td>6.61</td>
<td>VII</td>
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<td>$M_L = 6.8$</td>
<td></td>
<td>8.29</td>
<td>VIII</td>
</tr>
<tr>
<td></td>
<td>c 32.90</td>
<td>35.10</td>
<td>Ambraseys (2009)</td>
<td>$M_L = 6$</td>
<td>78.45</td>
<td>5.62</td>
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<td></td>
<td>$M_L = 6$</td>
<td></td>
<td>7.35</td>
<td>VII</td>
</tr>
<tr>
<td>551</td>
<td>a 34.00</td>
<td>35.50</td>
<td>Sbeinati et al. (2005)</td>
<td>$M_L = 7.2$</td>
<td>159.35</td>
<td>6.1</td>
<td>VI</td>
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<td>$M_L = 6.8$</td>
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<td>7.78</td>
<td>VIII</td>
</tr>
<tr>
<td></td>
<td>b 33.70</td>
<td>35.20</td>
<td>Ambraseys (2009)</td>
<td>$M_L = 7$</td>
<td>136.96</td>
<td>6.14</td>
<td>VI</td>
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<td></td>
<td></td>
<td>$M_L = 6.7$</td>
<td></td>
<td>7.82</td>
<td>VIII</td>
</tr>
</tbody>
</table>

All $M_L$ values are converted to $M_s$ by the model proposed by Al-Tarazi (2005). The corresponding location of epicenter is marked in Figure 13.

* Estimated intensity using Darvasi and Agnon (2019), $V_{30} = 800 \text{ m/s}$.
† Estimated intensity using Darvasi and Agnon (2019), $V_{500} = 360 \text{ m/s}$.
‡ Estimated intensity using Darvasi and Agnon (2019), $V_{30} = 800 \text{ m/s}$ in Roman numerals.
§ Estimated intensity using Darvasi and Agnon (2019), $V_{500} = 360 \text{ m/s}$ in Roman numerals.

(Continued next page.)
TABLE 2 (continued)
A List of Major Earthquakes of the DST Fault from the Roman to Late Byzantine Time and Estimated Potential Intensities

<table>
<thead>
<tr>
<th>Date (A.D.)</th>
<th>Epicenter Location</th>
<th>Reference</th>
<th>Reported Magnitude</th>
<th>Distance (km)</th>
<th>Estimated Intensity</th>
<th>MMI Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Latitude (°)</td>
<td>Longitude (°)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>634</td>
<td>32.50</td>
<td>35.50</td>
<td>Abu Karaki (1987)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>659 a</td>
<td>32.00</td>
<td>35.50</td>
<td>Ambraseys (2009)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>659 b</td>
<td>32.50</td>
<td>35.50</td>
<td>Ben-Menahem (1979)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>746–749 a</td>
<td>32.00</td>
<td>35.50</td>
<td>Ben-Menahem (1979, 1991)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>746–749 b</td>
<td>32°.50</td>
<td>35.60</td>
<td>Sbeinati et al. (2005)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All $M_L$ values are converted to $M_I$ by the model proposed by Al-Tarazi (2005). The corresponding location of epicenter is marked in Figure 13.

* Estimated intensity using Darvasi and Agnon (2019), $V_{130} = 800$ m/s.
† Estimated intensity using Darvasi and Agnon (2019), $V_{130} = 360$ m/s.
‡ Estimated intensity using Darvasi and Agnon (2019), $V_{130} = 800$ m/s in Roman numerals.
§ Estimated intensity using Darvasi and Agnon (2019), $V_{130} = 360$ m/s in Roman numerals.

Tripoli–Beirut thrust (to the west) by El-Isa et al. (2015) and a magnitude approximated to 6.2 ($M_L$). According to attenuation equation modeling results (Table 2), the intensity of this earthquake in Beit-Ras ranges between V and VI. This intensity is very low to produce the high damage in the theater; although, it caused most of the damage farther to the north, especially in Damascus (Ben-Menahem, 1979). It seems that it was a strong event that affected the area south of Lebanon and Syria.

A.D. 245 earthquake. The epicenter of the A.D. 245 earthquake ($M_L = 7.2$) was reported by Öztürk et al. (2000). It is located far from the study area (about 405 km), where its epicenter was near Antioch (Ben-Menahem, 1979; Sbeinati et al., 2005). Attenuation equation modeling results indicated an intensity range of VI–VII (Table 2). Sieberg (1932) stated that the A.D. 242–245 earthquake taking place at Antioch affected all of Syria, and it was also felt in Egypt and Iran. According to Sbeinati et al. (2005), this event produced intensities of VI–VII at Antioch and Syria, and III at Egypt and Iran. Therefore, this event can be considered as a potential candidate to have caused damage to the Capitolias theater.

The discussion about these candidate events suggests that there is not enough data in existing catalogs supporting the exact capable event(s), which could have damaged the theater before A.D. 261, although the events of A.D. 233 and/or 245 are the most likely responsible earthquake, resulting in the collapse of the eastern cavea and the external perimeter corridor (ambulacrum).

Scaena collapse and tilting preceding the abandonment of the theater

The second group of candidate events (A.D. 303–306, 347, 363, and 419) may have caused scena collapse and tilting, preceding the abandonment of the theater. In the following, we discuss these events.

A.D. 303–306 earthquake. Most of the investigated catalogs reported that the severe earthquake damaging the cities of Sidon and Tyre was felt in Caesarea, possibly referring to the earthquake A.D. 303–306. A record of a seismic sea wave indicated that this was rather a coastal earthquake, which probably had minimal impact east of the Jordan River (Guidoboni et al., 1994, p. 247; Ambraseys, 2009, p. 140). The location of the epicenter was reported by Ambraseys (2009) along the Roum fault (south of Lebanon); meanwhile, Abu Karaki (1987) and Sbeinati et al. (2005) reported the epicentral location further to the west within the eastern Mediterranean. This event largely destroyed many ancient towns in the southern part of Lebanon (Table 1; Fig. 1). According to earthquake observations and attenuation modeling (Table 2), the intensity in Beir-Shat was V–VIII. Thus, this event cannot be excluded as the one causing damage in Capitolias.

A.D. 347 earthquake. There is a single historical source that mentioned a catastrophic destruction only restricted to the city of Beir-Shat that took place in A.D. 347, as reported by Guidoboni et al. (1994) and Ambraseys (2009). It is worth
mentioning that this event was not reported by Russell (1985), and the location of the epicenter is only mentioned by Abu Karaki (1987). However, attenuation modeling of this event indicated an intensity of $V\text{--}VIII$ (Table 2).

**A.D. 363 earthquake.** It is from Guidoboni et al. (1994, pp. 264--265) and Ambraseys (2009, pp. 148--151) that multiple historical sources report the A.D. 363 event, giving the exact date: 19 May, A.D. 363. This might mean that both a northern and a southern segment of the DST slipped, one after the other. Levenson (2013) provided names of 21--23 destroyed cities. Russell (1985) briefly described archaeological sites within the area of destruction. Several contemporary inscriptions are mentioning the earthquake or the succeeding reconstruction. The area of destruction extended from Baniyas in the north of Syria to Ayla in the south of Jordan, and from the coastal littoral of the Mediterranean through the Jordan Valley and beyond, that is, Capitolias was certainly heavily damaged. According to earthquake observations and attenuation modeling (Table 2), the intensity in Beit-Ras reached to an intensity of VIII.

**A.D. 419 earthquake.** In A.D. 419, there was a felt and recorded earthquake in Jerusalem (Russell, 1985; Guidoboni et al., 1994; Ambraseys, 2009). Its epicenter was identified close to Safad, with a magnitude ($M_L$) of 6.2--6.5 (Ben-Menahem, 1979; Abu Karaki, 1987). Based on attenuation modeling results (Table 2), this event was capable of causing a seismic intensity of $VI\text{--}VIII$.

Although available historical catalogs did not report the exact location for the epicenter of the A.D. 303--306 event, this event was evidently documented as a causative earthquake across the Levant. However, the fact that it only occurred 45 yr after the inscribed date of reconstruction (A.D. 261) may suggest that this earthquake could have caused some damage to the theater, but it certainly did not cause a total abandonment. Evidently, it may have been responsible for some localized destruction, such as the observed damage across the eastern upper part of the theater that was repaired with basaltic stones (Fig. 9f). On the other hand, the A.D. 363 event can be suggested as the most likely damaging earthquake, as it was documented by many resources, and it was a significant major event that had the

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Figure 13. Location map of suspected earthquake events (Table 2), likely to have caused the observed damage to the theater of Beit-Ras/Capitolias. The color version of this figure is available only in the electronic edition.
capability of producing damage up to intensity VIII (Tables 1 and 2). Within the same notion, Retzleff (2003, her footnotes 34, 35) stated that other theaters (i.e., Antipatis and Diacaes on the Mediterranean coast and Amman today) had also been abandoned after the earthquake of A.D. 363. The A.D. 419 event just occurred 56 yr after a major earthquake (i.e., A.D. 363) that caused immense damage to the region, where the theater was already abandoned.

According to the previous discussion, one of these earthquakes could have caused damage that was significant enough to lead to the abandonment of the site, which was followed by the conversion of the theater body to a fortification. This conversion was carried out by connecting the city wall to the main structure of the theater, and by adding the buttressing wall in front of the tilted scena. It is inferred that the date of the earthquake was very close to the date of construction of the buttress wall. Accordingly, the responsible event should have been very intense and was capable of causing considerable damage and subsequent abandonment of the theater. Therefore, we strongly believe that the A.D. 363 earthquake is the most likely event, which caused severe damage (i.e., tilting and collapse of the scena wall) that led to the abandonment and subsequent burial of the theater.

**Post-abandonment events**

Other later earthquakes, A.D. 502, 551, 634, 659, and 749 (Table 1), occurred after the site was abandoned, during and after filling of the cavea and orchestra of the theater with debris, when most of the theater body became buried beneath the rubble. According to Table 2, these events were all capable of causing significant damages (i.e., VI–X). Although some damage may have resulted from more than one earthquake, which may have occurred much later after the structure was abandoned (Ambroseys, 2006, p. 1014); this is fortunately not the case in the theater of Beit-Ras. We believe that filling up the cavea and orchestra of the theater happened parallel with the construction of the enclosing wall that essentially put all of the remaining building underground. Underground facilities are significantly less vulnerable to seismic excitation than that above-ground buildings (Hashash et al., 2001). Understandably, when each wall and arch are supported by embedding sediment (dump in Beit-Ras), the observed deformations of the excavated theater mostly cannot develop unless unsupported. Therefore, evidence of damage due to any subsequent events, such as A.D. 551, 634, 659, and 749, cannot be observed, because the possibility of collapse of buried structures is not plausible. However, potential collapse of other above-ground structures within the site of Beit-Ras cannot be ignored, such as the upper elements of the theater’s structures, which were still exposed after the filling of the theater with debris. Several observations indicated that many collapsed elements of the upper parts of the theater were mixed with the debris, as documented in excavation reports by Al-Shami (2003, 2004). Another example suggesting the effect of the later events, such as that of A.D. 749. Młynarczyk (2017) attributed the collapse of some sections of the city wall of Beit-Ras to this event, based on the concentration of collapsed ashlars and the age of collected pottery from two trenches excavated to the west of the theater structure.

**Conclusions**

This research studied the archaeological stratigraphy and the existing archaeoseismic damage features of the Roman theater of the Decapolis Beit-Ras/Capitolias theater, with the aim of defining the relative chronological succession of the various phases of construction, destruction, and subsequent repairs. Parts of the theater vary in construction techniques and/or materials, which suggests possible temporal differences in the time of construction. Contrary to the long-lasting belief that the A.D. 749 event is the main candidate earthquake damaging most of the Decapolis cities, the correlation of the stratigraphy of the theater with earthquake indicators revealed that at least two severe earthquake phases have damaged the theater. It is most likely that the first phase occurred sometime between A.D. 98/97 and 261, which resulted in the collapse of the external perimeter corridor (ambulacrum) and the eastern cavea. The second phase occurred between A.D. 261 and the Late Roman–Early Byzantine times, which resulted in the tilting and collapse of the scena wall. We suggest that the A.D. 233 and/or 245 are the potential causative event(s) responsible for the destruction of the theater that preceded its major reconstruction before A.D. 261. A review of the seismicity of the Levant region during the first millennium indicates an incomplete documentation of the earthquake events, which might overlook other potential events.

The A.D. 303–306, 363, and 419 are probable candidate earthquakes for the second instance of severe damage to the theater during the second phase. The A.D. 363 earthquake is the most likely event that caused the abandonment and subsequent burial of the theater. Other subsequent events such as A.D. 551, 634, 659, and 749 occurred after the theater was filled up with the rubble. However, it cannot be excluded that other events, not mentioned in historical catalogs, contributed to the destruction of the theater. Observed EAEs suggest the size of the earthquake damage was, at least, VIII–IX for both phases. This study sets the grounds for future archaeological and seismological research on this site.

**Data and Resources**

Archaeoseismological and archaeological stratigraphy data were collected in situ from fieldwork at the theater, and from publications of Department of Antiquity reports, Jordan. All other data used in this article came from published sources listed in the references. Aerial Photographic Archive of Archaeology in the Middle East (APAAME) is accessible at www.humanities.uwa.edu.au/research/cah/aerial (last accessed August 2020).
Acknowledgments

This study is part of the "Mapping Archaeoseismic Damages across Jordan (MADAJ)" research project, conducted under the approval of the Department of Antiquities of Jordan. The project is led by Yarmouk University and in collaboration with the Hashemite University and the Jordan University of Science and Technology. The authors would like to express their gratitude to Yarmouk University (Dept. of Earth and Environmental Sciences) for the technical support and for giving access to needed geophysical and surveying instrumentation throughout the course of this work. Mohammad Al-Tawalbeh enjoyed a Stipendium Hungaricum Ph.D. scholarship while preparing this study in Eötvös Loránd University. The American Center for Oriental Research (ACOR) in Amman provided access to its excellent library. Krzysztof Gaidzik (Sosnowiec, Poland), Balázs Székely (Budapest, Hungary), and Yacine Benjelloun (Paris, France) provided advice and shared their ideas. The Department of Antiquities of Jordan kindly permitted the publication of this study. Special thanks are due to the Department of Antiquities for giving access to their archives and facilitating onsite activities. The authors are indebted and grateful to all of them. Insightful comments by Editor-in-Chief Allison Bent and an anonymous reviewer helped greatly improve this work.

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