

MEGIDDO EARTHQUAKES

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Megiddo owes its strategic advantage to the Carmel fault zone, an active branch of the Dead Sea Fault system. Mount Carmel rises southwest of the fault whereas northeast of it the Jezreel Valley subsides. The uplift of Megiddo where the main fault branches off to the Gilboa Fault gave those who commanded it control of the Jezreel Valley as well as of the international road connecting Egypt with Syria and Mesopotamia which descends into the valley near the site. The topographic relief is only one-fifth of the structural displacement accumulated across the fault (Rotstein *et al.* 1993), about 2 km of rock layers having been eroded from Mount Carmel. Achmon and Ben-Avraham (1997) studied the anomaly of the gravity field across the fault and verified that it is deep rooted (Fig. 31.1). A left-lateral component of movement (the valley moves in a northwesterly and the mountain in a southeasterly direction) is also inferred from analyses of earthquakes (Hofstetter *et al.* 1996) and offset stream channels (Achmon 1986). The recent activity of the fault is evident in the steepness of the cliffs, the displaced stream channels and the frequent microearthquakes (Fig. 31.1). In the past few decades a few earthquakes were even felt at nearby settlements and in the city of Haifa. On November 23, 1989, the Israel Geophysical Institute reported a very weak earthquake of local magnitude 2.1 (www.gii.co.il) directly beneath Tel Megiddo.

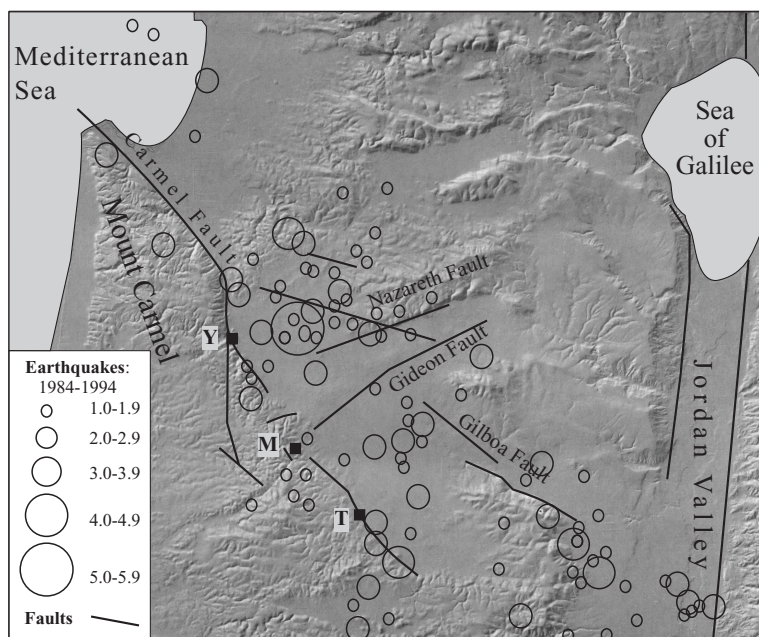


Fig. 31.1: Location of faults near Megiddo and recent earthquake epicentres in the vicinity of the Carmel Fault. (Y, M and T refer to Yoqne'am, Megiddo and Ta'anach respectively.) Earthquake data from the Geophysical Institute of Israel (www.gii.co.il).

The characteristics of the Carmel fault zone are typical of a fault that is capable of producing strong destructive earthquakes. Useful knowledge about these destructive earthquakes can be gleaned from damage in archeological sites. Nur and Ron (1997) pointed out the potential of Tel Megiddo for archaeoseismic studies and suggested that catastrophic earthquakes might be responsible for repeated damage and abandonment of the site. They went so far as to suggest that it was a destructive earthquake that inspired the Armageddon prophecy in the Book of Revelations.

The present study provides a systematic survey of structural damage at Megiddo which might be linked with earth tremors. The significance of Tel Megiddo comes from its location in close proximity to the trace of the Carmel Fault, and from the sequence of well-dated archaeological strata with many monuments, representing a history of several millennia. Hopefully, this study will also contribute to the reconstruction of the history of this unique site.

The major difficulty in an archaeoseismic study is the identification of the cause of the destruction. Earthquake-related damage often resembles that deliberately caused by humans, geotechnical failure, or slow deterioration over the ages. When the damage is widespread and contemporaneous it is generally assumed that an earthquake has occurred, but even in such a case geologists are faced with uncertainty regarding its source fault.

OBSERVATIONS

Structural damage of potentially seismic origin at Megiddo includes tilted walls and pillars, bent and warped walls, fractured building stones, dipping floors, liquefied sand, mudbrick collapse and burnt remains. Tight stratigraphic control enables correlation of earthquake damage with similar features across the mound and with other archaeological sites. Table 31.1 summarizes our observations and assesses the possible cause for the damage.

DISCUSSION

The crucial distinction that should be made in the study of archaeological sites is between earthquake-related damage and non-earthquake damage. In a large site such as Megiddo, the criterion for the former is time-constrained widespread damage. The temporal bounds should be tight enough to indicate that the damage occurred in a single catastrophic event. The damage should be evident in numerous localities and various structures in the form that precludes the possibility of man-made destruction. Supportive evidence includes the absence or scarcity of weapons, historical accounts describing the conquest of the given site, historical accounts describing earthquakes, deformation of coeval natural sediments, and the existence of certain types of damage that are uniquely associated with earthquakes.

At Megiddo, the only cases of structural damage that can be related to earthquakes with high certainty are the extension fractures in the walls of the Level J-4 temple and in the Late Bronze gate complex (Fig. 31.3h). However, the features of the overall damage provide important support for the interpretation of the damage as earthquake-related. Most of the observations suggest either E-W or N-S shaking directions (Fig. 31.2). We consider the fairly uniform pattern of the inferred direction of shaking as an indication for earthquake-related damage. The observed liquefaction (Fig. 31.3g), which is a typical earthquake-induced feature, may be regarded supportive evidence, but unfortunately its age is not absolutely clear.

TABLE 31.1: DEFORMED STRUCTURES SUSPECTED AS EARTHQUAKE-RELATED DAMAGE AT TEL MEGIDDO (SERIAL NUMBERS INDICATE LOCATION ON MAP IN FIG. 31.2)

<i>No.</i>	<i>Description</i>	<i>Cause</i>	<i>Date of structure</i>
1	In Area J, the monumental walls of the Level J-4 temple are fractured in several places along their strike (Fig. 31.3d) as well as perpendicular to the strike (Figs. 31.3e-f). The overlying walls of the EB III temple 4050 are not fractured.	Probably catastrophic horizontal shaking.	Early Bronze I, Level J-4 (Stratum XVIII), end of 4th millennium BCE.
2	Stone plates in the roof of Schumacher's Chamber f (see Chapter 5) are fractured at 90°. The chamber was never filled.	Probably catastrophic.	Late Bronze II, Level M-6, or late Iron I, Level M-4, University of Chicago Strata VIIA or VIA, 13th-12th or late 11th-10th centuries BCE.
3	Extension cracks in the Late Bronze gate. Ashlar stones in courses in the middle of the walls (sandwiched between other courses) are fractured in opening mode. Horizontal sliding of the fragments occurred everywhere in the same direction, sub-parallel to N-S trend of the wall (Fig. 31.3h). The gate has no foundations, a fact that could have made it particularly vulnerable to seismic vibrations.	Probably catastrophic horizontal shaking.	Late Bronze, probably built in Stratum VIII and continued to function in Stratum VII – 14th- 12th centuries BCE.
4	Distorted and liquefied sand horizon in the western section of the Schumacher trench, excavated in the early 20th century. (Fig. 31.3g).	Catastrophic shaking.	Seems to belong to destruction of Strata VIIA (12th century BCE) or VIA (10th century BCE), probably to the latter.
5a	A warped wall trending 220° in Area K is tilted to both sides 12°-15°. (Fig. 31.3i.)	Pressure of accumulating earth is unlikely where the wall tilts inward. Probably catastrophic.	Late-Iron I, Level K-4 (Stratum VIA), late 11th-10th centuries BCE.
5b	Area K, north section of Square M/11. A few joints appear 90 cm above the bottom of the excavation.	Probably catastrophic shaking.	Below the destruction layer of Level K-4 (Stratum VIA). For the date of Level K-4 see above.
6	In Upper Area M, Square AV/28 a pile of collapsed mudbrick is covered by a thick layer of ashes. Similar piles of brick collapse can be seen in many other places across the mound.	Possibly catastrophic.	Late-Iron I, Level M-4 (Stratum VIA), late 11th-10th centuries BCE.
7	A group of six pillars in Building 1A (Lamon and Shipton 1939: Fig. 6) are all tilted 8°-11° to the west (265°-295°). (Fig. 31.3b).	Probably catastrophic horizontal shaking.	Iron II, Stratum VA-IVB, 9th century BCE.
8	The corner of Building 338 is tilted. The eastern wall, which strikes 008° is tilted 3° to the east. The southern wall, which strikes 278° is tilted 5° to the south.	Probably catastrophic.	Iron II, Stratum VA-IVB, 9th century BCE.
9	An ash horizon overlain by collapsed mud-bricks in Area H.	Probably catastrophic shaking.	Iron II, Level H-5: Stratum VA-IVB, 9th century BCE, or an early phase of Stratum IVA, early 8th century BCE.

<i>No.</i>	<i>Description</i>	<i>Cause</i>	<i>Date of structure</i>
10	The south-western corner of Palace 6000 (Area L, Squares D/5, E/4-5) is tilted 3°-5° (top dipping to 250°-260° – Fig. 31.3a). In the northern baulk of Squares D-E/4, a white layer which belongs to the palace's floor make-up is also tilted. Immediately to the east, in the northern section of Square E/4, there are two fissures, each about 10-15 cm wide in the same floor make-up. The fissures are filled with grey unconsolidated soil that contains a few ceramic fragments. The white make-up for Floor 98/L/59 and plaster Floor 98/L/120 – both of the Level L-2 stables – are horizontal	Large scale deformation. Could be either a slow process (because of pressure on the westward slope) or a catastrophic one.	Iron II, Levels L-3 (Stratum VA-IVB), 9th century BCE.
11	In the courtyard of the Southern Stables, the westernmost (trend 010°-190°) wall is tilted 18° westward. This wall supported a fill several metres deep (see Lamon and Shipton 1939: Fig. 43), which had been laid under the surface of the courtyard and which was cleared in the course of the University of Chicago excavations. The present height of the wall is 80 cm.	Outward pressure of the fill. Could be either a slow or a catastrophic process.	Iron II, Stratum IVA, 8th century BCE.
12	Staircase leading from the Iron II gate complex to a water system/reservoir (Loud 1948: Fig. 389, Square H/10) is tilted 9°/000°. The staircase is built on a steep slope. (Fig. 31.3c).	Could be either a slow down-slope slide or a catastrophic process.	Iron II, Stratum IVA, 8th century BCE.
13	Faults and joints in the bedrock in rock-cut Tunnel 1000 of the water system. The bedrock is composed of limestone and chalk with scattered chert nodules; Eocene Maresha Formation.	Could be a slow and/or a catastrophic process.	Iron II, Stratum IVA, 8th century BCE.
14	The walls of Silo 1414 (Lamon and Shipton 1939:77) are lined with stones (mostly limestone and some basalt) that are up to 0.5 m in diameter. Many of the limestone stones are fractured and some are even shattered in various orientations. There is no dominant orientation and there is no relation between the original bedding planes and the fractures. Most of the basalt stones are not fracture	Probably catastrophic shaking.	Iron II, Stratum IVA or III, 8th or 7th century BCE.
15	A stone pillar (1 x 0.3 x 0.3 m) located north of the northern wall of the southern stables courtyard (Lamon and Shipton 1939: Fig. 72, Building 1513), is tilted 12° (top dipping to 275°).	Probably slow sinking.	Iron II, Stratum III, 7th century BCE.
16	Three ashlar in a row, located to the north of the northern wall of the Southern Stables courtyard (Lamon and Shipton 1939: Fig. 72, Building 1513, wall between Rooms 1512 and 1513), are tilted eastward. The easternmost one dips 22° (top dipping to 280°), the middle one fell eastward on a heap of small stones, and the western one is tilted 5° (top dipping to 90°).	Probably catastrophic horizontal shaking.	Iron II, Stratum III, 7th century BCE.
17	A west-striking wall in Assyrian Palace 1369 is bent northward along ca. 5 m.	Probably slow sinking, perhaps outward pressure due to flow of soil.	Iron II, Stratum III, 7th century BCE.

TABLE 31.2: EVIDENCE FOR MEGIDDO SHOCKS BY PERIOD/STRATA (LOWER AND UPPER LIMITS)

<i>Damaged (lower limit)</i>	<i>Upper limit</i>	<i>Observation nos. (Table 31.1)</i>	<i>Interpretation</i>	<i>Date of (possible) event</i>
Late EB IB building (Level J-4, Stratum XVIII).	Overlying walls of EB III temple are not fractured.	1	Shock which should probably be related to the abandonment of the Level J-4 temple.	ca. 3000 BCE (see Chapter 29).
Late Bronze gate and Chamber f	Unknown	2, 3	Shock postdating the two monuments. No upper limit – date unknown	Post ca. 1200 BCE (possible construction of Chamber f). Could be the event described in the next row.
Late-Iron I buildings (Level K-4 and M-4, Stratum VIA).	Collapse of brick walls throughout the mound.	4, 5a, 5b, 6	Shock, which possibly brought about the destruction of Stratum VIA. ¹	Mid-to-late 10th century
Early Iron II buildings (Stratum VA-IVB)	Level L-2 (Stratum IVA) northern stables undamaged	7, 8, 9, 10	Shock between the end of Stratum VA-IVB and the construction of the northern stables of Stratum IVA.	Between 835 and 800 BCE (possibly a bit later?)
Remains belonging to Stratum IVA.	Unknown	11, 12, 13, (14)	Possible shock postdating the relevant remains. No upper limit.	Postdating ca. 800 BCE. Could be assigned to the event described in the next row.
Structures of Stratum III	Unknown	15, 16, 17, (14)	Possible shock postdating Stratum III.	Postdating ca. 700 BCE; may have caused the damage described in the preceding row.

In modern earthquakes damage is highly localized and varies greatly because of the heterogeneous nature of the underlying ground. The ‘site effect’, a fundamental characteristic of earthquakes, may explain why certain parts of Megiddo were damaged while others seem to have remained intact.

Table 31.2 groups the evidence discussed above chronologically, according to six Megiddo layers (the University of Chicago’s Strata XVIII, VIII-VII, VIA, VA-IVB, IVA and III).

CONCLUSION

Two earthquake events at Megiddo are beyond doubt: one at the end of the fourth millennium BCE (for relevance to the history of the site in the Early Bronze Age see Chapter 3) and another in the 9th century BCE (which caused the damage in Stratum VA-IVB). Another event, which brought about the end of Stratum VIA, is probable but not conclusive (see Chapter 7). All other clues remain hypothetical: damage to the Late Bronze Age and 8th century (Stratum IVA) buildings could have been caused in later periods, and the classification of the damage in the Stratum III structures as evidence for a quake

1. This is the opinion shared by Marco, Agnon and Finkelstein. Ussishkin believes that Stratum VIA must have been destroyed in an enemy attack.

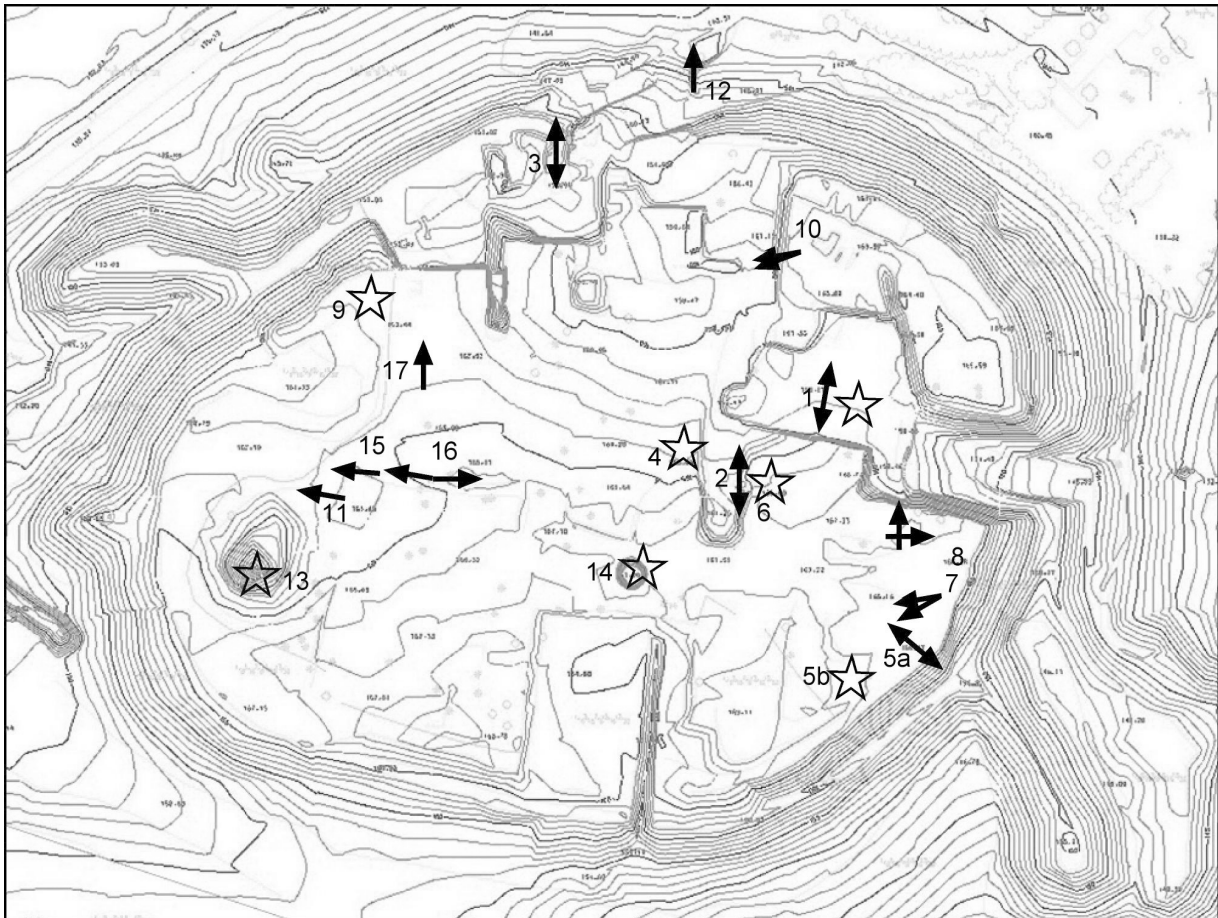


Fig. 31.2: Location map of deformed structures at Megiddo. Arrows indicate direction of shaking. Stars mark deformation that cannot be associated with a particular sense of movement.

is probable but not sure. Yet, the biblical evidence for a major earthquake in ca. 760 BCE (Amos 1:1) seems to indicate that the damage in the buildings of Stratum IVA should indeed be assigned to the 8th century BCE. The spatial extent and the apparent southward decrease in degree of damage at archaeological sites in Israel and Jordan led Austin *et al.* (2000) to suggest an epicentre in Lebanon with local magnitude estimated at about 8 on the Richter scale. Arguing that the recurrence interval of earthquakes during historical times was around a century, they attributed all damage observed in 8th century BCE sites to that particular event. We note that occasionally the recurrence interval was as short as a decade (e.g., 1202-1212 CE – see Amiran *et al.* 1994); hence the number of events in the 8th century BCE and their respective magnitude is yet to be determined.

The Carmel Fault is the most plausible source for the observed damages at Megiddo, though with the current state of knowledge the Dead Sea fault system cannot be precluded. The causative fault

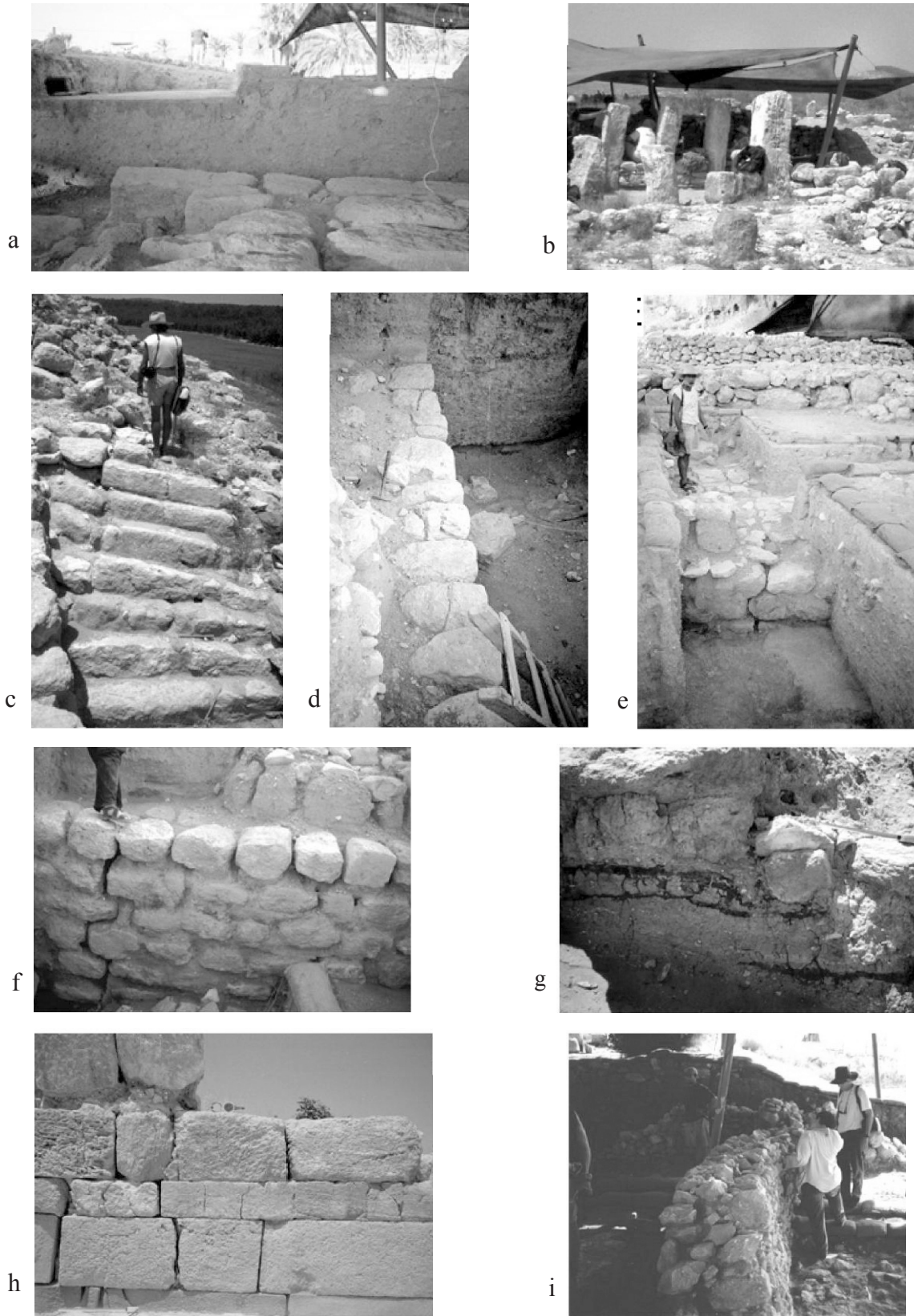


Fig. 31.3. Photos of earthquake damage at Megiddo. Numbers in Table 31.1; a) No. 10; b) No. 7; c) No. 12; d-f) No.1; g) No. 4; h) No. 3; i) No. 5a.

is a central issue in terms of seismic hazard in general and for understanding the characteristics of the activity of the Carmel Fault in particular. A more complete documentation of the deformation at Megiddo and its vicinity, combined with data from other contemporaneous sites, may yield a reliable estimate of the source.

This preliminary study demonstrates the potential for archaeoseismic research as well as the difficulties inherent in it.

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