

DESERT HABITATION HISTORY BY ¹⁴C DATING OF SOIL LAYERS IN RURAL BUILDING STRUCTURES (NEGEV, ISRAEL): PRELIMINARY RESULTS FROM HORVAT HALUQIM

Hendrik J Bruins¹ • Johannes van der Plicht² • Mordechai Haiman³

ABSTRACT. Traditional archaeological approaches in the central Negev Desert used to employ excavation techniques in post-prehistoric periods in which stratigraphy is based on architecture, while material culture forms the basis for dating assessment and chronology. Such an approach was understandable, as it focused on the most visible remains of past human habitation. However, the detailed habitation record is in the soil rather than in the walls. Moreover, ceramics and stone tools in desert cultures often have limited time resolution in terms of absolute chronology. The rural desert site of Horvat Haluqim in the central Negev yielded 2 habitation periods with the traditional methodology: (1) Roman period, 2nd–3rd centuries CE; (2) Iron Age IIA, 10th century BCE. We have conducted at Horvat Haluqim initial excavations in small building remains that were never excavated before. Our excavation methodology focuses on detailed examination of the archaeological soil in building structures, coupled with accelerator mass spectrometry (AMS) radiocarbon dating for chronology, and micromorphology of undisturbed soil samples to study stratigraphy and soil contents at the microscopic scale. Here, we report preliminary results, concentrating on the ¹⁴C dates. These suggest a much longer habitation history at the site during the Iron Age. The ¹⁴C dates obtained so far from these building remains cover Iron Age I, II, III, and the Persian period. The oldest calibrated date (charred C₄ plants) in a rectangular building structure (L100) is 1129–971 BCE (60.5%, highest relative probability). The youngest calibrated date in a round building structure (L700) is 540–411 BCE (57.9%, highest relative probability). This excavation methodology provides additional “eyes” to look at past human habitation in the Negev Desert, seeing more periods and more detail than was possible with traditional schemes and ceramic dating.

INTRODUCTION

Almost 50 km to the south of Beer Sheva, the rural desert site of Horvat Haluqim is situated in the central Negev highlands (Israel) on the southern slopes of the Haluqim hill range. The archaeological site is only 2 km northeast of Kibbutz Sede Boker (Figure 1), near an official weather station of the Israel Meteorological Service. The average annual rainfall during the decade 1990–2000 was 93 mm and the average annual temperature was 18.4 °C. A new climatic classification of the Negev with maps is now available (Bruins 2012), based on the high-resolution P/PET aridity index (P = the average annual precipitation; PET = the average annual potential evapotranspiration). The average climate in the Sede Boker area is classified as arid with an average P/PET value of 0.07, but there are significant differences between rainy years and drought years (Bruins 2012).

The building remains in this ancient village are situated along 3 small valleys that run more or less parallel to each other (Figures 1 and 2). These dry stream channels are tributaries of the main wadi in the area, Nahal Haroa. Archaeological excavations at Horvat Haluqim were carried out in the 1970s by Cohen (1976), who was for many years the district archaeologist of the Negev for the Israel Antiquities Authority. The methodology of excavation by Cohen focused on architecture and ceramics (Cohen and Cohen-Amin 2004). Two strata were discerned and dated by this approach (Cohen 1976): Stratum 1 (Roman period) and Stratum 2 (Iron Age IIA, 10th century BCE, associated with the reign of Solomon). The Roman period is represented by a watchtower, dated to the

¹Ben-Gurion University of the Negev, Jacob Blaustein Institutes for Desert Research, Sede Boker Campus, Israel. Also: Department of Bible, Archaeology and Ancient Near Eastern Studies, Beer Sheva Campus. Corresponding author. Email: hjbruins@bgu.ac.il.

²University of Groningen, Centre for Isotope Research, Groningen, the Netherlands. Also: Leiden University, Faculty of Archaeology, Leiden, the Netherlands.

³Israel Antiquities Authority, Jerusalem, Israel. Also: Bar-Ilan University, Ramat Gan, Israel.



Figure 1 The location of Horvat Haluqim with its 3 parallel valleys, marked by a rectangle, is shown on this image derived from Google Earth®. Houses of Kibbutz Sede Boker and modern agricultural fields are visible in the lower left. A dam blocking the dry stream channel of Nahal Haroa can be seen in the upper right corner. The dam was designed in the 1950s by Leslie Shanan to capture the floodwaters for irrigation of orchards in modern terraced fields, visible downstream. The 3 valleys of Horvat Haluqim contain about 70 ancient stone terrace walls of a much smaller scale (Figure 2), also designed to capture runoff/floodwater that enabled agriculture in the desert.

2nd–3rd centuries CE. This massive square structure (12 × 13 m), classified as Building 12 by Cohen (1976), is the best preserved building at Horvat Haluqim. Its position (B12, R) is indicated in Figure 2, together with the other buildings, the cisterns, and ancient agricultural terraces. The terraces were mapped later by Bruins (1986).

The remains assigned by Cohen (1976) to Stratum 2 include the oval fortress, most other buildings, the cisterns, and stone terraces in the 3 wadis (Figure 2). Buildings 1, 2, 3, 4, 5, and 12 were excavated by Cohen (1976); the terraced fields were not excavated by him. The buildings along the eastern wadi include the oval fortress (B1), which is the largest structure at the site, 23 × 21 m. Building 2 is a 4-room house (8 × 8 m) with courtyard (B2). The rectangular Building 3 is larger in size, 14 × 9 m, with 6 rooms around an inner courtyard (B3). Just south of the Roman watchtower lies Building 4, 9.50 × 9.50 m (B4). The latter Iron Age building was seriously damaged by the builders of the Roman watchtower, “who dismantled its walls and reused the stones for the construction of the tower overlying the north-east corner of the Iron Age building” (Cohen 1976:38).

These rural desert sites usually yield little diagnostic pottery remains, as noted by Cohen (1976:48): “The few ceramic finds in the buildings of Stratum 1 are insufficient for establishing an exact date. None of the vessels are complete and most of the sherds found were body fragments.” However, a coin found in the Roman watchtower could be dated by Meshorer to the early 3rd century CE (Cohen 1976:49). Concerning the handmade Negbite pottery of Stratum 2, Cohen (1976:44)

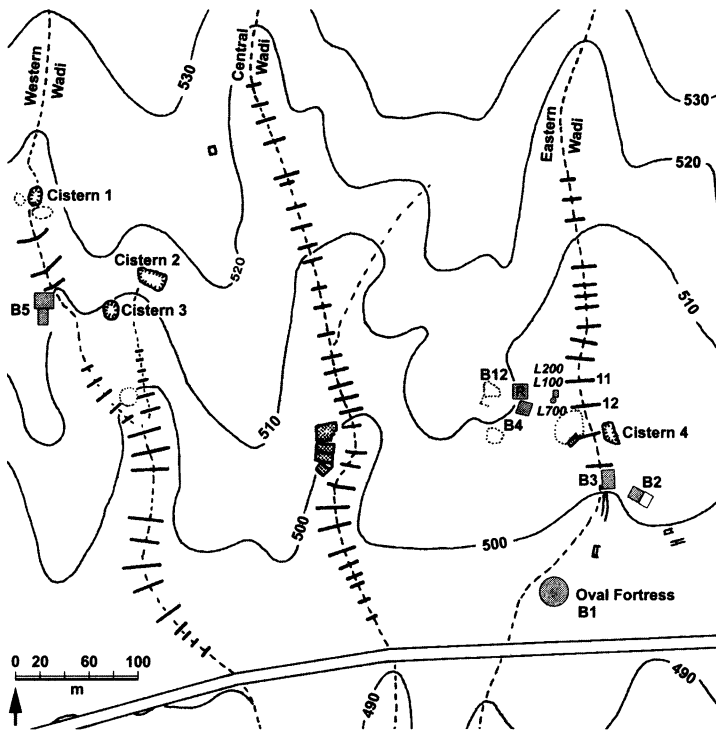


Figure 2 The rural desert site of Horvat Haluqim showing various building remains, 4 cisterns (water supply), and 70 stone terrace walls (Bruins 1986) for agriculture based on runoff/floodwater capture. The buildings excavated by Cohen (1976) have a B-number. The loci in small building remains (L100, L200, L700) are excavated by the present authors, situated between the Roman watchtower (B12, R) and the eastern wadi.

remarked: "This pottery, though commonly assigned to the 10th century BCE, may have had a comparatively long range and was possibly produced already at an earlier period in the southern Negev and other Negev sites. Thus it cannot be used as a chronological criterion."

EXCAVATION METHODOLOGY

Cohen invited Bruins in 1980 to develop landscape archaeology and study the relationships between archaeological sites and the desert environment in the context of the Negev emergency surveys. Thus, he participated in the excavations at Tell el Qudeirat in northeastern Sinai (Bruins 1986, 1990a). Since diagnostic ceramic finds are usually rare in landscape archaeology, Bruins began using radiocarbon dating at Tell el Qudeirat and its surroundings as the basis for chronology, in cooperation with the Radiocarbon Laboratory (Center for Isotope Research) at the University of Groningen (Bruins 1986; Bruins and Mook 1989). The fieldwork and excavations were conducted before the development of accelerator mass spectrometry (AMS) and only larger organic samples could be used. Bruins also began excavating in ancient agricultural terraces at Horvat Haluqim, as suggested by Cohen (Bruins 1986) and in Nahal Mitnan (Bruins 1990b) in cooperation with Haiman (1995).

The above experience in desert archaeology laid the foundation for development of an excavation methodology focused on stratigraphic soil analysis, using ^{14}C dating as the principal chronological

basis and using micromorphology of thin sections, derived from *in situ* undisturbed samples, as an additional source of stratigraphic information at the microscopic level (Bruins 1986; van der Plicht and Bruins 2001; Bruins and van der Plicht 2004, 2005, 2007). The same approach is now also being applied to building remains at Horvat Haluqim, in an archaeological project directed by Bruins. Excavations and field archaeology in selected buildings are jointly conducted by Bruins and Haiman. ^{14}C dating of the excavated organic material is carried out at the University of Groningen under the supervision of van der Plicht.

The detailed use of high-precision ^{14}C dating in the southern Levant to investigate the chronology of individual archaeological sites in the Bronze and Iron ages is a comparatively recent development in Near Eastern archaeology. It was, for example, done at Tell es-Sultan, Jericho (Bruins and van der Plicht 1995, 1998); Tel Rehov (Bruins et al. 2003a,b, 2005; Mazar 2005; Mazar et al. 2005); Tel Dor (Gilboa and Sharon 2001, 2003; Gilboa et al. 2009; Sharon et al. 2005); and Khirbet en-Nahas (Levy et al. 2004, 2008; Higham et al. 2005). A large collective ^{14}C investigation approach of many sites joined together was undertaken by the Iron Age Dating Project in Israel (Boaretto et al. 2005; Sharon et al. 2007). Concerning the southern Negev, Avner (1998, 2002, 2006) has systematically made ^{14}C dating a basic part of his extensive and detailed archaeological research, in cooperation with the Radiocarbon Lab at the Weizmann Institute of Science (Rehovot). The ^{14}C dates of his investigations indicate, in contrast to conventional schemes, rather continuous habitation in the southern desert region from the Late Neolithic to the Early Bronze Age IV, 6th to 3rd millennia BCE (Avner and Carmi 2001; Avner 2006). The historical archaeology in the ancient Near East, which covers the past 5 millennia, may be regarded as one of the last frontiers in the application of ^{14}C dating. Archaeological associations with historical chronologies, particularly those of Egypt, were considered far superior to ^{14}C dating. Therefore, the use of ^{14}C in Near Eastern archaeology used to be very limited. Recent developments include the first detailed dating of organic materials from Egypt, selected from museums, which could be related to various pharaohs and dynasties (Bronk Ramsey et al. 2010). The implications for Near Eastern archaeology in the 2nd millennium BCE were discussed by Bruins (2010).

Concerning the central Negev highlands, the surveys by Haiman (1986, 1991, 1993, 1999) revealed clear evidence for agricultural activity in the Iron Age. A large quantity of sickle blades was found in the context of Iron Age sites, as well as over 80 silos and 30 threshing floors (Haiman 1990, 1994). Survey and excavation techniques of pastoral and other desert sites in the region were developed by Rosen (1993, 1994, 2003; Rosen and Avni 1997; Rosen et al. 2005, 2007), Avni (1992, 1996), and Saidel (2001, 2002). The age of loess sediments in ancient agricultural terraces in the Negev highlands was investigated with optically stimulated luminescence (OSL) dating by Avni et al. (2006, 2009). Rural archaeological investigations at Atar Haroa, in the oval compound (oval fortress), were conducted by Shahack-Gross and Finkelstein (2008). They used sophisticated analyses of organic remains and phytoliths. There was no agriculture at the site during the Iron Age, according to their conclusion, which we consider farfetched. Their deduction is based on a nonagricultural space within a building and contradicts the multiple archaeological findings by Haiman (1990, 1994, 2003, 2007) and the excavations by Bruins in agricultural terraces at nearby Horvat Haluqim (Bruins 1986, 2007; Bruins and van der Plicht 2004, 2005; Bruins et al. 2011). Nevertheless, the excavation approach by Shahack-Gross and Finkelstein (2008) is commendable in terms of methodology, focusing in detail on the archaeological soils within building structures. The organic material retrieved in this way (seeds) resulted in an excellent ^{14}C investigation at Atar Haroa (Boaretto et al. 2010).

Following the important methodological developments of archaeological excavation by Wheeler (1954) and Kenyon (1957), in which more emphasis was placed on the stratigraphy of archaeological soil layers, Franken voiced in the 1960s his criticism of the overemphasis on architecture in Near Eastern archaeology: “Objects found within a certain complex of walls are dated alike without a close regard for the earth filling of that complex” (Franken and Franken-Battershill 1963:8–9). The soil material in archaeological excavations used to be regarded “as a sort of wood-wool in which the precious objects were packed” (Franken and Franken-Battershill 1963:31). The systematic use of baulks in modern excavations is an important development. However, the ability to discern delicate soil stratigraphy and apply related methodologies also require soil science training in archaeological education. This is more commonly considered in prehistoric archaeology, but less so in historical archaeology. The archaeological soil material, therefore, was studied less and discarded more easily in order to reach a wall and a floor. That was the common approach some 40 yr ago, also during the excavations at Horvat Haluqim (Cohen 1976). These pioneering investigations focused understandably on buildings and the most visible archaeological inclusions in the soil: ceramics and stone tools. However, chronological resolution remained simplified and underdeveloped in this approach.

HORVAT HALUQIM EXCAVATIONS IN LOCI 100, 200, AND 700

Our research in building structures at Horvat Haluqim focuses on the archaeological soils from the surface downward. This article reports the ^{14}C findings from the excavations in loci 100, 200, and 700. These buildings were never excavated before. They are situated in between the Roman watchtower (B12, R) and the eastern wadi (Figures 2, 3, and 4). Only the foundations seem to have been preserved. The conclusion by Cohen (1976:38) concerning the dismantling of walls and reuse of stones from Iron Age building 4 (B4) by the builders of the Roman watchtower may also apply here (L700, L100, L200).

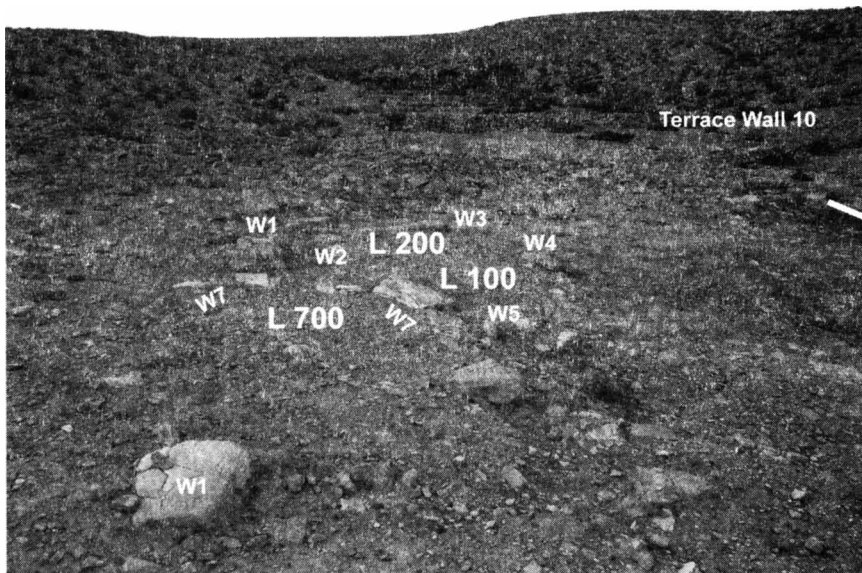


Figure 3 The area at Horvat Haluqim before excavation, showing various building remains between the eastern wadi and the Roman watchtower (Figure 2) The walls and loci to be excavated are indicated. The white line to the right marks the border with the ancient agricultural terraced field 12 of the eastern wadi. Terrace wall 10 is visible more to the north.

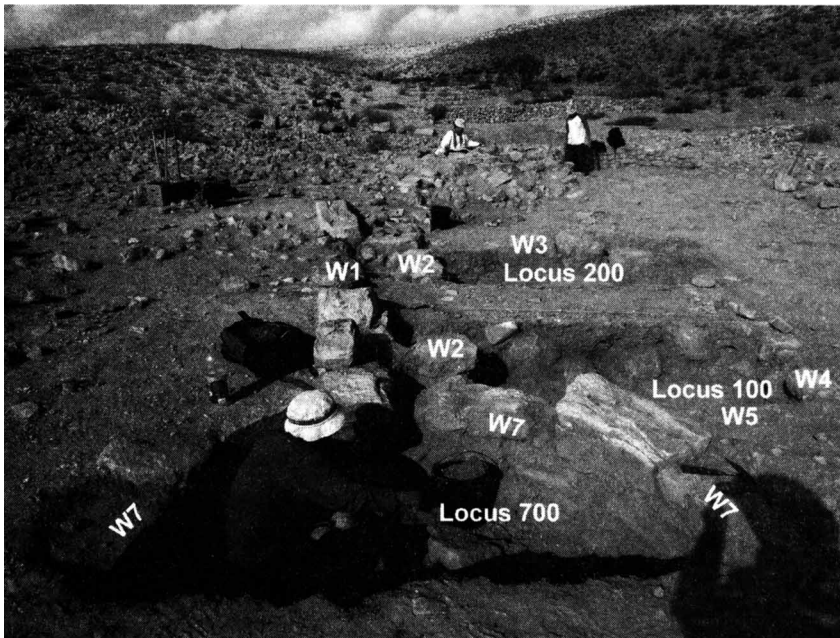


Figure 4 The excavation in progress, looking north.

The original surface of the area before the beginning of the excavation is shown in Figure 3. Notice the position of several walls, which hint at different architectural shapes, size of building stones, and a possibly complex archaeological history. Major attention in the excavations is on the discovery of charred organic material within the soil matrix for *in situ* sampling. Charred organic material, derived from human habitation, can be dated by ^{14}C to study the chronology of habitation in the respective buildings. However, there are a variety of questions that need to be addressed in such investigations of rural desert sites: Can the habitation history of individual buildings be reconstructed in this manner? What is the nature of earth living floors in areas where dust storms may add new dust material every year (Offer and Goossens 2001), causing the surface perhaps to grow slowly upward? Could building remains function also as dust traps after abandonment? Is bioturbation a disturbing factor? What may be the degree of disturbance of renewed habitation of a certain building on the existing archaeological soil layers following a hiatus in habitation? Obviously, more questions can be raised concerning potential difficulties in this methodology.

Here, we give a first account of our initial findings with the above approach, focusing on ^{14}C dates obtained from charred organic material found in the archaeological soil layers. Excavations of this type progress very slowly downward, as the soil is carefully removed and scanned centimeter by centimeter. Besides charred organic material and bones, ceramics and stone tools are collected, as well as mollusks. Undisturbed soil samples are taken at selected spots for impregnation with epoxy under vacuum in specialized labs. This hardening process of the soft soil does not disturb the *in situ* fabric. Subsequently, the soil sample becomes a very hard block of $8 \times 8 \times 3$ cm from which large-size thin sections are made that enable investigation of microstratigraphy and other features at the microscopic scale. The micromorphology studies will shed more light on the nature of the soil layers, earth living floors, and a number of questions outlined above. Stratigraphic drawings of the baulks in relation to the various walls have to wait until deeper levels are reached and the micromorphology samples have been studied.

RADIOCARBON RESULTS

Round Building Structure – Locus 700

The round building structure, Locus 700, has an inner diameter of 205 cm (Figures 4 and 5). The northern half of the building has been excavated so far to a depth of about 45 cm. The southern half is left untouched to keep a record of the stratigraphy of the soil layers. The round wall (W7) of Locus 700 is partly composed of 2 courses of limestone building stones, which are readily available in the surrounding hills. The size of the building stones is not uniform and ranges from 33 to 70 cm in length, 26–39 cm in width, and 25–35 cm in height. The few very large building stones in Wall 7 may have been taken from Wall 1.

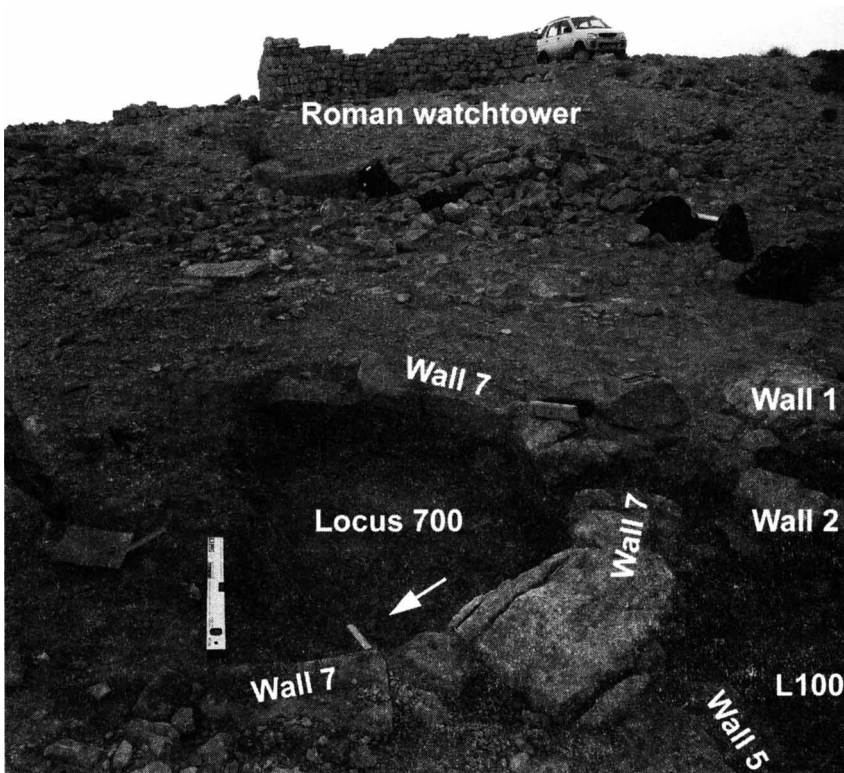


Figure 5 The positions of loci 700 and 100 with related walls, looking west to the Roman watchtower (Figure 2, B12-R), situated on the upper part of the hill spur. The white level on the unexcavated part of the round building is 60 cm long. The arrow points to a Negbite pottery sherd at a depth of 40 cm in the eastern part of Locus 700. The adjacent ruler is 15 cm long.

The 5 samples dated so far are all based on fine charred organic material found at different depths within the archaeological soil of the round structure (Table 1). No hearth was found in Locus 700 or the other loci. Black organic spots appear occasionally in the soil matrix. The material does not look like charcoal in which a woody texture has been preserved, but is often amorphous and hence difficult to diagnose botanically. The $\delta^{13}\text{C}$ values (Table 1) show that samples 3 and 5 are derived from C_4 plants. These have a different photosynthesis than C_3 plants and hence less negative $\delta^{13}\text{C}$ values. Most C_4 plants are short-lived and various annual grasses belong to this group, as shown by a botanical study in the Negev, Sinai, and Judean deserts (Vogel et al. 1986). The occasional charred organic

spots in the archaeological soil seem to result from habitation. However, disturbance in later periods and fill may also be involved in site formation. Micromorphology studies will be carried out and these will give more information at the microscopic level.

Table 1 Locus 700, ^{14}C dates of charred organic material inside the round building structure, embedded in the archaeological soil, and appearing occasionally as small black spots. Their size ranges from a few mm up to 1 cm. Samples 3 and 5 have less negative $\delta^{13}\text{C}$ values, i.e. C_4 plants, which are usually short-lived. Calibration was carried out with OxCal v 4 (Bronk Ramsey 2009) using the IntCal09 calibration curve (Reimer et al. 2009). The highest relative probability is in the 1σ range (68.2%) and the respective age ranges with their probabilities (in %) are given. The 2σ range (95.4%) is given undivided. The calibrated median is not to be interpreted as a point date, but as a useful value of the median probability of the calibrated age range.

L700 # ^a	Depth (cm)	Lab nr	$\delta^{13}\text{C}$ (‰)	^{14}C date (BP)	Calibrated date (BCE)		Median age cal BCE
					(1σ)	(2σ)	
01	28	GrA-48453	-24.29	2430 ± 35	722–695 (10.3%)	752–403	517
					540–411 (57.9%)		
02 w	33	GrA-48454	-24.84	2680 ± 35	893–877 (12.7%)	901–799	835
					846–803 (55.5%)		
03 e	40	GrA-48455	-11.45	2755 ± 40	968–964 (2.4%)	999–822	898
					929–838 (65.8%)		
04 e	42	GrA-48458	-22.61	2445 ± 40	740–690 (17.7%)	756–407	556
					663–648 (5.0%)		
05	49	GrA-48459	-10.61	2460 ± 40	549–414 (45.5%)	760–411	590
					752–686 (22.2%)		
					667–636 (9.8%)		
					622–614 (2.2%)		
					595–507 (27.0%)		
459–453 (1.5%)							
					440–419 (5.4%)		

^aThe spatial location of the samples within the round building is indicated: w = west; e = east. No indication means the sample is from a more central position.

The 5 dating results show 2 distinct time periods. Samples 2 and 3 are clearly related chronologically to the Iron Age IIA period. Sample 2 has a calibrated age range only in the 9th century BCE and sample 3 in both the late 10th and 9th century BCE. Hardly any ceramic remains were found in Locus 700, but a Negbite pottery sherd (Figure 5) appeared next to organic sample 3, composed of charred C_4 plants. Samples 1, 4, and 5 are significantly younger and are situated in a difficult part of the calibration curve, which has similar ^{14}C values over a long time period, ~770–400 BCE. The 3 dates relate to Iron Age III (732/701–520 BCE), according to the classification by Mazar (2005), or to the Persian period (539–332 BCE). The highest relative probabilities of these 3 dates are in the 6th and 5th centuries BCE (Table 1), which coincide largely with the Persian period. Habitation in the central Negev highlands is known from this period (Cohen and Cohen-Amin 2004). In fact, a square fortress, dated by ceramics to the Persian period, is situated nearby at Horvat Haroa, ~8 km to the east of Horvat Haluqim (Cohen and Cohen-Amin 2004).

It is emphasized that the ^{14}C results from Locus 700 indicate disturbance of the stratigraphy in the past (Table 1). The Iron Age III or Persian period dates are found at depths of 28, 42, and 49 cm, while Iron Age IIA period dates occur at depths of 33 and 40 cm. However, this should not be viewed as a negative result. The current methodology, using detailed ^{14}C dating of the archaeologi-

cal soil, is able to see and possibly decipher such complex archaeological site formation. It seems that the area was used during Iron Age IIA and later reused in Iron Age III or the Persian period, which caused disturbance of the stratigraphy. Wall 1 appears to be partly dismantled and has disappeared in the area where the round structure (Locus 700) was built (Figures 3 and 4). We have to await deeper excavation in Locus 700 with detailed stratigraphic analysis of its unexcavated section in relation to the walls, as well as micromorphological analysis. In any case, the current chronological results show a time signature of 2 habitation periods that are both younger than Stratum 2 in the excavations by Cohen (1976), assigned by him to the mid-10th century BCE, the time of Solomon. These results give entirely new evidence of a longer and more complex habitation history at Horvat Haluqim during the Iron Age and beyond.

Rectangular Building Structure – Locus 100

Just north of the round building structure (Locus 700) exists a rectangular building structure (Figures 3 and 4), which is about 330 cm long and 200 cm wide (loci 100 and 200, separated by a baulk). Some walls are made of irregular small stones, having a width of 25 to 30 cm; other walls have very large irregular stones up to 71 cm long and 40 cm wide, suggesting a possible multiperiod origin (Figure 7).

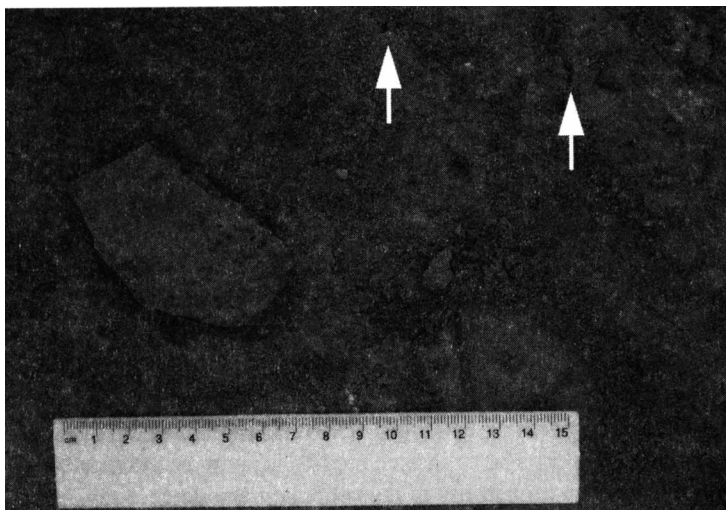


Figure 6 A Negbite pottery sherd found at 40 cm depth in the eastern part of Locus 700 (Figure 5). Two charred organic spots, a few mm in size, are visible nearby at the same level. This is the type of material composed of C_4 plants and dated by AMS (sample 3, Table 1), giving a most probable (65.8%) calibrated age range in the late 10th and 9th century BCE, i.e. Iron Age IIA.

Concerning Locus 100, the field archaeology shows that Wall 7 of the round structure (Locus 7) overlies walls 5 and 2 of the rectangular structure at the southwestern contact between the latter walls (Figure 7). Therefore, the round building appears to be younger than the rectangular building in terms of wall stratigraphy. The building stones of the latter structure (walls 2, 4, and 5) are usually about 25 cm wide. Wall 7 is composed here of 2 very large building stones, ~40 cm wide, one of them 70 cm long. These large stones are very similar in size and appearance as those remaining in Wall 1, which is located about 10 cm west of Wall 2 (Figure 7). The area west of Wall 1 has not yet been excavated.

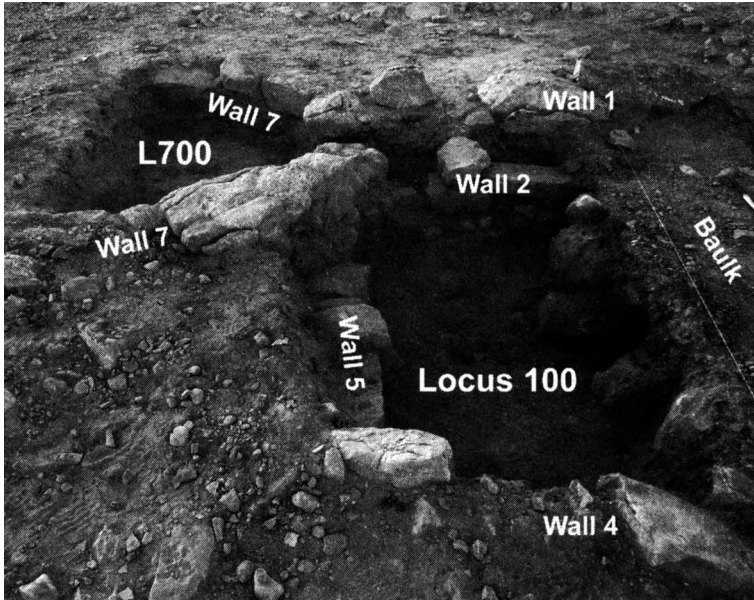


Figure 7 Westward view of Locus 100, which is the southern part of a rectangular building, in relation to Locus 700, which exhibits the northern part of a round building.

Four samples of charred organic material were collected in Locus 100 at various depths and dated by AMS (Table 2). The depth-age relationships seem consistent, ranging from a 2σ calibrated age of 1008–837 BCE (GrA-48370) at 13 cm to 1259–900 BCE at 56 cm depth (GrA-48422).

Table 2 Locus 100, ¹⁴C dates of charred organic material inside the southern part of the rectangular building structure. Small black spots embedded in the archaeological soil appear occasionally, with sizes ranging from a few mm up to 1 cm. Sample 05 has a less negative δ¹³C value, i.e. C₄ plants, which are usually short-lived. Calibration was conducted with OxCal v 4 (Bronk Ramsey 2009) using the IntCal09 calibration curve (Reimer et al. 2009). The highest relative probability is in the 1σ range (68.2%) and the respective age ranges with their probabilities (in %) are given. The 2σ range (95.4%) is given undivided. The calibrated median is not to be interpreted as a point date, but as a useful value of the median probability of the calibrated age range.

L100 #	Depth (cm)	Lab nr	δ ¹³ C (‰)	¹⁴ C date (BP)	Calibrated date (BCE)		Median age cal BCE
					(1σ)	(2σ)	
01	13	GrA-48370	-22.19	2780 ± 35	996–986 (4.8%) 980–896 (63.4%)	1009–837	928
02	22	GrA-48445	-25.45	2810 ± 35	1004–919 (68.2%)	1054–854	963
04	43	GrA-48373	-24.96	2790 ± 35	997–904 (68.2%)	1019–838	942
05	56	GrA-48422	-11.45	2870 ± 60	1129–971 (60.5%) 961–934 (7.7%)	1260–901	1054

The uppermost black spots of charred organic material in Locus 100 appeared already at just 13 cm below the surface. The deepest level reached into the southwestern corner of Locus 100 and here sample 05 consists of C₄ plants (δ¹³C = -11.45‰). The amount of material was small even for AMS and the standard deviation is somewhat higher (±60), as compared to the other dates (±35). The differences of the upper 3 ¹⁴C dates at 13, 22, and 43 cm depth are very small indeed. It should

perhaps be pointed out to archaeologists not so familiar with ^{14}C dating that these 3 dates (GrA-48370, -48445, -48373) are considered similar in physical terms, all within 1σ (± 35 yr BP).

These 3 samples have a calibrated age that places each of them either in Iron Age I or Iron Age II, according to the classification by Mazar (2005), in which the boundary is placed around 980 BCE. The classification by Mazar is based on archaeological considerations and the detailed ^{14}C research at Tel Rehov (Bruins et al. 2003a,b, 2005; Mazar et al. 2005). Mazar and Bronk Ramsey (2008, 2010) reevaluated the results of the Early Iron Age Dating Project (Boaretto et al. 2005) and responded to the criticism by Finkelstein and Piasezky (2010). In the Low Chronology, the boundary between Iron Age I and II is placed at about 920–900 BCE (Finkelstein 1996; Finkelstein and Piasezky 2003; Boaretto et al. 2005). The dating results measured in Groningen from various Iron Age sites in the Levant, Italy, north Africa, and Spain support a High Chronology for the Iron Age across the entire region (van der Plicht et al. 2009). These results were criticized in a rejoinder by Fantalkin et al. (2011), followed by a detailed response (Bruins et al. 2011) that adds more facets in favor of the High Chronology.

In the Low Chronology view, the above 3 dates at Horvat Haluqim of Locus 100 would *most probably* belong to Iron Age I, as the entire 1σ ranges cover mostly or entirely the 10th century BCE (sample 01, 996–986, 980–896 BCE; sample 02, 1004–919 BCE; sample 04, 997–904 BCE). Although, the 2σ range provides a low probability option to place the above dates in Iron Age IIA, according to the Low Chronology. However, sample 05 is firmly situated in Iron Age I (1σ 1129–971 [60.5%], 961–934 [7.7%]; 2σ 1260–901 [95.4%]). Even in the High Chronology, sample 05 has a much higher probability to belong to Iron Age I than to Iron Age II.

RECTANGULAR STRUCTURE – LOCUS 200

The northern part of the rectangular structure (Locus 200) is bound in the north by Wall 3 made up of large stones (Figure 8). This wall is ~40 cm thick and the length of the stones ranges from 50 to 70 cm. Wall 2 is composed of irregular smaller stones, 25 cm wide and 20–40 cm long. It seems that Wall 3 continues westward and joins Wall 1, also built of very large stones. Wall 1 and Wall 2 are almost parallel, but diverge somewhat going from south to north. In Locus 100, the distance between Wall 2 and Wall 1 is about 10 cm (Figure 7), while in Locus 200 the distance increases to 40 cm. These differences suggest a multiperiod archaeological history. The eastern wall in Locus 200 was either dismantled in the past for reuse of building stones or was never present. Further excavations to deeper levels will give a better view of the remaining architecture. Locus 200 is bound in the south by a baulk (Figure 8).

The uppermost organic sample in Locus 200 was found at a depth of 32 cm. It has the youngest ^{14}C date of the 4 results. Its calibrated age places this sample in Iron Age IIB (highest probability) or Iron Age III, according to the classification by Mazar (2005). Again, the interesting aspect of C_4 plants appears in this charred organic material ($\delta^{13}\text{C} = -10.12\text{‰}$). The other 3 ^{14}C dating results are from depths of 36, 45, and 56 cm, and have identical dates (Table 3). The dates are not only similar in physical AMS terms, considering the 1σ standard deviation of ± 35 yr BP, but are indeed virtually equal. The latter 3 dates are all situated in the 9th century BCE, both in the 1σ and 2σ calibrated ranges. However, the highest relative probability for each of the 3 samples is in the second half of the 9th century BCE. Considering the material cultural classification of the southern Levant linked to time, the dates can be related to both Iron IIA and Iron IIB, according to Mazar (2005). The rather delicate soil stratigraphies for all loci will be established later when the excavations continue to deeper levels and all micromorphology samples have been studied.

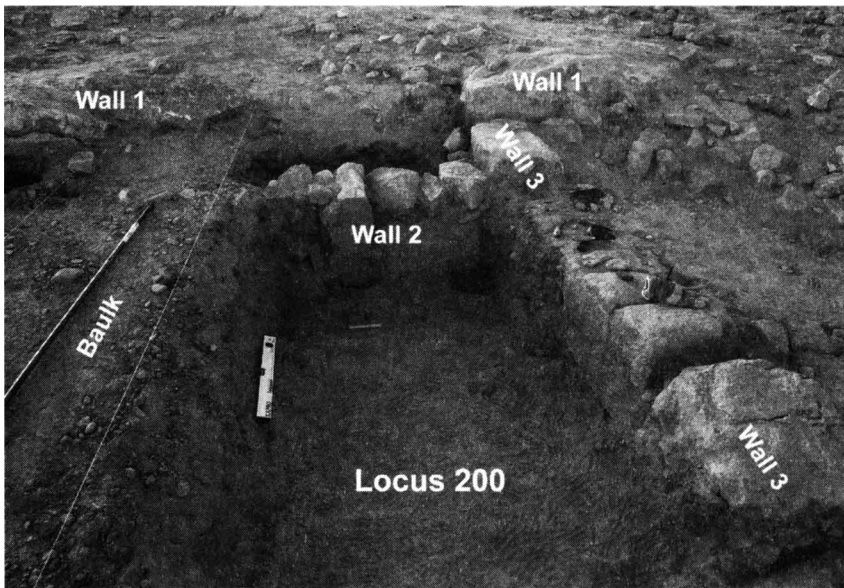


Figure 8 Westward view of Locus 200. The white level is 60 cm long. A ruler, 15 cm long, indicates a box with an undisturbed micromorphological sample taken *in situ*.

Table 3 Locus 200, ^{14}C dates of charred organic material inside the northern part of the rectangular building structure. Small black spots embedded in the archaeological soil appear occasionally, ranging in size from a few mm up to 1 cm. Sample 02 has a less negative $\delta^{13}\text{C}$ value, i.e. C_4 plants, usually short-lived. Calibration was carried out with OxCal v 4 (Bronk Ramsey 2009) using the IntCal09 calibration curve (Reimer et al. 2009). The highest relative probability is in the 1σ range (68.2%) and the respective age ranges with their probabilities (in %) are given. The 2σ range (95.4%) is given undivided. The calibrated median is not to be interpreted as a point date, but as a useful value of the median probability of the calibrated age range.

L200 #	Depth (cm)	Lab nr	$\delta^{13}\text{C}$ (‰)	^{14}C date (BP)	Calibrated date (BCE)		Median age cal BCE
					(1σ)	(2σ)	
02	32	GrA-48376	-10.12	2605 ± 35	810–775 (68.2%)	838–596	794
03	36	GrA-48377	-22.15	2680 ± 35	893–877 (12.7%) 846–803 (55.5%)	901–799	835
04	45	GrA-48450	-24.10	2675 ± 35	891–879 (9.1%) 845–801 (59.1%)	900–797	831
06	56	GrA-48451	-21.87	2670 ± 35	888–883 (3.4%) 843–800 (64.8%)	899–796	828

DISCUSSION AND CONCLUSIONS

The above excavation approach in the archaeological soil layers of small building structures at Horvat Haluqim, coupled with AMS ^{14}C dating, is like looking with new glasses to human history in the Negev Desert, seeing more periods and more detail than was possible with traditional methods and ceramic dating. The archaeological methodology of some 40 yr ago at Horvat Haluqim established the presence of 2 time periods: Stratum 1 – Roman period, 2nd–3rd centuries CE; Stratum 2 – Iron Age IIA, 10th century BCE (Cohen 1976; Cohen and Cohen-Amin 2004). Though the results of the

present excavations in loci 100, 200, and 700 are preliminary, the 13 ^{14}C dating results (Table 4) show the time signatures of more archaeological periods at Horvat Haluqim: Iron I; Iron II; Iron III; and the Persian period.

Table 4 Summary of all 13 ^{14}C dates and related archaeological periods, associated on the basis of time, according to the full 2σ calibrated age range.

Locus-sample #	Depth (cm)	Lab nr	^{14}C date BP	Age cal BCE (2σ)	Median age cal BCE	Archaeological period
L700-01	28	GrA-48453	2430 \pm 35	752–403	517	Iron III/Persian
L700-02	33	GrA-48454	2680 \pm 35	901–799	835	Iron II
L700-03	40	GrA-48455	2755 \pm 40	999–822	898	Iron I/II
L700-04	42	GrA-48458	2445 \pm 40	756–407	556	Iron III/Persian
L700-05	49	GrA-48459	2460 \pm 40	760–411	590	Iron III/Persian
L100-01	13	GrA-48370	2780 \pm 35	1009–837	928	Iron I/II
L100-02	22	GrA-48445	2810 \pm 35	1054–854	963	Iron I/II
L100-04	43	GrA-48373	2790 \pm 35	1019–838	942	Iron I/II
L100-05	56	GrA-48422	2870 \pm 60	1260–901	1054	Iron I/II
L200-02	32	GrA-48376	2605 \pm 35	838–596	794	Iron II/III
L200-03	36	GrA-48377	2680 \pm 35	901–799	835	Iron II
L200-04	45	GrA-48450	2675 \pm 35	900–797	831	Iron II
L200-06	56	GrA-48451	2670 \pm 35	899–796	828	Iron II

Our results can be compared with the ^{14}C dates from the nearby Iron Age site of Atar Haroa (Shack-Gross and Finkelstein 2008; Boaretto et al. 2010). The latter dates are from 2 buildings, the oval fortress (oval compound in their terminology), Loci 1 and 6, and from another building, Locus 25. The 11 ^{14}C dates of the oval fortress at Atar Haroa range between the youngest date of 2670 \pm 40 BP (RTT-5357), calibrated 2σ range 910–790 BCE, and the oldest date of 2820 \pm 35 BP (RTT-5356), calibrated 2σ range 1120–890 BCE. Both dates were measured on date seeds. The 5 ^{14}C dates from the other building at Atar Haroa, measured on grape and barley seeds, respectively, range between the youngest date of 2635 \pm 40 BP (RTT-5723), 900–760 cal BCE (2σ), and the oldest date of 2745 \pm 40 (RTT-5722), 1000–810 cal BCE (2σ).

It is clear that the ^{14}C dates from archaeological soil layers in building structures in Horvat Haluqim and Atar Haroa have many similarities. The 2 oldest dates at Horvat Haluqim, from Locus 100, are 2810 \pm 35 BP (GrA-48445) and 2870 \pm 60 BP (GrA-48422), while the oldest date from Atar Haroa (oval fortress, Locus 6) is 2820 \pm 35 BP (RTT-5356). Also, many of the other dates in loci 100, 200, and 700 at Horvat Haluqim are similar to those at Atar Haroa. These multiple similarities in time signatures strengthen of course the validity of both data sets. The results at both rural desert sites also show that detailed excavation of soil layers in building structures, coupled with ^{14}C dating, is able to reconstruct habitation history in a much more detailed and comprehensive way than architecture and ceramic dating.

At Horvat Haluqim, the small round building structure (Locus 700) also yielded 3 dating results that suggest habitation in Iron Age III or more likely the Persian period. The latter period was not represented by the ^{14}C dates at Atar Haroa, but there is a square fortress of the Persian period at Atar Haroa (Cohen and Cohen-Amin 2004:176–85) not far from the Iron Age village.

ACKNOWLEDGMENTS

We thank the Israel Antiquities Authority for the permission and license to excavate at Horvat Halujim. The research was partly funded by the Stichting Midbar Foundation. We thank the staff of the Sede Boker Field School and other volunteers for their participation in the archaeological excavations. We are grateful to the technical staff at the Centre for Isotope Research (University of Groningen) for pretreatment of the organic samples and AMS ¹⁴C dating. Finally, we acknowledge the critical but excellent remarks by 2 anonymous reviewers, whose suggestions led to a sharper focus of the concept and considerable improvements in both the structure and content of the article.

REFERENCES

- Avner U. 1998. Settlement, agriculture, and paleoclimate in 'Uvda Valley, southern Negev Desert, 6th–3rd millennia B.C. In: Issar A, Brown N, editors. *Water, Environment and Society in Times of Climate Change*. Dordrecht: Kluwer Academic. p 147–202.
- Avner U. 2002. Studies in the material and spiritual culture of the Negev and Sinai population, during the 6th–3rd millennia B.C. [unpublished PhD thesis]. Jerusalem: Hebrew University.
- Avner U. 2006. Settlement pattern in the Araba Valley and the adjacent desert areas, a view from the Eilat Region. In: Bienkowski P, Galor K, editors. *Crossing the Rift*. Oxford: Oxbow Books. p 51–74.
- Avner U, Carmi I. 2001. Settlement patterns in the southern Levant deserts during the 6th–3rd millennia BC: a revision based on ¹⁴C dating. *Radiocarbon* 43(3): 1203–16.
- Avni G. 1992. *Archaeological Survey of Israel: Map of Har Saggi—Northeast (225)*. Jerusalem: Israel Antiquities Authority and Archaeological Survey of Israel.
- Avni G. 1996. *Nomads, Farmers, and Town-Dwellers: Pastoralist-Sedentist Interaction in the Negev Highlands, Sixth–Eight Centuries CE*. Jerusalem: Israel Antiquities Authority.
- Avni Y, Porat N, Plakht J, Avni G. 2006. Geomorphologic changes leading to natural desertification processes versus anthropogenic land conservation in an arid environment, the Negev Highlands, Israel. *Geomorphology* 82(3–4):177–200.
- Avni G, Avni Y, Porat N. 2009. A new look at ancient agriculture in the Negev. *Cathedra* 133:13–44. In Hebrew.
- Boaretto E, Jull AJT, Gilboa A, Sharon I. 2005. Dating the Iron Age I/II transition in Israel: first intercomparison results. *Radiocarbon* 47(1):39–55.
- Boaretto E, Finkelstein I, Shahack-Gross R. 2010. Radiocarbon results from the Iron IIA site of Atar Haroa in the Negev highlands and their archaeological and historical implications. *Radiocarbon* 52(1):1–12.
- Bronk Ramsey C. 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51(1):337–60.
- Bronk Ramsey C, Dee MW, Higham TFG, Harris SA, Brock F, Quiles A, Wild EM, Marcus ES. 2010. Radiocarbon-based chronology for dynastic Egypt. *Science* 328(5985):1554–7.
- Bruins HJ. 1986. Desert environment and agriculture in the central Negev and Kadesh-Barnea during historical times [PhD dissertation]. Wageningen: University of Wageningen; Nijkerk: Stichting Midbar Foundation.
- Bruins HJ. 1990a. The impact of man and climate on the central Negev and northeastern Sinai deserts during the Late Holocene. In: Bottema S, Entjes-Nieborg G, van Zeist W, editors. *Man's Role in the Shaping of the Eastern Mediterranean Landscape*. Rotterdam: Balkema. p 87–99.
- Bruins HJ. 1990b. Ancient agricultural terraces at Nahal Mitnan. *'Atiqot* 10:127–8 (in Hebrew); 22*–28* (in English).
- Bruins HJ. 2007. Runoff terraces in the Negev Highlands during the Iron Age: nomads settling down or farmers living in the desert? In: van der Steen EJ, Saidel BA, editors. *On the Fringe of Society: Archaeological and Ethnoarchaeological Perspectives on Pastoral and Agricultural Societies*. BAR International Series 1657. Oxford: Archaeopress. p 37–43.
- Bruins HJ. 2010. Dating Pharaonic Egypt. *Science* 328(5985):1489–90.
- Bruins HJ. 2012. Ancient desert agriculture in the Negev and climate-zone boundary changes during average, wet and drought years. *Journal of Arid Environments* 86:28–42.
- Bruins HJ, Mook WG. 1989. The need for a calibrated radiocarbon chronology of Near Eastern archaeology. *Radiocarbon* 31(3):1019–29.
- Bruins HJ, van der Plicht J. 1995. Tell es-Sultan (Jericho): radiocarbon results of short-lived cereal and multiyear charcoal samples from the end of the Middle Bronze Age. *Radiocarbon* 37(2):213–20.
- Bruins HJ, van der Plicht J. 1998. Early Bronze Jericho: high-precision ¹⁴C dates of short-lived palaeobotanic remains. *Radiocarbon* 40(2):621–8.
- Bruins HJ, van der Plicht J. 2004. Desert settlement in the central Negev: first ¹⁴C indication of rainwater-harvesting agriculture in the Iron Age. In: Higham TFG, Bronk Ramsey C, Owen DC, editors. *Radiocarbon and Archaeology: Proceedings of the 4th International Symposium, Oxford, 2002*. Oxford: Oxford University, School of Archaeology, Monograph 62. p 83–98.

- Bruins HJ, van der Plicht J. 2005. Desert settlement through the Iron Age: radiocarbon dates from Sinai and the Negev highlands. In: Levy TE, Higham T, editors. *The Bible and Radiocarbon Dating: Archaeology, Text and Science*. London: Equinox. p 349–66.
- Bruins HJ, van der Plicht J. 2007. Radiocarbon dating the “Wilderness of Zin.” *Radiocarbon* 49(2):481–97.
- Bruins HJ, van der Plicht J, Mazar A. 2003a. ¹⁴C dates from Tel Rehov: Iron-Age chronology, pharaohs and Hebrew kings. *Science* 300(5617):315–8.
- Bruins HJ, van der Plicht J, Mazar A. 2003b. Response to comment on “¹⁴C dates from Tel Rehov: Iron-Age chronology, pharaohs and Hebrew kings.” *Science* 302(5645):568c.
- Bruins HJ, van der Plicht J, Mazar A, Bronk Ramsey C, Manning SW. 2005. The Groningen radiocarbon series from Tel Rehov: OxCal Bayesian computations for the Iron IB-IIA boundary and Iron IIA destruction events. In: Levy TE, Higham T, editors. *The Bible and Radiocarbon Dating: Archaeology, Text and Science*. London: Equinox. p 271–93.
- Bruins HJ, Nijboer AJ, van der Plicht J. 2011. Iron Age Mediterranean chronology: a reply. *Radiocarbon* 53(1):199–220.
- Cohen R. 1976. Excavations at Horvat Haluqim. *Atiqot* 11:34–50, Plates V–VIII.
- Cohen R, Cohen-Amin R. 2004. *Ancient Settlement of the Negev Highlands Volume II. The Iron Age and the Persian Periods*. IAA Reports 20. Jerusalem: Israel Antiquities Authority.
- Fantalkin A, Finkelstein I, Piasezky E. 2011. Iron Age Mediterranean chronology: a rejoinder. *Radiocarbon* 53(1):179–98.
- Finkelstein I. 1996. The archaeology of the United Monarchy: an alternative view. *Levant* 27:177–87.
- Finkelstein I, Piasezky E. 2003. Comment on “¹⁴C dates from Tel Rehov: Iron-Age chronology, pharaohs and Hebrew kings.” *Science* 302(5645):568.
- Finkelstein I, Piasezky E. 2010. The Iron I/IIA transition in the Levant: a reply to Mazar and Bronk Ramsey and a new perspective. *Radiocarbon* 52(4):1667–80.
- Franken HJ, Franken-Battershill CA. 1963. *A Primer of Old Testament Archaeology*. Leiden: Brill.
- Gilboa A, Sharon I. 2001. Early Iron Age radiometric dates from Tel Dor: preliminary implications for Phoenicia and beyond. *Radiocarbon* 43(3):1343–51.
- Gilboa A, Sharon I. 2003. An archaeological contribution to the Early Iron Age chronological debate: alternative chronologies for Phoenicia and their effects on the Levant, Cyprus, and Greece. *Bulletin of the American Schools of Oriental Research* 332:7–80.
- Gilboa A, Sharon I, Boaretto E. 2009. Tel Dor and the chronology of Phoenician “Pre-Colonization” stages. In: Sagona C, editor. *Beyond the Homeland: Markers in Phoenician Chronology*. Leuven: Peeters. p 113–204.
- Haiman M. 1986. *Archaeological Survey of Israel: Map of Har Hamran—Southwest (198)*. Jerusalem: Department of Antiquities and Museums and Archaeological Survey of Israel.
- Haiman M. 1990. Agricultural settlement in Ramat Barnea in the 7th–8th centuries CE. *Atiqot* 9:111–24.
- Haiman M. 1991. *Archaeological Survey of Israel: Map of Mizpe Ramon—Southwest (200)*. Jerusalem: Israel Antiquities Authority and Archaeological Survey of Israel.
- Haiman M. 1993. *Archaeological Survey of Israel: Map of Har Hamran—Southeast (199)*. Jerusalem: Israel Antiquities Authority and Archaeological Survey of Israel.
- Haiman M. 1994. The Iron Age II sites of the western Negev Highlands in light of the Negev Emergency Survey 1979–1989. *Israel Exploration Journal* 44:36–61.
- Haiman M. 1999. *Archaeological Survey of Israel: Map of Har Ramon (203)*. Jerusalem: Israel Antiquities Authority and Archaeological Survey of Israel.
- Haiman M. 2003. The 10th century B.C. settlement of the Negev Highlands and Iron Age rural Palestine. In: Maeir AM, Dar S, Safrai Z, editors. *The Rural Landscape of Ancient Israel*. Oxford: BAR International Series 1121. p 71–90.
- Haiman M. 2007. Pastoralism and agriculture in the Negev in the Iron Age II. In: van der Steen EJ, Saidel BA, editors. *On the Fringe of Society: Archaeological and Ethnoarchaeological Perspectives on Pastoral and Agricultural Societies*. Oxford: BAR International Series 1657. p 57–61.
- Higham T, van der Plicht J, Bronk Ramsey C, Bruins HJ, Robinson M, Levy TE. 2005. Radiocarbon dating of the Khirbat-en Nahas site (Jordan) and Bayesian modeling of the results. In: Levy TE, Higham T, editors. *The Bible and Radiocarbon Dating: Archaeology, Text and Science*. London: Equinox. p 164–78.
- Kenyon KM. 1957. *Digging up Jericho*. London: Ernest Benn Ltd.
- Levy TE, Adams RB, Najjar M, Hauptmann A, Anderson JA, Brandl B, Robinson MA, Higham T. 2004. Reassessing the chronology of Kibrit Edom: new excavations and ¹⁴C dates from Khirbat en-Nahas (Jordan). *Antiquity* 78(302):865–79.
- Levy TE, Najjar M, van der Plicht J, Smith NG, Bruins HJ, Higham T. 2005. Lowland Edom and the High and Low chronologies: Edomite state formation, the Bible and recent archaeological research in southern Jordan. In: Levy TE, Higham T, editors. *The Bible and Radiocarbon Dating: Archaeology, Text and Science*. London: Equinox. p 129–63.
- Mazar A. 2005. The debate over the chronology of the Iron Age in the Southern Levant. In: Levy TE, Higham T, editors. *The Bible and Radiocarbon Dating: Archaeology, Text and Science*. London: Equinox. p 13–26.
- Mazar A, Bronk Ramsey C. 2008. ¹⁴C dates and the Iron Age chronology of Israel: a response. *Radiocarbon* 50(2):159–80.
- Mazar A, Bronk Ramsey C. 2010. A response to Finkel-

- stein and Piasetzky's criticism and "new perspective." *Radiocarbon* 52(4):1681–8.
- Mazar A, Bruins H, Panitz-Cohen N, van der Plicht J. 2005. Ladder of time at Tel Rehov: stratigraphy, archaeological context, pottery and radiocarbon dates. In: Levy TE, Higham T, editors. *The Bible and Radiocarbon Dating: Archaeology, Text and Science*. London: Equinox. p 193–255.
- Offer ZY, Goossens D. 2001. Ten years of aeolian dust dynamics in a desert region (Negev desert, Israel): analysis of airborne dust concentration, dust accumulation and the high-magnitude dust events. *Journal of Arid Environments* 47(2):211–49.
- Reimer PJ, Baillie MGL, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE, Burr GS, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Hajdas I, Heaton TJ, Hogg AG, Hughen KA, Kaiser KF, Kromer B, McCormac FG, Manning SW, Reimer RW, Richards DA, Southon JR, Talamo S, Turney CSM, van der Plicht J, Weyhenmeyer CE. 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. *Radiocarbon* 51(4): 1111–50.
- Rosen SA. 1993. A Roman period pastoral tent camp in the Negev, Israel. *Journal of Field Archaeology* 20: 441–51.
- Rosen SA. 1994. *Archaeological Survey of Israel: Map of Makhtesh Ramon (204)*. Jerusalem: Israel Antiquities Authority.
- Rosen SA. 2003. Early multi-resource nomadism: excavations at the Camel Site in the central Negev. *Antiquity* 77(298):750–61.
- Rosen SA, Avni G. 1997. *The Oded Sites – Investigations of Two Early Islamic Pastoral Camps South of the Ramon Crater*. Beer Sheva: Ben-Gurion University of the Negev Press.
- Rosen SA, Savinetsky AB, Plakht Y, Kisseleva NK, Khassanov BF, Pereladov AM, Haiman M. 2005. Dung in the desert: preliminary results of the Negev Holocene Ecology Project. *Current Anthropology* 46(2):317–27.
- Rosen SA, Avni Y, Bocquentin F, Porat N. 2007. Investigations at Ramat Saharonim: a desert Neolithic sacred precinct in the Central Negev. *Bulletin of the American Schools of Oriental Research* 346:1–27.
- Saidel BA. 2001. Abandoned tent camps in southern Jordan. *Near Eastern Archaeology* 64(3):150–7.
- Saidel BA. 2002. The excavations at Rekhes Nafha 396 in the Negev Highlands, Israel. *Bulletin of the American Schools of Oriental Research* 325:37–63.
- Shahack-Gross R, Finkelstein I. 2008. Subsistence practices in an arid environment: a geoarchaeological investigation in an Iron Age site, the Negev Highlands, Israel. *Journal of Archaeological Science* 35(4):965–82.
- Sharon I, Gilboa A, Boaretto E, Jull AT. 2005. The Early Iron Age Dating Project: introduction, methodology, progress report and an update on the Tel Dor radiometric dates. In: Levy TE, Higham T, editors. *The Bible and Radiocarbon Dating: Archaeology, Text and Science*. London: Equinox. p 65–92.
- Sharon I, Gilboa A, Jull AJT, Boaretto E. 2007. Report on the first stage of the Iron Dating Project in Israel: supporting a Low Chronology. *Radiocarbon* 49(1):1–46.
- van der Plicht J, Bruins HJ. 2001. Radiocarbon dating in Near-Eastern contexts: confusion and quality control. *Radiocarbon* 43(3):1155–66.
- van der Plicht J, Bruins HJ, Nijboer AJ. 2009. The Iron Age around the Mediterranean: a High Chronology perspective from the Groningen radiocarbon database. *Radiocarbon* 51(1):213–42.
- Vogel JC, Fuls A, Danin A. 1986. Geographical and environmental distribution of C₃ and C₄ grasses in the Sinai, Negev, and Judean deserts. *Oecologia* 70(2):258–65.
- Wheeler M. 1954. *Archaeology from the Earth*. Oxford: Clarendon Press.