Developing a Radiocarbon-Based Chronology for Tel Azekah: The First Stage

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Declaration

I certify that the work presented in this thesis has not been submitted either in whole or in part for a higher degree at any other university or institution. This thesis is an original piece of research and the work of others has been duly acknowledged in the text.

Dated this 23rd day of October 2015

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Abstract

The need for more systematic, integrated use of radiocarbon dating within excavations of ancient Near Eastern sites for historical periods is well recognised. This thesis presents the first stage in developing an independent radiocarbon-based chronology for the site of Tel Azekah, Israel. Fifteen short-lived samples collected over three excavation seasons have been dated, deriving from Middle Bronze through to Hellenistic contexts. The results of this initial dataset, together with radiocarbon-specific fieldwork, have contributed to developing an effective methodology and working procedures for ongoing research. Targeted collection of datable material commenced in the 2015 excavation season, facilitated by a field role specific to radiocarbon research.

The first radiocarbon dataset for Tel Azekah focuses on the site's peak period of occupation – the Late Bronze Age. A sequence of samples allowed a major public building to be dated close to the first half of the 12th century BCE, with comparisons drawn to radiocarbon-dated strata of other sites. The sequence offers excellent potential for improvement and expansion in future research. A tentative date for a Middle Bronze destruction was obtained, which is consistent with a wider regional pattern. This research has placed some initial 'pegs' for the site's absolute chronology, and helped to set directions for the next stages of work. It has highlighted well the benefits of involving radiocarbon dating as an active part of archaeological interpretation.

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List of Abbreviations

Journal Abbreviations

AASOR	Annual of the American Schools of Oriental Research
ADAJ	Annual of the Department of Antiquities Jordan
AJA	American Journal of Archaeology
BASOR	Bulletin of the American Schools of Oriental Research
GCA	Geochimica et Cosmochimica Acta
IEJ	Israel Exploration Journal
IJES	Israel Journal of Earth Sciences
JAOS	Journal of the American Oriental Society
JAS	Journal of Archaeological Science
JCS	Journal of Cuneiform Studies
NEA	Near Eastern Archaeology
UF	Ugarit Forschungen
VT	Vetus Testamentum
PEF (QS)	Palestine Exploration Fund Quarterly Statement
PNAS	Proceedings of the National Academy of Sciences (USA)
ZDPV	Zeitschrift des Deutschen Palästina-Vereins

Period abbreviations:

EB	Early Bronze
IB	Intermediate Bronze
MB	Middle Bronze
LB	Late Bronze
IA	Iron Age
ED	Early dynastic Egypt
OK	Old Kingdom of Egypt
FIP	First Intermediate Period
MK	Middle Kingdom of Egypt
SIP	Second Intermediate Period
NK	New Kingdom of Egypt
TIP	Third Intermediate Period

Other Abbreviations

ABA	Acid-Base-Acid (equivalently AAA, Acid-Alkaline-Acid)
AINSE	Australian Institute of Nuclear Science and Engineering
AMS	Accelerator Mass Spectrometer
ANSTO	Australian National Science and Technology Organisation
NIG	New Israeli grid
OIG	Old Israeli grid
PDB	Peedee belemnite (the standard for $\delta^{13}C$ normalisation)
PEF	Palestine Exploration Fund

Chronological Reference Table

Table 1 Southern Levantine chronology from the Early Bronze Age to Hellenistic period (dates BCE).

EARLY BRONZE AGE		
• EB chronology has been the subject of much debate. Radiocarbon suggests adjustments of up to several centuries (Regev et al. 2012b; compare Mazar 1990: 30; 174-230)		
	Radiocarbon-based Chronology (Regev et al. 2012b)	
EB I	3700 – 3100/2950	• Contemporary with the Egyptian Protodynastic period and Dynasty 1
EB II	3100/2950 – 2900/2850	• Contemporary with ED Egypt
EB III	2900/2850 – 2600/2450	• Decline of EB urban culture • Contemporary with ED and OK Egypt
EB IV (previously MB I)	2600/2450 – 2000	• Characterised by sparse population, small villages, and a return to pastoral nomadic lifestyle • Contemporary with OK Egypt and the FIP
MIDDLE BRONZE AGE		
• MB chronology has also been subject to much debate and adjustment, especially MB I / MB IIA • The period is subdivided either using MB I / II / III (Dever 1987: 149-150), or the more traditional MB IIA / B / C (Mazar 1990: 30; 174-230; Ben-Tor 1992). The former is used in this thesis. • MB II and MB III material culture is often difficult to differentiate, and not all scholars support a division between them (Bienkowski 1989).		
MB I / MB IIA	2000/1950 – 1800/1750	• Revival of urban life after EB IV • A lower starting date c. 1920 is supported by (Marcus 2003; 2013) and (Bietak 2002) • Contemporary with Egyptian MK Dynasties 11/12
MB II / MB IIB	1800/1750 – 1650	• City-states with Amorite culture • Contemporary with SIP Dynasty 13
MB III / MB IIC	1650 – 1550/1500	• Strongly fortified cities • Contemporary with SIP Dynasty 15 (Hyksos) • The period ends with the fall of Avaris
LATE BRONZE AGE		
• The Late Bronze chronology shown here follows Martin (2011: Table 1), adapted using the new chronology of Schneider (2010).		
LB IA	1500 – 1450	• 18th Dynasty to sole reign of Thutmoses III
LB IB	1450 – 1390	• Until Thutmoses IV
LB IIA	1390 – 1300	• Amarna period
LB IIB	1300 – 1185	• 19th and early 20th Dynasties; strongest period of Egyptian control over Canaan
LB III / IA IA	1185 – 1140	• 20th Dynasty; weakening of Egyptian control; • Arrival of Philistines (timing debated);

Table 1 (continued)

<table>
<tr><td colspan="5">IRON AGE</td></tr>
<tr><td colspan="5">• Debate over Iron Age chronology has resulted in three different versions, the Low or Modified Chronologies being held by most. The LB III – IA IB and the IA IB – IA IIA transitions remain unresolved.</td></tr>
<tr><td></td><td>Conventional Chronology
(Mazar 1990:30; Stern 1993b)</td><td>Low Chronology
(Finkelstein 2005; Finkelstein and Piasetzky 2006)</td><td>Modified Chronology
(Mazar 2005; Lee et al. 2013)</td><td></td></tr>
<tr><td>IA IB / IA I</td><td>1150 – 1000</td><td>1140/30 – 920/900</td><td>1140/30 – 980</td><td>• Israelite culture in the highlands</td></tr>
<tr><td>IA IIA</td><td>1000 – 900/925</td><td>920/900 – 800/780</td><td>~980 – 830</td><td>• Period of rich material culture and monumental architecture; connected with the United Monarchy, a Judean state and/or the Omrides of the northern kingdom</td></tr>
<tr><td>IA IIB</td><td>900 – 732/700</td><td>800/780 – 732/701</td><td>830 – 732/701</td><td>• Monarchical period until the destruction of the Northern Israelite kingdom by Assyria</td></tr>
<tr><td>IA IIC</td><td colspan="3">732/701 – 586</td><td>• Period starts with Assyrian campaigns (Tiglath Pileser III 732 BCE to Sennacherib 701 BCE)</td></tr>
<tr><td colspan="5">BABYLONIAN RULE UNTIL ROMAN RULE</td></tr>
<tr><td>Babylonian Period</td><td>586 – 539</td><td colspan="3">• Period begins with the destruction of Jerusalem by Nebuchadnezzar II</td></tr>
<tr><td>Persian Period</td><td>539 – 331</td><td colspan="3">• Period begins with shift of governance in the Levant to Persian control following the fall of Babylon.</td></tr>
<tr><td>Hellenistic Period</td><td>331 – 60</td><td colspan="3">• Period begins with the arrival of Alexander the Great in the Levant and ends with Roman rule.</td></tr>
</table>

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I am indebted to many people for helping to make this research possible. I would like to express my thanks to the Azekah excavation directors Prof. Oded Lipschits, Dr Yuval Gadot and Prof. Manfred Oeming for inviting me to work on radiocarbon dating at Azekah. Yuval gave me wonderful support and encouragement in the field, and spent many hours on weekends providing valuable input, reviewing the results and commenting on drafts of this thesis.

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Last but certainly not least, I owe a huge thankyou to my husband, Jared Dye, who patiently put up with my unsociably long working hours. The many discussions over aspects of research and his editorial assistance were of great help; and without him I would not have had such beautiful maps.

Chapter 1 Introduction

Over the past few decades radiocarbon dating has become an increasingly important chronological tool for the archaeology of the Near East in historical periods (3rd millennium BCE onwards). An accurate and precise technique, it can help reconstruct the history of sites, as well as contribute to major regional chronological debates. With both these aims in mind, there is a great need to integrate radiocarbon dating in current excavations of Near Eastern sites. The work presented in this thesis is the first stage in radiocarbon dating the occupational layers within the ancient city mound of Tel Azekah.

Tel Azekah is located within the Southern Levant – an area that encompasses today's Israel, Palestinian territories and Jordan, and which formed a vital land bridge between Egypt and Mesopotamia in antiquity. The site is situated in central [modern] Israel, within the Shephelah – a lowland region between the coastal plain and the highlands. The Shephelah is crossed by a number of major valleys, which served as vital access routes and centres of agricultural activity. Tel Azekah's location in relation to other key archaeological sites is shown in Figure 1. The ancient city is attested in ancient sources, and archaeological work reveals occupation stretching from the 3rd millennium BCE through to the late 1st millennium BCE.

The motivation behind radiocarbon dating at Tel Azekah – and by implication the initial stage of research presented here – needs to be examined from two angles: 1) limitations of the approach traditionally used in reconstructing ancient Near Eastern chronology for historical periods; and 2) advances in the use of radiocarbon dating. The history of radiocarbon dating within the Southern Levant is particularly pertinent, and will be dealt within a separate chapter.

1.1. The Traditional Approach to Chronology

The chronology of Near Eastern sites and regions during historical periods has traditionally been reconstructed using the following three elements: ceramic typology, stratigraphy and links to established political-historical chronologies. The temporal ordering of pottery styles is most readily seen through their appearance within well-stratified sites, and the examination of these two elements together provides a relative or 'floating' chronology. Regional relative chronologies have been developed by comparing the pottery sequences of multiple sites.

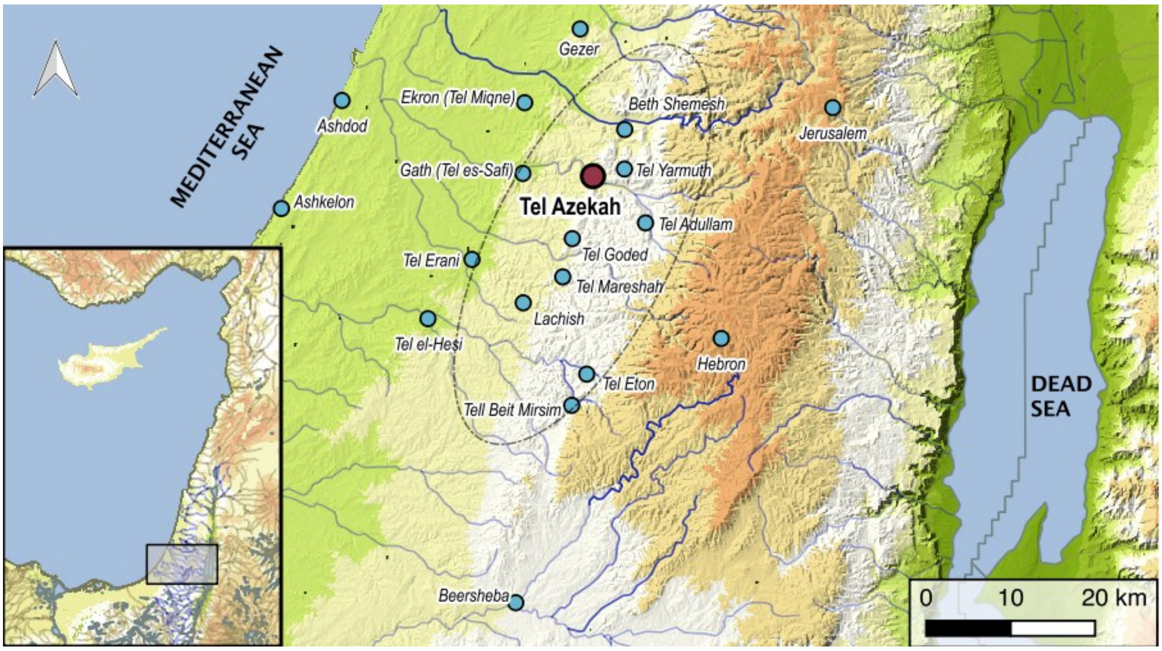

Figure 1 Location of Azekah between the coastal plain and highlands of southern Israel. The Shephelah region and the major sites within it are marked; several key sites in adjacent regions are also shown.

Many regions of the Near East and Mediterranean lack secure, extensive political-historical chronologies of their own, particularly in the third and second millennia BCE. Hence during this time, they depend upon Egypt for absolute chronology and, to a lesser extent, Mesopotamia. The essential outlines of these two major chronologies have been known to scholarship since the 19th or early 20th century. They were reconstructed from ancient texts, king lists and monuments; vital links to the calendar are provided by records of astronomical observations.[1] Since the Levant acted as a land bridge between major civilizations, significant amounts of foreign material were deposited within its ancient cities. Levantine material was also deposited in Egypt and Mesopotamia. This exchange of material is the avenue by which local archaeological sequences are connected to external political-historical chronologies. Materials that can serve as foreign synchronisms include inscriptions, scarabs and seals bearing the names of known pharaohs or kings, and various imported goods.

For the entirety of the Bronze Age and the early Iron Age, the history of the Southern Levant is especially closely linked to Egypt. Much of the chronological framework (refer to Table 1) is related to political developments in Egypt and the waxing and waning of Egyptian involvement in 'Canaan'. A locally-derived political-historical chronology for the

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[1] For recent overviews of Egyptian chronology see Kitchen (2013) and Shortland (2013); for Mesopotamian chronology see Pruzsinszky (2009).

Southern Levant begins only in the Iron Age IIA, with the monarchies of Israel and Judah. Yet even this depends heavily on synchronisms with Assyria to establish absolute chronology.

1.2. Problems with the Traditional Approach

There are a number of notable problems with the traditional approach to Near Eastern chronology in historical periods. First, in many excavations few finds are uncovered that can provide reliable and sufficiently accurate synchronisms (e.g. Marcus 2013: 183; Toffolo et al. 2013: 1-2; 2014: 221). Some materials are problematic because they may be retained for long periods (e.g. scarabs and seals). Often the connections made between the local sequence and Egyptian chronology are indirect. For example, imported pottery rather than inscriptions are the most common synchronising material, and this pottery may originate in a 'third-party' location (e.g. Cyprus). One of the major weaknesses of the traditional approach is that reconstructed chronologies tend to hang from very complex webs of interrelations, leaving us vulnerable to circular reasoning (Bruins 2001: 1147-48; van der Plicht and Bruins 2001).

Relying on the history of distant empires to develop a site's chronology is clearly problematic. This is true not only because of the physical and cultural separation of these lands, but because of inherent challenges in linking archaeological data – which is predominantly cultural in nature – with political-historical chronologies (Bietak 1984: 474; Bruins and Mook 1989: 1021-22).

Within the Egyptian and Mesopotamian chronologies themselves there is substantial uncertainty. Varying understandings of astronomical records (e.g. observation locations), as well as differences of opinion regarding reign lengths and co-regencies, have resulted in multiple versions of chronology: the high and low chronologies of Egypt (Shaw 2000; Hornung et al. 2006) and no less than three Mesopotamian chronologies (Hasel 2004; Pruzsinszky 2009). Differences can span as much as two centuries.

1.3. Benefits of Scientific Dating

Scientific dating methods offer significant advantages over the traditional approach. Most importantly, through local measurements, they allow absolute chronologies to be reconstructed independently at each site. Foreign synchronisms become secondary rather than primary data. Hence many of the above problems can be avoided.

Scientific dating relies only on physical processes. Hence the same tool can be applied to a wide variety of geographic locations and archaeological situations – from ancient tells and short-lived peripheral settlements to isolated features like tombs, shipwrecks and mining installations. When the same tool is applied, results can be compared with relative ease. Of necessity, palaeoclimate reconstruction is approached almost exclusively with scientific dating,[2] and the tendency to apply different dating approaches to environmental and human history can result in difficulties synchronizing the two (Bruins 2001: 1148; see also Bruins 1994; Boaretto 2015: 207).

It is not suggested here that traditional dating information is to be discarded from the study of Near Eastern archaeology and chronology – certainly not. However scientific dating methods need to be integrated into chronological studies. Comparison between methods is a huge advantage that mitigates the limitations of each. The relative strength of different types of chronological data needs to be critically examined on an ongoing basis.

1.4. Radiocarbon-based Chronology

The most established scientific dating technique available for archaeological research is radiocarbon dating. The biggest 'consumer' of radiocarbon dating from its earliest days (ca. 1950) was prehistoric research – not least of all in the Near East. For several decades, however, the resolution of radiocarbon could not compete with the traditional approach to historical chronology for the ancient Near East. This picture has changed markedly over the past two to three decades, thanks to advances in radiocarbon measurement techniques, analytical tools and increasing scrutiny of fieldwork aspects. These developments are described in detail in Section 2.4. Radiocarbon dating is now well-equipped to contribute to Near Eastern historical chronology, and several major chronological debates have helped to bring it to the fore.[3]

The potential of radiocarbon dating has been somewhat inhibited by two intertwined issues: inertia within the discipline; and the mixed-quality and limited quantity of available data. Arguably the greatest current need is for radiocarbon to be properly integrated as a chronological tool within active excavations. When this occurs on a sufficiently broad

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[2] See, for example, recent climate research for the Southern Levant in historical periods (Langgut et al. 2013; 2014; 2015; Kagan et al. 2015).

[3] In particular the ongoing debates over the Santorini eruption (Heinemeier et al. 2009; Manning et al. 2014 and further literature) and over Iron Age chronology (Finkelstein and Piasetzky 2011; Mazar 2011 and further literature).

scale, many new series of good-quality dates will be available to better tackle regional chronological issues.

Radiocarbon dating research that is based on a single site has some distinct advantages. Notably single-site analytical (Bayesian) models tend to be more robust on account of clear stratigraphic relationships and more uniform data quality.[4] Single-site research also provides some advantage for maintaining objectivity, since it is primarily driven by the need for independent absolute dating across all of the site's strata, rather than by specific debates.[5] Data obtained by persistent, integrated radiocarbon work at individual sites is ultimately a better long-term approach to key debates than brief sampling at many sites (Bronk Ramsey 2013).

1.5. Radiocarbon dating at Tel Azekah

The overarching aim of radiocarbon research at Tel Azekah is to develop a radiocarbon-based chronology for the site: in other words, an absolute chronology that is not heavily dependent on inter-site comparisons, previously established regional chronologies or ultimately on the political-historical chronologies of Egypt or Mesopotamia. Tel Azekah would thus become a reliable, largely independent chronological reference point for future work in the region (especially the Shephelah), well-positioned to dialogue in broader debates. Clearly this goal will take years of work, but in the meantime each set of new dates will shed progressively more light on the site and provide more comparative material for the region. The initial stage of research presented in this thesis must be understood in this larger framework.

Several characteristics of Tel Azekah render it well-suited to the development of a robust and influential radiocarbon-based chronology:

- *The site's long occupation history with few gaps* (refer to Table 4 in Section 3.6); it can thus contribute to our understanding of the region in many periods.
- *Evidence for five destruction layers*. These have preserved large assemblages of

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[4] See Bronk Ramsey (2013: 34) in the context of sample limitations for deriving an Egyptian radiocarbon-based chronology. See also other multi-site projects (Boaretto et al. 2005; Sharon et al. 2007; Regev et al. 2012b).

[5] One of the problems evident within the Iron Age debate is that opposing groups have tended to develop models supporting their own a priori positions. Whilst this underscores the need to improve the sensitivity of models and scrutinise contexts (Lee et al. 2013; Boaretto 2015), it also highlights the benefit of approaching chronological work (at least initially) outside of 'hot' debates.

intact and restorable pottery vessels together with datable organic material. As discussed, pottery is critical for establishing relative chronology and making connections with neighbouring sites; absolute dating of the destruction layers with their assemblages will allow Tel Azekah to make a significant contribution to chronology in the region.

- *The historical importance of the site*: Azekah appears in both biblical and extra-biblical sources (see Section 3.3). The biblical text describes it as an important border town between the highland kingdom of Judah and coastal Philistia during the Iron Age, and even the powerful Assyrians boasted of conquering it. Two attacks on Tel Azekah are well-dated historically and there is potential to associate these events with the archaeology.
- *Occupation during periods for which published radiocarbon data is very limited*. Tel Azekah was occupied during the Middle Bronze Age and Late Bronze Age, the latter being its peak of occupation. As shown in Section 2.4, radiocarbon for these two periods is sparse in the Southern Levant. Significant Persian and Hellenistic activity at the site is also evident – periods to which radiocarbon dating is usually applied only sporadically.

Some aspects concerning sites in the surrounding region should also be considered here:

- *Limitations of radiocarbon data in the area.* With the exception of Tel es-Safi (Gath),[6] published historical-period radiocarbon data in the Shephelah has notable limitations. Radiocarbon dating was undertaken at Lachish (1973-1994), however many samples are subject to the 'old wood' effect, and measurement precision is low in some cases (Carmi and Ussishkin 2004). Radiocarbon dates from Khirbet Qeiyafa,[7] a site easily viewed from Tel Azekah, have contributed to discussions concerning Iron Age chronology and state formation of Judah; however, this is a single period site. Published radiocarbon dates from Beth Shemesh are currently limited to the Iron Age (Sharon et al. 2007). Tell Yarmuth is well-dated (Regev et al. 2012a) but restricted mainly to the Early Bronze Age.
- *Potential for comparisons with recent or ongoing excavations at nearby sites.* Particularly notable are the excavations at Tel es-Safi, Beth Shemesh and new work at Lachish. Recently completed work at Khirbet Qeiyafa also provides important comparative material for a restricted time frame.

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[6] Sharon et al. (2007); Toffolo et al. (2012); Shai et al. (2014); Asscher et al. (2015a).

[7] Garfinkel and Ganor (2009); Garfinkel and Streit (2014); and Garfinkel et al. (2012); (2015).

1.5.1 *The Overall Approach*

The excavators of Tel Azekah place a high value on the contribution of radiocarbon dating to site and regional chronology. Excavations have been underway only since 2012; after the first three seasons it was decided that the time was ripe to commence an active and ongoing radiocarbon dating program. At that point enough work had been done to establish a good overall understanding of the site, with preliminary phasing for many excavation areas (see Table 4); and sufficient samples were available to support an initial selection for radiocarbon dating.

Following the initial set of dates – presented in this thesis – radiocarbon dating will progress concurrently with the excavation. This will allow important feedback loops to develop as excavation work continues:

- *Sample collection / selection can target gaps* in previously processed radiocarbon data, working efficiently towards optimal time coverage and resolution.
- *Radiocarbon information can actively assist in identifying and resolving difficulties* in the archaeological picture. It adds an important and powerful line of evidence, and should be allowed to dialogue actively with other chronological information proceeding out of the excavation: stratigraphy and phasing of architectural elements, ceramic typology etc.[8]
- *There is opportunity to improve excavation processes* (and sample selection) to optimise the quality and quantity of data obtained.

Effective collection of material for radiocarbon dating is distinctly active rather than passive; this is the approach being taken at Tel Azekah. It means focusing efforts onsite to: a) retrieve datable material from key secure contexts as they are excavated; and b) fill gaps or resolve problems identified by previous sets of radiocarbon data. Clearly the latter will only be operative following the initial series of dates presented in this thesis. Significant progress in regards to (a) was made during the 2015 season: as the designated radiocarbon researcher, the author was alerted to contexts with high priority for dating, as they were being excavated. To improve the overall quality and quantity of samples obtained from the excavation, we aim to progressively integrate into the excavation new tools/techniques for collecting material and assessing contexts.

[8] Though care needs to be taken to first evaluate each piece of evidence independently.

In line with current trends towards tighter archaeological-scientific collaboration, the intent at Tel Azekah is to have a designated radiocarbon researcher for the site who is actively involved together with the excavation team in all stages: sample collection onsite, selection of material for dating, laboratory processing, Bayesian modelling and analysis. The researcher should have a background and interest in both the archaeological and scientific aspects. This approach assists in bridging the disciplinary gap more effectively.

As the excavation seasons progress, along with detailed analysis of stratigraphy, ceramic typology and radiocarbon dates, an independent absolute chronology for the site will develop. Comparisons to material culture (and radiocarbon data) from other sites will play an important role along the way, but this no longer needs to play a *primary* role for establishing absolute chronology as per the traditional approach.

1.5.2 The Initial Stage

The goals of this first stage of radiocarbon dating are essentially twofold:

1. *To date and analyse fifteen samples* (seeds), selected from material collected during the first three seasons of excavation. Dating was undertaken in June-August 2015 at the ANSTO (Australian National Science and Technology), with the support of a postgraduate research grant provided by AINSE (Australian Institute of Nuclear Science and Engineering). The author personally carried out pre-treatment of samples in the ANSTO laboratory. Bayesian analysis of the data was carried out in consultation with ANSTO radiocarbon specialists and the excavation directors/staff of the Azekah expedition.
2. *To explore strategies to more effectively utilise radiocarbon dating in the excavation going forward.* As the radiocarbon researcher for the excavation I was given a specific field role in the 2015 excavation season (July-August). As I had not previously excavated at Tel Azekah, this season was important for: a) gaining familiarity with the site; and b) developing my understanding of the archaeological contexts for the dated samples. For samples collected during the 2015 season (to be dated in the next phases) I have the advantage of first-hand familiarity with contexts.

Fifteen radiocarbon dates is a modest amount of data but sufficient to begin shedding light on several periods and areas of the site. Whilst only an initial step towards a radiocarbon-based chronology, this series of dates was anticipated to support some basic comparisons beyond Tel Azekah, to published radiocarbon data from other sites in the region. Most importantly this work is intended to form a springboard for ongoing research.

1.6. Roadmap

The following chapter provides theoretical and historical background to radiocarbon dating; the use of the technique in historical archaeology in the Southern Levant is traced and current challenges in its application are highlighted. Whilst the discussion focuses on the Southern Levant, most aspects are also relevant to the wider Near East. Chapter 3 gives a background to Tel Azekah, its history and archaeological exploration.

Concepts regarding strategies for sample collection and selection at Tel Azekah are treated in Chapter 4, which goes on to present the contexts of each of the 15 samples dated. Chapter 5 describes the dating process from a laboratory perspective. Chapter 6 presents calibrated radiocarbon results where the samples are treated independently; Chapter 7 seeks to improve precision by combining the measurements with stratigraphic information using Bayesian modelling. Comparisons with radiocarbon data from other sites are made in Chapter 8.

Chapter 2 The Radiocarbon Approach to Southern Levantine Chronology in Historical Periods

2.1. Radiocarbon Dating Principles

Radiocarbon is the naturally occurring radioactive isotope of carbon – ^{14}C ("Carbon-14"). The basic processes whereby it is produced, distributed and eventually decays are illustrated in Figure 2. Radiocarbon is produced in the upper atmosphere as a consequence of high-energy cosmic rays interacting with gas molecules. This interaction produces free neutrons, which subsequently interact with ^{14}N (the most abundant stable isotope of Nitrogen) to produce ^{14}C. The radiocarbon rapidly oxidises to form carbon monoxide (CO) and then carbon dioxide (CO_2). Via the carbon cycle, radiocarbon is dispersed through the

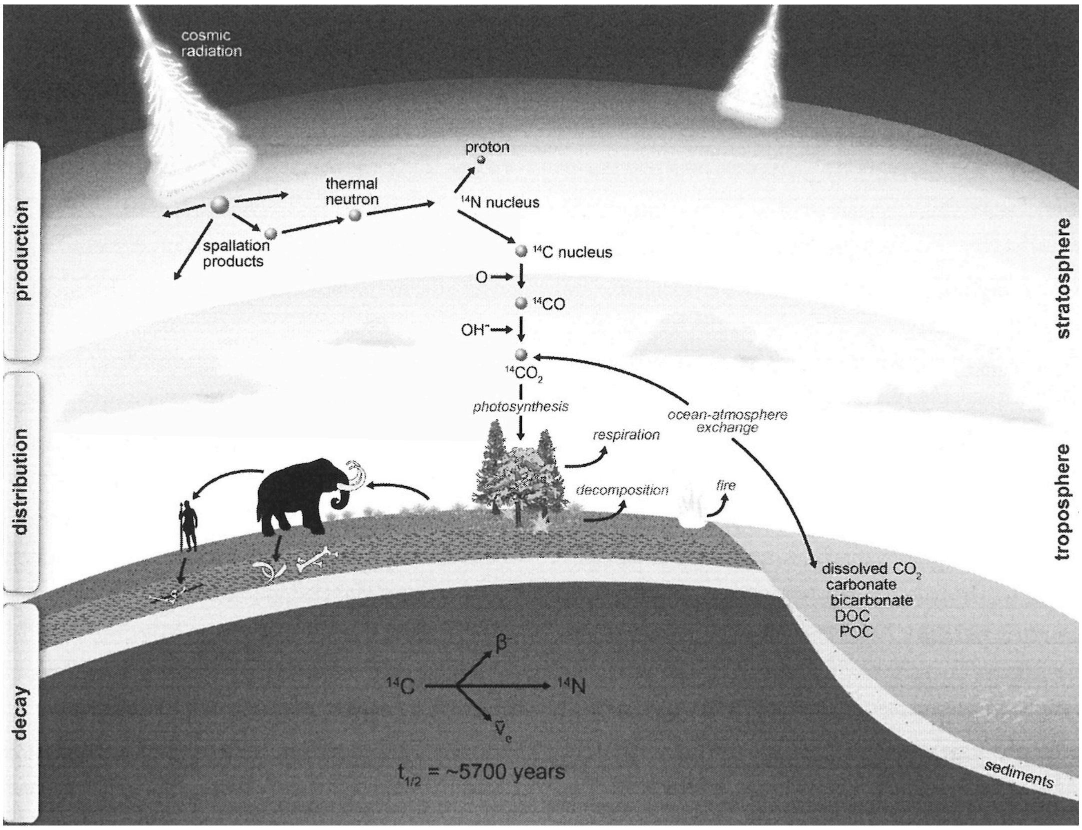

Figure 2 Radiocarbon production, distribution and decay (Taylor and Bar-Yosef 2014: 22).

environment, together with the more abundant stable isotopes ^{12}C and ^{13}C. As a first approximation the amount of ^{14}C in the atmosphere can be considered constant, with a balance between production and decay. Since living organisms are constantly exchanging carbon with the atmosphere via photosynthesis and respiration, they also maintain an equilibrium between the carbon isotopes. After death (or when parts of plants such as seeds or tree-rings stop growing), the exchange ceases and the ^{14}C content in the organic material decreases. The radiocarbon returns to nitrogen (^{14}N) by negative beta decay, whereby a neutron is converted to a proton with the release of an electron ("beta-minus particle", β^-) and an antineutrino ($\bar{\nu}_e$). While individual decay events occur randomly, the overall process is very predictable, with the quantity of ^{14}C halving every 5730 years (i.e. the "half-life", $t_{1/2}$). The decay process can be represented by an exponential equation:

$$A = A_0 e^{-\lambda t}$$

where A is the radiocarbon concentration ($^{14}C/^{12}C$) or activity measured at time t; A_0 denotes the original concentration or activity at the time the organism ceased its exchange with the atmosphere; and λ is the decay constant. λ is related to the half-life by $t_{1/2} = \ln(2)/\lambda$ and to the mean-life of a ^{14}C nucleus by $T = 1/\lambda$. Hence rearranging for t:

$$t\ (years) = T\ ln\ (A_0/A)$$

The above equation represents a theoretical model for radiocarbon age determination, and it is used to derive *conventional* radiocarbon ages.[9] A number of important limitations and assumptions need to be highlighted:

- While A is obtained directly from the sample to be dated, the true A_0 clearly cannot be measured directly and must instead be inferred from measurements on modern organic materials. This invokes the assumption that living organics (and the atmosphere) have had the same ^{14}C concentration through time. In reality there have been fluctuations in atmospheric ^{14}C concentration, raising the need for calibration (see below).
- By convention, a hypothetical constant ^{14}C concentration for living organics is defined using oxalic acid standards. This concentration is defined to reflect 1950, which is taken as the 'zero' year, rather than the year of measurement. Obviously A_0 and A are measured on the standard and sample now, not in 1950; but since both decay at the same rate, the ratio A_0/A will give the same result independent of measurement date (see Stuiver and Polach 1977: 356).
- Conventional radiocarbon ages are reported in years BP: the abbreviation is understood as 'Before Present'.[10]
- Both A and A_0 need to be corrected for fractionation effects. Fractionation refers

[9] For a more detailed understanding of conventional radiocarbon age calculations, the reader may wish to consult Taylor and Bar-Yosef (2014: 121-127), and the guide by Stenström et al. (2011). The standard publication is Stuiver & Polach (1977).

[10] Strictly speaking, BP was redefined as 'Before Physics' since it is relative to a fixed year (1950) (Flint and Deevey 1962; Taylor and Bar-Yosef 2014).

to the selective assimilation of lighter carbon isotopes that occurs to varying degrees in different organic materials. (A and A_0 are invariably measured on different materials.) By convention A and A_0 are normalised relative to a standard material (Peedee belemnite – PDB) before calculating the radiocarbon age (Stuiver and Polach 1977; Craig 1957).

- Conventional radiocarbon ages assume that ^{14}C mixes completely and rapidly throughout the environment. No effects due to region or reservoir (marine/land) are recognised.
- By convention the "Libby" half-life of radiocarbon is used (measured in the early days of the technique's development). This maintains consistency, even though the half-life is now more accurately known. Thus $t_{1/2}$ is taken as 5568 years (T = 8033). Conventions such as this do not cause problems since the dates have to be calibrated in any case (which effectively incorporates the correct $t_{1/2}$value of 5730 years).
- Note that the ratio of A and A_0 can be obtained either by direct counting of ^{14}C using Accelerator Mass Spectrometry (AMS), or by detecting radiation from decay events. Prior to the introduction of AMS, decay counting was the only option.

The conventional radiocarbon ages reported by radiocarbon laboratories cannot be understood as historical calendar dates. They need to be calibrated to account for fluctuations in atmospheric ^{14}C concentrations, as well as reservoir effects. Sometimes specific regional offsets also need to be applied. Calibration curves have been developed from independent dating methods. For our periods of interest, radiocarbon calibration data are based on measured ^{14}C concentrations in dendrochronologically-dated tree-ring series. The most recent curve for the northern hemisphere terrestrial carbon reservoir is IntCal13 (Reimer et al. 2013). This curve shows clear evidence of ^{14}C fluctuations: short-term "wiggles" and long-range changes are seen, mainly attributed to changes in cosmic ray influx (influenced by the solar wind and the earth's magnetic field). Drastic effects on ^{14}C concentration have occurred in recent times from human causes: fossil fuel use since the industrial revolution, and atomic bomb tests in the 20^{th} century (the latter requires separate calibration curves; Hua and Barbetti 2004; Hua et al. 2013).

To avoid confusion, only calibrated dates (which can be considered 'real' calendar dates) are reported as years BCE or CE. An example of a single date calibration is illustrated in Figure 3.

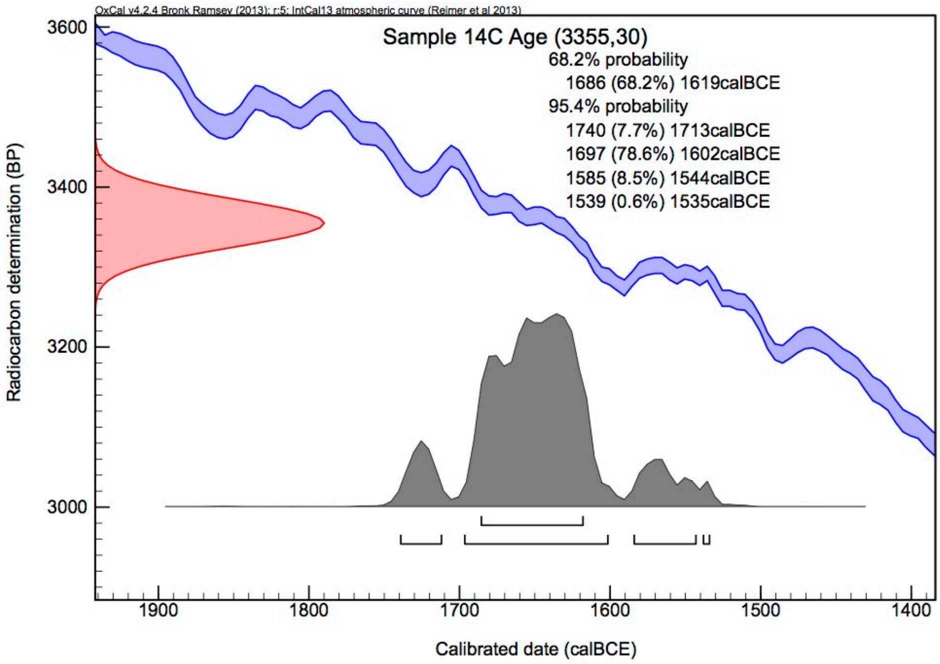

Figure 3 Calibration of a radiocarbon date (sample OZS876 from this thesis). The red curve on the y-axis is a conventional radiocarbon determination, shown as a normal probability distribution to account for measurement errors. The calibration curve with associated error bands is shown in blue. When the conventional date is mapped against the calibration curve, the resulting calibrated date – now a much more uneven probability distribution – appears in black on the x-axis. 1σ and 2σ age ranges are indicated, representing 68.2% and 95.4% confidence levels, respectively.

2.2. A Brief History of Radiocarbon Dating

Radiocarbon dating was developed by Willard Libby (1908-1980) in the late 1940s, for which he was awarded the 1960 Nobel Prize in Chemistry. The potential value of the technique was quickly recognized, and by the end of the 1950s at least 20 laboratories were in operation worldwide. The initial technology progressed quickly from solid carbon measurement to gas proportional and liquid scintillation counters (all methods that work by detecting decay events). By the 1980s measurement uncertainties were regularly less than 50 years.

In the 1950s and 60s, calendar dates had been calculated simply using the decay relationship and half-life of radiocarbon. In the late 1960s, fluctuations in atmospheric ^{14}C generation were recognized and consequently the need for calibration. The first major calibration plot, obtained by measuring radiocarbon in tree rings, was published in 1967 (Suess). Throughout the following decades, much effort has been directed at developing and improving calibration curves. Beginning in 1986, high-precision calibration curves were developed, with regular improvements to the present day.[11]

[11] Stuiver and Kra (1986); Stuiver et al. (1993; 1998); Reimer et al. (2004; 2009; 2013); McCormac et al.

Decay counting techniques require large sample sizes (several *grams* of extracted carbon). Direct measurement of ^{14}C concentration using Accelerator Mass Spectrometry (AMS) – a technique developed in the late 1970s – was a major step forward. With a sensitivity three orders of magnitude higher, measurements could now be regularly performed on *milligram* samples. Crucially this allowed the focus of archaeological measurements to move from longer-lived charcoal and wood, to short-lived seeds (see Taylor and Bar-Yosef 2014: 111-112). By 1986 ten AMS laboratories had been established, and today there are over 50. Decay counting techniques continue to be used in many places (largely due to lower cost). In total some 130 radiocarbon laboratories are in operation worldwide.[12]

2.3. Bayesian Analysis of Radiocarbon Dates

Since the early 1990s Bayesian analysis has become an important tool in radiocarbon dating (Buck et al. 1991; Buck et al. 1992; see overview in Bronk Ramsey 2009). This is because it provides a framework for combining radiocarbon measurements with prior information, such as the stratigraphical ordering of a series of dates, or known boundary conditions. Bayes' theorem can be expressed as:

$$p(\boldsymbol{t}|\boldsymbol{m}) \propto p(\boldsymbol{m}|\boldsymbol{t})p(\boldsymbol{t})$$

In our application, $\mathbf{t}$ is the unknown date, and $\mathbf{m}$ the radiocarbon measurement. $p(\mathbf{t})$ represents any prior belief about the date, and $p(\mathbf{m} \,|\, \mathbf{t})$ should be understood as the likelihood of obtaining a measurement $\mathbf{m}$ for a given calendar date $\mathbf{t}$. This likelihood function is in practice the calibration equation, which statistically combines the normal probability distributions of the sample measurement and the calibration curve. When the equation is evaluated across all possible $\mathbf{t}$ values, the result is not a normal distribution, due to the irregular nature of the calibration curve (c.f. Figure 3).[13] From Bayes' theorem one can evaluate $p(\mathbf{t} \,|\, \mathbf{m})$, known as the posterior probability distribution. Note that calibration of a single radiocarbon measurement without imposing any boundary conditions is the trivial case where the prior is a uniform distribution (i.e. all dates are considered equally likely).

(2004); Hogg et al. (2013).

[12] The journal Radiocarbon provides an annual list: http://www.radiocarbon.org/Info/lablist.html

[13] The irregular probability distribution of calibrated dates precludes the use of classical statistics, and hence led to the adoption of a Bayesian approach.

The strength of Bayesian analysis becomes apparent when multiple radiocarbon dates are considered together. Ordering and phasing of dates can be imposed within p(**t**). For example, to specify two dates as sequential ($\mathbf{t}_a < \mathbf{t}_b$), p(**t**) would become a Heaviside function and effectively eliminate portions of the calibrated ranges. p(**t**) can be constructed to reflect relationships between a large number of dates, forming complex chronological models.

Bayesian analysis can be used to combine diverse types of chronological information, and it could equally be applied to other scientific dating techniques. Current and potential applications of this tool within archaeology notably extend well beyond radiocarbon dating and chronology (Buck et al. 1996).

2.4. History of Radiocarbon Dating in the Southern Levant

Following the 'birth' of radiocarbon dating in 1949, the worldwide archaeological community was quick to utilise the method. It was applied most enthusiastically to prehistoric periods, for which no absolute dating method had previously been available. Kathleen Kenyon, among the first archaeologists to apply this dating tool in the Southern Levant, explains:

> "A chronology based on an ancient calendar… can take us no farther back than c. 3000 B.C. Until very recently, that was all that we had. Anything earlier was a sequence only and dates in years assigned to any phase were also only guesswork." (Kenyon 1979: 17)

Kathleen Kenyon's excavations at Jericho (1952-1958), which greatly developed understanding of early urbanisation, were carried out within the first decade of radiocarbon dating. Her attitude to the technique seems to have been very positive, despite its shortcomings at the time:

> "The method is not yet absolutely reliable, but a series of consistent results, including ones which can be checked against evidence from other sources, makes it probable that it can be of much use to archaeologists." (Kenyon 1960: 35)

The attitude of Kenyon and other Near Eastern archaeologists regarding the usefulness of radiocarbon dating for historical periods was radically different, however. From the third millennium BCE they had access to Egyptian and Mesopotamian historical chronologies. While the accuracy of these is not uniform, sub-century and decade resolution is often afforded. In contrast to these well-established and trusted chronologies, radiocarbon dating was a very new method in Kenyon's day. Its very validity had been tested using Egyptian historical data (Arnold and Libby 1949; Libby 1955); and despite general correlation, significant inconsistencies had not endeared the method to Egyptologists (e.g. Smith 1964; Edwards 1970). Notably, in the first several decades of radiocarbon dating the method suffered from severe limitations: measurements were accompanied by uncertainties of over a century and their accuracy was compromised by lack of calibration. The high cost of radiocarbon dating and the large sample sizes needed also served to discourage its use. It is little wonder that confidence in absolute dating by foreign synchronisms far outstripped radiocarbon dating in the 1950s and 1960s (e.g. Kenyon 1960: 35).

The view that radiocarbon is of little use for building or refining the chronologies of historical periods, persisted well beyond the early days of radiocarbon dating. This is clear from a perusal of major textbooks on Southern Levantine archaeology.[14] The opinion expressed is remarkably uniform: radiocarbon dating is essential prior to ca. 3000 BCE and of little use thereafter. This is despite marked improvements in the radiocarbon dating method over the same timeframe (see Section 2.2). Hence an element of inertia – a preference for familiar methods – is evident in the archaeological discipline, and it played a role in delaying the widespread application of radiocarbon dating to historical contexts.

An interesting snapshot of the application of radiocarbon dating in the Southern Levant is provided by Weinstein (1984). Among his collation of dates, the second millennium onwards was poorly represented (refer Table 2). Notably for the periods when Levantine chronology is most closely tied to Egypt – the Middle and Late Bronze Ages – there was a distinct minimum in the number of dates. The Iron Age was better represented in terms of quantity of dates, but they derived predominantly from just two places – Tell es-Sa’idiyeh

Table 2 Quantities of radiocarbon dates by period for the Southern Levant, as of 1984 (Weinstein).

Period	**No. Samples**
Palaeolithic	133
Neolithic	93
Early Bronze Age	96
Middle Bronze Age	12
Late Bronze Age	6
Iron Age	~40
Persian to Modern	~50

[14] Kenyon (1965; 1970; 1979); Aharoni (1982); Mazar (1990); Ben-Tor (1992)

in the Jordan Valley, and the copper mining sites of Timna. The Persian period through to the modern era was also poorly represented. Interestingly, the number of published dates for the Early Bronze Age was comparable with earlier prehistoric periods. This is because foreign synchronisms with Egypt are sparse during much of the third millennium BCE, and Egyptian chronology itself is less secure. In Weinstein's view:

> "Radiocarbon dating provides the *principal* chronometric data for …[prehistoric] periods in the southern Levant. It is a *secondary* source of dating evidence for the Early Bronze age, when archaeological correlations with Syria and especially Egypt become available. For the Middle and Late Bronze age, Iron age, Persian, Hellenistic, Roman and Byzantine periods, ^{14}C dating has only *limited value* because the technique is less precise than the normally available archaeologic and historic materials." (Weinstein 1984: 297, emphasis mine)

Whilst radiocarbon dating at historical period sites – especially multi-layered 'tels' – was very limited until the 1990s, a number of excavations showed considerable initiative in applying it. An example is the excavation by David Ussishkin of Tel Aviv University at Lachish (1973-1994), notably just 17 km from Azekah. A total of 52 samples were dated from contexts attributed by traditional dating to the timespan 1550 – 586 BCE. In a comparable way to more recent multi-period dating efforts at Megiddo (e.g. Toffolo et al. 2014: 224-225) and now at Azekah, this suite of dates was justified on the basis of: "the importance of the site, its established stratigraphical sequence, the fact that several strata were destroyed by fire and some can be historically dated, and the fact that the dated samples originate in different periods and many strata" (Carmi and Ussishkin 2004: 2508). Whilst the radiocarbon dates had limited impact on overall chronology and interpretation of the site, and mainly served for comparison, a positive approach to radiocarbon dating was expressed: "It is of much interest to compare the ^{14}C dates to the historical dates. In some cases they also assist in understanding the archaeological data" (Carmi and Ussishkin 2004: 2511).

Following the release of the first high-precision calibration curves (Stuiver and Kra 1986), a call was made for wider application of radiocarbon dating to historical periods (Bruins and Mook 1989). These authors noted key weaknesses in the traditional chronological approach and highlighted the value of radiocarbon dating as an independent absolute dating method. The same view was expressed by Hassan and Robinson (1987), as they set out to apply radiocarbon to Egyptian chronology:

> "Radiocarbon dating began in archaeology with ancient Egypt, for it was to the securely dated materials from Egypt that Willard Libby naturally turned when his new radiocarbon method needed verification from reliable historical sources. *With this paper the reverse process begins: verifying and correcting the conventional chronology for Egypt and neighbouring regions by calibrated radiocarbon."* (Hassan and Robinson 1987: 119, emphasis mine)

During the 1990s the use of radiocarbon dating at Southern Levantine sites increased. However, the real turning point in the role of radiocarbon for historical periods came in the late 1990s and early 2000s. The catalyst was the debate over Iron Age chronology that began in the mid-1990s. Up until 2000 this debate hinged on standard archaeological and historical arguments.[15] Nevertheless the potential of radiocarbon to assist in the debate was recognised (e.g. Mazar 1997) and several excavations began actively seeking organic samples from Iron Age contexts – especially at Beth Shean, Tel Rehov and Tel Dor. Application of radiocarbon to this sub-century debate was encouraged by two important developments: 1) the introduction of Bayesian statistics for modelling series of dates (Levy and Higham 2005: 9; Bronk Ramsey 2005); and 2) the proliferation of the AMS measurement technique. The application of Bayesian statistics to analyse sets of dates from well-stratified sites markedly improved the precision of chronological information that could be obtained. AMS enabled measurements on individual short-lived seeds (Taylor and Bar-Yosef 2014: 111-112); since seeds are regularly obtained from excavations in the Southern Levant, this meant radiocarbon analysis could be conducted utilising little if any long-lived material (wood, charcoal), which may have the 'old wood' problem.[16]

In the early 2000s radiocarbon took centre-stage as series of dates and Bayesian models were published in quick succession. These came initially from Dor (Gilboa and Sharon 2001) and Beth Shean / Tel Rehov (Mazar and Carmi 2001; Bruins et al. 2003; Mazar et al. 2005), but quickly expanded to other sites. One major project dated samples from over 20 sites (Boaretto et al. 2005; Sharon et al. 2007). A particularly high-resolution series of dates was obtained from Megiddo (Gilboa et al. 2013; Toffolo et al. 2014) as part of the project 'Reconstructing Ancient Israel – The Exact and Life Sciences Perspective'. Other important radiocarbon series for the Iron Age have been obtained from sites such as Tel

[15] Finkelstein (1995; 1996a); Mazar (1997); Ben-Tor and Ben-Ami (1998); Ben-Tor (2000). Refer to Table 1.

[16] Compare the proportion of seed vs. charcoal samples utilised in projects of the past decade (e.g. Sharon et al. 2007; Toffolo et al. 2014) with earlier ones that relied on decay counting (e.g. Weinstein 1984; Gilboa and Sharon 2003: 59; Carmi and Ussishkin 2004).

Dan (Bruins et al. 2005), Khirbet Qeiyafa,[17] Kuntillet Ajrud (Meshel et al. 1995; Carmi and Segal 2012), Kadesh Barnea (Carmi and Segal 2007; Gilboa et al. 2009) and Atar Haroa (Boaretto et al. 2010). On the east side of the Jordan Valley, Tell Abu al-Kharaz and Pella deserve mention (Wild and Fischer 2013: 457-463). Very extensive radiocarbon dating work was done in the Faynan copper mining region (Higham et al. 2005; Levy et al. 2004; 2005; 2010), and new dating efforts have been undertaken at the Timna mines (Ben-Yosef et al. 2012). While much radiocarbon dating for the Iron Age has emphasised the Iron I / Iron IIA transition, other recent work has focussed on the Late Bronze / Iron I transition e.g. at Qubur el-Walaydah (Asscher et al. 2015b) and Tel es-Safi (Toffolo et al. 2012; Asscher et al. 2015a). The Iron Age debate has major implications for the entire eastern Mediterranean due to chronological ties with the Southern Levant, and hence research has also turned in this direction (van der Plicht et al. 2009; Fantalkin et al. 2011; 2015; Toffolo et al. 2013).

The Iron Age debate continues today. Whilst a consensus has not yet been reached and many challenges remain (see for example, Lee et al. 2013: 731-732; Boaretto 2015: 208), the research and discourse of the past two decades has firmly established radiocarbon dating as a valuable chronological tool for historical periods, and demonstrated its ability to contribute to sub-century discussions.

It is fair to say the past two decades have seen an explosion of radiocarbon studies in the Southern Levant. This extends beyond the Iron Age to other historical periods. A great deal of work has been done in recent years on the Early Bronze Age (Regev et al. 2012a; 2012b; Shai et al. 2014), for which dates from more than 50 sites are available. Since the 1990s work has been underway to obtain radiocarbon dates for the early part of the Middle Bronze Age (Marcus 2003; 2013). The later part of the Middle Bronze through to the early Late Bronze has also received some attention – for example at Tel el-Ajjul (Fischer 2009) and Tel Abu al-Kharaz (Fischer 2006). An excellent high-resolution radiocarbon series for the Late Bronze Age has been published from Megiddo (Toffolo et al. 2014), and a Middle Bronze Age series is anticipated in coming years.

Whilst this discussion has focused on developments in Southern Levantine archaeology, it is important to emphasise that similar trends have been underway in neighbouring areas. Here it will suffice to mention several major radiocarbon dating projects. Since the 1990s, radiocarbon has played a crucial role in the debate surrounding the Santorini eruption (see

[17] Garfinkel and Ganor (2009); Garfinkel and Streit (2014); and Garfinkel et al. (2012); (2015).

Heinemeier et al. 2009; Höflmayer 2012; Manning et al. 2014 and further literature). It also featured in recent efforts to synchronise the chronologies of Near Eastern lands in the second millennium BCE (Bietak 2000; 2003; 2007). Equally, radiocarbon is a vital part of efforts to synchronise chronology for the third millennium BCE (the ARCANE project).[18] Turning to Egypt, several efforts have been made to refine Egyptian chronology using radiocarbon dating (e.g. Hassan and Robinson 1987; Haas et al. 1987; Bonani et al. 2001). Most recently a radiocarbon-based chronology was developed for the Early Dynastic period through to the New Kingdom (Bronk Ramsey et al. 2010; Shortland and Bronk Ramsey 2013; Dee et al. 2013). Use of radiocarbon dating in the Northern Levant and Mesopotamia has been more limited, in large part due to regional conflicts.

To complete this discussion of radiocarbon-dating in the Southern Levant, sites with published radiocarbon dates for the Bronze and Iron Ages have been collated and are plotted in Figure 4 and Figure 5 (refer also to Table 10). Application of radiocarbon dating to the Persian and Hellenistic periods has been very sporadic; therefore it was decided not to include them here. Note the collated data includes material processed recently and in the early days of the technique, so the quality is mixed. For clarity the most southern desert sites are not shown on the maps. Transjordanian sites that lie along the edge of the Jordan Valley are included, but not inland sites. The maps readily show that the Middle and Late Bronze Ages remain under-represented. By comparison the Early Bronze is relatively well-represented (as it was in 1984; Weinstein), driven by the paucity of early historical material and synchronisms. The Iron Age is now well-represented on account of the recent chronological debate.

[18] Refer to http://www.arcane.uni-tuebingen.de/

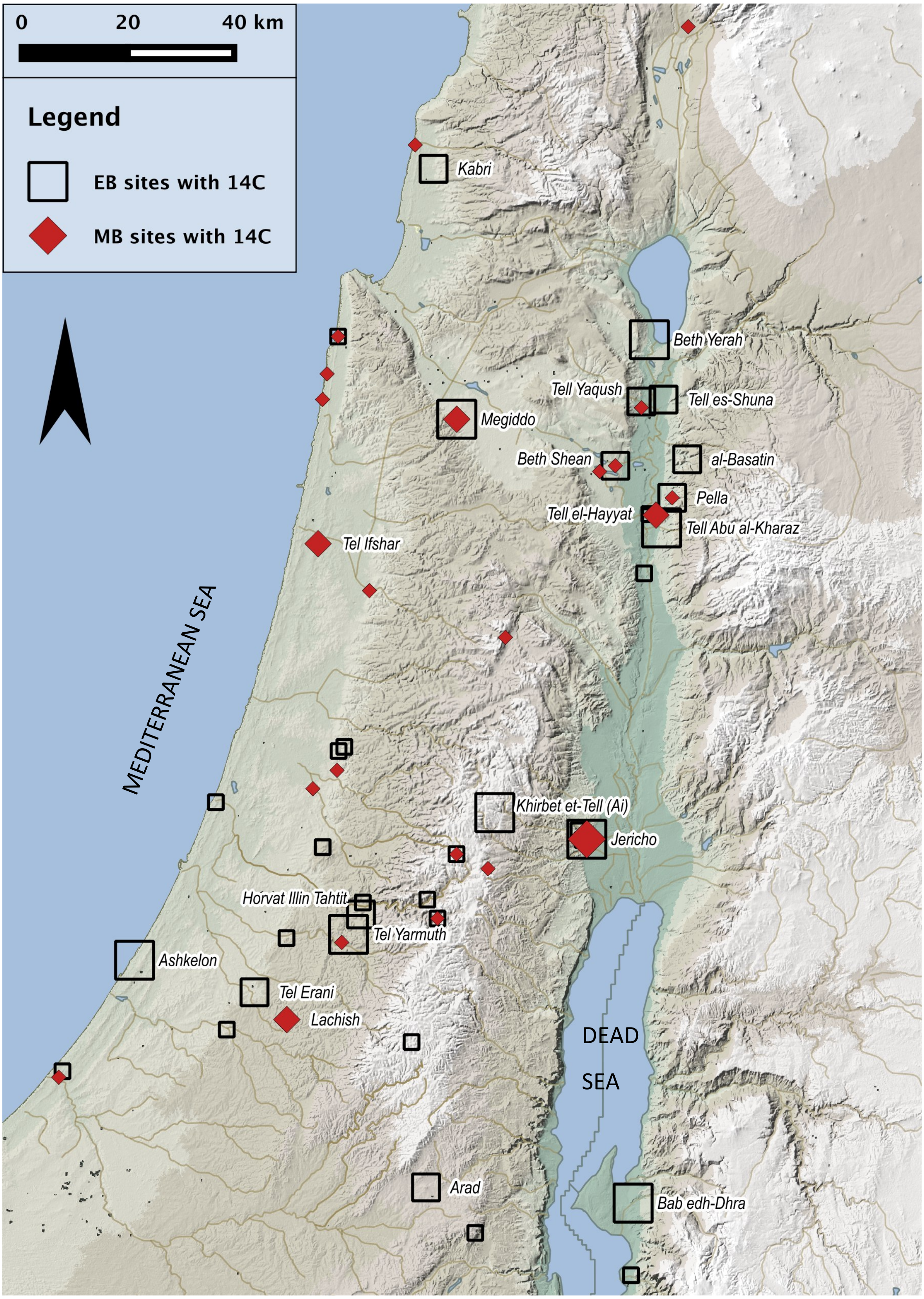

Figure 4 Sites in central-northern Israel and the Jordan Valley with published radiocarbon dates for the Early Bronze Age (squares) and Middle Bronze Age (diamonds). The size of the marker is indicative of the quantity of data. The names of sites with the most published data are labelled.

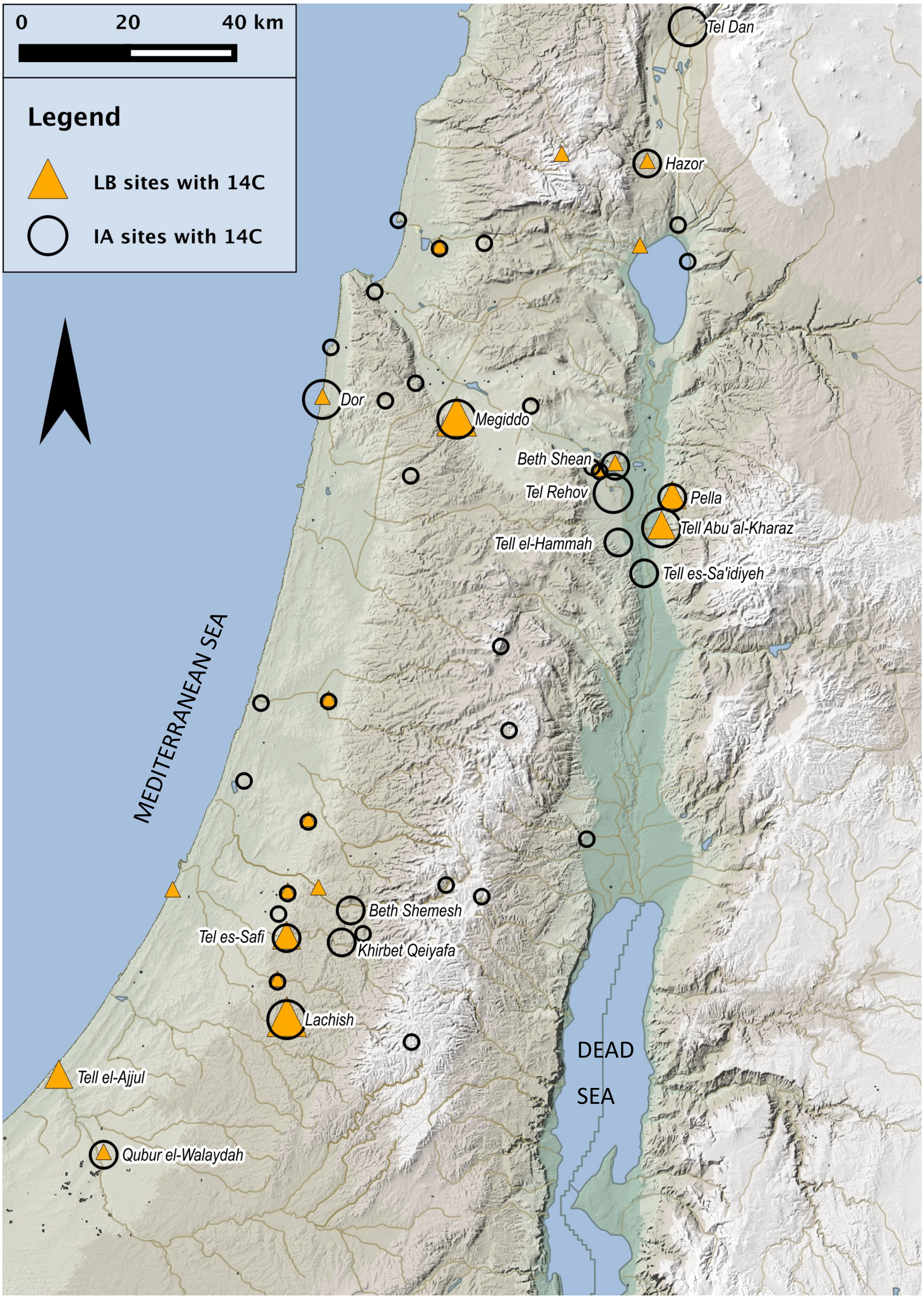

Figure 5 Sites in central-northern Israel and the Jordan Valley with published radiocarbon dates for the Late Bronze Age (triangles) and Iron Age (circles). The size of the marker is indicative of the quantity of data. The names of sites with the most published data are labelled.

2.5. Current Challenges and Directions

As we have seen, radiocarbon dating has rapidly gained acceptance as a key chronological tool rather than a peripheral one for historical periods in the Southern Levant. There remain, however, many challenges: some relate to technical limitations in radiocarbon dating and analysis, but most concern applied aspects.

Published radiocarbon data suffers from large variations in both quality and quantity. As we have noted, certain periods are much better represented than others. While quantity of radiocarbon data from a given excavation will obviously be affected by preservation levels and funding limitations, more influential is the value placed on radiocarbon dating by excavators, together with their interests and prevailing chronological debates.

A major factor affecting the quality of published data is that the dates derive from excavations of varying quality over the past 60 years or more. Generally, earlier excavations had less control over stratigraphy and poorer documentation. This can be exacerbated when materials from storage or museum collections are used, often associated with loss of contextual information and higher risks of contamination (e.g. Brock and Dee 2013). Radiocarbon measurements made during the 1950s to 1970s suffer from poor measurement precision.

The non-uniformity with which radiocarbon dating has been (and continues to be) applied at excavations is a significant factor in both quantity and quality of available dates. Though collection of datable organic material has become a part of general practice, the level of effort focused around collection as well as dating and analysis, varies considerably. Confidence in radiocarbon still varies somewhat among archaeologists. While differing value estimates on any research tool are expected, lack of familiarity with scientific tools also plays a role. A current focus at many institutions is to improve the balance of archaeological training between arts and hard science components.

For radiocarbon dating to be an effective tool in the development of independent absolute chronologies (for sites as well as regions), the need for new series of good-quality dates from current excavations is widely recognised (van der Plicht and Bruins 2001; Toffolo et al. 2014: 221-222). To achieve this, radiocarbon dating needs to become a more integral part of excavations; this will ultimately be more effective than sporadic projects undertaken to resolve specific debates. More consistent and uniform application of radiocarbon across excavations should be sought, but this will clearly take time.

The vast majority of anomalous radiocarbon dates occur because of problematic associations between samples and the archaeological context for which a date is sought (Boaretto 2007; Bronk Ramsey 2008: 263; Taylor and Bar-Yosef 2014: 43). The use of AMS to measure individual seeds has made researchers increasingly alert to these problems (e.g. Toffolo et al. 2012). Consequently more effort is being focused on reducing the likelihood of inadvertently dating intrusive or redeposited material. Close scrutiny of 'macro' context is paramount, but innovative methods are also being introduced to characterise sample contexts at a 'micro' level (*ibid*).

Advances in radiocarbon dating to enable phytoliths, plaster and organic residues to be dated is highly desirable (Boaretto 2009: 277-278; 2015: 212-214). These are regularly found in secure contexts and have excellent potential for dating, yet technical difficulties currently hamper their use. Ongoing challenges for analysis include efforts to date periods that are affected by 'wiggles' or flat areas (e.g. the Hallstatt Plateau between 800 and 400 BCE); high-resolution dating with especially close attention to contexts is the best way to address this (Boaretto 2015). When trying to identify the extent of cultural periods, another area of concern is realistic construction of Bayesian models to account for the gradual nature of many transitions (Lee et al. 2013).

Chapter 3 Background to Tel Azekah

3.1. Site description

Tel Azekah / Tell Zakariya (map ref. 14400/12315[19]; elevation 400 m asl) is positioned on the northern end of a north-south hill range that subdivides the ‘high’ Shephelah to the east and the ‘low’ Shephelah to the west (Figure 6). Perched 127 m above the Valley of Elah (Nahal Ha-Elah or Wadi es-Sunt), which winds along the eastern and northern sides of the site, Tel Azekah dominates the local landscape. It guards a key junction between the valley and a north-south access route that leads to Beth Shemesh and Lachish.

Tel Azekah covers an area of 4.5 ha and is roughly triangular – its base at the southwest and narrowest tip inclined towards the northeast (Figure 7). The summit is flat except for a 6 m higher acropolis (0.6 ha) in the southeast corner. Artificial low terraces surround the southern and south-western slopes of the tell. The site is naturally defensible: it has three steep sides and is connected to the range by a saddle, which may have been artificially lowered in antiquity (Dagan 2011: 73). As the easiest approach, the main city gate would have been located here and enemies undoubtedly attacked from this direction.

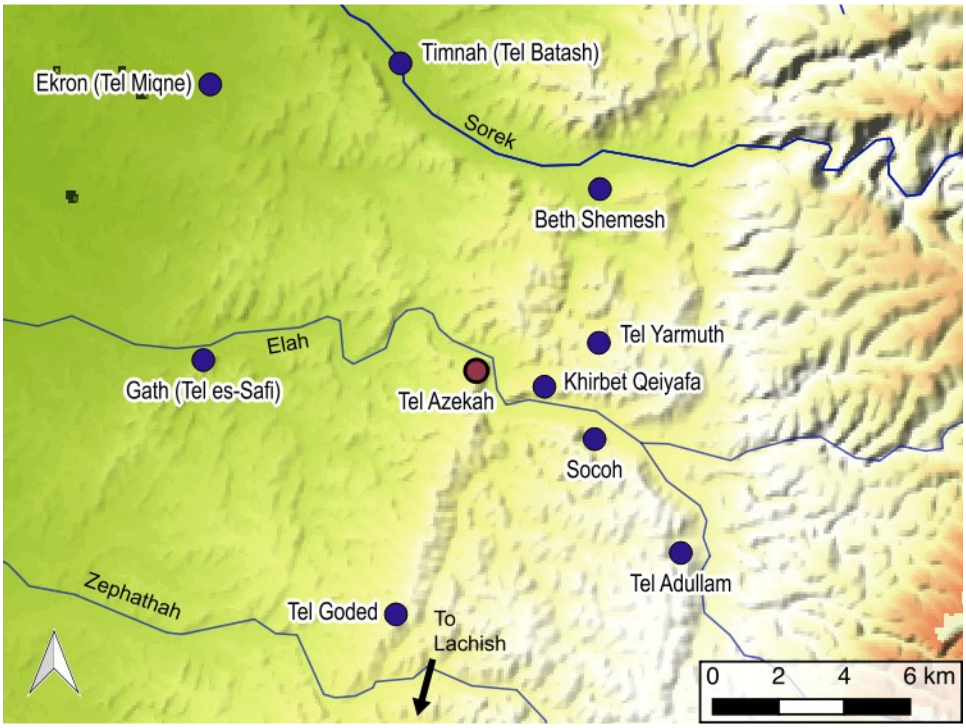

Figure 6 Location of Tel Azekah at a strategic point along the Elah Valley.

[19] I have used the Old Israeli Grid (OIG) system as commonly quoted in archaeological literature; the New Israeli Grid (NIG) coordinates are 19400/62315;

Figure 7 Aerial views of Tel Azekah: 1945 (Lipschits et al. 2012) and 2011 (Google Earth).

3.2. Azekah Before Textual Sources

Based on archaeological evidence we know that Azekah was a thriving city well before the Iron Age, when it first appears in textual sources. It was initially occupied in the Early Bronze Age, during the peak period of urbanisation in EB II-III. Limited activity during the Intermediate Bronze Age (or EB IV) is evident at Azekah (from archaeological survey), but the period is characterised across the Southern Levant by a return to nomadic pastoralism (Mazar 1990: 151). Azekah was occupied in the Middle Bronze Age, and fortified in the MB II-III; the phenomena of strongly fortified sites – both major centres and smaller settlements – is characteristic of MB II-III (Mazar 1990: 198-208; Burke 2010: 45-47).[20] Like many sites in the Southern Levant, Azekah seems to have been destroyed towards the end of the Middle Bronze Age. The destructions occurred not as a single wave, but seem to have been spread over a century or more (Bunimovitz 1992a; 1998: 322); the cause/s are not well established (as discussed in Section 8.1).

The peak period of occupation at Azekah occurred during the Late Bronze Age, when Egyptian involvement in the region became very strong (e.g. Weinstein 1981). No reference to Azekah has been identified within second-millennium sources; it does not appear in the Amarna letters, which include correspondence between the Egyptian pharaohs and Canaanite city-state rulers. The letters feature several cities near Azekah, however, notably Gath and Lachish (Moran 1992; Maeir 2012: 6). It is presumed that during this period Azekah was under the rule of its neighbours, most likely Gath

[20] See also Bunimovitz (1992b); Finkelstein (1992) and Burke (2008).

(Finkelstein 1996b). Azekah was destroyed at the end of the Late Bronze Age (LB III) (refer to Metzer 2015); this event is likely connected with the major upheaval seen across the Mediterranean at this time (refer to Langgut et al. 2013; Cline 2014 and further literature).

3.3. Azekah in Textually-Supported Periods

During the Iron Age, Azekah appears in both biblical and extra-biblical sources. These provide evidence for the site at least during Iron Age II, when archaeological evidence also supports a major period of occupation. The toponym appears in Joshua 10:10-11; 15:35 and 1 Samuel 17:1, all of which provide important geographic information, though the historical value of the episodes may be questioned. 2 Chronicles 11:9 reports that Rehoboam king of Judah fortified Azekah to protect the approaches to his highland-based kingdom. The combined picture of Azekah that emerges from these texts is a Judahite town on the border with the Philistines. The extent to which this reflects earlier phases of the Iron Age may be debated, but it was indeed the nature of the site by the 8th century BCE, as seen in the following Assyrian war account (British Museum no. 81-3-23, 131; Figure 8a):

> "(3) [.... Ashur, my lord, encourag]ed me and against the land of Ju[dah I marched. In] the course of my campaign, the tribute of the kings of Philistia? I received ....
>
> (4) [.... with the mig]ht of Ashur, my lord, the province of [Hezek]iah of Judah like [...
>
> (5) [....] the city of Azekah, his stronghold, which is between my [bo]rder and the land of Judah [....
>
> (6) [like the nest of the eagle?] located on a mountain ridge, like pointed iron daggers without number reaching high to heaven [....
>
> (7) [Its walls] were strong and rivaled the highest mountains, to the (mere) sight, as if from the sky [appears its head? ....
>
> (8) [by means of beaten (earth) ra]mps, mighty? battering rams brought near, the work of [...], with the attack by foot soldiers, [my] wa[rriors ....
>
> (9) [...] they had seen [the approach of my cav]alry and they had heard the roar of the mighty troops of the god Ashur and [their] he[arts] became afraid [....
>
> (10) [The city Azekah I besieged,] I captured, I carried off its spoil, I destroyed, I devastated, [I burned with fire ...."
>
> (translation by Na'aman 1974)

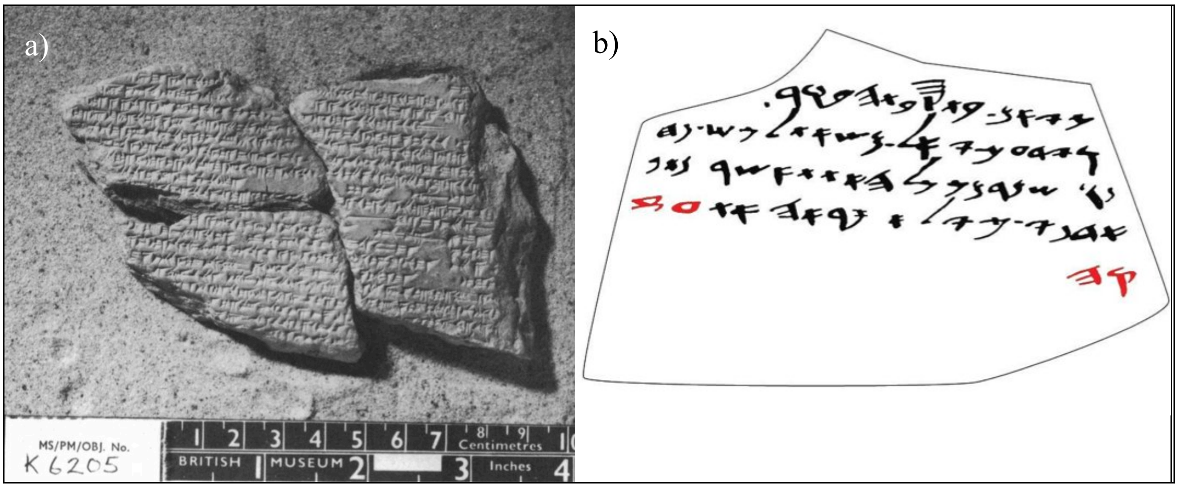

Figure 8 (a) "Azekah Inscription"; and (b) Lachish Letter no. 4. (Images from Na'aman 1974: 27 and Lipschits et al. 2012: 198).

The Assyrian record describes a natural attack route against highland Judah from the west, with Azekah being the first border town encountered after leaving Philistia. Though the Assyrian monarch is not named, the event should be connected with Sennacherib’s 701 BCE campaign against King Hezekiah of Judah (the latter name is reconstructed in the translation above).[21] It is noteworthy that the Assyrians considered a conquest of Azekah worth boasting about.[22] The natural defensibility of the site and how it towers over the local landscape indeed fit well with the Assyrian description.

Azekah was rebuilt after the Assyrian campaign, possibly during the rule of Manasseh or Josiah (Lipschits et al. 2012: 197). A second major attack against the city is then attested in historical records. Jeremiah 34:7 states that besides Jerusalem, Azekah and Lachish were the last two fortified cities left holding out against the Babylonians. Dated to this time is an ostracon mentioning both Azekah and Lachish, in a military context. The letter (Figure 8b) was found in the burned gate of Lachish amid the destruction of Nebuchadnezzar’s campaign. Its last lines read:

> “And let [my lord] know that we are watching for the signals of Lachish, according to all the indications that my lord has given, for we cannot see Azekah.” (translation from Lipschits et al. 2012: 198)[23]

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[21] Tadmor (1958: 80-81) attributed the inscription to Sargon II’s 712 BCE campaign, but Sennacherib’s campaign seems more likely given that the declared target is Judah (Na'aman 1974).

[22] This is true, despite the inclination of royal texts to exaggerate their victories.

[23] See also the *editio princeps* translation by Torczyner (1938)

The lack of a fire signal from Azekah suggests that the city had finally fallen (Torczyner 1938; Lemaire 2004; for another view see Begin 2002). Following the Babylonian exile, Nehemiah lists Azekah as one of the towns resettled by Judahite families in the Persian period: “Zanoah, Adullam and their villages, in Lachish and its fields, and in Azekah and its settlements (Nehemiah 11:30).

A village carrying the name Azekah seems to have existed through to the common era, as testified by Eusebius bishop of Caesarea (early 4th century) (Freeman-Grenville et al. 2003: 19). The Madaba Map (6th century CE) calls the same area Beit Zakariya (associated with the prophet Zachariah). This may be the same location given in 1 Maccabees 6 for a major battle in which Judas Maccabaeus was defeated (2nd century BCE), and would be consistent with the Hellenistic-era fortress and dwellings found on the tell. A village bearing the name Beit Zakariya – located on the other side of the valley – appears in the writings of various pilgrims and church writers[24]; it continued into modern times.

3.4. Site identification

Research in the modern era concerning Azekah and the identification of Tell Zakariya begins with the explorations of biblical scholar Edward Robinson and Reverend Eli Smith (Robinson 1856a: 16-17; Robinson 1856b: 283-284). They did not link the site with a biblical place (Robinson 1856a: 17), though they did identify it as the Beit Zakariya of 1 Maccabees 6 (Robinson 1856b: 283-284). The first person to connect the site with Azekah was the biblical geographer Rabbi Joseph Schwarz. His description reads:

> “Azekah עזקה. Three English miles east of the valley Saphia is the village Tell Ezakaria, which is probably the ancient Azekah, which was not far from Socho. (Com. 1 Sam. xvii. 1.)” (Schwarz 1850: 102)

Tell Zakariya was described in the Palestine Exploration Fund (PEF) survey of Conder and Kitchener, but no identification was offered (Conder and Kitchener 1880: map XVI; Conder and Kitchener 1883: 27). Bliss and Macalister, who excavated at the site half a century later, had difficulty identifying Tell Zakariya (e.g. Bliss 1899a: 25). After their excavations they proposed that it be identified with Socoh, suggesting that the name had later transferred to Khirbet Shuweikeh (located 6 km east-southeast of Tell Zakariya (Bliss and Macalister 1902: 66-67). Albright’s survey at Khirbet Shuweikeh contradicted this

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[24] For example, Sozomen in the 5th century CE (Hist. Eccl. 9.17) and Antoninus of Piacenza in the 6th century CE (Martyr 1887: 25).

view; on the basis of ceramics that he dated to the first temple period, it was argued that biblical Socoh should be associated only with Khirbet Shuweikeh. Albright accepted Tell Zakariya as biblical Azekah (Albright 1924: 9), an identification that has been upheld in scholarship to the present day.[25]

3.5. History of Archaeological Investigation at Tel Azekah

3.5.1 Early Investigation

The importance of Tell Zakariya as an archaeological site was initially recognised in the PEF Survey of Western Palestine. The first excavations were conducted in 1898-1899, under the direction of Frederick J. Bliss and R. A. Stewart Macalister.[26] The work, conducted over three seasons, focused on the following areas (refer Figure 9): 1) three separate towers on the south-western edge of tell; 2) a fortress dominating the acropolis; 3) the main plateau; and 4) rock cuttings and caves on the slopes. The south-western towers and the acropolis fortress were visible on the surface prior to excavation, attesting to the importance of the site and its strategic nature.

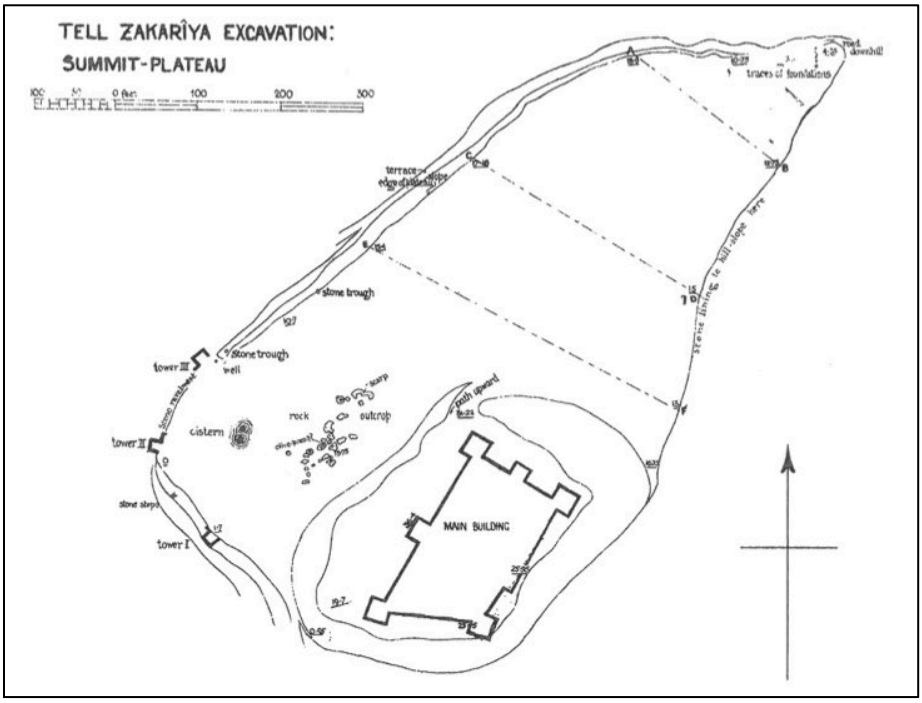

Figure 9 Plan of Tell Zakariya by Bliss and Macalister (1902 pl. 2)

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[25] Ahlström (1982: 19); Aharoni (1979: 214, 345, 353, 410, 431); Rainey (1983: 3, 7); Kallai (1986: 384); Stern (1993a); Negev and Gibson (2001: 64); Dagan (2011); Lipschits et al. (2012).

[26] Excavations were conducted as part of a regional study (the first in Israel-Palestine) which included three other Shephelah sites: Tell es-Safi, Tel Maresha and Tel Goded.

Trial pits were dug along three lines on the plateau (A-B, C-D and E-F), followed by several large “clearance” pits in the last season. Bliss and Macalister discerned two main strata on the plateau, which they referred to as “Jewish” and “pre-Israelite”. Five ceramic groups were identified (modern equivalent in brackets): “Archaic Ware” (EB II-III), “Phoenician Ware” (LB I-II), “Jewish Ware” (IA I-II), “Greek Ware” (Persian, Hellenistic) and “Roman Ware” (see Dagan 2011: 76-77). In all areas that Bliss and Macalister explored, they found clear evidence of multi-period occupation.

The foundations of the south-western towers were examined, and effort made to find connecting walls. Since the latter was unsuccessful, Bliss and Macalister concluded these structures were individual forts built to protect the town where it was most vulnerable. The ‘forts’ were dated to the Roman / Byzantine era, though it is difficult to ascertain how Bliss and Macalister reached this conclusion (Napchan-Lavon et al. 2015: 85). Dagan (2011: 77) suggested reassigning them to the Iron Age on the basis of dissimilar stonework. Nevertheless a Hellenistic date cannot be ruled out (Napchan-Lavon et al. 2015: 86).

Bliss and Macalister concentrated much effort on the acropolis fortress, tracing its walls and excavating half of the interior. The fortress plan (Figure 10) is an asymmetric quadrilateral shape – probably as an adaption to the topography. Unfortunately no clear connection with floor surfaces was made, largely due to the excavation methods (which included tunnelling). The fortress was dated to the Iron Age, predominantly on the basis of Azekah’s appearance in Rehoboam’s list of fortified cities (2 Chr. 11:5-12). Despite the lack of clear archaeological support, this dating was accepted by many scholars until recently (e.g. Negev and Gibson 2001; Stern 1993a). However Dagan (2011) re-examined Bliss and Macalister’s records and concluded that the fortress ought to be dated to the Hellenistic period. His basis was the appearance of some drafted and bossed stone in the walls, and a comparison of the layout with Hellenistic fortresses elsewhere. Hellenistic remains uncovered near to the fortress by current excavations seem to support this dating (see Section 3.6). Nevertheless, the possibility exists that a poorly-preserved Iron Age fortress existed in the same area (*ibid* : 83).[27] Reinvestigation of the fortress is an important subject for future work.

[27] As noted by Napchan-Lavon et al. (2015: 91), the majority of *lmlk* royal stamp impressions were found in this area.

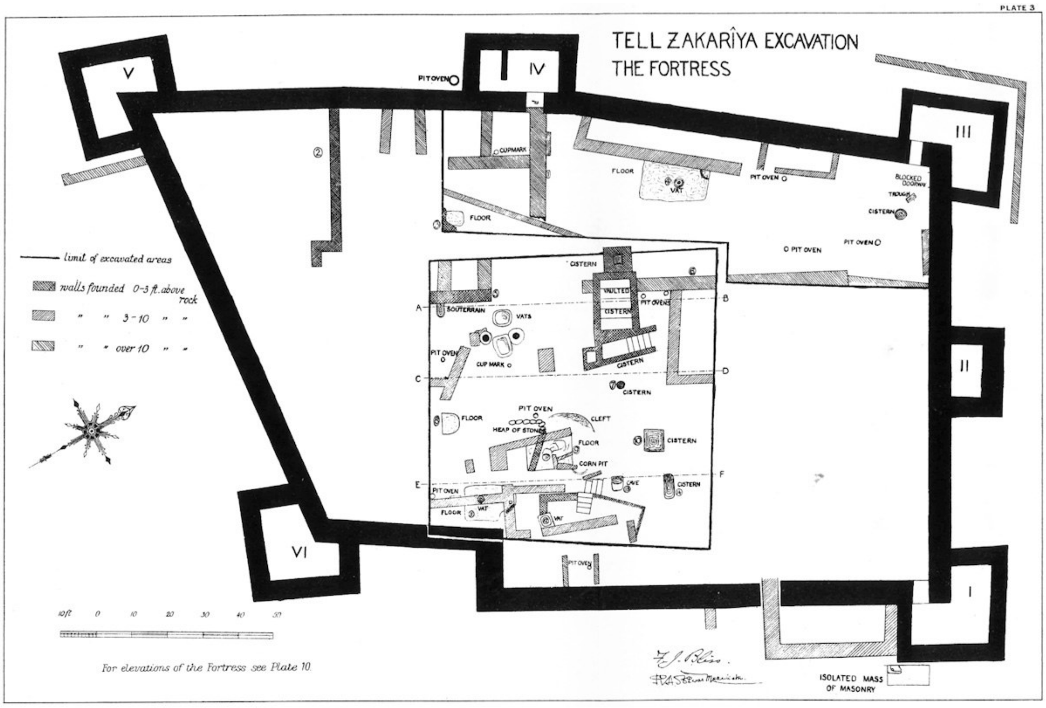

Figure 10 Plan of the acropolis fortress (Bliss and Macalister 1902 pl. 3)

Bliss produced four preliminary reports for Tell Zakariya (Bliss 1899a; 1899b; 1899c; 1900), and an overall report on the Shephelah project (Bliss and Macalister 1902). Whilst these records show important developments in archaeological methodology at the time, their usefulness to modern investigators has major limitations. Particular problems are coarsely defined stratigraphy and poor association with finds; some loss of documentation and materials has also occurred since the excavation. Napchan-Lavon studied unpublished materials including field diaries and finds lists; while these provide some clarification and assist our understanding of the site's occupation, "it is clear that no accurate historical picture of the settlement of Azekah can be ascertained from the unpublished materials" (Napchan-Lavon et al. 2015: 84).

Early work at Tel Azekah creates some challenges for modern excavators. Notably, the location of test pits and large "clearance" pits (80 x 60 feet) – which new excavations generally take great pains to avoid – are poorly defined in records. Their location is not evident on the surface today, since the fortress and all pits were backfilled (by agreement with the locals who cultivated the tell). New investigations of the fortress in the future will be challenging because much of it was excavated and the walls were largely disconnected from floor remains that could help to date the structure.

3.5.2 Recent Surveys

Tel Azekah was surveyed in the 1980s-90s as part of regional surveys in the Shephelah (see Dagan 2011 and further literature). Results of these surveys, together with consideration of Bliss and Macalister's excavations, led Dagan to conclude that Tel Azekah was occupied during the following periods: EB II-III, IB / EB IV, MB II-III, LB I-II, IA I-II, Persian, Hellenistic, Roman, Byzantine and Early Islamic. Occupation thus spans some three millennia.

An intensive surface survey of Tel Azekah was conducted prior to commencement of the current excavations (Emmanuilov 2012). This survey essentially confirmed the occupation periods above, noting also material from the Ottoman era. Crucially, it identified two settlement peaks: in the Late Bronze Age and Iron Age II. A major peak during the Late Bronze Age is amply supported by the many New Kingdom Egyptian objects obtained by Bliss and Macalister.

3.6. Current Excavations

No excavations were conducted at Tel Azekah for more than 100 years after Bliss and Macalister. The Lautenschläger Azekah Expedition, a consortium of universities led by Tel Aviv University, commenced excavations in 2012. The directors are Professor Oded Lipschits, Dr Yuval Gadot and Professor Manfred Oeming. Four seasons (conducted annually) are now complete, with plans for about fifteen more.

Ten areas are currently under excavation (see Figure 11). Note that area names designate directional position and T=Top. Areas W1, W2, W3, S1, N1, E1 and E3 are located on the edges of the tell; these are designed to expose stratigraphy and investigate the fortifications or boundary of the site. Wider exposure in flat areas was intended for T1 and T2 on the plateau, and S2 on the lower terrace. A brief list of key features in the various excavation areas is given in Table 3.

Excavations have largely confirmed Azekah's long occupational history, though much further investigation is needed to elucidate the changing plan and extent of the site. Three seasons of work have enabled a good understanding of site stratigraphy to be developed. A phasing chart, Table 4, shows the relationship between strata encountered in the various areas, together with their assignment within the relative chronology of the Southern Levant.

Figure 11 Topographical map of Tel Azekah showing excavation areas (prepared by Shatil Emmanuilov). The approximate location of the newest area (E3) is indicated.

Table 3 Key features of current excavation areas

Area	Key Features
S1	• Well-built Persian period building, with Iron Age architecture underneath (located in the highest part of the area) • Architectural complex of the Late Bronze Age on the slope • Evidence for a Middle Bronze Age destruction (also found in Area N1 during 2015) • Early Bronze remains (lower on the slope)
S2	• Late Bronze and Iron Age lower city, featuring public architecture, a paved plaza and a water reservoir • Deep cut in the bedrock. Its earliest use and date of creation are unclear, but major buildings were constructed within it during the Late Bronze Age.
W1, W2	• Bronze Age (Early through to Late), Iron Age and Persian remains • Solid mudbrick city wall from the later part of the Middle Bronze Age
W3	• Investigation of a large well-built tower • Remains of mudbrick fortification (same as in W1, W2)
T1	• Hellenistic and Iron Age remains
T2	• Mainly Iron Age and Late Bronze Age remains • LB III destruction only a short distance below the surface
N1	• Public structure with monumental stones and threshold >3m wide • Domestic complex of the Persian period • Middle Bronze walls and destruction layer identified on the slope in 2015
E1	• Hellenistic, Byzantine and Early Islamic remains; • Hasmonean village; numerous tabuns • Isolated massively-built Roman building • Rock-cut features • Iron Age remains reached in 2015.
E3	• Opened in 2015 to look for an Assyrian siege ramp (Sennacherib's 701 BCE campaign), as found at Lachish. • Middle Bronze, Late Bronze and Hellenistic contexts have been found on the slope, and the walls of a very large structure (date to be determined).

Table 4 Phasing table (subject to ongoing development; N1 phasing not yet available). Phases with evidence for destruction are marked in red. (Table by Yuval Gadot.)

Period	**Chronology (historical)**	**S1**	**S2**	**W1**	**W2**	**W3**	**T1**	**T2**	**E1**	**E3**
EB III	25^{th} c. BCE	S1-13 S1-12			W2-13 W2-12	W3-7				
MB I-II	18^{th} c. BCE	S1-11			W2-11 W2-10	W3-5/6				E3-5
MB II-III	17^{th}-16^{th} c. BCE		S2-9?		W2-9					
LB I	15^{th}-14^{th} c. BCE		?							
LB II	14^{th}-13^{th} c. BCE	S1-10 S1-9b S1-9a S1-8	S2-8 S2-7 S2-6 S2-5		W2-8			T2-3b		
LB III	12^{th} c. BCE	S1-7	S2-4		W2-7 (a-b)?	W3-4?		T2-3a		E3-4
Gap	Late 12-11^{th} c. BCE									
IA IIA	10^{th}-9^{th} c. BCE	S1-6 S1-5		W1-7 W1-6 W1-5	W2-6?		T1-6	T2-2b		E3-3
IA IIB	8^{th} c. BCE	S1-4b S1-4a	S2-3				T1-5	T2-2a		
IA IIC	7^{th} c. BCE	S1-3	S2-2	W1-4					E1-7	
Persian	6^{th}-5^{th} c. BCE		S2-1	W1-3c W1-3b W1-3a	W2-5		T1-4			
Per./ Hell.	4^{th} c. BCE	S1-2		W1-2 W1-1	W2-4		T1-3 T1-2	T2-1		
E. Hell.	3^{rd} - 2^{nd} c. BCE						T1-1			
L. Hell	2^{nd} - 1^{st} c. BCE								E1-6 E1-5 E1-4 (a-b)	E3-2
E. Rom	1^{st} c. CE								E1-3	
L. Rom	2^{nd} c. CE									
Byz	4^{th} - 5^{th} c. CE								E1-2	E3-1
E. Islam	6^{th} - 8^{th} c. CE								E1-1	

3.6.1 *Area S2 Stratigraphy*

It is necessary to describe in more detail the stratigraphy of Area S2, particularly the Late Bronze Age phases which are a major focus of the current stage of radiocarbon dating. Area S2 is located on the south-western side of the tell, on a low terrace that extends along the western and southern slopes (see Figure 7 and Figure 11). It was opened in order to investigate the existence of a lower city, suggested by plentiful Late Bronze and Iron Age pottery sherds in the archaeological survey and by the artificial appearance of the terrace (Lipschits et al. 2012: 204; see also Emmanuilov 2012). This was soon verified with evidence of public architecture during both the LB II and IA II periods. The area has been excavated for four seasons, working in 14 excavation squares.

The descriptions that follow should be read with reference to Table 5 and the plans in 0. Note that loci numbers are prefixed with 'L' and features (walls, floors, installations etc) with 'F'. In both cases this code is preceded by the year of excavation and the area name (labels in figures omit the latter).

Table 5 Current phasing for Area S2

Phase	Cultural Period	Description
S2-9	?	• Rock cut
S2-8	LB I? / LB IIA?	• Two walls (14/S2/F581, 15/S2/F594)
S2-7	LB IIA / LB IIB	• Single wall (13/S2/F559); floor (13/S2/F565); • Pit below floor (15/S2/F590), though this attribution is now uncertain
S2-6	LB IIB	• "Boulder Building"; floor 13/S2/F564 (paved portion 13/S2/F554)
S2-5	LB IIB	• "Pillared Building" (modification of the "Boulder" building); floor 13/S2/F556 (13/S2/F558 between bedrock and pillars)
S2-4	LBIII	• Public plaza (12/S2/F513) and warehouse (floor 12/S2/F507), silo (13/S2/F548) and water cistern (12/S2/F518; earlier origin possible but unclear)
S2-3	Iron Age IIB – 8th century BCE	• Ashlar structure (15/S2/F591) and steps (15/S2/F592) near cistern; other buildings • Reuse of the plaza (12/S2/F513) with added walls
S2-2	Iron Age IIC – 7th century BCE	• Ashlar structure (15/S2/F591-F592) out of use • Reuse of the plaza (12/S2/F513) • Massive fills added with mudbrick structure on top • Sealing of the water cistern (12/S2/F518)
S2-1	Persian	• Reuse of the cistern (12/S2/F518) for burial

The earliest feature in the area is a deep rock cut (phase S2-9; Figure 12 and Figure 34). The bottom of the cut has not yet been reached in excavations, and the date of carving and nature of original use remain unclear. Structures were erected within the cut during the Late Bronze Age. The earliest detected architectural phase, S2-8 (tentatively dated LB I/LB IIA; Figure 34), consists of two walls (14/S2/F594 and 15/S2/F581) plus fills below a pit (15/S2/F590); the walls do not form a coherent plan but both were sealed below the same floor (13/S2/F565). This floor was excavated in two squares (J6 and J7) during 2015; it is placed in phase S2-7 (LB IIA / LB IIB; Figure 13 and Figure 35), along with wall 13/S2/F559 which it abuts. Pit (15/S2/F590) was cut into the S2-8 fills and was initially attributed to S2-7 on the basis that it seemed to be built by the occupants of S2-7 immediately before laying floor 13/S2/F565. As will be discussed in this thesis, however, the phase attribution of pit 15/S2/F590 has come into question.

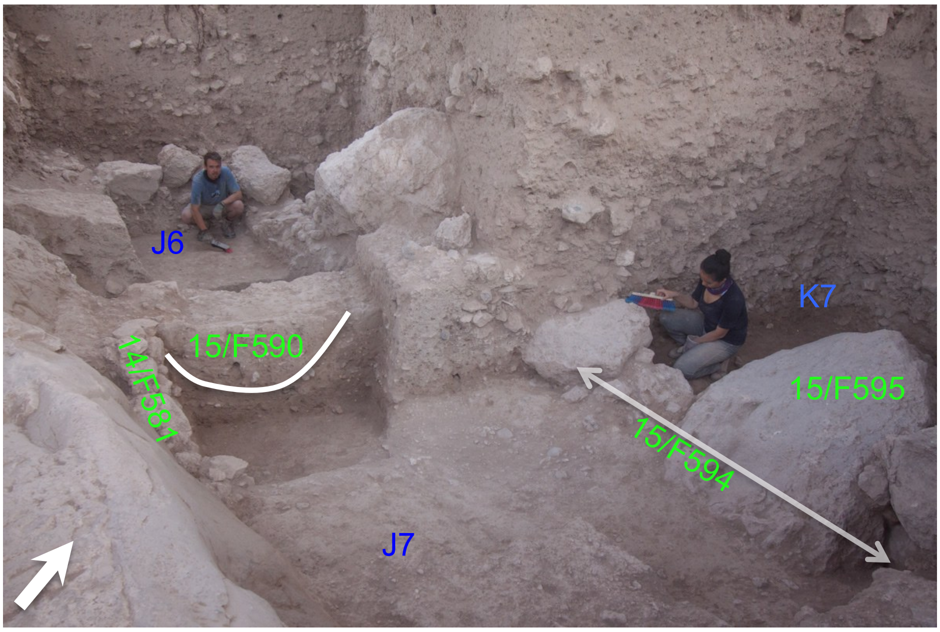

Figure 12 Rock-cut of Area S2 at the end of the 2015 season.

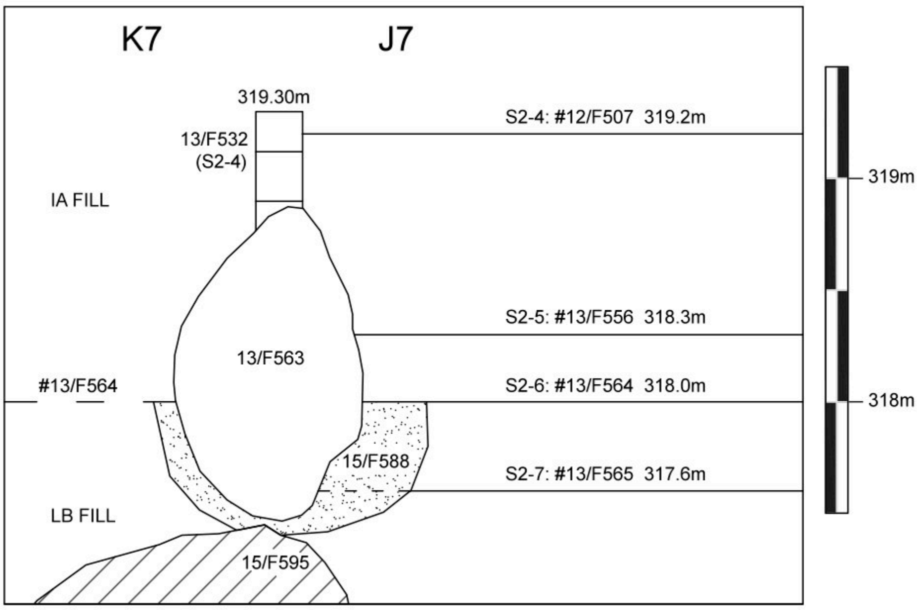

Figure 13 Floor levels of Late Bronze Age phases in Area S2

Two phases of a large public building were found above S2-7 (Figure 14). The building was clearly aligned with the side of the rock cut. In its first phase (S2-6; Figure 36) the structure is designated the “Boulder Building” because the major wall (13/S2/F563) was constructed with large boulders. The S2-6 floor (13/S2/F564) was found 0.35-0.40 m above the S2-7 floor (13/S2/F565) (Figure 13). The second phase (S2-5; Figure 37) is designated the “Pillar Building” since an extension was made by adding a row of pillars (13/S2/F555) on the very edge of the rock cut (13/S2/F557). A new floor (13/S2/F556) was built at a level 0.25-0.30 m above the old floor (and extended over a shelf in the bedrock as 13/S2/F558). The Pillar Building may have ended in destruction, though the evidence is equivocal.

In phase S2-4 (Figure 38) thick fills were laid over the Pillar Building remains, and a new structure was built above – a “warehouse” containing many typical Late Bronze Age "Canaanite" storage jars. The floor (12/S2/F507) was laid close to the top of the rock cut, approximately 1 m above the S2-5 floor. Contemporary with the warehouse were many other features in the area adjacent to the rock-cut, notably an open paved public plaza (12/S2/F513), large silo (13/S2/F548) and water cistern (F518; possibly in use earlier). Phase S2-4 was destroyed in a fierce conflagration and the area was abandoned until IA II.

Figure 14 Area S2 Late Bronze Age public building (phases S2-6 to S2-5), constructed within the rock-cut.

Two Iron Age phases have been identified in Area S2 – one attributed to IA IIB (S2-3) and the other to IA IIC (S2-2). These are described only briefly since the current stage of radiocarbon dating addresses the Late Bronze and Persian phases. Both Iron Age phases reused the plaza, with the addition of enclosure walls. A stepped entrance (15/S2/F591-F592) to the water system with ashlar blocks was built during S2-3; it cuts into earlier material and is contemporary with a floor and installation that lie above the S2-4 destruction. By the end of S2-2, the water system had gone out of use and the ashlar entrance was covered over. Iron Age construction activity significantly damaged Late Bronze Age strata in square K7 (no radiocarbon samples were taken from this square).

Area S2 was not occupied during the Persian period but the cistern (12/S2/F518) was reused for burials.

Chapter 4 Excavation and Selection of Samples for Radiocarbon Dating

4.1. General Principles

Successfully obtaining reliable radiocarbon dates for archaeological contexts is dependent upon the following major factors:

1) Good excavation and recording practices;
2) The availability of material that can be reliably dated;
3) The clarity of the archaeological context (e.g. phase / stratum attribution); and
4) The certainty of the association between the sample and its context.

Good excavation and recording practices ensure that contexts can be confidently reviewed in the office when selecting material for dating, and when interpreting the results. Points (2) through (4) need to be assessed both in and out of the field, to support targeted collection of samples as well as later selections for dating (e.g. Boaretto 2007).

Evidently the standard of excavation needs to be high, so that information about the sample and its relationships to context, phases/strata and the broader archaeological picture, are trustworthy. Organic material intended for dating needs to be appropriately handled and stored to avoid contamination: standard practice is to avoid touching samples and to collect/store them in aluminium foil (Taylor and Bar-Yosef 2014: 96). To optimise the quality and quantity of material available for radiocarbon dating, one can add (and hopefully integrate) specific techniques to the conventional archaeological process. Some of these will be discussed below.

The datable materials most commonly found at Near Eastern sites like Tel Azekah are bone, wood charcoal and carbonised seeds.[28] As short-lived materials provide the most accurate dates (and with AMS facilities now readily available) seeds have naturally become the primary target for dating projects.[29]

The best retrieval method is field picking, but without the use of sieving little would be recovered. It is generally impractical to sieve everything; under conventional excavation procedures this is done only for material from good contexts like destruction layers, floors and installations. Standard excavation sieve meshes are coarse (5-10mm), however, and

[28] In particularly arid areas other short-lived materials may be preserved e.g. textiles, straw and other plant parts.

[29] E.g. Boaretto (2007); refer also to discussion in Section 2.4.

few seed types except well-preserved olive pits are large enough to be captured. Wet sieving and flotation have been increasingly utilised on excavations to improve the yield of organic material, but washing the material can increase the risk of contamination.[30] Finer dry sieving would be preferable for radiocarbon dating but, like wet sieving and flotation, it is time-consuming and could only be used selectively. Another strategy that helps to obtain seeds from well-defined contexts is sampling from well-stratified vertical sections or conducting extra slow and careful 'mini' excavations down through a slice of such a section (e.g. Regev et al. 2014).

The goal at a stratified site is usually to infer dates for an entire phase or stratum.[31] Hence archaeological features selected for dating (typically floors, destruction layers or installations) should have a clear attribution, as assessed through architectural and stratigraphic connections, and pottery. While this must be the rule at the time of selection for dating, nevertheless radiocarbon results sometimes help to identify potential problems with context interpretation; such is the case for some samples discussed in this thesis.[32] Ongoing dialogue between radiocarbon dating and standard archaeological observations (stratigraphy, architecture, pottery) is extremely valuable to the overall interpretation process.

The final factor in the list above requires us to assess the likelihood that the date obtained from the organic material will properly represent the archaeological features with which it was found. Samples should always be selected with a view to minimising the risk that the organic material is redeposited or intrusive.[33] Preference should be given to samples with the best evidence for primary deposition (Boaretto 2015: 209-210). For example, clusters of seeds found together on a floor are less likely to been redeposited than single seeds. Samples obtained from within ceramic vessels or installations are especially good contexts; retrieval from within lenses of burnt or phytolith-rich material also suggests primary deposition.

It should be noted that sieving can have a negative impact on context quality. If sieving is resorted to hastily, at the expense of careful excavation, opportunities to identify and

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[30] Concerning flotation in particular see Lass (2008: 196).

[31] A 'phase' pertains to an occupational level in one excavation area; eventually the phases can be correlated into 'strata' for the entire site.

[32] Refer to discussions regarding OZS882 and OZS883 in Section 6.2.2 and OZS878 in Section 6.2.4.

[33] Old organic material can remain in the environment and be redeposited. Later disturbances can be caused by humans or bioturbation (the movement of material underground by rodents or other animals).

isolate clusters of seeds will be lost. This is less concerning if the context is well-bounded horizontally as well as vertically (e.g. inside a tabun, silos, or a localised burnt patch).

In most dating projects, including Tel Azekah to-date, the quality of contexts for radiocarbon dating are assessed only visually. Additional information about the context can be obtained at a 'micro' level, by analysing the soil in which the seed was found (Weiner 2010; see, for example, Toffolo et al. 2012; Regev et al. 2014). Typical micro-level proxies used to characterise anthropogenic sediments (and hence to help determine whether the deposition is primary or secondary) include: phytolith and phosphate concentration, the presence of spherulites, ash and heat-altered clays.[34] A useful tool for this purpose is Fourier Transform Infrared Spectrometry (FTIR; Weiner 2010: 275-316) These measures can be extremely helpful, and constitute a very positive direction for research. However they are not yet widely applied in excavations. Utilisation of these 'micro' proxies at Tel Azekah is being considered for future work, however it should be emphasised that the main responsibility for assessment of context quality will always remain at the 'macro' level and a great deal can be learned from careful visual inspection and recording.

AMS radiocarbon measurements remain expensive, and the number of samples that can be processed is quite limited. As far as practicable outliers are to be avoided; the presence of too many outliers will tend to obscure the correct dating and reduce confidence in the results (Boaretto 2007: 209) . By carefully excavating and selecting samples from good contexts, researchers are better able to avoid the pitfall of throwing out dates that do not suit *a priori* chronological positions.

Most often it is impossible to avoid outliers altogether, even when contexts are carefully scrutinised (Boaretto 2007: 210; see also discussion in Sharon et al. 2007: 5-7). It is not always practical to restrict ourselves to the very best context types (e.g. seeds/grains within vessels or installations, clusters on floors) because relatively few of these are found; in many cases there simply would not be enough samples to date the various strata.

[34] Refer to Shahack-Gross et al. (2005); Berna (2007); Regev (2010); Shahack-Gross (2011)

4.2. Radiocarbon Samples for this Project

4.2.1 Collection

Seeds are commonly found in the archaeological strata of Tel Azekah, and preservation of carbonised seeds is typically very good. Consequently radiocarbon dating research can (and should) target only short-lived samples. All fifteen of the samples dated for this thesis are seeds. In future work there may be specific circumstances where other materials are dated, however seeds will continue to be the dominant material. The most commonly obtained seed type by far is olive.

All seeds are handled and stored with radiocarbon dating in mind. Specifically, all participants in the excavation are clearly told not to touch seeds with their hands, but rather to use a trowel or tweezers. Seeds are collected and stored in aluminium foil, never paper or plastic. Storage of charcoal is less strict because it is used only for botanical analysis.

Dry sieving (typically 5-10mm) is applied to good contexts.[35] Wet sieving and flotation are utilised at Tel Azekah, but not for radiocarbon dating. Instead, finer dry sieving was trialled in the 2015 season.

Excavation and recording are of a high standard at Tel Azekah. Going forward we intend to utilise specific techniques to increase the quality and quantity of datable material: fine dry sieving, collection of material from sections, ‘micro’ excavation, and ‘micro’ proxies for characterising sample contexts (see Section 4.1).

Through fieldwork and use of the excavation database, the author has identified several ways in which recording should be improved to better support radiocarbon research. Clusters are not always recognised as such; location of clusters is often recorded in detail, but not consistently enough across all areas.[36] Recording the retrieval method (field-picking, wet or dry sieving) is also important but currently not always made clear. Improving these aspects simply requires good communication with supervisors and team members.

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[35] Not necessarily all of the material from these contexts is sieved; sieving is initiated or discontinued depending on whether the material seems to contain organic material (and/or small finds such as beads).

[36] Where samples are field-picked – even if not clusters – it would be worth trying to record locations and describe their relationship to floors and architecture in as detailed a manner as possible. For example, where floors are fragmentary, confidence in the samples attribution would be enhanced if there is a specific record noting that they were found in/under a clear patch of the floor.

4.2.2 Selection

Selection of the samples for the first stage of radiocarbon dating was carried out in early 2015 by the excavation directors, with input from area supervisors. The author had minimal involvement; having not excavated at the site, I was yet unfamiliar with the site's stratigraphy and the available samples. The situation will be different for the next phase of sampling: during the 2015 season I began fieldwork with the Azekah expedition, actively targeting samples and gaining firsthand knowledge of contexts. A key goal of ongoing research at Tel Azekah is to have the radiocarbon researcher closely involved with the evaluation of sample contexts both in and out of the field.

The approach adopted for radiocarbon dating at Tel Azekah is not to pursue a specific question or narrow time range, but rather to build a radiocarbon-based chronology that will ultimately cover as much of the site's occupation history as possible. The current project, however, is just the first stage in working towards this goal. The number of samples that can be dated here is statistically significant but nevertheless limited. Consequently the excavation directors sought to balance the competing goals of: a) time-coverage; and b) sufficient sample density from one period and/or excavation area to enable effective application of Bayesian statistical modelling. Context quality was given due consideration (see Section 4.1). Since we are not targeting very specific periods or strata, sample selection followed – to a large extent – the locations and phases where the best samples were available.

Fifteen samples were chosen for dating (see Table 6). Samples from many periods are included: from the end of the Middle Bronze Age through to the Hellenistic period. They come from five different excavation areas: S1, S2, T2, W1 and E1 (refer to Figure 11). Representation from these periods and areas is divided as follows:

- The main focus is a series from Area S2. Seven samples were obtained from successive Late Bronze Age floors. This reasonably dense sequence provides opportunity to effectively combine stratigraphy with radiocarbon using Bayesian modelling to obtain more precise chronological information. As has been noted, the Late Bronze Age is the peak period of occupation at Tel Azekah, and therefore establishing a reliable and well-defined chronology for this period is a high priority.
- Two samples were chosen from an MB II-III layer in Area S1 featuring strong evidence for destruction. This event is probably part of the region-wide destruction pattern evident at the end of the Middle Bronze Age (see Sections 3.2 and 8.1). Radiocarbon dating should help in understanding where the event at Azekah fits

into the long sequence of destruction events, and with which sites it forms a common horizon.

- One sample was selected from a clear Late Bronze Age destruction, attributed to the LB III (see Metzer 2015: 142-145). This destruction has been recognised in several excavation areas, but is seen most dramatically in Area T2. The layer is extensive, rich in finds and restorable pottery, and included several human skeletons that show clear evidence of sudden death in a devastating event. The event may be connected with the wider Late Bronze Age collapse seen across the Mediterranean region.
- Two samples were selected from contexts understood to be Iron Age (IIB-C). Both are from Area S1. One of the contexts appears to be a destruction layer, for which one of several historical events could account. The Iron Age is the 'biblical' period, and provides the most textual references to Azekah. As discussed in Section 2.4 this period has been the target of much radiocarbon work in recent decades. These two samples are a simple starting point; more radiocarbon work on Iron Age phases is anticipated in future seasons.
- Two samples were selected from Persian contexts (in Area S2 and Area W1). Much architecture from the Persian period has been uncovered at the site, and clarifying the nature and timing of activity at the site during this period is important. The nature of Judah and surrounding areas during the Persian period has become a major focus of research in recent years. Few radiocarbon dates have been published for this period.
- One sample was selected from a Hellenistic context. It was specifically chosen in the hope that the date could shed light on the establishment of the fortress.

Table 6 is a summary of the samples and contexts selected for the first stage of dating, and is followed by more detailed descriptions. Key photographs are provided in the text, but additional supporting information (plans and photographs) is provided in 0 and Appendix C.

Note that a locus designates material excavated as one context. It may be very confined or extend across much of an excavation square (e.g. when uncovering a floor) (Laughlin 2000: 25). The location of sieved seeds within the locus is usually not recorded, whereas the position of clusters is known more precisely. A basket number (abbreviation B) designates seeds removed and bagged together. The AMS laboratory gives a unique number to the seeds processed for dating – usually a small subset of the basket. Each radiocarbon laboratory in the world has a unique prefix, in this case OZ for the ANSTO laboratory (the letter S and numbers are simply a running sequence).

Table 6 List of samples, together with context information

Cultural Period	Area & Phase	Sq.	Locus	Basket No.	Elev. (m asl)	Context Description	Sample Type	ANSTO Lab #
MB II-III	S1-11	P7	14/S1/ L305	12389	329.84	Destruction debris with in situ vessels and evidence of burning. Sample obtained from a dark burnt patch.	Olive	OZS876
MB II-III	S1-11	P7	14/S1/ L312	13017	329.82-329.61	Ash layer directly above floor, in which a seed concentration was found. Note that 14/S1/312 was excavated below 14/S1/305, and both are clearly part of the same destruction layer.	Hulled barley	OZS877
LB IIA/B	S2-7?	J7	14/S2/ L384	21782	316.92-316.80	Phytolith-rich layer, initially interpreted as a floor. Now understood to be a layer within a well-stratified pit (F590), recognised as such during the 2015 season.	Olive	OZS883
LB IIA/B	S2-7?	J7	14/S2/ L378	21756	317.58-317.43	Dismantling a surface, possibly floor 14/S2/F565 of S2-7. Since the 2015 season, consideration must be given that this is instead part of pit 15/S2/F590.	Olive	OZS882
LB IIB	S2-6	J6	13/S2/ L294	21324	317.52-317.24	Fill and make-up below floor 13/S2/F564.	Olive	OZS874
LB IIB	S2-6	J7	14/S2/ L372	21648	318.03-317.90	Dismantling floor 13/S2/F564. Earth-beaten with some plaster remnants.	Olive	OZS881
LB IIB	S2-5	J7	13/S2/ L280	21011	318.27-317.91	Dismantling floor 13/S2/F558. In this location the floor was laid directly over a shelf cut in the bedrock.	Olive	OZS873
LB IIB	S2-5	J7	14/S2/ L363	21512	318.18-318.16	Dismantling a plaster layer, make-up of floor 13/S2/F556. Remnants of the paved surface were found directly above this locus.	Olive	OZS880
LB IIB	S2-5	J7	13/S2/ L308	21212	318.1	Remains on floor 13/S2/F556, with pottery for restoration.	Olive	OZS875
LB III	T2-3a	E3	14/T2/ L407	42790	340.23	Destruction layer. Seeds found close to fully-articulated skeleton, along with restorable vessels and many finds.	Olive	OZS884
IA IIB	S1-4 On-floor remains (but S1-3/2 fills in same locus)	S7	14/S1/ L361	12749	335.27	Destruction debris with in situ vessels and evidence of burning. This sample was part of a large seed concentration. Iron IIB pottery, including a *lmlk* jar. The destruction debris was used as a make-up for a Persian period floor (13/S1/F558).	Olive	OZS878
IA IIC	S1-3/2	T8	14/S1/ L394	12639	335.61	Fill, containing pottery attributed to the 7th century BCE.	Olive	OZS879
Persian	S2-1	J8	12/S2/ L196	20434	316.5-316.23	Burial reusing cistern 12/S2/F518. Seeds found close to skeleton.	Olive	OZS872
L. Pers.	W1-3a	Q6-R6	14/W1/ L366	52216	340.05-339.96	Floor make-up of granary building. Seeds found under olive press weight.	Olive	OZS885
L. Hell. / E. Rom.	E1-2	L10	12/E1/ L208	30671	337.49-337.24	Ashy layer with much Hellenistic / early Roman pottery, indicating that it is a living surface. Context understood to be contemporary with, or to pre-date, a glacis constructed for the Hellenistic fort on the hill above.	Legumes	OZS871

4.2.3 *Middle Bronze Age Destruction – Area S1*

Samples OZS876 and OZS877 were obtained from closely connected loci in square P7 of Area S1 (the south western slope of the tell). They were obtained from a destruction layer, together with restorable in situ vessels and evidence of burning. The destruction is attributed to MB II-III; a more specific attribution cannot be made yet, since restoration and detailed study of the pottery has not been completed. It should be noted that excavation of this destruction level at Azekah is still very limited in extent (one square in Area S1; possible new evidence appearing in Area N1).

Both seed samples were obtained from within dark burnt patches, which can easily be seen in Figure 15. Locus 14/S1/L312 was excavated below locus 14/S1/L305. Whereas 14/S1/L305 covered the whole step area and included several burnt patches, 14/S1/L312 was confined only to the central area where the main concentration of dark material (approx. 25 cm deep) and in situ vessels was found. It seems quite clear that all the evidence of burning was caused by one event.

Figure 15 Contexts of MB II-III samples in Area S1: a) OZS876; and b) OZS877.

<u>OZS876 (S1-11, 14/S1/L305, B12389)</u>

More than five seeds were retrieved from 14/S1/L305. They do not constitute a cluster, and their exact find location within the locus is not known. One seed from this locus (an olive pit) was dated as OZS876.

<u>OZS877 (S1-11, 14/S1/L312, B13017)</u>

Basket 13017, consisting of more than ten seeds, was retrieved from lower down in the central burnt patch. Locus 14/S1/L312 consisted of material peeled back immediately on top of a floor (14/S1/F591). Since these seeds were found together in a well-confined context they could be treated as a cluster, however at this stage only one barley grain has been dated.

4.2.4 Late Bronze Contexts – Area S2

Three successive LB II phases were investigated with radiocarbon dating: S2-7, S2-6 and S2-5 (refer to Table 5). Three samples were dated from the “Pillar Building” and two samples from the previous phase of the same building (S2-6, “Boulder Building”). Two samples were selected to date the phase that preceded this structure, S2-7. Unfortunately none of the samples are clusters, however all are associated with distinct stratified layers, mostly floors (refer to Figure 13). The find locations of the seven samples are indicated on single-phase plans (see Figures 17-19). In most cases, sample locations are not known more precisely than the boundaries of the relevant loci.

Each sample for S2-5 and S2-6 is associated with the floors (13/S2/F556 and 13/S2/F564) of the two respective building phases. All were obtained while dismantling the floors, except for one sample (OZS875) found in debris above the S2-5 floor. The samples for S2-5 are from the one square (J6), helping to make their association to a single floor more secure (Figure 19). The two S2-6 samples were obtained from adjacent squares (Figure 18).

The samples intended to date S2-7 require some discussion (OZS882 and OZS883; Figure 17). Both were obtained from a probe dug at the north end of square J6 during 2014 (Figure 16). At the time the samples were selected and submitted for dating (prior to the 2015 excavation season), both contexts were understood as layers pre-dating the “Boulder Building”. The upper context was understood to be a floor, below which a possible pit (15/S2/F590) was evident in the section. The lower context was understood to be either another floor or part of the pit.

The presence of pit 15/S2/F590 near/in the 2014 probe became much clearer during the 2015 season when the adjacent J6/J7 baulk was excavated (Figure 16). Above the level where the pit was clearly recognised, several distinct layers were identified as the S2-5, S2-6 and S2-7 floors.[37] The material most clearly identified as pit 15/S2/F590 was found directly below the layer identified as the S2-7 floor (13/S2/F565). It included several thick phytolith-rich layers. 15/S2/F590 was assigned to S2-7 because it appeared that the occupants of this phase had created the pit immediately before laying floor 13/S2/F565. If

[37] It should be noted that the S2-7 floor was definitely found elsewhere in J6 and J7 during 2015.

this stratigraphical understanding is upheld then both OZS882 and OZS883 should indeed date S2-7: the former should be associated with floor 13/S2/F565 whereas OZS883 is from a phytolith-rich layer in the pit.

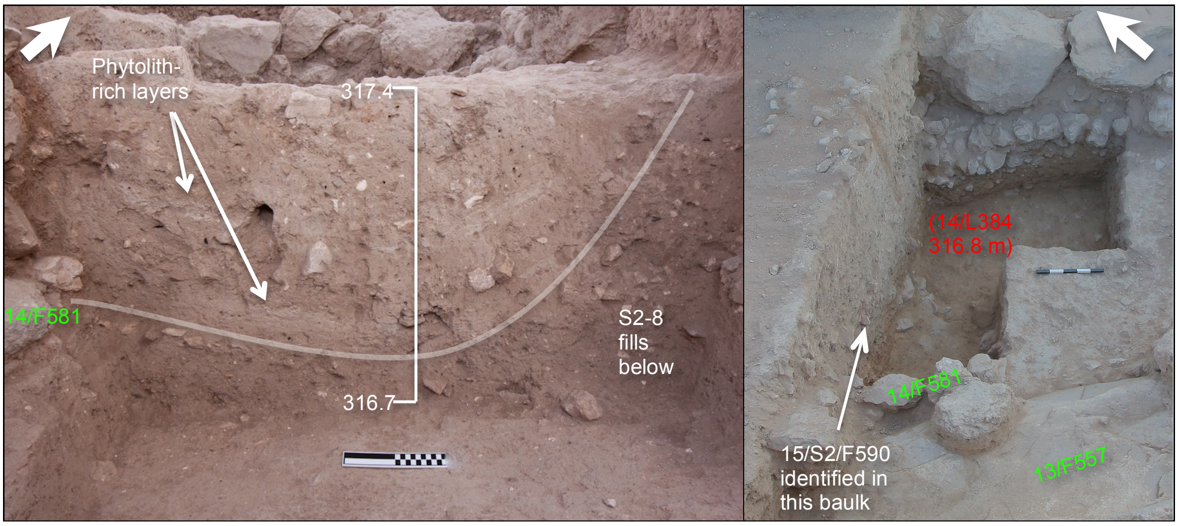

Figure 16 Left: Pit 15/S2/F590 seen in section. Right: Probe dug in 2014, next to the baulk in which 15/S2/590 was identified. Samples OZS883 and OZS882 were obtained within the probe.

The 2015 excavation season brought to our attention a number of uncertainties with the above interpretation, however. Firstly, there is some lack of clarity regarding the S2-5 through S2-7 floor sequence immediately above pit 15/S2/F590 in baulk J6-J7. This is on account of: a) the damaged nature of the floors; and b) the fairly narrow window in which they were dug in this location. Two probes had been dug in previous seasons: one mentioned already at the northern end of J6, and the other between the baulk and wall 13/S2/F559 in square J6. Consequently the attribution of the ‘floors’ identified above pit 15/S2/F590 in baulk J6-J7 is not secure. A second concern is that initial pottery analysis during the excavation did not seem to show the material culture becoming earlier with depth in this location. By contrast earlier LB material did seem to be present at a comparable elevation elsewhere in J6 and J7. This observation is yet to be followed up by detailed pottery analysis. As we shall see, the radiocarbon results presented here do not solve this problem, but add to the concerns. Additional samples from S2-7 found during the 2015 season well away from pit 15/S2/F590 will be dated in the next stage of work, but in the interim we must present the radiocarbon results in light of both stratigraphical interpretations. All succeeding discussion in this thesis will refer to these as Option 1 – where OZS882 and OZS883 belong to an S2-7 floor and pit respectively – and Option 2 – where the samples and pit 15/S2/F590 intrude from higher above (probably S2-5 or S2-6, with the S2-4 floor sealing them).

Detailed descriptions of each Late Bronze sample and context from Area S2 are provided below. Reference may be made to further photos provided in Appendix C.2.

S2-7(?) Samples

<u>OZS883 (S2-7?, 14/S2/L384, B21782):</u>

This sample was obtained from a phytolith-rich layer excavated in 2014 within a probe at the northern end of J6 (Figure 16). As such, it seems to be a layer within pit 15/S2/F590. This is the lowest elevation in Area S2 from which a sample was selected for radiocarbon dating. Several olive pits were obtained, and one was dated as OZS883.

<u>OZS882 (S2-7?, 14/S2/L378, B21756):</u>

Higher in the same probe several olive pits were recovered from within a layer first identified as the S2-7 floor (13/S2/F565). One pit was dated as OZS882. The locus included small finds and imported pottery.

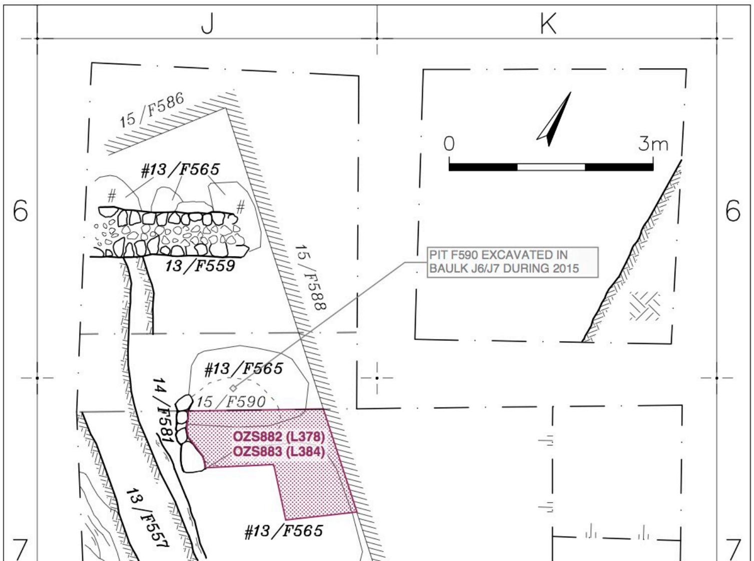

Figure 17 Find locations of S2-7 (?) samples. Main drawing by S. Emmanuilov; sample locations overlaid by the author.

S2-6 Samples

<u>OZS874 (S2-6, 13/S2/L294, B21324):</u>

Locus 13/S2/294 was excavated in square J6. It consisted of fill and floor make-up below a paved floor (13/S2/F564) of the "Boulder Building". Some difficulty distinguishing between the floors of S2-6 and S2-5 at this location should be noted. Several olive pits were recovered in the portion of the locus south of wall 13/S2/F559. The locus included small finds and much LB pottery (including fragments of imported ware). One seed was dated as OZS874.

<u>OZS881 (S2-6, 14/S2/L372, B21648):</u>

About four olive pits were obtained from locus 14/S2/372 in square J7 while dismantling the floor 13/S2/F564 (surface and make-up). The floor was plastered, but unfortunately quite damaged. The locus contained fragments of imported pottery. One seed was dated as OZS881.

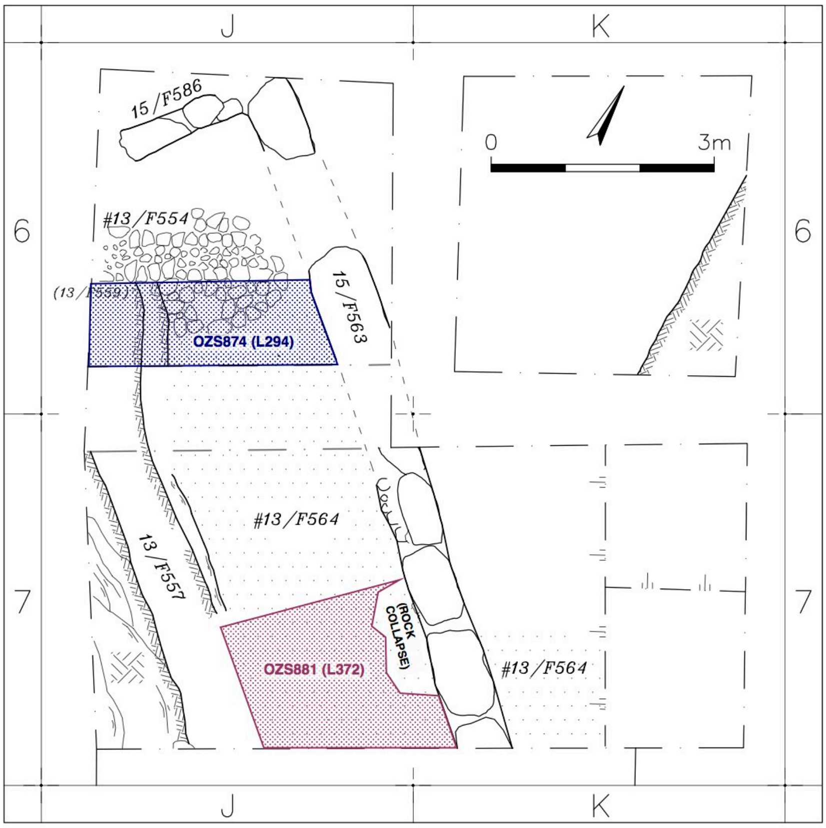

Figure 18 Find locations of S2-6 samples. Main drawing by S. Emmanuilov; sample locations overlaid by the author. Note: The pavement of 13/S2/F554 is the same floor as 13/S2/F564.

S2-5 Samples

OZS873 (S2-5, 13/S2/L280, B21011):

As we have noted, phase S2-5 extended the public building by adding a row of pillars (13/S2/F555). Locus 13/S2/L280, in which some five olive pits were found, consisted of dismantling the "Pillar Building" floor (13/S2/F558) between the pillar bases and bedrock. In this area the floor was built directly over a 'shelf' cut into the bedrock. Above this locus was fill for the construction of the S2-4 warehouse building. One pit was dated at OZS873.

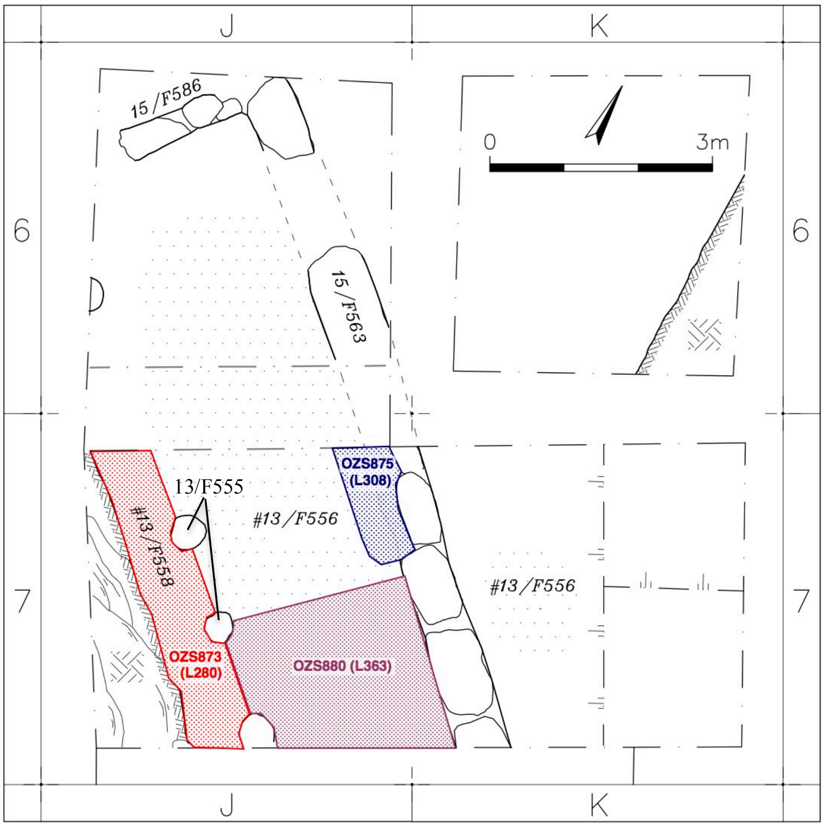

Figure 19 Find locations for S2-5 samples. Main drawing by S. Emmanuilov; sample locations overlaid by the author.

OZS880 (S2-5, 14/S2/L363, B21512):

More than five olive pits were recovered from this locus while dismantling floor 13/S2/F556. This locus consisted of plaster that was part of the floor make-up. Other distinct layers of floor make-up were excavated below this, and a few remnants of paving were found above. This locus included much pottery, including imported wares, and some small finds (e.g. bead, obsidian). One pit was dated at OZS880.

OZS875 (S2-5, 13/S2/L308, B21212):

Locus 13/S2/L308 is part of the collapse debris found on floor 13/S2/F556. The locus was located near the edge of the floor where it abuts the main wall of the building, 13/S2/F563. Several olive pits were found. The locus contained mudbrick debris and in situ vessels. Above this locus was fill for the construction of the S2-4 warehouse building. One pit was dated at OZS875.

4.2.5 Late Bronze Destruction – Area T2

OZS884 (T2-3a, 14/T2/L407, B42790)

This sample was found within a destruction layer attributed to the end of the Late Bronze Age (LB III). The destruction layer was very rich in restorable pottery and other finds, and covered much of Area T2. It included several fully articulated skeletons of individuals who clearly died in a dramatic event. The destruction layer was analysed in detail by Metzer who suggests (on the basis of typology) a date for the event shortly after the middle of the 12th century BCE (Metzer 2015: 145).

One of the skeletons was found in locus 14/T2/L407, together with restorable vessels (at least three jars), carefully-worked stone tools and small finds. 14/T2/L407 was sealed by an Iron Age floor (14/T2/F607) and wall (12/T2/F510) (see Figure 20). The boundary of the Iron Age fill and the destruction layer is clearly discernable.

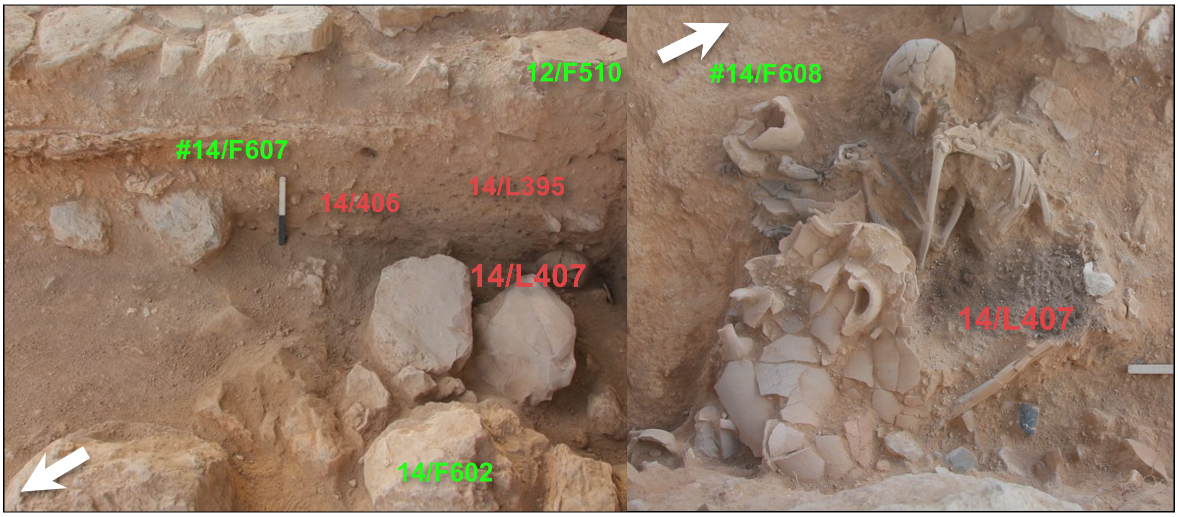

Figure 20 Context for sample OZS884 in Area T2

Several olive pits were retrieved from the material immediately around the skeleton. The soil showed evidence of burning from its dark colour and ashy texture. The pits were obtained by dry sieving and do not constitute a cluster. One seed was dated as OZS884.

4.2.6 Iron Age, Persian and Late Hellenistic Contexts

OZS878 (S1-4, 14/S1/L361, B12749)

This sample was part of a large concentration of olive pits found immediately above a living surface, at the interface between floor 14/S1/F597 and an adjoining plaster installation 13/S1/F575 (see Figure 21). The seeds were found under a complete bowl, and the surrounding soil was ashy with deep brown patches – indicating destruction by fire. Floor 14/S1/F597, installation 13/S1/F575 and the adjacent walls (13/S1/F571, 13/S1/F574 and 14/S1/F589) are attributed to phase S1-4. Typological dating of the pottery on the floor (including *lmlk* jars, and many restorable vessels) points to the 8th century BCE (IA IIB), and a radiocarbon date consistent with this was anticipated for the seeds.

Figure 21 Context for sample OZS878 in Area S1

The stratigraphy above the S1-4 floor is not straightforward and some caution is needed. Locus 14/S1/L361 includes remains on the floor but also some debris or fill material above which a well-built Persian structure was erected (phase S1-2). The floor (13/S1/F558) of this later building is 65 cm higher than the S1-4 floor (14/S1/F597); it was missing above our locus of interest (14/S1/L361), though found close by (see Figure 22). The levelled debris and fills in 14/S1/L361 and the locus above have been attributed to phases S1-2/S1-3.[38] Note, however, that the plentiful pottery in these loci is IA IIB with no clear Persian pottery.

[38] S1-3 is a fragmentary intervening Iron Age phase (IA IIC) found in some parts of Area S1.

In the current stage of radiocarbon dating, just one single seed (OZS878) from the large concentration has been processed.

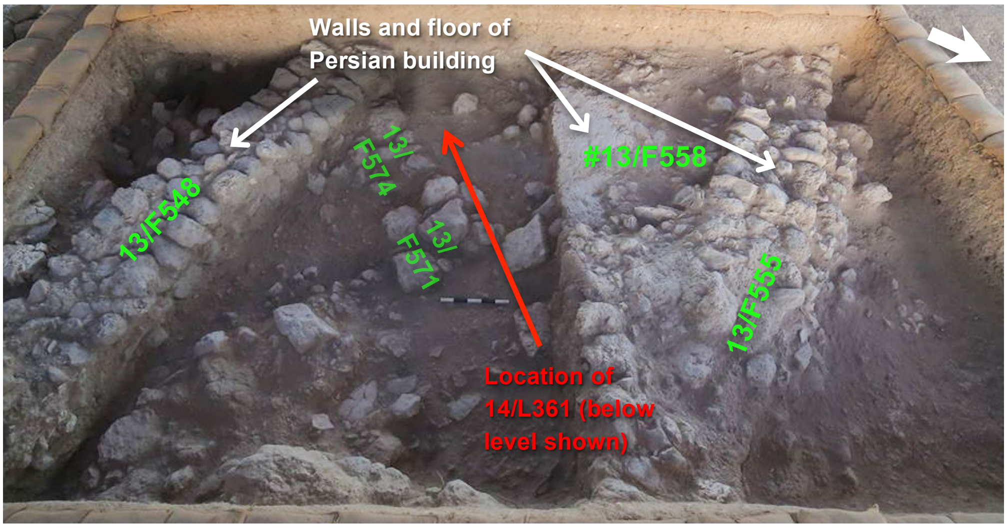

Figure 22 Context of OZS878 in relation to Persian structure above

OZS879 (S1-3/2, 14/S1/L394, B12639)

Locus 14/S1/394 also contained S1-3/S1-2 fills, in a different excavation square (Figure 23). Here architectural remains of both these phases were found (e.g. S1-2 Persian silo 13/S1/F559 and walls 13/S1/F548, 13/S1/F546; S1-3 Iron Age silos 14/S1/F581 and 14/S1/F584). Despite the possible effect of Persian construction, the pottery was Iron Age (8th and 7th centuries BCE). More than five olive pits were obtained but they did not constitute a cluster. One pit was dated as OZS879.

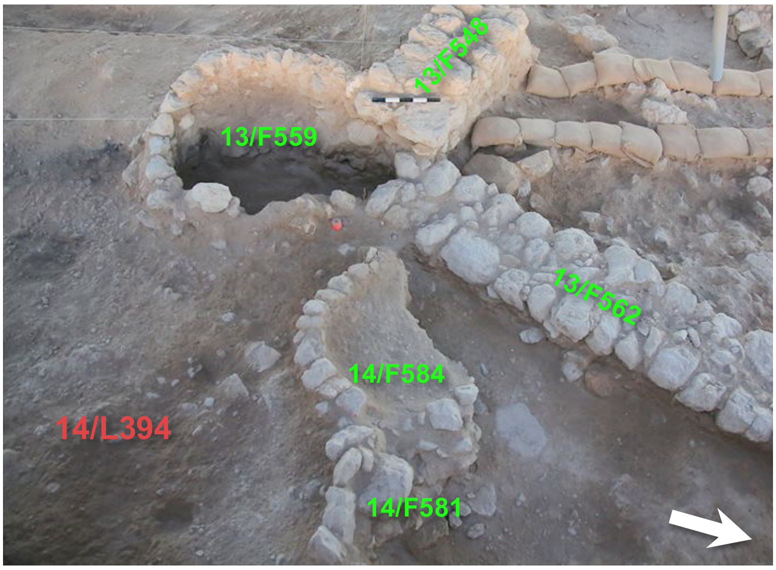

Figure 23 Context for sample OZS885 in Area S1

OZS872 (S2-1, 12/S2/L196, B20434)

This sample was found with a burial in the disused cistern (12/S1/F518) of Area S2. It is attributed to the Persian period. The locus contained small finds (e.g. beads), grinding stones and much pottery (Persian and Iron Age). More than five olive pits were obtained by dry sifting. One was dated as OZS872.

OZS885 (W1-3a, 14/W1/L366, B52216)

This sample was found in room 14/W1/F619 of the "granary building" in Area W1 (so called due to the presence of many silos; Figure 24). A number of items suggest that the building was used for agricultural purposes: several installations, an olive press weight and storage vessels. The floor of this room had a plastered floor (13/W1/F548), on which was found much restorable pottery (mainly storage vessels) typologically dated to the 4^{th} – 3^{rd} centuries BCE. Hence it was during this period that the granary building came to an end.[39] No floor was found above locus 14/W1/L366.

More than five olive pits were found under the olive press weight, which seemed to have fallen from some height, having crushed floor 13/W1/F548. The pits were removed directly from the context (not sieved) but probably cannot be considered a cluster. Several olive pit fragments were dated together as OZS885.

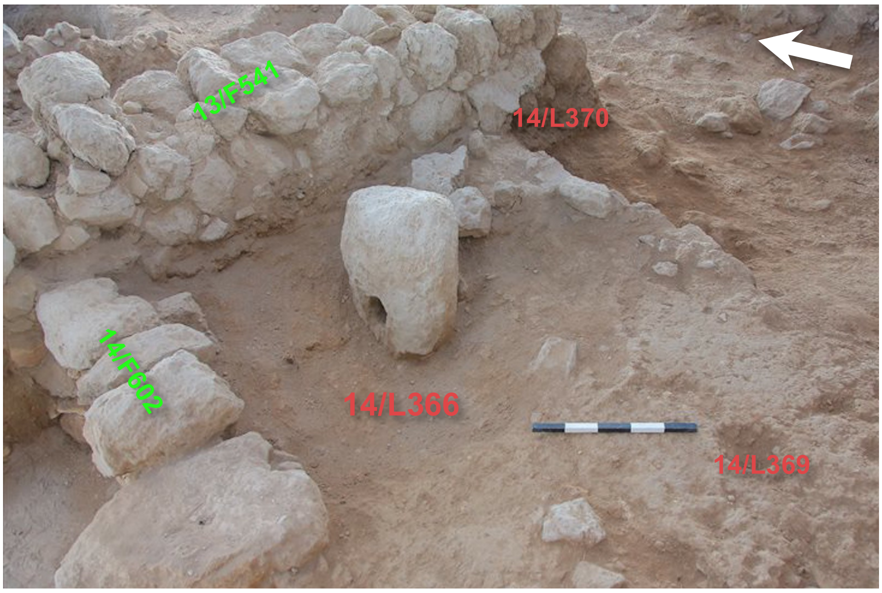

Figure 24 Location of sample OZS885 in Area W1

[39] The evidence can be interpreted as a destruction (drawing on the restorable pottery that covered the floor, and limited evidence of burning). However the excavators also consider abandonment followed by collapse to be a good explanation (noting that mainly large vessels were left behind).

OZS871 (E1-2, 12/E1/L208, B30671)

This sample was obtained from a context understood to either predate or be contemporary with a glacis built for the Hellenistic fortress. This is why it was selected for dating. Locus 12/E1/L208 was a distinct ashy layer containing Hellenistic pottery and a Hasmonean coin. It was anticipated that this sample could provide a *terminus post quem* for the construction of the fortress, whose dating has been difficult to establish clearly.

More than five seeds (legumes) were obtained from the locus by dry sieving. They do not constitute a cluster. A single seed was dated as OZS871.

Chapter 5 Laboratory Preparation and AMS Measurement

Following selection for dating, samples ('baskets') were sub-divided, with some material sent to Australia for dating and the remainder kept at Tel Aviv University. The material received in Australia was photographed – see Appendix D.

It is standard practice to report the type of seed dated whenever possible. Given that radiocarbon dating is a destructive process, this ought to be done beforehand. Most of the samples for this project were clearly olive pits, but several required review by an archaeobotanist. This was done by Andrew Fairbairn of the University of Queensland, prior to pre-treatment.[40] One sample was identified as hulled barley (OZS877, possibly also including wheat) and another as legumes (OZS871). Generally seed type has little to no impact from a dating perspective.

All samples were processed at the radiocarbon dating facility of ANSTO, in Lucas Heights, Sydney. Dating was funded by AINSE and ANSTO; laboratory staff supported the author in personally carrying out the pre-treatment.

From each sample a single seed or fragment was selected for dating. (There was one exception, OZS879, for which several fragments were prepared together.) This approach is taken to avoid inadvertently producing an average between seeds of differing date – something that is more likely to occur when samples do not constitute clusters. If the sample contains seeds that are in secondary deposition and hence do not reflect the archaeological context, it is better to obtain an obvious outlier than an average between two dissimilar seeds. The latter could be very misleading.

None of the seeds had large amounts of sediment clinging tightly to their surface. The seed surface was scraped free of as much sediment as possible using a scalpel, then cut into small pieces and placed in tubes. Seeds were weighed before and after pre-treatment. The majority of samples lost 40% to 60% of their weight. In one case the loss was considerably higher (OZS871, 85%).

The Acid-Base-Acid (ABA) pre-treatment was applied to all samples. This chemical process removes sedimentary and other contaminant carbonates, as well as organic acid contaminants (i.e. humic and fulvic acids). The final acid wash removes any dissolved atmospheric carbon dioxide absorbed during the base wash.

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[40] Identification by photograph rather than physical inspection was adequate.

Figure 25 STAR accelerator at the Australian National Science and Technology Organisation (ANSTO). (Image from: www.ansto.gov.au/ResearchHub/acceleratorsciencecentre/index.htm)

Specific implementation of the ABA pre-treatment on these samples is outlined as follows:

1. Each sample was placed in 5 mL of 2 M HCl, and kept at 60°C in a water bath for 2 hours, then rinsed with high purity MilliQ water.
2. This was followed by 5 mL of 0.5% NaOH for 1 hour at room temperature. This step was applied multiple times until the alkali remained essentially clear (indicating successful removal of humic acids). The legume sample (OZS871) and barley sample (OZS877) were mostly clear after only 2-3 alkali washes, however the olive pit samples generally took 6-7 washes to clear up properly. During the last few alkali washes the samples were kept in the 60°C water bath to speed up the process. (Between each alkali treatment, samples were rinsed with MilliQ water.)
3. The samples had a final wash in 2M HCl, left at room temperature for 2 hrs. This was followed by final rinsing with MilliQ water, and oven-drying.

The pre-treated samples were combusted in sealed quartz tubes at 900°C, and the carbon content determined from the resulting carbon dioxide (CO_2). The CO_2 was converted to graphite by reduction using hydrogen over an iron catalyst, then pressed into aluminium holders as targets for AMS measurement. The combustion and graphitization processes, as implemented at ANSTO, are described in detail by Hua et al (2001). Stable isotope analysis ($\delta^{13}C$) was performed on an aliquot of the graphite using Elemental Analyser – Isotope Ratio Mass Spectrometry (EA-IRMS) using an Elementar MicroCube EA and an IsoPrime IRMS.

Radiocarbon determinations for the samples, along with standards and blanks, were made using the STAR 2MV HVEE Tandetron at ANSTO (described by Fink et al. 2004).

Chapter 6 Conventional and Calibrated Dates

6.1. Results

The results of radiocarbon-dating the fifteen samples from Tel Azekah are shown in Table 7 and Figure 26. Radiocarbon ages are reported in conventional ^{14}C years before present (BP) following international convention (Stuiver and Polach 1977; Millard 2014). Stable carbon isotope ratios ($^{13}C/^{12}C$ or $\delta^{13}C$) are also reported; the values are all typical of C_3 plants (those utilizing only the Calvin cycle for carbon assimilation). Note that all dates have been corrected for isotopic fractionation, by normalisation to a $\delta^{13}C$ value of -25‰ relative to the accepted standard (PDB). Calibrated ages in calendar years were obtained using OxCal version 4.2.4 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer et al. 2013). One sample was calibrated using the Bomb 13 NH2 curve (Hua et al. 2013) as its percent modern carbon (pMC) is higher than 100.

6.2. Discussion

6.2.1 Middle Bronze Age Destruction – Area S1

The dates from the Middle Bronze destruction in Area S1 do not overlap very well if they are understood to represent a single event. The 2σ ranges overlap but not 1σ ranges. OZS876 points to a 17th century date, whereas OZS877 points to a 16th century date. We are left with a range of some 200 to 300 years within which this event may have occurred.

It is not advisable to average the dates. Firstly we cannot say if the seeds come from the same immediate context (i.e. a single dark patch).[41] The limited overlap of the dates, and the limited data, also preclude any justification for averaging.

On the basis that both samples are short-lived and this location was not reused immediately afterwards, the later date seems somewhat more likely to represent the event. Note also that 14/S1/L312 (with the later date) is a more reliable context.[42] However it is very difficult to make a judgement on just two dates; more measurementss are needed to pinpoint the event. 14/S1/L312 should be preferred for further dating; as the deposition is more likely to be primary (i.e. burnt in situ), multiple dates from this context should be readily averaged.

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[41] Recall that 14/S1/L305 contained several burnt patches, not only the central concentration of charred material whose excavation was continued as 14/S1/L312; refer to Figure 15.

[42] The seeds from 14/S1/L312 derive from a single well-defined burnt patch excavated immediately on a floor. Cf. the seeds of 14/S1/L305 which were mixed with debris higher up.

Table 7 Calibrated radiocarbon dates

			Calibrated Dates (BCE unless noted)					
Lab no.	**$\delta^{13}C$ ‰**	**^{14}C Age ± 1σ yrs BP**	**1σ (68.2%) range**	**2σ (95.4%) range**	**Median Age**	**Area & Phase**	**Locus**	**Expected Cultural Period**
OZS876	-19.4 ± 0.3	3355 ± 30	1686 – 1619 (68.2%)	1740 – 1713 (7.7%) 1697 – 1602 (78.6%) 1585 – 1544 (8.5%) 1539 – 1535 (0.6%)	1649	S1-11	14/S1/ L305	MB II-III
OZS877	-21.6 ± 0.1	3260 ± 25	1607 – 1583 (19.6%) 1559 – 1553 (3.6%) 1546 – 1501 (45%)	1614 – 1496 (91.3%) 1476 – 1460 (4.1%)	1537	S1-11	14/S1/ L312	MB II-III
OZS883	-19.6 ± 0.3	2935 ± 25	1208 – 1110 (68.2%)	1219 – 1049 (95.4%)	1145	S2-7?	14/S2/ L384	LB IIA/B
OZS882	-20.3 ± 0.1	2950 ± 25	1208 – 1125 (68.2%)	1231 – 1055 (95.4%)	1162	S2-7?	14/S2/ L378	LB IIA/B
OZS874	-21.3 ± 0.1	2985 ± 25	1262 – 1192 (58%) 1171 – 1168 (1.7%) 1143 – 1132 (8.5%)	1284 – 1122 (95.4%)	1214	S2-6	13/S2/ L294	LB IIB
OZS881	-21.8 ± 0.1	2915 ± 25	1188 – 1182 (3%) 1157 – 1146 (6.4%) 1129 – 1051 (58.8%)	1207 – 1141 (26.7%) 1134 – 1021 (68.7%)	1104	S2-6	14/S2/ L372	LB IIB
OZS873	-22.4 ± 0.2	2965 ± 30	1223 – 1126 (68.2%)	1268 – 1056 (95.4%)	1178	S2-5	13/S2/ L280	LB IIB
OZS880	-20.1 ± 0.1	2960 ± 30	1219 – 1125 (68.2%)	1263 – 1056 (95.4%)	1172	S2-5	14/S2/ L363	LB IIB
OZS875	-21.1 ± 0.1	2985 ± 30	1263 – 1192 (52.3%) 1176 – 1163 (7.3%) 1144 – 1131 (8.6%)	1371 – 1359 (1.5%) 1297 – 1116 (93.9%)	1213	S2-5	13/S2/ L308	LB IIB
OZS884	-21.3 ± 0.1	2420 ± 25	535 – 528 (3.5%) 520 – 412 (64.7%)	735 – 689 (12.2%) 663 – 648 (3%) 547 – 404 (80.2%)	488	T2-3a	14/T2/ L407	LB III
OZS878	-21.1 ± 0.1	2340 ± 30	415 – 379 (68.2%)	507 – 500 (1%) 491 – 366 (94.4%)	401	S1-4	14/S1/ L361	IA IIB
OZS879	-19.8 ± 0.1	2710 ± 25	895 – 866 (30.9%) 856 – 824 (37.3%)	905 – 811 (95.4%)	857	S1-3/2	14/S1/ L394	IA IIC
OZS872	-21.1 ± 0.1	2365 ± 25	474 – 444 (17.6%) 431 – 395 (50.6%)	513 – 391 (95.4%)	423	S2-1	12/S2/ L196	Persian
OZS885	-20.8 ± 0.1	2010 ± 20	41 BCE– 16 CE (68.2%)	50 BCE – 52 CE (95.4%)	11 BCE	W1-3a	14/W1/ L366	Late Pers.
OZS871	-26.6 ± 0.1	106.54 ± 0.38 pMC (% Modern Carbon)	2004 CE – 2007 CE (68.2%)	1957 CE (7.3%) 2003 CE – present (88.1%)	2002 CE	E1-2	12/E1/ L208	Late Hell.

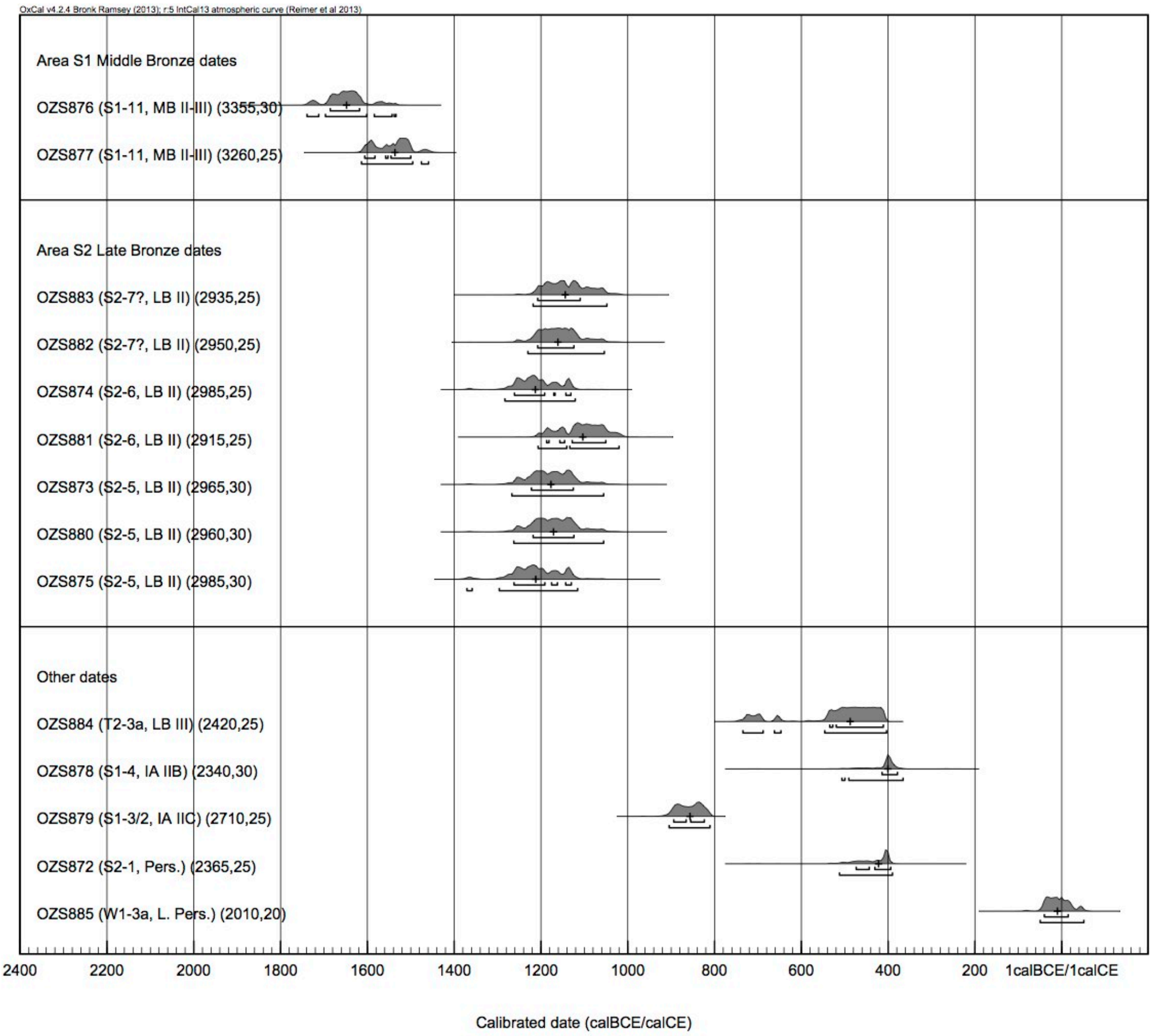

Figure 26 Probability distributions of calibrated radiocarbon ages. 1σ (68.2%) and 2σ (95.4%) ranges are indicated; also median age. Each date is labelled with the laboratory number, followed in brackets by area-phase and expected cultural period.

6.2.2 Late Bronze Age Contexts – Area S2

The calibrated dates for this sequence overlap significantly and there are no clear outliers. The probability range for each date covers some 200 years for 95.4% probability; this is due to the shape of the calibration curve here – characterised by two closely-spaced 50 year-long flat areas and a significant intervening wiggle (see Figure 27). Altogether the dates span the 13th to 11th centuries BCE, with greatest overlap during the first half of the 12th century BCE. This fits quite well with the LB IIB attribution of S2-5 and S2-6.

If we look at the ordering of the uncalibrated dates (and of the peak probability for calibrated dates), an apparent inconsistency with the stratigraphy appears: material from lower levels tend to yield later dates than the higher levels. Three main factors could contribute to this:

1. Fluctuations in atmospheric ^{14}C levels – clearly evident in this part of the calibration curve.
2. Secondary deposition of seeds. This risk needs to be considered, particularly since none of these seven samples are clusters. We also note that the floors were in some places damaged and/or difficult to trace during the excavation. Such factors could be invoked to explain the seemingly later date of OZS881 (found in the S2-6 floor), or the fact that the highest S2-5 sample (OZS875, found in destruction debris above the floor) yielded the oldest date.
3. As noted in Section 4.2.4, some concern has developed concerning the contexts of our two deepest samples (OZS883 and OZS882). If the pit with which both samples are closely associated actually intrudes from higher above rather than being sealed by the S2-7 floor, then an earlier date for these samples makes sense.

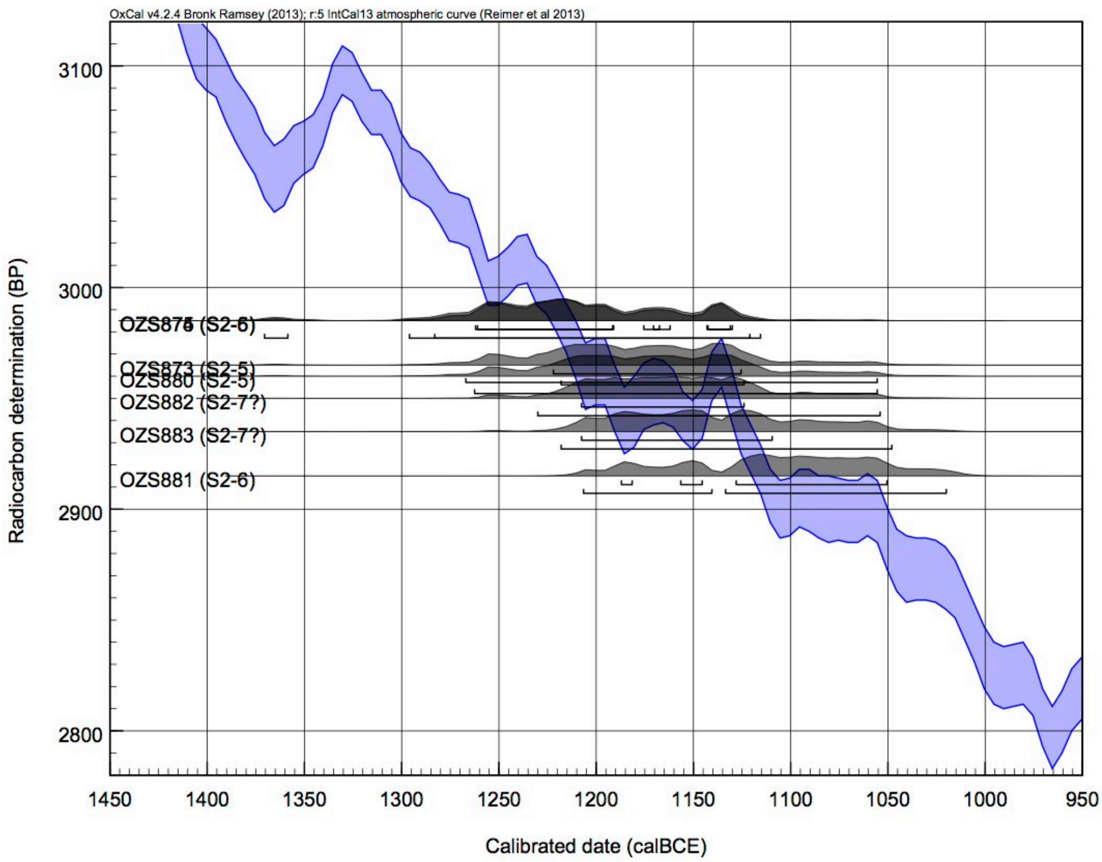

Figure 27 Calibrated Late Bronze dates from Area S2 superimposed on the calibration curve.

The probability ranges of the calibrated dates overlap significantly, and thus we cannot confidently conclude – by means of radiocarbon alone – that there are problems of association (factor 2) or stratigraphy (factor 3). Nevertheless the two deepest samples are statistically unlikely to date before 1200 BCE, contrary to expectations based on pottery and stratigraphy. As noted in Section 4.2.4, S2-7 is architecturally quite different from the

S2-6/5 public building and pottery more typical of earlier LB phases was encountered at a similar elevation elsewhere in Area S2. Thus radiocarbon evidence adds to the concerns regarding the phase attribution of OZS882 and OZS883.

In the following chapter we will combine our two stratigraphical interpretations with the radiocarbon data by means of Bayesian modelling.

6.2.3 Late Bronze Destruction – Area T2

<u>OZS884 (T2-3a, 14/T2/L407)</u>

This date is much too late for its context. It falls within the Hallstatt Plateau, thus pointing to IA II or the Persian period. This is contrary to in situ pottery and other finds that place the destruction clearly in the Late Bronze Age.

OZS884 was not part of a cluster, but in other respects the context is very good. The seeds were found well within a thick and distinct destruction layer, together with human remains and various finds that did not appear disturbed. The only reasonable conclusion is that the seed has penetrated into the destruction layer from fill below the Iron Age floor (refer to Figure 20). This must have occurred either through bioturbation or a larger disturbance that has not been detected (less likely).

This situation highlights the disadvantage of dating seeds that are not clusters, and obtaining just one date for the stratum. In view of the result obtained here, and the lack of seed clusters found in the destruction, dating this event should be addressed using bones from the skeletons.

6.2.4 Iron Age, Persian and Late Hellenistic Contexts

<u>OZ878 (S1-4, 14/S1/L361)</u>

OZS878 has produced a date that corresponds to the Persian period. It is very close to the Hallstatt Plateau, but seems to be sufficiently clear of it – with a 2σ range essentially in the 5^{th} century and first half of the 4^{th} century BCE. The 1σ range places the date close to 400 BCE.

As explained in Section 4.2.6, OZS878 was part of a seed concentration found together with IA IIB pottery. These seemed to be in situ remains on a floor, and hence the Persian date is surprising. Several possibilities need to be considered. It has been noted that 14/S1/L361 (and particularly the locus above) include levelled debris/fills from S2-3/2; also, the floor of the Persian building was locally missing. Hence the possibility ought to be considered that our context is not true remains on a floor but affected by later construction activity. We may have inadvertently dated the establishment of the Persian structure above, rather than the Iron Age layer below (both are important and worthwhile subjects for radiocarbon dating). Nevertheless the clean Iron Age material in and above this context remains puzzling.

The presence of the Hallstatt Plateau very close by on the calibration curve should also be considered. The effect of the plateau is such that a reduction in the radiocarbon determination of just 1-2 decades would introduce substantially earlier dates (Iron Age) into the calibrated probability range.

More seeds from the concentration ought to be dated. Firm radiocarbon dates from this concentration would help our understanding of the stratigraphy in this location.

OZS879 (S1-3/2, 14/S1/L394)

The date for OZS879 is Iron Age, however a 9th century date is earlier than expected. 14/S1/L394 contains pottery that typologically belongs to the 7th century BCE (late IA IIB / early IA IIC). It seems that we have dated a redeposited seed from an earlier stratum; the nature of the locus as a 'fill' supports this. 14/S1/L394 also contained 8th century BCE pottery and the locus below was characterised by earlier Iron Age pottery (IA IB and IA IIA). Dating further samples from this context is not recommended; more secure contexts should be sought.

OZS872 (S2-1, 12/S2/L196)

This sample has produced a very similar date to OZS878. In this case a Persian date is expected, since Persian pottery was found with the burial. This is a helpful outcome, given that pottery from the end of the Iron Age and the Persian period can be difficult to differentiate. Interestingly we have obtained evidence for contemporaneous activity in Area S1 (though the date was unexpected in its context): both dates fall close to 400 BCE.

OZS885 (W1-3a, 14/W1/L366)

OZS885 has produced a surprisingly late date, in the Roman period. Restored pottery from above floor 13/W1/F548 of the "Granary Building" is typologically 4th to 3rd centuries BCE. A few sherds of earlier pottery were found (IA and LB), but nothing later. Besides the date from OZS885, there is no evidence to suggest an intrusion from the Roman period. This context is not a cluster and not sealed by a floor above, but it was covered by building collapse and restorable pottery.

Though the context was considered reasonably safe, evidently we should abandon it and seek more secure contexts.

OZS871 (E1-2, 12/E1/L208)[43]

The modern date of OZS871 is puzzling. It implies that at least seven modern legumes have penetrated deep into the excavation square.[44] Whilst there is no floor above the context, it is a clearly distinguishable layer. Visual evidence of modern material, close to the surface, is one metre above 12/E1/L208. A trench from the excavations of Bliss and Macalister was identified within an adjacent excavation square, but this cause of contamination can be ruled out since the radiocarbon date is post-1950.

Unfortunately this sample has been unsuccessful at shedding light on the date of the glacis for the Hellenistic fortress. Other samples from Hellenistic contexts with clear associations to archaeological features have become available in the past season, and these will be pursued in future work.

[43] Concern of a modern date for OZS871 was raised by Andrew Fairbairn prior to this result, on the basis of its preservation. The sample was retained for dating on account of the generally good level of preservation at the site (confirmed by the expedition archaeobotanist, Dafna Langgut) and the reassessed security of the context (confirmed with the area supervisor).

[44] Alternatively the material was contaminated during the process of (dry) sieving; but this also seems unlikely.

Chapter 7 Bayesian Modelling

Chronological information can be made more precise by imposing our ‘prior’ knowledge of stratigraphical relationships on the radiocarbon data using Bayesian statistics. For the results we have obtained, Bayesian modelling is most useful for the Late Bronze Age sequence from Area S2. It can also constrain the two Middle Bronze destruction dates slightly. Unfortunately at this stage we cannot usefully model the various periods we have dated together in one model. Firstly the gap between periods is too large, and secondly, many dates from Iron Age to Hellenistic contexts (as well as the LB III destruction) have yielded problematic results that can only be addressed by dating additional samples.

The models presented below were completed using OxCal 4.2.4 (Bronk Ramsey 2009). The structure is quite simple, grouping dates together in phases or sequences according to the stratigraphy. Note that we have used only simple boundaries (i.e. uniform phases); more complex boundary types either cannot be justified or have negligible effect (Bronk Ramsey 2009).

7.1. Middle Bronze Age Destruction – Area S1

Figure 28 and Table 8 show the simplest of Bayesian models, specifying that the two Middle Bronze destruction dates belong to one uniform phase[45]. This causes the probabilities to shift slightly closer together. The result still leaves us with a 200-year range (1σ) for the destruction, between the early or mid 17th century and the end of the 16th century. Consequently the date of the Middle Bronze destruction at Azekah remains poorly defined. Only further measurements will allow us to determine which of our current two dates better captures the event.

[45] Were a significantly larger dataset available for this destruction layer, we could consider using an exponentially distributed rather than uniform phase (Bronk Ramsey 2009; Höflmayer 2012). But with just two dates there is no effect.

Table 8 Modelled and unmodelled dates for the Middle Bronze Age destruction

		UNMODELLED (BCE)			MODELLED (BCE)		
Sample	**14C Age ± 1σ years BP**	**68.2% Probability**	**95.4% Probability**	**Median Age**	**68.2% Probability**	**95.4% Probability**	**Median Age**
OZS876 *S1-11, 14/S1/L305*	3355 ± 30	1686 – 1619 (68.2%)	1740 – 1713 (7.7%) 1697 – 1602 (78.6%) 1585 – 1544 (8.5%) 1539 – 1535 (0.6%)	1649	1665 – 1611 (48.5%) 1581 – 1558 (15.3%) 1553 – 1545 (4.4%)	1692 – 1528 (95.4%)	1634
OZS877 *S1-11, 14/S1/L312*	3260 ± 25	1607 – 1583 (19.6%) 1559 – 1553 (3.6%) 1546 – 1501 (45%)	1614 – 1496 (91.3%) 1476 – 1460 (4.1%)	1537	1610 – 1580 (29.8%) 1561 – 1507 (38.4%)	1619 – 1497 (95.4%)	1559

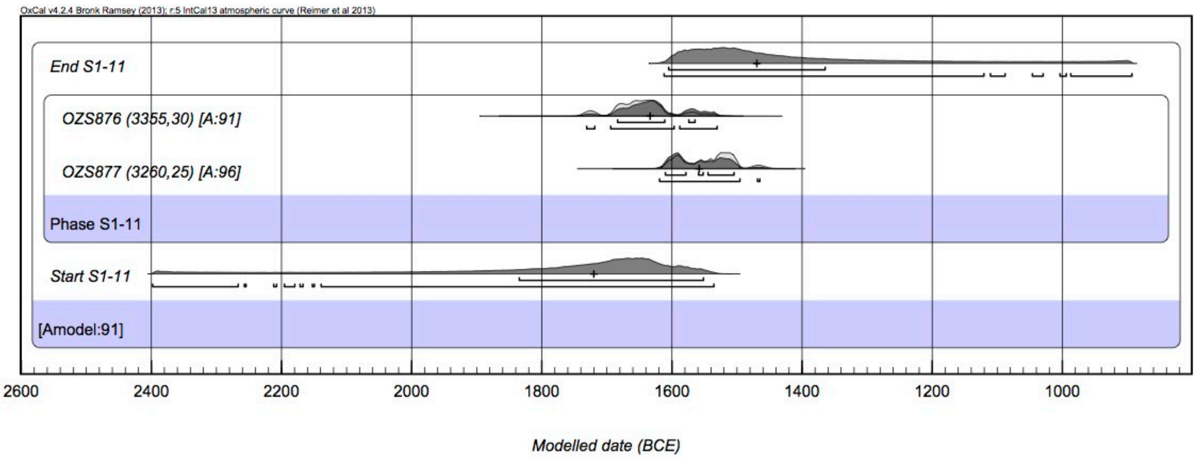

Figure 28 Bayesian model of the Area S1 Middle Bronze Age dates. Each date is specified by laboratory number, with the uncalibrated date in curved brackets and agreement index (%) in square brackets. Modelled 'posterior' probability distributions are shown in dark grey, and the 'likelihood' (probability distribution for independent calibrations) is shown in light grey.

7.2. Late Bronze Age Sequence – Area S2

As noted, the shape of the calibration curve results in broad ranges for each date in this series. However the precision of our chronological information can be markedly improved by imposing the stratigraphic sequence information.

Because of concern regarding the attribution of pit 15/S2/F590 uncovered in 2015 – hence also the contexts of our two lowest samples in elevation, it is necessary to build and examine two separate Bayesian models for the Late Bronze Age samples of Area S2. The need for 'Option 1' and 'Option 2' interpretations of the stratigraphy is explained in Section 4.2.4. The dating of further samples will be pursued in the near future specifically to clarify which interpretation is correct, but in the meantime we must consider both.

7.2.1 Option 1 – Three Successive Phases

Here we assume our original stratigraphical interpretation: that pit 15/S2/F590 and the two deepest samples (OZS882 and OZS883) belong to S2-7. The model shown in Figure 29 is constructed as a sequence of three phases – S2-7 followed by S2-6 then S2-5 (simple uniform boundaries assumed between phases). The model assumes that the phases are contiguous, as there is no evidence of occupational gaps (indeed, S2-5 and S2-6 are closely related phases).[46]

When this stratigraphic understanding is combined with the radiocarbon evidence, the reverse trend of the radiocarbon ages serves to tighten the bounds on the entire sequence (see also Figure 30). The model retains the earliest portion of the S2-7 probability range and the latest portion of the S2-5 range. Thus the modelled sequence starts in the late 13th century BCE and extends into the second half of the 12th century. The Bayesian model shows acceptable agreement indices (>60%) for individual samples and for the overall model (Figure 29, shown in square brackets).

The following concerns regarding the modelled need to be considered, especially in light of some further stratigraphic (and pottery) considerations:

- The three phases are very close together. While the combined 95.4% probability ranges cover almost 100 years, the median dates are separated from one another by a mere 10-15 years. Admittedly the series may not have captured the full length of S2-7 and S2-5, but this is nevertheless indicative of close spacing. It may not be unreasonable for S2-5 and S2-6 in view of their close architectural relationship, but it seems more problematic for S2-7.
- The date for S2-7 is significantly later than expected; pottery and stratigraphic considerations suggest it belongs earlier in LB II (LB IIA or earlier in LB IIB). Refer to Sections 4.2.4 and 6.2.2.
- The late date of OZS882 and OZS883 has the effect of constraining S2-5 to the latest part of its probability range. The dates centre around the mid-12th century

[46] Even if the phases are specified as sequential rather than continuous, the change to the model is negligible. Internal sequencing of samples from the phases also has little effect. The two S2-7 samples are treated as a sequence because they were obtained from distinct layers directly overlying one another. One might also argue that OZS875 should postdate the other S2-5 samples, but since the loci were not excavated directly over one another, and they are close to the same floor, internal sequencing does not seem justified.

BCE (the period assigned to LB III according to the standard chronological framework for the region; refer Table 1). S2-5 is not, however, the last LB phase of Area S2. Phase S2-4 represents a complete redevelopment of public architecture and seems to have been destroyed at the same time as buildings in Area T2 (T2-3). On the basis of typology Metzer (2015: 140-145) suggests that T2-3 was occupied in the first half of the 12th century, and destroyed near the middle of the century. The dating of S2-5 suggested by the Option 1 model would leave little time for the construction and destruction of S2-4 within LB III. Obtaining radiocarbon dates for S2-4 will be a high priority for future work.

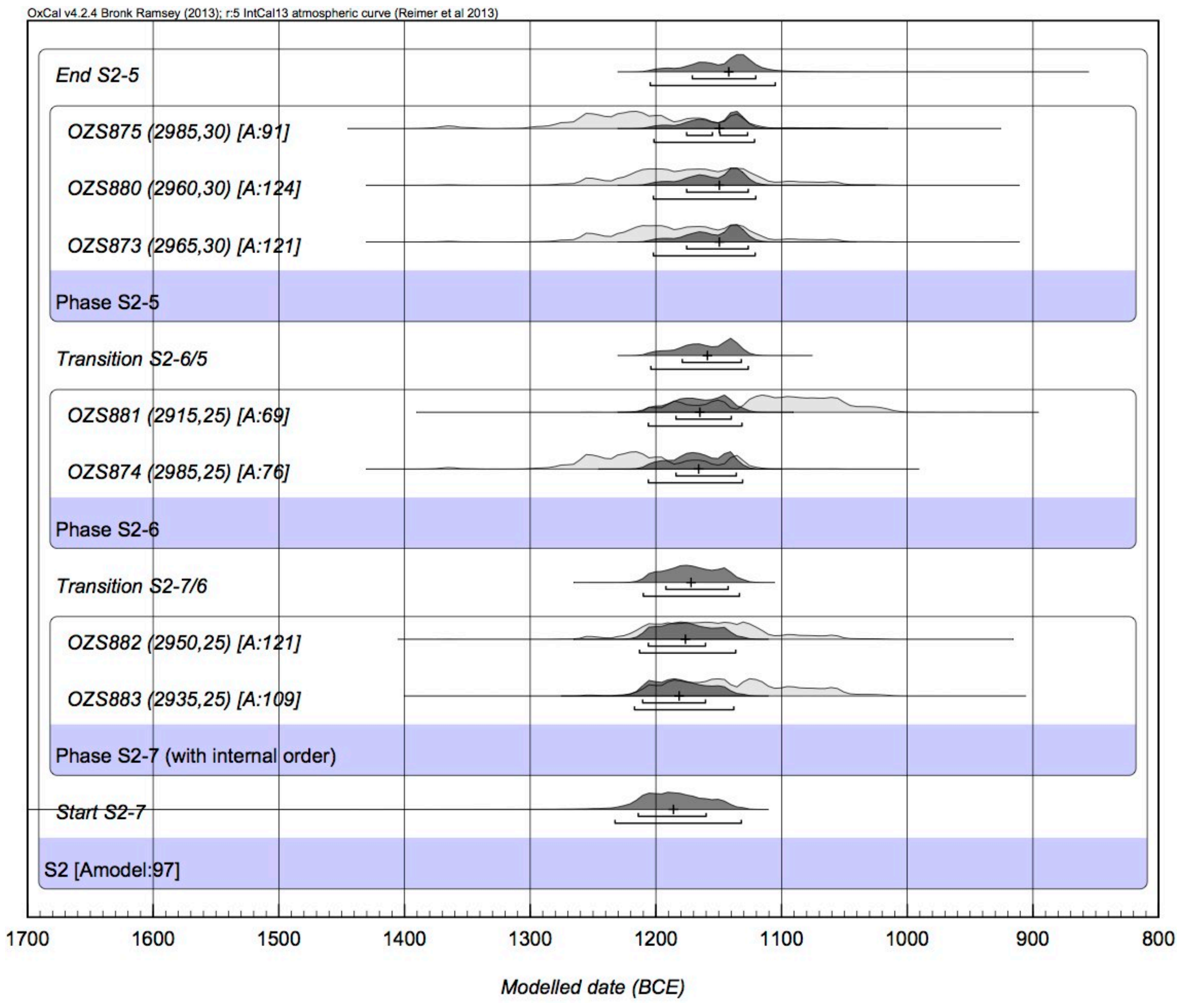

Figure 29 Bayesian model following the 'Option 1' interpretation of stratigraphy. Here we have a sequence of three phases, and we accept that the two deepest samples indeed belong to S2-7. The phases are arranged in stratigraphical order, and therefore proceed chronologically from the bottom to top of the figure. On the left each date is specified by laboratory number, with the uncalibrated date in curved brackets and the agreement index in square brackets. Modelled 'posterior' probability distributions are shown in dark grey, and the likelihood (probability distribution for independent calibrations) is shown in light grey.

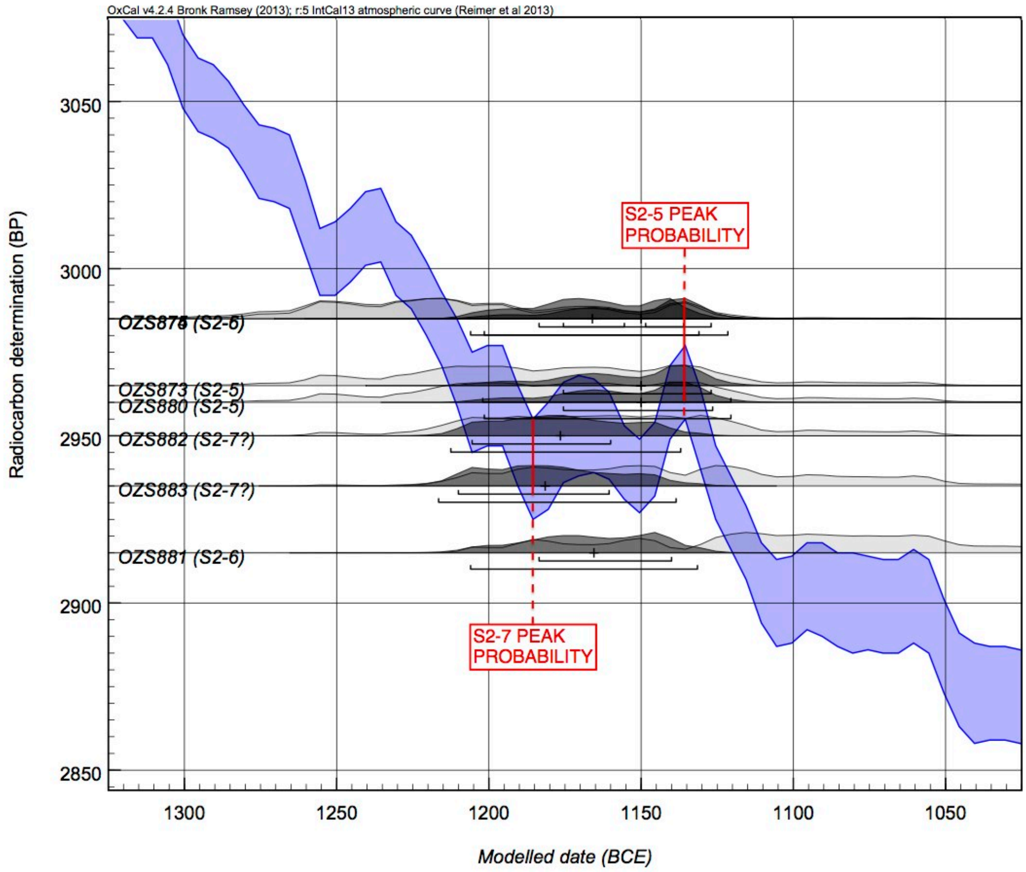

Figure 30 Curve plot illustrating how the combined effect of stratigraphy (Option 1), the reverse trend of the conventional radiocarbon ages, and the wiggles of the calibration curve works to constrain the dates of the S2 Late Bronze sequence. The peak probability of S2-5 is shifted to the latest possible wiggle, and the S2-7 peak to the earliest wiggle.

7.2.2 Option 2 – Overlapping Phases

We now assume that pit 15/S2/F590 excavated in 2015 is not sealed by the S2-7 floor, as we originally thought, but has in fact penetrated from higher above. Thus both pit 15/S2/F590 is later and our deepest two samples do not date phase S2-7. No assumption is made regarding which level the pit might have intruded from, and modelling proceeds as follows. As seen in Figure 31, the seven dates have been organised in two overlapping (i.e. essentially independent) phases: the first contains S2-6 and S2-5 (in sequential order), and the second contains the two samples attributed to pit 15/S2/F590 (also ordered, but with minimal effect).

As for the Option 1 model, the agreement indices for individual dates and the overall model are acceptable. Removing OZS882 and OZS883 from the sequence has allowed the modelled dates of S2-6 to shift earlier by ~20 years. The modelled dates for S2-5 are ~10 years earlier than in Option 1, but are still centred on the middle of the 12th century BCE. It should be noted that the dates for both phases are still being constrained to the lower part of their probability range by OZS881. This date for S2-6 seems late; the agreement index is only just acceptable (61%) but without further radiocarbon dates we cannot consider it an outlier (and thereby remove it from the model). Nevertheless it is fair to say that S2-5 and S2-6 could well be closer to the late 13th century and beginning of the 12th century BCE than the current model suggests (perhaps by a few decades). Additional radiocarbon dates for S2-6 could help to define this better.

We cannot tell which phase OZS882 and OZS883 might have intruded from, however the radiocarbon evidence is suggestive of S2-5 or S2-6. This is consistent with stratigraphical observations: the evidence for S2-4 floor 12/S2/F507 above pit 15/S2/F590 is clearer.

Option 2 eliminates the first two concerns expressed regarding the Option 1 modelled dates (see above).[47] The third concern remains: the short time available for construction and destruction of S2-4. As discussed above, S2-5 and S2-6 may in fact date slightly earlier than the model indicates (due to OZS881). Radiocarbon dating of S2-4 is clearly important for future work, while improvements to radiocarbon data for the earlier phases (especially S2-7 and S2-6) would also be helpful in positioning the sequence more firmly.

Despite the stratigraphical concern regarding S2-7 we have nevertheless comfortably dated the public building ("Boulder" / "Pillar" building) between the late 13th century and ~1130 BCE. Resolving the stratigraphical uncertainty regarding S2-7 – which we cannot confidently date with OZS882 and OZS883 – awaits further radiocarbon dates (from samples located well away from pit 15/S2/F590), complemented by a detailed examination of the pottery.

[47] The median dates of S2-5 and S2-6 according to the Option 2 model are separated by 25-30 years.

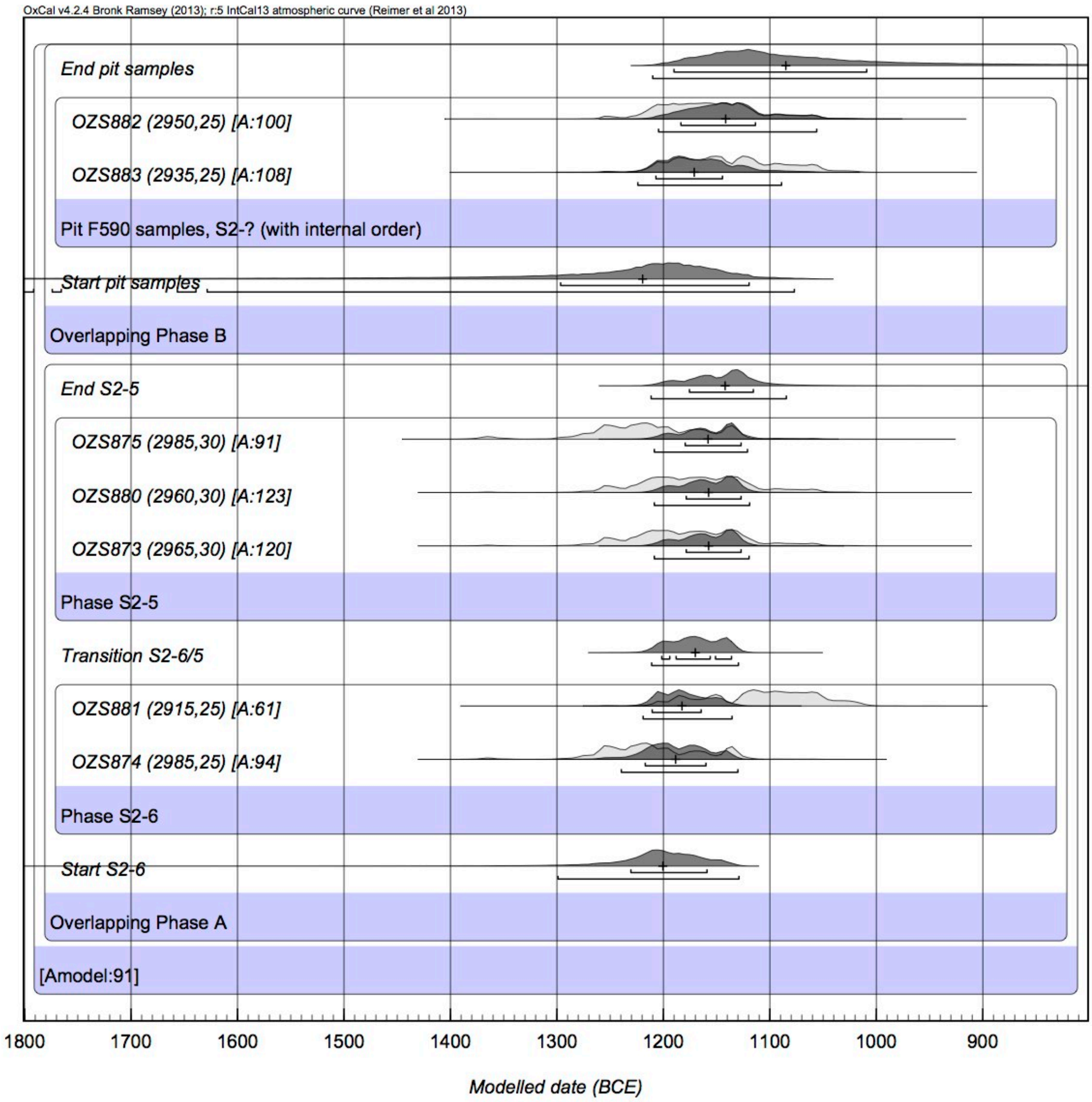

Figure 31 Bayesian model assuming the 'Option 2' interpretation of stratigraphy. Here we have two overlapping phases. We maintain the attribution of samples to phases S2-5 and S2-6, but allow the deepest two samples (and associated pit 15/S2/F590) to postdate S2-7. Aside from the overlapping phases themselves, the internal arrangement is according to stratigraphy, proceeding chronologically from bottom to top. On the left each date is specified by laboratory number, with the uncalibrated date in curved brackets and the agreement index in square brackets. Modelled 'posterior' probability distributions are shown in dark grey, and the likelihood (probability distribution for independent calibrations) is shown in light grey.

Chapter 8 Comparison with Radiocarbon Data from Other Sites

In this section we will make some basic comparisons with existing radiocarbon data from the Southern Levant. At present this can only be usefully done for the Middle and Late Bronze dates of Azekah.

8.1. Destructions at the end of the Middle Bronze Age

The Middle to Late Bronze Age transition is marked by destructions at many sites across the Southern Levant (Weinstein 1981: 2-5). Comparison of material culture indicates that these events did not occur in one wave, but were spread over more than a century, from the late 17th century to the end of the 16th century BCE (Bunimovitz 1992a; 1998: 322). Traditionally these have been attributed to Egyptian activity following the siege of Avaris (Tell el-Daba), the fall of Sharuhen (Tell el-Ajjul) and the expulsion of the Hyksos.[48] Textual support for this is severely lacking, however, suggesting that other explanations are needed.[49] While Egyptian raids could have contributed, a multi-causal model is needed to explain the collapse of Middle Bronze Age society, with internal as well as external factors (Ilan 1998: 314-315).[50]

Pottery from the MB destruction layer at Azekah has not yet been analysed in detail, and therefore it cannot be confidently attributed to a specific part of MB II-III. Hence from a material culture point-of-view, a connection with the widespread destructions that marked the Middle to Late Bronze Age transition remains tentative. It is worthwhile, however, comparing our two radiocarbon dates with published dates from destruction layers at other sites.

Radiocarbon dates for final MB layers are available for few sites (see Marcus 2010: 249). The best series from recent excavations is from Megiddo (level K10 in Toffolo et al. 2014); the dates fall in the 16th century BCE, though there is no destruction for this period. A multiplot of radiocarbon data for sites with MB III destruction levels is shown in Figure 32 together with the MB II-III dates from Azekah. Notably the sites—Lachish, Jericho and

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[48] Weinstein (1981); Dever (1990); (1992: 13-14); and Burke (2010).

[49] Shea (1979: 3-4); Redford (1979); Hoffmeier (1989); and Höflmayer (2015)

[50] A variety of other contributing factors have been suggested: internecine warfare, migrations, conflict between the retreating Hyksos and the Canaanite city-states, and natural disasters (Bienkowski 1986; Bartlett 1982; Bimson 1981; Na'aman 1994).

Dan—represent a wide geographic range.[51] The background of each dataset is as follows:

- The Jericho samples were obtained during Kenyon's excavations in the 1950s (Kenyon and Holland 1981) and dated in the 1990s (Bruins and van der Plicht 1995; 2003). Despite the disadvantage of utilising material from early excavations (refer Section 2.5), the precision of the measurements is high and a significant number of short-lived samples are included.[52]
- The Lachish dates come from the destroyed MB III palace (level P-4; refer to Ussishkin 2004d). Most samples were obtained and dated in the early 1990s, but several in earlier decades (Carmi and Ussishkin 2004). Six samples are from wood charcoal and one from seeds.
- Dan stratum IX (MB III) was destroyed in a fierce conflagration.[53] Two unpublished dates were made available to me by the current excavator, David Ilan.[54] Sample details and calibrated data are provided in Table 9 below.

Table 9 Previously unpublished MB III dates from Tel Dan (provided by David Ilan). They have been calibrated using OxCal version 4.2.4 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer et al. 2013).

							Calibrated Dates (BCE)		
Sample Name	**Lab No.**	**Field No.**	**Locus No.**	**Material**	**Context**	**^{14}C Age ± 1σ yrs BP**	**1σ (68.2%) range**	**2σ (95.4%) range**	**μ**
Dan 01	GrA-9757	24910	7545	Fine ash mixed with silt	On surface, Stratum IX	3360 ± 40	1733 – 1718 (7.0%) 1694 – 1613 (61.2%)	1746 – 1596 (81.9%) 1589 – 1531 (13.5%)	1651
Dan 25	GrN-22535	23148	4652	Olive pits	Burial jar of infant under floor Stratum IX	3290 ± 20	1611 – 1594 (15.3%) 1589 – 1532 (52.9%)	1618 – 1513 (95.4%)	1568

[51] Four dates exist for the MB III at Beth Shean (level R-3), but the destruction evidence is not clear-cut (Mazar 2003; 2010; Mazar and Mullins 2007). In any case, the dates are not helpful and all are from wood charcoal; two dates are far too early while the others sit in the 17th and 16th centuries. One sample from the MB III destruction at Shechem was processed in 1970 (Seger 1972: 31; Weinstein 1984: 347), but it falls too early and has poor precision (3510 ± 120 BP).

[52] The recent Italian-Palestinian expedition published two samples from a destroyed MB building, but the context is MB II, pre-dating the MB III destruction (Marchetti 2003: 315; 2000: 206; Lombardo and Piloto 2000). Both these dates have large uncertainties.

[53] The ca. 1 m deep destruction layer was encountered in multiple areas (B, B1, M and Y). The Middle Bronze strata of Tel Dan are not published, but see Biran (1994; 1996) and Ben-Dov (2011: 15).

[54] The dates were processed at the Groningen radiocarbon laboratory, in cooperation with Johannes van der Plicht and Hendrik Bruins.

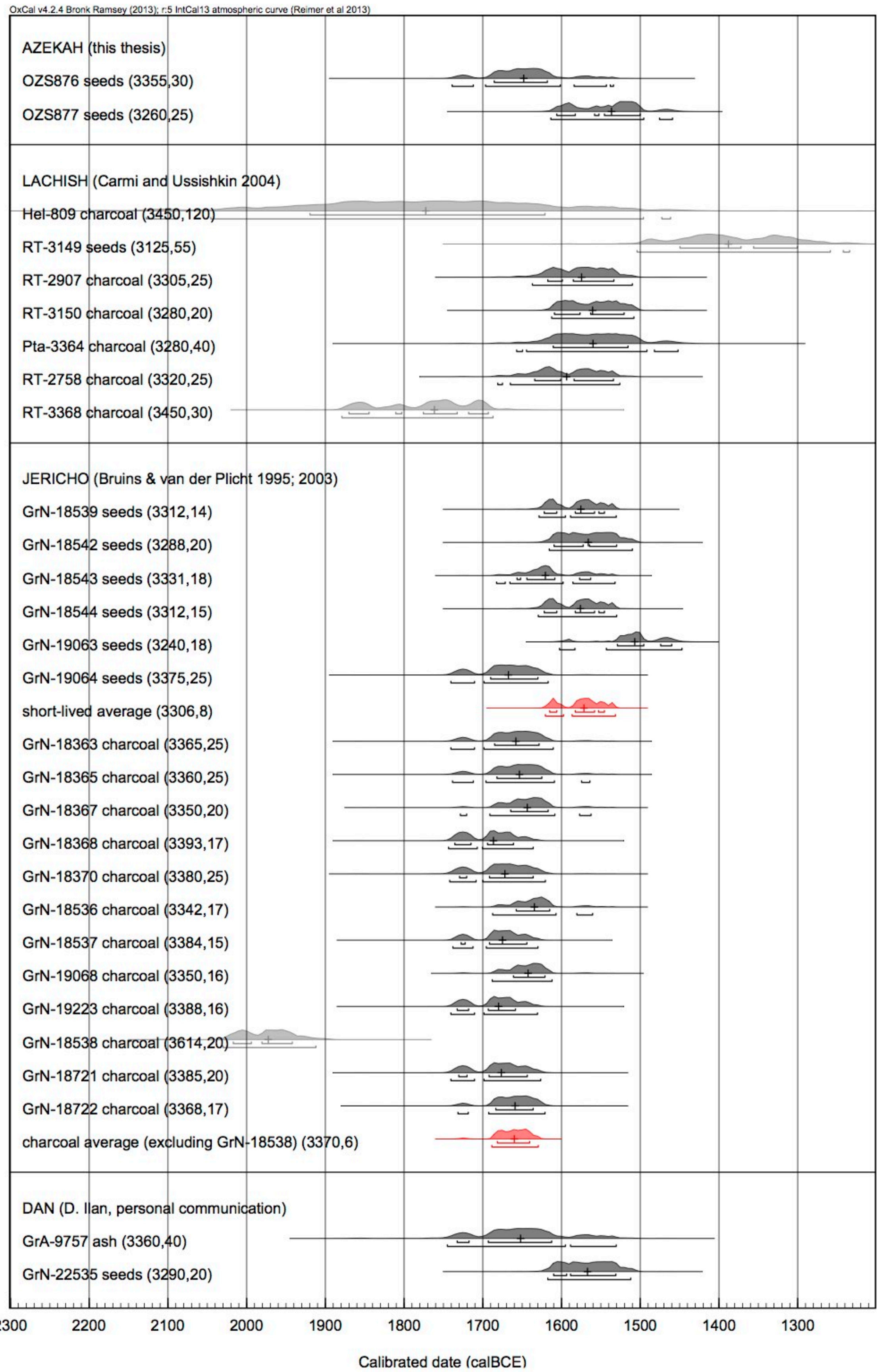

Figure 32 Comparison of Azekah MB II-III dates with radiocarbon data from well-established final MB destruction events at Lachish, Jericho and Dan. All dates were calibrated using OxCal version 4.2.4 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer et al. 2013). Note that samples described as “charcoal”, are from wood or unknown sources. Clear outliers are shown in light grey; averages are marked in red.

A comparison of the calibrated dates indicates the following:

- Four wood charcoal samples from Lachish give a consistent date range in the 16th century BCE (or very late 17th century) for the destruction of the P-4 palace.[55] Unfortunately the single short-lived date seems to be an outlier as it falls much too late. The two other charcoal samples fall too early (Hel-809 and RT-3368).

- The Jericho dates are very consistent. Unsurprisingly the charcoal gives an earlier date, probably reflecting a construction phase (Bruins and van der Plicht 1995: 217; 2003: 37). The short-lived samples favour a late 17th to 16th century date, and are more likely to reflect the date of the destruction.

- GrA-9757 from Tel Dan gives a date falling mainly in the 17th century BCE; however the sample material is vulnerable to old effects. The second sample (GrN-22535) is more reliable: olive pits from a jar burial just beneath the destroyed floor. As a burial, the date provides a terminus post quem for the destruction but probably does not predate the event by more than a few decades. The 1σ and 2σ ranges fall in the late 17th to 16th centuries BCE.

- If these destructions indeed represent the end of the Middle Bronze Age, they tend to place it closer to the mid-16th century rather than 1500.

The current weight of radiocarbon evidence supports destruction at multiple sites some time between the late 17th through 16th century BCE. Until better data sets from more sites are available, little can be said from radiocarbon regarding the temporal spread of the destructions within this timeframe; however the data is consistent with the accepted view of a long sequence of events.

The later date from S1-11 at Azekah fits best with the common trend from the other sites. As discussed in Section 6.2.1, this date (OZS877) is from a better context than OZS876 which falls earlier. Hence OZS877 seems more likely to reflect the destruction event. However this must be clarified by further radiocarbon dating (and a detailed analysis of the pottery).

Obtaining better data sets for the end of the MB (and LB I) is essential. Dates from destruction levels will improve our understanding of the timing and process for the MB collapse in the Southern Levant. More generally, detailed sequences from MB II-III and

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[55] This should be considered a terminus post quem for the P-4 destruction, due to possible 'old wood' effects.

LB I levels would contribute greatly to the chronological debates affecting this period across the Mediterranean region (focal points being the Santorini and the strata of Tell el-Daba).[56]

8.2. Late Bronze dates

Published radiocarbon sequences that may be compared with the dates from Area S2 derive from Megiddo (Toffolo et al. 2014), Lachish (Carmi and Ussishkin 2004), Tel es-Safi (Asscher et al. 2015a) and Qubur el-Walaydah (Asscher et al. 2015b). Two of these sites are located close to Azekah.

8.2.1 Megiddo

The best-sampled Late Bronze strata in the Southern Levant are from Area K of Megiddo. The modelled data for level K7 (LB IIB), and possibly also K6 (LB III especially the dates representing its occupation), fit with S2-6 / S2-5 at Azekah.

8.2.2 Lachish

Located much closer to Azekah – and as the major Late Bronze Age site of the Shephelah – Lachish deserves consideration despite the limitations of its radiocarbon data. Here the LB IIB and LB III are covered by some 18 dates (Carmi and Ussishkin 2004),[57] which derive primarily from Area S, P and GE.[58] There is considerable scatter in the data, and only five dates are from short-lived samples; some dates were measured in the 70s-80s and have large uncertainties. Nevertheless, when the short-lived samples are modelled using OxCal phases (Figure 33 below), the 2σ probability range for stratum VII (LB IIB) extends from the late 13th century to ~1120 BCE. The 2σ range for stratum VI (LB III) sits mainly in the 12th century but extends into the early 11th century BCE.[59] Both strata ended in

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[56] Tell el-Daba is an important link in establishing chronological connections between Egypt and the Levant. Currently a discrepancy of some 100 years persists between scientific and ceramic-based dating (Kutschera et al. 2012). This is despite other radiocarbon work supporting Egyptian chronology for the New Kingdom (Bronk Ramsey et al. 2010; Shortland and Bronk Ramsey 2013). For the dating of the Santorini eruption see Heinemeier and Friedrich (2009), Bietak (2013), Manning et al. (2014) and further literature.

[57] Note that the excavations at Lachish led by Ussishkin used somewhat different designations for Late Bronze Age divisions (Ussishkin 2004a: 57). LB IIIA in the excavation reports corresponds LB IIB here, and LBIIIB is equivalent to LB III.

[58] For the context information refer to: Barker and Ussishkin (2004); Ussishkin (2004c; 2004b)

[59] Despite the scatter of the data, even the charcoal dates exhibit a trend placing the LB IIB – LB III phases in

destruction; Ussishkin placed the destruction of stratum VII ca. 1200 BCE and that of Stratum VI ca. 1130 BCE (Ussishkin 2004a: 57).

Comparing Figure 33 with the Option 2 model for Azekah Area S2 (Figure 31) it appears that S2-6 / S2-5 fit better with Lachish stratum VII than VI, though it is difficult to be conclusive about this based only on the (available) radiocarbon data. This seems even clearer if we consider that OZS881 (a possible outlier) is constraining the S2-5/6 probabilities perhaps a few decades later than may be the case (see Section 7.2.2). This correlation makes good sense in view of the fact that the succeeding (and final) LB phase of Area S2 (S2-4) was most likely destroyed in the same event as the buildings of Area T2 (phase T2-3a).[60] The pottery of T2-3a has been shown to parallel Lachish stratum VI (Metzer 2015).

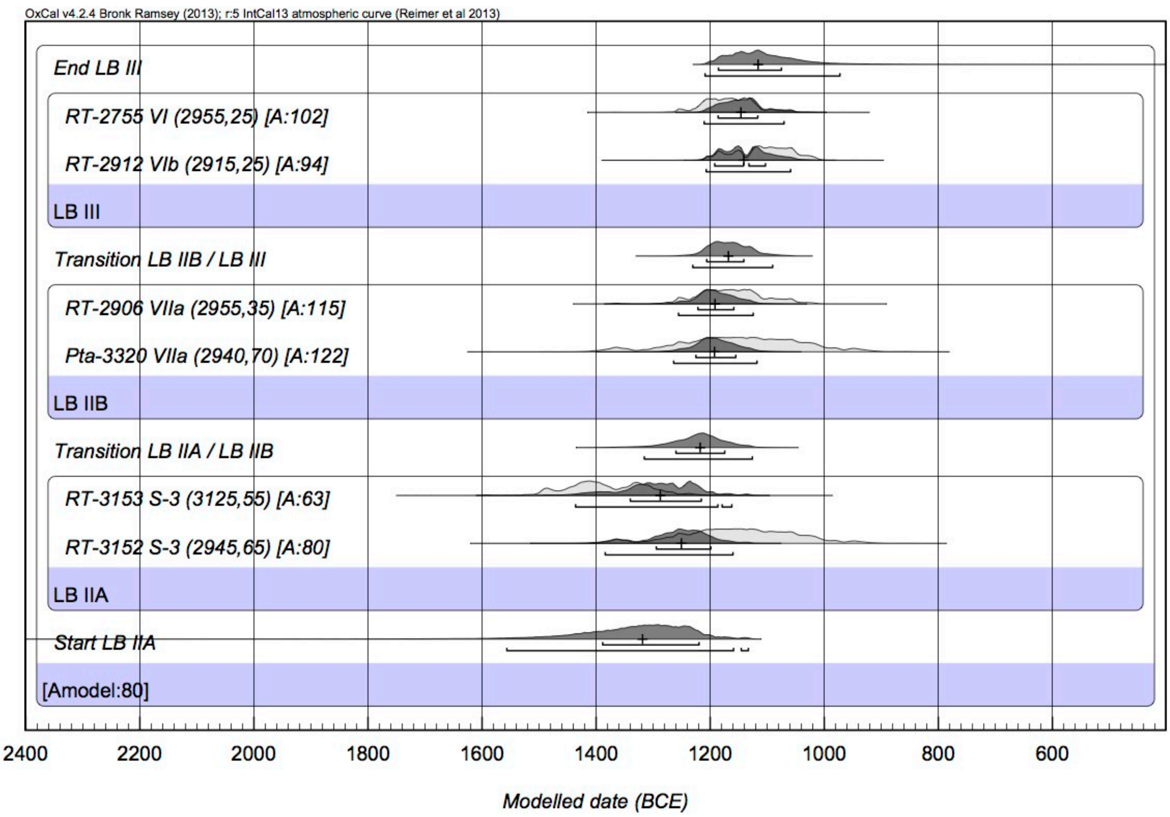

Figure 33 Bayesian model for short-lived samples from Area S of Late Bronze Lachish. One obvious outlier, RT-2754 is excluded.[61] Pta-3320 is included with caution: some wood charcoal was mixed with the seeds, yet the result appears consistent with the other dates.

the late 13th through 12th centuries.

[60] Detailed analysis of pottery from S2-4 has not yet been completed.

[61] There are two short-lived samples from Area P, however one is an obvious outlier and the other has a high uncertainty. In any case, analyzing samples from a single excavation area is preferable.

8.2.3 Qubur el-Walaydah and Tell es-Safi

Qubur el-Walaydah is located on the Nahal Besor in southern Israel – well south of the Shephelah region. As part of an effort to date the Late Bronze to Iron Age transition, dates were obtained from an "Egyptian" building complex (Asscher et al. 2015b). The unmodelled dates from phases 1-6 and 1-5e (attributed to LB IIB / LB III) compare well with the S2-5 / S2-6 dates from Azekah. The Bayesian model, however, restricts the probability range to the first half of the 13th century BCE. No material from the next LB phases (1-5a to 1-5c; LB III) was dated, but the model (which also includes Iron IB samples) suggests contemporaneity with S2-5 / S2-6 at Azekah.

A series of dates was published for Tell es-Safi, where the authors argue for an earlier Late Bronze to Iron Age transition in the south of Israel than in the north (Asscher et al. 2015a). The LB IIB samples from Areas A and P give dates consistently higher than we have obtained in S2-5 / S2-6 at Azekah. The best match for unmodelled dates is from Area F (stratum F2, LB III) (originally published in Toffolo et al. 2012). Similar to at Qubur el-Walaydah, however, the Bayesian model restricts the probability range of phase F2 to the 13th century, implying that material from well into the LB III or even the beginning of IA IB (!) might be contemporary with S2-5 / S2-6 at Azekah.[62] This is clearly problematic. The material from S2-5 and S2-6 seems to be LB IIB (subject to further analysis); and as explained above, phase S2-4 was probably destroyed in LB III. This apparent inconsistency between two very close sites serves to underscore the need for more radiocarbon work at both locations.

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[62] Compare the modeled Azekah dates with the modeled A6 dates from Tel es-Safi. Note level A6 contains material culture comparable to Megiddo levels H10/H11 and K5 (overall stratum VIB), whose dates fall in the 11th or very late 12th centuries.

Chapter 9 Conclusions and Future Directions

The research presented in this thesis is the first stage of long-term radiocarbon work planned for Tel Azekah. It involved radiocarbon-dating fifteen samples from different parts of the site – a dataset that provides a starting point for establishing directions and priorities for ongoing research. A second aspect of this initial research was field involvement, which allowed the author to: a) develop a good understanding of the site's stratigraphy, especially Area S2; and b) begin implementing specific excavation techniques to facilitate targeted collection of datable material.

Each of the fifteen samples were well-preserved and short-lived; the availability of this kind of material across the tell and through the various strata is very promising for continuing research. Results from the initial data set, along with involvement onsite, has helped to better develop the methodology and working procedures for effective and well-integrated radiocarbon research.

Among the results presented in this thesis, series of dates from stratigraphic sequences and dates obtained from clusters provided the most reliable and useful information. In particular the sequence of dates from Area S2 allowed us to date a major building and to suggest correlations with similar phases at other sites. The sequence of dates for Late Bronze phases has excellent potential for improvement and expansion in future research. A single date from a cluster found amid Middle Bronze destruction evidence seems to have dated the event and suggests a connection with a broader destruction phenomenon. When surprising results were obtained (for example OZS878), the dates from series and clusters were able to contribute to a reconsideration or modification of context interpretation.

Measurements made on a single pit (not from a cluster) to indicate the date of one phase – without dating preceding or following phases in the same area – generally proved unfruitful (with the exception of OZS872). This approach should be avoided in future; it is better to focus more measurements on effectively establishing the chronology of just a few areas or key contexts and not 'spreading oneself too thin'.

The discussion regarding S2-7 and pit 15/S2/F590 illustrates that radiocarbon dating is helpful not just for establishing the site's absolute chronology but also as a valuable contributor for debating the stratigraphy, alongside visual observations and ceramic typology. If radiocarbon research is progressed alongside the excavations, it can be an active part of the interpretation process, adding data that often becomes available only in the later stages of an excavation project (or after it is over).

9.1. Fieldwork Recommendations

Fieldwork can be fine-tuned to better support radiocarbon dating in two fundamental ways: 1) improvements to routine aspects of excavation; 2) focusing efforts to obtain datable material from specific strata/phases and contexts. The first requires effective communication with team members and volunteers so that key criteria are understood by all. The main concern is to adequately identify seed clusters and record their location. The retrieval method (sieving, field-picking) should be clearly noted for all seeds.

During the 2015 season I began to implement targeted collection of datable material, with excellent support from the excavation team. Selective use of fine dry sieving was used to obtain more material from good contexts (e.g. inside tabuns and kilns). If particular loci are high priorities for radiocarbon dating, but the material is poor in organic material, we found that persistent effort with dry sieving often prevails. Ways in which some material can be processed by finer dry sieving alongside our existing wet-sieving program may be considered in future.

In the 2015 season I also began sampling from exposed sections where the stratigraphy is well-defined. This is limited by the small quantities of material that can be extracted and sieved. A more effective approach, to be used in following seasons, is to excavate down through a 'slice' following the stratigraphy in the section.

Finally, use of 'micro' proxies to better characterise sample contexts is planned. As an initial measure, soil samples are now collected along with many of the best seed samples.

9.2. Chronological Outcomes of Initial Dating

Initial work at Tel Azekah has succeeded in establishing the first 'pegs' for a radiocarbon-based absolute chronology.

- The Middle Bronze destruction level evident in Area S1 most likely dates to the 16th century BCE, though further work is necessary to establish this firmly. It is best understood as part of the destruction pattern that characterised many Southern Levantine sites at the end of the period. The radiocarbon date from the best context at Azekah (14/S1/L312) is consistent with radiocarbon data from the MB III destructions of Lachish (P-4), Jericho (City IV) and Dan (stratum IX).
- The public building of Area S2—a major feature of the Late Bronze Age lower city—was shown to date between the late 13th and ~1130 BCE. The two phases of the building (S2-6, S2-5) seem to be parallel to Lachish stratum VII; this is supported by typological studies showing that the T2-3a destruction level parallels Lachish VI. The public building appears contemporary with K7 and perhaps part

of K6 at Megiddo. The difficulties establishing a good correlation with nearby Tel es-Safi need to be explored further.

- Persian period occupation close to 400 BCE is evident. The burial in cistern 12/S2/F518 of Area S2 seems contemporary with activity in Area S1 above the adjacent slope (though further work is required to properly establish the dates of S1-2 and S1-4).

9.3. Future Work

Following the methodology and work procedures for site-based radiocarbon dating discussed in this thesis, there is excellent potential for progressively adding reliable 'pegs' to the chronology of Azekah. Goals for future work that build upon the first series of results are as follows:

- The Late Bronze sequence in Area S2 will be improved and expanded. The phases immediately preceding and following the public building (i.e. S2-7 and S2-4) are a high priority. The date of S2-7 will be clarified using a large seed cluster found during the 2015 season.[63] Some existing samples for S2-4 are under consideration; this layer will be excavated further in 2016, at which point it is hoped that further samples can be obtained. Further radiocarbon dating should be paralleled by a more detailed examination of the Area S2 pottery. Establishing a solid Late Bronze sequence will allow engagement in important chronological dialogues in the Shephelah and further afield.
- Bone from the skeleton in 14/T2/L407 should be processed in order to better establish the date of the T2-3a destruction.
- More seeds from 14/S1/L312 in the MB II-III destruction will be processed to determine the date of this event more firmly, and hence also its correlation with MB III destructions at other sites. Samples may become available from other areas soon.
- More seeds from the cluster in 14/S1/L361 will be processed to resolve the date of this context and to better understand the Persian / Iron Age activity in Area S1.
- In the coming seasons more secure contexts from the Iron Age, Persian and Hellenistic periods will be actively sought. Several samples from such contexts were obtained during the 2015 season.

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[63] The context is secure: the seeds were found embedded in the S2-7 floor (15/S2/F590) at a location with secure architectural connections and far from pit 15/S2/F590.

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Appendix A Sites with Published Radiocarbon Data: Early Bronze to Iron Ages

The maps in Figures 4 and 5 were generated using the information in the table below. The table includes Early Bronze through to Iron Age dates for sites in Cisjordan as well as those close to the Jordan Valley (both sides). Inland Transjordanian sites are not covered. Unfortunately no radiocarbon database is currently available for historic periods, as it is for prehistoric periods.[1] The data collated here covers the great majority of sites but is not exhaustive. Persian and Hellenistic dates are not shown here: radiocarbon has been used very sporadically for these periods.

Three colour grades indicate the number of samples dated at each site. Note that I have endeavoured to count samples rather than determinations.

- 0-5 samples
- 6-15 samples
- 16+ samples

Table 10 List of sites with published radiocarbon data. Sites within Cisjordan and close to the Jordan Valley are included (but not inland Transjordan).

	EB	MB	LB	IA	References
COASTAL PLAIN (NORTH)					
Achzib					Carmi (1987)
Kabri					Bonani and Wolfli (1992); Regev et al. (2012b)
Akko					Carmi (1987); Carmi and Segal (1992)
Tel Keisan					Sharon et al. (2007)
Rosh Zayit					Sharon et al. (2007)
Tel Abu Hawam					Carmi and Segal (1992)
NORTH OF GALILEE					
Tel Dan					Segal and Carmi (1996); Bruins et al. (2005a); David Ilan (personal communication)
Hazor					Segal and Carmi (2004b); Sharon et al. (2007)
Tel Sasa					Segal and Carmi (1996); Stepansky et al. (1996); (2004b);
GALILEE AREA					
Bethsaida					Sharon et al. (2007); Arav and Boaretto (2009)
Et-Tabgha					Segal and Carmi (1996);
Tel Hadar					Sharon et al. (2007)
Beth Yerah					Carmi and Segal (1992); Segal and Carmi (1996); (2004b); (2006); Paz (2010); Regev et al. (2012b);
JEZREEL VALLEY					
Yokneam					Sharon et al. (2007)
Megiddo					Carmi and Segal (2000); Segal and Carmi (2004b); Boaretto et al. (2005); Boaretto (2006); Sharon et al. (2007); Regev et al. (2012b); Gilboa et al. (2013); Regev et al. (2014); Toffolo et al. (2014)
Sulem					Sharon et al. (2007)
Tel Amal					Segal and Carmi (1996);

[1] See http://context-database.uni-koeln.de/

Tel Eshturi					Segal and Carmi (2004b);
Beth Shean					Segal and Carmi (1996); Mazar and Carmi (2001); Mazar (2003); Segal and Carmi (2004b); Carmi et al. (2007); Mazar and Rotem (2009); Regev et al. (2012b)
Tel Rehov					Mazar and Carmi (2001); Bruins et al. (2003b); (2003a); (2005b); Mazar et al. (2005); Sharon et al. (2007)
Tell el-Hammah					Sharon et al. (2007)
JORDAN RIFT VALLEY WEST					
Tell Yaqush					Hedges et al. (1992); Regev et al. (2012b)
Gesher					Hedges et al. (1990); Housley (1994); Marcus (2003); Garfinkel and Cohen (2007)
Jericho					Burleigh (1981); (1983); Weinstein (1984); Bruins and van der Plicht (1995); Lombardo and Piloto (2000); van der Plicht and Bruins (2001); Bruins (2003); Regev et al. (2012b);
Cave 38					Segal and Carmi (1996);
Cave of the Sandal					Segal and Carmi (1996); (2004b);
Hazeva					Segal and Carmi (1996); (2004b);
Uvda					Avner et al. (1994); Segal and Carmi (1996); Avner and Carmi (2001); Regev et al. (2012b)
Ma'ale Shaharut					Carmi and Segal (1992); Avner et al. (1994); Avner and Carmi (2001); Regev et al. (2012b)
Yotvata					Segal and Carmi (1996); Avner and Carmi (2001); Regev et al. (2012b)
Samar					Avner et al. (1994); Avner and Carmi (2001); Segal and Carmi (2004b); Regev et al. (2012b)
Timna					Conrad and Rothenberg (1980); Weinstein (1984); Rothenberg (1990); Avner and Carmi (2001); Ben-Yosef et al. (2012); Regev et al. (2012b)
Be'er Ora					Segal and Carmi (1996); (2004b); Regev et al. (2012b)
Shehoret Hill					Avner et al. (1994); Avner and Carmi (2001); Regev et al. (2012b)
Har Shahmon					Segal and Carmi (1996);
JORDAN RIFT VALLEY EAST					
Tell es-Shuna					Philip and Millard (2000); Bronk Ramsey et al. (2002); Philip (2008); Regev et al. (2012b)
al-Basatin					Gibbs et al. (2010); Regev et al. (2012b)
Pella					Bourke (2006); Bourke and Zoppi (2007); Bourke et al. (2009); Bourke and Jacobsen (2010)]; Regev et al. (2012b); Wild and Fischer (2013); Wild et al. (2013);
Tell Abu en-Niaj					Bronk Ramsey et al. (2002); Regev et al. (2012b)
Tell el-Hayyat					Bronk Ramsey et al. (2002); Marcus (2003); Falconer and Berelov (2006) Marcus (2010)
Tell Abu al-Kharaz					Fischer (2003); (2006); Higham et al. (2007); Stadler and Fischer (2008); Regev et al. (2012b); Fischer and Bürge (2013); Wild and Fischer (2013);
Tell es-Sa'idiyeh					Pritchard (1985); Ambers and Bowman (1998); Regev et al. (2012b)
Bab edh-Dhra					Crane and Griffin (1970); Callaway and Weinstein (1977); Rast et al. (Rast et al. 1980); Rast and Schaub (2003); Regev et al. (2012b)
Numeira					Rast et al. (1980); Weinstein (1984); Regev et al. (2012b)
Faynan Area					Hauptmann (2000); Avner and Carmi (2001); Ben-Yosef et al. (2010); Higham et al. (2005); Levy et al. (2004; 2005; 2008; 2010); Regev et al. (2012b)

SHARON PLAIN					
Tel Sahar (Megadim)					Segal and Carmi (2004b);
Atlit					Carmi and Segal (1992); Segal and Carmi (1996); Haggi (2006);
Tel Nami					Hedges et al. (1997); (1998); Bronk Ramsey et al. (2002); Marcus (2003)
Dor					Carmi (1987); Sharon (2001); Gilboa and Sharon (2001); (2003); Sharon et al. (2005); (2007)
En Haggit					Segal and Carmi (2004b);
Tel Ifshar					Hedges et al. (1997); Bronk Ramsey et al. (2002); Marcus (2003); Marcus (2013)
Aphek-Antipatris					Sharon et al. (2007); Boaretto et al. (2009)
Tel Qasile					Boaretto et al. (2005); Sharon et al. (2007);
SHEPHELAH					
Gezer					Dever et al. (1974); Callaway and Weinstein (1977); Regev et al. (2012b)
Timnah (Tel Batash)					Bruins et al. (1997)
Beth Shemesh					Sharon et al. (2007)
Hartuv					Carmi and Segal (1992); Mazar et al. (1996); Braun (2001); Regev et al. (2012b)
Horvat Illin Tahtit					Segal and Carmi (1996); Braun (2001); Regev et al. (2012b)
Tel Yarmuth					Carmi and Segal (1992); Regev et al. (2012b); (2012a)
Nahal Yarmut					Segal and Carmi (2004b);
Khirbet Qeiyafa					Bronk Ramsey et al. (2009); Garfinkel and Ganor (2009); Higham et al. (2011); Garfinkel et al. (2012a); (2012b); Garfinkel and Streit (2014); Garfinkel et al. (2015)
Ekron (Tel Miqne)					Sharon et al. (2007)
Tel Harasim					Carmi and Segal (1992); Carmi and Boaretto (2000)
Gath (Tel es-Safi)					Sharon et al. (2007); Toffolo et al. (2012); Shai et al. (2014); Asscher et al. (2015a)
Tel Zayit					Tappy et al. (2006); Sharon et al. (2007);
Tel Erani					Barker et al. (1971); Weinstein (1984); Regev et al. (2012b)
Lachish					Ussishkin (1978); (1983); Weinstein (1984); Carmi and Ussishkin (2004)
JUDEAN HIGHLANDS					
El-Ahwat					Segal and Carmi (2004b); Sharon et al. (2007); Zertal (2012)
Mt Gerizim					Segal and Carmi (2004b);
Shechem (Tell Balata)					Seger (1972); Weinstein (1984)
Nahal Te'enim					Segal and Carmi (1996); (2004b);
Shiloh					Finkelstein and Piasetzky (2006); Sharon et al. (2007);
Khirbet et-Tell (Ai)					Callaway (1972); Kigoshi et al. (1973); Callaway and Weinstein (1977); Weinstein (1984); Regev et al. (2012b)
Gibeon					Pritchard (1964); Stuckenrath and Ralph (1965); Callaway and Weinstein (1977); Weinstein (1984); Regev et al. (2012b)
Nahal Zimri					Carmi and Segal (1992)
Jerusalem					Bronk Ramsey et al. (2002); Frumkin et al. (2003)
Moza					Sharon et al. (2007); Boaretto et al. (2009)
Sataf					Braun (2001); Regev et al. (2012b)

Nahal Refaim					Segal and Carmi (1996); Regev et al. (2012b)
Hebron					Sharon et al. (2007); Regev et al. (2012b)
COASTAL PLAIN (SOUTH)					
Horvat Hani					Segal and Carmi (2004b); Regev et al. (2012b)
Tel Bareket					Paz (2010); Regev et al. (2012b)
Cave 4 (Shoham)					Segal and Carmi (2004b);
Neve Yaraq (Lod)					Segal and Carmi (2004b);
Tel Hamid					Segal and Carmi (2004b);
Modi'in					Regev et al. (2012b)
Rishon Le-Ziyyon Assyrian fortress					Segal and Carmi (2004b);
Palmachim					Braun (2001); Segal and Carmi (2004b); Regev et al. (2012b)
Ashdod					Segal and Carmi (2004b);
Ashkelon					Segal and Carmi (1996); Baumgarten (2004); Braun and Gophna (2004); Segal and Carmi (2004b);(2004a); Boaretto (2008); Regev et al. (2012b)
Tel el-Hesi					Anderson (2006); Regev et al. (2012b)
Tell es-Sakan					Regev et al. (2012b)
Tell el-Ajjul					Gowlett et al. (1987); Gowlett and Hedges (1987); Fischer (2009)
Qubur el-Walaydah					Asscher et al. (2015b)
NEGEV					
Arad					Aharoni (1964); (1967); Vogel and Waterbolk (1967); Callaway and Weinstein (1977); Fishman and Lawn (1977); Weinstein (1984); Regev et al. (2012b)
Lahat					Carmi and Segal (1992)
Har Dimon					Segal and Carmi (1996); Avner and Carmi (2001); Regev et al. (2012b)
Nahal Boqer					Shahack-Gross et al. (2014)
Atar Haroa					Boaretto et al. (2010)
Horvat Haluqim					Bruins and van der Plicht (2005); (2007); Bruins et al. (2012)
En Ziq					Carmi and Segal (1992); Cohen (1999); Avner and Carmi (2001); Segal and Carmi (2004b); Regev et al. (2012b)
Be'er Resisim					Segal and Carmi (2004b); Regev et al. (2012b)
Nahal Ha'Elah fortress					Bruins and van der Plicht (2005); (2007)
Ha-Gamal site					Segal and Carmi (1996); Regev et al. (2012b)
Tell el-Qudeirat (Kadesh Barnea)					Carmi and Segal (1992); Segal and Carmi (1996); Bruins and van der Plicht (2005); (2007); Carmi and Segal (2007) Gilboa et al. (2009)
Kuntillet Ajrud					Meshel et al. (1995); Segal and Carmi (1996); Finkelstein and Piasetzky (2008); Carmi and Segal (2012)

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Appendix B Plans of Late Bronze Age Phases in Area S2

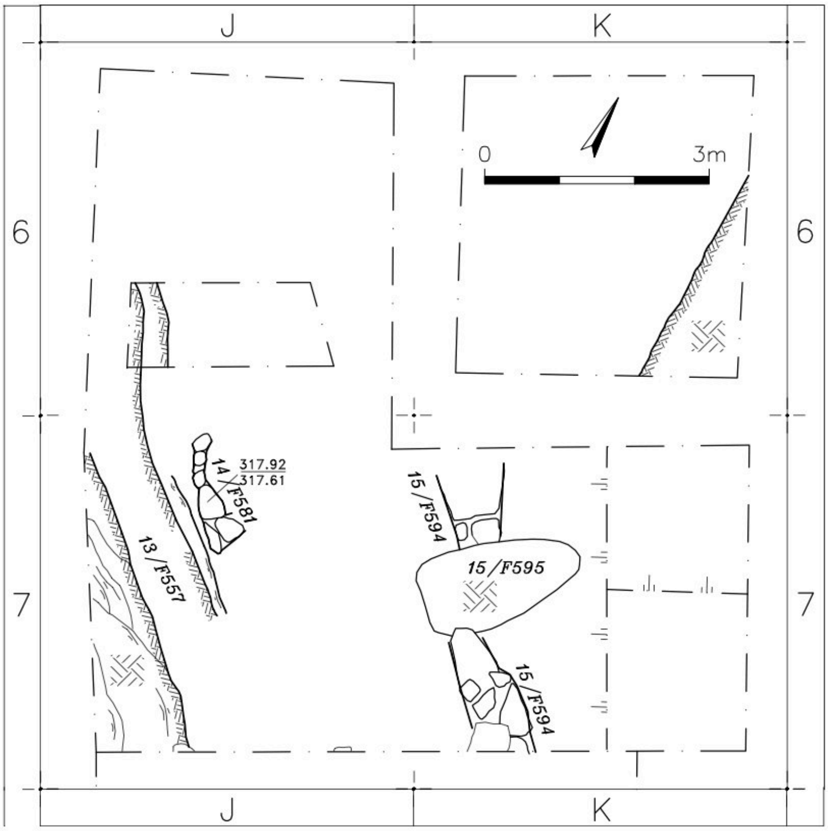


Figure 34 Phase S2-8 / S2-9

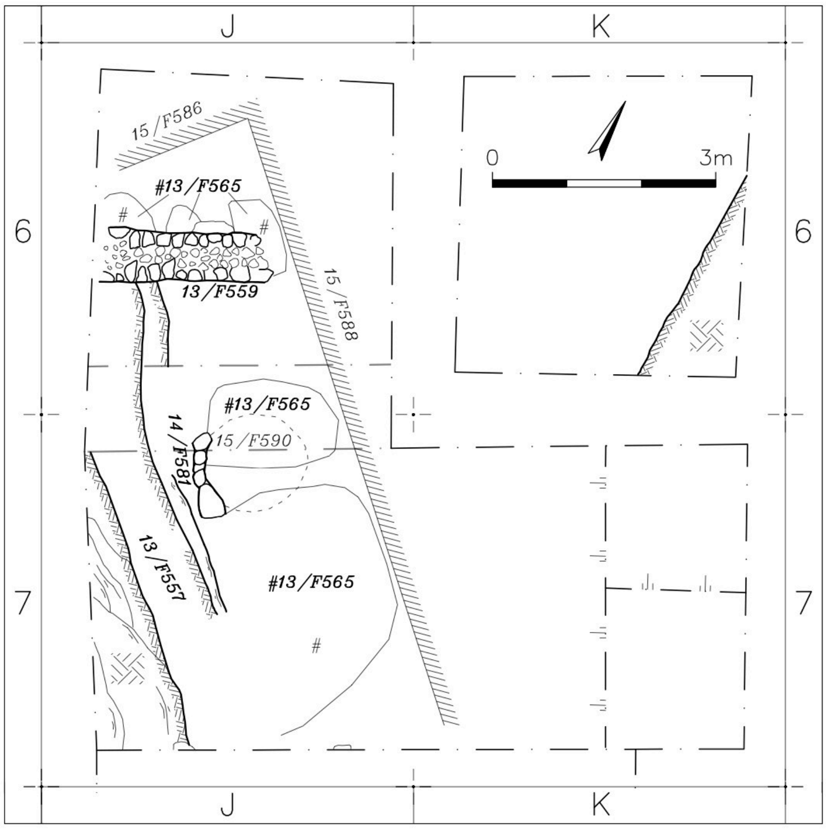


Figure 35 Phase S2-7

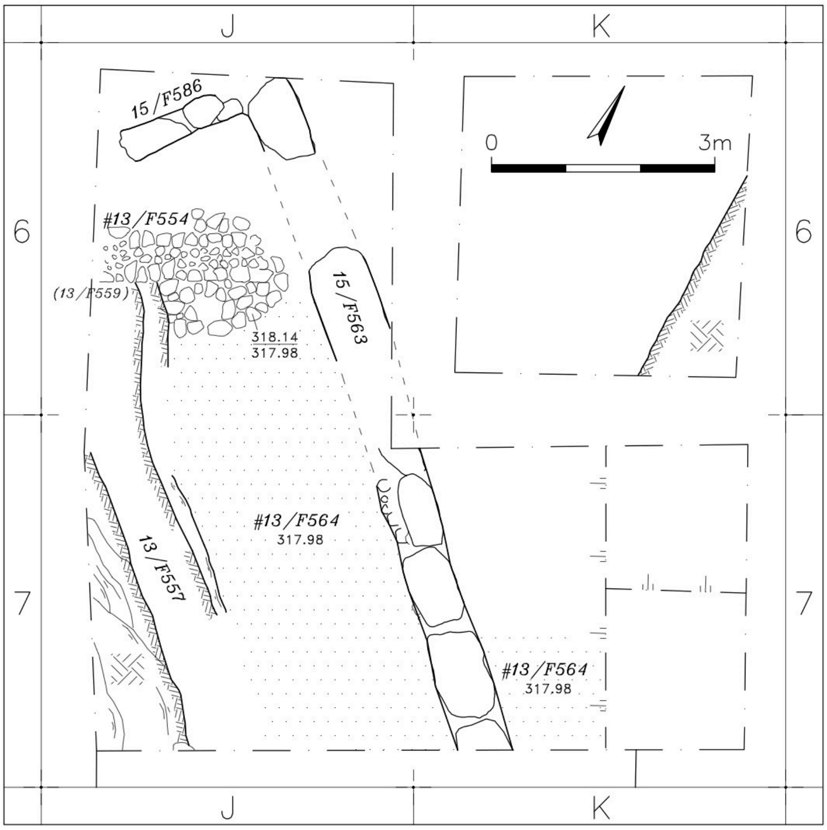


Figure 36 Phase S2-6

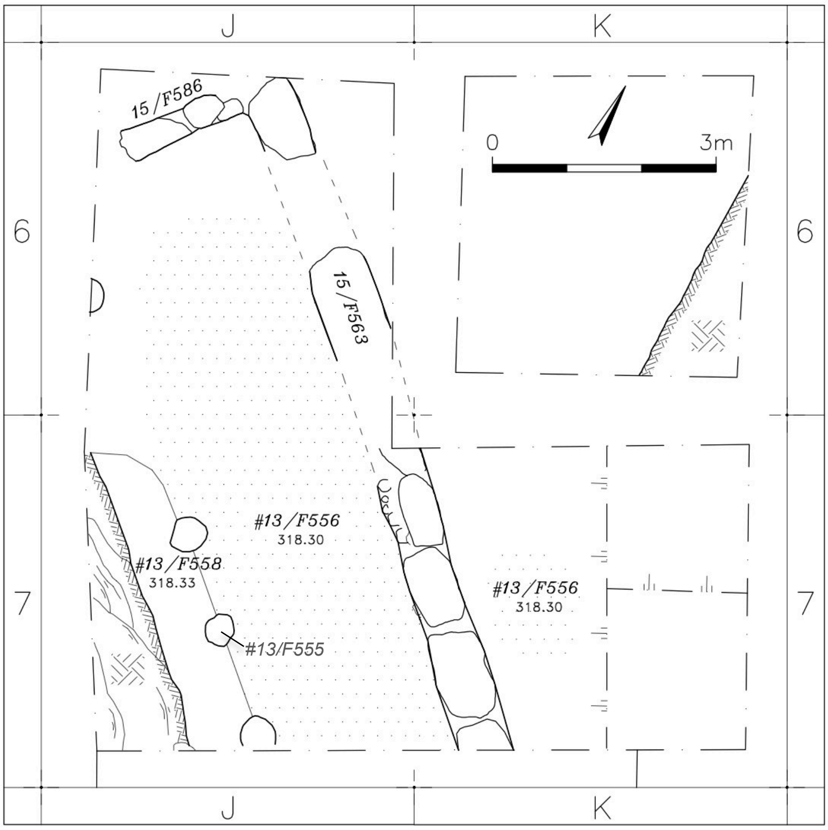


Figure 37 Phase S2-5

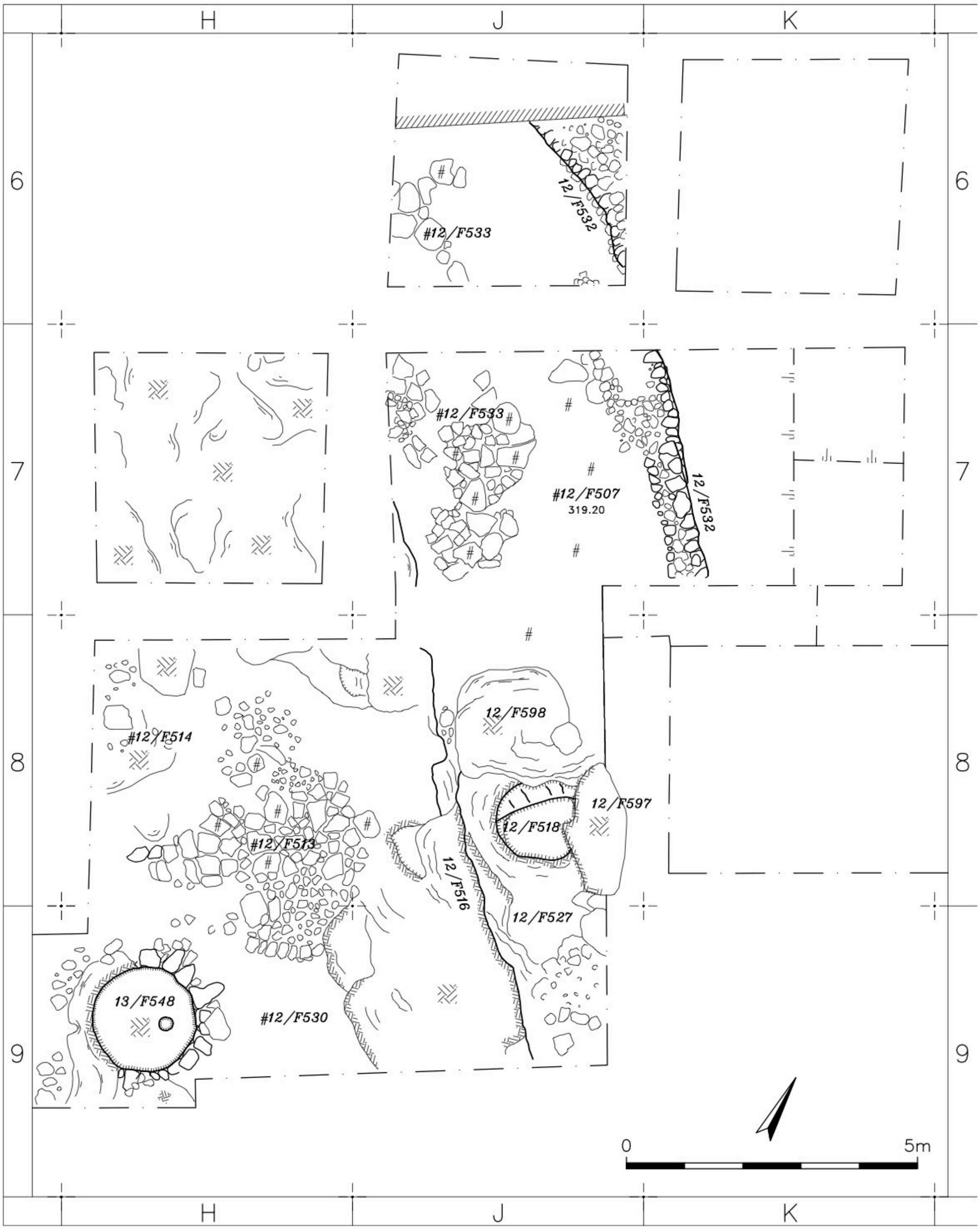


Figure 38 Phase S2-4

Appendix C Supplementary Information for Samples

For the following supplementary plans and images from the Azekah excavation database, please note:

- Loci and feature numbers are often (but not always) prefixed by the season in which they were excavated e.g. 14/L305 (excavated in the 2014 season).
- The # symbol denotes floor surfaces.

C.1 Middle Bronze Age Contexts

<u>OZS876 (S1-11, 14/S1/L305, B12389)</u>

Top plan showing locus 14/S1/L305 on the day the seed sample was taken (24 July 2014):

Photo of locus 14/S1/L305, taken 30 July 2014:

Note: 14/S1/L305 is defined as the whole of this step on the slope. B12389 was obtained from within dark ashy material, among in situ vessels.

Photo of 14/S1/L305, taken on 05 August, 2014:

OZS877 (S1-11, 14/S1/L312, B13017)

Top plan showing locus 14/S1/L312 on the day the seed sample was taken (17 August 2014):

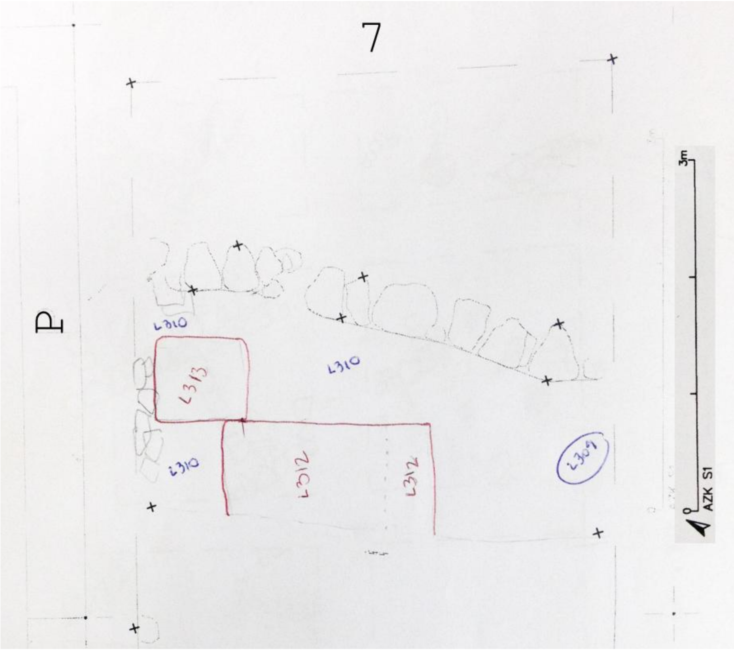


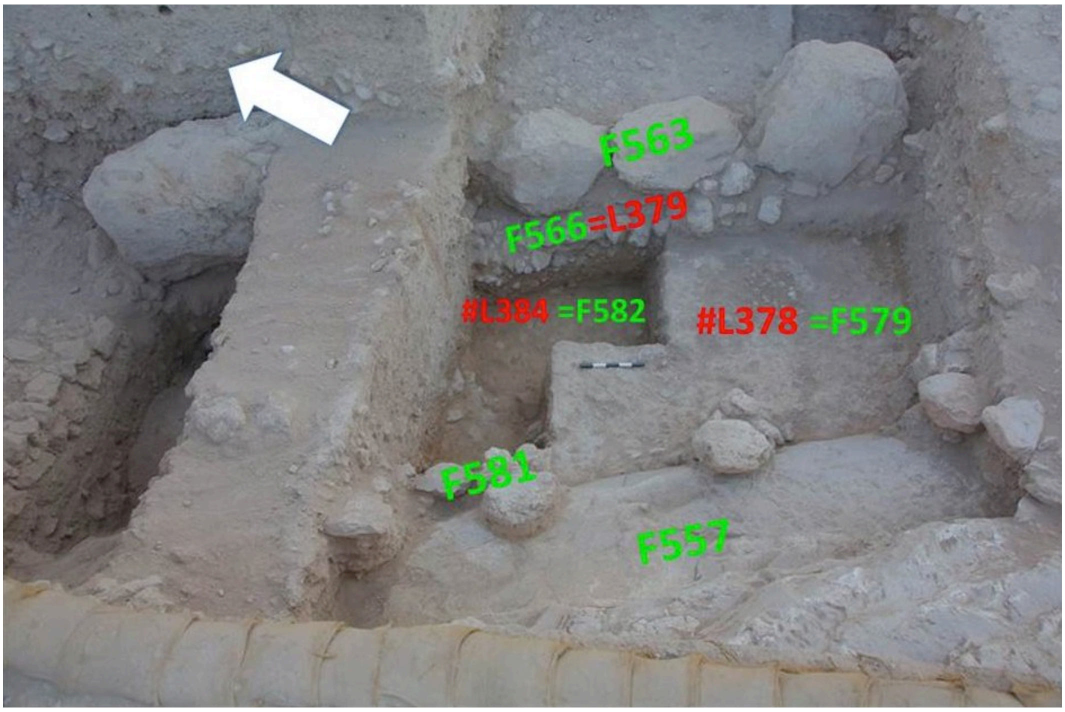
Photo of locus 14/S1/L312, taken 17 August 2014 (the same day the seed sample was retrieved):

Photos of locus 14/S1/L312, taken 20 August 2014:

C.2 Late Bronze Age Contexts, Area S2 (Photos)

OZS883 (S2-7?, 14/S2/L384, B21782)

Photos of locus 14/S2/L384, taken 13 August 2014 (sample collected the same day):




F557
F555
#L378
=F579
F581
#L384 =F582

OZS882 (S2-7?, 14/S2/L378, B21756)

Photos of locus 14/S2/L378, taken 30 July 2014 (sample collected 10 August):

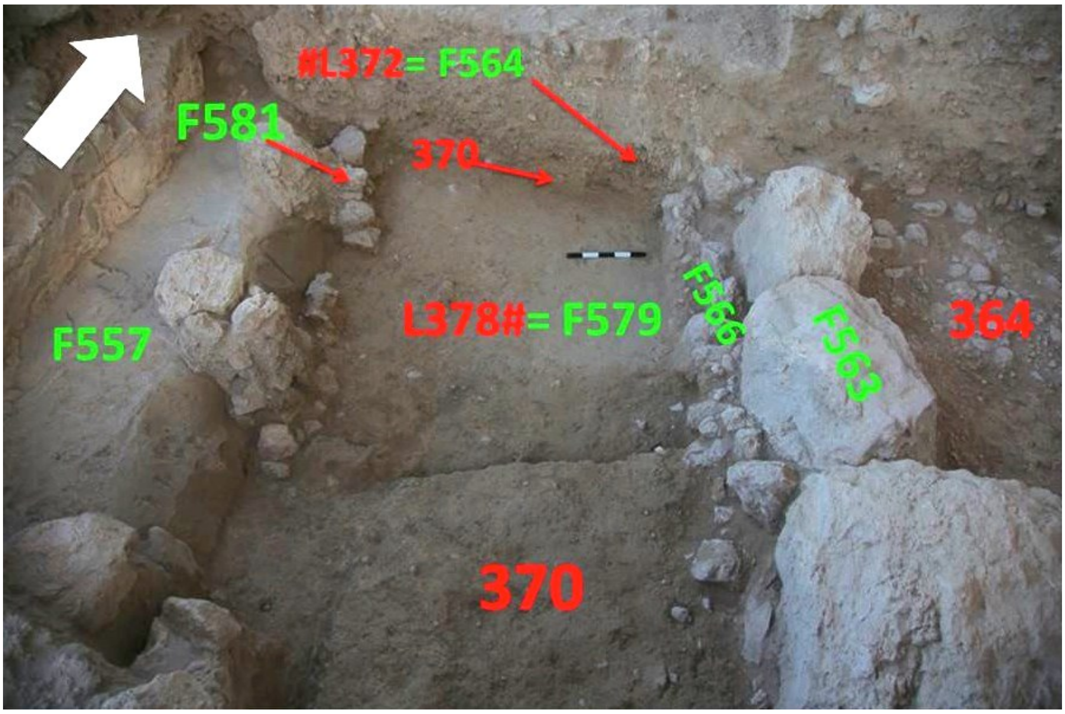
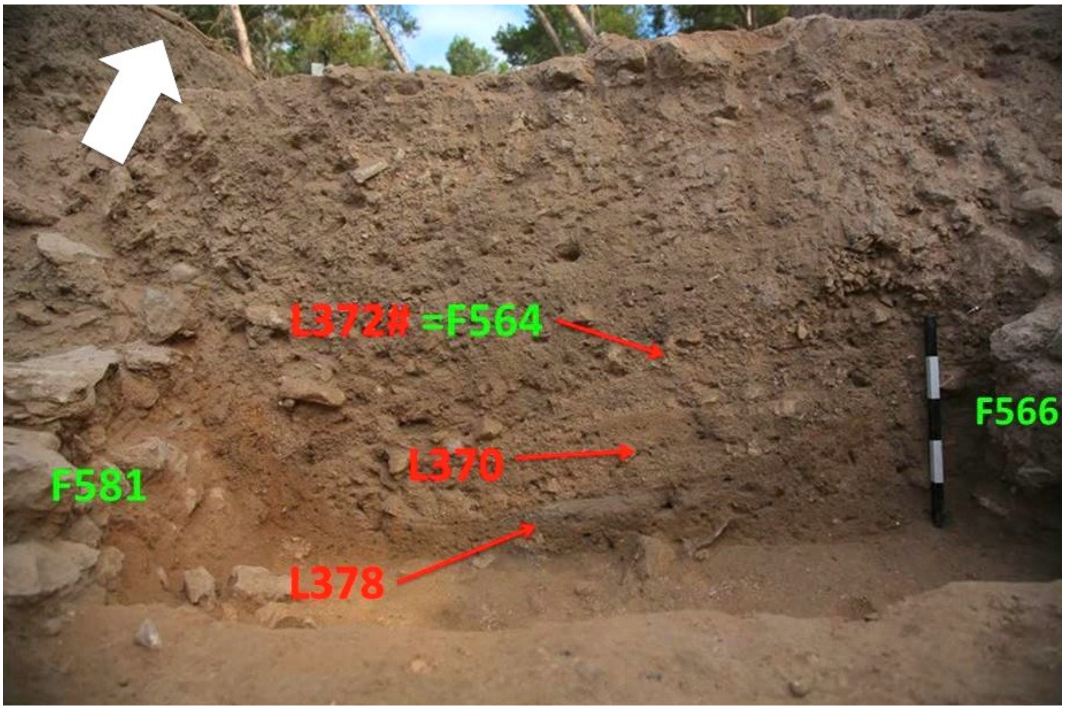


Photo of locus 14/S2/L378, taken 31 July 2014:



OZS874 (S2-6, 13/S2/L294, B21324)

Photo of locus 13/S2/L294, taken 12 August 2013 (sample collected 20 August):

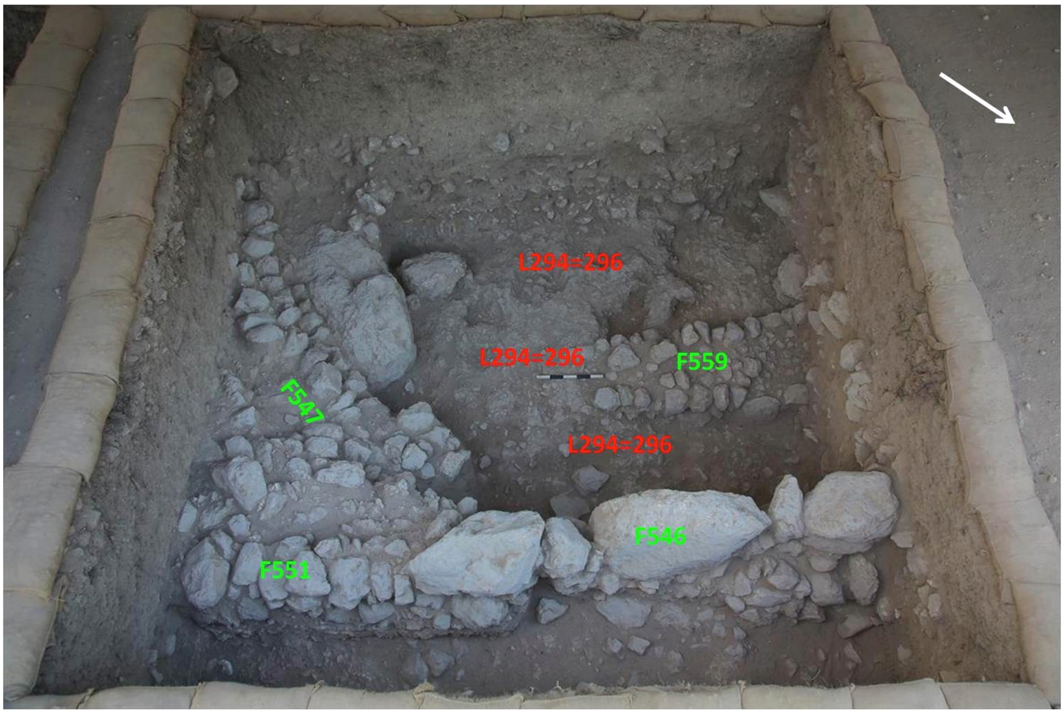


Photo of locus 13/S2/L294, taken 14 August 2013:

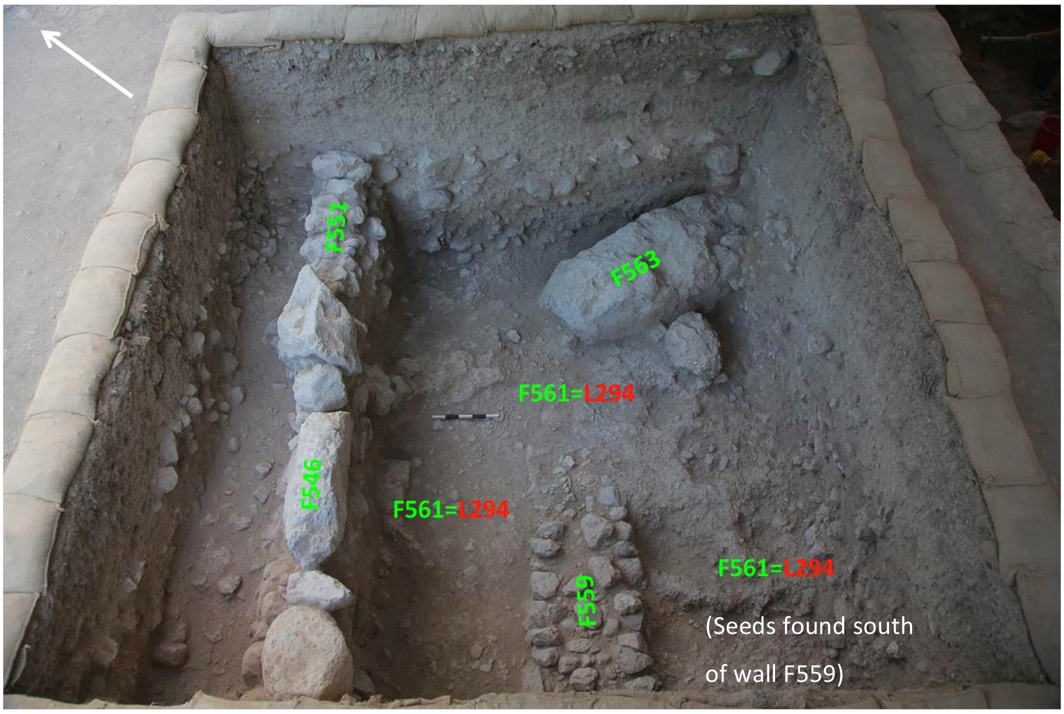
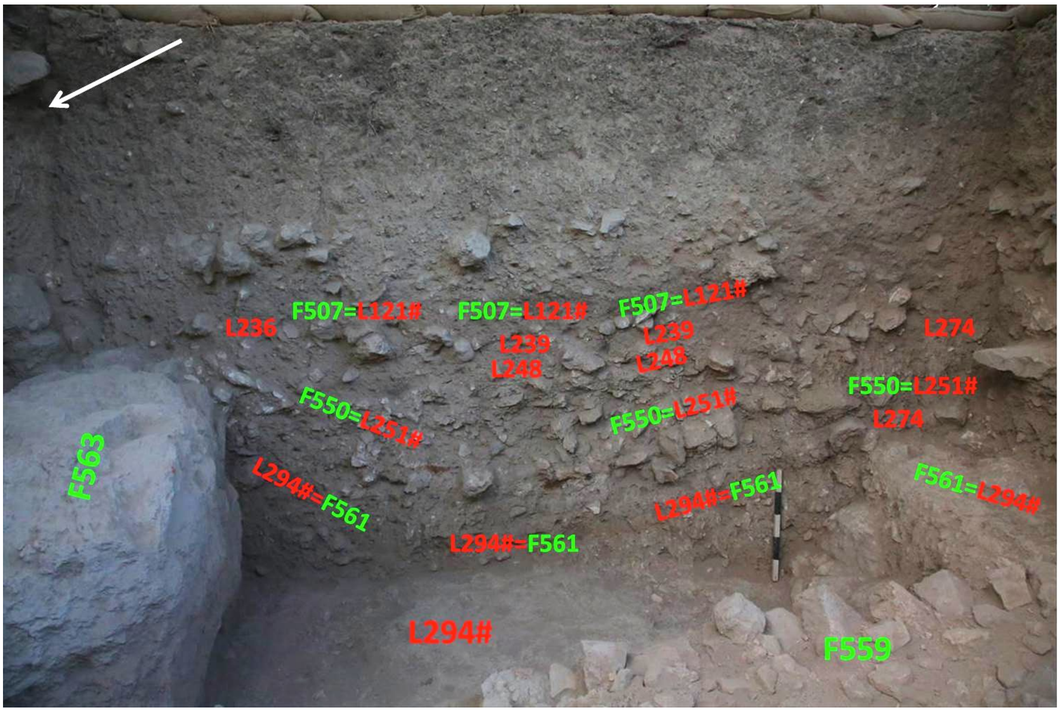
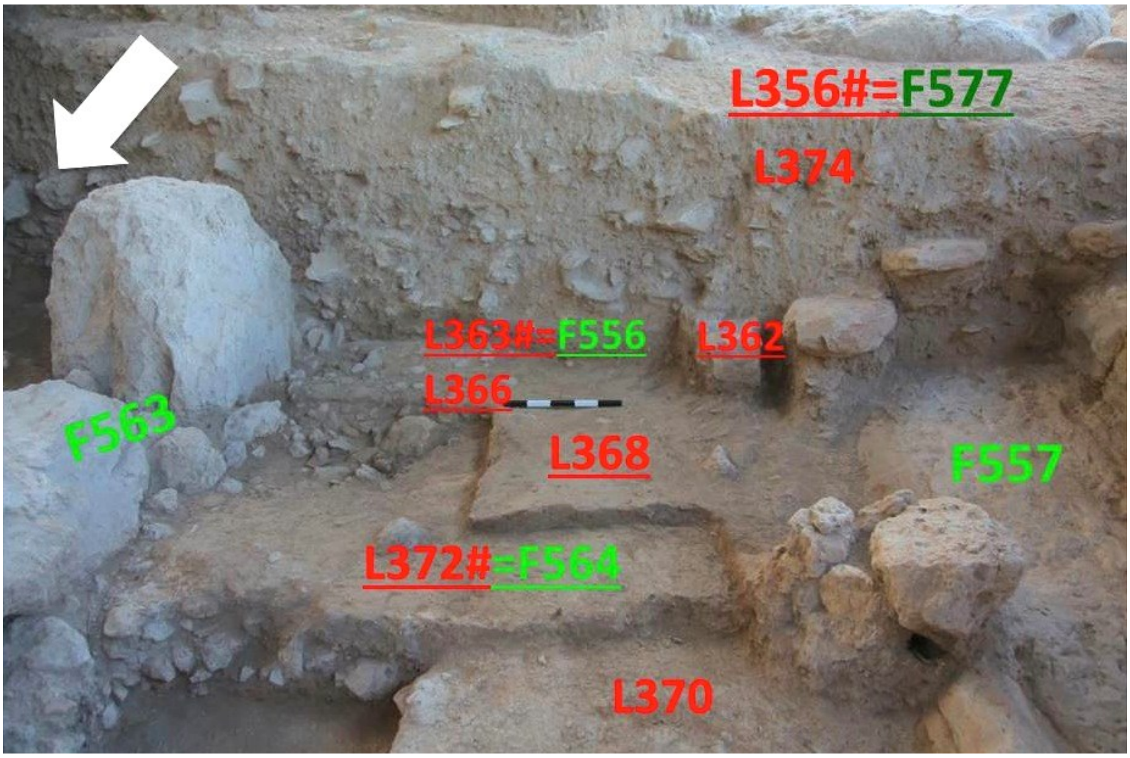


Photo showing locus 13/S2/L294 in section (20 August 2013):



OZS881 (S2-6, 14/S2/L372, B21648)

Photos showing locus 14/S2/L372, taken 24 July 2014 (sample collected 28 July):



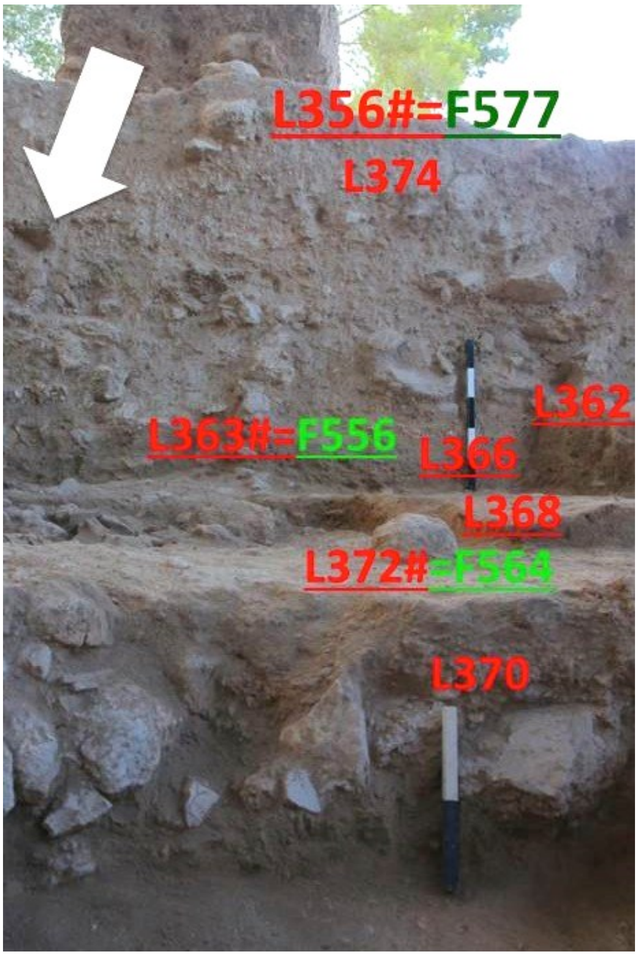


Photo showing locus 14/S2/L372, taken 27 July 2014:

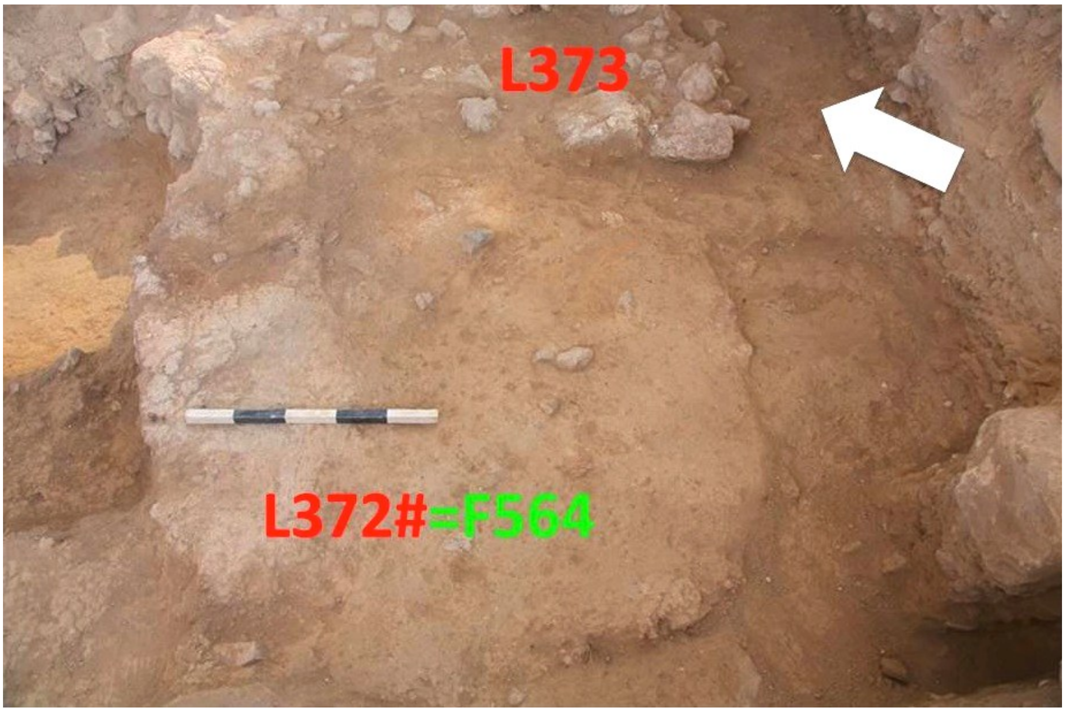
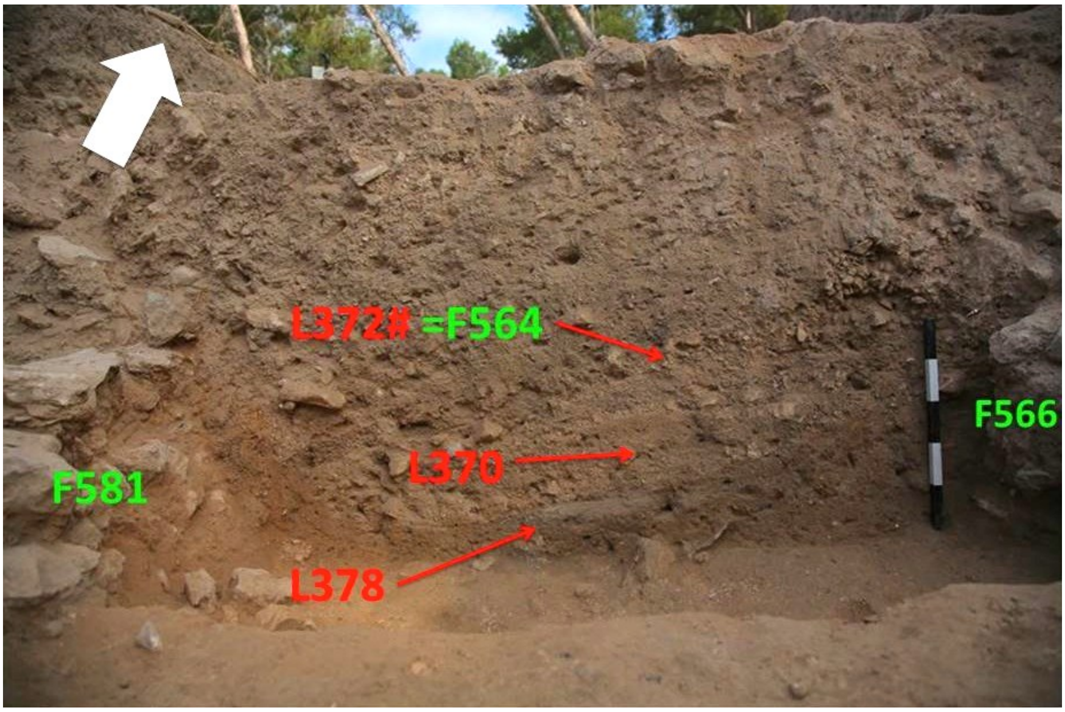
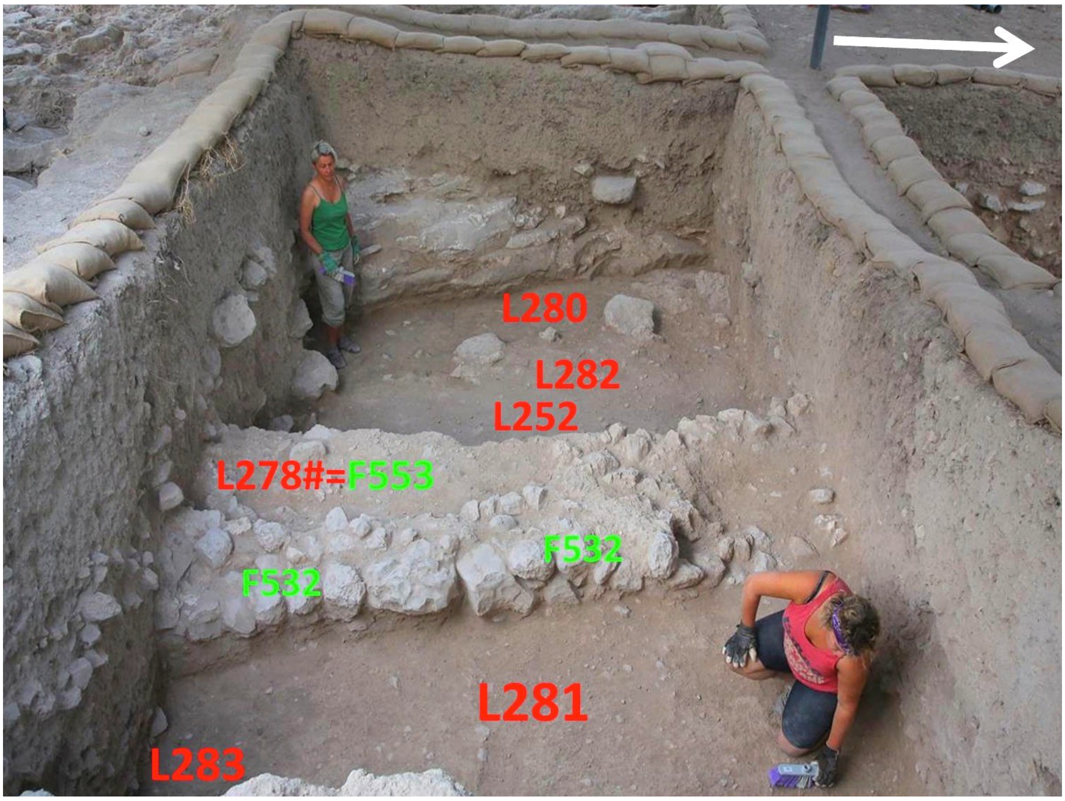


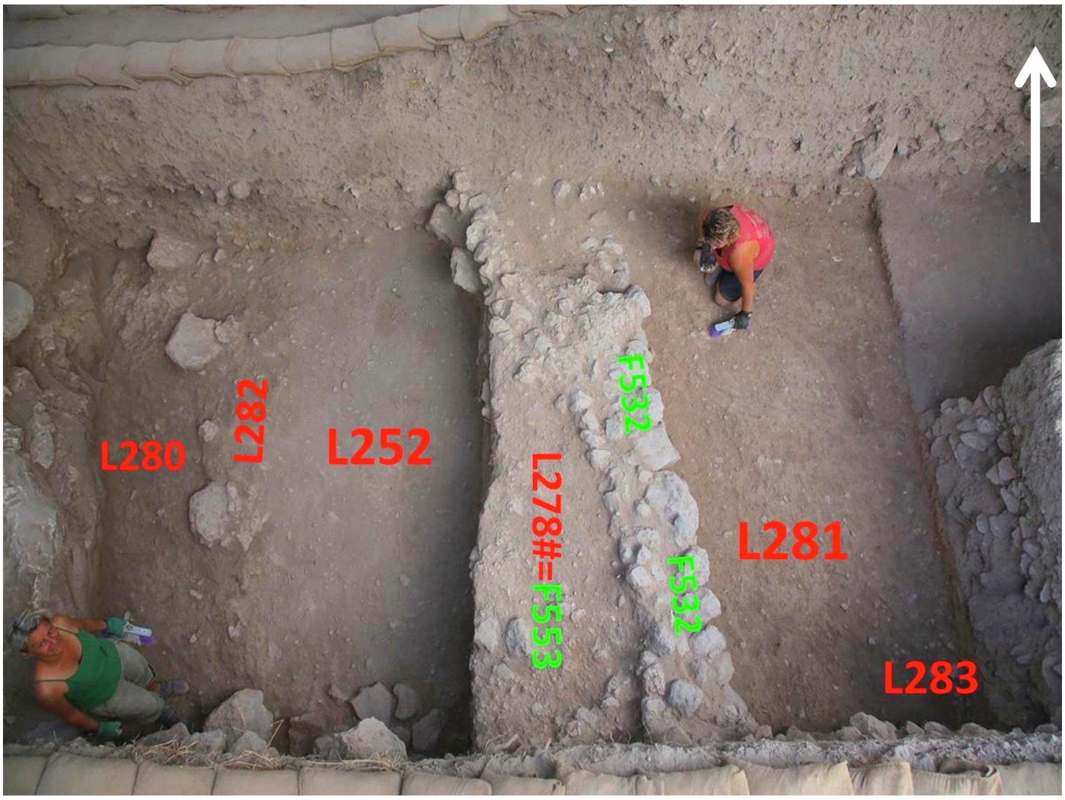
Photo showing locus 14/S2/L372, taken 31 July 2014:

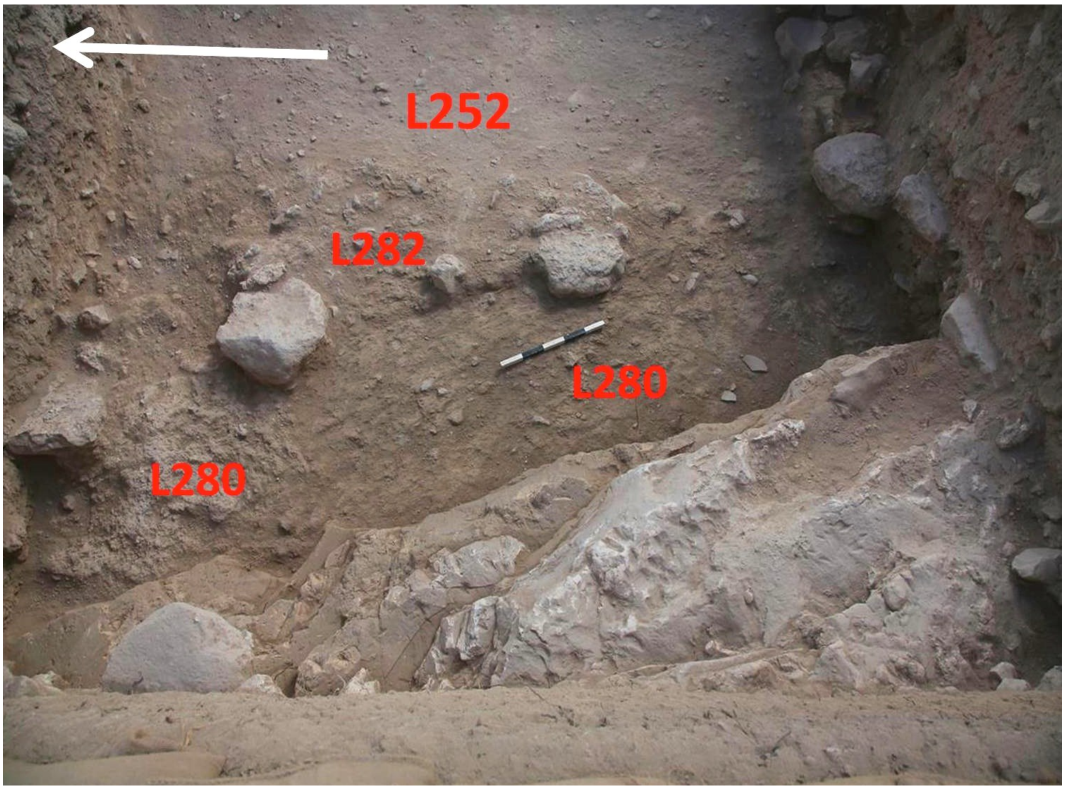


OZS873 (S2-5, 14/S2/L280, B21011)

Photos showing locus 14/S2/L280, taken 5 August 2013 (sample collected 8 August):

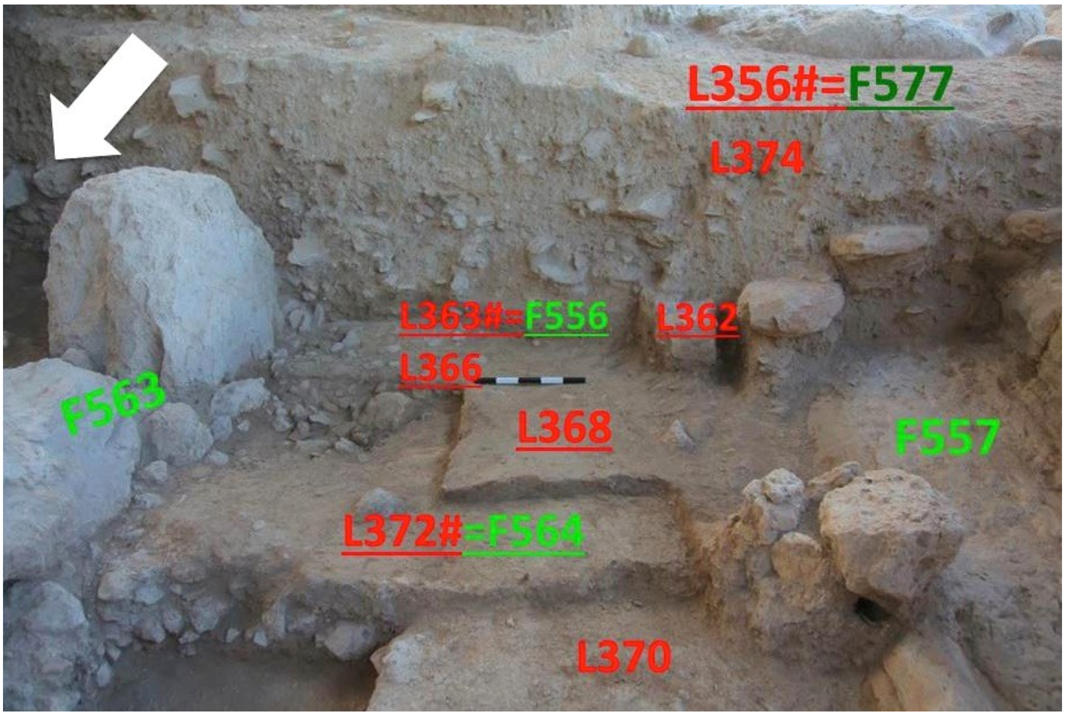






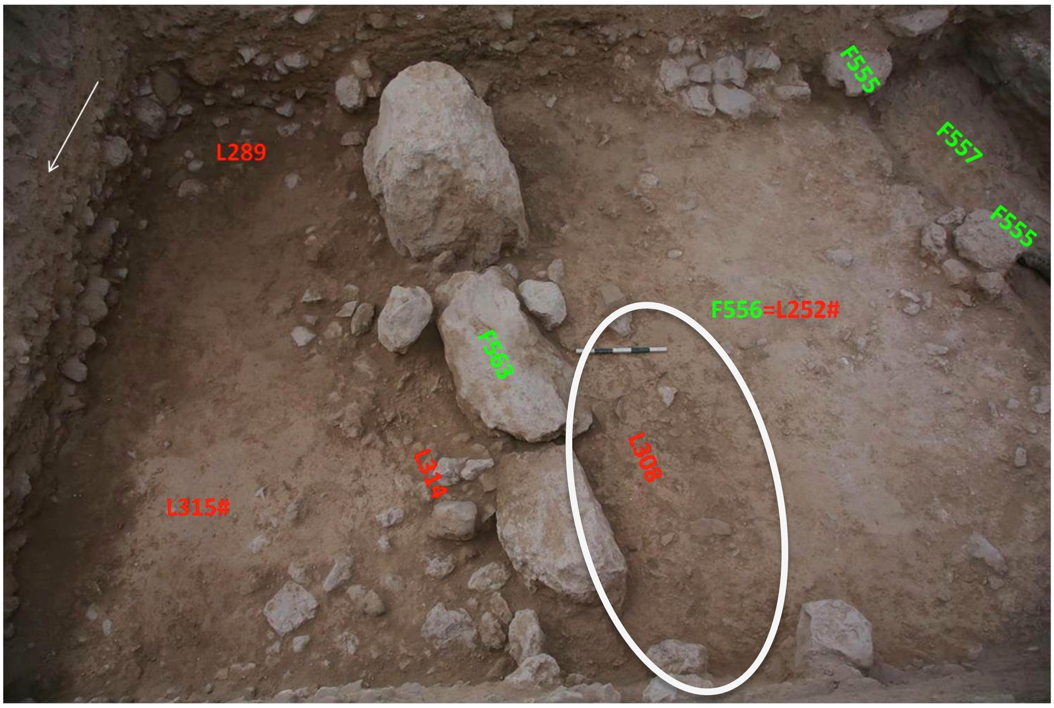
OZS880 (S2-5, 14/S2/L363, B21512)

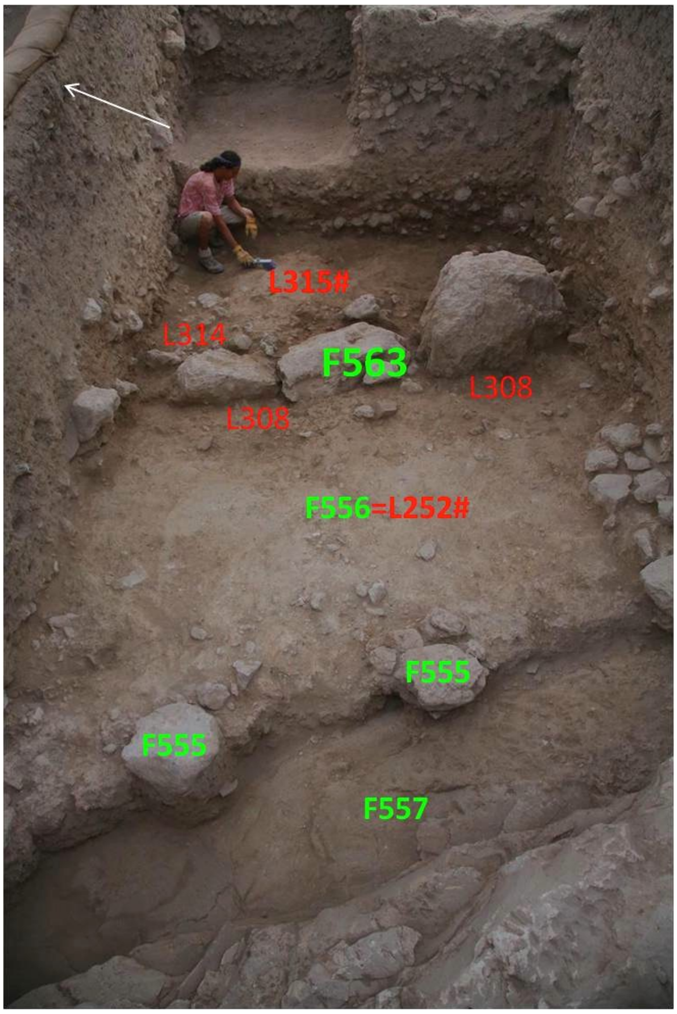
Photo showing locus 14/S2/L363, taken 24 July 2014 (sample collected 22 July):



OZS875 (S2-5, 13/S2/L308, B21212)

Photos showing locus 13/S2/L308, taken 15 August 2013 (sample collected 15 August):

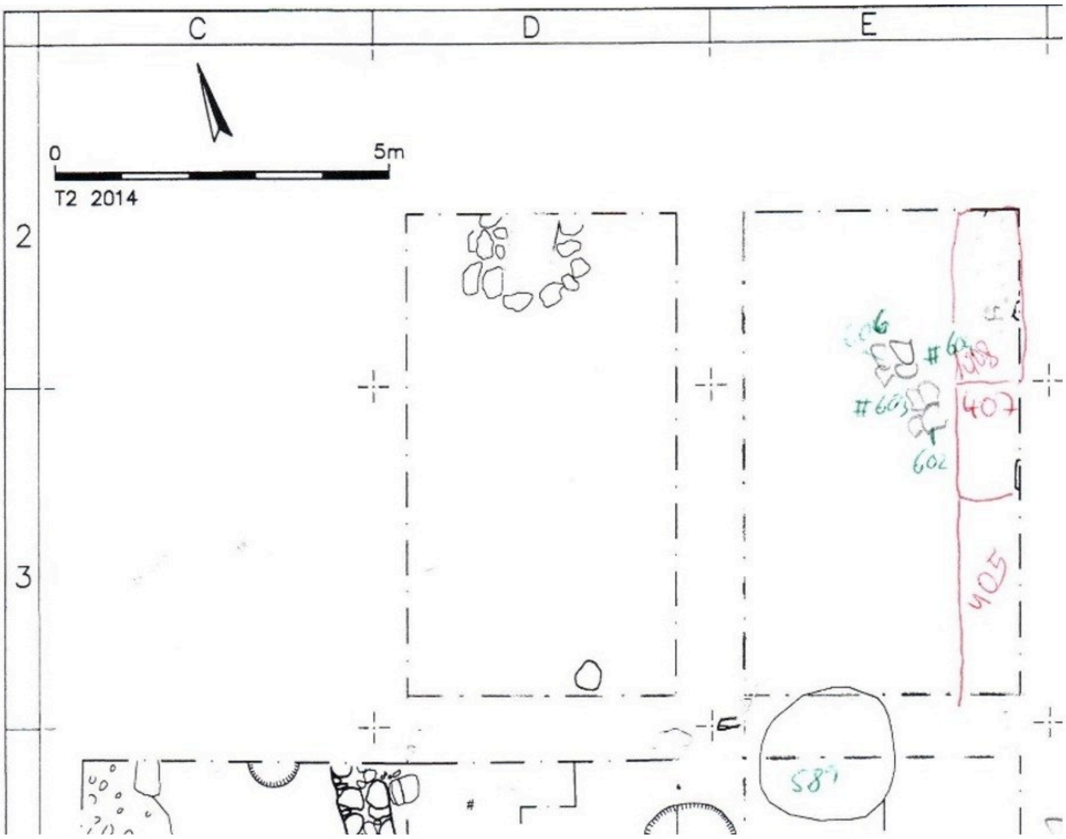




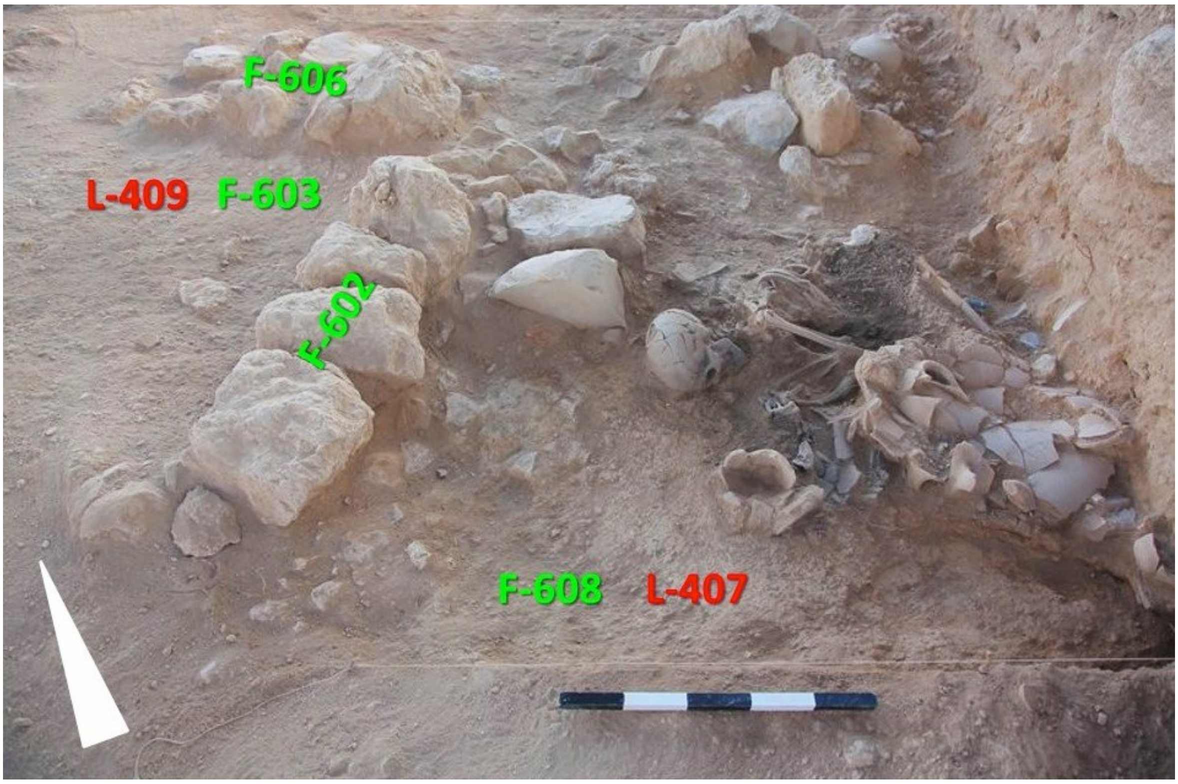
C.3 Late Bronze Destruction, Area T2

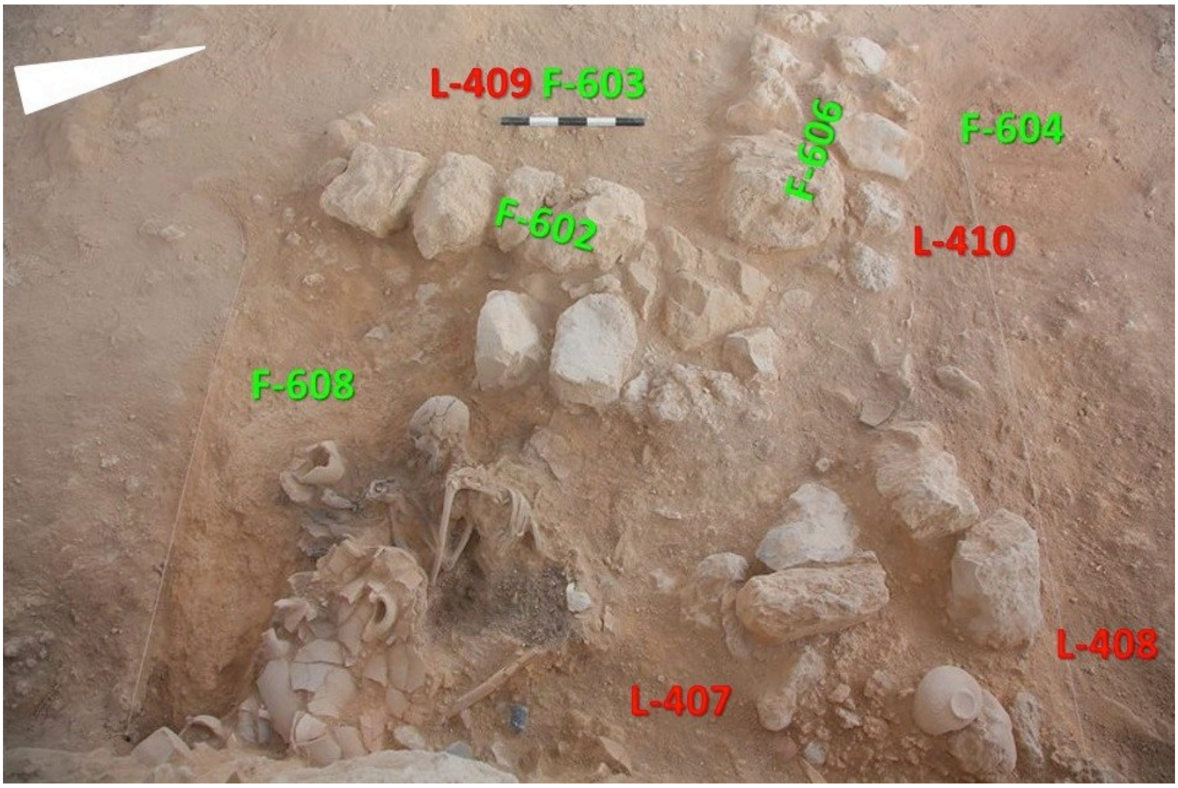
OZS884 (T2-3a, 14/T2/L407, B42790)

Top plan showing locus 14/T2/L407 on the day the seed sample was obtained (05 August 2014):



Photos of locus 14/T2/L407, taken 06 August 2014:





C.4 Iron Age, Persian and Hellenistic Contexts

<u>OZS878 (S1-2/3, 14/S1/L361, B12749)</u>

Top plan showing locus 14/S1/L361 on the day the seed sample was obtained (06 August 2014):

Photos of locus 14/S1/L361, taken 04 August 2014:

OZS879 (S1-2/3, 14/S1/L394, B12639)

Top plan showing locus 14/S1/L394 on the day the seed sample was obtained (04 August 2014):

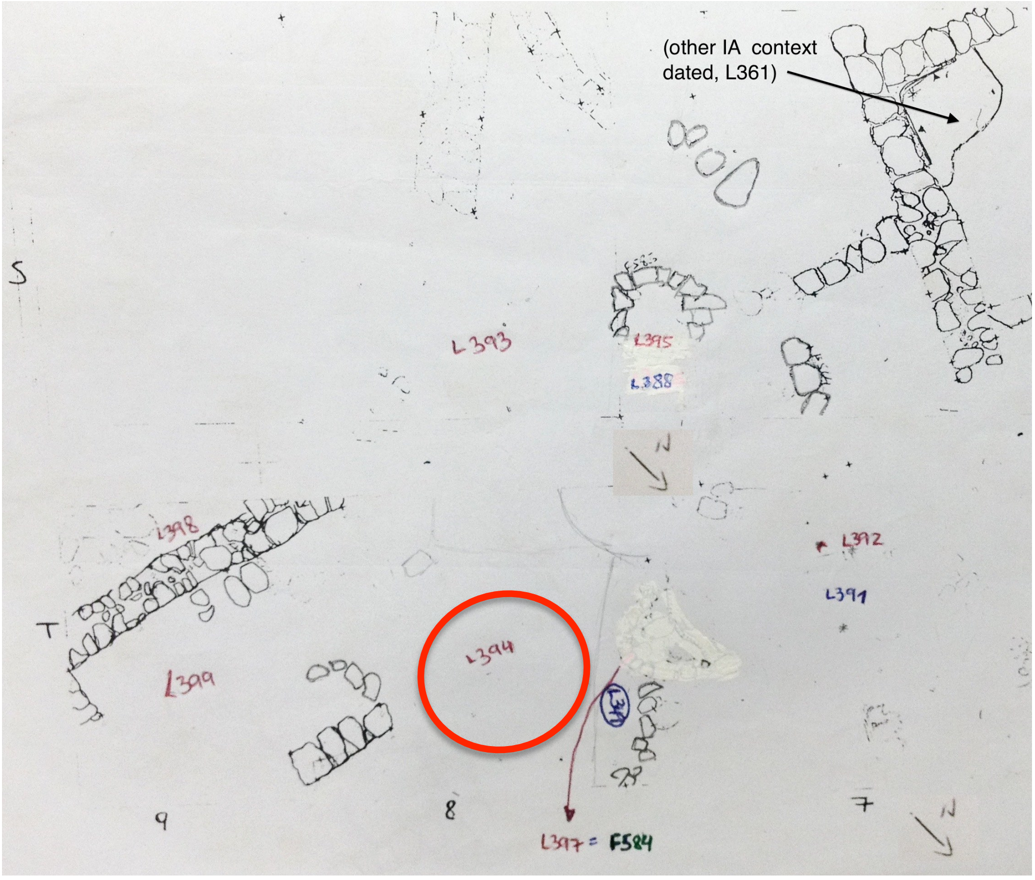


Photo of locus 14/S1/L394, taken 27 July 2014:

OZS872 (S2-1, 12/S2/L196, B20434)

Top plan showing the cistern entrance and indicating locus 12/S2/L196. The seed sample was obtained 16 August 2012.

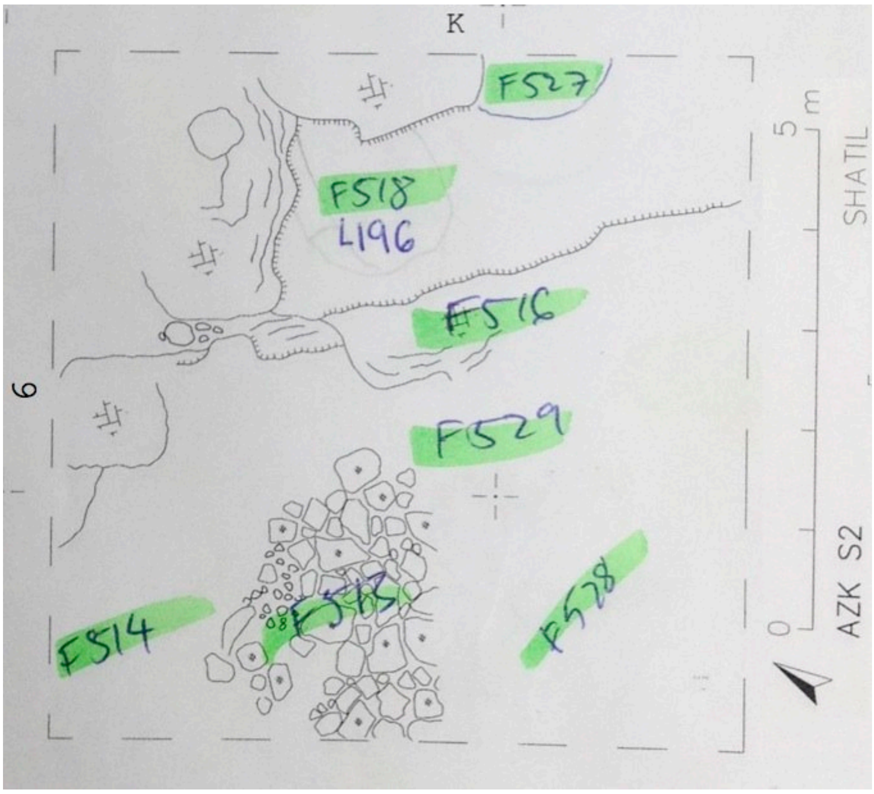
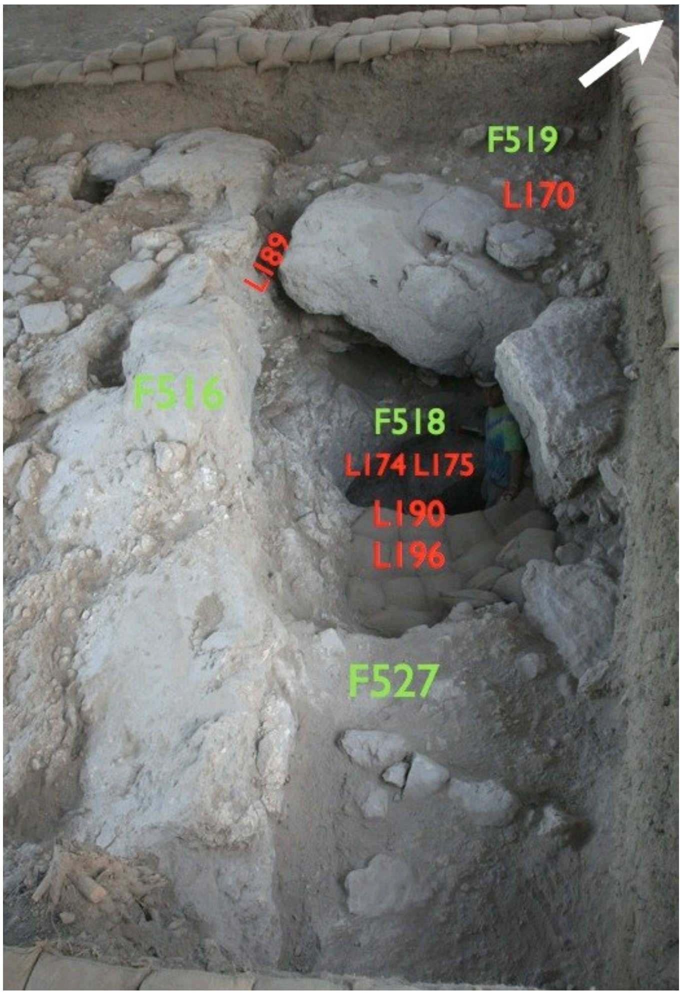


Photo of Locus 12/S2/L196, taken 17 August 2012:

Photo of the cistern indicating the position of locus 12/S2/L196:



OZS885 (W1-3a, 14/W1/L366, B52216)

Top plan showing locus 14/W1/L366 on the day the seed sample was obtained (07 August 2014):

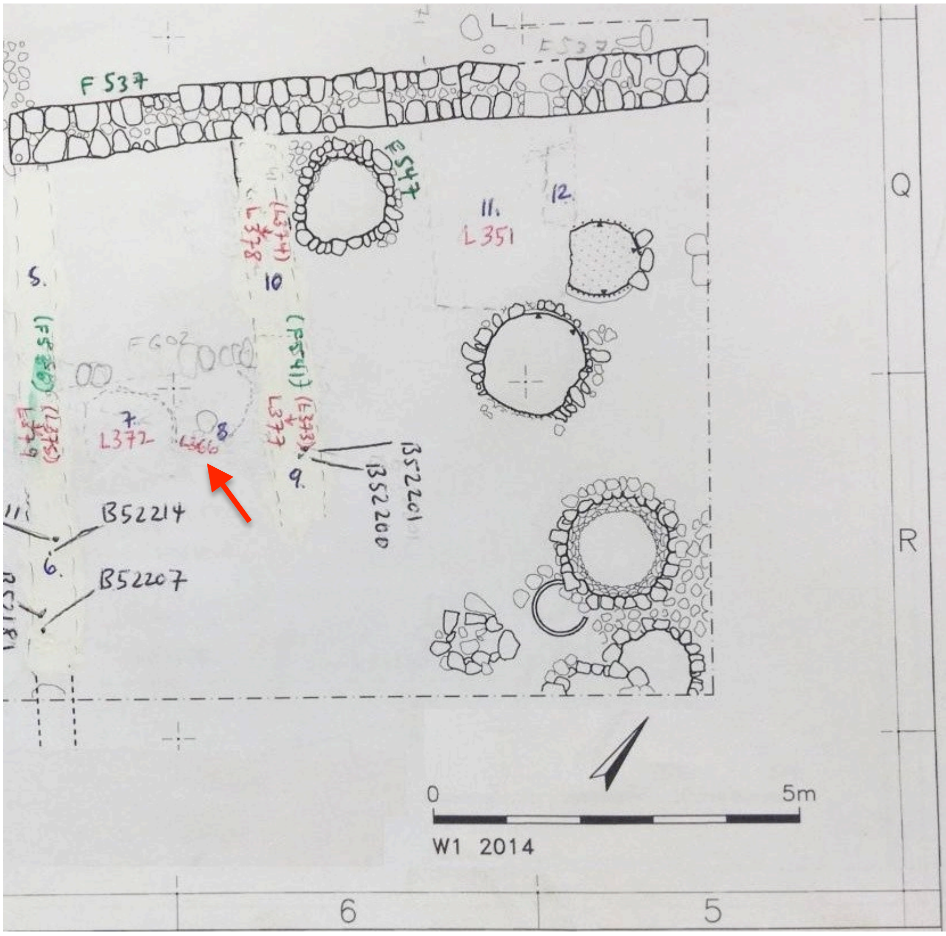


Photo of Locus 14/W1/L366, taken 07 August 2014:

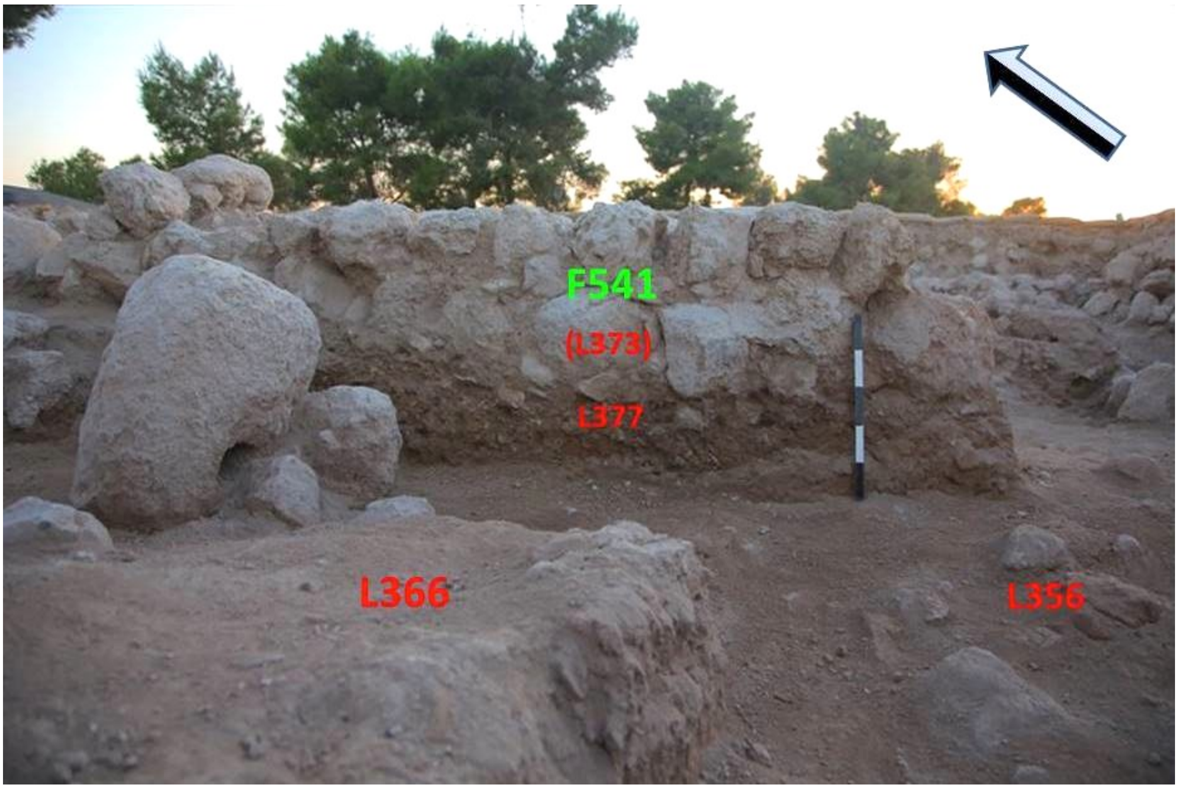
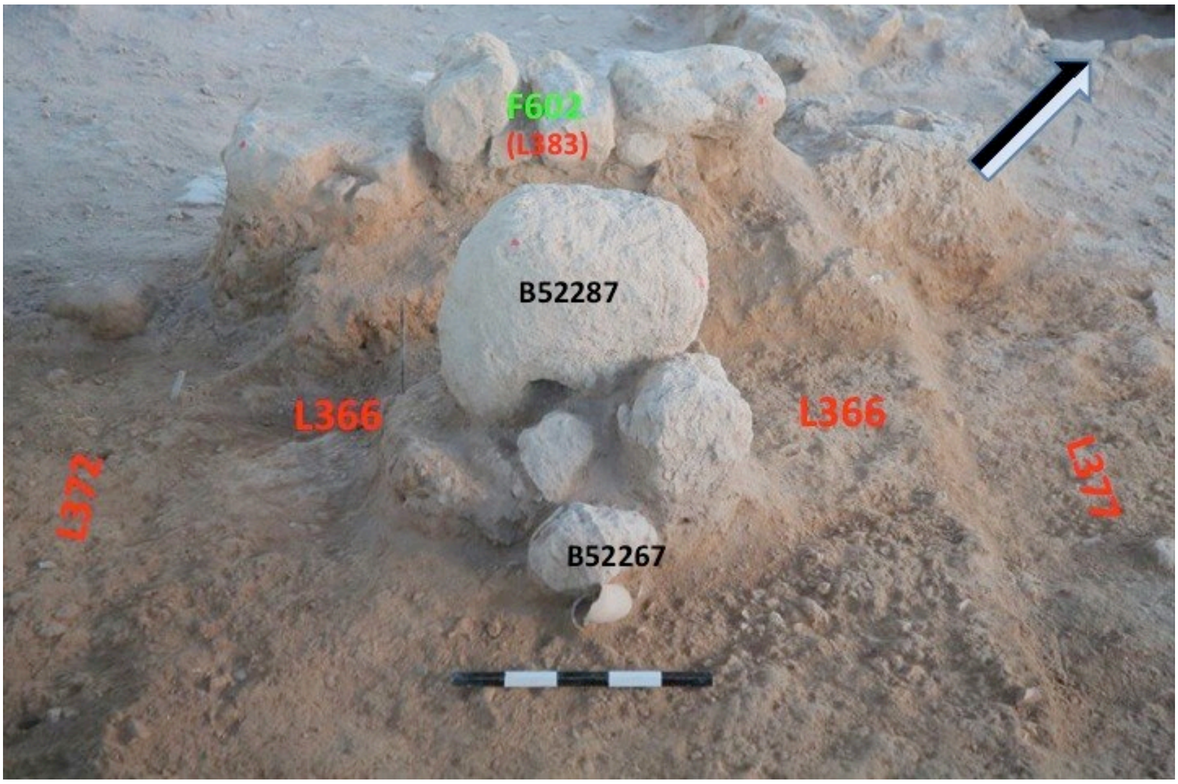
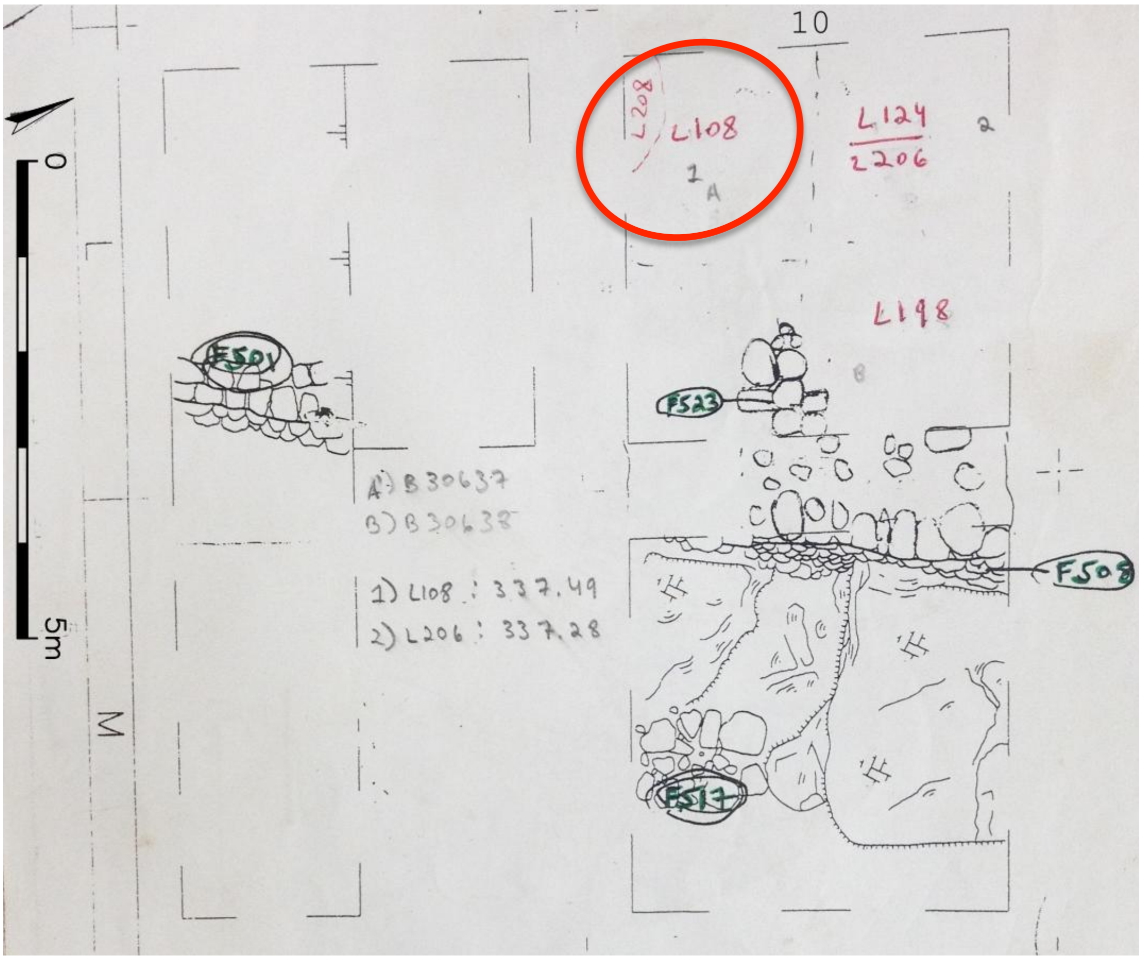


Photo of Locus 14/W1/L366, taken 11 August 2014:

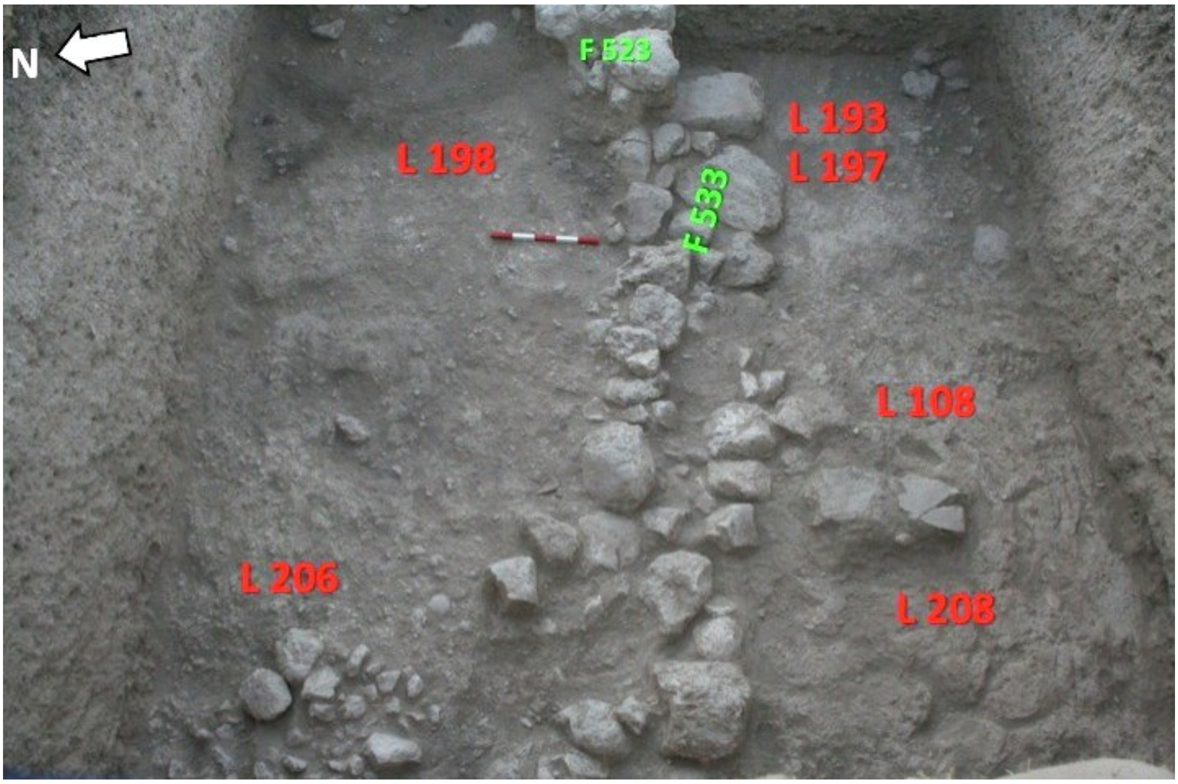


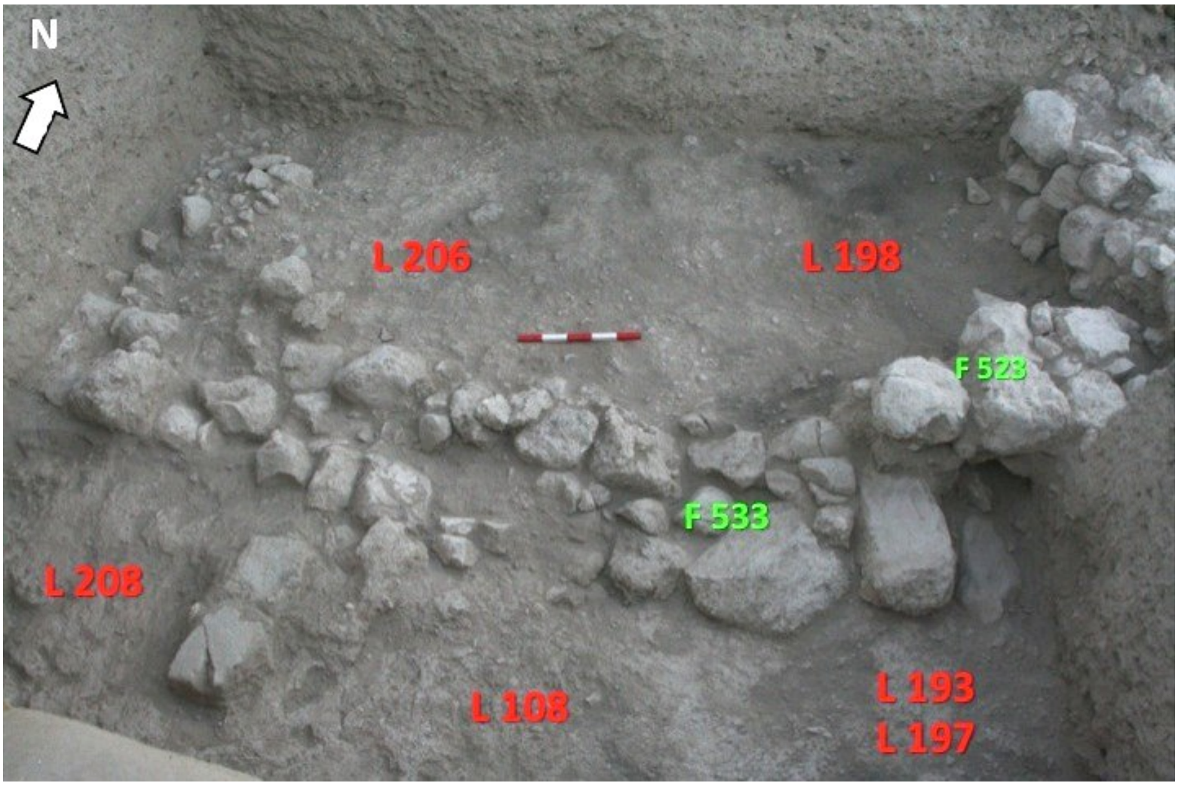
OZS871 (E1-2, 12/E1/L208, B30671)

Top plan showing locus 12/E1/L208 on the day the seed sample was obtained (22 August 2012):



Photos of Locus 12/E1/L208, taken 24 August 2012:

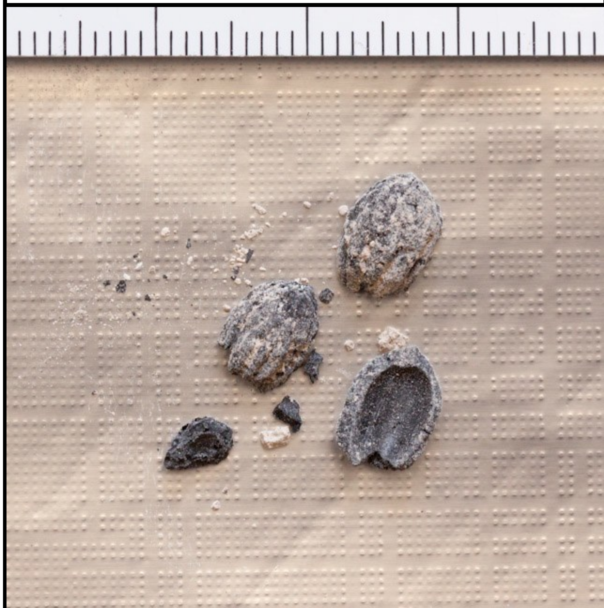




Appendix D Photos of Samples

OZS876 (S1-11, 14/S1/L305, B12389)

OZS877 (S1-11, 14/S1/L312, B13017)



OZS883 (S2-7?, 14/S2/L384, B21782)

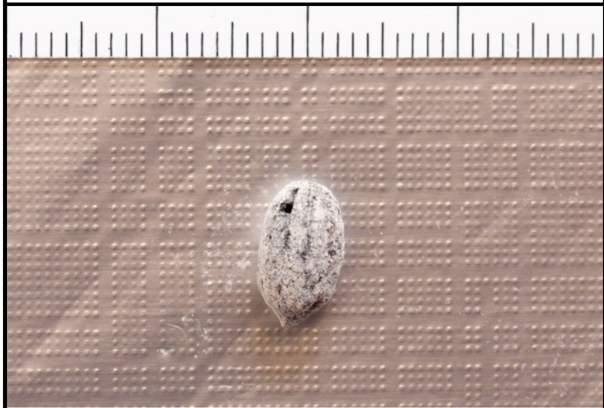
OZS882 (S2-7?, 14/S2/L378, B21756)

OZS874 (S2-6, 13/S2/L294, B21324)

OZS881 (S2-6, 14/S2/L372, B21648)

OZS873 (S2-5, 13/S2/L280, B21011)

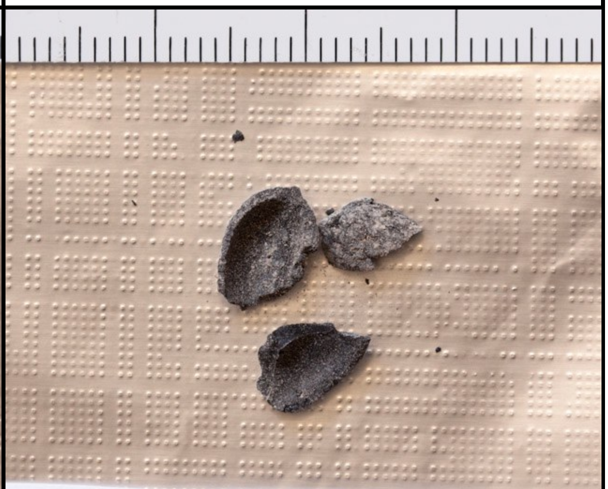
OZS880 (S2-5, 14/S2/L363, B21512)



OZS875 (S2-5, 13/S2/L308, B21212)

OZS884 (T2-3a, 14/T2/L407, B42790)

OZS878 (S1-3/2, 14/S1/L361, B12749)



OZS879 (S1-3/2, 14/S1/L394, B12639)

OZS872 (S2-1, 12/S2/L196, B20434)

OZS885 (W1-3a, 14/W1/L366, B52216)

OZS871 (E1-2, 12/E1/L208, B30671)

Notes:

- The photographs do not show the whole basket, but include the seeds that were dated.
- Wood charcoal is usually collected separately, but was bagged together with seeds in the case of B21011 (OZS873). Keeping seeds together with charcoal is not good since old charcoal from the wood could contaminate the seeds. Given the preservation of both the seeds and wood charcoal (minimal powdered charcoal) the risk is negligible.
- Sediment clinging to seed surfaces was quite minimal and is removed by pretreatment.
- B12749 (OZS878) included a modern rootlet. These can find their way into excavations; they are no concern and easily removed.

Preservation is excellent for most seeds (though less so for the barley, OZS877). (The legumes, OZS871, are exceptionally well-preserved but unfortuately modern!)

Appendix E Bayesian Models for Azekah

Middle Bronze dates, Area S1:

```
Plot()
    Sequence()
        Boundary("Start S1-11")
        Phase("Phase S1-11")
            Axis(-2600, -800)
            R_Date("OZS877", 3260 , 25)
            R_Date("OZS876", 3355 , 30)
            Interval("Duration of S1-11")

        Boundary("End S1-11")
```

Late Bronze dates, Area S2, Option 1:

```
Plot()
    Sequence("S2")
        Boundary("Start S2-7")
        Sequence("Phase S2-7 (with internal order)")
            Axis(-1800, -800)
            R_Date("OZS883", 2935 , 25)
            R_Date("OZS882", 2950 , 25)
            Interval("Span S2-7")

        Boundary("Transition S2-7/6")
        Phase("Phase S2-6")
            Axis(-1800, -800)
            R_Date("OZS874", 2985 , 25)
            R_Date("OZS881", 2915 , 25)
            Interval("Span S2-6")

        Boundary("Transition S2-6/5")
        Phase("Phase S2-5")
            Axis(-1800, -800)
            R_Date("OZS873", 2965 , 30)
            R_Date("OZS880", 2960 , 30)
            R_Date("OZS875", 2985 , 30)
            Interval("Span S2-5")

        Boundary("End S2-5")
```

Late Bronze dates, Area S2, Option 2:

```
Plot()
    Phase()
        Sequence("Overlapping Phase A")
            Boundary("Start S2-6")
            Phase("Phase S2-6")
                Axis(-1800, -800)
                R_Date("OZS874", 2985 , 25)
                R_Date("OZS881", 2915 , 25)
                Interval("Span S2-6")

            Boundary("Transition S2-6/5")
            Phase("Phase S2-5")
                Axis(-1800, -800)
                R_Date("OZS873", 2965 , 30)
                R_Date("OZS880", 2960 , 30)
                R_Date("OZS875", 2985 , 30)
                Interval("Span S2-5")

            Boundary("End S2-5")

        Sequence("Overlapping Phase B")
            Boundary("Start pit samples")
            Sequence("Pit F590 samples, S2-? (with internal order)")
                Axis(-1800, -800)
                R_Date("OZS883", 2935 , 25)
                R_Date("OZS882", 2950 , 25)
                Interval("Pit samples")

            Boundary("End pit samples")
```

The Late Bronze Age at Lachish (model using short-lived samples):

```
Plot()
    Axis(-2400, -400)
    Sequence()
        Boundary("Start LB IIA")
        Phase("LB IIA")
            Axis(-2400, -400)
            R_Date("RT-3152 S-3", 2945, 65)
            R_Date("RT-3153 S-3", 3125, 55)

        Boundary("Transition LB IIA / LB IIB")
        Phase("LB IIB")
            Axis(-2400, -400)
            R_Date("Pta-3320 VIIa", 2940, 70)
            R_Date("RT-2906 VIIa", 2955, 35)

        Boundary("Transition LB IIB / LB III")
        Phase("LB III")
            Axis(-2400, -400)
            R_Date("RT-2912 VIb", 2915, 25)
            R_Date("RT-2755 VI", 2955, 25)

        Boundary("End LB III")
```