The People Left Behind:
Four Victims of the Destruction of the Late Bronze Age City of Azekah

by

Karl Robert Berendt

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Department of Anthropology
University of Alberta

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Abstract

In the Late Bronze Age, the city of Azekah was a regional centre that probably prospered under the sponsorship of Egyptian rulers. However, the city was destroyed in the late 12th Century BCE by an unknown cause and abandoned thereafter. Building T2/627 was destroyed in this event: the building burned and collapsed, trapping four of Azekah's inhabitants inside. The arrangement of artefacts shows that this was a sudden disaster, leaving little time to prepare to evacuate. Between 2012 and 2014, the remains of these four individuals were excavated by the Lautenschläger Azekah Expedition. The lives and deaths of these individuals were reconstructed using the approach of osteobiography. Age at death and sex estimations were integrated with discussions of pathology, trauma, and musculoskeletal stress, to propose reconstructions of habitual activity and aspects of health and diet. Bone fractures and colour changes were classified and staged to give an estimate of fire conditions from the time of death, and postmortem scavenging patterns were discussed to attempt to explain the missing limbs and characterise the site after the destruction. The information from these analyses was taken into context with what is currently known about the history and archaeology of this region, to produce four portraits of life at ancient Azekah.

It was found that these individuals suffered from anaemia and other systemic illness during their lives. Patterns of musculoskeletal stress markers showed that they were likely highly active. In the context of artifacts recovered from the building, the markers suggest that specific activities included grinding grain and carrying heavy objects. After the destruction, it seems that the bodies burned quite extensively. The overall impression of high-temperature fire conditions drawn from bone colour changes contrasted with the relative lack of heat-induced fracturing of the remains and the absence of clear pugilistic posture. Possibly, a very hot fire aided by flammable goods stored in the building caused the building to collapse on top of these individuals and protect their bodies from

some of the effects of heat alteration. Together, these lines of evidence enhanced our understanding of these individuals' ways of life and manners of death against the backdrop of Azekah's destruction.

Preface

This thesis is an original work by Karl Berendt. This project received research ethics approval from the University of Alberta Research Ethics Board, project name "DIETARY RECONSTRUCTION AT TEL AZEKAH, ISRAEL", no. Pro00067887, 8 March 2017.

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Chapter 1 Introduction

At the end of the Bronze Age a period of widespread upheaval, known today as the Late Bronze Age Collapse, overturned the order of the Eastern Mediterranean world. Egypt's empire, stretching up the Levantine coast as far as the Upper Euphrates, had overseen relative peace in the Southern Levant and a flourishing Egyptianising culture among the Canaanite elite. However, deteriorating climate and political tensions led to social unrest, and in the early 12th Century BCE, a mysterious force known as the Sea Peoples began to attack the Mediterranean coast from Egypt to Anatolia (Cline 2014). Egypt retreated from the Southern Levant, taking with it its stabilising influence, and the cities of the Southern Levant were pitted against each other. One of these cities was called Azekah. Azekah stood quietly on a hilltop where it raised high walls above the Valley of Elah, watching over trade routes on the valley floor. Shortly after the retreat of Egypt, in the late 12th Century BCE, Azekah was destroyed. It is not yet clear what caused the destruction of the city. However, one structure on the hilltop has revealed clues to the circumstances of this event. Building T2/627 was a spacious building adapted for a production operation involving large quantities of grain and oil. Inside, four of Azekah's residents were presumably grinding grain and performing various tasks when the building caught fire without warning. It seems they gathered their belongings and tried to escape but were caught in the sudden collapse of the building. The city was abandoned for centuries after this destruction, yet the bodies of these four individuals were left behind in the rubble for three thousand years.

The present analysis examines the remains of these four individuals in their historical, cultural, archaeological, and biological contexts. In doing so, I attempt to offer these individuals the dignity of gathering up their shattered remains, telling their stories, and answering questions about their past.

Who were they?	What were their lives like? What can we say about their diet, health, and daily activity? What can we say about their social status, identities, and social roles?
What happened here?	What were these individuals doing in this building? Why didn't they escape the building? What kind of disaster was this? How does it relate to the widespread upheaval of the Late Bronze Age Collapse?
What happened afterward?	What was the site like after the destruction? Why weren't the bodies recovered?

Little is currently known about culture, identity, and daily life at Azekah, and many questions about the Southern Levant during this period remain unanswered, including what destroyed the city. This study may be able to provide some insight into how these individuals lived their lives, and particularly how aspects of their environment and culture, such as physical activity, diet, and disease, affected their bodies on a day to day basis. This study may also be able to provide insight into their deaths by observing how these remains were degraded by fire, crushing, and taphonomy. It is hoped that this analysis will provide some insight into these events by reconstructing what these individuals' lives were like, and what circumstances surrounded their deaths.

In the following text, these questions are explored using data from history, archaeology, osteology, and methods of fire scene investigation borrowed from forensic analysis. These lines of evidence are woven together to produce some expected, and some unexpected results. In the following chapter, I give a background sketch of the history of the Southern Levant during the Bronze Age, highlighting cultural, economic, and political elements that would have factored into these individuals' daily lives. In Chapter 3, this context is used to examine the Shephelah region in particular, and the current understanding of the history of Azekah. Chapter 4 details the methodological background of this study, including the ways in which we excavate and analyse households, how we interpret disasters in archaeology, how morphological and experimental methods can be used to assess the conditions of past fires, and how chemical analysis can give clues about diet and mobility in the past. Chapter 5 outlines exactly how all of these analyses were performed. In Chapter 6, I examine the remains of the four individuals in this analysis and draw conclusions about what their lives were like. Chapter 7 continues this examination, focussing on these individuals' deaths, the destruction of the building they were in, and the aftermath of this event. Finally, Chapter 8 ties together all of this evidence to conclude the analysis of these four ancient inhabitants of Azekah, and looks to future directions.

Largely due to political factors, the field of human osteoarchaeology is underdeveloped in the Near East, particularly the Southern Levant. Given that this is a large region of great importance to human history and cultural heritage, whose archaeological sites are continually threatened, it is of particular urgency that the knowledge attainable from human remains is promoted in this region. I hope that this thesis will provide inspiration for more archaeologists in this region to consider pursuing osteobiographical analysis of human remains discovered at their sites, and for more students, both local and international, to consider pursuing the study of human osteoarchaeology.

Chapter 2 History and Archaeology of the Bronze Age Southern Levant

The Levant is a region of the Eastern Mediterranean coast, bounded to the north by the Amuq Valley (and the Orontes River within it), to the east by the Euphrates River and the Syrian and Arabian deserts, to the south by the Gulf of Aqaba and the Wadi al-Arish in the Northern Sinai, and to the west by the Mediterranean Sea (Figure 2.1). These boundaries encompass parts of the modern nations of Turkey, Syria, Lebanon, Iraq, Jordan, Israel, the Palestinian Territories, and Egypt (Srinivasan et al. 2014, Suriano 2013). The Levant is separated into two parts by the Litani River of Lebanon: the Northern Levant, dominated by and occasionally synonymous with Syria, and the Southern Levant, comprising Cisjordan (modern Israel-Palestine) and Transjordan. The island of Cyprus (ancient Alashiya) is sometimes discussed together with this region but is a distinct entity (Gagarin and Fantham 2010, Suriano 2013).

The Levant forms the southwestern arm of the ancient Fertile Crescent, making it a rich site of human settlement since the Palaeolithic. Situated at the nexus of Africa, Asia, and Europe, the Levant has always been an important crossroads of trade and culture. This region has witnessed the initial migration of our species out of Africa, the foundation of the world's oldest cities, and the expansion of sea-borne trade across the world (Gagarin and Fantham 2010, Srinivasan et al. 2014). The Southern Levant, in particular, as part of the Egyptian sphere of influence, grew to base its economy on production and trade, connecting Egypt to regions further north and east. Its native inhabitants, the Canaanites/Phoenicians, became expert merchants, navigators, and naval mercenaries (Panitz-Cohen 2014, Srinivasan et al. 2014), eventually establishing colonies throughout the ancient Mediterranean world, sailing as far as southern Britain and perhaps India, and establishing the Carthaginian Empire in North Africa and Southern Europe by the mid-6th Century BCE (Markoe 2005). The Bronze Age, from circa 3500 to 1200 BCE (Table 2.1), witnessed the earliest roots of these people, as they established their first cities, developed as a cultural and political entity, and first encountered their neighbours in the Mediterranean and Near Eastern world.

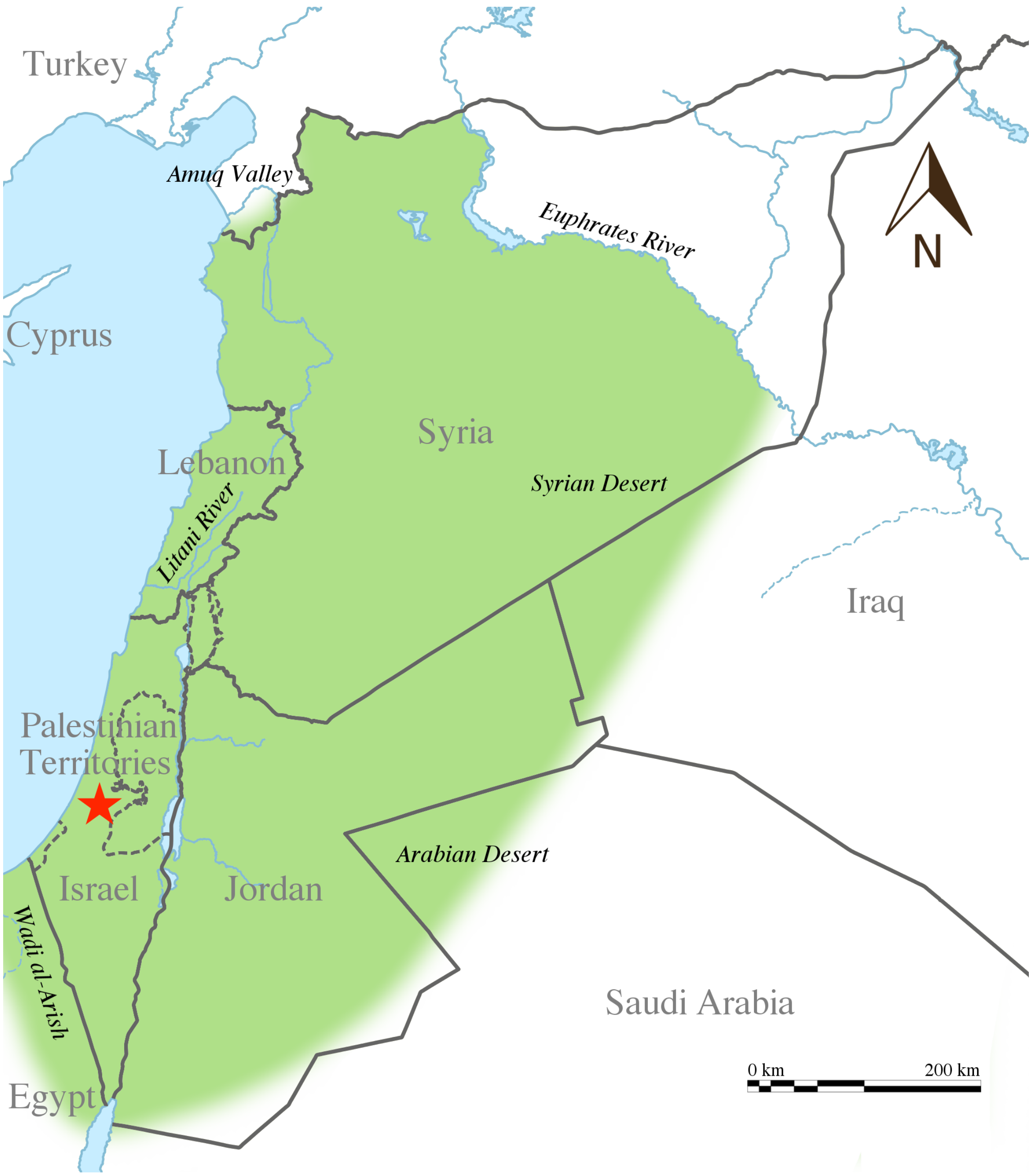

Figure 2.1. Approximate extent of the Levant, showing geographical boundaries, with the location of Tel Azekah marked in red.

Conventional Dates (BCE)	Radiocarbon Dates (BCE)	Period (as used herein)	Alternate Schemes		Egyptian Dynasty	Other Correlations		Description
3500–3150/2950	3700–3100/2950†	Early Bronze I (EB I)			Predynastic/Dynasty 0	Cypriot Chalcolithic		Pre-urban
3150/2950–2700/2600	3100/2950–2900/2850†	Early Bronze II (EB II)	EB II-III		Dynasties I–II			First cities
2700/2600–2300/2200	2900/2850–2600/2450†	Early Bronze III (EB III)			Dynasties III–VI	Early Cypriot		Urban culture
2300/2200–2000	2600/2450†–1900‡	Intermediate Bronze	MB I	EB IV	First Intermediate Period (Dynasties VII–XI)	Akkadian Empire	Ur III	Partial relapse to village-based societies
2000–1750	1900–1800‡	Middle Bronze I (MB I)	MB IIA		Dynasties XII–XIII	Middle Cypriot	Babylon I	New settlements
1750–1650	1800–1600/1550‡	Middle Bronze II-III (MB II-III)	MB IIB	MB II	Second Intermediate Period (Dynasties XIV–XVII) "Hyksos Period"	Late Cypriot	Middle Minoan	Canaanite cultural zenith
1650–1550			MB IIC	MB III				
1550–1479	1600/1550‡–1300/1200*	Late Bronze I (LB I)	Late Bronze IA (LB IA)		Dynasty XVIII	Mycenaean Greece	Late Minoan	Canaan annexed by Egypt
1480–1400			Late Bronze IB (LB IB)					*Pax Aegyptiaca*
1400–1330/1300		Late Bronze IIA (LB IIA)	LB II			Amarna Period		Warring city-states
1330/1300–1200/1150	**1300/1200*–1200–1100⁂**	Late Bronze IIB (LB IIB)	LB III		Dynasty XIX	Fall of Mitanni Empire		Egyptian dominance
1200/1150–1150/1100		**Late Bronze III (LB III)**	**Iron Age IA**		**Dynasty XX**	**Emergence of "Sea Peoples"**		**Collapse**

Table 2.1. Chronology of the Southern Levant. Conventional dates are synthesised from information given in Sharon (2014) and Mumford (2014). Radiocarbon dates are assembled from the following sources: (Regev et al. 2012, Webster et al. 2018)†, Höflmayer et al. (2016)‡, Toffolo et al. (2014)*, Finkelstein and Piasetzky (2010)⁂. **Boldface indicates the period associated with the individuals studied in this thesis (see Chapters 6 and 7).**

2.1. Early Bronze Age

The Early Bronze Age (EBA) in this region began in the early to mid-fourth millennium BCE. Radiocarbon dates suggest the transition from the previous Chalcolithic period can be dated to 3900/3700 BCE, although this transition is not clearly seen by archaeologists until about 3500 BCE (Regev et al. 2012, Sharon 2014; Table 2.1). The Early Bronze Age saw an increase in complexity of social and economic organisation from the semi-nomadic society of the Chalcolithic, followed by a gradual increase in the density and size of settlements leading to urbanisation. This economic and social shift was probably driven by the demand for olive cultivation (Langgut et al. 2016). Craft specialisation and long-distance contacts were established in this period, leading to cottage industry and slow, limited trade (de Miroschedji 2014). Egyptian architecture, pottery, and other goods are attested archaeologically in the Southern Levant, suggesting Egyptian imperialism, colonisation, or simply strong trade connections (Mumford 2014).

The first part of this period, termed the Early Bronze Age I (EB I), is characterised mainly by slow changes in settlement patterns as described above, without significant changes in material culture (Sharon 2014). Villages were small, and dwellings were generally rectangular or elongate ovals, single-roomed, with outer courtyards, similar to those seen in the Late Neolithic and Chalcolithic (de Miroschedji 2014; Figure 2.2). Small-scale agriculture or agropastoralism dominated the economy, and there may have been incipient formation of city-states around the major urban centres (de Miroschedji 2014, Dever 1987, Regev et al. 2012). The local Canaanites traded olive oil and wine with Egyptian colonies established in the southern coastal plain of Canaan (Langgut et al. 2016). After a few centuries of slow development, a distinct step up in size, fortification, and agglomeration of settlements occurred along with centralisation of ceramic industries, marking the Early Bronze Age II (EB II) around 3150/2950 BCE (Regev et al. 2012). In this period, most dwellings comprised one or two rooms, with additional storerooms and a courtyard, and public buildings such as temples and small administrative buildings are increasingly seen (de Miroschedji 2014). This urbanism may be linked to the sudden withdrawal of Egypt from the Southern Levant at the end of the EB I under Narmer (Menes), the founder of Egypt's founding dynasty (Dynasty 0), leaving a power and trade vacuum that stimulated local development (Greenberg 2014, Langgut et al. 2016). Apart from the urbanisation process, the EB II is distinguished from the EB I mainly by ceramic transitions: the disappearance of grey burnished ware, and the appearance of North Canaanite Metallic Ware along with Abydos Ware from Egypt (Sharon 2014). Ceramics during this period were relatively simple, produced with slower, hand-spun potter's wheels (Dever 1987). By the presence of Levantine EB II pottery in Egyptian tombs, and the presence of Egyptian First Dynasty pottery in Southern Levantine horizons, this transition can be correlated with the beginning of the First Dynasty in Egypt, specifically no later than the time of Djer, the third Pharaoh of the First Dynasty (Regev et al. 2012, Sharon 2014). This puts the EB I–EB II transition between 3150 and 2950 BCE (Sharon 2014), matching nicely with radiocarbon dates for this transition in the Southern Levant of 3200/2900 BCE (Regev et al. 2012). Due to the short duration and poorly resolved dates for the EB II, it is often grouped with the next period, the Early Bronze Age III (EB III), to form the EB II-III (Sharon 2014).

The Early Bronze Age III (EB III) is the last period in the Early Bronze Age. Recent radiocarbon data place the beginning of this period circa 2900 BCE (Regev et al. 2012), meaning that it almost eclipses the EB II, supporting the EB II-III grouping (Table 2.1). This period coincides with the Third to Sixth Dynasties of the Egyptian Old Kingdom. Intensifying urbanisation and the establishment of several important walled sites such as Yarmuth, Megiddo, Ai, and Khirbet ez-Zeraqun characterise this period. The first palaces, monumental temples, and evidence of competitive feasting suggest increased social status differentiation and the accumulation of wealth (de Miroschedji 2014, Regev et al. 2012). Ceramic industries are no longer centralised, and Khirbet Kerak Ware is introduced from the Caucasus (Figure 2.2). In the second half of the third millennium BCE, the flourishing urban society of the EB III began to collapse, leading to the end of the Early Bronze Age by 2200 BCE. Under Pharaoh Pepi I of the Sixth Dynasty, Egypt launched coastal military incursions into the Southern Levant (Regev et al. 2012, Sharon 2014).

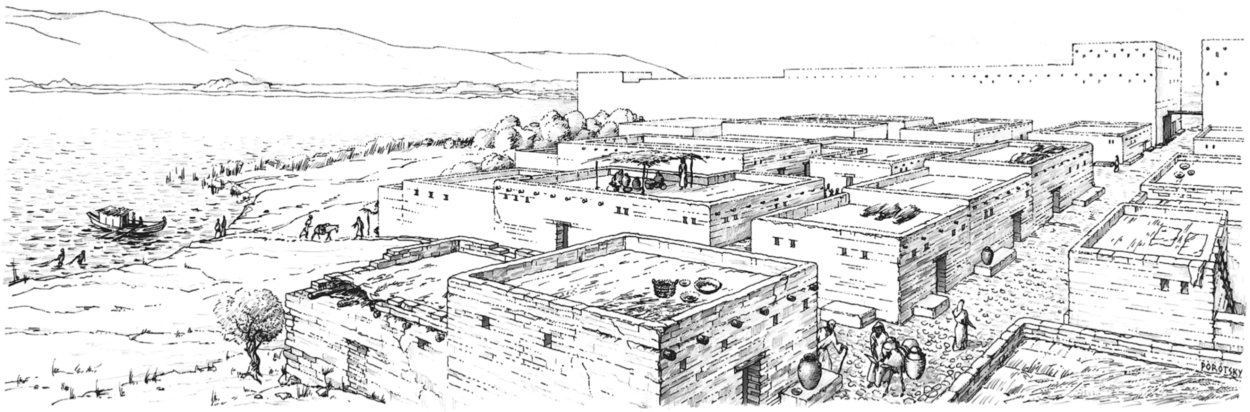

Figure 2.2. The city of Bet Yerah (Khirbet Kerak), the type site for Khirbet Kerak Ware, in the Early Bronze Age. Illustration by Dov Porotsky in Greenberg (2011).

2.2. Intermediate Bronze Age

The Intermediate Bronze Age, sometimes also termed the EB IV or MB I (Regev et al. 2012, Sharon 2014), is a transitional period between the EBA and the Middle Bronze Age. This period is traditionally dated to circa 2300/2200–2000 BCE, although radiocarbon dating suggests an earlier start of 2500/2450 BCE (Regev et al. 2012; Table 2.1). The Intermediate Bronze Age has been seen as a "dark age" for the Southern Levant (Dever 1987)—although for the Northern Levant it is characterised by another step up in size and fortification of settlements, and increased contact with Mesopotamia (Greenberg 2014). This seems to be linked to Egypt's abandonment of trade with the Southern Levant in the EBA, in favour of northern regions such as the Northern Levantine port of

Byblos (Langgut et al. 2016). In the Southern Levant, the urbanisation of the EBA was somewhat reversed, leading to a return to a more egalitarian society, with smaller, sparser settlements. It has been argued that this change, and the preceding collapse of the EB III society, was mainly driven by changes in climate (Fall et al. 2018, Migowski et al. 2006, Rosen 1995, 1997), however some recent scholarship (Langgut et al. 2014, 2015, 2016) has challenged this association. Many of the walled cities of the EB III were abandoned in this period, with smaller settlements founded at new locations (Greenberg 2014, Regev et al. 2012), and the people may have adopted or returned to a semi-nomadic lifestyle (Sharon 2014). Ceramic culture in the Southern Levant exhibits influence from the prospering northern regions. This period is traditionally aligned with the First Intermediate Period in Egypt, also seen as a "dark age", and possibly with the fall of the Akkadian Empire and the Third Dynasty of Ur in Mesopotamia (Regev et al. 2012, Sharon 2014). However, these trends of social collapse are not seen universally across the Levant during this period, and little can be done to correlate the events of the Intermediate Bronze Age to any ongoing process (causative or not) in the Levant, Mesopotamia, or Egypt, making the designation of this period somewhat contentious (Langgut et al. 2016, Sharon 2014).

2.3. Middle Bronze Age

Around 2000 BCE (Sharon 2014), there was a rapid resurgence of settlement densification and urbanisation, ending the "dark age" of the Intermediate Bronze Age (Cohen 2014). The Middle Bronze Age (MBA) in the Levant was contemporaneous with the Twelfth and Thirteenth Dynasties of the Egyptian Middle Kingdom, as well as the Second Intermediate Period (Dynasties 14–17) (Mumford 2014, Sharon 2014), and has been correlated with the First Dynasty of Babylon (Sharon 2014). MBA chronology is highly contentious, with many different systems used to demarcate the internal and external divisions of the period, sometimes incorporating the Intermediate Bronze Age (see Table 2.1 and Sharon 2014 for a review). In this thesis, I favour a bipartite subdivision (MB I, MB II-III), due to the lack of clear archaeological distinction between the MB II and MB III of the tripartite scheme (Cohen 2014). Throughout the MBA, nearly all of the fortified cities abandoned in the Intermediate Bronze Age were reoccupied, sometimes after centuries. These settlements expanded: their fortifications were augmented or new fortifications were built, and the urban elite classes seen in the EBA were re-established. Ceramic production increased in complexity, using faster potter's wheels spun by foot-controlled flywheels to produce more elaborate shapes and more delicate wares (Cohen 2014, Dever 1987). The MBA is also characterised by expanding contacts with the outside world, with strong cultural and trade ties to Syria and Egypt, sporadic trade with Cyprus and Mesopotamia, and evidence of visitors from at least as far as the Caucasus. Movement of peoples throughout the Levant gives evidence of both peaceful and hostile relations (Cohen 2014, Dever 1987, Mumford 2014). Most private houses were simple mud-brick structures, while elite houses were large, multi-room structures of mud brick and stone. Still more elaborate buildings featuring multiple stories and columns can be found at some sites, and probably housed officials who ruled over various cities or city-states. No unified state-level government or single dominant city is observed in this period, although there is some evidence that groups of cities could form leagues (Cohen 2014, Dever 1987, Yasur-Landau 2011).

The first part of this period, until 1750 BCE, is termed the Middle Bronze Age I (MB I) and is roughly contemporaneous with the Twelfth Dynasty of Egypt (Mumford 2014, Sharon 2014). The MB I is characterised by denser settlement in fertile regions and some migration out of the Levant, due to a period of dry conditions that began in the late Intermediate Bronze Age (Finkelstein and Langgut 2014, Langgut et al. 2015). Arable land, access to trade routes, and the easily defensible conditions of the Judean hills encouraged the formation of new towns and cities in this region, many of which became major urban centres for the later periods. These urban centres probably resembled city-states, each dominating a region of arable land as well as some of the surrounding cities and smaller settlements. These city-states began to compete for land, trade, and control of smaller cities, and fortifications began to be built at some sites, in a trend that only increased in later periods (Cohen 2014, Jasmin 2006; see section 2.4). The economy of these cities was based on small-scale agriculture, cottage industry, and moderate amounts of trade in luxury goods. Each city-state and its client cities and surrounding towns were closely linked in a centralised market economy (Cohen 2014, Dever 1987, Jasmin 2006). This period also saw the introduction of tin-bronze metallurgy, resulting in sharper, more intricate tools and weapons. This tin was probably acquired by trade with Anatolia, the Caucasus, or in the region of modern Afghanistan via Mesopotamia. At the end of the MB I, the Southern Levant first began to participate in maritime trade, importing pottery from Cyprus (Cohen 2014, Dever 1987).

Circa 1750 BCE the Middle Bronze Age II (MB II) began, roughly contemporaneous with the beginning of Egypt's Second Intermediate, or Hyksos Period (Sharon 2014). Due to the aforementioned lack of clear distinction, the MB II is sometimes grouped with the MB III to form the MB II–III, from 1750 to 1550 BCE (Mumford 2014, Sharon 2014) or 1800–1600/1550 BCE (Höflmayer et al. 2016). Climate improved in this period, leading to increased settlement in arid southern regions of the Southern Levant, and greater agricultural production (Langgut et al. 2015). Fortification of cities, including sophisticated city walls and gates, increased sharply as city-state competition erupted throughout the Southern Levant. The construction of defences was a continuous process through the MB II-III as elements were added or new structures were built on top of old ones to increase the height, depth, and sophistication of city walls and other defences, leading to an extraordinary variety of structures, building methods, and architectural styles (Cohen

2014, Dever 1987, Yasur-Landau 2011). Even smaller towns and villages were surrounded by city walls, and from the MB II onward almost every MBA site in the Southern Levant was fortified (Dever 1987). It has been argued that the purpose of these imposing structures was as much psychological as practical, allowing settlements to dominate the landscape in the minds of vassals and would-be attackers (Uziel 2010, Yasur-Landau 2011). Cities grew in size, and well-planned and standardised administrative structures, public and commercial areas, temples, water and food storage facilities, houses, stables, streets, and drainage systems are all attested from the cities of this period (Cohen 2014, Yasur-Landau 2011). The import of pottery from Cyprus increased, leading to several varieties of Black-on-Red and White Painted wares appearing in the Southern Levant (Cohen 2014). The late part of the MB II-III (approximately 1650–1500 BCE) was the zenith of Canaanite culture. During the Twelfth and Thirteenth Dynasties (MB I and early part of MB II-III), a West Semitic people called the Hyksos had entered Egypt in large numbers, possibly seeking greener pastures due to the climate crisis of the MB I (Finkelstein and Langgut 2014; Figure 2.3). These people founded the city of Avaris between 1900 and 1800 BCE (early MB I). Avaris was basically a Canaanite exclave, with a demonstrably Canaanite population and material culture that grew throughout the MBA as more Canaanites colonised Egypt. It is interesting that as Canaan waxed and Egypt waned, these former vassals rose to power as Egypt's Fifteenth Dynasty, ruling for a hundred years with Avaris as their capital. Thus, they reversed centuries of Egyptian colonisation in their homeland (Cohen 2014, Dever 1987).

This greatly affected trade and politics in the Southern Levant. The Hyksos rulers exported rich artefacts to the Levant, while Canaanite officials began adopting Egyptian seals and titles. Small juglets for perfume manufactured in the Southern Levant, known as Tell el-Yahudiyeh ware, began to be manufactured throughout the Levant, Cyprus, and Egypt (Mumford 2014). During this period (but possibly earlier or later, see Wimmer (2010) for a short summary of the current debate), the first local writing system was invented. Its appearance, though late compared to the surrounding cultures, was both sudden and highly advanced. This writing system bears similarities to Egyptian hieroglyphs in its earliest forms, but is thought to have been invented in this period in a single event by an unknown person or persons, perhaps connected to a sort of official Canaanite-Egyptian bilingualism during the Hyksos period (Lemaire 2008). The proto-Canaanite script would go on to be the basis for modern writing systems from Greek to Ge'ez (Dever 1987, Lemaire 2008, Wimmer 2010). The Second Intermediate Period of Egypt ended in 1540 BCE, when Egyptian forces under Pharaoh Kamose took back power from the Hyksos, and the city of Avaris was destroyed and abandoned. The Egyptians then continued their campaign under Pharaoh Ahmose into the Levant, besieging cities, claiming land, and bringing an end to the MB III in the Southern Levant. Every MB III site excavated to date in the Southern Levant exhibits one or more destructions between 1550 and 1480 BCE (Cohen 2014, Dever 1987).

Figure 2.3. Wall painting from the tomb of Khnumhotep II, probably depicting Canaanite merchants in Egypt shortly before the Hyksos period. Reproduced from Kamrin (2009).

2.4. Late Bronze Age

The beginning of the Late Bronze Age (LBA) in the Levant is contemporaneous with the Egyptian New Kingdom (Dynasties 18–20) and the Late Minoan I in the Aegean, around 1550 BCE (Mumford 2014, Sharon 2014), or 1600 BCE according to radiocarbon data (Höflmayer et al. 2016; Table 2.1). The LBA is divided in this paper into the Late Bronze Age I, IIA, and IIB, with the LB III (following Ussishkin (1985)), or LBA–Iron Age transition, discussed in section 2.5 as a separate period. The Late Bronze Age saw a resurgence of Egyptian influence in the Levant, progressing from an aloof hegemony to outright cultural domination and the launch of a devastating series of military campaigns that decimated the region (Panitz-Cohen 2014). Nevertheless, Canaan increased in wealth and culture as trade routes through the region became ever more important, and became a complex, cosmopolitan society specialising in long-distance trade over land and sea. At the end of this period, the Mediterranean world collapsed into a chaotic period known as the Crisis Years or Late Bronze Age Economic Collapse, bringing an end to the 2000-year-old established order of the Levantine peoples, and the rise of new kingdoms, technologies, and ways of life in the Iron Age (Killebrew 2014, Panitz-Cohen 2014).

The Egyptian campaigns into the Levant, which brought an end to the MB III following the demise of the Hyksos, continued into the first part of the LBA, the Late Bronze Age I (LB I). Egypt annexed the Levant at the beginning of Egypt's Eighteenth Dynasty, likely between 1570 and 1545 BCE (Panitz-Cohen 2014, Sharon 2014). Egyptian forces under the Eighteenth Dynasty pharaohs led campaigns further and further up the coast, finally reaching the Euphrates River under Thutmose I in ca. 1504 BCE (Höflmayer 2015, Panitz-Cohen 2014, Sharon 2014). Prior to 1479 BCE (sometimes known as the LB IA) is a largely chaotic period sometimes viewed as transitional, featuring natural disasters, territorial incursions by nomadic peoples, continued military campaigns, and internal strife (Panitz-Cohen 2014). The period after 1479 BCE (sometimes known as the LB IB), starting with the ascension of Thutmose III, is viewed as unequivocally Late Bronze in character. Many cities were abandoned for a generation or more, before being slowly reoccupied between 1450 and 1400 BCE, and a *Pax Aegyptiaca* was established. New settlement patterns are observed, focussing on the Mediterranean coast in addition to several key inland valleys. Production and distribution of goods was less centralised than at the height of the MBA, with more emphasis on household workshops and local distribution (Panitz-Cohen 2014).

The LB IIA, from 1400–1330/1300 BCE (Sharon 2014, Mumford 2014) is the period described in Egypt's famed Amarna Letters. Following a peace treaty and the establishment of marriage alliances with the Mitanni Empire to the north during the LB I, Egypt was able to demilitarise the Southern Levant and rule from afar (Panitz-Cohen 2014, Pfoh 2016). As described in the Amarna Letters, the politics of this period were centred on a network of warring city-states (described in section 2.4.1) under the hegemony of the last pharaohs of Egypt's Eighteenth Dynasty. These states vied for power and the favour of Egypt, and contended with strife caused by pastoral and nomadic peoples such as the 'Apiru (Hebrews) and the Shasu. Even with the rich source of information in the Amarna letters, archaeologists and historians are divided on how to characterise this period, and several questions remain. Was this city-state squabbling a symptom of the breakdown of Egyptian rule, or rather the proof of an efficient Egyptian rule that divided and conquered its vassals? Similarly, there is an apparent contrast between the many examples of opulent material culture indicating wealth, compared to the lack of monumental architecture and the poor quality of local pottery (Panitz-Cohen 2014). The LB IIB (corresponding to Egypt's Nineteenth Dynasty) saw a sharp increase in Egyptian presence in the Southern Levant, including an increase in the punitive military campaigns conducted by the Egyptian rulers of the Nineteenth Dynasty against unruly city-states. It is theorised that Egypt's stranglehold of taxation and tribute over the Levant caused the decline of many LBA cities and led to uprisings, however other cities seem to have benefitted from the Egyptian administration (Bienkowski 1989, Metzer 2015). The LB IIB began with military campaigns by Seti I and Ramesses II against these cities (Panitz-Cohen 2014). Furthermore, during the LB IIA, and continuing into the LB IIB, Egypt's control over its northernmost vassals began to wane, particularly due to the fall of the Mitanni Empire, Egypt's ally, to the Hittites and Assyrians (Mumford 2014). In the latter part of the LB IIB, this growing political instability was enhanced by immigration from Anatolia, Syria, and the Aegean world having a significant influence on local demographics (Panitz-Cohen 2014). Egyptian hegemony over the region ended with the short-lived successors of Ramesses II around 1190 BCE, and Egyptian presence in the region slowly dwindled until 1140 BCE (Metzer 2015, Panitz-Cohen 2014).

2.4.1. Canaanite City-States in the Late Bronze Age

It is estimated that around 20 major city-states controlled the Southern Levant during this period, in what was probably a closely-knit patchwork that formed in the 15th Century BCE (early LB I). Rather than a few large cities controlling wide hinterland regions with little border contact as in the MB, the LB city-states were smaller, more densely distributed, and enmeshed in a complex hierarchical system. This new arrangement was possibly connected to population depletion since the MB (Burke 2010, Finkelstein 1996a, b; Panitz-Cohen 2014). Within this system, these cities were almost constantly in conflict, possibly encouraged by Egypt as a strategy to dilute power centres and affirm its own dominance (Jasmin 2006, Panitz-Cohen 2014). The hierarchy between different city-states was probably controlled by differential access to resources, strategic locations and proximity to trade routes, and simply wherever Egypt chose to install governors and garrisons (Panitz-Cohen 2014). Although the term "city-state" is preferred in Levantine archaeology, these city-states functioned like small kingdoms[1], often incorporating several subordinate cities surrounding the principal city, each of which might operate as a local centre of administration, controlling its own hinterland of cities and villages in a second degree of subordination. Larger subordinate cities might even vie for the status of the principal city within the city-state's region (Jasmin 2006, Pfoh 2016, Savage and Falconer 2003; Figure 2.4).

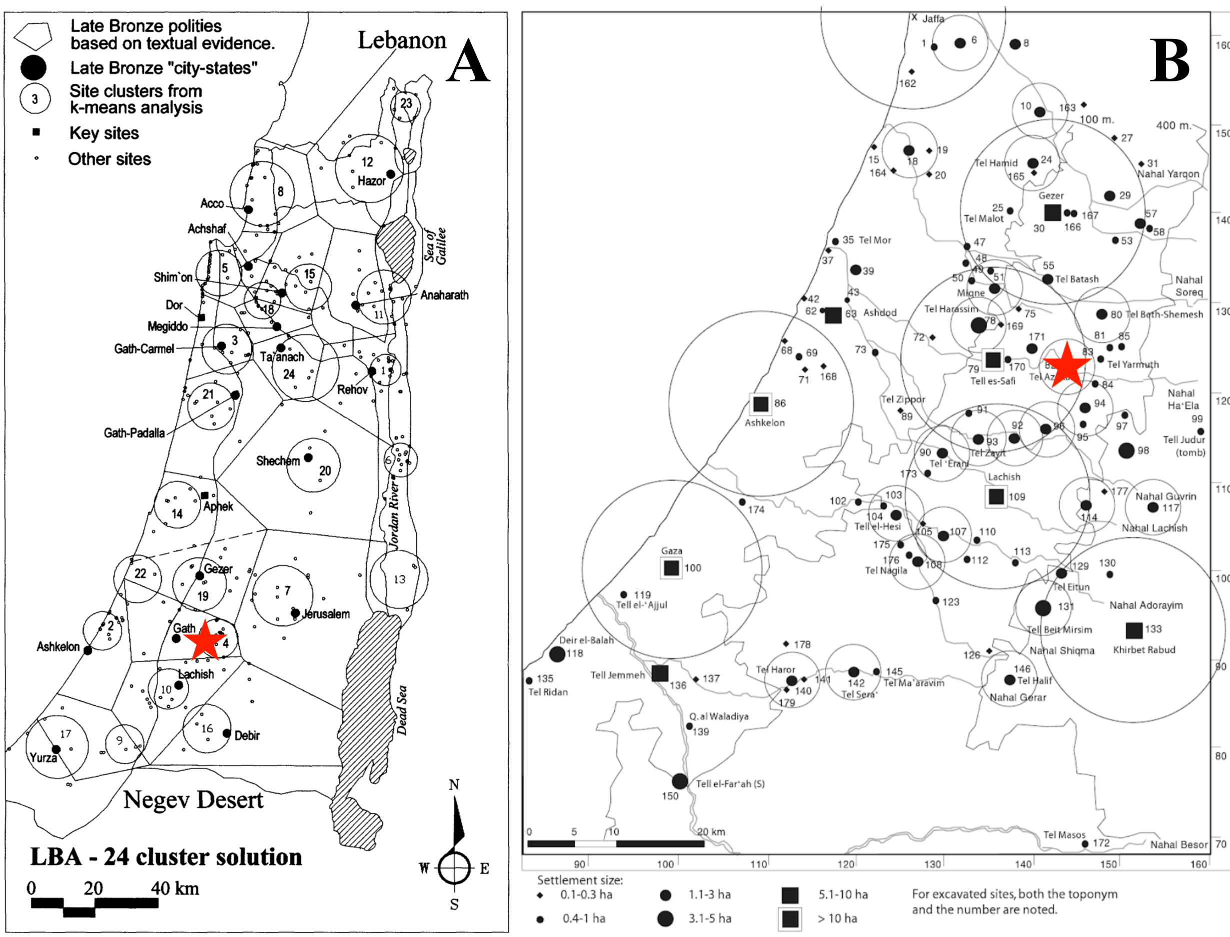

Figure 2.4. Polities in the Late Bronze Age of Canaan. Reproduced from A) Savage and Falconer (2003) and B) Jasmin (2006), altered to mark Azekah in red. In A, circles designate site clusters while polygons describe approximate territorial boundaries of polities. In B, the circles of various sizes represent zones of control of major and minor settlements.

[1] The LBA Canaanite city-states challenge the conventional taxonomy of settlement patterns in anthropology, being more complex than a chiefdom, but less delineated and centralised than a state. Savage and Falconer (2003) and Pfoh (2016) compare these city-states to the concept of the Early State Module proposed by Renfrew (1975), and their dynamics to the Peer Polity Interaction theories of the same author (Renfrew 1986).

Peripheral sites sometimes functioned as border outposts, which could switch their allegiances or be conquered by nearby principal cities, allowing city-states to grow and gain power within the region at the expense of their neighbours (Jasmin 2006, Savage and Falconer 2003). In this way, some city-states such as Hazor, Shechem, and Gezer gained predominance over other cities within their region, taking on the characteristics of the classical definition of a kingdom, and leading to a higher tier of inter-regional conflict between these "territorial kingdoms" (Finkelstein 1996a, b; Jasmin 2006, Na'aman 1997; Panitz-Cohen 2014, Pfoh 2016, Savage and Falconer 2003). However, the total power and territory that a city-state held was limited by the Egyptian hegemony, which preferred to prevent any one city-state from gaining dominance over the others (Jasmin 2006). The rulers of the Canaanite city-states, sometimes called "small kings" or "petty kings", enjoyed a degree of autonomy—but final power rested with the "great kings" from Egypt (Pfoh 2016, Sharon 2014, Sherratt 2014, Tadmor 1979). Though frequently referred to in the literature as "small kings", these leaders are better described as "mayors" (by literal translation from the Amarna Letters (Na'aman 2011, Savage and Falconer 2003)), and can be characterised as having power somewhere between the true city-state kings elsewhere in the ancient world (such as Mesopotamia) and the village sheikhs of the modern Levant (Herzog 2003, Pfoh 2016). It is thought that the political power of the "small kings" (i.e. Egypt's political interest) was probably closely connected to their trade prospects and the strength of their economies. However, this situation is made no less complex by the fact that several of the leaders of different polities may have been blood relatives, members of elite families installed by Egypt (see section 2.4.2), and their ties with each other and with Egypt were influenced by their kinship relations. The complex relationships between these leaders are attested in the Amarna Letters, famous for their deferential, plaintive tone as of squabbling siblings appealing to their parents—which, in a very real way, is what they sometimes were (Panitz-Cohen 2014, Pfoh 2016).

2.4.2. Egypt's Influence in Late Bronze Age Canaan

One of the most important features that characterises this period is the various ways in which Egypt exerted its control and influence over the Southern Levant, which extended beyond the political relations with city-states described in the Amarna Letters. Egypt was interested in the Levant for its trade connections and fertile land, but the region was also an important strategic zone and buffer between Egypt, the Hittite and Mitannian Empires, and the rest of the Mediterranean world (Gadot 2010, Panitz-Cohen 2014, Redford 1990). From the description of this era in Redford (2000), three phases can be discerned for the development of the Egyptian administration in Canaan. Firstly, during the Eighteenth Dynasty reigns of Thutmose III and his successors, was a period of conquest and consolidation, as well as conflict with the Mitanni Empire to the north of Canaan. Following a peace treaty and the establishment of marriage alliances with the Mitanni, there was a *Pax Aegyptiaca* over the Southern Levant at the end of the LB I. Military strongholds and harbour bases were constructed, and garrisons were placed in key towns (Burke 2010, Metzer 2015, Panitz-Cohen 2014). The second phase, during the LB IIA, was marked by circuit commissioners and garrison cities, which characterised Egypt's rule from afar during the Amarna period. In the third phase, during the LB IIB, Redford (2000) describes the Egyptian administration as complex, with a "god-ordained tradition". In this phase, Egypt once again tightened its hold over Canaan, increasing military personnel in the region to quash local uprisings and defend against the growing northern threat of the Hittite Empire (Gonen 1992, Metzer 2015). Overall, Canaan in the Late Bronze Age was somewhere between a vassal state and an Egyptian province, with Egypt balancing local rule with its own administration to maintain strategic control of the territory, without exhausting any great economic interest (Higginbotham 2000, Na'aman 1981).

In the era of the *Pax Aegyptiaca*, local elites loyal to the Hyksos dynasty of the MB II-III changed their loyalties or were replaced, and a new elite class was installed in the region from Egypt. These new elites were either local or the children of marriages between Levantine and Egyptian nobles, who were raised in Egypt but returned to rule over the Levantine city-states of their origin. This Egypto-Levantine government may have formed a hybrid ruling class, helping cement Egypt's power over the region (Koch 2014, Mumford 2014, Pfoh 2016). The presence of these elite families in the LBA Levant is attested by the construction of palace-like "Patrician Houses", lavishly furnished dwellings with abundant examples of Egyptian or emulated Egyptian material culture. These may also have been centres for local administration (Metzer 2015, Panitz-Cohen 2014). Egypt's administration was centred in a network of key cities, particularly the sites of Gaza, Jaffa, and Beth She'an, which presided over the existing political order of the Levantine city-states. These cities contained the centres of local government and military garrisons, as well as the locales for collection of tribute from the Canaanite rulers. The administrative centres seen from this period are distinct in architecture and function compared to Levantine palaces, and are termed by Oren (1984) and subsequent literature as "Governor's Residences". However, these "governors" may not have resided permanently in these locations, instead travelling circuits through the various polities to collect taxes and tribute, deliver messages, and supervise official activities (Gadot 2010, Higginbotham 2000).

With these new leaders in place, Egyptian cultural influence steadily increased in the region, mostly in funerary and temple artefacts (Mumford 2014). In the LB IIB, there is substantial evidence from the Amarna letters and other sources that Egyptian and Kushite soldiers, officials, merchants, servants, and other civilians were living in regions throughout the Levant. These immigrants and the locals alike created a demand for Egyptian-style products and emulations of Egyptian architecture, culture, and religion (Mumford 2014, Panitz-Cohen 2014). Temples were dedicated or rededicated to Egyptian deities, Egyptian and Egyptianised artefacts are common, and burials in anthropoid coffins, in an imitation of the Egyptian style, were practiced in the Southern Levant. However, it has been argued that the notion that Egypt's presence is responsible for the increase in Egyptian material culture in the LB IIB is incomplete. The concept of elite emulation has gained traction since its original proposal in Higginbotham (1996), arguing that the Canaanite rulers, raised in Egypt, were responsible for this surge in demand rather than Egyptian rulers transplanted to the region. To the local elites, and possibly to the broader society, Egyptian culture became an expression of high status. Wherever the Egyptians had an economic interest, prosperity was enjoyed and this elite emulation is observed (Higginbotham 1996, 2000; Koch 2014, Koch et al. 2017, Metzer 2015, Panitz-Cohen 2014, Pfoh 2016). In any case, Higginbotham (2000) reaches the conclusion that a dual system of transplanted pharaonic officials from Egypt ruling over acculturated local princes is most likely.

Morris (2005) identifies three categories of artefacts from this period: Egyptian, Egyptian-style, and Egyptianising. Imported Egyptian objects can be traced back to production in Egypt by X-ray fluorescence (XRF) and other methods, but are typically also recognisable by their superior workmanship and adherence to established styles. Objects termed "Egyptian-style" are typically very similar to Egyptian objects, but produced locally by Egyptians, or those who had fully adopted Egyptian culture. However, they may vary in the strictness of their adherence to Egyptian styles and their quality of production. Egyptianising objects, by contrast, are simply local objects that exhibit some influence of Egyptian motifs, and represent a materialisation of the acculturation process seen among the local Canaanites in this period (Burke and Lords 2010, Higginbotham 1996, 2000; Koch 2014, Koch et al. 2017, Morris 2005) This accounts for observations in the archaeology, where some sites have large numbers of Egyptian imports, Egyptian architecture, and locally produced Egyptian-style artefacts, and thus were probably home to Egyptians, while other sites may exhibit Egyptian imports but no local adoption of Egyptian styles or Egyptianising artefacts, a sign of Canaanite elites emulating Egyptian culture by importing objects, while common people continued to produce local styles of material culture. In spite of this growing cultural influence, or perhaps because of it, the Canaanite people nevertheless retained a homogeneity in material culture suggesting shared language, religion, and cultural identity in the face of Egyptian domination (Morris 2005, Panitz-Cohen 2014, Pfoh 2016).

2.4.3. Canaanite Trade and Seafaring

Within this context of Egyptian cultural domination, the Canaanite people discovered their niche as masters of trade, exploration, and colonisation. Although Egypt had long conducted its own trade with Byblos and other Levantine ports by sea, the Levantine coastal centres were generally considered the better maritime traders, and expanded Egypt's connection to maritime trade throughout the Mediterranean (Sherratt 2014). Canaanites, particularly those inhabiting coastal regions, were experienced in shipbuilding and maintenance, and were well-known as sailors. The Canaanite storage jar, a large torpedo-shaped, stirrup-handled vessel originating in the Levant, was an extremely efficient transport and storage vessel, and a common sight in ports throughout the Mediterranean (Panitz-Cohen 2014, Sherratt 2014). This vessel's form, increasingly elongated with a narrow mouth for a stopper, and two or four handles plus a button base that acted as an extra handle, emphasised efficiency of handling and economy of space. Larger vessels could be carried by pairs of people from both sides or supported on wooden poles or ropes through the handles, while smaller vessels could be carried on the shoulder (Grace 1979, Killebrew 2007, Twede 2002). The form of these vessels also increased durability, and may have facilitated stacking in multiple layers

(Knapp and Demesticha 2016). Ancient depictions and modern reconstructions show these vessels with their pointed bases placed in wooden stands or embedded in soil or brush, often neatly arranged in grid or rosette pattern with their handles secured together with rope or wooden poles for support (Figure 2.5). In the concave space of a ship's hold, their shape allowed them to be stacked against the hull in layers to maximise the use of space (Killebrew 2007, Knapp and Demesticha 2016, Twede 2002; S. Kleiman pers. comm.). The LB IIB Uluburun shipwreck, off the coast of southern Anatolia, demonstrates that these vessels were used in large quantities to transport resins and/or wine (Haldane 1993, Pulak 2008), and it is demonstrated from other ancient shipwrecks, archaeological sites, and documented in epigraphic sources that these vessels carried an extraordinary variety of goods at least as far as the Mycenaean world (Knapp and Demesticha 2016). In the LB and later periods, the Canaanite storage jar was widely copied, and is considered to be the precursor to the Graeco-Roman amphora (Knapp and Demesticha 2016, Panitz-Cohen 2014)—in fact, the Greek word *amphiphoreous*, meaning "carried on both sides", describing the handling of the vessel, is the origin of this word (Grace 1979).

This figure was removed because of copyright restrictions. It depicted Canaanite storage jars arranged in the hull of a ship for transport. Original source:

Bass, G. F. (1987). Oldest known shipwreck reveals splendors of the Bronze Age. *National Geographic*, *172*(6), 692–733.

Figure 2.5. Canaanite storage jars in a reconstruction of a Canaanite ship from the Late Bronze Age (the Uluburun shipwreck). Painting by Ned and Rosalie Seidler, published in Bass (1987).

Canaanite sailors and sub-elite merchants often acted as free traders, middlemen, or mercenaries in trade niches such as pottery, scrap metal, and knockoffs of elite luxury items. Canaanite imitations of Cypriot and other high-quality imported pottery were produced by Canaanite traders to stimulate market competition (Panitz-Cohen 2014). On land as well, the Levantine city-states, particularly in the central Shephelah region, were valued as gatekeepers to the land trade routes for northern and eastern sources of luxury items, such as lapis lazuli and amber, and locally produced goods such as pigments, olive oil, incense, wine, and metals. In addition to the elite emulation of Egyptian culture, Levantine elites began to adopt an elite *koine*, or international style, a fusion of exotic luxury designs that became a mark of elite status and sophistication (Sherratt 2014). The establishment of the Canaanites' identity as a seafaring people in the Late Bronze Age may have led to cultural divergence between the coastal Canaanites and their inland relatives. This new identity has been connected to the people who would later emerge in the Iron Age as the Phoenicians (Astour 1965, Berkowitz and Ra'ad 2001, Quinn 2011, Stager 1991, Stieglitz 1990). In this new form, Canaanite cultural traditions continued through the Iron Age, later metamorphosing once more into the Carthaginian civilisation in the Western Mediterranean (Faust 2000, Gilboa 2005, 2014; Ra'ad 2001). The Canaanite-Phoenician-Carthaginian culture continued until the conquering of the Phoenicians by the Persians in the 6th Century BCE, and of the Carthaginians by the Romans in the 2nd Century BCE. However, their cultural legacy persisted, and can be found in language, religion, and daily life throughout the Mediterranean today (Gilboa 2014, Markoe 2005, Moscati 2001).

2.5. Late Bronze Age–Iron Age Transition (LB III)

Many authors, including Steiner and Killebrew (2014), refer to the transitional period before the Iron Age simply as the Late Bronze–Iron Age Transition. This nomenclature is sometimes favoured due to enduring disagreement over the designation of this transitional period as LBA, Iron Age, both, or neither (Asscher et al. 2015, Finkelstein et al. 2017, Mazar 2011, Mazar et al. 2005, Panitz-Cohen 2014, Sharon 2014, Sherratt 2014), as well as the long duration of this transition making it almost a period unto itself (Killebrew 2014, Sharon 2014). However, following Ussishkin (1985), and for ease and clarity of reading, this paper uses the shorter term LB III to refer to this period—which also emphasises, importantly to this paper, its strong connection to earlier periods. The LB III involved a dramatic collapse of the political and economic organisation of the Southern Levant between 1200/1150 and 1150/1100 BCE (Table 2.1). This process may have had its roots in invasions, plagues, earthquakes, mounting dysfunction in the political system, or a slow change in climate (Cline 2014, Finkelstein 1996b; Langgut et al. 2013, Zuckerman 2007). Supporters of climate as the driving factor behind this change particularly identify a severe drought event beginning in the late 13th or early 12th Century BCE (Kaniewski et al. 2012, 2015a) as the root cause of this transition (Drake 2012, Kaniewski et al. 2008, 2012, 2013, 2015a, b; Langgut et al. 2013). This caused crop failures and famines, leading to or exacerbating existing social tensions and destabilisation of the complex LBA city-state system (Gilboa 2014, Knapp and Manning 2016, Langgut et al. 2013).

In this period, from the late 13th through most of the 12th Century BCE, many or most large cities and secondary towns in the city-state architecture of the Southern Levant were destroyed (Cline 2014). Some of these were totally ravaged and abandoned, while others were only partially destroyed and recovered quickly (Gilboa 2014, Langgut et al. 2013). At the sites of Beth-Shean, Deir ‘Alla, and Akko, we find specific evidence that these destructions were perpetrated by Egyptians in the late 13th or early 12th Century BCE. It has been suggested that these cities became too powerful in the final years of the reign of Ramesses II, prompting a punitive campaign by Merneptah (Metzer 2015). The sites of Lachish, Beth Shemesh, and possibly Azekah were the only sites not completely destroyed in Merneptah's campaign (Metzer 2015). These cities retained their status or even enhanced it after this period of destructions, occupying the power vacuum and winning the favour of Egypt. However, these cities too met their end in the late 12th Century BCE after Egypt withdrew from Canaan, and they were no longer protected from other invaders, neighbouring city-states, and internal unrest (Cline 2014, Metzer 2015). The fact that the destructions of this period took place over several decades, rather than over the course of a few years, in conjunction with the fact that a few of these sites (such as Lachish) exhibit multiple destruction layers several decades apart, is consistent with the theory that the Late Bronze Collapse was due to a slow decline in climate rather than a single instance of invasion (Cline 2014). In any case, contemporary with these destructions, an influx of foreign immigrants is also thought to have contributed to the gradual loss of Canaanite culture (Cline 2014, Langgut et al. 2013, Panitz-Cohen 2014). The inhabitants of these cities may have fled into the Judaean hills in the Iron I, resulting in an unprecedented settlement wave (Kaniewski et al. 2013, Langgut et al. 2013), however recent stable isotopic analysis of human remains has given evidence against a large-scale population movement (Gregoricka and Sheridan 2017).

In the wider Eastern Mediterranean, this transitional period, known commonly as the Crisis Years, has been connected to the collapse of the Aegean palatial system, the fall of the Hittite empire in Anatolia, the decline of Alashiya (Cyprus), Ugarit, and other prominent trading powers, and the decline of Egypt (Cline 2014, Langgut et al. 2013, Panitz-Cohen 2014, Sharon 2014). These events are documented in sources from the early 12th Century BCE, such as the accounts of the battles of Ramesses III with the mysterious Sea Peoples (Figure 2.6), as well as a series of dramatic letters from Ugarit describing maritime raids on settlements along the coast (Cline 2014, Langgut et al. 2013). The fall of key cities, possibly combined with hostile elements roaming Mediterranean waters, appears to have resulted in the collapse of several key trade routes in this period, causing a domino effect that devastated the Late Bronze Age economy across the Mediterranean world (Cline 2014). However, the collapse of trade routes has alternatively been interpreted as a natural transformation of the economy away from centralised, political control, leading to the rise of private merchants—who can possibly be identified in the aforementioned Sea Peoples themselves (Cline 2014, Sherratt 1998, 2014). Whether they are characterised as hostile invaders marauding along the coast, or simply as entrepreneurial nomadic merchants, the Sea Peoples can be seen only as one of many elements leading to the collapse of the Late Bronze Age Mediterranean regime. Overall, it seems that declining climate, leading to famine, civil unrest, and possibly internal rebellions, was compounded by invasions from external forces who may have been migrating due to the same climatic conditions. On top of this, a series of severe earthquakes is documented from this era. Each of these factors can be said to have contributed to one or more destruction layers known from almost every major Mediterranean site in the first half of the 12th Century BCE, from whose ashes rose the new order of the Iron Age world (Cline 2014).

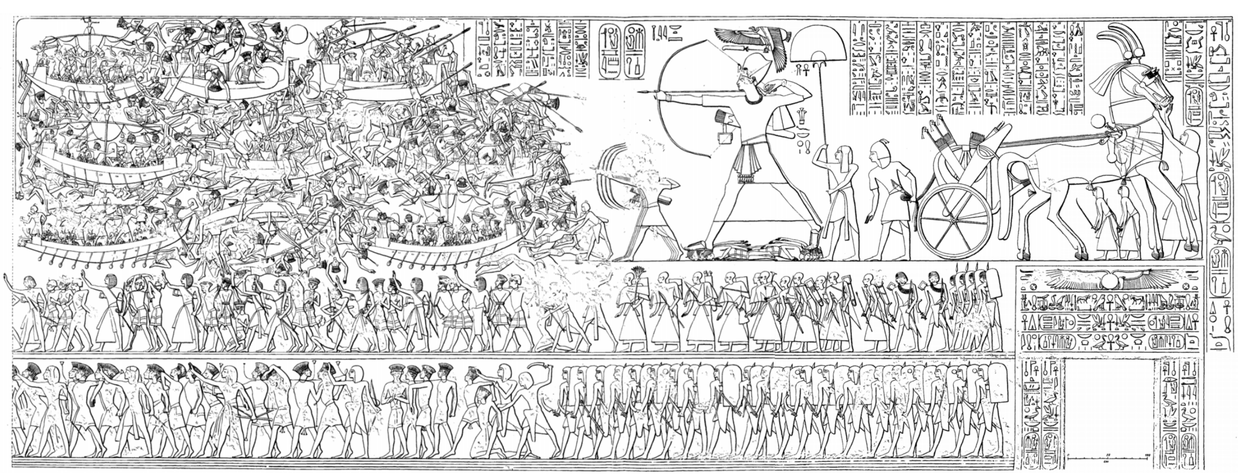

Figure 2.6. Ramesses III defending Egypt from the Sea Peoples, depicted on the walls of his mortuary temple at Medinet Habu. Reproduced from Nelson (1930).

2.6. Bioarchaeology of Destruction in the Southern Levant

As described in Chapter 4, a destruction context is the assemblage of artefacts, features, and human and animal remains that were present at the time of a disastrous event that destroyed a site, and were buried or abandoned in place (Driessen 2013). As a disaster approaches with some amount of warning, as in the case of a city siege when citizens might observe an army approaching the city, individuals have a certain amount of time to react. In this case it could be several hours, allowing collection of precious items, abandonment of other items, and safe evacuation of the city, a period defined by Schiffer (1985) as the second stage in the abandonment process. However, if this hypothetical army attacked at night, the preparation time could be reduced to a matter of minutes. Even less response time would be possible in a natural disaster such as an earthquake, where inhabitants would be forced to evacuate their homes within seconds or be crushed, and might evacuate the city shortly after due to fires (Ashmore 2000, Driessen 2002, 2013; Kreimerman 2017). These sudden destructions and abandonments are seen relatively often in Levantine archaeology, and the speed of abandonment in these scenarios has direct bearing on what is found by archaeologists: more rapidly abandoned contexts will exhibit more objects abandoned *in situ*, i.e. in the same locations and contexts in which they were being used, while more gradually abandoned contexts may have been cleared out by the inhabitants prior to evacuation (Driessen 2013, LaMotta and Schiffer 1999, Metzer 2015). Destruction contexts tend to exhibit large amounts of pottery finds and hoards of precious items, as these were either abandoned suddenly or collected in the final moments before the destruction but never retrieved (Driessen 2013, Kreimerman 2017). Such an arrangement of artefacts that reflects the normal use of these items immediately before the destruction has been termed "de facto refuse", and represents a snapshot or time capsule of life before the destruction (Driessen 2013, Kleiman et al. 2016, Metzer 2015, Schiffer 1985, 1987; see section 4.3.2 in Chapter 4). The vast majority of destruction layers are partially or completely abandoned for a long period of time following the destruction, often untouched until they are rediscovered by archaeologists (Kreimerman 2017).

More rarely discovered in destruction layers are the inhabitants of destroyed buildings, victims of the destruction event. Across the Southern Levant in different periods, three main trends are observable in the spatial distribution and context of destruction-layer victims, as described in Kreimerman (2017) and outlined in Table 2.2. Firstly, their remains are usually covered in rubble and crushed, and sometimes also burnt. It is very rare to find human remains in a destruction layer that are not covered in rubble (Kreimerman 2017). Secondly, destruction layer remains exhibit spatial trends, generally being found in private residences, often near the city gate. Thirdly, human remains are most often found in destruction contexts that are thoroughly burned and abandoned, with sites that are partially burned or quickly resettled exhibiting few if any remains (Kreimerman 2017; see also Albright (1931, 1939), Arensburg (2006), Mazar (1999), Namdar et al. (2011), Smith (2004), Stager et al. (2011)). Kreimerman (2017) argues that these trends are driven primarily by human activity following the destruction. In a military context, the conquerors might remove the remains for hygienic reasons, or in order to mutilate and display them as an insult. Similarly, following a natural disaster, the inhabitants or resettlers would likely remove the remains for reinterment elsewhere (Kreimerman 2017, Zorn 2014). Thus, according to Kreimerman (2017) there may actually have been many victims in any given destruction, but most of the time the bodies are removed. This offers an explanation for the first trend described above: debris overlying the remains would prevent discovery and removal by contemporaries. This is further supported by cases of unrecovered bodies in localised destructions that affected only a small part of a site, where there were clearly people available to recover the corpses, but they were simply inaccessible (Kreimerman 2017, Mazar and Mullins 2007, Panitz-Cohen and Mazar 2009, Sharon and Gilboa 2013; see Table

2.2). In many cases, this debris would be greatest near the city gate, where siege destruction was massive. Furthermore, all removal of corpses would be most likely to occur in open areas and public buildings that were looted, whereas corpses in private dwellings might be overlooked, explaining the second trend. If no one returned to remove corpses from the site, and/or the site was so thoroughly destroyed that many corpses were unrecoverable, this might result in such sites exhibiting higher numbers of destruction layer remains, explaining the third trend (Kreimerman 2017, Table 2.2).

However, this behaviour-based explanation has several issues, and can only partly explain archaeological evidence. For one thing, in the clearest examples of city sieges that we have in the Southern Levant and the broader Near East, the casualties were in fact granted proper burial within the city rather than removed (Finkelstein 2009, Kreimerman 2017, Panitz-Cohen and Mazar 2009). Kreimerman (2017) asserts that in a military destruction, the inhabitants would have been executed, and the city would be "cleaned" from corpses before it was burned—and that at least a few hours would have passed between the conquest and burning of a city. Certainly, mass graves outside besieged cities are found in the ancient Near East. However, many of these do exhibit skeletons with evidence of burning, and in any case it is not clear who created these graves, and at what stage in the siege process, which could have taken multiple years (Eph'al 2013, Risdon 1939, Ussishkin 1982, 2004; Yadin 1963). Overall, the osteological evidence for this scenario is limited. In the case of Azekah (discussed in Chapters 6 and 7), there is good evidence that the disaster was very sudden, that the inhabitants were responding to a fire before they died, and that the collapse occurred sometime during the fire—not before. In the sites discussed by Kreimerman (2017), only 11% of destruction layers actually contained human remains, and even then usually in small numbers. This may support an alternative explanation simply that there were usually very few casualties in these events, and that the trends identified by Kreimerman (2017) are random or due to other factors.

Site and Stratum	Period	MNI	Age and Sex	Context	Crushed	Burnt	Notes
Beth Shean R4	MB IIB	2	Adult and child	Private house	n.d.	Yes	Localised
Shechem XV	MB III	~8	n.d.	City gate	Yes	Yes	
Gezer XVIII	MB III/LB I	1	Adult female	Private building near city gate	Yes	Yes	Holding basalt bowl
Tell Beit Mirsim D	MB III/ LB I	10+†	Adults and children†	Private houses	No†	Yes	Many face down
Gezer (unpublished)	LB II	3	Two adults and one child	Public building or palace	Yes	Yes	Self-protective posture
Tel Batash VII	LB IIA	2	Adult male, n.d.	Patrician house?	Yes⁑	Yes	
Lachish VI	LB III	5–7	Two adult females, three children, infant‡	Private houses	No‡	Yes	Two children were face down
Azekah (unpublished)	**LB III**	**4**	**Adult female and male, adolescent female, indeterminate adolescent**	**Patrician house or manufacturing**	**Yes**	**Yes**	**Self-protective postures**
Beth Shean VI	LB III	2	Adult male, n.d.	Private house	n.d.	Yes	Ceremonial burial
Megiddo VIA	Iron Age IB	8–13	4–5 adults, child, infant	Private houses	Yes	Yes	Ceremonial burials
Tel Dor	Iron Age IB/IIA	1	Adult female	Private house	Yes	No	Localised, self-protective posture
Aphek A7	Iron Age IIA	1	n.d.	Private house	Yes	Yes	
Horbat Rosh Zayit IIA	Iron Age IIA	1	n.d.	Cistern just outside city gate	No	Yes	
Tell es-Safi A3	Iron Age IIA	5**	Adult female, adolescent male and female, child**	Private house	Yes**	Yes**	
Tel Ira VII	Iron Age IIB	2	n.d.	Room adjacent to city gate	n.d.	Yes	
Tel Batash III	Iron Age IIB	~3	Adult female, adult male, child	Private house and public building	n.d.	Yes	Lots of storage jars in house
Tel Rehov A3	Iron Age IIB	2	Adult female, indeterminate	Private house	No*	Maybe	
Tell es-Safi D3**	Iron Age IIB	3**	Three adult females**	Public building**	Yes**	Yes**	Pugilistic posture
Ashkelon XII	Iron Age IIC	1	Adult female	Private house	Yes††	Yes	

Table 2.2. Summary of destruction layer human remains in the Southern Levant, with the site studied in this thesis in bold type. Adapted from Kreimerman (2017) with additional data from: †Albright (1931, 1939), ‡Smith (2004), *Mazar (1999), ⁑Arensburg (2006), ††Stager et al. (2011), **Faerman et al. (2018).

In summary, the presence and distribution of skeletons in destruction layers can be partially explained by human activity in several ways: either the corpses were not found, due to abandonment of the site or burial in debris, or they were left intentionally. However, it may simply be that casualties were relatively rare in destructions, and only occurred in the case of sudden fires or building collapses. In any case, some combination of these factors seems most likely, and hopefully this thesis and other studies will contribute to the body of knowledge that will support our growing understanding of destruction contexts in the Southern Levant. Table 2.2 summarises the context of every destruction layer victim currently known from the Bronze and Iron Ages of the Southern Levant, as reported by Kreimerman (2017), with additional data from cited sources.

2.7. Conclusion

The Bronze Age was a formative period for the Southern Levant, where the urban culture of the Canaanite people first appeared and began to flourish. As the Canaanite settlements proliferated, they produced dense trade networks that connected the disparate regions of the Middle East, Europe, and North Africa for the first time, and brought wealth and a flourishing urban culture. However, these trading city-states also came into conflict with each other, causing them to raise sophisticated fortifications and compete for the interest of foreign powers and hegemons. Throughout the Bronze Age, the Southern Levant experienced waves of settlement, destruction, and resettlement as these cities and empires spread and retreated across the land, leaving behind artefacts, traditions, ideas, and genes. In the ruins of the Southern Levantine city-states we find traces of these serial destructions, which contain snapshots of daily life and activities where objects were abandoned in place. Occasionally, humans are found in these destructions: the victims of violence, or perhaps simply caught in these sudden disasters.

As the peoples of the Levant established their identities in this period and began to look outward at the larger world to find their place in it, they gave the world the best of their cultural traditions and technologies, including one of the world's most prolific writing systems. However, they left behind little evidence of their daily lives and identities. The human remains that we find in Levantine destruction layers are key evidence to produce an improved understanding of the average person and the daily aspects of life in this period. This informs our understanding of the acculturation, social stratification, and social unrest that occurred during this period, particularly as Egypt struggled to assert control over the region.

Chapter Three Tel Azekah and the Shephelah

The Shephelah is an inland region of the Southern Levant, forming a natural boundary between the coastal plain and the Judean highlands (Figure 3.1). As a whole, the Shephelah has been described as a liminal region, one which connects the coast to the inland hills, and the arid, Egyptian-dominated south to the fertile north and its Anatolian, Mesopotamian, and Caucasian connections (Creel 2017, Tappy 2008). Characterised by its easily defensible hilltops and fertile valleys, this region has always been strategically important (Finkelstein and Na'aman 2004, Morton 1962, Rainey 1983). The Shephelah is crossed by five main east-west valleys, the Ayalon, Sorek, Elah, Zephathah, and Qubeiba, each of which forms a natural route for trade and movement of peoples between the coast and the inland hills (see Figure 3.2). In ancient times, these five valleys were of paramount geopolitical importance for trade, agriculture, and military strategy, and had a unique influence on settlement patterns in the region (Metzer 2015, Morton 1962).

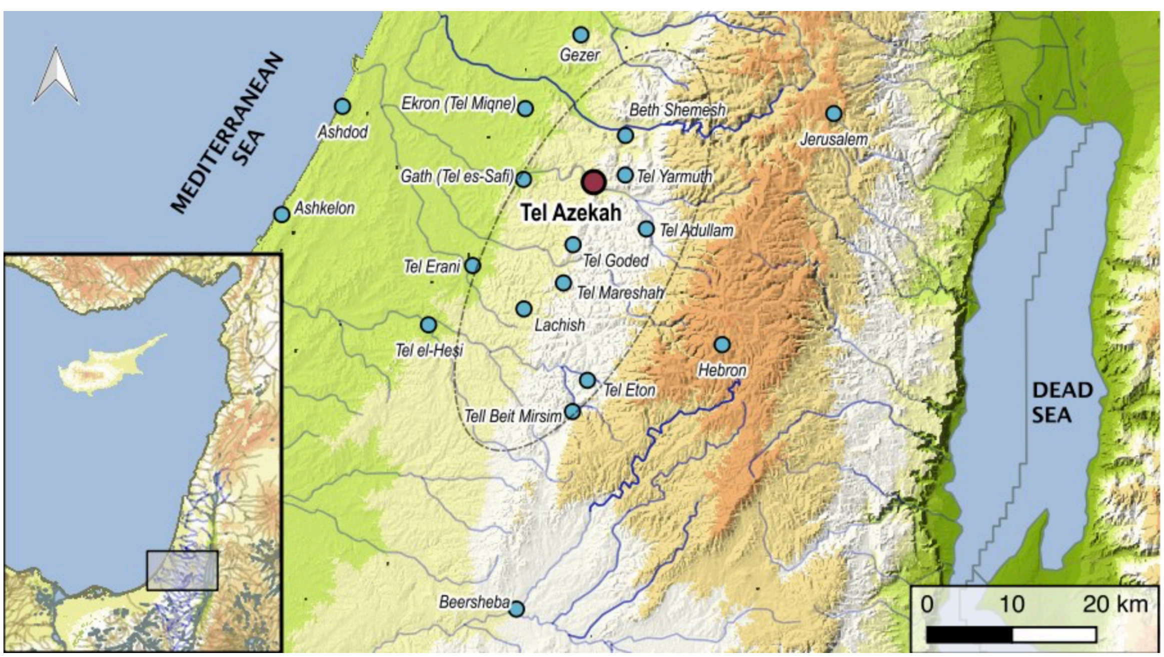

Figure 3.1. Topographical map of ancient Canaan showing the Shephelah region. From Webster (2015).

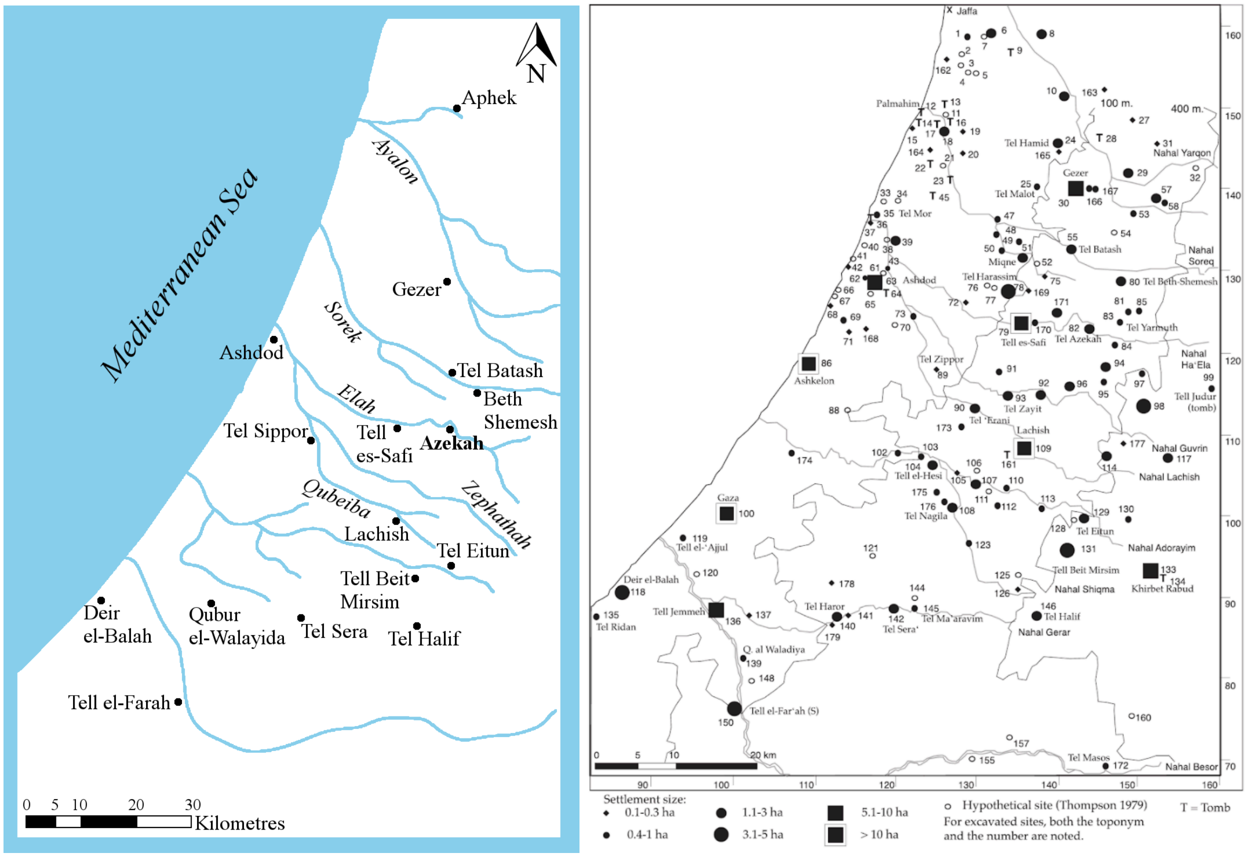

Figure 3.2. Important sites and major river valleys in the Shephelah region. A) Adapted from Metzer (2015), and B) from Jasmin (2006).

3.1. Egyptians in the Late Bronze Age Shephelah

The Shephelah, like the rest of the Levant, was largely dominated by Egypt in the Late Bronze Age, and the cultural and political interactions between Egypt and the Shephelean polities are what primarily shape the region's history in this era (see Chapter 2 for a more detailed description). As one of the closest regions to Egyptian centres of power in the southern coastal plain, the Shephelah would have been closely controlled by Egypt during the Late Bronze Age via its existing political network of city-states (Morris 2005, 2006; see Chapter 2). As discussed in Chapter 2 and the citations therein, many artefacts from this period can be classified as either Egyptian, Egyptian-style, or Egyptianising, and these classifications allow us to characterise the influence of Egypt's empire throughout the Southern Levant. In this period, Gath, Gezer, and Lachish were probably the most important polities in the Shephelah region (Na'aman 2011). Using these principles and the evidence outlined below, archaeologists have suggested that in the 13th Century BCE, during Egypt's Twentieth Dynasty, these cities probably had direct connections to the Egyptian empire and were visited by circuit officials, but were not centres of administration with a permanent Egyptian presence. Instead, permanent Egyptian presence primarily took the form of farms and small estates in the region (Higginbotham 2000, Koch 2018, Morris 2005, Na'aman 2011).

The ancient city of Gath (Tell es-Safi) exhibits Egyptian influence by the presence of several seals and scarabs, as well as part of an Egyptian stela, and two bowl fragments with hieratic inscriptions, but no Egyptian or Egyptian-style pottery has been found there (Bliss and Macalister 1902, Keel and Münger 2012, Maeir 2012, Wimmer 2012). This site does contain an LBA Patrician House (see Chapter 2) that was possibly destroyed by fire in an event that has been connected to the Sea Peoples (Maeir 2012)[2]. Egyptian artefacts are found at the site (Keel 2013, Keel and Munger 2012), but no Egyptian-style or Egyptianising pottery has been found (Maier 2012), suggesting no direct Egyptian presence in the city. Gath is also a prime example of the high density of settlement in the Shephelah, one of the reasons for Egypt's interest here, but also for the internecine strife the region experienced (Na'aman 2011). Finkelstein (1996b) estimates that Gath in the LBA had a population of over 10 000, while Kennedy (2013) increases this estimate to around 20 000. This is smaller than contemporary Egyptian cities such as Per-Ramesses (around 100 000 people), but still quite sizeable by ancient standards, and given Gath's relatively small territory, quite dense (Kennedy 2013). In fact, Finkelstein (1996b) reports that Gath's hinterland included 21 known towns (although Gath's leader Šuwardatu claims to have at least 30 vassal towns in Amarna letter EA 283), making it the most densely populated polity in all of LB Canaan (Uziel 2003, Uziel and Maeir 2005).

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[2] Note that in this volume, the chapters by Shai et al. (2012) and Gadot et al. (2012) disagree, finding no destruction.

Gezer (Tell el-Jazari) is considered by many scholars to have been one of the dominant cities in Canaan during the Late Bronze Age (Hasel 1998, Morris 2005, Singer 1986, 1988), although this position is debated (see review in Metzer 2015). Gezer controlled vital trade routes, and was powerful enough that, when Pharaoh Merneptah led a punitive campaign into Canaan and conquered several cities (see section 3.1.1 and Chapter 2) he singled out Gezer particularly in referring to himself as the "subduer of Gezer" on the walls of the Amada temple in Nubia (Na'aman 2011, Singer 1988). Gezer exhibits the remains of a possible Egyptian "Governor's Residency" (Singer 1986; see Chapter 2) and several Egyptian imports, but probably no permanent Egyptian presence at the site due to the lack of Egyptian-style or Egyptianising artefacts (Morris 2005, Ortiz and Wolff 2012). After the city's destruction (which may only have been partial), Gezer decreased in size but retained its connections with the Egyptian empire (Ortiz and Wolff 2012).

Lachish (Tell ed-Duweir) was one of the largest polities in the Southern Levant by area, and would have been a vital city to control due to its large territory, strategic location, many vassal towns, and abundance of resources. Lachish also contains a possible "Governor's Residency", as well as one of the largest assemblages of Egyptian alabaster and faience vessels in the Southern Levant, a possible Egyptian temple, several Egyptian-style figurines, scarabs, seals, pendants, two anthropoid coffins, and many other artefacts classed as Egyptianising (Bietak 2002, Higginbotham 2000, Ussishkin 2004a). Based on the relative lack of Egyptian-style objects versus the abundance of imports, it is concluded that this site probably had no permanent Egyptian presence, but the city may have been visited by circuit officials and the city's elite may have emulated Egyptian culture (Higginbotham 2000, Martin 2011, Ussishkin 2004a). Lachish was also violently destroyed; the cause of this is uncertain, but it was possibly connected to the invasions of the Sea Peoples (Ussishkin 2004a).

3.1.1. Merneptah's Campaign and Decline of Egypt's Power

The reign of Pharaoh Merneptah, the fourth pharaoh of Egypt's Nineteenth Dynasty, is particularly important to Egypt's role in the history of the Shephelah. Following the conquests of the Eighteenth Dynasty pharaohs, and the Nineteenth Dynasty period of administration and consolidation led by his grandfather Seti I and his father Ramesses II (the Great), Merneptah took the throne. Merneptah led a punitive campaign into the Shephelah at the end of the 13th Century, destroying Gezer and Ashkelon, while his descendants led campaigns to destroy Gath and the nearby town of Beth Shemesh (Singer 1988, Yurco 1986; see Figure 3.2). However, Lachish, Beth Shemesh, and possibly Azekah seem to have prospered after this destruction while other sites declined or were abandoned, suggesting that they filled the power vacuum left by the others (Kleiman et al. 2016, Metzer 2015). Interactions between Canaan and Egypt dwindled, although Egypt continued to control administrative centres along the Sinai border (Morris 2005).

As described above, Azekah and Lachish seem to have escaped the thorough destructions suffered by surrounding sites and prospered into the 12th Century, taking on new, more powerful roles (Kleiman et al. 2016). However, the retreat of the Egyptian empire from the region in the mid-12th Century meant that these two cities lost their valuable imperial connection, and probably the protection that came with it. Both cities fell victim to a destruction in the late 12th Century BCE (Webster et al. 2018) that was extensive enough that the cities were not re-established following this event (Kleiman et al. 2016, Lipschits et al. 2012, 2017; Metzer 2015, Ussishkin 2004a). About 30 years after Merneptah's campaign, during the reign of Ramesses III, the Crisis Years led to a decrease in Egypt's administration of Canaan, according to the orthodox view (see Chapter 2). New archaeological evidence, however, suggests that Egyptian presence in Canaan actually expanded in the Twentieth Dynasty in the form of inland estates and farms (Kleiman et al. 2016, Koch 2018).

3.2. Tel Azekah

Tel Azekah is a hilltop site in the central Shephelah, overlooking the strategically important Elah Valley (*Nahal HaElah, Wadi es-Sunt, Wadi 'Ajjur*) at an elevation of 127m from the valley floor (Lipschits et al. 2017; Figure 3.3). In ancient times the site would have overlooked and controlled the east-west road from the coast via Gath to the Judean hills, and the north-south road running through Beth Shemesh to the north and Lachish to the south (Lipschits et al. 2017; Figure 3.4). It is also positioned on a ridge that subdivides the high Shephelah to the east from the low Shephelah to the west (Lipschits et al. 2012, 2017). Tel Azekah covers approximately 4.5 hectares in area[3] and is roughly triangular in shape, with the steeply sloped tip of the triangle pointing northeast into the valley, and the southwest side of the triangle having a more gradual slope connecting it to the adjacent hills by an artificially lowered saddle and some terraces (Figure 3.3). This lower area was probably settled in some periods, and as the easiest approach may be where the city gate was located (Dagan 2011, Lipschits et al. 2012, 2017). At the southeast corner of the tel, overlooking the valley to the east, is an acropolis of about 6m further elevation where a fortress was located in the Hellenistic period, and perhaps also in earlier periods (Dagan 2011, Webster et al. 2018).

[3] This describes the physical area of the tel's flat summit, which could be seen as approximately equivalent to the area of the ancient city proper; it does not describe the size of Azekah's full territory, which is briefly mentioned in Jasmin (2006) but is not currently fully understood.

Figure 3.3. Satellite image of Tel Azekah from Google Earth, with topographical map (prepared by S. Emmanuilov, courtesy of Lautenschläger Azekah Expedition) inset.

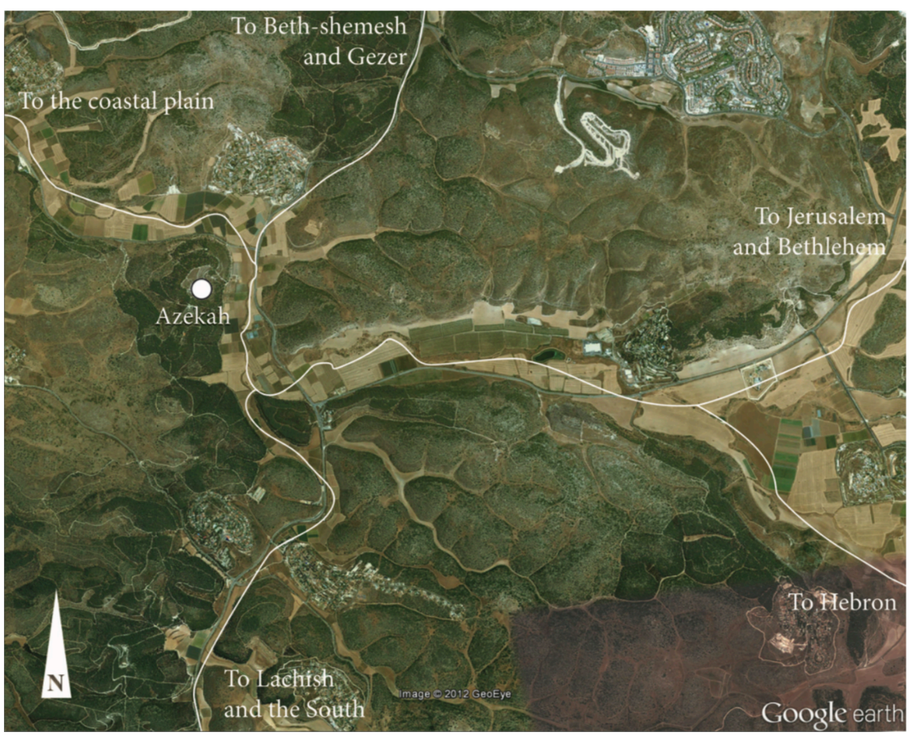

Figure 3.4. Satellite image of Tel Azekah showing the historical roads (in white). From Lipschits et al. (2012).

3.2.1. History of Excavations

Originally (and often still) known in Arabic as Tell Zakarîya, this site was identified in the mid-19th Century by geographer Rabbi Yehoseph Schwartz (Schwartz 1850) as the city of Azekah, at the time known only from biblical references (Lipschits et al. 2017). It was first excavated in 1898–1899 by Frederick J. Bliss and R. A. Stewart Macalister of the British Palestine Exploration Fund (Napchan-Lavon et al. 2017). Bliss and Macalister's excavations focussed on three perimeter towers on the southwest corner of the mound, the Hellenistic fortress on the acropolis of the mound, sixteen trenches across the surface of the tel, and a large clearance pit that was dug to the lowest layer of settlement in an attempt to locate cuneiform tablets. They identified four phases of occupation that they termed Early Pre-Israelite, Late Pre-Israelite, Jewish, and Seleucid. These phases were very roughly contemporaneous, respectively, with the Early to Middle Bronze Age, Late Bronze Age to Early Iron Age, Late Iron Age, and Persian and Hellenistic periods (Napchan-Lavon et al. 2017; see Table 3.1). One feature from their Pre-Israelite phase, which was identified by Bliss and Macalister as a large earthen oven (Bliss 1900), may have been a burned and destroyed domestic unit (Metzer 2015). Here, the excavators found pottery sherds, stones, fragments of mudbrick, and human remains, all of which exhibited a high degree of burning. It is unknown whether this poorly documented discovery corresponds to Azekah's LB III destruction or any other (Napchan-Lavon et al. 2017).

Azekah was not studied again by archaeologists until one hundred years later, when Yehuda Dagan conducted a regional survey of the Shephelah that included Azekah (Dagan 2000, 2011). Dagan showed that Tel Azekah was occupied during the EB II, EB III, Intermediate Bronze, MB II-III, LB I to III, Iron Age I to II, Persian, Hellenistic, Roman, Byzantine, and Early Islamic periods (Dagan 2011). These findings were confirmed in 2012 by Shatil Emmanuilov (Emmanuilov

2012) and the subsequent seasons of the Lautenschläger Azekah Expedition (six seasons from 2012 to 2018 at the time of this writing), which also noted Ottoman occupation, and found that Azekah's ancient society had two peaks in the LBA and Iron Age II, when settlement extended over the entire surface of the tel as well as the lower plateau to the southwest. This survey also identified an occupational gap during the Iron Age I (Emmanuilov 2012, Lipschits et al. 2012, 2017).

Conventional Dates (BCE)	**Period** (as used herein)	**Archaeological Findings** (Lipschits et al. 2017)
3500–3150/2950	Early Bronze I (EB I)	Unoccupied
3150/2950–2700/2600	Early Bronze II (EB II)	Initial occupation
2700/2600–2300/2200	Early Bronze III (EB III)	Urban settlement
2300/2200–2000	Intermediate Bronze	Limited activity
2000–1750	Middle Bronze I (MB I)	Urban settlement
1750–1650	Middle Bronze II-III (MB II-III)	Urban settlement, fortification, destruction
1650–1550		
1550–1479	Late Bronze I (LB I)	Urban settlement, fortification
1480–1400		
1400–1330/1300	Late Bronze IIA (LB IIA)	Settlement peak
1330/1300–1200/1150	Late Bronze IIB (LB IIB)	
1200/1150–1150/1100	**Late Bronze III (LB III)**	**Destruction**
1150–1000	Iron Age I	Settlement gap
1000–586	Iron Age II	Settlement peak, destruction (701 BCE)
586–539	Iron Age III (Babylonian)	Resettlement
539–332	Persian	Urban settlement
332–63	Hellenistic	Fortress built, destruction
63 BCE–324 CE	Roman	Continued settlement, gradual decline
324–640 CE	Byzantine	
640–1517 CE	Islamic Periods	
1517–1917 CE	Ottoman	
1917–2018 CE	Modern	Current excavation

Table 3.1. Chronology of Azekah. Chronological periods from Sharon (2014) and Mumford (2014) for the Bronze Age, Mazar (1990) for the Iron Age, and Baram (2002) thereafter. These periods are correlated approximately with stratigraphic phases from the sources given and their descriptions. **Boldface indicates the period associated with the individuals studied in this thesis (see Chapters 6 and 7).**

3.2.2. Principal Findings to Date

Azekah was initially occupied in the Early Bronze Age III, during the peak of the first wave of urbanisation in the Southern Levant (see Chapter 2). As with most cities in the region, it was likely depopulated during the ensuing Intermediate Bronze Age, and limited activity is observed from this period. Azekah was reoccupied in the MBA, and the city grew throughout the MB II-III, when major mudbrick and stone fortifications were built. However, Azekah experienced a destruction at the end of the MBA that led to a decline (Webster 2015, Webster et al. 2018). In the LBA, Egyptian involvement in the region strengthened, and Azekah apparently grew and prospered, although it is not mentioned in any known textual sources from this period[4]. During the LBA-Iron Age transition (LB III), Azekah was again violently destroyed by an unknown cause likely connected to the unstable geopolitical situation of this era (see Chapter 7). After a settlement gap following this destruction in the Iron Age I, Azekah again became a prosperous city (Lipschits et al. 2017), putting into context its mention in biblical texts (Joshua 10:10–11, 15:35; 1 Samuel 17:1, 2 Chronicles 11:9) as well as a notable Assyrian war account known as the Azekah Inscription (British Museum n. 81-3-23, 131). In the Azekah Inscription, King Sennacherib of Assyria provides a quite dramatic, possibly hyperbolic description of the city, shown here as translated by Na'aman (1974):

> …between my border and the land of Judah… like the nest of an eagle located on a mountain ridge, like pointed iron daggers without number reaching high to heaven. Its walls were strong and rivalled the highest mountains, to the mere sight, as if from the sky appears its head…

From the textual evidence at least, it seems that by the Iron Age II Azekah had become quite an impressive fortified city. It was destroyed by the Assyrians in the campaign described above around

[4] This is slightly surprising since several of Azekah's neighbours such as Gath and Lachish are well-known from textual sources. The lack of explicit textual evidence may be explained if Azekah was considered very close to and/or under the rule of one of its neighbours (most likely Gath), or perhaps if the site had a different, unknown name in ancient times (Finkelstein 1996a,b; Maier 2012, Lipschits et al. 2017).

701 BCE, rebuilt sometime in the next century, and destroyed once again in 586 BCE by the Babylonians under King Nebuchadnezzar. Azekah must have continued in some form after this destruction, as a village by this name is recorded much later in the early 4th Century CE by Eusebius of Caesarea, however by the 6th Century CE the Madaba Map records this location as Beit Zakariya. A village by this name exists to this day on the other side of the valley (Lipschits et al. 2012, Metzer 2015, Webster 2015; see Figure 3.4). While these sources and the settlement history of Azekah after the Bronze Age are fascinating subjects and make valuable contributions to our understanding of the region's history, they are beyond the scope of this thesis, and the remainder of this discussion generally will not include the Iron Age or later.

Current excavations of Tel Azekah focus on ten areas, named after the cardinal directions (N, E, S, W) and the top (T) of the tel (Figure 3.3). Areas W1–3, S1, N1, E1, and E3 are all located on the edges and slopes of the tel, where they are intended to expose stratigraphy and investigate Azekah's fortifications. Areas T1 and T2 are located on the plateau, and are geared toward wider exposure and investigation of the main settlement. Area S2, on the lower terrace to the south, is also intended to expose a wide area of occupation in Azekah's "lower city". A brief overview of finds in these areas by the current excavations is given below (Table 3.2).

Area	Chronology	Key features
S1	EBA–Persian	• Persian period building with Iron Age architecture underneath • LB architectural complex • MB destruction • Donkey burials from the EB III
S2	Iron Age LBA MBA	• LB and Iron Age lower city, public architecture and a paved plaza • Water reservoir cut deep into bedrock from LBA at the latest
W1, W2	EBA–Persian	• Large mudbrick city wall from the MB II-III
W3	MBA	• Large stone tower • Remains of MB II-III mudbrick fortifications
T1	Hellenistic Iron Age LBA	• Iron Age and Hellenistic remains • LB III destruction layer
T2	**Persian-Hellenistic** **Iron Age** **LBA**	• **LB III destruction layer**
N1	Persian MBA	• Monumental public structure • Persian period domestic complex • MB II-III walls and destruction layer
E1	Early Islamic Byzantine Hellenistic	• Hasmonean village • Massive Roman building • Rock-cut features
E3	Hellenistic LBA MBA	• Very large structure, undated

Table 3.2. An overview of major finds to date in Azekah's excavation areas. Compiled from data in Lipschits et al. (2012, 2017).

3.3. Area T2 and Building T2/627

Area T2 is located on the flat top of the tel. Thus far, four phases have been identified:

- T2-1: Persian-Hellenistic period
- T2-2: Iron Age II
- T2-3: Late Bronze Age III
- T2-4: Late Bronze Age II.

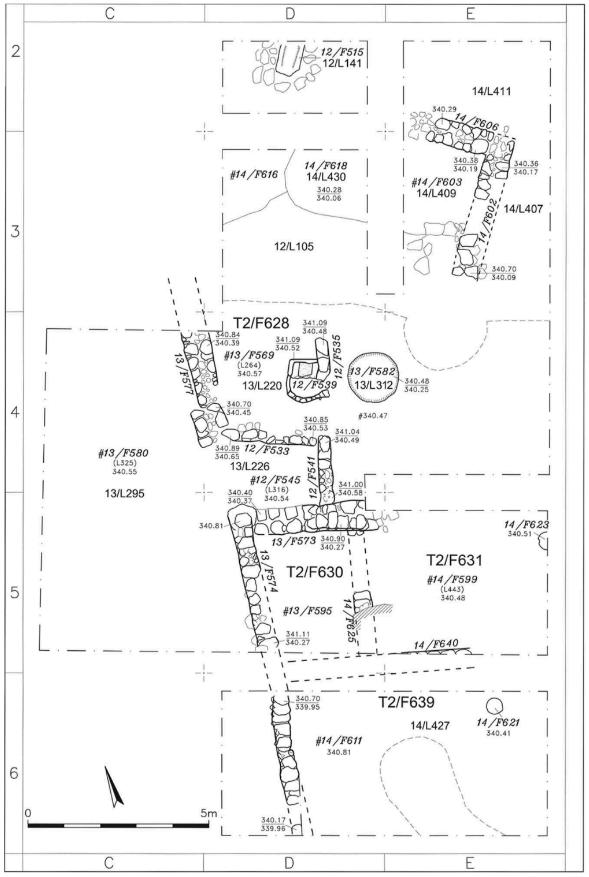

Figure 3.5. Plan of the excavated portions of building T2/627 in phase T2-3. From Kleiman et al. (2016).

Excavation is ongoing, but to date the phase from the LB II is the earliest phase uncovered in this area (Lipschits et al. 2012, 2017; Kleiman et al. 2016). Phase T2-3 is divided into two subphases: a later subphase in T2-3a and an earlier one in T2-3b. Nearby is an open area that was probably a street. Building T2/627 comprised two sections: a northern room with two or more pillars (T2/F629), and a southern section that was partitioned into three or four rooms (Figure 3.5; see also Figure 7.1). During this phase (T2-3b), the entrance into the building led into the northern pillared room (T2/F629). Archaeological remains show that the pillared room was roofed, and that this roof was apparently used for storage.

In the next phase, T2-3a, this building was altered to add two partition walls through the pillared room, slightly raise the floor, and redirect the building's entrance to the southern section of the building. A grinding installation connected to a collecting vat was added to the pillared room. In this phase, the ground floor has been defined as an activity area, especially for grinding. It appears from the size of the grinding installation, the storage capacity, and the large number of grinding stones and other implements that the grinding activity would have gone beyond the needs of a single household, suggesting that this activity was part of a larger production chain related to the site's economy. The roof space was densely occupied by Canaanite storage jars (see Chapter 2) and other vessel types, indicating it was probably used as an industrial-scale storage area, lending further evidence that a large-scale production operation was taking place in this building during Phase T2-3a (Metzer 2015; S. Kleiman pers. comm.). These storage jars contained residues of plant and animal oils (Linares 2015). Evidence of further Phase T2-3a construction can be found to the north of the building, and this is the subject of continuing investigation. The alterations to the northern, pillared room of this structure in the later phase were of rather poor-quality construction. Both partition walls consist of single rows of stones. One of the walls, T2/F533, was so poorly built that only the distribution of finds could securely identify the division of the space: north of the wall the area was packed with destruction debris, whereas south of the wall almost no finds were recovered (Metzer 2015). The grinding installation, by contrast, was of high-quality construction. The large grinding stone was made of imported beach rock and was surrounded by a plastered clay enclosure which opened into a small collecting area leading to a larger collecting vat, also plastered (T2/F582). A small bench of mudbrick and stone was situated nearby (T2/F535) (Metzer 2015). The overall poor construction of this section of the building may be seen as "crisis architecture"—hasty building construction to suit the changing use of space during a time of crisis (Driessen 1995)—suggesting that the site was declining for some time prior to the destruction of this area. However, the high quality of the grinding installation casts some doubt on this hypothesis, and the general wealth of finds in Building T2/627 shows that the site was probably prosperous at the time of the destruction (Kleiman et al. 2016).

The building in Phase T2-3a was violently destroyed in the second half of the 12th Century BCE (Kleiman et al. 2016). The roof collapsed upon the lower storey and its inhabitants, resulting in two distinct, non-temporal layers of debris within the destruction layer, visibly separated by a thin layer of ashy debris. The upper storey contained a large quantity of storage jars, while the lower storey contained implements and pottery related to grinding, and personal items including jewellery. Two individuals (Individuals 2 and 3) were caught in the destruction in room T2/F630, a room connected to the building's entrance in the southern section (Figure 3.5), where the charred remains of a wooden beam or pillar were found at the entrance. In the northern section of the building, another skeleton (Individual 1) was found near the grinding installation (T2/F539; Figure 3.5). Personal items including jewellery were found close to the lower part of this individual's body, as though they were holding them in their hand or in a bag around their waist at the time of death (see Koch et al. 2017). Since it is unlikely that a single individual would have carried all of these items as part of daily life, it is possible that this individual collected the items shortly before death to save them from the disaster (Koch et al. 2017, Metzer 2015). Finally, a fourth skeleton (Individual 4) was found some distance away close to the disturbed northeastern section of the building. This individual was associated with a production kit including a basalt plate, grinding stones, a weight, and several stones used to make pigment (Koch and Richardson 2017, Richardson 2016). These four individuals are discussed in detail in Chapters 6 and 7 (see Figure 7.1).

The destruction layer exhibits a full assemblage of *in situ* pottery items (in the locations and arrangement in which they would have been used, rather than stored away), evoking what has been termed "*de facto* refuse" (Schiffer 1985), indicating a sudden abandonment (Metzer 2015; see section 4.3.2 in Chapter 4). Thus, from the arrangement of the objects in Building T2/627, it can be inferred that they were in use immediately prior to the destruction, suggesting a sudden destruction event (Metzer 2015). Obviously, the presence of ash and burnt material, in addition to human remains trapped in the rubble, also indicate a sudden destruction and abandonment. Metzer (2015) suggests that Individual 1 might have been working in the production area immediately prior to the destruction, and tried to save the personal items before being caught in the ceiling collapse. The cause of this disaster remains unknown, and may have been natural, or a sudden assault by unknown forces (see Chapter 7). The fact that the victims of this destruction as well as their personal belongings were left behind for centuries points to a large-scale catastrophe that in some way rendered the site uninhabitable following the destruction; perhaps the territory changed hands, or the destruction was so complete that the city was considered unsalvageable. Fortunately, the remains of this building and its inhabitants were almost completely sealed by a thick layer of debris following the destruction, preserving the contents and clearly demarcating this phase (Metzer 2015).

The analysis by Kleiman et al. (2016) found that pottery typology indicates a close connection with the nearby site of Beth Shemesh (Figure 3.2), but no clear connections to Egyptian culture. Azekah does indeed exhibit many Egyptian artefacts, but this could all simply have been imported, and does not necessarily reflect on the local culture. Following Higginbotham (1996, 2000), it is necessary to consider locally produced pottery in occupational strata to assess a true cultural connection. No imported pottery, and only one Egyptian-style vessel has been found to date, with the rest of the pottery exhibiting a strong Canaanite cultural tradition. Nevertheless, there is a close resemblance between some of Azekah's pottery and that of Egyptian administrative centres in southern Canaan, such as Tell el-Farah, Deir el-Balah, Tel Sera', and Qubur al-Walaydah, as well as that of an Egyptian-style tomb from Lachish (Kleiman et al. 2016). This connection to Egyptian centres could indicate that Azekah had a direct political connection to Egyptian administration. If Building T2/627 was in fact a Patrician House, it could have been home to a wealthy elite family who emulated Egyptian culture by importing Egyptian artefacts. At this time, it is conservatively concluded that Azekah clearly demonstrates some connection to the Egyptian empire (Koch et al. 2017, Lipschits et al. 2017, Kleiman et al. 2016), although further investigation will be needed to characterise what kind of connection it had, and how it compares to other sites.

3.4. Conclusion

During the Late Bronze Age, the Shephelah prospered under Egyptian control, but also suffered from punitive campaigns and increasing instability. The dense population controlled the region's trade routes and strategic hilltops, and city-states competed for the favour of Egypt while elite families emulated Egyptian culture. In this period, Azekah was a fairly large city, with a cultural and political connection to Egypt that might have made it a regional centre. When Pharaoh Merneptah led a campaign into the Shephelah and destroyed the surrounding cities, Azekah appears to have survived and gained power in the aftermath. However, when Egypt withdrew from the region, Azekah could not be protected from hostile neighbours and civil unrest, which may have contributed to its destruction during the Crisis Years (see Chapter 2). In one area, a building was discovered from the time of this destruction. This may have been the dwelling of an elite family, which at some point was transformed into a production facility. When this building collapsed, it preserved signs of the final moments before the destruction, showing that Azekah's end was sudden and unexpected. The destruction of this building trapped four of Azekah's ancient inhabitants in the collapse and fire. These individuals may have been working in the production facility at the time of the destruction, and might have had a limited time to gather belongings and attempt to escape. However, they were ultimately unsuccessful, and their story is told in Chapters 6 and 7.

Chapter 4 Theoretical and Methodological Background

The present analysis is a study of remains that are burnt and crushed, from a site heavily altered by the same processes, and from a people whose daily life we do not fully understand. In order to extract information from this problematic context, a strong grounding in established theory and methodology is required. With a secure foundation in the literature, an interpretive framework can be constructed to draw informative conclusions from a context that seems impossible to analyse. This chapter explores current theory and methods in the excavation and analysis of individuals and households, of destroyed and abandoned sites, and of heat-altered bone. This interpretive framework forms the basis for the analyses in the following chapters and is intended to be useful to other authors as a way to examine remains from similar contexts in the Southern Levant and other areas of the world.

4.1. The Osteobiography of Households

The household has been called the basic unit of the economy, the smallest unit of society above the level of the individual (Bender 1967, Smith 1987). This refers not to the house as a structure, but to the collective and individual social roles of the inhabitants, and the emergent properties of the inhabitants as a group—family traditions, reputation, collective wealth, or any kind of shared social role. Households can be defined by their economic contribution, their cultural importance, their political roles, or even their biological relevance to the population (Hardin 2011, Wilk and Rathje 1982, Yasur-Landau et al. 2011). In this way, it is important to understand the household when studying past societies, and it is important to understand the individual when studying the household. The concept of the household has been studied through the lens of spatial archaeology, which investigates the *habitus* (Bourdieu 1977) of individuals and groups, or the way their identities, needs, and beliefs shape the environment around them through behaviour, transforming "space" into "place" (Chapman 1991, Verhoeven 1999). In this way, each individual influences the arrangement of the house and the physical organisation of the community, producing a mosaic of spaces related to the activities and identities of each inhabitant (Gadot 2011, Yasur-Landau et al. 2011). In a simple example, a cook might turn an empty room into a kitchen. More abstractly, a child might rearrange artefacts around a site in a way that facilitates play, such as collecting seashells or building a small fort, thereby imprinting their identity on the space. Regardless of their place in the household hierarchy, individuals' activities and preferences will inevitably go toward shaping the space around them to some degree. For this reason, a house is different from any other structure examined in archaeology: this is the place where the individual identities of the household's diverse members are displayed across the space, particularly when in the private sphere the social identities of women and children are not dominated by those of men (Hardin 2011, Yasur-Landau et al. 2011).

As stated above, in order to fully understand the household, one must understand the individual. The human body has been conceptualised as an element of material culture that reflects physical and biological, but also sociocultural, aspects of its society. This concept depends strongly on the body's connection to the spaces and objects with which it interacts. This way of thinking was first popularised in the 1960s and 70s as part of the processual New Archaeology movement begun by Lewis Binford (Binford 1962, Rakita 2014) and the new concept of bioarchaeology put forth by Jane Buikstra (Rakita 2014, Sofaer 2006). Their work studied how the physical capabilities and needs of the body shaped how individuals interacted with their environment. Put simply, the distance an individual can travel in a day, how far they can reach, how far they can throw, how much they can lift, how much food they need depending on their activity level and body size, or how much of a given good they can produce in a day, are all factors that will inevitably influence their own bodies, and the arrangement of objects in space around them. These are all factors which are highly individualised, and directly or indirectly biologically controlled, making them figurative projections of individual bodies on their physical environment (Sofaer 2006). In this sense, to recapitulate the above, the human body is simply one of the artefacts that leads to the formation of a site across time and space. Returning to the concept of the household, the emergent properties of the individuals composing a household have a similar effect on their surroundings. Collective actions of the household members will have inevitable influences on the spatial and social formation of their communities, industries, and governments (Wilk and Rathje 1982). In this way, the household is truly a member of society, just as an individual is a member of the household.

Bioarchaeology functions to connect an individual's physical remains to the actions and interactions that they performed during life to shape their environment. Bioarchaeology grew in three waves of theoretical engagement: the first producing population studies in the 1970s, the second emphasising advances in technology and methodology in the 1990s and 2000s, and the third and current wave seeking to gain a meaningful understanding of the human experience (Agarwal and Glencross 2011). The field has also been separated into two "tribes" by Rakita (2014): a biological adaptation tribe, and an anthropological question tribe. It is out of this third wave and second tribe that osteobiography first appeared. Osteobiography is a technique in bioarchaeology first suggested in 1961 by Frank Saul (Saul and Saul 1989), who took methods traditionally used to understand population demographics in first-wave bioarchaeology, such as age, sex, and pathology, and used them toward understanding the lives of individuals. This coincided with the growing emphasis on the study of the individual in processual archaeology, leading to studies investigating the daily life of the average person as a way to understand the past (Knüsel 2010, Rakita 2014, Stodder and Palkovich 2012). Osteobiography typically comprises analyses of age, sex, pathology and trauma, habitual activity indicators, and taphonomy. A great emphasis is placed on individualising characteristics, and many lines of evidence beyond those listed above can be drawn upon to help understand an individual's life (Knüsel 2010, Sofaer 2006). These studies make their greatest contributions when addressing the individual-level, social circumstances surrounding historical events, and are well suited to lending evidence to answer anthropological questions such as how labour was divided by gender and age, what foods made up the diet, and how mortuary practices reflected social identity (Knüsel 2010).

One emerging use of osteobiography is to understand households via the individual and the family. The osteobiography of the household functions as a small population study, one in which the lives of the individuals involved are intimately related, and therefore possibly also the biological and physical factors in their lives that leave marks on bone, such as disease, diet, and habitual activity. The integration of osteobiography into the overall understanding of a site in this way is a relatively new venture, and is capable of providing a deeper understanding of the site through an embodied human experience (Knüsel 2010, Rakita 2014, Sofaer 2006). However, household osteobiography ideally requires a sound ethnographic understanding of the typical household in a given time and place. Without this understanding, one cannot speculate on the lives of members of the household, since it is unknown how or even whether the individuals under study form a household. In other words, it cannot be assumed that human remains found within a dwelling represent members of its household, and even if they are it is difficult to speculate which members of a household they represent (Gadot 2011, Johnson and Paul 2016). However, with a detailed, integrative analysis of spaces, objects, and osteobiographies as discussed in this chapter, combined with ancient textual evidence or modern ethnographic analogy, it is possible to provide a conservative understanding of past lives, interactions, and relationships that approximates the complex entity of the household (Hardin 2011, Johnson and Paul 2016, Zoëga 2015). While the study of the household is not infrequent in other areas of archaeology, bioarchaeologists tend to focus on the related concept of the family, which shares many of the same features, but is easier to examine from a biological perspective (Johnson and Paul 2016). In the osteobiography of families, while it is impossible to fully understand a given past society's concept of kinship, ethnographic data can be combined with morphological and genetic studies to attempt to identify whether a group of skeletons are closely genetically related (Johnson and Paul 2016; see Seeman 2011 and Zoëga 2015 for recent examples). Although "family" and "household" are by no means interchangeable concepts in the ancient Near East (Gadot 2011), some of the osteological features often characterising a family, such as diet and shared episodes of stress, may also be seen in all members of a household, regardless of how or whether they are related. In revealing the social ties between individuals through biology, bioarchaeologists reconstruct the family and the household just as other archaeologists might map architectural remains to reconstruct the physical house. Bringing together the biological household and the physical house, we observe how the *habitus* of individuals creates a microcosm of their society within the physical space, while it could be said that the *habitus* of households is what forms the very fabric of the society. In this very important way, the study of the social and biological individual is a crucial part of our understanding of the past.

4.2. Osteology of Trauma, Stress, and Activity

Osteobiography is the theoretical approach used by bioarchaeologists to bridge the gap between the biological and social individual. The osteobiography contains basic data such as age at death and sex, but some of the most interesting details for reconstruction of social and political conditions in the past are skeletal indicators for trauma (whether accidental, degenerative, or violent), and activity-related musculoskeletal stress. Integrating these data with the osteobiography and what is known from archaeological investigation of the site can deepen understanding of the human experience in the past, and can directly inform the understanding of how sites were actually used by their inhabitants. The following sections provide an interpretive background for skeletal indicators of trauma and musculoskeletal stress that were examined in this analysis, and how they can be used together to understand daily life in the past.

4.2.1. Trauma

Skeletal trauma analysis can enrich osteobiographies and help to reconstruct activity by detailing the types of injuries encountered by individuals in their everyday lives. When an individual survives an injury to bone, it may present in the skeleton as antemortem trauma exhibiting some degree of healing. With many years of healing, bone trauma can be completely obliterated, leaving only faint traces of fracture lines or changes in the shape of the bone. Perimortem trauma generally does not exhibit evidence of healing, however both antemortem and perimortem traumata will follow patterns that relate to mechanisms of injury, which are usually consistent and predictable to some degree and relate to the biomechanics of the body (Lovell 2007, Passalacqua and Rainwater 2015; Figure 4.2). Well-recognised eponymous injury patterns, such as Colles' and Monteggia fractures or Bankart and Hill-Sachs lesions, are all recognisable in dry bone, and have been found in archaeological contexts where they can be linked to activity or simply accidental injury (e.g. Khudaverdyan 2014, Lovell 2014a, Martin and Harrod 2015, Miles 2000). Other injuries, especially Le Fort or other cranial fractures, can result from interpersonal violence (Martin and Harrod 2015). Far more common, however, are minor traumata such as dental avulsions, stubbed toes, and hip and vertebral fractures that may occur due to pathological weakening of bone structure. Generally, little can be said about such common injuries, but they may nevertheless contribute to the understanding of an ancient life. Overall, whether antemortem or perimortem, skeletal trauma can be used to understand the hazards that an individual encounters in daily life, which can help to reconstruct activity and build the osteobiography (Buikstra and Pearson 2017, Lovell 1997, 2007).

Antemortem trauma is usually easily distinguished from perimortem and postmortem trauma by signs of healing (Passalacqua and Rainwater 2015). However, perimortem and postmortem fractures are far more difficult to interpret and distinguish. Particularly important to this analysis is the distinction of perimortem fracturing due to trauma from peri- or postmortem heat-induced fracturing. Here this will be performed using fracture geometry, as outlined in Mayne (1990). Fractures due to heat are generally rectilinear and are more likely to be longitudinal, since fractures follow the orientation of collagen fibres as heat gradually causes the tissue to shrink. Fragments tend to have smooth edges that are bevelled or stepped, and may preserve the original architecture of the bone. Heat-induced fractures are also associated with other heat-induced features such as delamination, patina fracturing, and curved transverse "thumbnail" fracturing (see section 4.4.2 and Chapter 5). Traumatic fractures by contrast are seldom longitudinal, as the suddenness of the application of force causes fractures to bisect collagen fibres rather than run between them. Fragment edges are rough and irregular, fragments often form points or slivers, and the bone tends to be flattened due to the force of the trauma, obliterating its original architecture (Christensen et al. 2014, Herrmann and Bennett 1999, Mayne 1990, Moraitis and Spiliopoulou 2006, Pope and Smith 2004, Wedel and Galloway 2013).

Figure 4.1. Heat fracturing in the right femur of Individual 4. The bone exhibits partial calcination and a longitudinal fracture ending in a straight transverse fracture, creating a rectilinear fracture pattern typical of heat alteration. Photograph by Karl Berendt.

The distinction of all of these types of fracturing from taphonomic postmortem fracturing relies on a few basic tenets. Taphonomic fracturing generally occurs long postmortem, after the bone has lost most of its organic component. While living bone exhibits "green bone" behaviour due to the elasticity of its retained organic component, long postmortem it exhibits "dry bone" behaviour, producing cleaner fractures rather than ragged, "green stick" fractures. Furthermore, while living bone tends to exhibit fracture patterns reflecting biomechanical mechanisms of injury (see above), postmortem taphonomic fracturing is more or less random, reflecting only the weakening of the bone structure over time and its responses to soil pressure (Cappella et al. 2014, Christensen et al. 2014, Passalacqua and Rainwater 2015, Ubelaker and Adams 1995, Wheatley 2008).

Figure 4.2. Perimortem and taphonomic fracturing of the right clavicle of Individual 4. The bone exhibits a postmortem taphonomic longitudinal fracture at the lateral end (right side) that would be highly unlikely to occur in living bone, and exhibits clean edges with some colour difference. The fracture at the medial end (left side) has more ragged edges with no colour difference, and may be perimortem. Photograph by Karl Berendt.

4.2.2. Musculoskeletal Stress Markers

Musculoskeletal stress markers (MSMs) are changes in bone that develop as habitual activities produce biomechanical strain in the muscle, bone, connective tissues, and other soft tissues such as intervertebral discs that may leave impressions on bone. It is important to note that these lesions form due to chronic rather than acute stress, meaning that only specific movements that are performed consistently over a long period of time may produce musculoskeletal stress markers. Consequently, these would have to be daily activities practiced for several years at least (Foster et al. 2014, Schlecht 2012, Weiss 2015, Westh et al. 2008). A specific class of MSMs known as enthesopathies appear as bony outgrowths or irregular concave excavations at enthesis (the sites where tendons, ligaments, and muscles attach to bones), when the muscle habitually stresses the bone during daily activity. Enthesopathies have a long history of being used to reconstruct activity based on the relationships of muscles and muscle groups to specific motions, and from there to specific activities (Foster et al. 2014, Villotte and Knüsel 2013). However, this type of activity reconstruction is not without its challenges (see section 4.2.3). Other indicators of musculoskeletal stress result from remodelling and changes in robusticity of elements, such as expansion and shape changes of long bone cross-sectional area in athletes (Niinimäki et al. 2017), activity-related degeneration of joint surfaces (Weiss and Jurmain 2007, Buikstra and Pearson 2017), or structural failure of elements due to excess biomechanical strain (see below).

One classic presentation of activity-related change is a set of alterations in the vertebrae that is often argued to be associated with strenuous load-bearing activity. This can be defined as any activity wherein loading forces are transmitted longitudinally through the lumbar area of the spine; examples would include tasks such as lifting and carrying of heavy objects (Niinimäki et al. 2013, Sofaer Derevenski 2000). These transmitted forces cause the vertebrae, especially in the lumbar region, to respond in characteristic and visible ways. Wedge fractures happen when the stress transmitted through a vertebra exceeds the amount that can be dissipated by the bone structure, and the vertebral body slowly collapses over time from a cylinder to an anterior-pointing wedge. Wedge fractures could in some ways be construed as antemortem trauma, but are more accurately classed as indicators of habitual activity since they occur slowly due to activity rather than quickly due to trauma (Landham et al. 2015). When longitudinal forces are transmitted through the intervertebral disc, they create pressure that can cause the disc to herniate into the body of an adjacent vertebra, forming a localised depression. This is known as a Schmorl's node, a feature which is often interpreted as a sign of chronic pressure on the spine, although recent work has emphasised these lesions' connection to acute trauma and genetic susceptibility (Faccia and Williams 2008, Mattei and Rehman 2014, Plomp et al. 2012, Üstündağ 2009, Williams et al. 2007). Pressure in the intervertebral disc is also responsible for the formation of marginal lipping and peripheral osteophytes, which expand outwards from the upper and lower rims of the vertebral body as the intervertebral disc bulges and puts stress on the ligamentous attachments between the edges of vertebral bodies

(Myszka et al. 2014). Wedge fractures, Schmorl's nodes, marginal lipping, and peripheral osteophytosis develop over long periods of time, and thus would likely be indicative of lifelong daily activity. Marginal lipping and peripheral osteophytosis increase in frequency with age, while Schmorl's nodes appear to be age-independent (Faccia and Williams 2008, Üstündağ 2009).

4.2.3. Activity Reconstruction

Musculoskeletal stress markers, trauma, and some pathologies of bone can be used together to reconstruct habitual activity. Joint conditions such as osteoarthritis or osteochondritis dissecans (see Chapter 6) are the main pathological indicators of activity. These simply reflect overuse of the joints (Palmer et al. 2016), however they can be used in combination with other indicators of habitual activity to provide more specific reconstructions. Musculoskeletal stress markers have been used quite successfully in recent studies such as Villotte et al. (2010), correlating entheseal changes with physical activity; Havelkovà et al. (2011), studying social differentiation in activity levels; Milella et al. (2012), studying sex and age differences in activity levels; and Palmer et al. (2016), reconstructing specific activities from patterns of entheseal changes. All of these studies used large populations to make their conclusions, and the former three were focussed on big-picture conclusions and the challenges of activity reconstruction. Reconstruction of specific activities at the individual level is more difficult. These and other recent studies have criticised activity reconstruction at the individual level, which is fraught with analytical difficulties and confounding factors, in favour of larger population analyses where reconstructions can be corroborated in multiple individuals. Individual variation, the effects of body mass, the lack of specific connection between movements and activities, and the suspicion of confirmation bias are all common concerns with activity reconstruction of individuals (Jurmain et al. 2012, Mariotti et al. 2007, Santos et al. 2011, Stirland 1998, Villotte et al. 2010, Villotte and Knüsel 2013, Weiss 2015, Weiss et al. 2012).

The cautions put forth by previous work indicate that if activity reconstruction is conducted at the individual level and/or linked to specific activities, certain factors must be taken into consideration during any analysis. For one, clinical and palaeopathological studies suggest that some individuals are simply "bone-formers", meaning they tend to form enthesopathies faster than others, suggesting that idiosyncratic variation may be an important consideration (Mays 2016, Rogers et al. 1997). Furthermore, these conclusions cannot easily be discussed relative to the age and sex of the subjects, since these correlations have been shown to be confounding factors (e.g. Milella et al. 2012). Palmer et al. (2016) emphasise that comparative samples from the same population and sound ethnographic data are needed in order to make conclusions about activity. Despite all of these factors, a long tradition of activity reconstruction at the individual level exists in the literature, and despite the theoretical concerns it seems to work well in practice (e.g. Cardoso and Henderson 2010, Eshed et al. 2004, Hawkey and Merbs 1995, Molleson 2007, Molnar 2006, Peterson 1998, 2000). With these considerations in mind, the reconstructions in this analysis were considered based on a secure founding of biomechanical, cultural, and archaeological evidence, to generate well-supported, conservative proposals about habitual activity.

4.3. Bioarchaeology of Fires and Other Mass Disasters

Archaeological interpretations of mass disasters in the past are one of the few areas in archaeology in which the lives and actions of individual humans have always been recognised. Compared to natural death and ceremonial burial, non-natural death and burial are dynamic events, the appearance of each individual skeleton giving clear evidence of that individual's final moments (or, at least, allowing the observer to imagine them) (Kreimerman 2017, Stamati and Stiros 2018, Zhao et al. 2017). Despite their seeming clarity, however, accidental deaths and interments are problematic contexts. In the absence of careful ceremonial burial or other mortuary treatment that seeks to protect and preserve the body, skeletons are more likely to be fragmented or disarticulated, crushed, weathered, scavenged, or disturbed, and the preservational environment is seldom ideal (Barker et al. 2016, de Leeuwe and Groen 2017, Knüsel and Robb 2016, Sledzik and Rodriguez 2002). These analytical challenges are encountered in destruction layers throughout the Southern Levant exhibiting these characteristics (Kreimerman 2017; see Chapter 2). In these contexts, the observer must rely on careful, painstaking analysis to produce meaningful conclusions from the scant evidence. Therefore, bioarchaeological analysis of past disasters is ideally treated at the individual level, where a single life can be carefully investigated with maximal attention to detail.

4.3.1. Body Positioning and Behaviour of Modern and Ancient Fire Victims

In many cases, the positions of bodies can be used to interpret signs of behavioural responses to fire, and knowledge from modern fire investigations gives us a window into past behaviour. In modern fires, the smoky environment, creating low-visibility conditions and toxic fumes, is a key factor in shaping victims' behaviour. Unable to see, fire victims will follow walls in order to locate an exit, and are often found next to a wall in close proximity to a window or doorway, which may or may not be an actual building exit. However, they rarely make it far, and are often found in a hallway outside the room of the fire's origin (Battle and Weston 1978, Dirkmaat 2002, King and King 1989). Bodies are commonly found in a crawling position, suggesting that they were crawling to avoid smoke and heat when they died, or collapsed on the ground due to smoke and fume inhalation (Alarie 2002, Dirkmaat 2002, Miller 2005). In fact, a number of studies have found that inhalation of smoke or other fumes is a leading cause of death in residential fires, rather than the fire itself (Alarie 2002, Miller and Beever 2005). Overall, victims tend to underestimate the seriousness of the situation in the initial stages of a fire, and are often quickly overwhelmed (Brennan 1999, Proulx 2001). Unless the fire is directly visible to them, many people (especially children) are reluctant to leave, sometimes attempting to seek shelter rather than to escape (Dirkmaat 2002, Özkaya 2001, Proulx 2001, Roan 2014). Building collapse may kill those who remain in or return to buildings during the advanced stages of a fire (Fahy 2002, Fahy et al. 2009, Miller 2005, Roan 2014). Although these findings are based on studies of modern fire victims, the behaviours described appear to be rooted in deeper human perceptions of threat and safety, and there is no reason to suspect that they would not be found in ancient people.

Although fire victim postures may reflect behaviour immediately before death, there is another possibility that should not be ruled out without careful analysis. Pugilistic posture is a position adopted by the body when it is burned, due to the heat-induced contraction of muscles and ligaments in the body. When exposed to heat, larger muscle groups contract more strongly, bending the joints into typical positions (Pope 2007, Symes et al. 2015). Classically, this results in curling of the fingers and wrist, progressing to supination of the forearm and flexion of the elbow so that the arm is held up much like the defensive position of a boxer (giving pugilistic posture its name). The toes curl, the feet plantarflex at the ankle, and the legs flex at the knee and hip. In advanced cases, the back and neck will be arched posteriorly (Figure 4.3; Pope 2007). This classic pose can be altered if limbs are trapped or obstructed, or if they are broken before this process begins. Once the muscle is completely burnt away, the bones tend to fall randomly, erasing evidence of this posture (Dirkmaat et al. 2012, Mayne 1990, Pope 2007, Symes et al. 2015). Given the typical 'defensive' position of the arms and flexed hips and knees, it is not surprising that pugilistic posture is frequently mistaken for a self-protective posture.

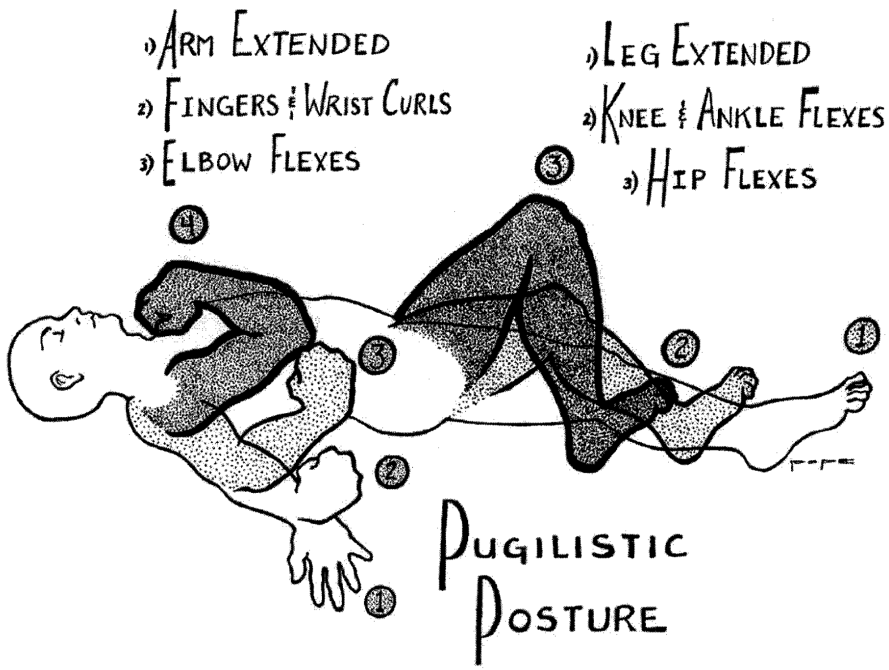

Figure 4.3. Pugilistic posture. Adapted from Pope (2007).

One famous example of such a mistaken identification is the excavations at the Roman cities of Pompeii, Herculaneum, and surrounding sites. With his decision to pour plaster into voids in the ash layer in 1863, archaeologist Giuseppe Fiorelli achieved overnight fame. The contorted positions of these casts created sensations in Europe and around the world, and were seen as proof that the inhabitants of these sites died slowly and painfully due to burning and suffocation in ash (Coates and Seydl 2007, Petrone et al. 2014). This human story is one of the most well-known and enduring tales from archaeology in the popular imagination. However, recent work has shown that the inhabitants of Pompeii and Herculaneum did not slowly burn or suffocate, and their positions probably do not primarily reflect an intentional response to the eruption of Vesuvius. Rather, these people died instantly of thermal shock, and the contortions of their bodies represent simply the involuntary heat spasm of the body during this sudden death, one form of pugilistic posture (Mastrolorenzo et al. 2001, Petrone et al. 2014). A similar, and almost as sensational mistake was made by archaeologists during the excavation of a burnt and collapsed Minoan temple at Anemospilia, Crete. As somewhat dramatically reported in National Geographic in 1981, this temple contained a shocking tableau:

> Thirty-seven centuries ago, in a time when savage earthquakes were rocking the island of Crete, a Minoan priest sought to avert final catastrophe with a rare, desperate act: To the deity of his hillside temple he offered up the ultimate sacrifice: a human life. But the victim died in vain. Scarcely had his death rattle ceased than a climactic temblor brought the temple roof and massive stone walls tumbling to earth, killing the priest beside the body of the young man he had just slain (Sakellarakis and Sapouna-Sakellaraki 1981: 205).

The skeleton of the "young man" mentioned above was examined at the time by anthropologists and a coroner, who described this individual as "peacefully curled on his right side" (1981: 219), with a bronze sacrificial knife lying on top of the remains. They ruled that this individual must have died due to blood loss prior to the collapse and fire, their rationale being that "there is evidence that when a body with its blood supply intact is burned, the bones turn black… But if the blood has been drained before the fire, the bones will remain white" (1981: 219). Noticing that the upward-facing left side of the skeleton was white, while the downward-facing right side was black, it was concluded that "half this man's blood had been drained before the fire" (1981: 219).

The last few decades of research have shown us that this scenario, while interesting and highly dramatic, is not supported by the evidence. The black and white colouration of the bones probably more likely reflects a burning pattern caused by shielding of the downward-facing side from the fire, causing it to remain black, while the unshielded side burnt beyond the blackened stage to a calcined white (Hughes 1991, Mayne Correia 1997, Pope 2007, Symes et al. 2015). This same pattern was seen in Individual 4 in this analysis (see Chapters 6 and 7). In a later re-examination of this site, Hughes (1991) concluded that there was nothing unusual about such burn patterns in a fire setting. It is possible that the 'peacefully curled' posture of the young man was actually pugilistic posture (see above; Figure 4.3). In fact, the authors' description of the skeleton includes the detail that the legs were extremely tightly flexed in a manner highly reminiscent of heat spasm, and furthermore, another skeleton exhibiting pugilistic posture was found directly adjacent to the altar. This and one other skeleton were found in an adjacent room and hallway (Hughes 1986, 1991; Sakellarakis and Sapouna-Sakellaraki 1981). Finally, the altar was later demonstrated likely not to be an altar at all, and the sacrificial knife, in fact, a spearhead (Hughes 1991). My personal opinion, based on the published evidence and employing the interpretive framework established in this chapter and Chapter 7, is that the fire at Anemospilia must have begun before the collapse of the building, due to the fact that the bodies were apparently able to achieve pugilistic posture, indicating that they were not covered by rubble, and that the behavioural signs are consistent with a response to fire. Classic escape patterns of fire victims were not seen in Pompeii due to the suddenness of the disaster, but could explain the positions of the Anemospilia skeletons. It is perhaps not surprising that the excavation of burnt remains in archaeology creates such dramatic thinking and leads investigators to jump to conclusions. Fortunately, advances in method and the increasing availability of evidence-based academic sources online mean that such errors may be less likely to occur in current research.

4.3.2. Archaeological Destruction Layers

The overall challenge encountered by archaeologists in the interpretation of disaster assemblages is the complex, chaotic relationship between features and artefacts as a result of the event that makes up what is known as a destruction layer. A destruction layer in archaeology is typically a thick layer of sediment containing broken objects and architectural components. If fire is involved (as it usually is), the destruction layer will contain high concentrations of ash, and objects and human remains contained within will exhibit signs of heat alteration (Driessen 2013, Schiffer 1987; see Chapter 2). Finkelstein (2009) stipulates that a destruction layer cannot be conclusively identified without two or more of: a black layer with charcoal, a thick accumulation of collapsed bricks or stones, and an accumulation of finds on the floor. Somewhat uniquely, the destruction layer may contain a sort of internal stratigraphy that, unlike true temporal stratigraphy, basically represents a flattened version of the building that was destroyed (i.e. it represents actual vertical position rather than temporal superposition) (Driessen 2013, Galadini et al. 2006). This same sort of stratigraphy can be seen in modern building collapses (Dirkmaat 2002). However, unlike the modern context, where forensic anthropologists rely on an undisturbed site that is visited within hours of the destruction, a collapsed building in archaeology is visited hundreds or thousands of years later. This means that it is quite likely in these contexts that elements have been lost to scavenging, erosion, or anthropogenic disturbance. However, if conditions are ideal, the site may be sealed by a thick layer of burnt mud-bricks and ashy debris, which creates a beneficial preservational environment (Driessen 2013, Kreimerman 2017). This is what occurred in the Vesuvius eruption, creating some of the best preservation known in archaeology, and was likely a factor at Anemospilia and at Azekah (see Chapters 3, 6, and 7).

Despite the example of Vesuvius, it is important to acknowledge the logical fallacy of the Pompeii Premise, the idea that the objects found in an archaeological site will correspond perfectly to how and where they were used during the site's habitation (Schiffer 1985). Rather, following Schiffer (1985) and La Motta and Schiffer (1999), there are several formation processes during the habitation and abandonment of archaeological sites that will each affect the distribution and associations of artefacts—and also, logically, of human remains. During the habitation stage of a site objects are discarded as primary refuse. These objects may be broken or otherwise unuseable, and archaeologists can expect that the location of these objects will reflect this status, being removed from the location and context in which they were used. The contents of a midden are a clear example of primary refuse. Subsequently, in the stage of the site before abandonment, archaeologists may find abandonment refuse, items which were deposited by the inhabitants who were consciously preparing for abandonment with some warning. In contrast to primary refuse, abandonment refuse might include items that were still useable, but were discarded due to the need to vacate the site. In their abandonment of the site, the inhabitants might take with them items that were easy to transport and/or difficult to replace, while leaving as abandonment refuse items difficult to transport and/or easy to replace (La Motta and Schiffer 1999). While these items might be somewhat removed from the location and context in which they were used, they would generally not be disposed of in the same way as primary refuse. Finally, *de facto* refuse is that which is laid down at the moment of abandonment. *De facto* refuse is more likely to reflect the location and arrangement of objects as they were used in life, as it consists of items that were simply abandoned in place by the inhabitants. According to Gadot and Yasur-Landau (2006), objects abandoned during a sudden, unanticipated destruction are especially representative of normal habitation, since no change in behaviour occurred prior to the destruction event, and therefore no abandonment refuse is observed. However, in this situation the concept of *de facto* refuse must be adjusted, since if there was some warning of the destruction, or if the destruction event occurred over some duration of time, a few of the least replaceable but easiest to transport items in the site may be rearranged or removed.

In these three depositional processes, I believe that a parallel can be found in human osteoarchaeology. The position and location of human remains in a site can inform archaeologists about conditions during the habitation phase, changing conditions in the period leading up to abandonment, and what happened during the moment of abandonment. During a site's habitation phase, the bodies of the dead are ceremonially interred, cremated, or otherwise ritually treated according to the cultural norms and expectations of their community. In other words, normative burials in the archaeological record reflect daily life proceeding as usual. However, in the phase leading up to an abandonment, daily life changes. Whatever social, environmental, political, or economic factor has necessitated the abandonment of the site will also affect patterns of behaviour of the site's inhabitants. If this extends to the ceremonial treatment of human remains, archaeologists may observe changes in burial customs. For example, Laneri (2007) describes widespread shifts in burial customs from centralised cemetery tombs to private intramural cist graves and finally to lower-quality pit graves during the decline of the site of Titriş Höyük, Turkey, reflecting changing social organisation and perhaps declining wealth. Finally, human remains may also be deposited at the moment of the site's abandonment. In this situation, the abandonment would need to involve some form of disastrous destruction that claims the lives of people in the site. Obviously, skeletons deposited in this way will exhibit a lack of purposeful positioning of the body or placement of grave goods in ceremonial treatment. Instead, positioning of the body might reflect activities and actions performed at the moment of death, and objects surrounding the body might be those used, carried, or worn by the individual at the time of death. If a disaster is very sudden, individuals might be killed in place, presenting a snapshot of exactly where they were and what they were doing at the time of death, following the Pompeii Premise. However, if some amount of reaction time is possible, even as little as a few minutes, this may allow inhabitants to change their behaviour and move around the site. Attempts to escape or to find shelter are examples of behaviours that might occur immediately preceding a destruction (see section 4.3.1 above and section 2.6 in Chapter 2). Thus, when interpreting human remains found in destruction layers it is important for archaeologists to consider that, unlike objects, humans have the capacity to alter the way in which they are deposited into the archaeological record. Contrary to the Pompeii Premise, the position and location of destruction-layer victims will in most cases reflect deviations from normal behaviour in response to the disaster. In other words, the intentionality of humans must be considered by archaeologists and physical anthropologists when interpreting human remains in destruction layers, instead of viewing skeletons simply as a feature of the archaeological context in which they are found.

4.4. Heat Alteration of Bone, Enamel, and Dentine

Collagen and bioapatites in bone, enamel, and dentine have similar chemical and physical properties when considered in isolation (Boskey 2007, Elliott 2002, Harbeck et al. 2011), and bone, enamel, and dentine can all be characterised as rearrangements of this common set of materials. Each substance reacts to heat differently, having unique consequences for the tissues and structures formed, as well as the stable isotopes contained within each tissue, as discussed in the next section. Despite their differences, enamel, dentine, and bone can be compared if the chemical and physical properties of their constituent materials are sufficiently understood. For this reason, this section begins at the molecular level, providing data about isolated collagen and bioapatites that allow us to putatively fill in gaps in the existing scholarly data on burnt bones and teeth.

4.4.1. Molecular Components

In fully-formed teeth, the organic component of enamel is almost non-existent, but it plays an important role in both dentine and bone (White et al. 2012a, b). The organic component of dentine and bone is primarily (around 90%) composed of Type 1 collagen, a fibrillar structural protein that provides tensile strength to tissue. Noncollagenous proteins also exist that are involved in the control of mineralisation (Boskey 2007, Tang et al. 2015). At the quaternary structural level, the triple-helical tropocollagen molecules forming collagen bundle into fibrils, which connect end-to-end and form a staggered arrangement that is wrapped into long fibres (Boskey 2007, Fratzl et al.

1998, Ottani et al. 2002, Ramachandran and Venkatachalam 1966). In dentine and bone, the mineral component is found as calcium phosphate crystals packed in gaps between these staggered collagen fibrils (Boskey 2007, Harbeck et al. 2011). The mineral component is usually referred to as hydroxyapatite, but this is just one of the many possible configurations of calcium phosphate into a crystal lattice structure, and bone is prone to differ in crystal structure due to ion substitutions that primarily reflect environmental conditions, location in the body, diet, age, and pathology. The exact crystal structure of this substance is not as well-understood as is generally assumed by many anthropologists, leading some authors to prefer the terms 'bone/enamel/dentine apatite' or more generally 'bioapatite' (Boskey 2007, Elliott 2002, Glimcher 2006). Hydroxyapatite is usually expressed using the formula $Ca_{10}(PO_4)_6(OH)_2$, but can also be expressed using the general formula $Ca_{10-x+\omega}X_y(PO_4)_{6-x}(CO_3)_x(OH)_{2-x+\omega}$ to reflect the variable inclusion of carbonates and other ions in the crystal structure (Elliott 2002, Munro et al. 2007). In enamel, bioapatite crystals are arranged in prisms radiating outward from the dentino-enamel junction, that mark the paths taken by groups of ameloblasts during the initial secretion of the enamel matrix (Antoine and Hillson 2016, Moore et al. 2016, White et al. 2012a, b). Enamel prisms exhibit variations in density known as cross-striations, which track the circadian rhythm during development. In a circaseptan rhythm, variations in density of mineralisation form striae of Retzius, visible on the external surface of the tooth as perikymata (Antoine and Hillson 2016). Since enamel forms on a matrix of amelogenin and enamelin, unlike bone and dentine, bioapatite crystals in enamel are around ten times larger in all dimensions, with greater regularity of structure (Boskey 2007, Elliott 2002). Crystal size also varies with age (Boskey 2007).

As temperature increases from normal body temperature, collagen is the first major material to experience heat alteration, undergoing first denaturation, then combustion. In its biological roles, collagen is adapted to perform at body temperatures between 36 and 38°C. Above these temperatures, collagen gradually begins to lose its quaternary, tertiary, and secondary structure, due to the heat energy dissipating atomic and intermolecular bond energy (Leikina et al. 2002, Ottani et al. 2002). Harbeck et al. (2011) report that in bone, most collagen denaturation occurs between 100 and 200°C followed by combustion between 300 and 400°C (Harbeck et al. 2011, Holden et al. 1995, Schurr et al. 2008), although a small amount of collagen is retained above these temperatures until 700°C (Harbeck et al. 2011). By 600°C, the carbon begins to dissipate in the form of carbon dioxide, leaving only the mineral component as a calcined model. These processes also result in substantial weight loss of the tissue (Beach et al. 2015, Harbeck et al. 2011, Shipman et al. 1984).

The crystal structure of bioapatites, though disorganised, seems to be generally robust to the addition of heat, retaining the same basic structure to very high temperatures. Earlier studies concluded that addition of heat catalysed the conversion of hydroxyapatite to tricalcium phosphate in bone (DeNiro et al. 1985; see Piga et al. (2016)), but more recent studies have shown that this is not the case (Harbeck et al. 2011, Hiller et al. 2003, Rogers and Daniels 2002). A reduction in the unit cell volume of hydroxyapatite is observed between 0°C and 200°C, indicating that the crystal structure is becoming more compact and regular. This may be caused by denaturation and loss of collagen surrounding hydroxyapatite crystals, as well as loss of structural water bound within the crystal lattice (Harbeck et al. 2011, Roberts et al. 2002). Harbeck et al. (2011) report retention of the hydroxyapatite mineral phase until 600°C, following which a minor phase of magnesium oxide was detected by crystal diffractometry. Between 500 and 600°C, degradation of the organic component allows more direct contact between crystals, facilitating structural rearrangement in the process of recrystallisation. Recrystallisation of hydroxyapatite occurs gradually up to about 700°C, as addition of heat energy to the crystal structure encourages de-binding of impurities and improves regularity in the crystal lattice. As low as 500°C, but usually cited in the range of 700–800°C (Harbeck et al. 2011), the mineral component of bone, dentine, and enamel undergoes sintering. Sintering is similar to and often simultaneous with recrystallisation, but is a distinct process that only occurs in crystalline solids with the addition of heat below the melting point. In this process, the atoms in the material diffuse between molecules, and the crystal structure is transformed into a dense, more uniform mass. Sintering causes the mineral component to become denser and more regular, and therefore harder. During this process, carbonate ions are thought to be given off from the hydroxyapatite crystal lattice, resulting in a rapid increase in crystallinity (Harbeck et al. 2011). Crystallinity Index (CI) is a way of measuring the amount of mineralisation and uniformity of crystal structure in a substance, a value which increases with increasing temperature (Piga et al. 2016). Lee-Thorp and Sponheimer (2003) suggest that tissues with higher crystallinity indices are more robust to diagenesis.

4.4.2. Dental and Skeletal Tissues

With an understanding of the effects of temperature on collagen and bioapatites in isolation, we can apply this knowledge to understand changes in bone, enamel, and dentine. Generally speaking, teeth tend to be less affected by heat than other bodily organs, including bones, and often survive fire even when the bones are thoroughly destroyed (Mayne 1990). Posterior teeth are affected later than anterior teeth, due to the protection and insulation of the soft tissues in the cheeks (Bohnert et al. 1998, Mayne 1990). When bone, enamel, and dentine are exposed to heat, they undergo some degree of alteration in gross and microscopic morphology, surface appearance, and physical properties. Both skeletal and dental materials undergo a predictable sequence of colour changes, starting as neutral white or pale yellow (their natural colour), darkening through yellow to brown with red and purple hues to black, progressing from there to neutral grey with bluish hues, and finishing in a neutral white (see section 4.4.3). The initial yellowing of the tissues is attributed to denaturation of collagen during heating—the apparent yellowing of collagen-free enamel being explained in this scenario as an illusion caused by yellowing of the underlying dentine (Beach et al. 2015, Bennett 1999, Harbeck et al. 2011, Shipman et al. 1984; Table 4.1). However, others have theorised that the yellowing in enamel, and to a lesser extent in dentine and bone, could be due to changes in crystal structure of bioapatites altering spectral properties (Beach et al. 2015, Mayne 1990). Following this, the tissues progress through brown to black, as collagen gradually combusts to black carbon, and then is lost as carbon dioxide (as described above), leaving behind only the white mineral component in the process of calcination. As collagen denatures, it also loses its tensile properties, becoming weaker and more friable, and this combined with bone shrinkage and warping causes fissuring in tissue microstructures that leads to macroscopic changes in bone and tooth structure. This process continues at all temperatures until collagen is lost at around 700°C, giving additional evidence that collagen is still present in small quantities at these high temperatures (Harbeck et al. 2011). Macroscopic changes include fracturing producing longitudinal, right-angled fragments, delamination (flaking), complex patina fracturing on bone surfaces, straight transverse fractures, and curved transverse 'thumbnail' fracturing (Figure 4.4; Herrmann and Bennett 1999, Mayne 1990, Mayne Correia 1997).

Figure 4.4. Heat-induced fracturing of bone. Above: A) longitudinal, B) curved transverse, C) straight transverse, D) patina, E) delamination, adapted from Mayne (1990). Below: bone fragments from Individual 3 produced by longitudinal and transverse fracturing, exhibiting patina and thumbnail fractures, photograph by Benjamin Sitzmann.

As bioapatites recrystallise and sinter, the surfaces of bones and teeth undergo microscopic changes. According to Shipman et al. (1984), surface roughness generally increases with heat, but changes suddenly to a glassy, smooth surface around 285–440°C. This progresses to a frothy or fleecy appearance at 440–800°C, and to a smooth, nodular appearance at 800–940°C (Table 4.1). These changes are attributed to sintering of the crystals, and x-ray diffraction studies have shown that when heat is added, crystal size expands, and crystal structure becomes denser and more regular in the mineral components of bone and tooth tissues (Piga et al. 2016, Shipman et al. 1984, Stiner et al. 1995; Table 4.1). The crystal structure of enamel tends to be more regular than that of dentine or bone, making it harder. A larger crystal size, meaning a smaller surface area to volume ratio of crystals, makes enamel less soluble than dentine or bone (Boskey 2007). Shrinkage of bones occurs progressively with increasing temperatures, accelerating above 600°C. This change is due to gradual loss of moisture from the bone's organic component (Shipman et al. 1984, Ubelaker 2009; Table 4.1).

4.4.3. Bones and Teeth

Throughout the process of heat alteration, different parts of the dentition and skeleton are progressively exposed as the soft tissues burn away. In teeth, the crown is directly exposed to heat from the start, giving it the longest period of heat exposure, one of the reasons it experiences so much degradation. The root is initially protected by bone and soft tissue, but becomes progressively exposed as these burn away, especially when the crown separates (see section 4.4.3.2). This means that dentine generally exhibits less heat alteration than enamel (Beach et al. 2015, Schmidt 2015). Similarly, in the skeleton, those bones or parts of bones that are shielded by thick soft tissue tend to exhibit less burning than those that are closer to the surface. Therefore, the vault of the skull and the bones of the finger tend to exhibit the greatest degree of heat alteration, while the long bones of the limbs and the os coxae are generally less affected (Pope 2007, Symes et al. 2015).

The heat alteration process in bones and teeth has been separated into stages by Beach et al. (2015) and Shipman et al. (1984). Both bones and teeth undergo a predictable sequence of colour changes and changes in physical characteristics that relate to the intensity (i.e. the combination of temperature and duration) of a fire. Shipman et al. (1984) report bones and teeth essentially progressing through these stages at the same rate, but the changes reported by Beach et al. (2015) seem to show teeth progressing through these stages essentially one step ahead of bone. This may be due to differences in their staging systems or methods, or due to the effect of soft tissue that initially protects the bone, mitigating heat alteration. In this discussion, the changes in bones and teeth have been standardised into the stages and temperature ranges reported by Shipman et al. (1984) for colour change in bone, with data from Beach et al. (2015) interpolated where possible.

- Stage I: 20–285°C

In bone, Stage I is characterised by little or no alteration in colour or morphology. Although the overlying soft tissue would be significantly altered, bones essentially retain their normal appearance (Shipman et al. 1984). In the teeth, Beach et al. (2015) noted enamel flaking and translucency around the cementoenamel junction (CEJ), and a colour change to pale brown in the enamel, and dark reddish brown in the dentine.

- Stage II: 285–525°C

Stage II begins with a colour change in bone, where surfaces darken through yellow to brown. This colour change is thought to be caused by degradation of collagen molecules, as discussed in section 4.4.1 (Beach et al. 2015, Harbeck et al. 2011). The surface of the tooth root at this stage is typically black, while the enamel appears as a dark greyish brown with patina fracturing (Beach et al. 2015, Mayne 1990). In this stage or later, the cemento-enamel junctions of the teeth exhibit extreme enamel flaking, and the crown of the tooth may separate entirely from the root (Beach et al. 2015, Schmidt 2015). This occurred at 427°C in Beach et al. (2015). The delicate crown then often cracks or crumbles and is frequently completely destroyed. Two major theories have been proposed to explain this separation, and debate is currently ongoing as evidence is gathered to support or refute either theory. The null hypothesis is that the crown simply falls off due to denaturation of the tissues at the CEJ (Beach et al. 2015). However, some authors propose a "popcorn model", which posits that this separation of crown and root occurs due to boiling of fluid in the pulp cavity, causing steam to exert pressure on the crown and exploit the weakness of the CEJ (Schmidt 2015). However, support for this model is controversial, with authors like Beach et al. (2015) and Muller et al. (1998) finding no support for "popcorn" teeth.

- Stage III: 525–645°C

Bone is typically blackened at this stage as the organic content carbonises, and heat fracturing is underway (Shipman et al. 1984, Mayne 1990, Mayne Correia 1997). The tooth enamel degrades further and separates from the root at this stage if it didn't do so earlier. Once separated, the enamel often crumbles away completely. If enamel remains, the colour lightens to a neutral grey, with a similar lightening occurring in the root. Root apices often degrade as well, and calcination (see section 4.4.3.5) may begin in the roots in the upper end of this range (Beach et al. 2015).

- Stage IV: 645–940°C

Stage IV is beyond the temperature range recorded by Beach et al. (2015) for the teeth, but Shipman et al. (1984) report similar changes in bones and teeth at this stage. A neutral grey colour with bluish hues is characteristic, and heat fracturing becomes quite pronounced (Mayne 1990, Mayne Correia 1997).

- Stage V: >940°C

Stage V essentially involves terminal degradation of bones and teeth. This phase is also associated with the process of calcination, where the organic component is completely eliminated from the tissue, leaving only the mineral. The mineral structure is also morphologically altered with heat, as discussed in section 4.4.2, which makes it harder and denser (Beach et al. 2015, Mayne 1990, Schmidt 2015). Calcined teeth and bones are characterised by a tinkling sound when tapped, sounding similar to other mineral substances such as ceramic, chalk, or flint (Beach et al. 2015, Mayne 1990).

All of these factors depend on the temperature and duration of heating. Bennett (1999) discusses the effects of low intensity, long duration burning, versus high intensity, short duration burning on physical changes in bone. With low heat and long duration, distortion is minimal, heat fracturing is rare, and colour tends to be uniform. This occurs because the alterations produced by heat exposure are gradual and constant. By contrast, high heat and short duration burning is more chaotic and inconsistent, with dramatic fluctuations in temperature, and produces multiple surface colours and moderate distortion. Thompson (2005) examined dimensional changes in bone at temperatures between 500 and 900°C for 15 and 45 minutes. He found that the characteristics of dimensional changes differed between low temperature/long duration and high temperature/short duration treatments, but this study was unable to characterise the pattern of these relationships. Additionally, crystal size in bone bioapatites was found to increase with greater duration of heating at all temperatures. By contrast, Beach et al. (2015) found little difference in appearance of dental tissues between different durations of heat exposure at the same temperature. Beach et al. (2015) used temperatures of 204–593°C for 30 or 60 minutes. No other study besides Thompson (2005), and Beach et al. (2015) could be found that quantitatively examined temperature and duration of heating simultaneously in bone or teeth. It must be remarked that all of these studies examined only a single pair of time intervals, which were all on the scale of approximately one hour or less, making it difficult to extrapolate an overall trend for the effects of increasing duration of burning.

Furthermore, the pairs of intervals in these studies were all relatively close together in magnitude and scale, which may be of limited utility when assessing the real effects of duration on heat alteration, which may require a larger temporal spread to assess. Even less is known about the range of conditions in between the high temperature/short duration and low temperature/long duration scenarios, and the isolation of the effects of duration of burning as opposed to temperature of burning. Several authors have proposed that the duration of heating is essential to the changes seen in the heat alteration process, and that the correlations between temperature and macroscopic appearance seen in previous studies may not be as strong as previously thought (Asmussen 2009, Bennett 1999, Clark and Ligouis 2010).

	Stage I (20–285°C)	**Stage II** (285–525°C)	**Stage III** (525–645°C)	**Stage IV** (645–940°C)	**Stage V** (>940°C)
Colour	Neutral white, pale yellow, or yellow	Brown with reddish, yellowish, or grey hues	Neutral black, with medium blue or reddish-yellow	Neutral white with light blue-grey or light grey	Neutral white with some medium grey and reddish-yellow
Microscopic Morphology	Increased surface roughness	Glassy and very smooth	Frothy or fleecy appearance	Smooth-surfaced globules or nodules	
Crystal Structure	Unchanged	Unchanged	Transition point to larger crystal size	No further change	No further change
Shrinkage	0-6%	0-6%	2-5%	2-11%	4-17%

Table 4.1. Summary of changes occurring in bones and teeth in temperature-defined stages, after Shipman et al. (1984). Although Shipman et al. (1984) use different temperature ranges to stage different parameters, their results have been standardised here into one set of temperature ranges.

4.4.4. House Fires

The temperature of a modern house fire without accelerants is reported in experimental sources and case reports in the range of 400–1000°C, with most estimates centring around 600–800°C, although conditions can vary widely, and temperatures in a single fire can rise or fall suddenly as these conditions change (Crewe et al. 2014, Dirkmaat et al. 2012, Herrmann and Bennett 1999, Holland 1989, Lilley 1996, Mayne 1990, Yuen et al. 2014). All five stages of burning are documented from house fires, and a single victim may display multiple stages; however, the skeleton of a body that is burned in these conditions for longer than an hour typically reaches Stage III and often reaches Stage V (Pope 2007).

4.5. Stable Isotope Analysis of Heat-Altered Tissues

The practice of stable isotope analysis of bones and teeth depends on predictable variation in isotopic content due to subsistence-related or other culturally significant processes. Classically, these include migration and mobility, relative amounts of C_3 and C_4 plant consumption, amount and source of meat consumption, weaning practices, and marine vs. terrestrial origin of diet (see Garvie-Lok (2009, 2013), Katzenberg (2008), Lee-Thorp (2008), and Price (2015) for comprehensive reviews). However, additional variation introduced by taphonomic processes is poorly understood and often unpredictable, and has the potential to reduce reliability of these lines of evidence. Teeth are especially important in stable isotope analysis, since their formation in the early juvenile through early adulthood periods provides useful diachronic signatures of diet and mobility (Burt and Garvie-Lok 2013). Burnt remains are found in archaeological contexts including disasters, funerary contexts, and conflict assemblages, and by modification of remains occurring long post-mortem, such as when a natural or man-made fire occurs on top of an archaeological site (Asmussen 2009, Bennett 1999, Clark and Ligouis 2010). These contexts in which burnt remains are found are often crucial to reconstruction of past events such as settlement patterns, conflicts, subsistence strategies, and funerary rituals. If the remains recovered in such contexts can successfully be subjected to stable isotope analysis, valuable archaeological information could be gained about these contexts and the individuals therein.

It has been established through multiple studies (reviewed below) that heat has significant effects on the elemental and isotopic composition of human and other animal bone. However, no literature exists that I am aware of that directly examines the effects of heat on isotope concentrations in teeth. This is an important question, because not only are teeth vital to many stable isotope analyses, and stable isotope analysis vital to any thorough osteobiography, but teeth are often the only part of the body that survives with any integrity after a fire. Although the crowns commonly separate and fragment (see section 4.4.3.2), tooth roots are quite dense and are protected in sheaths of bone, giving them a second degree of resistance to heat. Even after the bone disintegrates due to burning, intact dental roots can be located in the ashes (Hill et al. 2011, Mayne Correia 1997). Teeth are also more resistant than bone to soil compression, leaching, diagenesis, and possibly heat exposure, making them useful sources of evidence in archaeology and forensics (Beach et al. 2015, Lee-Thorp and Sponheimer 2003).

Light elements like carbon, nitrogen and oxygen preferentially form elastic covalent bonds, rather than rigid ionic bonds. These elastic bonds allow vibration of the atoms, and the greater the mass of an isotope, the lower the frequency of vibration. Therefore, it is generally easier to break covalent bonds between lighter isotopes, a fact which has significant bearing on heat-related isotope fractionation (Harbeck et al. 2011, Munro et al. 2007). Harbeck et al. (2011) propose that as long as heat exposure occurs under oxygenated conditions, isotopic fractionation will cause heavy isotopes to prefer strong bonds in oxidised compounds, while light isotopes prefer weaker bonds in reduced compounds. During combustion, reduced compounds are left behind in tissue, while oxidised compounds are degraded. Therefore, the heavier isotope should always be depleted during combustion. However, the discrepancy of results between Harbeck et al. (2011) and others (DeNiro et al. 1985, Munro et al. 2007, Schurr et al. 2008) does little to corroborate this model.

4.5.1. Nitrogen (N)

Nitrogen atoms are found solely in the organic components of bone and dentine, being part of the amino acids and peptide bonds that make up collagen and other proteins. As this component of tissues is altered by heat, the different isotopes of nitrogen within the molecules react at different rates, changing the ratios between them (the $\delta^{15}N$ value). Chemical processes such as dissolution (DeNiro et al. 1985), combustion (Harbeck et al. 2011), and soil leaching (Lee-Thorp and Sponheimer (2003)) can all prefer one isotope over another. DeNiro et al. (1985) reported shifts in collagen $\delta^{15}N$ of up to ±4‰ in bones heated to temperatures above 295°C, with little deviation observed below this temperature. He also observed that duration of heating may play a factor, independent of the temperature of heating—for example, a low-temperature fire sustained for a very long period could have as much of an effect as a high-temperature fire sustained for a short period. Schurr et al. (2008) found that at even lower temperatures, between 200 and 300°C, an increase of +4–6‰ was observed. Conversely, Harbeck et al. (2011) observed $\delta^{15}N$ decreases of up to -9‰ at temperatures up to 1000°C.

4.5.2. Carbon (C)

Carbon atoms are found in both the mineral and the organic components of enamel, dentine, and bone. In the mineral components, they exist within carbonate ions substituted into the crystal structure of bioapatites, while in the organic component, they are found forming the backbone of amino acid chains in collagen and other proteins. Carbon is lost during heating as collagen denatures, or as carbonates escape the crystal structure of hydroxyapatite as carbon dioxide (Harbeck et al. 2011). DeNiro et al. (1985) reported that $\delta^{13}C$ from bone collagen decreased by as much as -5‰ at temperatures above 295°C, but little shift was observed below this temperature. Schurr et al. (2008) increased this temperature limit, showing that at least until 450°C, collagen $\delta^{13}C$

does not appear to change significantly (Schurr et al. 2008). Unlike DeNiro et al. (1985), they did not find any effect on $\delta^{13}C$ with increasing time intervals. Harbeck et al. (2011) found significant bone collagen $\delta^{13}C$ decreases at temperatures as low as 200°C. However, Munro et al. (2007) found no such change, instead concluding that carbon was unaltered during heating. As discussed in section 4.4.2, collagen is only present at lower stages of heat alteration due to combustion, and at higher temperatures only the mineral component is available for $\delta^{13}C$ analysis. In bioapatites, carbon in carbonate ions ($\delta^{13}C_{ca}$) decreases by about -4‰ between 200 and 700°C, but begins to increase again between 700 and 1000°C. This rebound can be explained by chemical reactions first depleting the heavy isotope and/or enriching the light isotope, then for unexplained reasons beginning to deplete the light isotope and/or enrich the heavy isotope, returning the $\delta^{13}C_{ca}$ almost to original, unaltered levels (Harbeck et al. 2011).

4.5.3. Oxygen (O)

Oxygen atoms are found primarily within the mineral components of enamel, dentine, and bone, as phosphate oxygen within the fundamental structure of hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$], or as carbonate oxygen or hydroxyl oxygen within different ions (Harbeck et al. 2011). These different oxygen environments can be extracted differently and isolated during processing, therefore this distinction is important. Oxygen atoms are lost during combustion when atoms are exchanged between bioapatite and water vapour in the environment, and probably also during the loss of structural carbonate and the formation of calcium oxide (CaO) (Munro et al. 2007). Oxygen isotopes appear to be more resistant to diagenesis during burning than carbon or nitrogen, possibly because the mineral component where they are found is less susceptible to burning (Harbeck et al. 2011, Munro et al. 2007). Munro et al. (2007) found that bone $\delta^{18}O_p$ (from phosphate oxygen) decreased by -4-7‰ when heated above 300°C, although little change occurred below this threshold. In bioapatites, oxygen in carbonate ions ($\delta^{18}O_c$) decreases by around -8‰ between 200 and 700°C. Harbeck et al. (2011) also showed a possible rebound for oxygen between 700 and 1000°C similar to that observed above for carbon, but could not rule out methodological errors for this effect.

4.5.4. Strontium (Sr)

Strontium is found in trace amounts in the mineral components of enamel and dentine, most commonly as strontium-88 (Bentley 2006), along with lesser amounts of strontium-87 and strontium-86. Fewer studies have examined strontium in heat-altered remains. However, the available evidence shows that strontium isotope composition is probably the most resistant to diagenesis, as bones appear to show little to no change in $^{87/86}Sr$ even at temperatures as high as 1000°C (Grupe and Hummel 1991, Harbeck et al. 2011).

4.5.5. Feasibility of Stable Isotope Analysis of Burnt Bone

Experimental evidence from scholarly sources to date is contradictory, and the observations of various authors have not been conclusively explained. With the exception of strontium, heating generally causes decreased stable isotope values, indicating a depletion of the heavier isotope and/or an enrichment of the lighter isotope. This occurred at temperatures as low as 200°C (carbon and nitrogen), and as high as 800°C (oxygen) in the sources reviewed above. However, the exact nature of these trends, including the magnitude of shift in stable isotope ratios and the interactions between heating temperature and heating duration, are at this point unclear and even contradictory. Several explanations have been proposed for these trends, most convincingly by Harbeck et al. (2011) who proposed a biochemical model where heavier isotopes prefer stronger bonds in oxidised molecules, making them more likely to be removed by combustion. From this evidence, it can be concluded that heat alteration shifts bone stable isotope ratios to an unacceptable degree, making bones unsuitable for stable isotope analysis if they are burned above a Shipman et al. (1984) Stage II, as recommended in Harbeck et al (2011). However, there are several caveats to this conclusion that lend hope to the practice of stable isotope analysis in burnt bone. Firstly, Harbeck et al. (2011) found anecdotally that the interior regions of bone samples exhibited a lower degree of thermal alteration. They speculate that this would make them suitable for DNA and stable isotope analysis despite the heat alteration. Future work could examine whether it is possible to obtain accurate results using only the interior regions of burnt tissue samples for stable isotope analysis. Harbeck et al. (2011) state that histological examination can be used to assess whether a tissue sample is suitable for stable isotope analysis, offering another potential way forward. Secondly, a trend is observable overall, where lighter elements (such as carbon and nitrogen) exhibited larger shifts than heavier elements (such as strontium). As discussed in Munro et al. (2007) and Harbeck et al. (2011), it may be that this trend extends across all elements. It is unknown how this would affect hydrogen ($\delta^{2}H$), but this lends encouragement to the use of heavier elements such as sulphur ($\delta^{34}S$), lead ($\delta^{206}Pb$), and any other heavy elements of potential interest to archaeology, such as iron, copper, and zinc.

4.5.6. Feasibility of Stable Isotope Analysis of Burnt Teeth

As Boskey (2007), Elliott (2002), and Piga et al. (2016) report, bioapatites are actually very similar in structure in bone and tooth tissues, although in enamel the crystal lattice is more regular and less substituted, and crystal size is much larger (Boskey 2007, Elliott 2002). Furthermore, as alluded to in the previous sources and directly observed by Beach et al. (2015) and Schmidt (2015), the physical properties of bioapatites in enamel, dentine, and bone are also very similar. In one analysis, looking at soil diagenesis in archaeological contexts, Lee-Thorp and Sponheimer (2003) found that bone which had undergone some degree of permineralisation, making it more "enamel-like" in their words, was more resistant to diagenesis. This "enamel-like" quality was measured with increasing crystallinity index (CI), a parameter that is in fact higher in enamel and dentine than in bone. Furthermore, CI is known to increase with heat alteration (Piga et al. 2016), suggesting that heat alteration may actually make tissues more resistant to isotopic fractionation. All of the experiments cited in this paper that analysed hydroxyapatite found smaller isotopic shifts than those that analysed collagen, and no literature sources were found to contradict this trend. In particular, within a single analysis, Harbeck et al. (2011) found consistently lower shifts in mineral $\delta^{13}C$ than in collagen $\delta^{13}C$. This may indicate that more mineralised tissues are more robust to isotopic fractionation during heat alteration than organic tissues. This strongly suggests that enamel and dentine, exhibiting a higher degree of mineralisation than bone, would exhibit less isotopic fractionation with the same degree of heat alteration.

The preponderance of evidence suggests that the effects of heat alteration on stable isotopes in bone is significant, and that these observations most likely translate well to teeth. However, the molecular structure of teeth may be somewhat more resistant to heat alteration. This is strongly encouraging to future research in the area. In the analysis of Schurr et al. (2008), the authors were still able to make conservative conclusions without attempting to adjust for isotopic shifts due to burning. This demonstrates that, while isotopic fractionation due to heat alteration does certainly warp results, this may not be as serious as previously assumed, and these data should not be rejected out of hand. Furthermore, the available literature is unanimous that smaller degrees of heat alteration (e.g. below 200°C) do not significantly bias results. Therefore, further research is necessary in this field to determine just how useful burnt tissues can be to the practice of stable isotope analysis. Authors should attempt to make conservative conclusions from burnt materials, and if possible adjust for heat-related isotopic fractionation to make more powerful conclusions. DeNiro et al. (1985) calculated a potential of up to 33% error in stable isotope analysis from burnt bone.

However, the evidence above indicates that this position may need to be revisited when considering burnt teeth. While studies on diet using $\delta^{15}N$ and $\delta^{13}C$ might be difficult with burnt remains, accounting for isotopic shifts due to burning could provide valuable data that would otherwise be impossible to attain. This study is encouraging to analyses of mobility using $\delta^{18}O$ and $\delta^{87/86}Sr$, showing that these isotopes are scarcely altered, especially in teeth. Analyses using other heavy isotopes are also encouraged, and I eagerly anticipate further work in this field.

4.6. Conclusion

Despite the problematic context, with the right analytical tools it is possible to extract information from these remains, and likely from other remains that come from similar contexts. Though it is not possible to determine exactly how or whether these individuals are biologically or culturally related, it is nevertheless possible to interpret how the biological individuals relate to one another and to the physical space using osteobiography. Despite the extensive damage to the bones, it is possible to distinguish antemortem fractures, perimortem heat-induced fracturing, perimortem blunt-force trauma, and postmortem taphonomic fracturing. These data can be combined with analyses of entheses and other activity-related marks on bone to help to reconstruct activity. By studying modern fire victims, we can make sense of the behaviour seen here, and by studying how heat affects bones we can make conclusions about the temperature and extent of the fire. Bringing all of these lines of evidence together, it is clear that although the remains are heavily altered by heat and crushing, and although the context does not carry cultural meaning in the same way a ceremonial burial would, we can still make conclusions and speculate on lifestyle, activity, social identity, and understand the manner of death including the conditions of the fire and collapse. Hopefully, the methodological background discussed here, and its application in Chapters 6 and 7, will provide an interpretive framework that future authors can build upon in analyses of other victims of destruction.

Chapter 5 Materials and Methods

The methodologies used in this study are drawn from the background and source materials discussed in the previous chapter. However, the human remains under study here are in poorer condition compared to most remains analysed in osteoarchaeology. The bones are highly fragmented due to crushing and burning, there has been a certain amount of weathering and possible animal scavenging, and burning has also changed the colour, consistency, and possibly the shape of many bones. Therefore, in some cases, I have altered, combined, or changed the application of various methods, due to the difficulties inherent in the analysis of these highly fragmented, burnt archaeological remains. One relatively novel aspect of the methods used here is the borrowing of techniques from forensic anthropology. This is a field with which my study has a lot in common, since these are accidentally interred remains, as opposed to the ceremonially buried remains typically analysed in osteoarchaeology. In this way, the methods used in my thesis research are interdisciplinary and carry a degree of inherent uncertainty. However, I justify these approaches by making conservative conclusions, and including as much analytical redundancy as possible to reduce uncertainty.

The human remains analysed in this study were excavated in the summers of 2012, 2013, and 2014 at Tel Azekah, Israel. Excavation was carried out by a team of general archaeologists and volunteers (including myself, as at the time I had little training in biological anthropology). Due to faith-based debates specific to the region, it was necessary to remove the human remains as quickly as possible and transport them away from the site (see Sheridan 2017), therefore, only a few photographs were taken before the bones were removed from the ground, and most analysis occurred *ex situ*, using bone fragments in conjunction with these photographs. Fortunately, the field photographs were professionally taken, and in high enough resolution that it was possible to identify and locate many individual bone fragments, aiding in the ex situ reconstruction. This was the first step in the analysis, which I performed at Tel Aviv University in the summer of 2016. All elements were cleaned using brushes and wooden picks. Bone fragments were sorted into separate boxes by anatomical region, and then individual bones were refitted from fragments and studied to ensure that none of the highly fragmented material was missed. Additionally, teeth were selected from the dentition and transported to the University of Alberta for potential stable isotope analysis. Due to the time-consuming nature of these tasks, only a preliminary osteobiographical analysis was possible in the summer of 2016. Data gathering for the osteobiographies was completed during a return trip in the summer of 2017.

This study employs the method of osteobiography, as discussed at length in the previous chapter. Specifically, the parameters used to create the osteobiographies were age at death, sex, pathology, trauma, body positioning, and taphonomy (weathering, scavenging, and diagenesis). The study began with a thorough skeletal inventory, where each tooth, bone, or bone fragment was identified and recorded on a modified version of the forms provided in Buikstra and Ubelaker (1994). However, due to the difficulty of visually depicting the highly comminuted bones, a verbal descriptive approach proved more useful and is included in Appendix 1. Although it was initially planned that stable isotope analysis would be conducted as part of these osteobiographies, these attempts have been put on hold due to the failure of a preliminary feasibility study, as described in section 5.6.

5.1. Age at Death

Age at death was estimated according to the standards outlined in Buikstra and Ubelaker (1994), with the addition of some recent advances in technique. Skeletal maturity was assessed using epiphyseal union patterns, following the ages at union published in Scheuer and Black (2008). Epiphyseal union was usually assessed as a binary of union or non-union, although in some cases where it was clearly visible, degrees of partial or incomplete union were recognised and used to qualitatively inform the age estimation. In this method, the age is expressed using maxima (the highest possible age for an epiphysis not to have united) and minima (the lowest possible age for an epiphysis to have united), which come together to produce age ranges. It must be noted that the standards used in Scheuer and Black (2008) were calibrated using data from children of European ancestry, a genepool somewhat removed from the population under study in my analysis. Some research suggests that this may limit the applicability of this source, due to regional differences in skeletal growth and maturation, some of which may be genetic (Eveleth and Tanner 1990). However, this source provides the best standards currently available, and is still likely to provide accurate age estimates. Dental maturity was assessed using the London Atlas (AlQahtani 2009, AlQahtani et al. 2010, 2014), where the stages of crown and root formation and completion are assessed visually. In this method, the age is expressed as a whole number plus an uncertainty range. Skeletal and dental age were treated separately, and when an overlap occurred, this was used to narrow the range of the overall age assessment, producing a final estimate.

There are a few caveats to be noted when conducting age estimation from human remains such as these. Firstly, in order to produce an accurate estimation, a researcher ideally has access to a well-preserved, whole skeleton, with all epiphyses and the complete dentition represented. The highly fragmented and burnt skeletons in this analysis were far from this ideal, and therefore it was necessary to reduce error by making rather conservative conclusions. It is unknown how much this could have affected the accuracy or precision of my age estimates. Secondly, the age estimate produced by this method ultimately reflects not chronological age, but physical maturity. Skeletal and dental maturation can be influenced by factors such as genetic variation, pathology, and nutrition, meaning that physical maturity can fall out of step with chronological age (Scheuer and Black 2008). It must be considered in this analysis that the observed pathologies (see Chapter 6) could have affected skeletal and dental maturation, as this is always an unknown in age estimation, and is one of the fundamental errors of this technique. Thirdly, neither chronological age nor maturation corresponds strictly to social age, which is an achieved social status based on a variety of physical and behavioural factors (Halcrow and Tayles 2008). As in any bioarchaeological analysis, these limitations must be kept in mind when drawing conclusions about cultural practices based on the age estimations.

5.2. Sex

Sex was estimated according to the standards of Buikstra and Ubelaker (1994). This is a visual system, where features are given a numerical score based on the degree of expression of the characteristic as judged by the investigator. Lower numbers indicate feminine characteristics, while higher numbers indicate masculine characteristics, meaning that each feature can be individually classed as female (1), probable female (2), ambiguous (3), probable male (4), and male (5). The scores of each individual feature were taken together and used to inform a qualitative determination whether the features were overall masculine (male) or feminine (female). Features scored in this way are listed in Tables 5.1 and 5.2. Also listed in those tables in italics are some generally accepted sex-based characteristics that were used in this analysis, but are not scored using the five-point system[5].

Feature	Feminine Characteristic	Masculine Characteristic
	1 2	3 4 5
Nuchal crest	Smooth, few projections	Projecting, forms a hook
Mastoid process	Small	Very large, projects inferiorly
Supraorbital margin	Sharp border	Blunt border
Supraorbital ridge/glabella	Smooth, little projection	Large, thick, and protruding
Mental eminence	Vertically short, no projection	Vertically tall, projecting
Frontal bosses	*Prominent, rounded*	*Smooth, not discernable*
Gonial angle	*Relatively obtuse, smooth*	*Close to 90°, everted, rugose*
Root of the zygoma	*Not extensive, smooth*	*Extends beyond external acoustic meatus*
Muscle markings	*Generally smooth*	*Generally rugose*

Table 5.1. Sexually dimorphic features of the skull. Italicised entries are characteristics that are not scorable using the five-point system.

Feature	Feminine Characteristic	Masculine Characteristic
	1 2	3 4 5
Greater sciatic notch	Wide	Narrow
Ventral arc	*Present*	*Absent*
Subpubic concavity	*Concave*	*Flat or convex*
Ischiopubic ramus	*Sharp, lipped edge; narrow*	*Blunt, rounded edge; broad*
Subpubic angle	*>90°*	*<90°*
Iliac crest	*Flaring, divergent*	*Narrow, more vertical*
Acetabulum	*More anterior*	*More lateral*

Table 5.2. Sexually dimorphic features of the pelvis. Italicised entries are characteristics that are not scorable using the five-point system.

It should be noted that most of the features listed in Tables 5.1 and 5.2 are characteristics which emerge during sexual maturation, and are therefore less reliable sex indicators in individuals who are not fully mature. In fact, Milner and Boldsen (2012) conclude that individuals under about 15 years of age are ineligible for sex determination using these methods. Given this, one individual in the group was excluded from sex determination (see Chapter 6).

[5] A scoring system of one to three exists for the attributes of the subpubic region listed in Table 5.2 (ventral arc, subpubic concavity, and ischiopubic ramus), but was not used in this analysis.

5.3. Pathology

A large part of this osteobiographical analysis was concerned with pathology, a key indicator of quality of life and living conditions in archaeological populations. Analysis of bone pathology includes a mixture of qualitative and quantitative approaches. The palaeopathological analysis began with a thorough examination of all recovered elements for apparent lesions or anomalies. When these were seen, they were documented using photographs and written descriptions. Comparison to the published literature allowed identification and interpretation. In some cases, lesions and anomalies were described using standardised systems detailed here, while other lesions and anomalies are discussed on an individual basis in Chapter 6.

5.3.1. Cribra Orbitalia

Cribra Orbitalia was photographed and described in detail, and its severity was staged according to the method of Stuart-Macadam (1985). In this method, descriptions are used to stage the severity of the condition from light (Stage 1) to severe (Stage 3). To assess this, the extent of the lesion, size of the foramina, relative amount of convergence of the foramina, and relative amount of exposure of the trabecular bone were all described, and if possible it was noted whether the lesion was bilateral, and how the two sides compared in these respects. The type of bone (trabecular, cortical, woven, Haversian) is particularly important to the differential diagnosis of this condition, and was noted in all cases. When necessary, exposure of the diploë due to damage was differentiated from exposure due to pathology by looking closely at the edges and floors of the lesions using a handheld lens and closeup photographs for signs of breakage. The amount of remodelling was assessed by looking at rounding of lesion edges and new bone formation producing floors between the trabeculae, to determine how long ago the lesion occurred.

5.3.2. Dental Lesions and Wear

Carious lesions were recorded and described according to Buikstra and Ubelaker (1994). The location, extent, and depth of each lesion were noted visually and verbally, and teeth were photographed. Where possible, teeth were also examined for antemortem versus perimortem loss, and signs such as the sharpness of alveolar edges and degree of alveolar remodelling were recorded. Dental wear was recorded according to the standards of Buikstra and Ubelaker (1994), who recommend a combination of the systems developed by Smith (1984) for this incisors, canines, and premolars, and by Scott (1979) for the molars. The location of the wear, cusps affected, and patterns of dentine exposure were described verbally and visually, using scoring templates in Buikstra and Ubelaker (1994), and the teeth were photographed. The systems used stage tooth wear from 1 to 8 (for whole incisors, canines, and premolars) or 1 to 10 (for molar cusps), where Stage 1 is the least wear, and Stages 8 and 10 are the most wear. Additionally, overall patterns in wear were described: the amount of wear on anterior vs. posterior molars, the symmetry of wear patches on incisors, and the way the wear might have been affected by tooth loss and other dental pathology.

5.3.3. Trauma

The bones were thoroughly analysed for any signs of blunt or sharp force trauma as well as the signs of heat-induced and taphonomic fracturing described in the previous chapter. Using Passalacqua and Rainwater (2015) as a guide, fracture patterns were recorded in detail, looking at individual bones as well as the overall skeleton to record what kind of trauma was represented, where on the body it occurred, and how extensive it was. Simple fractures, appearing as relatively smooth breaks in bone, were differentiated from greenstick fractures, which appear as ragged, splintering breaks that may not pass through the entire bone (Passalacqua and Rainwater 2015). Both of these were differentiated from heat-induced fractures, by looking for the rectilinear pattern and delamination characteristic of heat-induced fractures (see Chapter 4 and Figure 4.4). Additionally, bone fragments were carefully examined to differentiate perimortem and postmortem fractures. Using the background explained in Chapter 4, fractures were examined for patterns and locations that relate to biomechanical mechanisms of injury, such as eponymous fractures, to ascertain whether they might have occurred perimortem. The edges of fractures were also examined for roughness of texture and colour differentiation from the surrounding bone surfaces, indicating a postmortem fracture, compared to smoothness of texture and colour similarity to nearby bone surfaces, indicating a perimortem fracture (Wieberg and Wescott 2008). For this purpose, published descriptions and photographs were consulted from recent sources, including Calce and Rogers (2007), Cappella et al. (2014), Moraitis and Spiliopoulou (2006), Outram et al. (2005), and Wieberg and Wescott (2008). Postmortem fractures were examined for colour differences showing whether they occurred relatively shortly postmortem, long postmortem, or recently (during excavation and transport).

Burning trauma was evaluated, photographed, and described. Fracture patterns due to burning were differentiated, and classed as longitudinal, straight transverse, rectilinear (a combination of longitudinal and straight transverse), curved transverse (or thumbnail), or patina (Mayne 1990, Mayne Correia 1997, Schmidt and Symes 2015, Ubelaker 2009; see Figure 4.4). Colour changes were described using the Munsell Soil Colour Chart (Munsell Soil Company Inc. 1954) and related to temperature ranges, following Shipman et al. (1984). While application of this method has occasionally been criticised in the literature (see Pope (2007) for a review), I believe that it is quite securely used in non-forensic contexts, where relative amounts of burning are more important than determining exact fire temperature. Calcination was evaluated by a stark white colour change, in addition to testing resonance with a metal pick, to listen for the ceramic-like sound characteristic of calcined bone (Schmidt and Symes 2015; P. Mayne Correia, pers. comm.). These techniques were used in this case to differentiate types of bone fracturing in this analysis with some success, although this is not to the level of certainty that would be expected in the forensic world where these methods developed. Therefore, care was taken to be conservative with any conclusions based on bone fracturing.

5.4. Musculoskeletal Stress Markers

The Musculoskeletal Stress Markers (MSMs) described in Chapter 4 were assessed in these individuals visually. After some consideration it was decided not to use an entheseal recording and scoring system, such as those of Hawkey and Merbs (1995), Villotte (2006, 2009) or the most recent Coimbra Method presented in Henderson et al. (2013, 2016). This was due to the poor preservation of the remains, resulting in the difficulty of observing some important features, and the fact that these scoring systems are usually recommended for quantitative research using larger skeletal populations (Henderson et al. 2016). Instead, using the University of Alberta Department of Anthropology's extensive osteological reference collection, entheses were assessed qualitatively on a comparative basis. I conducted these assessments alone to avoid interobserver error, and documented each one using several angles of photography and lighting for further consideration. Overall size of the enthesis, including the relative proportion of the bone surface it covered, and the distance it projected from the bone or the depth of the excavation, was one major factor taken into consideration as an indicator of relative robusticity. Also observed as important signs of relative robusticity were the rugosity of the surface of the enthesis, and whether the size or shape of the enthesis appeared to have resulted in remodelling of the surrounding bone to provide additional strength. Since only four individuals were analysed, it was not possible to control for potential confounding variables such as age at death or body mass.

Although this is an older approach than using a standardised system, I feel that it was better suited for this analysis, where the small number of individuals under consideration allowed time for every enthesis on the skeletons of all four individuals to be thoroughly considered. Furthermore, since no clear comparative population of similar ancestry and lifestyle was available for these individuals, this qualitative method has the advantage of providing a nuanced assessment of entheseal robusticity that allowed relative amounts of musculoskeletal stress between these four individuals to be examined. Similar qualitative approaches to assessment of entheseal robusticity are strongly represented in the literature, and although they are not without their problems (see Jurmain et al. 2012), they seem to be accurate and informative. Future work on these skeletons (such as that described in Chapter 8) could potentially employ a recording and scoring method such as the Coimbra Method, especially if these individuals could be connected to a comparative population of sufficient size.

5.5. Body Positioning and Taphonomy

The position of each skeleton was photographed on site, showing the exact positions of each body part and bone at first exposure in the field. This was used to reconstruct body position at death. Furthermore, the location and orientation of each skeleton within the building was recorded on a hand-drawn plan of the archaeological site that was augmented with GPS data. These factors were taken into account and evaluated to determine the events before and after death that led to this positioning of the bodies. Taphonomic processes were also examined to help explain body position. The remains were examined for signs of weathering, which were photographed and recorded. Missing and broken elements were recorded and described, and attempts were made to relate these features to patterns that might be expected due to erosion, or different types of animal scavenging.

5.6. Stable Isotope Analysis

While stable isotope analysis was initially planned for this project, much of it was ultimately abandoned due to failure of a preliminary feasibility study that was conducted. In this experiment, teeth from a dog (*Canis lupus familiaris*) were used to test the effects of different degrees of thermal alteration on dental collagen, and the concentrations of stable carbon and nitrogen isotopes ($\delta^{13}C$ and $\delta^{15}N$) within it. For the purposes of this experiment, antimere pairs of upper and lower canines as well as upper and lower molars from a dog (*Canis lupus familiaris*) were selected. In each pair of antimeres, one member served as a control, while the other was experimentally exposed to heat. Following this, collagen was extracted from both members of each pair, with the intention of comparing the stable isotope concentrations within pairs.

The burned teeth included segments of soft tissue and bone surrounding each tooth root to simulate the insulation and protection these tissues would provide in a real-life setting (Mayne 1990, Pope 2007). Before each burn, the teeth were given specimen numbers and photographed, and any features of note recorded. The experimental teeth were heated in a lab furnace to 200, 250, 300, and 500°C. These temperatures were chosen to be low enough to fall below the 500–600°C threshold for combustion of collagen as published in Mayne Correia (1997) and Harbeck et al. (2011), and below the threshold of 538°C for enamel disintegration, as described by Beach et al. (2015), but high enough to cause a Stage IV alteration in molecular structure and to come close to the range of 525–645°C for transition in crystal structure as described by Shipman et al. (1984). Each tooth in the experimental group was burned for one hour. Teeth and surrounding tissues were placed in a porcelain crucible and inserted into a muffle furnace. The furnace was programmed to perform a one-hour heating cycle, where it elevated the interior from room temperature to the target temperature, and held it at that value until the hour was complete, after which the tooth was allowed to cool naturally. Temperatures were recorded every minute during heating and cooling. After cooling, teeth were extracted from any remaining alveolar bone and placed in a 1% solution of hydrochloric acid (HCl) alongside their antimere controls (see below).

Because the initial goal of the stable isotope analysis was to look at childhood diet and environment of the Tel Azekah individuals, the canid teeth were prepared for sequential dentine analysis. This analytical technique requires the teeth to be slowly demineralised to form collagen models. The preparation method used was based on Method 2 in Beaumont et al. (2013). Whole teeth were placed in a 1% solution of hydrochloric acid (HCl) at room temperature for demineralisation. The acid solution was changed every second day, until the teeth stopped visibly reacting with the acid, and became translucent with a spongy texture. The teeth were then rinsed with distilled water. Normally, these steps would be followed by slicing of the dentine into sequential 1 mm segments for analysis. However, this step along with the rest of the experiment was abandoned when the HCl solution completely dissolved the burnt teeth from all but the 200°C trial. On this basis, it was determined that sequential dentine analysis would not be feasible for the Tel Azekah teeth. Bulk dentine analysis may still be feasible if a collagen isolation method more appropriate for the extraction of badly degraded collagen is used (e.g. Harbeck et al. 2011). However, this would require destruction of an entire tooth, and even if the extraction were successful it would produce a single set of $\delta^{15}N$ and $\delta^{13}C$ values averaging many years of changing juvenile diets. This being the case, it was decided that dentine analysis of the Tel Azekah remains carried an unjustifiably low likelihood of producing useable results.

There is still a plan to carry out stable isotope analysis of the enamel of the human teeth. As discussed in Chapter 4, the mineral component of tooth and bone is less affected by heat than the organic component. Studies to date show that oxygen, and particularly strontium from tooth enamel, are less affected by heat. However, given that most of the initially anticipated stable isotope data will not be collected, this part of the analysis is planned for future work.

5.7. Conclusion

The highly damaged condition of the remains in this study necessitated a great deal of research and prior consideration in order to adapt existing methods or determine if existing methods would be suitable for these remains. Age and sex estimation were able to proceed normally with some success, since these interpretations are based on many small parts of the skeleton, of which several could be identified from the fragmentary remains. Analysis of pathology and trauma was challenging due to poor preservation, but was usually possible as long as it was considered that some information could have been obliterated with the crushing of the bones. However, the burnt condition of the remains raised too many difficulties for stable isotope analysis to be included in this study. Overall, the consideration of multiple lines of evidence in this study ensured that some information was obtained from these bones whose condition might otherwise make them unattractive for osteobiographical analysis. Bearing in mind all of the caveats and considerations outlined in Chapter 4, the methods described in this chapter were able to successfully produce meaningful conclusions in chapters 6 and 7, greatly enriching the biography and increasing the understanding of the lives of these ancient individuals.

Chapter 6 Four Individuals from Azekah: Their Lives

At the end of the Late Bronze Age, Azekah was at its peak. Following the destruction of Gezer and Gath, the city of Azekah grew and prospered as it occupied the power vacuum left by these cities. From this period, Azekah exhibits a rich tradition of architecture, pottery, and an array of imported Egyptian finery (Kleiman and Hadash 2017, Metzer 2015). A large building was constructed on top of the tel with architecture resembling an elite Patrician House, filled with an undeniable luxury of items. However, at some point this wealthy dwelling was converted into a production facility where massive amounts of grain were processed (Metzer 2015; see Chapter 3). The following analysis uses the approach of osteobiography (see Chapter 4) to document the lives of four of Azekah's ancient inhabitants who occupied this building. Age and sex profiles are constructed for each individual and complemented with details of pathology and signs of habitual activity to give an impression of the lifestyles of these individuals. These data are taken into context with historical information about the LBA–Iron Age transition from Chapters 2 and 3, in order to make conclusions about what life was like at ancient Azekah directly from the human evidence. The full skeletal inventories and detailed observations used to make these determinations can be found in Appendix 1.

6.1. Osteobiographies

6.1.1. Individual 1

During the 2012 excavation season, a single set of human remains was uncovered during the initial exposure of Building T2/627. The skeleton was first encountered during the articulation and removal of three complete, smashed Canaanite storage jars (see Chapter 2). The ossa coxae were noticed and quickly identified as human by the excavators, allowing a careful investigation of the rest of the skeleton as it came to light beneath the pottery fragments. The skeleton was badly crushed and burnt, and the legs were missing except for the proximal 5–6 cm of the femora (see Chapter 7). These remains were positioned directly on Floor T2/13/F569 in Room T2/F628, in close proximity to feature T2/12/F639, a grinding installation. Notably, this individual was found in association with several valuable objects including scarabs, amulets, and beads (Metzer 2015, Koch et al. 2017; see Chapter 3).

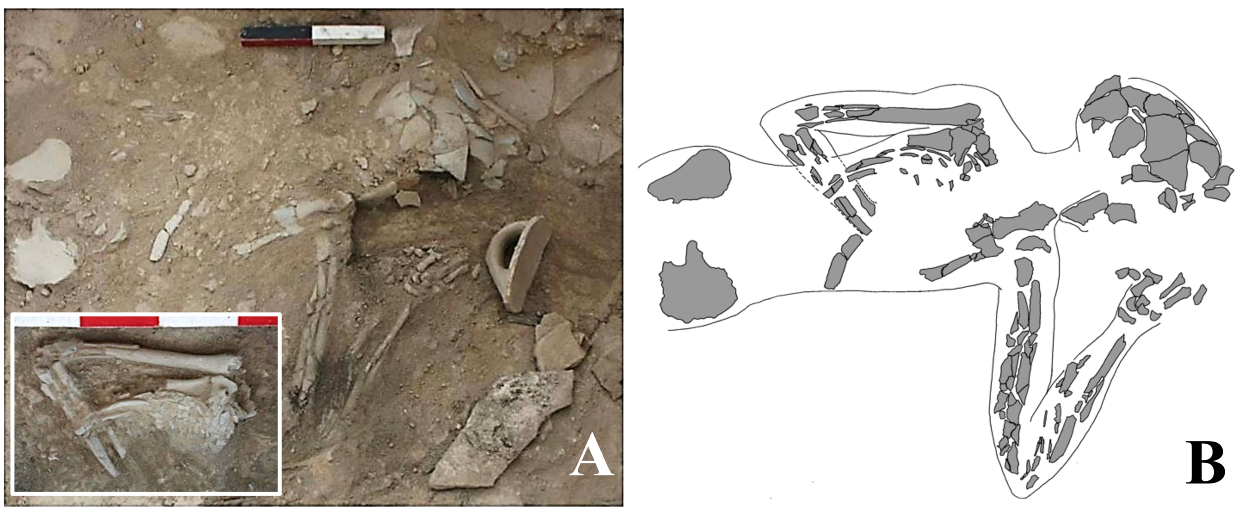

Figure 6.1. Remains of Individual 1. A) In situ photograph (left arm inset), and B) positional diagram. Photographs and diagram by Karl Berendt.

6.1.1.1. Age at Death

The overall evidence from the remains suggests that Individual 1 was most likely 15–16 years of age at the time of death. The left maxilla was largely intact at recovery, with premolars and molars in situ. Using the London Atlas (AlQahtani 2009, AlQahtani et al. 2010, 2014), this dentition corresponds well to the stage of 15.5 years ±6 months, or 15–16 years of age. Evidence from the skeleton corroborates this assessment. Union of the epiphysis of the distal pollical phalanx, combined with lack of union of several proximal and intermediate phalangeal epiphyses of the hand, also pinpoints this age range (Cardoso and Severino 2010, Scheuer and Black 2008). The unfused left proximal radial epiphysis, which normally fuses by 17 years of age (Scheuer and Black 2008), exhibited increased granularity and loss of clear billowing on the diaphyseal growth plate surface, suggesting that it was close to union at the time of death, and therefore that this individual was, at most, not much younger than 17 years of age. Other preserved features of the skeleton, including lack of fusion in the iliac crests, triradiate sutures, femoral heads, left humeral head, radial heads, metacarpal heads, glenoid epiphyses, and thoracic vertebral epiphyses, are consistent with an age range of 15–16 years.

6.1.1.2. Sex

Individual 1 exhibits generally slight muscle markings and gracile features in the skeleton. However, such classic methods of skeletal sex estimation are not reliable for individuals of this age, because most of the male-female differences in robusticity and morphology on which they rely have not developed yet (Milner and Boldsen 2012). In other words, although the gracility of Individual 1 may reflect female sex, it may also simply reflect youth. While some morphometric sexing techniques are claimed to be accurate in juveniles (see Işcan and Steyn 2013 for review), their reliability is debated, and the fragmented and calcined condition of Individual 1's remains makes them a poor candidate for these methods in any case (Gonçalves 2011). Given these considerations, skeletal sex estimation was not performed for this individual.

6.1.1.3. Pathology and Trauma

The skeleton exhibits cribra orbitalia, or porotic hyperostosis of the orbital roofs. This condition presented bilaterally as scattered, isolated large and small foramina, some of which are merged to expose areas of diploë and form a trabecular structure. Damage made it impossible to assess whether the orbital plates were thickened as would be expected, but no proliferation of bone was observed on the surface to suggest an alternative such as inflammation due to scurvy or injury, and the bilaterality of the lesions suggests a systemic cause. The cribra can be characterised as medium in severity after Stuart-Macadam (1985) but are quite well remodelled with smoothing of the edges of the foramina, suggesting that the condition triggering them was resolved quite some time before death. Cribra orbitalia is usually linked to megaloblastic or haemolytic anaemia during childhood (Roberts and Manchester 2007, Walker et al. 2009; see section 6.1.3).

Figure 6.2. Cribra orbitalia in Individual 1. Note the areas of unrelated depositional damage indicated by the arrows. Photograph by Karl Berendt.

Megaloblastic anaemia results from a deficiency in vitamins B9 (folic acid) and/or B12, which are found in meat, eggs, dairy, and some plant foods. A significant lack of these vitamins generally reflects an overall poor diet, or poor nutrient absorption (Steyn et al. 2016, Walker et al. 2009, Zariņa et al. 2016). Haemolytic anaemia is caused by inherited conditions such as sickle-cell anaemia, thalassaemia, and spherocytosis (Steyn et al. 2016). Whatever the cause, cribra orbitalia evolves when childhood anaemia causes the marrow cavities in the roofs of the eye orbits to expand to produce more erythrocytes to assist in iron absorption. This results in the outer table of the bone being resorbed, exposing the diploë, presenting as a scattered collection of large and small foramina that join to expose areas of trabecular bone (Steyn et al. 2016, Stuart-Macadam 1985, 1992). This lesion is specific in the sense that it can be linked to anaemia, however it cannot be determined without further information what condition caused this anaemia. Thalassemia, sickle-cell anaemia, and malaria cause pathognomonic lesions in other parts of the skeleton (Hershkovitz et al. 1997, Lagia et al. 2007, Lewis 2012, Smith-Guzman 2015), but these vary in severity between individuals, and the poor preservation of this individual's remains prevents many of them from being observed. This being the case, it is most prudent to conclude that the lesions reflect an unspecified chronic illness or malnutrition (Steyn et al. 2016).

6.1.1.4. Musculoskeletal Stress Markers

A distal phalanx of the left or right pollex exhibited changes of the joint surface and at the insertion of the flexor pollicis longus that could be connected to musculoskeletal stress on this joint (Cashmore and Zakrzewski 2013, Rack and Ross 1984; Figure 6.3). A semi-circular area of resorption was noted with a diameter of approximately five millimetres on the palmar aspect of the proximal end of the bone. The edges of the lesion were irregular and exhibited a beaded appearance that was highly suggestive of blastic activity in combination with the lytic excavation. This lesion was excavated deeper and in a different orientation than the normal concave topography of that part of the bone, and exhibited a bony floor, showing that it could not be an artefact of damage or burning. It was considered that this lesion could be due to antemortem trauma or secondary to arthritis, but ultimately the location and topography of the lesion make it most likely to be an enthesopathy of the insertion of the flexor pollicis longus. Some irregular, scattered porosity was also observed on the joint surface that may be associated with inflammation of the joint secondary to this enthesopathy, but this was not securely diagnosable due to damage.

Figure 6.3. Enthesopathy in a distal pollical phalanx of Individual 1. Photograph by Karl Berendt.

6.1.1.5. Other Observations

Individual 1 exhibits bipartite occipital condyles. The occipital condyles were smoothly divided between two-thirds and halfway along their length into rostral and occipital parts. Although the joint surfaces exhibited areas of postmortem damage, no trauma or associated pathology was observed, and the corresponding joint surfaces of the atlas exhibited two connected articular areas that matched the topography of the occipital condyles, showing that this condition existed in life. Bipartite occipital condyles are usually considered to be incidental and genetic, perhaps a mild form of cranial border shifting (Barnes 1994, 2013).

Figure 6.4. Bipartite occipital condyle in Individual 1. Photograph by Karl Berendt.

6.1.2. Individual 2

During the 2013 excavation season, two more skeletons were uncovered during further exposure of the southern section of building T2/627. The first of these, Individual 2, was uncovered in Room T2/F630 next to Wall T2/13/F574, on Floor T2/13/F595 (see Chapter 3), in close proximity to Individual 3 (see section 6.1.3). This skeleton was also badly crushed, with its left leg missing entirely (see Chapter 7). In this phase of the building, room T2/F630 was connected to the main entrance to the building (see Chapter 3).

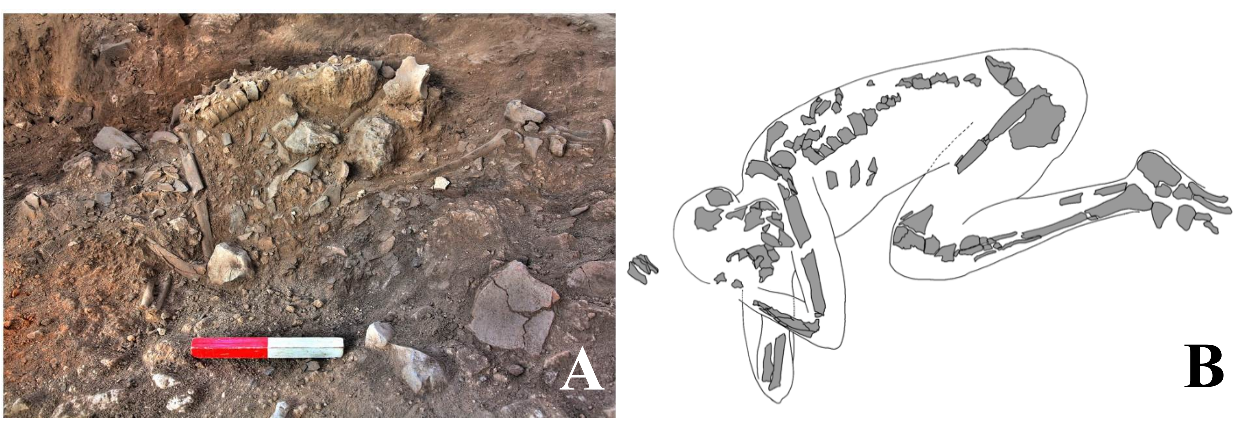

Figure 6.5. Remains of Individual 2. A) In situ photograph and B) positional diagram. Photograph by Benjamin Sitzmann, diagram by Karl Berendt.

6.1.2.1. Age at Death

The combination of skeletal and dental evidence shows that Individual 2 was between 19 and 25 years of age at the time of death. Skeletal evidence suggests an age between 17 and 25 years. This minimum age was set based on full fusion of the left iliac crest, which occurs at or after 17 years (Scheuer and Black 2008). Full fusion of other elements, including the left radial head, right femoral head, left medial clavicle, and right distal tibia, agrees with this minimum age. The sacrum is fragmentary due to some breakage, but the inferior aspect of the body of the first sacral vertebra exhibits a full surface, indicating that the first two sacral vertebrae were not fused at this point. Fusion here usually occurs by 25 years of age, setting the maximum osteological age (Scheuer and Black 2008). It was considered, especially given the mild occipitocranial border shifting seen in Individuals 1 and 4, that this lack of union could instead reflect lumbarisation of the first sacral vertebra. However, the preserved portion of the sacrum does not match the expected morphology for a lumbarised S1 (Barnes 1994, 2013), and its inferior surfaces in the regions of the sacral alae are broken rather than unfused, with trabecular patterning suggesting normal union with S2. In the dentition, the left maxillary third molar is fully erupted with a completed root, matching at minimum the London Atlas standard of 19.5 years ±6 months, or 19–20+ years of age (AlQahtani 2009), increasing the minimum age estimate to 19 years of age.

6.1.2.2. Sex

Sex estimation for this individual was challenging because of poor preservation and some mixed observations. The mastoid process and mental eminence were both scored at 3 after Buikstra and Ubelaker (1994), suggesting indeterminate sex. However, the mandibular ramus is very broad and acutely angled, with highly rugose masseteric and pterygoid insertions that strongly suggest a male. The morphology of the mandible in isolation is considered to be a highly accurate indicator of sex (Donnelly et al. 1998, Williams and Rogers 2006). Furthermore, the greater sciatic notch was given a score of 4, and the roots of the zygomae extend posterior to the external auditory meatus, both indicators of a probable male (Buikstra and Ubelaker 1994, Langley et al. 2018). Overall, it is most likely that Individual 2 is a male.

6.1.2.3. Pathology and Trauma

In Individual 2, a large section of the right tibial diaphysis exhibited signs of moderate periostitis. This presented as a moderately well-defined wood grain appearance in the anterior (subcutaneous) aspect of the cortical surface, extending over 20 cm or about two-thirds of the way along the shaft. No involution or sequestration was observed, and it was observed via areas of postmortem damage surrounding this lesion that it did not extend into the medullary bone, ruling out osteomyelitis. The isolated, subcutaneous location of this lesion makes it unlikely to have spread from an infection elsewhere in the body, and no associated trauma or other pathology was evident, making non-specific periostitis due to generalised systemic stress the most likely diagnosis. Smoothing of the edges in the wood-grain topography was observed, showed that some healing had occurred and that this lesion was not active at the time of death (Roberts and Manchester 2007).

Figure 6.6. Periostitis in one fragment of the tibia of Individual 2. Photograph by Benjamin Sitzmann.

This lesion was identified as periostitis, an inflammation of the periosteum that can occur secondary to factors such as infection and injury, but in absence of other indicators, and particularly in the anterior tibia, is most often linked to generalised physiological stress, such as might be caused by a systemic illness, malnutrition, parasite, or severe infection (Gladykowska-Rzeczycka 1998, Klaus 2014, Weston 2008). This causes a reaction in the surface of the bone with both lytic (bone-destroying) and blastic (bone-forming) properties, resulting in a striated appearance (Klaus 2014). Periostitis can sometimes evolve into osteomyelitis, a much more serious bone infection. As with the habitual activity markers described above, these pathological lesions require continuous stress over a long period of time in order to form. Therefore, they usually result from chronic conditions that take place over a number of months to a number of years due to a long-lasting, even lifelong, environmental trigger (Klaus 2014, Roberts and Manchester 2007).

6.1.2.4. Musculoskeletal Stress Markers

The lateral condyle of the right femur, as well as the lateral articular facet of the right patella, exhibited corresponding areas of porosity involving foramina of various sizes that converged to form a web-like structure. On the femoral condyle, this porosity occupied a roughly circular area of about one centimetre in diameter on the inferiormost extent of the femoral condyle, with possible further involvement extending a few millimetres posteriorly. These lesions were less extensive along the joint surface than would be expected in osteoarthritis (Weiss and Jurmain 2007, Lieverse et al. 2016), and no eburnation was observed. Edges of the foramina were smooth and exhibited heat-related discolouration that matched the rest of the joint surface, ruling out postmortem damage.

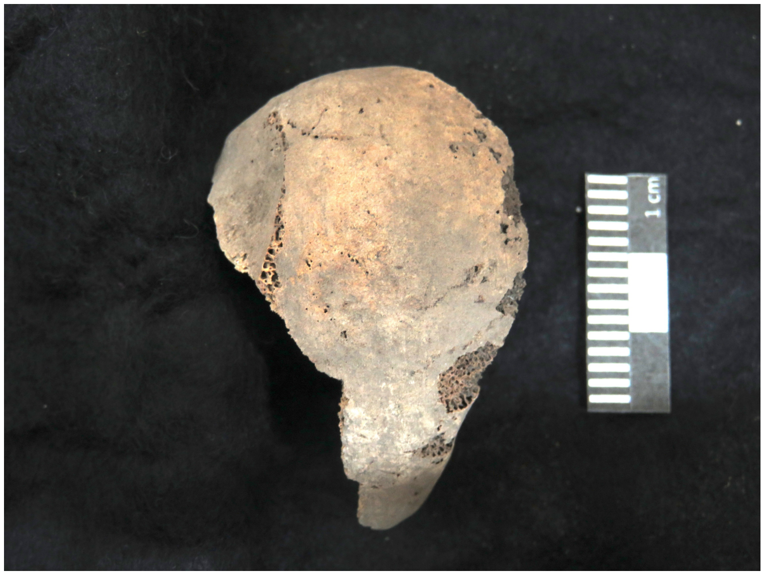

Figure 6.7. Osteochondritis dissecans on the surface of the lateral condyle of the right femur of Individual 2. Photograph by Karl Berendt.

This appearance is consistent with descriptions of osteochondritis dissecans, an identification further confirmed by the classic location of the lesion (Waldron 2008). Osteochondritis dissecans is a change in the subchondral bone of a joint due to activity-related stress. Most often it is seen in the femoral or patellar joint surfaces of the knee, but can be found in other joints due to the same aetiology. This condition commonly occurs in highly active people who are still growing, especially males, and may be due to activity-related repetitive microtrauma to the articular surface (Lewis 2016, Vikatou et al. 2017). This stress leads to chronic avascular necrosis in the subchondral bone surface when the blood supply is interrupted, leading to resorption, collapse, and sequestrum formation. The condition may be asymptomatic, or the necrotic bone fragments that form may interfere with the joint (Nault and Kocher 2014, Roberts and Manchester 2007, Waldron 2008). In dry bone, osteochondritis dissecans is most clearly seen as a well-circumscribed, porous defect that is sunken below the normal joint surface, and can be distinguished from other joint pathologies such as arthritis using these criteria (Roberts and Manchester 2007).

Individual 2 also exhibits generally strong muscle markings in all areas of the body. The bicipital tuberosities were thick, extending several millimetres from the bone in the anterior/palmar direction, but also associated with expansion of the bone in the mediolateral direction, producing a bulbous area from which the tuberosity emerged, especially on the left radius. The entheses themselves were partially raised and partially excavated, and formed strong ridges on their medial and lateral borders. The ischial tuberosities were thick and dense, the ischial spines were long and quite substantial, and the anterior inferior iliac spine was noted to be large and blunt on the left ilium. The gluteal and pectineal lines on the right femur were quite noticeably raised and rugose, the tuberosities of the right patella were rugose and formed spurs superiorly and inferiorly, and the right calcaneal tuberosity was large and formed a posterior spur.

Figure 6.8. Schmorl's nodes in a lumbar vertebra from Individual 2. Photograph by Karl Berendt.

Several lumbar vertebral bodies exhibited depressions that were identified as Schmorl's nodes, although damage precludes certainty. These were observed as defined depressions in the superior and inferior surfaces that often took on the shape of a horseshoe opening to the posterior. Some of these had a single, large depression, while others had two or more smaller depressions connected by less depressed saddles. All of these lesions, though eroded, exhibit evidence of a bony floor showing that they were not caused by damage (Roberts and Manchester 2007; Figure 6.8).

6.1.3. Individual 3

Individual 3 was uncovered in the summer of 2013, in the same room as Individual 2 (see section 6.1.2), which was connected to the entrance. These remains were next to Wall T2/13/F573, and near the pathway into an adjacent room (T2/F631). The skeleton was crushed and fragmented, and the legs were absent from a point slightly above the knee (see Chapter 7). The remains were found among architectural remains and a large amount of pottery.

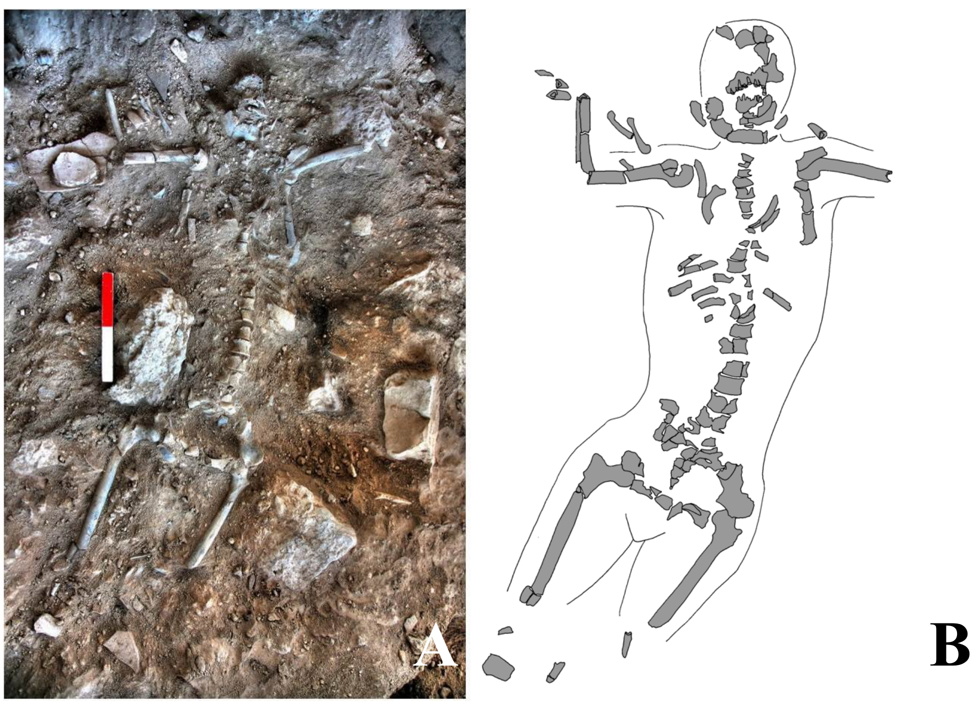

Figure 6.9. Remains of Individual 3. A) In situ photograph and B) positional diagram. Photograph by Benjamin Sitzmann, diagram by Karl Berendt.

6.1.3.1. Age at Death

Osteological and dental evidence identifies Individual 3 as an adult between 35 and 45 years of age. The auricular surface was analysed using the method of Lovejoy et al. (1985) as described in Buikstra and Ubelaker (1994). Despite some damage, it was classed as a Stage 4–5, giving an age at death of 35–45 years (Bedford et al. 1989, Buikstra and Ubelaker 1994, Lovejoy et al. 1985, Ubelaker 1989). The costal face of the first rib was analysed using the method of Kunos et al. (1999), and was found to be consistent with this age range (Digangi et al. 2009, Kunos et al. 1999). Other skeletal and dental indicators are fully mature and corroborate the assessment of adult age. Full eruption and root tip completion of the right maxillary and mandibular third molars indicates an adult, matching at minimum the London Atlas standard of 19.5 years ±6 months, or 19–20+ years of age (AlQahtani 2009).

6.1.3.2. Sex

The mastoid process was scored at 1–2 after Buikstra and Ubelaker (1994), the supraorbital margins, glabella, and greater sciatic notch were all given scores of 2, and the mental eminence and nuchal region were given scores of 2–3, making them all relatively gracile characteristics suggestive of a probable female. Overall, given the consistent agreement of these sex-related characteristics, Individual 3 can be characterised as a probable female.

6.1.3.3. Pathology and Trauma

Individual 3 exhibits cribra orbitalia, the same condition as seen in Individual 1. This had a very similar presentation to that of Individual 1 described in section 6.1.1.3, with lytic porosity including scattered large and small foramina on the roofs of the orbits, exposing the diploë and forming a trabecular structure, and no associated blastic activity. These lesions were also characterised as medium in severity in this individual after Stuart-Macadam (1985), and exhibited smoothing of the edges of some foramina and reduction of others to pinpoints, indicating that the lesions were well healed and no longer active, and that the condition triggering them occurred long before death (Roberts and Manchester 2007, Walker et al. 2009). As with Individual 1, Individual 3 most likely suffered from megaloblastic or haemolytic anaemia in childhood (see below).

Figure 6.10. Cribra orbitalia in Individual 3. Photographs by Benjamin Sitzmann.

The dentition of Individual 3 was preserved well enough to allow scoring of dental wear. Dental wear is the result of mechanical attrition and abrasion of the teeth, and is a normal consequence of chewing and other activities over time (Roberts and Manchester 2007). A large body of anthropological research has been devoted to identifying and seriating stages of dental wear, showing that they are quite well correlated with age in adults, when controlling for population and diet (Brothwell 1981, Buikstra and Ubelaker 1994, Miles 1958, 2001; Murphy 1959a, b; Scott 1979, Smith 1984, Passos et al. 2013). Dietary factors that increase dental wear include greater consumption of tough foods such as uncooked root vegetables and meats, and consumption of stone-ground flour (where miniscule pieces of stone tend to remain in the ground product). Individuals may also exhibit greater or lesser dental wear due to trauma, and/or cultural practices using the teeth—both of which can be used to reconstruct habitual activity (Eshed et al. 2006, Lovejoy 1985, Passos et al. 2013, Roberts and Manchester 2007). In a typical person, less dental wear is expected in later-erupting teeth (i.e. the second and third molars in adults) while more dental wear is expected in earlier-erupting teeth near the front of the mouth, and normal chewing produces greater wear on the lingual parts of the upper molars and the labial/buccal parts of the lower molars. These typical patterns, however, can be affected by diet and cultural practices (Irish and Scott 2016). As shown in Figure 6.11, most of the dentition of Individual 3 could not be scored; the few scorable teeth exhibited light to moderate wear.

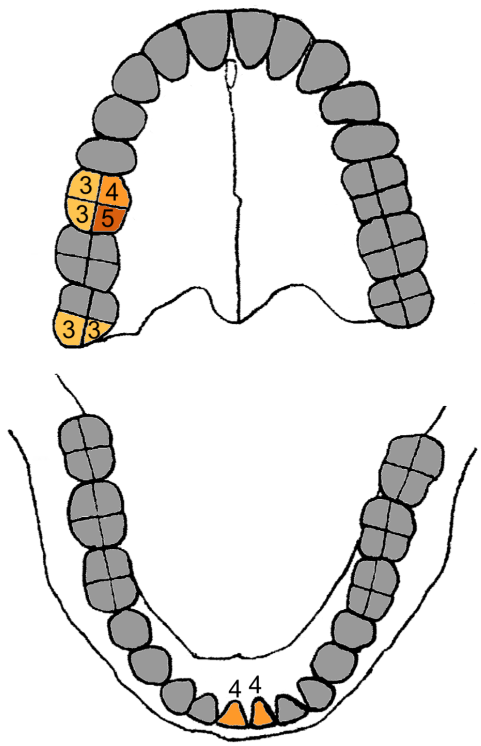

Figure 6.11. Dental wear scores for Individual 3. Parts of the dentition filled in grey were missing or unscorable. Diagram adapted from Buikstra and Ubelaker (1994) by Karl Berendt.

6.1.3.4. Musculoskeletal Stress Markers

Individual 3 exhibited slight lipping of the superior and inferior edges of several lumbar vertebrae, which formed incipient exostotic growth is some areas. Clear Schmorl's nodes are also seen in the lumbar spine, and were quite deep with ossified floors, somewhat irregular in shape but tending toward the horseshoe shape as described for Individual 2 in section 6.1.2.4.

Figure 6.12. A lumbar vertebra from Individual 3 exhibiting a Schmorl's node as well as slight lipping and incipient exostotic growth. Photographs by Benjamin Sitzmann.

This individual also exhibited several robust muscle markings. Well-developed trapezoid lines and costal tuberosities were seen on the clavicles, that were quite sharply defined with moderate rugosity, and the conoid tubercle of the right clavicle was large and projecting. The deltoid tuberosities, as well as the tuberosities of the pectoralis major, latissimus dorsi, and teres major, were highly robust, forming both ridges and furrows that significantly altered the original surface topography of the humeral shaft. The greater and lesser tubercles were large and angular, creating between them a deep and extensive intertubercular sulcus. The right bicipital tuberosity was moderately sized with both raised and excavated areas. Some bony proliferation was observed around the margin of both glenoid fossae, forming roughened but even rings that were set back (i.e. medially) 1–2 millimetres from the joint surface. The location and topography of these lesions suggests that they could relate to ossification of the glenoid labrum due to stress on the joint capsule (Crubézy et al. 2002, Pfahler et al. 2003, Prescher 2000). On both femora, the quadrate tubercles were large and rounded, and sharp, rugose, and extensive gluteal and pectineal lines were observed.

6.1.4. Individual 4

Individual 4 was uncovered in the summer of 2014. This skeleton was located some distance away from the others on Floor T2/14/F603 next to Wall T2/14/F602, in a location that may have been outside building T2/627, but nevertheless contemporaneous and exhibiting signs of fiery destruction. Individual 4 was better preserved than the others, with relatively intact bones, although the legs were missing below the knee (see Chapter 7). This individual was found in association with several precious items, as well as a production kit for grinding pigment (Koch and Richardson 2017).

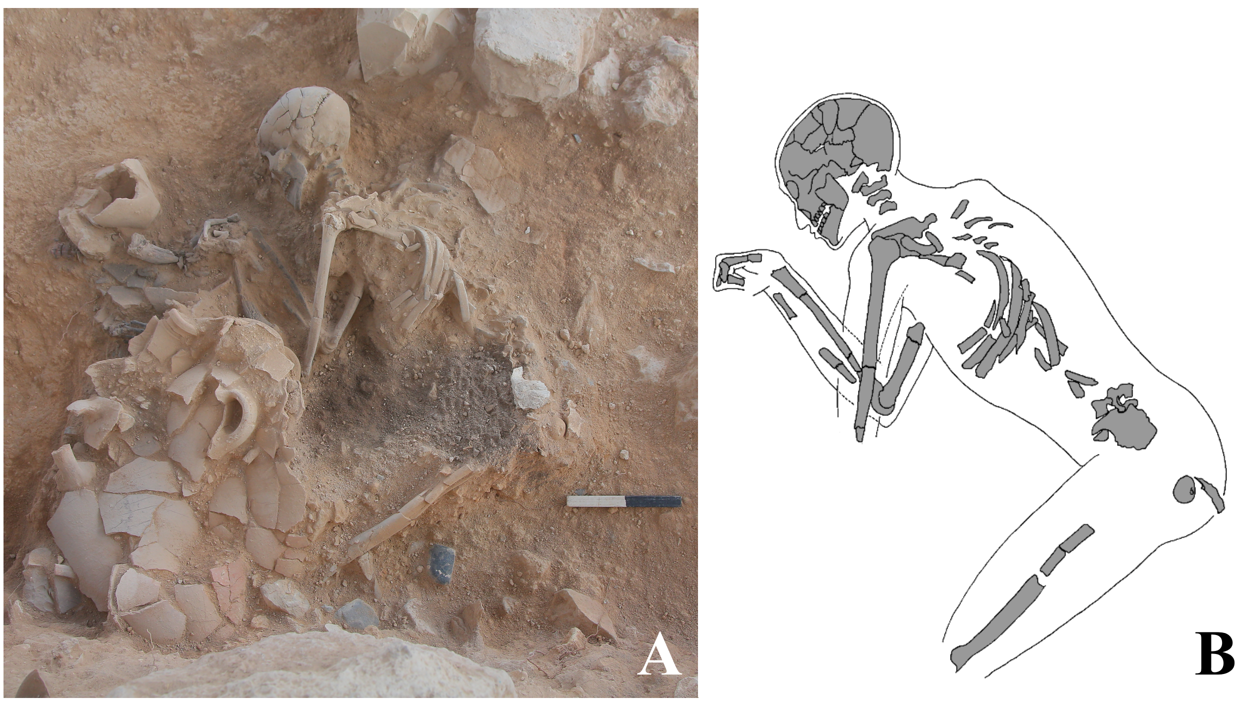

Figure 6.13. Remains of Individual 4. A) In situ photograph and B) positional diagram. Photograph by Oded Lipschits, diagram by Karl Berendt.

6.1.4.1. Age at Death

The dental and skeletal features of Individual 4 support an age estimate of 15–17 years at death. Skeletal maturity agrees with an age of at least 13 years, but less than 17 years. The left humeral head epiphysis was recently fused at the time of death, with a deep line of fusion still observable around its circumference, giving a minimum age of 13 years (Scheuer and Black 2008). The right humeral head epiphysis was not attached, but granularity on the diaphyseal fusion surface and the trabecular appearance of broken areas suggest that it was partially united at the time of death. Full union of the right radial head and left femoral head agrees with the minimum estimate. Lack of fusion of the left radial head gives a maximum age of 17 years at death, and lack of fusion of the right distal radial and ulnar epiphyses and the right humeral head closely corroborate this estimate (Scheuer and Black 2008). Lack of fusion of the S1 and S2 vertebrae, lack of union of the iliac crests, and incomplete union of vertebral endplate epiphyses throughout the spinal column are typical of this age range. Dental development provides a minimum age of 15 years. The maxillary third molars show incomplete root tip formation on both sides (Moorrees Stage Rc on the left and Moorrees Stage A ½ on the right (AlQahtani 2009)), a combination of observations that suggests an age of 15 to 20 years at death (Liversidge and Marsden 2010).

6.1.4.2. Sex

Although Individual 4 was quite young, the slightly older age at death and better skeletal preservation compared to Individual 1 make a cautious sex estimation possible. This skeleton's features were noted as highly gracile overall, with extremely long and slender humeri, radii and ulnae, metacarpals, phalanges, and femora (see Figure 6.13 as well as metric data in Appendix 1). The orbital margins and the mastoid process were both given scores of 1 and the nuchal region was given a score of 1.5, all indicating a probable female. The mental eminence was given a score of 3, indeterminate. The greater sciatic notch was partial, but wide (approximate score of 2), also suggesting a female (Buikstra and Ubelaker 1994). Given the good agreement of all of these observations, this individual was most likely female.

6.1.4.3. Pathology and Trauma

Like Individual 3 above, the dentition of Individual 4 was well enough preserved to record dental wear (Figure 6.14). Overall light to moderate dental wear, plus small carious lesions scattered throughout the molar fissures, is consistent with a starchy and reasonably abrasive agricultural diet (Eshed et al. 2006, Forshaw 2014, Gamza and Irish 2012). However, in this individual some unusual patterns of wear were observed. The left maxillary lateral incisor (22) exhibited highly oblique wear on the lingual aspect of the tooth rather than the expected location on the occlusal edge. In the lower arcade, the left mandibular lateral incisor (31) exhibited hardly any wear at all, inconsistent with the moderate wear exhibited by the central incisor (32). The combination of these observations suggests anterior malocclusion. Left-right asymmetry in wear between the right (17) and left (27) upper second molars, with increased wear on the lingual cusps of the 17, may be related to this phenomenon, although this could not be conclusively assessed without a complete dentition. This malocclusion may be the result of the antemortem loss of the right mandibular central (41) and lateral (42) incisors, clearly lost long before death as evidenced by complete healing of the alveolar ridge, producing a smooth, rounded, slightly depressed gap where the tooth used to be. No clear cause for the loss is seen in the remaining teeth or surrounding bone. However, trauma is a reasonable suggestion, as the generally light to moderate tooth wear and lack of periodontitis, severe caries, or abscessing elsewhere in the mouth argue against tooth loss due to dental disease, and teeth at the front of the mouth are the most vulnerable to accidental injury. Some kind of activity-related use of the teeth is not ruled out, but would require further corroborating evidence (see discussion in section 6.2.3). It must also be remarked that the loss of these teeth, combined with the malocclusion, could have changed her appearance and made it difficult for her to eat, affecting her quality of life.

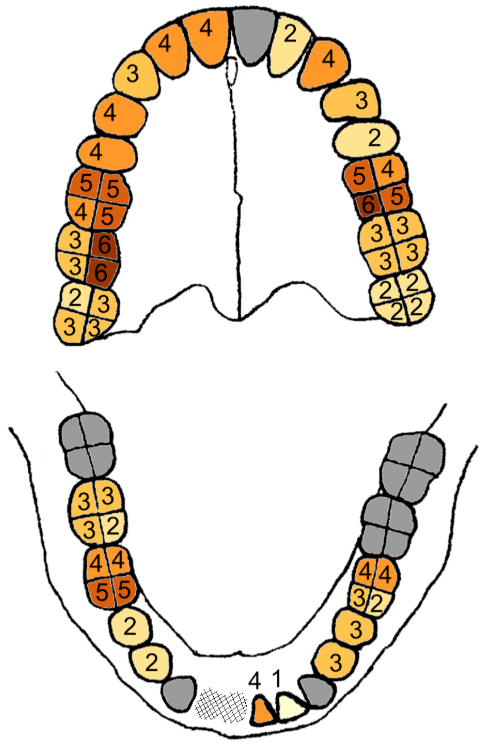

Figure 6.14. Dental wear scores for Individual 4. Parts of the dentition filled in grey were missing or unscorable. Note the cross-hatched area indicating antemortem tooth loss and remodelling of the alveoli. Diagram adapted from Buikstra and Ubelaker (1994) by Karl Berendt.

6.1.4.4. Musculoskeletal Stress Markers

Individual 4 exhibits a strong, rugose costal tuberosity and large conoid tubercle on the right clavicle. The greater and lesser tubercles of the humeral head were damaged but appear to have been quite large, forming between them a deep intertubercular sulcus. The tuberosities for the pectoralis major, latissimus dorsi, and teres major on the left humeral shaft were pronounced and formed ridges and furrows that altered the surface topography of the bone. The bicipital tuberosities were very large and expanded in both anterior/palmar and mediolateral directions, also associated with bulbous regions of bone as seen in Individual 2. The right side particularly projected several millimetres in the anterior/palmar direction and was both raised and excavated, forming two distinct proximodistal ridges with a deep furrow between. The gluteal and pectineal lines on the femur were sharp and rugose. Slight wedge fracturing was observed in the bodies of individual lower thoracic and lumbar vertebrae. Clear Schmorl's nodes were noted in the superior and inferior surfaces of several vertebral bodies; these were very wide and deep, often forming horseshoe shapes echoing the shape of the vertebral body. The margins of the vertebral bodies were too damaged to accurately assess, and the vertebral body epiphyses were not united.

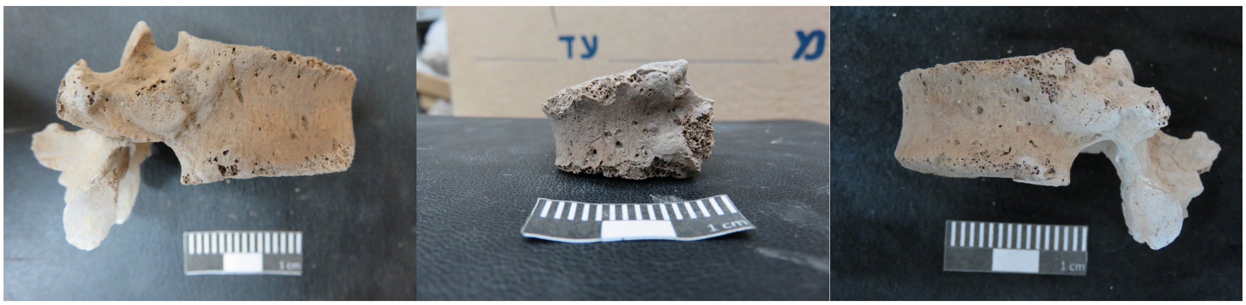

Figure 6.15. Wedge-shaped vertebral bodies in the skeleton of Individual 4. Left: T12, centre: L1, right: L5. Photographs by Karl Berendt.

Figure 6.16. Schmorl's node in the L5 vertebra of Individual 4. Photograph by Karl Berendt.

6.1.4.5. Other Observations

Similar to Individual 1, Individual 4 exhibits a possible bipartite occipital condyle. In this individual, the partition of the condyle was far less apparent from the joint surface, although it was observed clearly in the articulating surface of the atlas (Figure 6.17).

Figure 6.17. Possible bipartite occipital condyle in Individual 4. Note the matching joint surface on the atlas. Photograph by Karl Berendt.

	Individual 1	Individual 2	Individual 3	Individual 4
Age	15–16 years	19–25 years	35–45 years	15–17 years
Sex	Indeterminate	Male	Female	Female
Pathology	Cribra orbitalia	Tibial periostitis	Cribra orbitalia	None
MSMs	Generally slight, flexor pollicis longus	Generally robust, load-bearing	Habitual use of the arms and shoulders, load-bearing	Habitual use of the arms and shoulders, load-bearing
Context	Several precious objects	No associated artefacts	No associated artefacts	Several precious objects, production kit

Table 6.1. Summary of principal osteological findings and context.

6.2. Activity Reconstruction

With the exception of Individual 1, it has been demonstrated above that the individuals recovered at this site show well-developed entheseal changes at multiple locations. As reviewed in Chapter 4, there are currently debates over how well entheseal changes reflect individual activity patterns. However, traditional approaches to osteobiography would infer from these signs that these three individuals were quite physically active in general. Large insertions for the gluteus maximus, gluteus minimus, and/or pectineus were observed in Individuals 2, 3, and 4. Attachments for the quadriceps femoris, gastrocnemius and soleus, and the thigh adductors were quite pronounced in Individual 2. These muscles are used generally in activities such as running, jumping, and climbing, so the development of these muscle attachments would agree with an active lifestyle involving strenuous use of the legs on a regular basis (Buikstra and Pearson 2017, Niinimäki and Baiges Sotos 2013). Individual 2 in particular exhibited generally strong muscle markings all over the body in addition to osteochondritis dissecans in the right knee joint and dorsal spurring of the right calcaneal tuberosity, both of which may be associated with strenuous physical activity involving the legs (Lewis 2016, Vikatou et al. 2017, Weiss 2012).

It is generally agreed that life in the ancient world for most people involved a greater degree of physical activity than is seen today. People walked longer distances and manually performed many tasks that are no longer necessary in most industrialised societies today (Applebaum 1992, Niinimäki et al. 2013, Scheidel 1995, 1996). Therefore, these findings are in keeping with ordinary inhabitants of the Near East during the Late Bronze Age (e.g. Boutin 2008, Green 2013, McKenzie 1999, Molleson and Hodgson 2000). However, it is important to note that not all strenuous physical activity can be attributed to labour, which is a culturally defined concept. For instance, in modern Western societies, strenuous physical activity might be undertaken for the purpose of leisure (sports activities) or body modification (weight training). Furthermore, it is difficult to connect the construct of 'labour' to social status without an intimate knowledge of the culture under consideration (Hendon 1996, Robb et al. 2001). Thus, suggestions of strenuous physical activity do not necessarily translate into arguments for low social status in the individuals described here.

6.2.1. Grinding

In addition to their general physical activity, Individuals 3 and 4 both exhibited muscle markings and entheseal changes that may be linked to specific physical motions performed on a regular basis over a long period of time. These include large bicipital tuberosities, as well as robust attachments of the rotator cuff muscles on the humeral head and robust trapezoid lines, conoid tubercles, and costal tuberosities on the inferior and lateral clavicle that could reflect stress on the ligaments that stabilise the shoulder joint. In addition, Individual 3 exhibited highly robust deltoid tuberosities as well as reactive bone formation around the margin of the glenoid fossa on both sides. The tuberosities of the pectoralis major, latissimus dorsi, and teres major on the shaft of the left humerus were also very robust (the right humerus could not be assessed). Individual 4 also exhibited robust tuberosities of the pectoralis major, latissimus dorsi, and teres major on the shaft of the left humerus, while the right side did not preserve. This pattern of musculoskeletal stress markers is consistent with habitual flexion, extension, and perhaps abduction and rotation of the arm, combined with flexion and supination of the forearm. In other words, these two individuals were manipulating their environment in some way that meant they had to push and pull with force in front of their bodies and perhaps to the side (Ibáñez-Gimeno 2015, Ibáñez-Gimeno et al. 2013, Marchi et al. 2006, Palmer et al. 2016, Villotte et al. 2010).

This pattern of musculoskeletal stress markers has been used in several archaeological studies to infer habitual motion associated with the use of a grinding stone and saddle quern to process grain or other products (Eshed et al. 2004, Molleson 2007, Munson Chapman 1997, Perry 2004, Wesp 2015). Furthermore, it has been reported that processing of grain in this method can result in wedge fracturing of the 12th thoracic vertebra (Molleson 2007), which was observed in Individual 4. Ultimately, it is clear that grinding was performed by somebody at this site, given the presence of a prominent and well-used grinding installation in the room from which these skeletons were recovered (see Chapter 3). Based on this evidence, I believe that it is reasonable to argue that Individuals 3 and 4 were engaged in this task, which might have been necessary for many hours a day on a daily basis. However, other activities involving strenuous use of the arm and shoulder in a similar way cannot be ruled out. In any case, it should also be noted that the musculoskeletal stress markers mentioned above were more clearly and extensively seen in Individual 3 compared to Individual 4. Possibly, Individual 3 performed this activity more frequently or more extensively than Individual 4, however this effect could simply be due to the older age of Individual 3 (Milella et al. 2012, Villotte and Knüsel 2013).

6.2.2. Carrying

As described above, Individuals 2, 3, and 4 all exhibit changes in their spines consistent with lifting and carrying of heavy loads. The aetiology of these lesions is described in Chapter 4. While Schmorl's nodes may have some genetic connection, and compression and marginal changes to the vertebral bodies can occur for other reasons, this pattern of lesions is widely accepted to be related to spinal compression during heavy lifting and carrying (Faccia and Williams 2008, Mattei and Rehman 2014, Plomp et al. 2012, Üstündağ 2009, Williams et al. 2007). The skeletons were further examined for signs of different types of load-bearing. Individuals who bear loads on the head tend to exhibit hypertrophy of the uncinate processes and degeneration of the articular facets of the cervical vertebrae (Lovell 1994, 2014b; Molleson 2007, Molleson and Hodgson 2000). None of these features were clearly seen in these individuals, and the cervical vertebrae in general did not preserve well enough to assess this with any certainty. Carrying of loads on the back and shoulder(s) is suggested by Munson Chapman (1997) and Molleson (2007) to be result in expanded attachments for the trapezoid and costoclavicular ligaments, while Sofaer Derevenski (2000) details expansion of the sacroiliac joint as one classic sign of carrying heavy loads on the back. While Individuals 3 and 4 do exhibit expanded attachments for the trapezoid and costoclavicular ligaments, these are more parsimoniously related to the grinding activity described in section 6.2.1, and none of the individuals exhibited expansion of the sacroiliac joint. The only likely sign of a specific method of carrying was the large bicipital tuberosities seen in Individuals 2, 3, and 4, which is consistent with carrying loads in front of them with their forearms flexed (Havelkovà et al. 2011). The nearby presence of the large (about 65 cm tall) and very heavy Canaanite storage jars found in the building is interesting because it links the signs of activity in these individuals to a specific potential stress. Historical evidence from artistic depictions (Figure 6.18), literary works, and even historical linguistics indicates that two people could transport these two- or four-handled vessels by supporting them from both sides with bent arms (Grace 1979, Killebrew 2007; see Chapter 2).

This figure was removed because of copyright restrictions. It depicted two women carrying an amphora. Original source:

Grace, V. (1979). Amphoras and the ancient wine trade. Athens: American School of Classical Studies.

Figure 6.18. Two women carrying an amphora depicted on a Greek coin from ca. 500 BCE. Reproduced from Grace (1979).

6.2.3. Spinning and Weaving

One additional possibility for activity reconstruction was considered. Based on the presence of several spindle whorls in Building T2/F627, it has been suggested that the northern room of the ground floor may have been used for spinning activity (Metzer 2015; see Chapter 3). Less investigation into the reconstruction of spinning activity is found in the literature compared to grinding and carrying, however those studies that do mention spinning usually discuss it together with weaving, and stipulate formation of mediolateral grooves in the anterior dentition, remodelling of the mandible to form a "rocker jaw" with strong masseter and pterygoid insertions, as well as enthesopathies and degenerative changes to the forearm and hand (Eshed et al. 2004, Lovell 2014b, Molleson 2007, Molleson and Hodgson 2000, Perry 2004, Wesp 2015). While individuals 2 and 4 did exhibit strong masseteric and pterygoid insertions, these changes do not fit the documented patterns of alteration suggested to reflect spinning, and the preserved anterior dentitions do not exhibit grooving as documented in the literature for some individuals who may have been spinning (Molleson 2007). It is tempting to suggest that the unusual dental wear and trauma seen in Individual 4 could reflect use of the teeth as a "third hand" in spinning/weaving or another activity, but this is speculation only. Individual 1 does exhibit an enthesopathy of the distal pollical phalanx, as detailed in section 6.1.1.4. This is quite clearly a sign of habitual flexion of the thumb (Cashmore and Zakrzewski 2013, Rack and Ross 1984), which would match the expected motion of the thumb during spinning (Perry 2004, Wesp 2015). This is not enough on its own to reconstruct spinning activity, but it can be said that the relative gracility of this individual, combined with this lesion, suggests that this individual may have performed some activity at the site that involved less strenuous use of the whole body, and more delicate activity with the hands, for which spinning is one possible candidate. Overall, spinning activity cannot be conclusively reconstructed from the evidence, although it remains a possibility. Another possibility is hand-grinding using a pigment production kit such as that found with Individual 4 (see Chapter 3). This illustrates the importance of having a larger population for comparison and a reasonable level of cultural context and clinical comparison, which has become the standard for activity reconstruction studies in recent years.

6.2.4. Conclusion

It is shown above that the inhabitants of this household, with the exception of Individual 1, were involved with strenuous physical activity that could be characterised as labour. While Individual 2 showed a more even pattern of relatively robust muscle markings, indicating that he was overall quite physically active and probably involved in lifting and carrying, entheseal markers in Individuals 3 and 4 can be cautiously linked with certain activities. Subjectively speaking, these were more clearly and extensively seen in Individual 3, possibly owing to her older age. Historical and archaeological sources tell us that grinding was a dominant activity in almost all subelite households in the ancient Near East, and would have been performed by women in the household (Ebeling and Rowan 2004, Meyers 2002, Molleson 2007, Peterson 2000, Yasur-Landau et al. 2011). The fact that a prominent and well-used grinding installation is found at this site (Chapter 3) supports the reconstruction of grinding activity in these two individuals. Furthermore, the dozens of large storage jars found at this site would have been quite heavy, and would require strenuous effort to lift and transport (Metzer 2015), offering an explanation for the signs of heavy lifting. All things considered, it is not unreasonable to presume that Individuals 3 and 4 performed labour such as grinding in this household, and that they along with Individual 2 would carry storage jars and other heavy objects around the site. For Individual 1, few musculoskeletal stress markers were observed in general. It is not possible to determine whether this is due to poor preservation and extensive fragmentation of the skeleton obscuring MSMs, this individual's relative youth which did not allow time for MSMs to form, or simply that this individual was not significantly physically active. The evidence for degenerative arthritis in the pollex of this individual may suggest that this individual was accustomed to more delicate work with the hands.

6.3. Health and Diet

Individuals 1, 2, and 3 exhibited signs that they suffered from periods of illness or poor nutrition severe enough to leave markings on their bones. In Individuals 1 and 3, the cribra orbitalia that was observed is a condition that is usually linked to megaloblastic or haemolytic anaemia, and can only form during childhood (Walker et al. 2009; see Chapter 4). It is particularly interesting to note that, since these two individuals were of different ages (15–16 and 35–45), their separate childhood periods in which these lesions would have formed would have been several years or even decades apart, an observation which is interpreted below.

Individual 2 exhibits tibial periostitis, an inflammation of the periosteum that is most often linked to generalised physiological stress, such as might be caused by a systemic illness, malnutrition, parasite, or severe infection (Gladykowska-Rzeczycka 1998, Klaus 2014, Weston 2008). As mentioned in section 6.1.2.3, evidence of healing shows that this lesion was not active at the time of death and was resolved sometime before death—but not more than a few years before (Roberts and Manchester 2007). In other words, this individual likely suffered this episode of stress sometime in his late teenage years or early twenties. Notably, this lends evidence to indicate that the stress suffered by these three individuals was not limited to childhood; for this individual at least, stressful conditions of poor nutrition or disease continued into adulthood. This lends further evidence to suggest that these conditions were continuous over a long period of time in this population, rather than limited to a single event. No signs of poor nutrition or disease were observed in Individual 4, but this could have many explanations. Although the skeleton of Individual 4 was generally in better condition than the others, poor preservation might have obliterated any lesions initially present. Even if there were truly no signs of stress to be seen in this skeleton, it does not necessarily indicate that this individual experienced no stress during life, as not all stressed individuals will exhibit these markers (DeWitte and Stojanowski 2015, Wood et al. 1992).

It can be concluded that some level of long-term stress affected three out of four individuals analysed here, though it cannot be said whether malnutrition, disease, or a combination of the two was of primary concern. Both malnutrition and disease were not uncommon in the ancient world, and in the stressful conditions of the LBA–Iron Age transition in the Southern Levant, this is not a surprising find. It is shown above that episodes of stress occurred in these individuals at different times: in two childhood periods many years apart, and in one adulthood period. This suggests both that stressful conditions were present at this site over a long period of time, and affected individuals at all stages of life. These observations may reflect a long period of poor nutrition and/or disease at Azekah that lasted until close to the time of the city's destruction. However, this observation cannot be confirmed without an understanding of normal levels of stress at Azekah during other periods, which would be provided if more general research on skeletal remains from the site ever became possible.

6.4. Conclusions

Four individuals are observed in this analysis: a teenager of indeterminate sex (Individual 1), a young adult male (Individual 2), an adult female in her late 30s or early 40s (Individual 3), and a teenage female (Individual 4). Given their recovery from the same structure, it is possible to speculate that they could have been family members. The bipartite occipital condyles shared by two of these individuals may be a genetic trait which could suggest familial relation, but this is not conclusive, as this is not an uncommon anatomical variant. This does not preclude the possibility, however, that they were part of the same household—an entity which can include many types of non-genetic relationships (see Chapter 4). It has been suggested to me multiple times during the course of this analysis that, based on the presence of precious artefacts in association with some, but not all, individuals, we may be able to observe differences in social status. However, while it can be said that the presence of these artefacts reflects the wealth of the site and likely also of this particular building (Metzer 2015), it cannot necessarily be interpreted that these objects belonged to the individuals who were carrying them. Furthermore, indicators of disease and musculoskeletal stress seem to indicate that these individuals experienced these stressors more or less uniformly between them. Therefore, at least from the biological perspective, social status differences are not observed between these individuals.

The four individuals found in Building T2/627 experienced lives full of biological stress, hard work, and in the end, trauma. As children, at least two of them experienced disease and/or nutritional stress resulting in severe anaemia. Stressful conditions were also seen in the late teenage years or early twenties for one individual. All appeared to have worked during their lives, with two individuals performing hard work that might have included grinding grain, and another individual possibly performing more delicate work such as spinning. Despite these adverse conditions, this building and the larger city exhibit signs of considerable wealth in architecture, pottery, and other precious items during the Late Bronze Age (Koch and Richardson 2017, Metzer 2015; see Chapter 3). This contrast could be explained in many ways. Possibly, a sudden period (perhaps a few decades) of hard times fell on this wealthy site in the years leading up to the disaster, creating stressful conditions of malnutrition and/or disease during the lifetimes of these individuals. This could also be what led to the possible "crisis architecture" modification of the Patrician House-style Building T2/627 to transform it into a production facility (Metzer 2015; see Chapter 3), where these individuals performed daily hard work. However, it must also be considered that even at the wealthiest sites in the ancient world, individuals in poor health who worked hard could be found—whether these were lower-class workers, or the elites themselves. I eagerly anticipate whether future work at this or another site will be able to compare indicators of health, nutrition, and physical activity across the LBA–Iron Age transition to allow this question to be answered using population-level comparative data.

Chapter 7 Four Individuals from Azekah: Their Deaths

At the end of the Late Bronze Age, the city of Azekah was destroyed in an event of unknown cause. All across the site, traces of fiery destruction are found from this time that point to a sudden, large-scale event that left the city in ruins and led to its abandonment. It also resulted in the collapse and burning of Building T2/627, trapping inside four individuals (Lipschits et al. 2017, Metzer 2015; see Chapter 3). At the time of the destruction, these individuals worked and possibly lived here:

- Individual 1 was a slight teenager of indeterminate sex who was anaemic as a child, may have worked delicately with the hands, and died with a rich array of jewellery.
- Individual 2 was a strongly built young man who probably lifted and carried heavy objects, potentially including storage jars such as those found in the building, on a habitual basis. He suffered from a serious illness in his late teens or early 20s.
- Individual 3 was a woman in her late 30s or early 40s who also habitually lifted and carried heavy objects such as the jars, and may have ground grain for hours every day on a quern similar to that found in the building. She likely suffered from anaemia in her childhood.
- Individual 4 was a teenage girl who also probably spent large amounts of time grinding grain. She had a permanent front tooth knocked out at some point, causing malocclusion of some other anterior teeth that may have changed her appearance and made eating more difficult. She also died holding expensive objects, as well as a kit for grinding pigment[6].

[6] Note that the descriptions given here contain a certain degree of interpretation. See Chapter 6 for a full discussion of the caveats underlying each of these descriptions.

These people were killed in this event, and their bodies were buried and sealed under a layer of burnt rubble (S. Kleiman, pers. comm). Between the 2012 and 2014 excavation seasons of the Lautenschläger Azekah Expedition, the remains of these individuals were rediscovered after over 3000 years in the ruins of Building T2/627. Osteological analysis was conducted on these skeletons between 2016 and 2018. It is impossible at this point to determine the cause of this destruction. However, clues in the bones of these individuals allow us to investigate the circumstances of their deaths, and what happened in the aftermath of the destruction. The following discussion takes a perspective borrowed from fire scene analysis in modern forensic anthropology, as discussed in Chapter 4, and justifications for the arguments below can be found in that chapter. Here, I pick up where the previous chapter left off, and describe how these ancient inhabitants of the city of Azekah met their end, and what happened afterward.

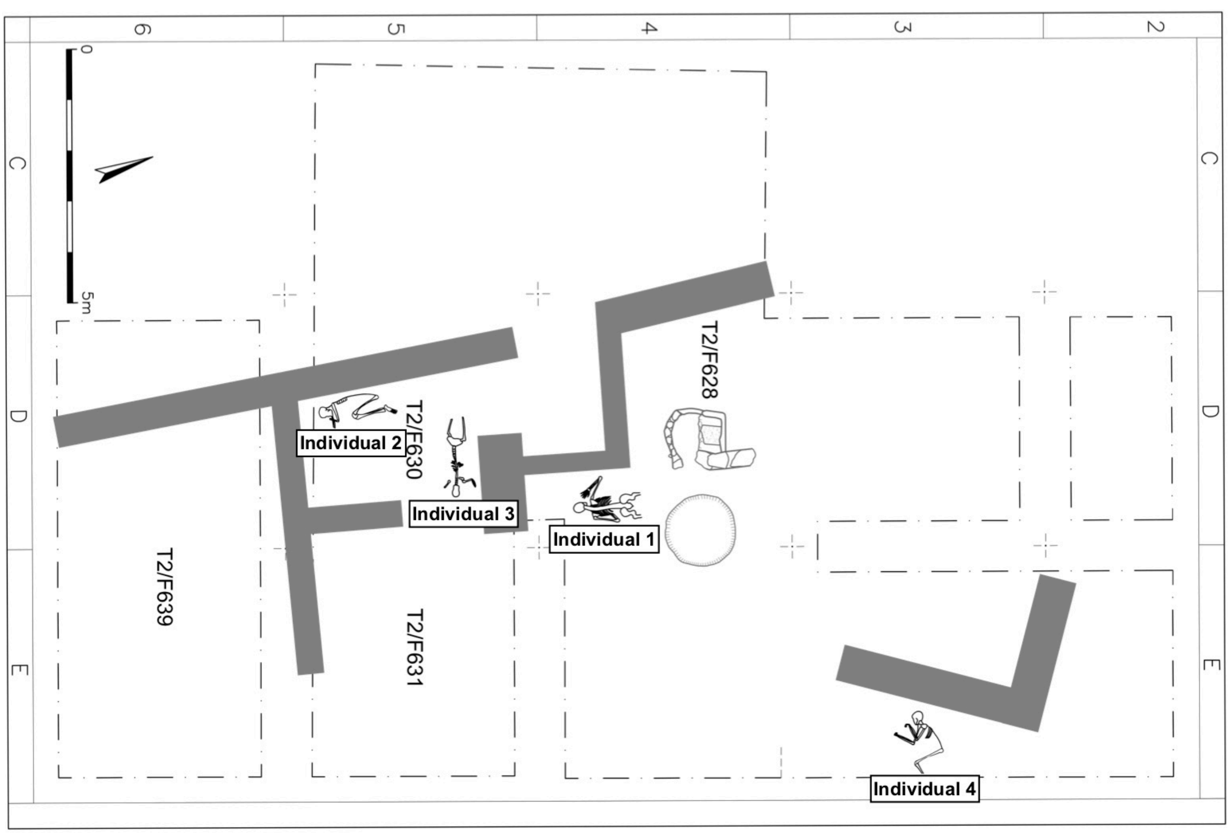

Figure 7.1. The four destruction layer victims of Building T2/627. Courtesy of S. Kleiman, Lautenschläger Azekah Expedition.

7.1. Fractures and Body Positioning

As soon as they were discovered, it was noted that the skeletons of all four individuals were highly fragmented. They exhibited a mixture of perimortem blunt-force trauma, heat-induced fracturing, and taphonomic fracturing, each of which were analysed and distinguished according to the methods in Chapter 4. The perimortem fracturing affected all parts of the body more or less equally in Individuals 1, 2, and 3, showing that it likely occurred simultaneously over the whole body as part of the building collapse. Individuals 1, 2, and 3 also exhibited flattening of the skull and thorax, and in at least one case (Individual 3) it appears that pottery sherds entered the thoracic region as the body was pressed down on top of them. These events clearly resulted from enormous pressure on the body, most of which was ostensibly due to the collapse, although a certain amount of pressure may logically be attributed to subsequent activity on top of the rubble and more than three thousand years of soil pressure. Heat fracturing was even over the whole body (see analysis below), and the taphonomic fracturing affected all bones more or less equally.

7.1.1. Individual 1

Individual 1 was buried under debris that had apparently fallen from a height, which resulted in the position of the skeleton directly beneath three complete ceramic vessels (Metzer 2015; see Chapter 6). A handle of one jar was found embedded in the remains of the skull, which certainly would have been fatal in itself regardless of what other injuries were sustained at the time. The skeleton was positioned face down, with the right arm tightly flexed at the elbow joint and adducted at the shoulder, its hand next to and pointed slightly away from the skull. The left arm was in a tightly flexed position directly beneath the torso of the skeleton. This positioning suggests that Individual 1 was in a crawling position at the time of death, collapsed due to smoke and fume inhalation, or was knocked to the ground by these falling jars and other debris.

7.1.2. Individual 2

Individual 2 was covered in melted and burnt mud brick, and a large rock was found in the region of the skull, presumably the cause of the skull's extensive fragmentation. The skeleton was in a tightly flexed position on its right side, with the spine curved forward, and both arms tightly flexed. The right femur was flexed about 90° at the hip, with the tibia tightly flexed at the knee and the foot plantarflexed. As discussed in section 7.3, the left leg was not recovered. It was considered that this positioning might represent pugilistic posture. However, the forward curvature of the spine contradicts the classic backward arch of pugilistic posture, and the right arm is not in the expected position, assuming instead a posture suggesting Individual 2 was using it as a head rest (Fojas et al. 2015, Pope 2007, Symes et al. 2015; P. Mayne Correia pers. comm.). After careful analysis of the skeleton, it appears more likely that the positioning of the skeleton represents a self-protective foetal position that was assumed by Individual 2 shortly before death, an unusual finding in fire settings that may suggest that this individual was killed by the collapse rather than the fire. The proximity of this individual, along with Individual 3, to a doorway is a classic finding in fire investigation. It can only be speculated why Individuals 2 and 3 were not able to escape in such close proximity to an exit. One possibility is that Individual 2 reached the doorway to find it blocked by collapse or fire, and with no other escape attempted to seek shelter next to the wall. In fact, the charred remains of a wooden beam were found on the floor near this doorway (see Chapter 3). Alternatively, the individual may have been following the wall in an attempt to locate a doorway, due to the reduced visibility in the smoky atmosphere. The foetal position may have been adopted as a reaction to the imminent collapse of the ceiling, as is clearly seen in Individual 3 below.

7.1.3. Individual 3

Individual 3 was uncovered near the remains of Individual 2. The remains were buried in a collapse of architectural stones and fragments of mud brick, resulting in a high degree of fragmentation in the skeleton. The skeleton was found in supine position, with both legs apparently extended and both arms abducted. The legs were absent from a point slightly above the knee. The left humerus was preserved in a flexed position, projecting almost directly upward (Figure 7.2), and fragments of radius, ulna, carpals, metacarpals, and phalanges were found scattered in the region of the cranium. This suggests that Individual 3's hands were positioned protectively above the face at the time of death. In addition, breakage patterns and positioning of the bones of the forearms suggest that they were fractured and deformed by a sudden, longitudinal impact while the soft tissues were still in place. In the right arm, the radius and ulna were fractured together into three main segments, each time remaining in their parallel position, indicating that they were still connected by soft tissues. These three segments sit at opposing angles, suggesting a longitudinal impact on an outstretched arm that broke the bones together in several places and severely deformed the forearm (Figure 7.2). The left radius and ulna were also recovered in several fragments. Most of these were so small that identification was impossible, but the distal radius and ulna were positioned very close to the proximal humerus, in an orientation that suggested that the left forearm was bent at an extremely acute angle relative to the humerus, possibly by the same process that deformed the right arm (Figure 7.2). These deformations are consistent with the apparent cause of death.

Figure 7.2. Fragmentation pattern of the arms of Individual 3. A) Right arm, and B) left arm. Scapulae in yellow, humeri in red, radii in blue, ulnae in orange, and carpals, metacarpals, and phalanges in green. Photographs by Karl Berendt.

The posture of Individual 3, with arms raised vertically above the face, suggests a response to a sudden impact from above, such as from a collapsing ceiling. This individual could have been knocked to the ground by the collapse, however the defensive posture described above suggests that they were already on the ground (like Individual 2) when the collapse occurred. The proximity to the wall suggests either an attempt to seek shelter, or perhaps an unsuccessful attempt to follow the wall to find a doorway in the smoky, low-visibility environment. Like Individual 2, this individual may have been unable to access the nearby doorway because of thick smoke or fallen building debris.

7.1.4. Individual 4

Individual 4 was uncovered in the summer of 2014. This skeleton was located some distance away from the others, was less severely burnt than the others, and exhibited less crushing and better overall preservation. The skeleton was positioned on its left side, in a loosely flexed, semi-prone position, with both femora flexed around 90° relative to the trunk. Both arms were acutely flexed at the elbow joint and parallel, with the metacarpals and phalanges clearly wrapped around a bone object held close to the body. The proximity to a wall suggests an attempt at shelter. The positioning of this skeleton likely does not indicate pugilistic posture, due to the lack of flexion (<90° angle) of the knees, and lack of posterior curvature of the spine. Instead, this position is reminiscent of self-protection similar to the foetal position of Individual 2. Alternatively, Individual 4 could simply have lost consciousness and collapsed in this position before being killed by smoke inhalation and/or fire. Unlike the other three individuals in this analysis, Individual 4 was not clearly killed by the collapse of the building.

7.2. Heat Alteration

In addition to being crushed by the collapse of the building, it appears that the bodies of these four individuals were quite thoroughly burnt. Heat alteration was analysed according to the methods discussed in Chapter 4, and the logic and data supporting the following discussion are discussed at length in that chapter. The evidence for heat alteration discussed here was presented to a forensic anthropologist and expert in heat alteration, Pamela Mayne Correia of the University of Alberta, who corroborated the conclusions below, and guided some of the finer points of the analysis.

7.2.1 Individual 1

The remains of Individual 1 were highly discoloured, lightweight, and calcined. The bones and teeth exhibited patina fracturing and longitudinal splitting consistent with heat alteration, but remained relatively intact. Most bones and teeth were a uniform light grey or blue-grey, suggesting Stage IV-V burning after Shipman et al. (1984). This corresponds to a temperature in the range of 645–940+°C, most likely in the upper end of this range given the complete absence of brown or red colouration in the bones. This temperature corresponds well with reported average temperatures for house fires without accelerants, but might be in the upper end of this range (see section 7.2.5 and section 4.4.4 in Chapter 4). In the dentition, the enamel of most teeth was shiny and blackened, with a slight bubbly appearance in some teeth, and roots were a neutral grey or white. Most teeth were highly fragmented, with crowns missing and root tips eroded, another indicator of advanced heat exposure. The teeth were individually scored for heat stages after the methods of Beach et al. (2015) and Shipman et al. (1984). All teeth fell between Stage III and Stage V, with most exhibiting features on the boundary of Stages IV and V, suggesting a high temperature of around 940°C (Shipman et al. 1984). This corresponds neatly with the heat alteration seen in the bones, and overall indicates a high degree of heat alteration. However, surprisingly little heat fracturing is seen for this temperature range, something which may indicate that this burning occurred slowly, and/or while the skeleton was protected and held in place by rubble (see section 7.2.5).

7.2.2. Individual 2

The remains of Individual 2 exhibit a lower overall degree of heat alteration and greater variation in colour than Individual 1, only a few metres away in an adjacent room. They are generally a light beige, with dark brown and reddish areas, and scattered black charring. Heat-related fracturing is relatively slight, and only a few areas exhibit calcination. The cumulative appearance of the bones suggests Stage III–IV burning after Shipman et al. (1984), corresponding to a temperature in the vicinity of 645°C. The dentition exhibits Stage IV burning, with blackened roots and separated crowns, giving a temperature of 645-940°C (Beach et al. 2015, Shipman et al. 1984). Individual 2 exhibits slightly lower heat alteration than Individuals 1 and 3, although still comfortably within the temperature range attributable to house fires. This discrepancy in heat alteration levels might be explained by local differences in the temperature of the fire, and the fact that Individual 2 was tightly encased in a layer of mud-brick, which may have mitigated heat alteration (Bennett 1999, Ullinger and Sheridan 2015).

7.2.3. Individual 3

The remains of Individual 3 were very similar in condition to those of Individual 1. The bones were highly calcined overall, with many elements exhibiting delamination and patina and thumbnail fracturing consistent with heat alteration, although many bones were largely intact. Bones exhibited neutral white or light blue-grey discolouration, suggesting Stage IV–V burning after Shipman et al. (1984), or around 940°C. The dentition exhibited blackened enamel, crown separation, and an overall high degree of fragmentation. Heat alteration scores of individual teeth fell between Stage III and Stage V, with most centring around Stage IV, or 645-940°C (Beach et al. 2015, Shipman et al. 1984). As in Individual 1, this evidence agrees well with reported average temperatures for house fires, but there is surprisingly little heat fracturing for the observed degree of colour change.

7.2.4. Individual 4

In Individual 4, while a few elements exhibited signs of a higher degree of heat alteration including patina fracturing, most bones and teeth were yellow or reddish-yellow, indicating Stage II burning after Shipman et al. (1984), in the range of 285–525°C. This temperature corresponds to a smaller/cooler fire, or a larger/hotter fire some distance away (Asmussen 2009, Bennett 1999, Mayne 1990, Shipman et al. 1984, Ubelaker 2009). Dental heat alteration also ranged from Stage II to Stage III (525–645°C), corroborating this assessment. This lesser degree of heat alteration could be related to Individual 4's relative distance from the apparent centre of the fire, and possible location outside the building or in an adjacent building (see Figure 7.1 and Chapter 3).

7.2.5. Temperature and Duration of the Fire

Some of the fire temperatures inferred from the remains in this analysis are relatively high. As discussed in Chapter 4, modern house fires may reach temperatures as high as 940°C without the use of accelerants, but this is the upper end of their typical temperature range. This suggests that accelerants may have been present to increase the temperature of this fire, consistent with the scenario proposed by Sabine Kleiman (pers. comm.; Kleiman and Hadash 2017) in which oil stored in the large jars (Linares 2015) is argued to have acted as an explosive and an accelerant, increasing fire temperature and contributing to the destruction of the building. The greater degree of heat alteration in Individuals 1 and 3 may therefore stem from the greater concentration of storage jars in this part of the room as documented by Metzer (2015). However, an apparent discrepancy exists between the advanced colour change seen in the bones and teeth of these individuals, and the relative lack of heat fracturing, destruction, and disarticulation of their remains. As per the discussion in Chapter 4, the former condition suggests a high temperature, while the latter suggests a low temperature.

This discrepancy could be resolved if the remains were covered by a layer of material while the heat alteration occurred over a longer period of time. This layer would hold the remains in place, reducing movement disturbance and preventing them from disintegrating, and also even out the distribution of heat that reached the remains, allowing heat alterations to occur more gradually and constantly and therefore cause less heat fracturing. Under these conditions, the remains could attain a high degree of colour change over several hours or even a few days, without incurring the typical degree of fracturing and fragmentation for this level of heat alteration (Bennett 1999, Stiner et al. 1995, Ullinger and Sheridan 2015). A layer of material over the remains would also prevent the development of pugilistic posture (Pope 2007). If this scenario is correct, it would suggest that the collapse of the building occurred before the majority of the heat alteration to the remains. In other words, it seems that soon after losing consciousness or being killed by the fire, these four individuals (with the possible exception of Individual 4) were buried by the collapse, and the remainder of the heat alteration occurred over a longer period of time while the remains were buried. It can be suggested from this evidence that the rubble of the building continued to smoulder for some time after its collapse, suggesting complete abandonment of the site immediately following the destruction. These interpretations are discussed in context further below.

7.3. Post-Depositional Activity

With the exception of Individual 4, all individuals were missing elements from their skeletons. After excavation, all human and animal bone finds from all surrounding loci for each individual were reviewed again, but these missing elements could not be located. In the case of Individual 3 in particular, the bones were identified as human immediately upon discovery, making it highly unlikely that any elements were overlooked or misplaced during excavation. Therefore, it is most likely that these elements were already missing at the time of excavation, and their absence can be attributed to processes occurring before recovery, and most likely after death.

Both of the legs of Individual 1 were missing below the first 5–6 cm of the femur. Similarly, in Individual 3, the legs were absent from a point slightly above the knee. Since the legs in these individuals were separated through the middle of the femora, rather than at the joints, it is most likely that this separation occurred after the thick layers of muscle and skin around this part of the leg were already decayed, burnt away, or very badly damaged by the collapse. For Individual 2, however, the entire left leg was absent at the time of excavation, apparently cleanly removed at the hip joint, while the right leg was intact, articulated, and well preserved. Animal activity such as scavenging is one possibility to explain these observations. No tooth marks associated with scavenging can be seen on the remaining bones. However, if the legs were very badly crushed or burnt, they could conceivably have been removed without further damage to the skeleton, and either taken elsewhere where they remain to be found, or completely consumed. Such a scenario would be consistent with documented scavenging patterns of local carnivores, such as striped hyaenas (*Hyaena hyaena*) (Haglund et al. 1988, 1989; Lotan 2000). In Individual 1, the legs were the only part of the skeleton not covered by the storage jars (see Chapter 6), so it makes sense that they would be vulnerable to post-mortem processes that did not affect the rest of the skeleton. Since the skeleton of Individual 2 was on its right side, the left leg would have been on top of the body, making it the most accessible to scavengers.

Another possibility is that these elements were removed by a natural process such as erosion. In this scenario, the removal of the limbs would have to occur after skeletonisation. No obvious signs of weathering were observed on the bones, however several of the remaining bones are highly fragmentary, and very lightweight due to loss of water and organic content during the burning process (Beach et al. 2015, Shipman et al. 1984). If the missing elements were in a similar condition, and were exposed, any number of natural processes could have removed them completely. Finally, the simplest scenario that might explain the evidence is that the missing limbs completely disintegrated due to the fire. Since the missing elements seem to have been slightly more exposed than the other bones, they could have experienced greater heat alteration. Although many sources contend that the complete destruction of bones does not occur in fires (e.g. Bass 1984, Eckert et al. 1988, Pope 2007, Symes et al. 2015), it is known to occur in many situations, especially when combined with other taphonomic effects or disturbance during recovery, and could very well explain the pattern of missing limbs in these individuals (Waterhouse 2013, Symes et al. 2015; P. Mayne Correia, pers. comm.).

7.4. Interpretations of Azekah's Disaster Assemblage

Much like a forensic investigation, the interpretation of this site began by collecting clues. These clues came from the bones and their surrounding environment, and each one gradually provided evidence that allowed the elimination of possibilities in the sequence of events that destroyed Building T2/627. This resulted in a version of events that was best supported by the evidence, with a strong logical basis. The following discussion considers several versions of events that were proposed as possibilities based on history and analogy with other destruction layers. Each of these is eliminated by the evidence, whether specific points or the overall impression, to reach the final conclusion.

7.4.1. Fire After the Collapse?

Firstly, the possibility was considered that the fire could have occurred entirely after the collapse, rather than before. In other words, perhaps the building was destroyed, and then the rubble was burned sometime later. As will be discussed in section 7.4.5, this is what might be expected in a city siege. It has been shown that it is possible for bones that are buried to be altered by heat from a fire on the surface, and that this can result in a fairly even pattern of heat alteration and less damage to the bones (Bennett 1999, Stiner et al. 1995, Ullinger and Sheridan 2015)—exactly what was observed in this analysis. This scenario seems convincing at first, but it was rejected because it fails to satisfy certain details. For one thing, if the collapse occurred before the fire, it is difficult to explain the classic fire victim positioning of the remains, and why Individual 4 died despite not being crushed by the collapse. Of course, it is possible to imagine other reasons that individuals might be found on the ground in crawling or foetal positions, but this would require a great deal of unparsimonious further explanation and speculation to satisfy the scenario. The second and more telling argument against this scenario is that if the fire did occur on top of the rubble, it would need to be impossibly hot or long-lasting to penetrate the full thickness (up to 50 cm) of the destruction layer (Bennett 1999, De Graaff 1961, Stiner et al. 1995)[7]. This suggests instead that the fire must have burned for some amount of time before the collapse, resulting in evidence of combustion on the floor level before material collapsed on top of it.

7.4.2. Death Before the Collapse?

Secondly, it was briefly considered that death could have occurred before the fire or the collapse, due to an unknown cause. Specifically, they could have been killed with blunt or sharp force by attackers during a siege or a revolt in the city, events which have been discussed for other destructions at nearby sites (see Chapters 2 and 3). Certainly, if blunt or sharp trauma was inflicted before the collapse, it might have been obscured by the extensive fracturing and burning of the remains. However, careful analysis of every fragment of the bones could detect no sign of such an injury. Additionally, the pattern of behaviour seen in these individuals matched that of modern fire victims trying to escape a building, and at least two of them seemed to show body positioning that reflected attempts at self-protection to an impact from above. It can also be speculated that, if these individuals were killed by attackers, these attackers would likely have looted a number of the precious items that were found around the bodies of Individuals 1 and 4. Therefore, death at the hands of attackers seems unlikely.

[7] Bennett (1999) found no heat alteration to bones buried below 15cm in any soil type after 72 hours of burning on the surface with a wood-fuelled fire.

7.4.3. Ceremonial Burial?

Thirdly and lastly, it was also briefly considered that given the artefacts found around Individuals 1 and 4 (which Koch et al. (2017) state are normally known from funerary contexts), they might represent some form of partial burial within the rubble. Kreimerman (2017) describes such burials of corpses *in situ* following a destruction. However, the prone positioning of the bodies and the apparent lack of purposeful arrangements of the artefacts makes this unlikely.

7.4.4. Reconstructing the Disaster

Overall, the following reconstruction requires the fewest assumptions and the least extrapolation and is therefore the logically supported scenario. Based on the evidence from the scene, it appears that these individuals were exhibiting the typical behaviours of fire victims when they died, suggesting that they were alive and moving around the building for a short period while it was on fire. The degree of heat alteration in the bones of Individuals 1 and 3 suggests that the fire burned hottest and/or longest in Room T2/F628, or around Walls T2/12/F541 and T2/13/F573, a feature which could indicate that the fire started in that location (although a long, hot burn would be expected in the vicinity of these jars containing oil, regardless of where the fire started). Then, sometime during the fire they were killed by the collapse of the building, which buried them, slowed the burning process on their bodies, and prevented the adoption of pugilistic posture. Following the collapse, the site was abandoned, and this is likely when scavengers or other natural processes were able to destroy small parts of the remains that were not fully covered by rubble. These events were clearly quite sudden, allowing little time for escape. Although the events seem to have occurred in quick succession, it is concluded from this evidence that the fire started a short time before the collapse and may have caused it—but after the collapse, the building continued to burn, and the collapse may have in turn led to more fire. Both events appear to have contributed to these individuals' deaths, and no other cause or manner of death is proposed.

7.4.5 Identifying the Cause of the Disaster

If a siege caused this disaster, there are several things we should expect to see. Kreimerman (2017) states that sieges could last as long as a few years, during which time people might be trapped in a city with dwindling food resources. It could be speculated that the conversion of Building T2/627 into a production facility (see Chapter 3) could have been done during a prolonged siege in order to sustain the site by processing grain stores to produce a city's worth of food. Eventually, the invading force would conquer a city by knocking down part of the wall, or the city would capitulate. Soldiers would enter a city, possibly massacre the inhabitants, loot it for a few hours, and then burn it (Kreimerman 2017). If this building collapsed during the siege, the remains and associated precious artefacts would lie under the rubble and might escape notice by looters. However, at a site like Azekah, with a commanding view of the surrounding landscape, any large approaching force would probably be detected early enough that civilians would be able to escape the city. Kreimerman (2017) reports that this often happened during siege warfare in the ancient Near East. Possibly an attack did occur, but it is more likely to have been a sudden attack rather than a prolonged siege, probably by a smaller force than an army (Metzer 2015). Either way, no clear evidence of an attack has been found at the site to date[8], and it remains to be seen if future excavations will locate any direct evidence.

If an earthquake caused this disaster, it could certainly be described as a sudden, unexpected event. Possibly, tremors in advance of the earthquake overturned an oil lamp or other household

[8] With the exception of a single arrowhead found in the destruction layer (Metzer 2015).

flame, causing the building to burn for a short time before it finally collapsed on top of the four individuals as the earthquake grew more intense. Earthquake victims are known from archaeological sites in the Eastern Mediterranean, and patterns of behaviour are seen in these sites that resemble those of the victims in Building T2/627 (e.g. Hughes 1986, 1991; Sakellarakis and Sapouna-Sakellaraki 1981, Stamati and Stiros 2018). In fact, the destruction of this site bears several similarities to a house at Megiddo from a later period that is thought to have been destroyed by an earthquake which started a fire (Gadot and Yasur-Landau 2006). Unlike a siege, no artefact exists to provide clear positive proof for an earthquake scenario; however, one would expect to see similar contemporaneous destructions at nearby sites. In fact, the LB III destruction of Lachish exhibits a strong parallel to Azekah's destruction, and this site was both nearby and likely closely connected with Azekah (Kleiman and Hadash 2017, Metzer 2015). However, this destruction event was concluded to have been caused by humans, despite minimal direct evidence (Ussishkin 2004b)[9]. Furthermore, smaller surrounding settlements were not destroyed in this period, only these two larger cities—something which is highly suspicious for human rather than natural involvement (Metzer 2015).

7.5. Conclusions

This analysis sheds some light on the sequence of events surrounding the deaths of these individuals. It can be reconstructed from the evidence that all four individuals were active in the building while it was burning, before the roof (and the heavy pottery it was supporting) suddenly collapsed on top of them. After this collapse, the fire appears to have continued to burn, perhaps to smoulder for several hours or days. Animal scavengers may have been able to access parts of the

[9] Again, a single arrowhead (Ussishkin 2004b).

remains, likely after the rubble had cooled, and possibly after the remains had started to decay. This suggests that the site was completely abandoned immediately after the destruction, which agrees with the large occupational gap revealed in the stratigraphy of the area (see Chapter 3).

This analysis is ultimately unable to identify the disaster that led to the fall of Azekah. Regarding Building T2/627 alone, while it is clear that a fire occurred sometime before the collapse of the building, this does not necessarily support the reconstruction of a siege, earthquake, or any other scenario. However, regarding the broader site and region, the fact that Lachish and Azekah were destroyed in this period while the surrounding towns survived supports human involvement, as concluded by previous investigations (Kleiman et al. 2016, Kleiman and Hadash 2017, Metzer 2015). At least in the case of Azekah, this would have to have taken the form of a sudden attack by a smaller group, rather than a protracted siege by an army (Metzer 2015). In the contemporaneous destruction of nearby Lachish, Ussishkin (2004b) suggested that the Sea Peoples might have been responsible. In the destruction of Hazor, Zuckerman (2007) concluded that forces within the city must have destroyed it as part of a rebellion against the elite. Both of these examples illustrate how volatile this time period was, and how any number of internal or external factors could have led to the site's destruction after the withdrawal of Egypt's sponsorship and protection (see Chapters 2 and 3). It seems that Azekah was yet another victim of the broader internecine strife that characterises this period.

Chapter 8 Conclusion

When this thesis was first conceived, three principal questions were imagined, each leading to a set of further questions. Who were these individuals: what were their lives like, what can we say about their diet, health, daily activity, society, and culture? What happened here: what kind of disaster was this, what were they doing in the building, and why didn't they escape? What happened afterward: what was the site like after the destruction, and why weren't the bodies recovered? While the complexity of the historical context made this a fascinating study, the complexity of the evidence made it a challenging one. After an exhaustive examination of the archaeology, osteology, and supporting literature from every angle, many of these questions were ultimately answered, but some remain unanswered, and some new questions were raised. This thesis concludes with a reconstruction of life and death at the end of Azekah's Late Bronze Age that is most parsimoniously supported by the evidence.

In the Late Bronze Age of the Southern Levant, Egypt's imperial control produced an era of relative stability. The political involvement of the Canaanite city-states with Egyptian imperial government became crucial to their success, and when Egypt withdrew from the Southern Levant, it may have created tensions at Azekah that only enhanced the already difficult conditions of the Late Bronze Age Collapse (Chapter 2). Apparent symptoms of this declining situation are observed in building T2/627 at Azekah. Archaeologically, this was either a wealthy household that engaged in significant grain production, or more likely a manufacturing facility that was perhaps architecturally adapted from a wealthy dwelling (Chapter 3). Whatever the case, these four inhabitants worked here and possibly also lived here, and performed labour that included grinding, carrying, and other tasks related to grain production. They would have had long days of hard work for most of their lives, as many people did in the ancient world. They also suffered from disease and/or malnutrition, which may indicate that the community was under stress for several years (Chapter 6). The event that destroyed Azekah included the fiery destruction of several areas of the city. It is not clear what caused this fire: an earthquake is a possibility, but the scenario of a sudden attack on the city by an unknown force is currently preferred by the excavators. This fire was probably very sudden and with little warning, and led to the collapse of Building T2/627, as well as the four inhabitants within it. The fire was apparently very hot and destructive, possibly aided by the presence of highly flammable materials. After being killed by the collapse and sealed beneath the rubble, the site was likely quickly abandoned, and the bodies of these individuals continued to be altered by heat for a long period of time. Once the rubble had cooled, but before the remains had decomposed, scavengers were able to remove parts of the corpses, further showing that the site was completely abandoned (Chapter 7).

Before this analysis was conducted, from the archaeological evidence alone it was already clear that a destruction had occurred that was sudden, involved a fire, and led to abandonment. Regarding the human remains, anthropological analysis was not necessary to conclude that these four individuals were trapped in the collapse, probably while they were still alive. However, this thesis was able to both confirm this understanding of the events, and to expand upon it. Careful analysis showed that this was a high-temperature fire that must have begun shortly before the collapse, but it also displayed some characteristics of a more gradual, cooler fire, as though the fire had eventually died down to smoulder for some time after the collapse. No sign of sharp-force or other violent trauma was observed from the remains, corroborating that the destruction of the building was likely solely responsible for these individuals' deaths. Finally, this analysis found that the remains were disturbed following the destruction, possibly by scavengers, which would indicate that the site was completely abandoned in the aftermath of the destruction.

Moreover, this thesis was able to provide a glimpse into the lives of these individuals, which in turn informs our understanding of Building T2/627 and the larger site. Three of these individuals showed signs that they suffered from significant periods of poor health, which appear in different stages in life and at different times, suggesting that some level of adverse health conditions was normal at Azekah or at least in this part of the city during the lifetimes of these inhabitants. All four individuals showed signs of activity which could indicate that they worked in the house, and if so it seems that they were performing different tasks related to large-scale production as part of their daily lives. The apparent conflict between the material wealth of this building and the difficult lives of the inhabitants is satisfied if we consider that high social status did not always indicate less physical activity in the past, and in any case, it cannot be established whether the material artefacts found at this site actually belonged to these individuals.

8.1. Future Directions

As mentioned above, several questions about this site remain unanswered, and some new questions have been raised. It remains unknown what this disaster was, and the skeletal evidence equally supports a natural or human-made disaster. Circumstantially, the archaeology supports a human-made destruction, but if more human remains can be found from this destruction layer in other areas of the site, they may provide further evidence. The presence of additional destruction layer victims would demonstrate that this disaster was indeed sudden and widespread. Any sign of perimortem trauma could help confirm what happened, and further signs of illness in the skeletons could help specify whether disease, malnutrition, or both were endemic to this site, and for how long. Of course, more signs of habitual activity would also help to characterise Azekah's economy and social landscape in this time period.

With the four individuals in this assemblage, we encountered problems with stable isotope analysis due to the heat alteration of the remains that took us back to the drawing board. The next step in this research will begin with a revised version of the stable isotope analysis that was originally planned for this project. This will probably be limited to strontium, oxygen, and carbon analysis from dental enamel. With these data, we will be unable to make significant conclusions about diet, but we may be able to say something about mobility. Currently, the null hypothesis is that these individuals were local. Certainly, they seem from pathology and musculoskeletal stress markers to be similar to ordinary inhabitants of the region, and the dentition of Individual 4 was consistent with a typical agricultural diet. However, in the multinational Egyptian empire, it was not uncommon for people to move around and adopt one another's culture and lifestyles. Therefore, the alternative hypothesis that these individuals came to Azekah from elsewhere in the Egyptian empire is not an unreasonable suggestion.

8.1.1 Beyond Azekah

New questions were raised during this study, and it is hoped that these questions can be answered by expanding this work beyond Azekah. The four individuals exhibited signs of stress due to nutrition or disease. If we can compare these four individuals to other skeletons from the same time period and region, we may be able to ascertain whether nutritional and disease stress, indicating declining economy and perhaps social tensions, is something that can be observed in individuals across the Southern Levant in this period. To accomplish this, many more skeletons will need to be examined to discover skeletal manifestations of pathological conditions related to stress and nutrition. To assess whether there is a deviation from the normal background levels of stress-induced pathologies in this region, examples will also be needed from the periods immediately before and immediately after (i.e. the Late Bronze Age II and the Iron Age I).

The preparations for such a project are currently underway. The core of the study will consist of a comprehensive survey of archaeological skeletal remains in the Tel Aviv University collections that come from Late Bronze II, Late Bronze III, and Iron Age I sites in the Southern Levant. Bones will be closely examined for signs of generalised physiological stress, such as periostitis, linear enamel hypoplasia, or growth retardation, that could be indicative of undernutrition or chronic disease. Cribra orbitalia and porotic hyperostosis are two conditions that will be taken into account as indicators of megaloblastic or haemolytic anaemia, which is related to dietary insufficiency or disease. Further, deficiencies in specific nutrients can be inferred from conditions such as rickets, osteomalacia, and scurvy. If signs of infectious disease are discovered, they may also be taken into account, as infectious disease can also correlate with adverse conditions such as starvation. All of these pathologies are known to be indicators of communities under stress, and have been extensively studied in association with social or political change in the past. Remains will be examined on a site-by-site basis, taking into account the geographical, temporal, and cultural context of each site. Following this treatment, sites will be grouped into a broader, phase-by-phase consideration. If sample size allows, quantitative palaeoepidemiological analysis may be possible—for statistical purposes, this would ideally require a minimum of 30 individual skeletons from the same site or close contemporary sites within each period. If sufficient evidence of the above conditions can be found, the frequency and severity of each condition could be examined over time to examine trends across the Late Bronze Age–Iron Age transition.

If this initial study is successful, and funding allows, this study could be reinforced by stable isotope analysis. Analysis of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes will be used to assess the relative contributions of plant and animal foods to the diet, and the sources and varieties of these foods. As discussed in Chapter 4, $\delta^{13}C$ allows us to distinguish C_3 and C_4 plant consumption, which could tell us which grains were being cultivated, and possibly detect whether there was seasonal variation or a change over time in these crops. $\delta^{15}N$ allows us to distinguish what kind of animals were eaten and how much of the diet was made up of meat and dairy as opposed to plant foods. Both isotopes can also be used to detect the contribution of seafood to the diet. Another specialised use of $\delta^{15}N$ is to study nursing and weaning practices, which can also respond to the stresses affecting a population. Strontium ($^{87}Sr/^{86}Sr$) and oxygen ($\delta^{18}O$) can be used to determine origin and mobility in past populations (Bentley 2006, Garvie-Lok 2009, Price 2015). $^{87}Sr/^{86}Sr$ reflects the isotopic composition of the soils in which an individual's plant-based foods were grown, while $\delta^{18}O$ reflects the isotopic composition of the drinking water. Both of these measurements vary locally, and can be used together to distinguish the geographical areas in which an individual has spent their life, and look at how this might have changed over time. In other words, these two isotopes together can show whether these individuals were local or foreign to Azekah, whether they travelled significantly during their lives, and when this occurred. These methods can also be used in a very similar way to examine whether an individual's food was locally produced or imported. These analyses will provide an intimate, human perspective on the Late Bronze Age Crisis Years, making an invaluable contribution to the archaeology and history of the region.

This study has helped understand how the Late Bronze Age Collapse affected the citizens of Canaanite city-states, and future research into this question is an exciting prospect with a lot of potential. Ongoing excavations at Azekah continue to deepen our understanding of this site, and have already revealed that the city was probably of greater importance to the region than previously thought. I hope that this thesis will contribute to our understanding of the site, and will inspire more osteoarchaeological research in the region.

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Appendix 1 Raw Osteological Data

As stated in Chapter 5, the recording forms designed and recommended by Buikstra and Ubelaker (1994) were used during field analysis. However, due to the extensive fragmentation of the remains, resulting in many pieces too small to accurately depict and several shaft fragments whose exact location could not be determined, the resulting skeletal inventory was messy and overly complicated. Therefore, this recording method was abandoned in favour of a descriptive approach. The following inventories describe each bone as it was observed in the field for all four individuals. The fragments of the bone that remained in the field are described in the inventory, with counts provided where possible, while colour and other pertinent observations are recorded for each bone. Any elements not listed in the inventories below were not present.

Individual 1

Bone	Inventory	Colour	Pertinent Observations
Mandible	Isolated left condyle, mental eminence, right side body fragment	White and blue-grey with areas of charring	Several detached crowns, blackened and extremely friable with fine patina fractures, roots are dark grey Mental eminence score = 1-2
Frontal	Left side fragment of squamous part including sinus and orbit, right side fragment of orbit	White on endocranial surface, blue-grey and reddish-brown on ectocranial surface	Calcined Cribra orbitalia Slight bossing
Left Parietal	Several fragments	White	Calcined
Right Parietal	Several fragments	White	Calcined
Occipital	Left lateral portion, basilar + right lateral portion	White	Unfused spheno-occipital synchondrosis Bipartite left condyle
Left Temporal	Petrous portion	Blue-grey and white	Mastoid = 1
Right Temporal	Only a couple fragments	White	Not calcined
Left Maxilla	Complete	White	Root marks

			Teeth are dark grey with blackened crowns
Left Zygomatic	Complete	Grey-white	Malar tubercle has low-medium rugosity
Other Facial Bones	Auditory ossicles	Grey	
Left Scapula	Axillary border with glenoid fossa and scapular spine	White	Calcined Glenoid and subcoracoid centres unfused
Right Scapula	Axillary border with glenoid fossa and partial acromion	White	Calcined, lots of delamination Glenoid and subcoracoid centres unfused
Left Clavicle	Acromial end	Mottled grey-white	Some delamination Almost no conoid tubercle Very delicate, little muscle rugosity at all
Right Clavicle	Acromial end	White	
Left Humerus	Proximal end, shaft fragment (10-11 cm)	Blue-grey and light brown	Head unfused, surface is smooth with minimal granulation Deltoid tuberosity is very slight
Right Humerus	Shaft fragments	Blue-grey and white	Lots of delamination
Left Radius	Proximal end (2.5cm) + 4-5cm shaft fragment	White	Calcined, some delamination and straight transverse fractures Head unfused
Right Radius	Shaft fragments	Blue-grey and white	Lots of delamination
Left Ulna	Fragment of coronoid process and radial notch	n. d.	
Right Ulna	Distal epiphysis (unfused), fragment of proximal end, some shaft fragments	Blue-grey	Several areas of delamination Distal epiphysis unfused
Right Scaphoid	Present	n. d.	
Right Lunate	Present	n. d.	
Right Triquetral	Present	n. d.	
Right Capitate	Present	n. d.	
Right Hamate	Present	n. d.	
Right MC1	Proximal part	n. d.	Four unidentified unfused distal MCs, white and calcined with patina fractures

Left MC2	Proximal part	Blue-grey and white	
Left MC4	Proximal part	Blue-grey and white	
Right MC4	Complete, distal epiphysis unfused and missing	n. d.	
Proximal Phalanges	Several, many fragments	Blue-grey and white	2.9 cm maximum length
Intermediate Phalanges	Several, many fragments	Blue-grey and white	Unfused proximal ends 1.95cm, 1.7cm maximum length
Distal Phalanges	Several, many fragments	Blue-grey and white	First distal exhibits enthesopathy and changes on the joint surface First distal is 1.45cm maximum length
C1	Complete, intact	White	Calcined
T1	At least five thoracic vertebral bodies in uncounted fragments	n. d.	Annular epiphyses unfused
Sacrum	S1, right side	White and light brown	
Left R1	Partial	White	Calcined
Left Other Ribs	Several fragments	Blue-grey and white	Calcined, delamination Possible weathering
Right Other Ribs	Several fragments	Light brown with charring	Calcined, delamination
Left ilium	Complete	White on exterior surface, blue-grey and grey-brown on interior surface	Unfused iliac crest Narrow greater sciatic notch (5)
Right Ilium	Partial	Blue-grey and white	Unfused iliac crest Narrow greater sciatic notch (4-5)
Left Ischium	Isolated ischial tuberosity + 1/3 acetabulum (unfused)	Blue-grey and white	Extremely friable
Right Ischium	Partial	Grey-white	Unfused triradiate suture
Left Pubis	Partial	White	Calcined
Left Femur	Head and neck (greater trochanter broken off)	Grey-white	Patina fractures Epiphysis unfused
Right Femur	Proximal 4-5cm	White	Calcined, patina fractures on head Epiphysis unfused

Tooth	Inventory	Colour	Pertinent Observations

12 (RI^2)	Only a small fragment of the crown remaining, root complete	Blackened enamel, grey-brown root	
14 (RP^1)	Nearly complete, one root tip broken off	Shiny, blackened enamel, grey-brown root	
15 (RP^2)	Two root fragments, identification not certain	Grey-brown	
16 (RM^1)	Two root fragments, identification not certain	Dark grey-brown	
17 (RM^2)	Single upper molar root with a tiny fragment of crown	Grey-brown	
18 (RM^3)	Roots complete with a small portion of the crown	Blackened enamel, grey root	
22 (LI^2)	Nearly complete, root tip broken off	Blackened enamel, medium brown root	
23 (LC^1)	Most of the crown gone, root complete	Blackened enamel, blue-grey and brown root	
33 (LC_1)	Tips of cusps spalled off, tip of root broken off	Grey	
34 (LP_1)	Tips of cusps spalled off, tip of root broken off	Grey	
36 (LM_1)	Most of the crown missing but root complete. Small fragment of alveolar bone clinging to tooth.	Blue-grey and black enamel, medium brown root	Possible charred calculus
48 (RM_3)	Most of the crown missing, root complete	Black enamel, blue-grey root	

Individual 2

Bone	Inventory	Colour	Pertinent Observations

Mandible	Partial with right side fragment	Light orange-brown and blue-grey	Very robust pterygoid and masseter insertions Ascending ramus is wide, mental eminence = 3 Teeth are medium reddish-brown, crowns popped off and mostly black
Frontal	Many tiny pieces of calvaria	Pale yellow-orange and dark orange-brown with charring, come fragments were blue-grey to white with lots of delamination	
Left Parietal	Fragments	Dark brown with pale yellow-orange inside	
Right Parietal	Fragments	Dark brown with pale yellow-orange inside	
Left Temporal	Fragmentary	Light yellow-brown	Root of zygoma ends beyond external auditory meatus
Right Temporal	Partial	Dark orange and reddish-brown with charring	Root of zygoma ends just beyond external auditory meatus
Left Maxilla	Fragment	Light brown with charring	
Right Maxilla	Fragment with premolar alveoli	Medium brown	
Left Scapula	Acromion process, glenoid region, axillary border	Blue-grey patches on orange-beige or pale yellow-orange, some charring	
Right Scapula	Glenoid fossa, acromion, axillary border, inferior angle	Pale yellow-orange with charring	
Left Clavicle	Complete but fragmentary	Blue-grey and light brown	Sternal end fused
Right Clavicle	Acromial end + sternal end fragment	Mostly dark yellow-orange with charring	Conoid is medium-sized

Left Humerus	Large shaft fragment and some head fragments	Blue-grey and light brown	
Right Humerus	Humeral head + several shaft fragments	Pale yellow-orange	A few shaft fragments refit well, looks like perimortem breakage Head fragment is in the shape of an unfused epiphysis, but no fusion surface visible
Left Radius	Proximal third, minus head and neck	Blue-grey and grey-beige	Fracturing looks like a mixture of heat and taphonomic Bicipital tuberosity is well-developed
Right Radius	Proximal half	Blue-grey and light brown	Bicipital tuberosity is well-developed Break at distal end looks heat-related Head fully fused
Left Ulna	Proximal half, coronoid and olecranon broken off	Mottled blue-grey with reddish patches	Distal end is unevenly broken, looks like a mixture of heat taphonomy Many longitudinal fractures
Right Ulna	Fragment of coronoid including radial notch	n. d.	
Right Scaphoid	Present	n. d.	
Proximal Phalanges	One manual phalanx, probably proximal	n. d.	
C1	Complete	n. d.	
T1	Nine or more thoracic vertebrae, most very fragmentary	Grey-beige	
L1	Four lumbar vertebral bodies, not seriated	Dark brown and reddish brown with pale yellow patches and charring	Hints of Schmorl's nodes
L5	Probable L5	Dark brown and orange	Schmorl’s node
Sacrum	S1, S2+3, other fragments	Dark brown with some charring	S1 is unfused to S2. S2 and 3 are fused, S4 and S5 are also fused but broken at S3-4.
Left R1	Partial	Dark brown	
Left Other Ribs	Many fragments	Dark brown and reddish brown with pale yellow patches and charring	

Right Other Ribs	Many fragments	Dark brown and reddish brown with pale yellow patches and charring	
Left ilium	Partial ilium, iliac crest, auricular surface	Blue-grey and white on external surface, dark grey on internal surface, trabeculae are dark brown and black	Iliac crest is fused, auricular surface has low-medium granularity Large, blunt anterior inferior iliac spine, thick ischial tuberosity, large ischial spine Greater sciatic notch reconstructed from several adjoining fragments, score=4
Right Ilium	Fragments	Dark orange-brown, blue-grey, and brown with charring	Rough perimortem breaks
Left Ischium	Complete	Grey-beige and blue-grey with charring	Rough perimortem breaks Ischial tuberosity and ischial spine are large Acetabulum is large and ischial tuberosity is thick
Right Ischium	Fragment	Dark brown and blue-grey	Rough perimortem breaks
Right Pubis	Two pieces that might be the pubic symphyses	Dark grey and blue-grey	Fresh breaks
Right Femur	Head and neck, proximal half, distal half with condyles broken off	Areas of dark brown, blue-grey, reddish brown, black, pale yellow-orange	Rectilinear fractures proximally, lots of delamination throughout Some porosity on the joint surface of the medial condyle Head epiphysis is fully united Rugose gluteal and pectineal lines and lateral supracondylar ridge
Right Patella	Present	Medium reddish brown	Slight porosity on medial facet Very rugose
Left Tibia	A few fragments	Grey-beige and blue-grey	Probable periostitis
Right Tibia	Many reconstructable fragments, half to 2/3 present	Dark brown and reddish brown	Crisp, uneven fractures Tibial periostitis found on all sides of the bone but mostly the anterior surface, extends more than 20cm along the midshaft, about 2/3 the total length

Right Fibula	Proximal and distal ends, uncountable shaft fragments giving the impression of a complete bone	Dark reddish brown with charring	Smooth postmortem fractures Delamination Lots of sooty material on surface
Right Talus	Complete	Dark brown	
Right Calcaneus	Partial	Dark brown, some lighter brown in trabeculae	Rough perimortem fractures Slight posterior spurring
Right Cuboid	Present	Dark brown	
Right Navicular	Present	Dark brown	
Cuneiforms	Medial and intermediate present	Dark brown	
Right MT4	Present	Dark brown with dark orange at the distal end	Rough perimortem fractures 6.7cm maximum length
Intermediate Phalanges	#2 or #3	Medium orange-brown	

Tooth	Inventory	Colour	Pertinent Observations
14 (RP^1)	Roots complete, crown fragments	Orange-brown with black patches, blackened enamel	
16 (RM^1)	Fragment of left or right upper first or second molar, identification uncertain	Orange-brown with grey and grey-beige	
28 (LM^3)	Roots complete, crown fragments	Pale yellow-orange with dark brown and black, blackened enamel	

Individual 3

Bone	Inventory	Colour	Field Observations
Mandible	Right side fragment	Mottled blue-grey	Mixed perimortem and postmortem fractures Teeth are dark grey-brown, crowns are mostly black and popped off

Frontal	Complete, fragmentary	Grey-beige with blue-grey	Mixed perimortem and postmortem fractures Cribra orbitalia
Occipital	Complete, fragmentary	Blue-grey inferiorly, darkening to dark grey at lambda	Mixed perimortem and postmortem fractures Nuchal region is gracile (score=2-3)
Left Temporal	Fragments	Blue-grey	Crisp postmortem breakage
Right Temporal	Complete, fragmentary	Blue-grey	Rough perimortem fractures Mastoid=1-2
Left Maxilla	Complete, fragmentary	Blue-grey	Crisp postmortem breakage Teeth are dark grey
Right Maxilla	Fragments	Blue-grey	Crisp postmortem breakage Teeth are dark grey
Sphenoid	Fragments	Blue-grey and light grey	
Left Scapula	Fragments	Blue-grey and white	Mixed perimortem and postmortem fractures Evidence of bony expansion around the glenoid
Right Scapula	Fragments	Blue-grey	Mixed perimortem and postmortem fractures Expansion around the glenoid
Left Clavicle	Partial	Blue-grey	Mixed perimortem and postmortem fractures Highly rugose at all major entheses
Right Clavicle	Acromial end	Blue-grey	Mixed perimortem and postmortem fractures Large conoid
Left Humerus	Proximal half	Dark grey and blue-grey	Head fully united Deltoid is fairly robust (esp. posterior)
Right Humerus	Fragments	Blue-grey, neutral grey, white	Mixed perimortem and postmortem fractures Delamination Robust deltoid tuberosity, particularly posteriorly
Left Radius	Fragments	Blue-grey	Mixed perimortem and heat fractures
Right Radius	About half	Blue-grey and white	Rough perimortem fracture at proximal end Longitudinal and rectilinear fractures at distal end Medium bicipital tuberosity, partly excavated and partly raised
Right Ulna	Partial	White and neutral grey	Perimortem fracture at proximal end, postmortem fracture at distal

Left Scaphoid	Present	Blue-grey	Some splitting that looks heat-related
Right Scaphoid	Present	Blue-grey and white	
Right Lunate	Present	Blue-grey and white	
Left Trapezoid	Present	n. d.	
Right Trapezoid	Present	n. d.	
Left Trapezium	Present	Grey-beige and blue-grey	
Right Trapezium	Present	n. d.	
Right Capitate	Present	Blue-grey	
Right MC1	Present	Blue-grey	Longitudinal fractures
Right MC2	Present	Blue-grey	Longitudinal fractures
Right MC3	Present	Blue-grey	Longitudinal fractures
Right MC5	Present	Blue-grey	Longitudinal fractures
C1	Present	Blue-grey	Calcined
C2	Present	Blue-grey	Calcined
T1	Five full thoracic vertebrae, many other fragments	White, grey, grey-beige	Rough perimortem fractures Not quite calcined
L1	Five lumbar vertebrae are present (three wholes, two right halves, one left half, three other partials)	Grey, white, beige	Rough perimortem fractures Lightweight Two of the wholes have Schmorl's nodes, plus one of the right halves, and the left half
Left R1	Present	Blue-grey	Sternal end is shallowly cupped with rounded, wavy edges
Right R1	Present	Blue-grey	
Left Other Ribs	Six sided	Blue-grey and white	
Right Other Ribs	Three sided	Blue-grey and white	
Sternum	Small fragment of sternal body	Blue-grey and white	Rough perimortem fractures
Left ilium	Acetabulum and surrounding area	Blue-grey	Mixture of crisp and crumbly Auricular surface has medium granularity with most of the transverse organisation lost Greater sciatic notch is reconstructable, wide (score=2)

Right Ilium	Disembodied greater sciatic notch, two fragments of acetabulum	Blue-grey and white	Mostly crumbly Greater sciatic notch is wide (score=2)
Left Ischium	Partial	Light grey	Rough perimortem fractures
Left Femur	Proximal half	Blue-grey with charring	Rough perimortem fractures Longitudinal fractures and delamination Linea aspera is medium, strong GPS lines and quadrate tubercle
Right Femur	Proximal half	Blue-grey with charring	Ends in an old, stepped fracture about halfway down No patina Lots of root marks Linea aspera is small, strong GPS and quadrate tubercle
Left Tibia	Many tiny fragments	Blue-grey and white with charring	Clear thumbnail and other heat fractures
Right Tibia	Several unsided tibia fragments	Blue-grey and white	Longitudinal and stepped fractures, some nice thumbnail fractures Some evidence of striations consistent with periostitis
Left Fibula	Tiny fragments	Blue-grey and white	Some great patina fractures
Right Fibula	Many fragments (probably close to complete)	Blue-grey and white	Longitudinal and stepped fractures
Left Talus	Superior half	Blue-grey	
Left Calcaneus	Superior half	Blue-grey	
Left Cuboid	Present	Blue-grey	
Left Navicular	Present	Blue-grey	
Cuneiforms	Lateral	Blue-grey	

Tooth	Inventory	Colour	Pertinent Observations
16 (RM^1)	Complete except for missing mesial root	Dark grey with blue-grey patches, blackened enamel with white patches	No calculus Wear: • Mesiobuccal: 3 • Mesiolingual: 4 • Distobuccal: 3 • Distolingual: 5
18 (RM^3)	Distal half of tooth in two fragments	Blue-grey and dark brown, enamel	Calculus present Wear: • Distobuccal: 3

		blackened with white patches	• Distolingual: 3
26 (LM^1)	Small fragment of root and crown	Dark brown and dark grey with blue-grey patches	Wear not scorable
31 (LI_1)	About half the enamel spalled off	Dark reddish brown with blue-grey patches	Wear: 4
34 (LP_1)	Small fragment, identification uncertain, probably a left or right lower premolar	Dark grey-brown and blue-grey	
37 (LM_2)	Two joining fragments form complete roots, but crown is mostly missing	Dark brown and blue-grey	Wear not scorable
41 (RI_1)	About half the enamel spalled off	Reddish brown with blue-grey patches and blackened enamel	Wear: 4
43 (RC_1)	Root with a small remnant of crown	Reddish brown with blue-grey patches and blackened enamel	Wear not scorable
47 (RM_2)	Fragment with mesial root and damaged portion of crown	Reddish brown near apex, blue-grey near neck, dark grey at occlusal end with blackened enamel	Wear not scorable
48 (RM_3)	Entire occlusal surface spalled off	Dark brown with blue-grey patches	Wear not scorable

Individual 4

Bone	Inventory	Colour	Pertinent Observations
Mandible	Complete but fragmentary	Left side is blackened through, right side is reddish-	Rough perimortem fractures Rugose pterygoid, slight masseteric Relatively slender ramus and body

		brown with pale orange inside	Teeth are dark reddish brown, crowns popped off Shiny, flaky, black substance on bone surface
Frontal	Right side with portion of orbit and temporal line, fragment of left orbit, other fragments	Pale yellow-orange on right, dark grey on left	Crisp postmortem fractures What's left of orbital rim is quite sharp
Left Parietal	Multiple fragments	Charred dark brown surface, dark brown or black inside	Rough perimortem fractures
Right Parietal	Multiple fragments	Reddish to dark red-brown, pale yellow-orange inside	Rough perimortem fractures A few trowel marks
Occipital	Complete, fragmentary	Basilar portion is dark reddish-brown with charring, squama is charred on the surface but reddish-brown inside, right side of squama is dark reddish-brown but not charred	Some lipping around the condyle (and corresponding surface on atlas) Trowel marks on outer table Spheno-occipital synchondrosis fused Very gracile, 1-2
Left Temporal	Complete, fragmentary	Blackened through squamous portion, petrous portion is dark brown inside	Small lip on posterior side of condylar fossa Mastoid=1
Left Maxilla	Found in tooth boxes	Black laterally and dark reddish-brown medially	Crisp postmortem breaks
Right Maxilla	One fragment with anterior nasal spine, alveoli for 11–15, part of palate, part of maxillary sinus	Light brown	Rough perimortem fractures

Left Zygomatic	Complete	Black	
Right Zygomatic	Complete, attached to part of maxilla	Pale yellow-orange with some charring	Rough perimortem fractures
Sphenoid	Complete but fragmentary, some parts attached to occipital	n. d.	
Other Facial Bones	Several fragments of palatine, ethmoid, other small bones	n. d.	
Left Scapula	Left glenoid fossa and coracoid process	Posterior is grey-beige, anterior is dark brown with surface charring	Rough perimortem breaks
Right Scapula	Right glenoid, acromion, medial border	Black with reddish-brown on medial part of acromion	Patina fractures on medial acromion Shiny, flaky, black substance on surface
Left Clavicle	Acromial end, sternal end	Pale yellow-orange	Mixture of perimortem and postmortem fractures Medial end unfused Very strong conoid
Right Clavicle	Acromial end, medial end, shaft fragment	Blackened through at both ends, grey-brown with charring on shaft	Rough perimortem fractures Medial end unfused Strong costal tuberosity
Left Humerus	Proximal end (5-6cm), shaft fragment, distal end, condyles (i.e. complete)	Neutral grey, mottled reddish and bluish with charring at proximal end, distal end is charred and thoroughly blackened	Flaky, delicate cortex at distal end Epiphysis exhibits deep line of fusion, with some unfused surface exposed Deltoid tuberosity is very slight Shiny, flaky black substance on surface
Right Humerus	Proximal humerus, many humeral head fragments, shaft fragment, distal end	Black with areas of dark brown	Typical rectilinear heat fractures Fusion surface is granular and broken at parts as though it was partially fused >31cm maximum length Shiny, flaky, black substance on surface

Left Radius	Proximal end, shaft fragment, distal end, distal epiphysis (i.e. complete)	Black with shiny surface	Proximal epiphysis is missing, consistent with unfused surface (slightly convex), but no bone left to confirm. Distal epiphysis present and unfused, both surfaces very granular. Shiny black flaky substance adhering to surface 25.2cm maximum length
Right Radius	Partial	Black	Multiple perimortem fractures with hingeing Proximal epiphysis fully fused, distal epiphysis unfused Bicipital tuberosity is quite large and half raised, half excavated Shiny, flaky, black substance on surface
Left Ulna	Proximal end (~5cm), shaft fragment, distal end, distal epiphysis (i.e. complete)	Black	Rough perimortem break in the middle Distal epiphysis unfused, both surfaces have moderate granularity 29.2cm maximum length Shiny, flaky, black substance on surface
Right Ulna	Proximal ~10cm, distal end	Black and dark reddish-brown with charring	Multiple perimortem fractures with hingeing Delamination at distal end Distal epiphysis unfused 28.6cm maximum length Shiny, flaky, black substance on surface
Left Scaphoid	Present	n. d.	
Right Scaphoid	Present	Dark brown	
Left Lunate	Present	Black	Shiny, flaky, black substance on surface
Left Triquetral	Present	Dark grey-black	
Left Trapezoid	Present	Dark grey-black	
Right Trapezoid	Present	Dark brown	
Left Capitate	Present	Dark grey-black	
Right Capitate	Present	n. d.	
Right Hamate	Present	Medium brown	
Left MC1	Assorted distal ends of metacarpals	Dark grey-black	
Left MC2	Proximal end	Dark grey-black	

Right MC2	Proximal end	Black	
Left MC3	Proximal end	Dark grey-black	
Right MC3	Proximal end	Black	
Left MC4	Proximal end	Dark grey-black	
Right MC5	Proximal end	n. d.	
Proximal Phalanges	Several plus many fragments	Black at proximal end, pale yellow-orange at distal end	4.7cm, 4.2cm, 3.2cm maximum length
Intermediate Phalanges	One identified, another proximal end	Grey-brown with charring	2.9cm maximum length
Distal Phalanges	Three	n. d.	1.65cm, 1.7cm maximum length
C1	Left half, anterior arch, right half	Blackened through, right half is charred	Condyle is lipped and slightly porous, facet for axis is also slightly lipped and porous
C2	Complete	Black	Slight lipping and porosity on condyles
C3	Probable C3	Black	
C4	Probable C4	Black	
C5	Probable C5	Black	
C6	Probable C6	Surface is black-grey, inside is a mixture of black and medium brown	
C7	Complete	Body is charred and blackened through, laminae and spinous process are light reddish-brown	Vertebral endplates fused superiorly and inferiorly
T1	Probable T1	Anterior part of body is blackened through, the rest is blue-grey with beige trabeculae	Possible peripheral exostosis in lower thoracic vertebrae Endplates fused
T2	Uncertain ID	Anterior part of body is blackened through, the	

		rest is blue-grey with beige trabeculae	
T3	Uncertain ID	Charred and reddish-brown	Small depressions in superior and inferior surfaces of body Endplates recently fused
T4	Uncertain ID	Blue-grey with charred areas	
T5	Uncertain ID	Red-black anterior, grey-white posterior	Small depressions on superior and inferior body Endplates recently fused
T6	Uncertain ID	Charred, some areas blackened through, some reddish brown	
T8	Complete	Areas of black and grey	
T9	Uncertain ID	Blue-grey on spinous process and laminae, pale yellow-orange on anterior aspect of body	Slight depressions on centre of body superiorly and inferiorly, exostosis Endplates unfused
T10	Uncertain ID	Grey and reddish-brown	Depression in inferior aspect of body, exostosis
T11	Possibly T12	Pale yellow-orange anterior, charred grey posterior	Schmorl's node in inferior body, exostosis Endplates unfused
T12	Probable T12	Anterior and trabeculae are pale yellow-orange, posterior is grey	Possible wedge fractures Large Schmorl's nodes superiorly and inferiorly, slight marginal lipping and exostosis Endplates unfused
L1	Probable L1	Reddish-brown with charring	Possible wedge fractures Large Schmorl's node in inferior body Endplates unfused
L2	Probable L2	Beige with grey areas	Schmorl's node on superior body Endplates unfused
L3	Complete	Grey-white, posterior parts are white and calcined	Slight depression in superior body, some lipping Endplates unfused
L4	Probable L4	Blue-grey and white	Possible Schmorl's node in superior body

			Endplates unfused
L5	Probable L5	Blue-grey and white	Calcined Endplates unfused
Sacrum	Left half of S1	Mottled blue-grey with some white areas and charring	S1 is unfused, other sacral vertebrae look partially united
Left R2	Possibly identified	n. d.	
Right R2	Possibly identified	Dark grey-black	
Left Other Ribs	Nine sided	Black and blue-grey with areas of pale yellow-orange	Two sternal ends are shallowly cupped, one with rim wavy and uneven, one with sharper but regular rim
Right Other Ribs	Four sided	Dark grey and pale yellow-orange	
Sternum	Two unfused sternebrae	Dark grey-brown, charred on posterior	
Left ilium	Partial blade	Blue-grey	Rough perimortem fractures Calcined, some rectilinear fractures and delamination Iliac crest unfused with little granulation, auricular surface appears mature Greater sciatic notch appears narrow
Right Ilium	Partial blade, iliopubic ramus with 1/3 acetabulum and pubic tubercle, several more fragments of acetabulum	Blue-grey and white	Postmortem breakage, although some could be perimortem Calcined Iliac crest unfused, surface is smooth and rippled with no granularity visible
Left Ischium	Left ischial tuberosity with partial acetabulum	Blue-grey and white	Rough perimortem fractures Calcined Ischial tuberosity is relatively small
Right Ischium	Right ischial tuberosity with partial acetabulum	Blue-grey and white	Rough perimortem fractures Calcined Ischial tuberosity is relatively small
Left Femur	Head, several midshaft fragments, condyles	Head is white, shaft is blue-grey and white	Calcined, several areas of delamination, patina fractures on head
Right Femur	Head, greater trochanter, several shaft fragments	Head is white and calcined with blue-grey	Longitudinal fractures, stepped fractures, delamination Very rugose muscle attachments on posteromedial aspect

		areas, shaft is blue-grey	
Left Patella	Possible partial	n. d.	
Right Patella	Present	Dark reddish-brown with pale orange trabeculae	
Left Tibia	Several fragments including plateau area	n. d.	Rough perimortem fractures
Right Tibia	Plateau, a few shaft fragments	Beige with areas of white and charring on the condyles	Rough perimortem fractures
Left Fibula	Several fragments	n. d.	
Right Fibula	Head, two shaft fragments	Head is beige, shaft fragments are white and calcined	
Left MT1	Two unidentified MT fragments	Blue-grey and grey-beige	

Tooth	Inventory	Colour	Pertinent Observations
11 (RI^1)	Crown largely complete, distal end of root missing	Dark reddish-brown root, enamel natural colour with some orange	
13 (RC^1)	Root missing, crown split vertically into two halves	Dark reddish-brown root, enamel natural colour with some orange	Calculus present
14 (RP^1)	Complete except for tip of root	Orange and reddish brown root, enamel natural colour	
15 (RP^2)	Crown with about half of root	Black root, enamel is natural colour with some dark brown	
16 (RM^1)	Crown complete, roots missing	Black roots, enamel natural colour with some charring	Small round carious lesion in central occlusal fissure Wear: • Mesiobuccal: 5 • Mesiolingual: 5

			• Distobuccal: 4 • Distolingual: 5
17 (RM^2)	Complete except for two root tips	Orange and reddish-brown root, enamel natural colour	Pinpoint carious lesion in central occlusal fissure Wear: • Mesiobuccal: 3 • Mesiolingual: 6 • Distobuccal: 3 • Distolingual: 6
18 (RM^3)	Complete	Black root, enamel natural colour with some charring	Roots fully formed Wear: • Mesiobuccal: 2 • Mesiolingual: 3 • Distobuccal: 3 • Distolingual: 3
21 (LI^1)	Labial aspect of crown only	Dark reddish brown dentine with enamel natural colour	Wear not scorable
22 (LI^2)	Complete	Dark brown root with enamel natural colour	Wear: 2 Wear is highly oblique on the lingual aspect
23 (LC^1)	Complete but split in two vertically	Black and dark brown root, enamel natural colour with some charring	Wear: 4
24 (LP^1)	Intact with tip of one root broken	Black root, enamel natural colour with black mottling	Wear: 3
25 (LP^2)	Intact with tip of one root broken	Dark reddish-brown root with pale yellow-orange enamel	Wear: 2
26 (LM^1)	Crown complete, roots missing	Black root, enamel natural colour with charring	Wear: • Mesiobuccal: 4 • Mesiolingual: 5 • Distobuccal: 5 • Distolingual: 6
27 (LM^2)	Complete	Black root, enamel natural	Wear: • Mesiobuccal: 3 • Mesiolingual: 3

		colour with charring	• Distobuccal: 3 • Distolingual: 3
28 (LM^3)	Complete	Orange and reddish-brown root with pale yellow-orange enamel	Root tips still in formation, stage Rc Wear: • Mesiobuccal: 2 • Mesiolingual: 2 • Distobuccal: 2 • Distolingual: 2
31 (LI_1)	Crown and occlusal fragment of root	Black and dark brown root with natural colour enamel	Calculus Wear: 4
32 (LI_2)	Crown and occlusal fragment of root	Reddish brown root with natural colour enamel	Calculus Wear: 1
34 (LP_1)	Crown and small occlusal fragment of root	Black root, enamel natural colour with some charring	One small carious lesion in occlusal fissure Wear: 3
35 (LP_2)	Crown and small occlusal fragment of root	Black root, enamel natural colour with some charring	Wear: 3
36 (LM_1)	Crown in two fragments, root missing	Black root, enamel natural colour with some charring	Wear: • Mesiobuccal: 2 • Mesiolingual: 3 • Distobuccal: 4 • Distolingual: 4
44 (RP_1)	Complete	Reddish-brown root, enamel natural colour with slight yellowing	Wear: 2
45 (RP_2)	Complete	Dark reddish-brown root, enamel natural colour with slight yellowing	Wear: 2
46 (RM_1)	Complete	Reddish-brown root, enamel natural colour with slight yellowing	Wear: • Mesiobuccal: 5 • Mesiolingual: 5 • Distobuccal: 4 • Distolingual: 4

47 (RM_2)	Complete	Reddish-brown root, enamel natural colour	Wear: • Mesiobuccal: 3 • Mesiolingual: 2 • Distobuccal: 3 • Distolingual: 3