# The life-history of the basalt ground stone artefacts from an early urban domestic neighbourhood in the southern Levant: the remains from Early Bronze III Tell es-Safi/Gath, Israel

**By**

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## Abstract

The research presented in this thesis is a reconstruction of the life-history of basalt ground stone artefacts from the recently excavated urban settlement of Tell es-Safi/Gath. In a broader scope, the life-history encompasses the production, distribution, and consumption of these artefacts. The investigation into these economic components sought to provide information on the domestic life and activities at Tell es-Safi/Gath and in the southern Levant, the socio-economic standing of Tell es-Safi/Gath in the Shephelah, and the nature and impact of economic systems in early complex societies of the southern Levant. This was examined through archaeological excavation, a provenance analysis using XRF, a typological analysis, and macroscopic observations.

Results reveal that the basalt sources in the north-eastern sub-regions of the southern Levant were locally exploited for the small-scale production of basalt artefacts by non-specialised artisans. These imported commodities were likely transported by middlemen to Tel Yarmuth or directly to Tell es-Safi/Gath in the Shephelah where they were further redistributed to the settlement residents by a centralised authority. The socio-economic role of Tell es-Safi/Gath is considered to be one of top-tier dominance within the Shephelah given its large size and role in intra-regional exchange networks. Within the neighbourhood of Tell es-Safi/Gath, the residents utilised the basalt artefacts for traditionally domestic tasks, further indicating the non-elite status of the neighbourhood. As such, economic systems are stressed as an important contributing factor to the development and maintenance of early complex societies within the EB II-III southern Levant.

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# Chapter 1. Introduction

## 1.1 Introduction

A complete understanding of the archaeological record continues to and will forever elude archaeologists. At present there is an insufficient amount of information generated on the daily activities of everyday people of the past. The material culture of these people is often passed over for more popular remains. This neglect leaves questions regarding their mundane behaviour insufficiently answered. These questions address economic aspects of everyday life and common activities in which we ourselves similarly engage on a day-to-day basis. Some examples are:

- From which sources did people procure their raw material?
- With whom did people interact in order to acquire their commodities?
- What was the organisation of production associated with everyday commodities?
- What was the nature of distribution of everyday commodities?
- What were the consumption and disposal strategies associated with everyday commodities?

In respect to many societies, regions and time periods, such inquiry remains to be fully understood. Consequently, this thesis was an effort to deepen our understanding of these economic endeavours. As a whole, this research involved an archaeological focus in an attempt to reconstruct human behaviour from the material remains and to examine economic systems in early complex societies. More specifically, it is an investigation into the nature of production, distribution, consumption, and discard of basalt ground stone artefacts during the Early Bronze Age (hereafter EBA) of the southern Levant. As a result, it is a contribution to the long-standing tradition of Near Eastern archaeology.

## 1.2 Complex societies in the Near East

The Near East (Figure 1.1) has long been identified as the geographic region where the earliest complex societies originated (Wright, 1994a:65-72; de Miroschedji, 2009:119). Complex societies are typically characterised by the presence of a centralised authority (elites) and a developed state (Wright & Johnson, 1975; Wright, 1977:381; Trigger, 1996:533-534; Earle, 2002:43).

Complex societies first appeared independently in the primary states of Mesopotamia (ca. 3500 BCE) and Egypt (ca. 3100 BCE), later spreading to the southern Levant during the latter EBA (ca. 3100-2350 BCE) (Wenke, 1989; Mazar, 1990:91; Shwartz, 1994:163; Cowgill, 2004:530-532). The interaction between the two primary and literate states, Egypt and Mesopotamia, at either end of the Fertile Crescent (Figure 1.2) resulted in the formation of secondary state societies in the southern Levant (Figure 1.3) (Falconer & Savage, 1995:48; Greenberg, 2014:615). However, the mechanisms of interaction that generated and maintained the secondary state societies and large urban settlements in the southern Levant are not fully understood (Cowgill, 2004:530). The formation of secondary states is influenced by two factors: 1) the structure of local social organisation prior to state formation, and 2) the scale of interaction between the developing state and neighbouring primary states (Parkinson & Galaty, 2007).

## 1.3 Urbanism during the EBA of the southern Levant

The formation of early complex societies in the southern Levant occurred in tandem with a rise in urbanism. This aggregation of people into larger settlements in the southern Levant initially developed during the EB II and continued throughout the EB III, when it reached a zenith (Richard, 1987; de Miroschedji, 2009). During the EB II large

villages (e.g., Arad, Bet Yerah, Tel Yarmuth) expanded into large urban centres, dominating the smaller polities under their domain (see Figure 3 in de Miroschedji 2009:107) (Finkelstein, 1995; Fall, Lines & Falconer, 1998:108).

The development of urbanism in southern Levantine settlements has been studied in detail at the elite (de Miroschedji, 1988; de Miroschedji, 2003) and at the workshop (Mazar, 2001; Greenberg *et al.*, 2012) levels. However, less attention has been given to an examination at the residential level and the activities of the "everyday" people. This preference for analysing more "glamorous" remains has left the commoners, or non-elite residents, overlooked in the archaeological record (Allentuck, 2004:7; Allentuck & Greenfield, 2010:12). The material remains of such people should receive scholarly attention because of their potential to provide information on the domestic activities and the daily life of the majority of a population (Brumfiel & Earle, 1987:4; Hendon, 1996:46; Allentuck & Greenfield, 2010:12). This source of information is equally, if not more important, than that of elite, glamorous remains.

**1.4 Economic systems and exchange in early complex societies**

Economic systems and exchange, the movement of commodities, are important components of human behaviour and group interaction, both in the present and past. For the most part, basic economic principles govern the nature of production, distribution, and consumption behaviour (Sinopoli, 1988; Masson, 2005; Rice, 2005:168). However, economic systems often transcend the simple acquisition of commodities for subsistence (Polanyi, 1977:35-38). Not only do economic systems connect producers with consumers through exchange, but they also serve as a means by which relationships are generated

and maintained on many social levels within and between geographic regions (Nash, 1966:4; Sahlins, 1972:186).

Archaeological research on early complex societies has identified several mechanisms involved in their formation, namely administrative networks, economic systems and economic specialisation (Gelb, 1967; Wright, 1977; Adams, 1981). Economic systems were key components in the emergence and prosperity of urban settlements and complex societies, particularly those of the southern Levant during the EBA (Wright & Johnson, 1975:268; Polanyi, 1977:59; Ben-Tor, 1986:4-5). Throughout the southern Levant, urban and rural settlements participated in various scales of exchange. These included local networks involving domestic commodities to the exchange of high demand elite commodities intra-regionally within the southern Levant and inter-regionally with Syria, Sinai and Egypt (Harrison, 1993:86; Stager, 2000). An understanding of the economic systems and exchange networks reveals the relationships and interactions among neighbouring and distant communities and regions (Masson, 2005:1138; Wright, 2008: 130-143). However, the nature and impact of intra-regional exchange of locally produced commodities for domestic consumption on the evolution of early complex societies in the southern Levant during the EBA are not well understood (Wright & Johnson, 1975:277; Cowgill, 2004:530; Shai & Uziel, 2010:69; Milevski, 2011:4-5).

**1.5 Potential of ground stone artefacts**

In recent years, the study of ground stone artefacts has proven useful to increasing our understanding of the formation and nature of early complex societies. The analysis of ground stone tools can be organised into three broad approaches: 1) a purely typological

approach to categorising their function (Wright, 1992; Hovers, 1996; e.g., Citron-Katz, 2012), 2) a tribological approach, involving the study of interacting surfaces, to examine their use-wear patterns and to determine the grinded material (Adams, 1993; Dubreuil, 2004; Hamon, 2008; Liu *et al.*, 2010; Adams, 2014a), or 3) a provenance approach to identifying their source (Philip & Williams-Thorpe, 1993; Rowan, 1998; Rutter, 2003; e.g., Mallory-Greenough & Greenough, 2004). Individually, these approaches provide information on separate aspects of a ground stone artefacts life-history. However, ground stone artefacts have the potential to reveal much more about the human behaviour associated with them. In this thesis, this was accomplished through a *longue durée* examination of their life-history and by the incorporation of analytical aspects of each of the aforementioned approaches.

## 1.6 Tell es-Safi/Gath as an appropriate locale for research

Archaeological excavations at Tell es-Safi/Gath in the Shephelah, Israel, have uncovered the remains of an EBA settlement (Maeir, Shai & Horwitz, 2011; Greenfield, Shai & Maeir, 2012; Shai, Uziel & Maeir, 2012; Uziel & Maeir, 2012; Shai *et al.*, 2014). These remains are located on the lower tell, away from the acropolis of the site and have been securely dated to the EB III. Analyses of the remains suggest that this section of the settlement contained a residential, non-elite neighbourhood composed of approximately four housing structures. Further EBA remains have been discovered across the tell, including massive stone fortifications, and represent the area that the EB III settlement covered (ca. 24 hectares) (Uziel & Maeir, 2005:56). Due to the extent and volume of the remains, Tell es-Safi/Gath can be considered a large urban centre during the EB III of the southern Levant. The analysis of material from Tell es-Safi/Gath, specifically its

residential neighbourhood, provides an opportunity to investigate issues regarding human behaviour at a large urban centre during a period of socio-political complexity in the southern Levant.

## 1.7 Focus of research

From the brief presentation above, it is evident that three main areas of archaeological inquiry require further research: 1) the domestic life and activities at Tell es-Safi/Gath and in the southern Levant, 2) the socio-economic standing of Tell es-Safi/Gath in Shephelah and southern Levant, and 3) the nature and impact of economic systems in early complex societies. In order to fill in these gaps of knowledge and to investigate the questions posed in the first section of this chapter, I attempt two tasks. First, I summarise the knowledge acquired from an extensive literature review and second, I present the results of a study on the life history of ground stone artefacts from the excavations of the EB III neighbourhood at Tell es-Safi/Gath, Israel.

More specifically, this research involved an examination of the production, distribution, consumption, and discard of the basalt ground stone assemblage of a southern Levantine settlement. This examination was performed in anticipation that information would be generated about the proposed nature of their provenance, proficiency of craftsmanship, typology, use-wear, use-life stage, and condition. It incorporated a number of methods and techniques, each focused on a different aspect of the life-history of the basalt ground stone artefacts. The significance of this study offers insight into the nature of economic systems that involved the residents of Tell es-Safi/Gath and the role economic systems played in early complex societies during the EB

II-III of the southern Levant. As such, it increases our understanding of early secondary states and their development over time.

## 1.8 Research outline

A description of the geographic, temporal, and socio-political setting of the EB II-III southern Levant is presented in Chapter 2 and is accompanied by a description of the EB III remains of Tell es-Safi/Gath. Two chapters present the theoretical background to this thesis. This information is contained in Chapter 3 regarding economic systems and exchange and in Chapter 4 discussing the research and life-history of ground stone artefacts. Based upon this review, Chapter 5 outlines the questions and hypotheses investigated and the methods and techniques through which this investigation was performed. The data generated and the subsequent analyses are described and tested against the hypotheses in Chapter 6. From the verification or rejection of the hypotheses, a reconstruction of the life-history of the basalt artefacts is presented and interpreted in the larger context of Tell es-Safi/Gath and the EB II-III southern Levant in Chapter 7. Additionally, the significance of research, future research, analytical considerations, and concluding remarks are included in Chapter 7.

# Chapter 2. Region, site and settlement description

## 2.1 Introduction

The EB II-III of the southern Levant has been referred to as a period of socio-political transformation through societal rise and collapse (de Miroschedji, 2009). As this thesis is immersed the same context, it is important to understand the cultural and natural settings in which these transformations occurred.

This chapter describes the cultural and natural settings of the EB III Tell es-Safi/Gath and the EB II-III southern Levant. This is accomplished by a synthesis of previous research focusing on the historical geography, chronology, and socio-political environment of the EB II-III southern Levant and the excavations at Tell es-Safi/Gath. The latter topic includes a breakdown of the residential remains and stratigraphic phases discovered at the EB III settlement. As a result, the contents of this chapter provide the spatial and temporal context for the proceeding chapters.

## 2.2 Historical geography of the EB II-III southern Levant

This section outlines the natural boundaries of the encompassing region of the southern Levant and sub-regions within it. In addition, the climate during the EBA is described.

### 2.2.1 Regional geographic boundaries of the southern Levant

The southern Levant is situated in the southwestern side of the Fertile Crescent (Figures 1.1 and 1.2). It is both a prehistoric and historic archaeological hot spot as it lies in close proximity to the gate to the Sinai, the gate of Africa. The borders of the southern Levant are loosely defined, save for the eastern coast of the Mediterranean Sea that forms the western border of the region. The southern Levant encompasses modern Israel with

exception of the southern portion, concluding at the beginning of the Negev Desert (Mazar, 1990:3; Milevski, 2011:5). The border between Israel and Lebanon, and the border between Israel and Syria serves as the northern border. To the east, the southern Levant retains an ambiguous boundary, roughly demarcated by a decrease in the concentration of settlements as one approaches the Eastern Desert to the east of the plateau on which sits modern and ancient sites of Amman and Madaba (Mazar, 1990:2; Beitzel, 2003:5; Milevski, 2011:5).

### 2.2.2 Geographic sub-regions of the southern Levant

Natural and environmental boundaries serve to divide the southern Levant into sub-regions. Within the southern Levant these boundaries include the Jordan River, the Dead Sea and changes in topography and vegetation (e.g., flat plains to foothills) (Suriano, 2014:91-93). Boundaries such as these segregate areas into the following sub-regions: the Shephelah, the Jezreel Valley, the Dead Sea Plain, the Jordan Valley, the Southern Coastal Plain, the Central Coastal Plain, the Central Hill country, the Golan, the Hulah Valley, the Lower Galilee, the Western Galilee, and the Southern Hill Country. These divisions allow the relationships between sub-regions and settlements to be analysed more effectively and on a smaller scale. A useful division of the southern Levant into sub-regions in presented by Milevski (2011:6) and this standard is used throughout the thesis (Figure 2.1).

### 2.2.3 Climate of the EB II-III southern Levant

Data from geo-archaeology, palynology and dendrochronology indicate that the climate of the EB II-III was more temperate than that of the present (Rosen, 2003:14; Levy-Reifer, 2012:558). Hospitable climatic conditions of the southern Levant provided

the inhabitants with a lush environment in which to cultivate both plants and animals (Levy-Reifer, 2012:558). This enabled the inhabitants to cultivate in areas that were topographically unpleasant in previous centuries, such as the stepped highlands. Many rivers, running from the highlands to the Mediterranean coast, and seasonal *wadis*, small channels of water, provided the southern Levantine inhabitants with water sources for hydration and irrigation. Orchards, groves, and vineyards sprang up as woodlands were cut down (Levy-Reifer, 2012:558). It has been proposed that changes in the climatic, the conditions of which have not received consensus, influenced the societal collapse and abandonment of cities at the end of the EB III (Weiss & Bradley, 2001; Faust & Ashkenazy, 2007).

## 2.3 Chronology of the EBA southern Levant

This section discusses the EBA chronology of the southern Levant. It is important to establish the temporal setting of the southern Levant as it narrows the focus of analysis for this thesis not only into temporal periods, but also into cultural periods. Furthermore, it permits cross-regional comparisons and allows for cultural developments and changes to be identified and monitored over time. This is accomplished in the following sections through of the cultural periodization, absolute dating results, and synchronisms between the Egyptian chronology and the southern Levant.

### 2.3.1 Cultural periods of EBA of the southern Levant

Using the principles of artefact seriation presented by Petrie (1881), pioneers in Near Eastern archaeology, such as Wright (1936; 1971) and Amiran (1969), were able to successfully divide the EBA of the southern Levant into four sub-periods. These sub-

periods are based on ceramic sequencing and changes in the material culture. A summary of the four sub-periods is included below.

#### *2.3.1.1 Early Bronze Age I (ca. 3500-3060 BCE)*

The EB I of the southern Levant is characterised by polymorphic societies where mobile groups existed alongside small villages and town-sized settlements (de Miroschedji, 2009:101). It is distinguished from the Chalcolithic by the advent of regional site-size hierarchies where there is a movement toward the beginning of urban lifestyles during the EB I (Greenberg, 2014:614).

Inhabitants of the southern Levant continued to rely heavily on agriculture and the exploitation of livestock and their secondary products (Richard, 2003:287). Pottery production appears restricted to individual sub-regions with the appearance of the Proto-Urban industries (Amiran, 1969:42; de Miroschedji, 2009:105). In addition, there is a shift from shaft tombs and secondary burials to larger communal tombs containing primary burials representing a de-emphasis on the individual (Harrison, 2001:217-219).

#### *2.3.1.2 Early Bronze Age II (ca. 3060-2925 BCE)*

The EB II of the southern Levant is demographically marked by an abandonment of many EB I villages, a significant increase in the scale of urbanism with the emergence of cities (de Miroschedji, 2009:106). A three-tier settlement-size system first appears during this sub-period. The first or lowest tier is characterised by unfortified and rural villages. The second tier settlements, many of which are also fortified, are fewer in number than first tier settlements, but larger in size (Richard, 2003:289). They correspond to towns. The third or upper tier settlements are considered cities as they are larger in size, more complicated in their structure, and surrounded by large-scale

fortifications (Greenberg & Paz, 2005). It is likely that each of the upper-tiered settlements dominated their local sub-regions (Finkelstein, 1995).

New pottery industries also emerge, namely Northern Canaanite Metallic Ware, Abydos, and grey burnished ware (Greenberg & Porat, 1996). These industries are not restricted to several sub-regions, but are discovered across the southern Levant and in Egypt as well (Shai & Uziel, 2010:68).

#### *2.3.1.3 Early Bronze Age III (ca. 2925-2545 BCE)*

The EB III of the southern Levant experiences a continuation of the settlement and other cultural patterns found in the EB II (de Miroschedji, 2014:986). As a result, the two sub-periods are often grouped together in the literature (e.g., Mazar, 1990; de Miroschedji, 2009).

During this sub-period, urbanism reaches its pinnacle and city-states dominate the sub-regions (Finkelstein, 1995; Rast, 2001). However, several large EB II settlements in both the northern and southern sub-regions (e.g., Arad, Bet Shean) are not occupied during this sub-period. The growth of fortified cities and abandonment of some may mark the advent of inter-settlement competition and conflict since they are not peacefully abandoned.

New industries of pottery appear, collectively marking the transition to the EB III. Khirbet Kerak Ware, a pottery industry developed around Bet Yerah and the Galilee sub-region, appears as a defining indicator of EB III material culture (Greenberg *et al.*, 2012:99; Greenberg, 2014:863).

For reasons that are still debated by archaeologists and range from climate change to conflict, almost all of the large and small settlements were abandoned at the end of the

EB III (Weiss & Bradley, 2001; Faust & Ashkenazy, 2007). This results in a relatively abrupt conclusion to the prosperous EB III sub-period and the ushering in of the more ephemeral EB IV.

#### *2.3.1.4 Early Bronze Age IV (ca. 2545-2300 BCE)*

The EB IV, alternatively called the Intermediate Bronze (IB) or Middle Bronze I (MB I), of the southern Levant is a quiet sub-period in the southern Levantine chronology as there is little evidence of large-scale sedentary settlements (Chapman, 2009:6). With the abandonment of the EB II-III settlements, the nature of settlement patterns change – small temporary villages and campsites were erected and occupied (Prag, 2014:1235). It is often debated whether mobile groups from the desert took advantage of the region or whether these are the remains of the once-proud occupants of the EB II-III cities The evidence supports the latter, since artefact industries were locally produced and consumed and display some evidence of continuity to those of the EB II-III (Prag, 2014:1222).

Ultimately, the inhabitants of the region left few defining archaeological traces causing archaeologists to debate whether this sub-period should be included in the EBA, be an independent transitional period, or be part of the MB (Richard, 1987:36). Several settlements, mainly those in Jordan (e.g., Khirbet Iskander), demonstrate more cultural continuity with the EBA than with the Middle Bronze Age (Richard, 2003:294-295).

### 2.3.2 Southern Levantine synchronisms with Egyptian chronology

Interest in Near Eastern archaeology and Egyptology sought to chronologically connect the two regions. This task was first attempted by Petrie (1881; 1891) through his work on pottery seriation from Tell el-Hesi (Anderson Jr., 2006:103). However, it was

not until the 1930-1960s that significant strides were made in this endeavour (e.g., Wright, 1936; Wright, 1937). However, there were no absolute dates to which the cultural sub-periods could be assigned. A lack of historical records in the southern Levant left archaeologists unable to attach absolute dates to the EBA chronology (Shai & Uziel, 2010:69). As a result, archaeologists turned to synchronisms with the closest neighbour of the southern Levant that had a fixed historical chronology: Egypt (Shaw, 2000:480-489). This was possible because by the 1960s Egypt had a well-arranged historically-anchored chronology based on king lists, synchronisms with celestial events, and other historically anchored kingdoms (Kitchen, 1991:202). The use of pottery as a means for chronological synchronisation and the constructed relative chronology of the EBA are discussed below.

#### *2.3.2.1 Chronological synchronisation through artefact seriation*

Synchronisms between the sub-phases of the EBA southern Levant and the Egyptian chronology are constructed through artefact correlations, namely inter-regional pottery seriation (Regev, de Miroschedji & Boaretto, 2012:505). Understanding the exchange of pottery between Egypt and the southern Levant is vital to establishing this shared chronology. Imported vessels from the southern Levant have been discovered in dated Egyptian contexts, such as tombs, providing a date range for that specific industry and typology in the southern Levant (Dever, 2003:84). For example, one pottery industry, Abydos ware, was discovered in the tombs of nobles found in Upper Egypt (Mazar, 1990:135; Braun, 2009:28). This ware, dated to Egyptian Dynasty I, has been provenanced to the southern Levant where there is further evidence of its production and local distribution in the EB II around the Sea of Galilee (Dever, 2003:84; Sharon,

2014:148). Hence, roughly all contexts in which Abydos ware is found within Levantine sites are dated to the same time period as these tombs. This classic relative dating technique, horizontal pottery seriation, has anchored the EBA dates for the southern Levant for the past sixty years, providing a reasonable intersection of historical records and relative dating. While there are minor discrepancies in date ranges based on the author cited (Mazar, 1990; e.g., de Miroschedji, 2009; Milevski, 2011), it is apparent that each cultural transition of the EBA corresponds with changes in Egyptian Dynasties.

#### *2.3.2.2 Relative chronology of EBA southern Levant*

In summary, the synchronisms with the Egyptian chronology provided a stable chronological framework for the relative chronology of the EBA of the southern Levant. The synchronisms are outlined in Table 2.1. In general, the EB I aligns with the Naqada reign and Dynasty 0, while Dynasty I marks the commencement of the EB II which lasts through Dynasty II (Kitchen, 1991; Ben-Tor, 1992:82; Shaw, 2000:480-489; Hasel, 2004; Sharon, 2014:148-149). The EB III begins with the Old Kingdom (Dynasty III) and ends with Dynasty V. The EB IV correlates with Dynasties VI-VIII (Kitchen, 1991; Ben-Tor, 1992:82; Shaw, 2000:480-489; Hasel, 2004; Sharon, 2014:148-149).

### 2.3.3 Absolute chronology of the EBA southern Levant

Until recently the southern Levant had been without an absolute chronology, relying on relative dating techniques with the Egyptian Dynasty chronology. Radiocarbon (C14) dates from various EBA settlements were produced in separate studies, typically appearing in site reports (Weinstein, 1984; Golani, 2004; e.g., Anderson Jr., 2006). Recently, most of the data have been amalgamated into a larger regional study, conducted by Regev et al. (2012), producing a set of absolute dates for the EBA and its sub-periods.

These provide a more concrete absolute chronological framework for the EBA southern Levant and its sub-periods (Table 2.2). Consequently, the chronology generated by Regev et al. (2012) is used throughout this thesis.

However, these absolute dates are earlier than initially anticipated (Philip, 2008:167; Regev *et al.*, 2012:525). This absolute chronology stands in contrast to that of the previously established EBA chronological framework based on synchronisms with the Egyptian chronology, as seen in Table 2.2 (Regev, de Miroschedji & Boaretto, 2012; Regev *et al.*, 2012). The dates of the EB I are similar between the two chronologies. The EB II dates have been greatly shortened from the 400-year span of the relative chronology (ca. 3050-2600 BCE) to an approximate 150-year span (ca. 3500-3060 BCE) based on the absolute dates. In addition, the absolute dates of the EB III (ca. 2925-2545 BCE) are earlier than those of the relative chronology (ca. 2600-2300 BCE). The following EB IV dates of the absolute chronology (ca. 2545-2300 BCE) are also earlier than those synchronised in the construction of the relative chronology (ca. 2300-2000 BCE).

The C14 absolute chronology system for the EBA indicates a higher (earlier) chronology than that based on the synchronisms with Egypt. This breaks the link between the EBA sub-periods and the various Egyptian dynasties. As a result, the temporal parameters of the EBA southern Levant have come under scrutiny and are in the process of revision, suggesting that the integration of an absolute chronology for the EBA southern Levant is imminent.

## 2.4 Socio-political environment of EB II-III southern Levant

The transition from the EB I to the EB II of the southern Levant is characterised by a rapid increase in urbanism and the emergence of large permanent settlements (Richard, 2003:290; de Miroschedji, 2009). The former polymorphic societies of the EB I, consisting of mobile groups and small villages, expanded into EB II urban centres or were abandoned (de Miroschedji, 1999:4). Many urban centres thrived during the EB II-III until a socio-political collapse that marked the end of the EB III. The EB III marks the zenith of urbanism and socio-political complexity of the EBA southern Levant (Mazar, 1990:111; Greenberg, 2014:622).

Urbanisation during the EB II produced a different socio-political environment than that of the EB I. It is in this political environment that the life-history of the basalt artefacts from Tell es-Safi/Gath occurred. However, the nature of this socio-political environment has not received consensus. Two models have been put forth: city-states (Finkelstein, 1995; Greenberg, 2002; de Miroschedji, 2009) and corporate villages (Chesson, 2003; Chesson & Philip, 2003; Savage, Falconer & Harrison, 2007; Philip, 2008). This scholarly divide appears between archaeologists analysing Israeli and Jordanian sites respectively. Although they appear as polar ends of the socio-political complexity spectrum applicable to the EBA (de Miroschedji, 2014:986), it is possible for both models to coexist (Greenberg, 2003:27). These two models are reviewed in the sections below in order to provide a framework in which to consider the life-history of the basalt artefacts of Tell es-Safi/Gath and the southern Levant.

### 2.4.1 City-states

The city-states of the EB II-III southern Levant are argued to be the result of secondary state formation. The formation of secondary states is influenced by two factors: 1) the structure of local social organisation prior to state formation, and 2) the scale of interaction between the developing state and neighbouring primary states (Parkinson & Galaty, 2007). Situated between two primary state societies, Egypt and Mesopotamia, the southern Levant interacted with both (Mazar, 1990:110; Cline, 2003:361). Due to this proximity, it is likely that the southern Levant was influenced during the EBA by developments in both of these two regions. Overland exchange routes, extending from the northern Levant and Mesopotamia to Egypt, passed through the southern Levant (e.g., Way of Horus, King's Highway) (Savage, 2011). Not only would commodities move through the southern Levant, but ideas, information, and people as well (Broshi & Gophna, 1984:50). Secondary state formation in the southern Levant was then the result of a trickle-down effect of what was occurring else where in the Near East.

The city-states model maintains that the largest urban settlements of the EB II-III southern Levant retained a centralised authority that dominated the local sub-region (Shai & Uziel, 2010:68; de Miroschedji, 2014:995). Fortification, palaces, temples, and large-scale workshops testify to the centralised control that was necessary to organise people in order to erect these structures (de Miroschedji, 2003; Greenberg *et al.*, 2012:92). As settlements of various sizes have been discovered, it is plausible that there was a hierarchy of settlements within a sub-region (Richard, 1987:27). Simultaneously, a core-periphery relationship between the larger settlements and the surrounding smaller settlements was generated (Richard, 2003:286). Variations of this model exist that refrain

from using the term *city-states* (e.g., Finkelstein 1995). However, in the variations of this model, the sub-regional *polities*, the term used in place of city-states, are described as operating in a similar fashion.

Prominent EB II-III settlements, such as Megiddo in the Jezreel Valley, Beth Shean in the Jordan Valley, Bet Yerah on the border of the South Galilee, Arad and Ai in the Southern Hill Country, and Bab edh-Dhra in the Dead Sea Plain, emerged as the dominant urban centres of the sub-regions in which they resided (Amiran, 1978; Greenberg, 2003). It is hypothesised that the elites of urban centres controlled the distribution of commodities to and from the peripheral settlements and villages within the native sub-region (Milevski, 2011:234).

This trend was also present in the Shephelah as the urban centre of Tel Yarmuth rose to prominence (de Miroschedji, 1988; de Miroschedji, 1999:17). Due to its rapid increase in settlement size and the presence of palatial structures, it is considered to be the dominating centre in its local sub-region (de Miroschedji, 2003; de Miroschedji, 2006:74). Recent archaeological investigation at Tell es-Safi/Gath question this assumption, suggesting that Tell es-Safi/Gath may have been a sister or competing sub-regional centre in the Shephelah (Shai *et al.*, 2014). As most of the literature regarding Tel Yarmuth predates excavations at Tell es-Safi/Gath, it is imperative that an examination of the relationship between these two urban centres be conducted.

### 2.4.2 Corporate villages

An alternative theory regarding the socio-political environment of the EB II-III southern Levant contrasts with the aforementioned one in that it demotes the hype of urbanism (Falconer & Savage, 1995). This reduction of the "grand narrative" of the linear

evolution of social complexity in the southern Levant does not consider "urban centres" to be locations of centralised authority or as large-scale cities (Chesson & Philip, 2003:4). It is argued that, due to their settlement sizes and dependence on local rather than imported resources, the large urban centres were neither cities nor could support a system as complex as a city-state (Harrison and Savage 2003:50; Savage et al. 2007:294).

In contrast, the corporate village model consists of village communities that were internally tied together by kinship, where economic units (households) worked together for economic gain (Philip, 2008:165). This model heightens the importance of peripheral villages, maintaining that they were more complex than previously supposed (Schwartz & Falconer, 1994:2).

Social bonds are generated and maintained by common needs and participation in community activities (Chesson, 2003:82). Transmission of behaviour and wealth would occur through each household, eventually creating disparities in influence and power between households. The wealth of a household within a neighbourhood promoted them to the status of a cooperate estate, where power is shared with other cooperate estates within the village community (Philip, 2008:165). In turn, these villages, particularly those within Jordan, are identified as corporate villages (Philip, 2008:165). While corporate villages are not wholly egalitarian, it is proposed that the absence of elites forced households to cooperate with each other in an effort to construct community structures (Chesson, 2003:82). Leaders of separate corporate estates would organise the construction and maintenance of non-residential projects, including agriculture, fortifications and temples. The local economy is sustained through the individual village as wealth was deployed through public projects rather than through a consolidation by

elites (Philip, 2008:166). The population and physical size of these villages would increase or decrease in relation to their local prosperity. Consequently, when applying the corporate village model, the focus is placed on internal mechanisms of growing complexity, not only within the southern Levant, but within the villages and households (Harrison and Savage 2003; Savage et. al 2007).

## 2.5 The EB II-III of Tell es-Safi/Gath

The sections that follow describe the EB III remains at Tell es-Safi/Gath and place it in a both a geographic and archaeological context. It is imperative that this thesis be grounded in a firm understanding of the geographic setting cultural environment in which the occupants of Tell es-Safi/Gath resided and performed daily activities. For the same reasons, it is important to describe the excavations and archaeological remains of Tell es-Safi/Gath as the basalt ground stone assemblage originates from the recovered material culture.

### 2.5.1 Geographic setting of Tell es-Safi/Gath

The archaeological site of Tell es-Safi/Gath is located in central Israel, around the midway point between modern Ashdod and Bet Shemesh, approximately 25km inland from the Mediterranean Sea. Situated on the border of the Shephelah and Coastal Plain, the ancient settlement of Tell es-Safi/Gath resided atop a natural mound protruding on the landscape. Constructing a settlement atop the elevated mound was advantageous to the occupants as it allowed them to identify an advancing military enemy from a great distance. The necessity of security at Tell es-Safi/Gath is further attested by the recent discovery of massive stone and mud-brick fortifications encompassing the mound.

This isolated mound, rising to 231 meters, belongs to an Eocene geological formation of deep-water chalk (Ackermann & Bruins, 2012:124). The land surrounding the tell was arable and permitted agricultural production. Additionally, as seasonal rains occurred, the local wadi of Nahal Ha'elah became flooded and provided an accessible source of water. During the EBA, the water table would have been higher providing an abundance of flowing water year round (Ackermann & Bruins, 2012:124). The cumulative factors mentioned above made Tell es-Safi/Gath a strategic and hospitable location to occupy.

### 2.5.2 Occupation at Tell es-Safi/Gath

Millennia of occupation at Tell es-Safi/Gath has produced sequential layers of cultural material resulting in a *tell*, a mound of artificial strata. The sequential layers of are composed of multiple temporal periods, with occupation stretching from the Chalcolithic to 20$^{th}$ century CE, represented at the site (Uziel and Maeir 2005).

The name of the site is thought by some to derive from the underlying geological base that displays defining white or *safi* (meaning white or pure in Arabic) cliffs. However, biblical scholars also note that the *Safi* in Arabic is probably also derived from the ancient Canaanite and Hebrew name of the site, *Tsafit*, which means "watchtower" (Maeir, 2012:7). This is an appropriate name for its location with views from the Mediterranean to the mountains of Judea. Furthermore, this tradition is evident in the French Medieval name of the site, *Blanche Garde* (or White Fortress) (Maeir, 2012:67). Blanche Garde was a medieval crusader fort built atop Tell es-Safi/Gath and is noted by the visit of King Richard the Lion-hearted (Boas, 2012:154).

The second half of the name Tell es-Safi/Gath, *Gath*, is name of the site when it was the biblical Philistine city associated with the popular Philistine hero Goliath (Levin, 2012:141). The Philistine or Iron Age I-IIA (ca. 1200-925 BCE) remains have been discovered across the site and have been identified as the city of Gath (Macalister, 1914:72; Maeir, 2012:6). Several occupational layers below this Iron Age city are the remains of an extensive EBA settlement.

### 2.5.3 Tell es-Safi/Gath archaeological project

Since 1996, a large-scale archaeological excavation of Tell es-Safi/Gath, Israel, has been conducted. This project is organised through Bar Ilan University, Israel, and directed by Prof. Aren Maeir. The Tell es-Safi/Gath excavation receives participation from a number of different universities and disciplines, including the University of Manitoba.

The University of Manitoba has been involved in the excavation since 2008 under the supervision of Prof. Haskel Greenfield. The participation of the University of Manitoba has been funded by a variety of grants, including most recently (2012) a SSHRC partnership grant entitled *Nature of Early Urban Neighbourhoods in the Southern Levant: Early Bonze Age at Tell es-Safi*. This recent SHHRC grant sponsors the excavations in Area E and where the EBA settlement has been uncovered. As a result, it is from these remains that the material culture analysed in this thesis originates.

### 2.5.4 EB III remains of Tell es-Safi/Gath

The EB III remains of Tell es-Safi/Gath are mostly recovered from Area E on the eastern slope of the tell. Other EBA remains have been discovered in Areas F, G, and P, but these were too limited to use in this thesis. Although only a small fraction of the total

EBA remains buried on the tell have been excavated, it is expected that a significant amount of knowledge will be generated from them.

The remains from Area E appear to be that of a domestic neighbourhood. There is no evidence of industrial or specialised productive activities. The remains consist of several houses (so far, 4 spatially, but 7 temporally have been uncovered) aligned on either side of a narrow alleyway. No doorways have yet been discovered that link rooms together. Neither the edges of the neighbourhood nor full extent of any of the structures have been identified. There is no evidence of elite artefacts or structures in the remains. From within all the rooms, an abundance of pottery, fauna, and chipped stone artefacts have been recovered. However, it does not seem to be the remains of a poor or low-class neighbourhood. At best, it can be surmised that it is the remains of a residential or domestic neighbourhood (Shai et al. 2014), although it has elsewhere been proposed that it may represent a middle-class merchants quarter (Greenfield, Shai & Maeir, 2012:44).

At present, three stratigraphic EBA layers have been identified: (in descending order) Strata E5, E6, and E7 (Shai *et al.*, 2014). The dating of each stratum is as follows: Stratum E5 – latter half of the EB III, Stratum E6 – earlier part of EB III, and E7 – most likely EB II (Shai *et al.*, 2014). The most extensively excavated of these strata is Stratum E5. A much smaller area of the underlying Stratum E6 has been uncovered to date. As Stratum E7 is completely unexcavated and poorly understood at this time, the focus of the thesis was on remains from Stratum E5 and Stratum E6. Little has been published on these remains with the only information coming from Shai et al (2012) and Shai et al. (2014). A description of the remains in each stratum is entailed in the following sections.

#### *2.5.4.1 Stratum E6*

Only small excavations of Stratum E6 have occurred, limiting the amount of knowledge extracted from it. Evidence of mud-brick walls, possibly a superstructure atop stone foundations, has been discovered directly underneath almost all of the walls of Phase E5c. The walls of Stratum E6 lie directly below the walls of Stratum E5, following the same orientation. This suggests that the Stratum E5 occupants built directly upon the underlying remains of Stratum E6 walls in an effort to reproduce the neighbourhood layout (Shai *et al.*, 2014). Two circular hearth-like installations were discovered in the south-west corner of Area E. Nothing more has been published on the Stratum E6 remains, as yet.

#### *2.5.4.1 Stratum E5*

Stratum E5 is the most excavated EBA phase at Tell es-Safi/Gath (Figure 2.2). To date, Stratum E5 contains three architectural *phases* E5a, E5b and E5c, with E5a being the latest phase (Shai *et al.*, 2014). These phases contain shared architectural structures, but with several additional architectural changes that occurred in each later phase (Shai *et al.*, 2014). The phases are listed from earliest to latest as E5c, E5b, and E5a, and are described below.

2.5.4.1.1 Phase E5c

During this phase, the walls associated with the houses in the neighbourhood are established. The entire neighbourhood is rebuilt along the lines of the Stratum E6 architectural layout testifying to the cultural continuity between the two periods.

In general, the remains associated with Phase E5c include walls, rooms, hearths, and other various installations (Figure 2.3). The orientation of the walls is NW-SE and

follows the elevation of the tell (Shai, Uziel & Maeir, 2012:221). These walls are identified as two parallel courses of stacked field-stones, though during the EB III the stones would have served as the foundation for a mud-brick superstructure. Although the structural integrity of the mud-brick walls has been damage due to destruction, rebuilding and time, the field stone foundations still demarcate the various rooms. Three buildings existed during this phase: 134307, 134817, and 114805. However, it is possible that they are all part of one larger patrician building (Shai *et al.*, 2014:23). These are described below.

Building 134307 is a large residential complex containing five rooms (Shai *et al.*, 2014:23). It is suggested that, due to the size of the central room (114602), it probably served as an open-air courtyard as the other rooms are considerably smaller by comparison (Shai *et al.*, 2014:23). In the centre of the courtyard a large circular feature (94606) composed of pile field-stones with a flat top was discovered. A concentration of phytoliths and a hearth-like installation (114607), composed of small pebbles and filled with ash, were immediately adjacent to the piled field-stone feature (Shai *et al.*, 2014:24). The floor of the courtyard was beaten earth (114502) (Shai *et al.*, 2014:24). A donkey burial (134602) was exhumed within the south-west corner of the courtyard and its burial pit was sealed by the compacted soil of Phase E5c (Shai *et al.*, 2014:24). Little is known about the function of the rooms (134311, 134313, 134309, and 134404) adjacent to the courtyard (Shai *et al.*, 2014:24). However, Room 134309 contained a beaten earth floors mixed with crushed limestone (Shai *et al.*, 2014:24).

Building 114805 is located in the north-west corner of Area E and has been partially destroyed by LBA occupation (Shai *et al.*, 2014:23). Its sole room (114805) has

been partially excavated but revealed significant finds. Among these is a circular installation (104804) elevated on a mud-brick platform (Shai *et al.*, 2014:23). This installation was composed of small pebbles and laden with ash. An ivory cylinder seal was discovered in a pottery vessel next to the installation that suggests that the occupants were not of the lowest class and were socio-economically connected to administrative activities (Wright & Johnson, 1975:271; Maeir, Shai & Horwitz, 2011).

Building 134817 has also received limited excavation and contains two rooms (134817 and 134814). Room 134817 contains a semi-circular dome-shaped installation (134413) composed of stones and baked earth. It was constructed to reach the surrounding walls and its function is not yet known (Shai *et al.*, 2014:23).

At the west end of the buildings, an alleyway (104306) runs parallel to the NW-SE walls and on the same orientation. What lies on the other side of the alleyway is as yet unknown since excavation has not reached to that depth yet.

2.5.4.1.2 Phase E5b

For the most part, Phase E5b retains the same residential complex structure from the earlier phase (Figure 2.4). However, minor additions are evident.

Such additions are visible in the large residential complex, formerly Building 134307 now Building 74512. The courtyard (74512) contains installation 94606 from Phase E5c and a new similar installation (104904/13506). These installations may have operated as pillar bases for a roof. Adjacent to the courtyard (74512) several new walls are constructed separating the space into Rooms 84405 and 104604. A game piece was discovered in Room 84405.

Building 84309 was continued from Building 134817. Its full size is unknown but contains at least two rooms (84309, 134803). Pieces of a game board were discovered in room 84309 (Shai *et al.*, 2014:23).

2.5.4.1.3 Phase E5a

The walls of Phase E5a were constructed from large field stones stacked in two courses with a mud-brick superstructure on top in the same tradition as the previous two phases. They continue the same orientation (NW-SE), re-using many previous walls to demarcate the rooms (Figure 2.5). The two buildings that are present during this phase, 114206 and 104311, are discussed below (Shai *et al.*, 2014:26).

Building 114206, situated on the east side of the alleyway, contains a courtyard (114206) and four adjacent rooms (104207, 104602, 74612, 11402, and 94413). The courtyard (114206) is surrounded by walls except for the east side where it has likely been lost to erosion. Although there is no associated floor, the courtyard contains an installation (84109) composed of field-stones whose function is not yet known. However, the absence of pillar bases and the large dimensions of the courtyard indicate it may have been an open-air courtyard. Rooms 104207, 94413, and 104601 contain small circular hearth-like installations (114207, 94113, and 104602 respectively). A large LBA pit destroyed and removed remains within Room 74612, leaving it bare and enclosed by two walls (Shai *et al.*, 2014:26).

To date, Building 104311 consists of two rooms (104311 and 104018) but no discernable courtyard (Shai *et al.*, 2014:26). The two rooms in this residential complex are segregated by walls that run NW-SE. Room 104108 contains three distinct layers. The bottom layer, comprised of very fine, dark grey soil, yielded a surplus of organic

remains and two installations (E15AT04, E15AT06) composed of small pebbles. Atop this layer is a film of ash, the presence of which suggests a large fire. Sherds from broken vessels are sporadically distributed throughout and on top of the ash layer, suggesting they may have fell off of a shelf during the destruction of the structure. The ash layer is sealed by a large amount of mud-brick debris, comprising the final layer implying that this area of the EB III settlement was abandoned (Shai *et al.*, 2014:26).

The two buildings are separated by an alleyway (104306) that runs NW-SE. The alleyway is contoured to the downhill slope of the tell and is composed of intermittent layers of natural and artificial fill (e.g., pebbles and stones of various sizes, fragmented sherds, fauna, flora, and inorganic rubbish). It is plausible that these fills were discarded in the alleyway in an attempt to retard erosion (Shai *et al.*, 2014:26).

## 2.6 Conclusion

Archaeological excavations at Tell es-Safi/Gath have revealed an EB III residential neighbourhood composed of domestic remains. This neighbourhood is part of a large fortified urban settlement in the Shephelah sub-region of the southern Levant and contains a several occupational phases. These phases of occupation coincided with the pinnacle of EBA urbanism and a period of temperate and hospitable environmental conditions in the southern Levant. The fertile nature of the southern Levant, combined with anthropogenic mechanisms of survival and subsistence, provided a region in which an early complex society could thrive. One of these mechanisms, economic systems, is explored in the next chapter.

# Chapter 3. Literature review: economic systems and exchange

## 3.1 Introduction

The nature of exchange in past and present societies has been investigated through Anthropology since the origin of the discipline (e.g., Malinowski, 1922). In attempting to explain the nature of exchange in various societies, Anthropology has borrowed concepts from Economics and Sociology (e.g., capitalism, Marx, 1887). This has lead to a standardisation of the term *exchange* as the movement of physical commodities, information or services from one person or group to another (Renfrew & Bahn, 2004:357; Masson, 2005:1139). Exchange is viewed as an essential mechanism or "prime mover" in the formation of state or complex societies (Wright & Johnson, 1975:268; Adams, 2001:350).

Understanding the theoretical background of exchange was essential for this thesis. As a result, this chapter begins with a review of how commodities are exchanged and how this movement is identified and described in theory and in an archaeological context. The second section is a review of the exchange systems in early complex societies, and local, intra-regional, and inter-regional exchange of the EB II-III of the southern Levant. It further serves to describe different models and networks of exchange both in general and during the EB II-III of the southern Levant, how they arose and the components involved in their maintenance. The review of this literature provides the theoretical basis of exchange systems that is necessary to interpret the data in the chapters that follow.

## 3.2 Components of economic systems

Economic systems are composed of three elements: production, distribution and consumption (Costin, 1991:1; Abadi-Reis & Rosen, 2008:113). In any society, these elements cannot be considered in insolation of each other (Costin, 2005:1041). The sections below discuss the theoretical background for production, distribution, and consumption in relation to commodities. This discussion provides groundwork for understanding exchange in general, early complex societies, and the EB II-III of the southern Levant.

### 3.2.1 Production

The production of artefacts is a unique process as it converts natural raw material into cultural commodities. Production involves two components: procurement and manufacture. Hence, it is further identified as the economic organisation through which manufacture and procurement is arranged, including the degree of specialisation (Costin, 2005:1050). This allows the manipulation of technology and the environment to be studied in a social context (Schortman & Urban, 2004; Wright, 2008:150).

Manufacture is described as the act of material reduction or addition to form a commodity (Rice, 1996:173; Costin, 2005:1035). Procurement is the action of raw material extraction, typically occurring at quarries or sources of that are often denoted by the most proximate settlement. In the same manner, production centres are broadly referred to as the settlement in which manufacture occurs, though manufacture typically occurs in a house or workshop (Costin, 2005:1058).

#### *3.3.1.1 Craft specialisation*

Specialised production or craft specialisation is an aspect of production that involves the "regular, repeated provision of some commodity" (Costin, 1991:3). A high demand for a commodity often pressures craftsmen to devote more time to their craft, enhancing their skill increasing their productive output (Costin, 2005:1045). It is expected that a trained artisan engaging in repetitive manufacture techniques will produce artefacts types of high quality and similar form (Costin, 2005:1066). As a result, craft specialisation is traditionally identified by a standardisation in the typology of the commodities, a high quality of the commodities, and a consistency and in manufacture techniques (Shafer & Hester, 1986:159; Blackman, Stein & Vandiver, 1993:61; Costin, 2005:1066). This concept is present in the pottery (Rice, 1996; Rice, 2005:202) and chipped stone industries (Rosen, 1997:108) and can be applied to the ground stone industry (VanPool & Leonard, 2002; Wright, 2008:151).

#### *3.3.1.2 Organisation of production*

Several typologies outlining the organisation of production have been proposed (e.g., Costin 1986, Earle 1981, Peacock 1982). These are based on various criteria, namely the scale, intensity, and degree of centralisation. Such criteria categorise the models of production into typologies that range from household production to large-scale industries or factories. These typologies are expanded upon in Costin (1991) where further parameters (context, concentration, scale, and intensity) are considered (see Figure 1.4 in Costin 1991:9).

The *context* of specialisation contains two categories: independent and attached. Independent specialised artisans service unspecified consumer groups, allowing anyone

to acquire these commodities. Conversely, attached specialised artisans produce commodities for a specific consumer group, such as an elite person (e.g., king, pharaoh) or institution (e.g., temple). The context is identified by the location of the workshop and production remains. The workshops of independent artisans will typically be discovered in domestic structures and residences while attached artisans may work in community or elite structures.

The *concentration* of production addresses how the specialised artisans are demographically and geographically organised. If they are evenly spread across an area or servicing a number of consumers, they are described as dispersed. The clustering of specialised artisans within an area results in nucleation and increased competition. Concentration is identified through a regional approach that involves examining the number workshops and their proximity to each other.

The *scale* of production is divided into the system of recruitment and the number of participating personnel. The range in scale consists of a kin-based system to groups of unrelated contracted individuals working for compensation. The determination of scale is very difficult and operates under several assumptions: 1) the size of the workshop is related to the number of artisans, 2) a low output of commodities suggests few artisans, and 3) the size of the surrounding community does not indicate the size of output.

Another parameter, *intensity*, addresses the time invested into production, typically either a part-time to full time investment. Artisans must consider the efficiency, risk, and scheduling of their work. Intensity is arguably the most difficult parameter to identify.

Attempts have been made to do this through the examination of artefact, debitage, and debris densities under the hypotheses that the sparser the density the more likely part time production occurred. However, this does not account for the number of people involved as many part time artisans could produce the same output as a single full time artisan. Another approach, at least for households, is to examine the economic activities as a whole. This provides insight on the amount of time the household invested in each activity, including craft production.

These four parameters are combined to lay the groundwork for detailed models of production that range from individual to retainer workshop (see Table 1.1 in Costin 1991:10). Each is defined by a specific set of criteria. These parameters above and models of production served as the rubric employed in this thesis when addressing the life-history of basalt ground stone artefacts.

### 3.2.2 Distribution

Within Anthropology, there are three broad categories of distribution that connect producers with consumers: reciprocity, redistribution, and market exchange (Sahlins, 1972:185-188; Hodder, 1978:199-206; Rice, 2005:191). The core principles, variations, and examples of each are described below. These three categories are frequently divided into numerous sub-forms that may be applicable to early complex societies (Renfrew, 1975; e.g., Adams, 1992:144; Harrison, 1993:89; Garraty, 2010). These are addressed in the sections that follow.

#### *3.2.2.1 Reciprocity*

Reciprocity is often termed gift-giving and refers to the exchange of commodities or services of equivalent value between people, in order to create or maintain an amicable

relationship (MacCormack, 1976:89; Lazzari, 2010). This form of exchange can occur repeatedly (Mode 4), changing possession multiple times, or over long distances (Modes 2 and 3) (Figure 3.1).

A notable example of reciprocity is found in the gift giving by big men of the Mt. Hagen region of Papua New Guinea (Sahlins, 1963). Here *big men*, community leaders, engage in a system of exchange where gifts, usually pigs, are moved in an effort to acquire prestige through the generosity (Sahlins, 1963). The larger the gift given, the greater the prestige acquired.

The impact of reciprocity is greatest in pre-state societies (e.g., Maori, !Kung, Pilaga) (Lombardi, 1975:245; MacCormack, 1976:92). Because reciprocity exists on a small and personal scale, it is considered unlikely to have played a significant role in the mass movement of commodities over long distances, specifically in state-level societies (Brumfiel & Earle, 1987:2; Zeder, 1994:71; Wright, 1994a:71; Masson, 2005:1140; Stark & Garraty, 2010:44; Shaw, 2012:121). As a result, reciprocity is not expanded upon nor considered further in this thesis.

#### *3.2.2.2 Redistribution*

Redistribution is the second broad category of distribution. This form of exchange encompasses the collection of commodities by an agent, often a centralised authority, and a later apportioning of those commodities to their subjects (Bates & Lees, 1977:828; Masson, 2005:1140). This is typically performed to demonstrate a position of superiority, generate external alliances and to provide supporters with a certain standard of living (Earle, 2002:58). There is a large effort on the part of the centralised authority to be involved in craft production and exchange to enhance their political status.

A basic demonstration of this exchange, performed on a smaller scale, is through the potlatch ceremonies of northwest coast of North America aboriginal tribes (e.g., Tinglit, Nookta). During these elaborate ceremonies, the host, a man of high status, will provide the guests with gifts (commodities) that he accumulated over a lengthy period of time (Piddocke, 1965). The potlatch system maintains many crossovers with reciprocity systems, however it is typically classed under redistribution due to the unidirectional nature of exchange (Piddocke, 1965:255). It is also common for the distributors to anticipate an increase in prestige with each ceremony they perform (Barnett, 1938:350).

A notable example of centralised redistribution is a tax or tribute system, such as that observed in the Maya (Freidel, 1981). In these systems, members of a society contribute various amounts of finances or commodities to a central authority that, in turn, uses those commodities for socio-political causes or services (e.g., military protection, academic institutions) (Service, 1969:133-134). Centralised redistribution is exemplified by Mode 5 (Figure 3.1) where group *A* brings commodities to a central authority at a central location, receiving other commodities in return (Renfrew, 1975:42). The original commodities brought by group *A* are given to group *B* and group *B* brings their commodities to the central authority (Renfrew, 1975:42). Two variations of the generalised model of redistribution are presented below.

3.2.2.2.1 Political-mobilisation model

Generalised redistribution has been often criticised for its simplicity (Brumfiel & Earle, 1987:2). An alternative is the political-mobilisation model (Earle, 1977; Hirth, 1998), where the redistribution of commodities is not as generous as originally proposed. In this case, the centralised authority retains the majority of acquired commodities,

mainly for subsistence, and provides their subjects with a reduced portion (Earle, 1977:215-222; Earle, 1987:67). The elite groups are viewed as the primary beneficiaries of this exchange as they strategically sponsor craft production, manage distribution, and promote specialisation (D'Altroy & Earle, 1985: 187-206:197-202). This is a means to enhance the social inequality, construct and maintain political coalitions, and display sacred symbols (Flannery, 1968:94-103; Brumfiel & Earle, 1987:3). Increasing craft specialisation is considered a result of political intervention in economic systems (Earle, 1987:67). This model addresses the needs of the elite groups through the acquisition of subsistence commodities on the assumption that the non-elite groups are self-sufficient (Masson, 2005:1140).

3.2.2.2.2 Adaptationist model

Another model, proposed as a variation of general redistribution, is the adaptation model (Wittfogel, 1957; Johnson, 1973). This model is fluid in that is considers that centralised authorities arose out of necessity, due to an adaptation to various social-political and environmental forces (e.g., famine, restricted access to resources) (Brumfiel & Earle, 1987:2). The involvement by a centralised authority in economic systems and exchange offered benefits to the non-elite group, such as insurance against commodities shortages, access to additional resources, and protection for resources (Bates & Lees, 1977:833). In this model, large-scale exchange systems and specialisation arise in societies that practice redistribution (Service, 1969; Brumfiel & Earle, 1987:2). The exchange of commodities over long-distances is accomplished through the organisation of a centralised authority (Rathje, 1972:386). This creates a reliance on the centralised authority by the non-elite groups for certain commodities, reinforcing their status of

importance (Muller, 1987:19-21). The non-elite forfeit a degree of their autonomy in order to participate in the redistribution of imported commodities and receive further benefits (Sahlins, 1963:300; Rathje, 1972:371).

#### *3.2.2.3 Market exchange*

The third broad category of distribution is arguably most complex form of exchange in pre-industrial societies: *markets* (Childe, 1936; Polanyi, Pearson & Ahrensburg, 1957). Markets can be describe as the economic system or as physical locations, including intermediary ones, to or from where commodities can be moved by producers or middlemen, in order to be further exchanged to consumers (Renfrew, 1975:45; Masson, 2005:1151; Garraty, 2010:4). Market exchange involves an organised aggregation of producers and consumers and is primarily based on profit or the acquisition of commodities rather than on the formation or maintenance of social relationships (Hodder, 1978:205-211).

Although, markets offer producers an opportunity to mass-produce and distribute their finished commodities, the relationship between supply and demand influences the value of their commodities (Garraty, 2010:5-6). A surplus of a commodity will often decrease its value and the inverse if often true as well. Alterations in value regulate the scale of production (Costin, 1991:38; Earle, 2002:12). Demand, supply, and specialisation also become intertwined and vary with the scale of one another (Costin, 1991:13-14; Zeder, 1994:176). The high demand for commodities stimulates a greater supply that, in turn, allows for increased craft specialisation and full-time artisanship (Rice, 1981:220; Brumfiel & Earle, 1987:5).

A basic example of market exchange is contemporary farmer's markets. Here producers and consumers gather at a specific location in order to exchange locally produced commodities for cash. Such informal exchanges of commodities for cash is also known in complex societies (Silver, 1983:798), such as the ancient Israelites as recorded in the Hebrew Scriptures (2 Kings 7:1).

Markets are often a defining characteristic of many complex societies and exist in a variety of forms and on various scales, such as the local and regional level (Service, 1969; Wright & Johnson, 1975:277; Berdan, 1980). Perhaps one of the largest forms is that of centralised markets (Figure 3.1 Mode 6). In this situation a centralised authority organises a market, a central location to distribute commodities. They typically receive compensation through a percentage of the earnings from producers or middlemen, or exchange commodities of which they sponsored the production or acquisition (Berdan, 1980:37-39; Earle, 2002:12). The establishment of such exchange systems is an attempt to achieve economic stability and profitability. Centralised authorities can restrict what commodities are exchanged, increasing the homogeneity of household assemblages (Stein, 1994:11; Garraty, 2010:21). However, the management in centralised markets allows for elite sponsored production, ultimately increasing craft specialisation (Brumfiel & Earle, 1987:5-6).

### 3.2.3 Consumption

The third element of economic systems is how commodities are used and who used them. Consumption occurs at all levels of society. In order to narrow the scope of research, the content of this thesis focuses on household consumption. This is discussed below.

#### *3.2.3.1 Categories of consumption*

Consumption is often divided into three categories: productive, personal, luxury/prestige, and (Narotsky 1997:104; Appadurai 1986:38; Sherratt and Sherrat 1991). Productive consumption refers to the use of commodities that are obtained in order to further produce other commodities (e.g., cores) (Narotsky 1997:104). Personal consumption, perhaps the most common, is the use of commodities for direct subsistence, maintenance, and reproduction of life (Narotsky 1997:104). Luxury/prestige commodities, may intersect with personal commodities, but are not considered necessities. Instead, they serve to display and acquire power (Brumfiel & Earle, 1987:3).

#### *3.2.3.2 Visibility of consumption*

Consumption is related to the formation processes involved in forming the archaeological record (Schiffer, 1996). However, few studies delve into consumption in great detail (Renfrew & Bahn, 2004:384; Hardin, 2011:14). Most studies on consumption have relied on ethnographic analogy and the "form equals function" principle (Adams, 1999:476). For example, an EB III pottery platter from southern Levantine assemblages is so named due to analogous contemporary forms and is thought to have served food in the same way. The analogy is not far-fetched and seems plausible.

Household consumption revolves around the analysis of traditionally domestic artefacts. The size of the household is often calculated by the number of artefacts, such as the quantity of pottery vessels (Shahack-Gross, 2011:29; Singer-Avitz, 2011:285). The functions of activity areas, rooms, or houses are frequently inferred from the collective spatial analysis of assemblages (Flannery & Winter, 1976:36; Hardin, 2011:26). In this sense, the case is made that chipped stone debitage in a courtyard signals the use of that

area for manufacture or retouching (Andrefsky Jr., 2005:201-203). Meanwhile the resulting typology (form/morphology) will reflect how the tools are used (e.g., projectile point – hunting). Residue analysis and aspects of use-wear analysis also provide information on the nature of consumption (Adams, 1993; Gregg, 2009). Kitchen areas will often yield pottery vessels with organic remnants embedded in their walls, informing the archaeologist about the diet of the occupants and what function the vessels served in food preparation (Rice, 2005:350; Fowler, 2011:157). Analysis of use-wear of chipped stone and metal blades have the potential to yield evidence of the handedness of the user and the amount of curation the artefact received (Shott, 1996).

## 3.3 Exchange systems in early complex societies

The sections that follow describe various aspects involved in the exchange systems of early complex societies and the mechanisms that sustain them. Specific reference is made to the EB II-III southern Levant, although these are discussed in more detail later in the chapter.

### 3.3.1 Involvement of centralised authority

Many early complex societies experienced an increase in population, social stratification, and the emergence of centralised authorities (Shwartz, 1994:165). As these centralised authorities gained power, they became involved in the production and distribution of commodities. As a result of their involvement, exchange occurred on a larger scale and in more forms (e.g., tribute, taxation) (Wright & Johnson, 1975:274). Such centralisation occurred at various levels, including administration within workshops. For example, centralisation has long been identified in early Mesoamerican complex societies where the elite first acquired imported commodities prior to

distributing them locally (Rathje, 1972). However, centralised and decentralised production and distribution have been identified as co-existing in early complex societies (Brumfiel & Earle, 1987:2; Garraty, 2010:36; Shaw, 2012:121). It should be noted that increasing social complexity is considered to precede a rise in craft specialisation (Muller, 1987:20; Earle, 1987:67; Adams, 2001:350-356). The support of a centralised authority provides an environment and demand in which specialised artisans may thrive.

The existence of centralised distribution systems during the EB II-III of the southern Levant has been proposed based on the extent and scale of production and distribution of several industries (e.g., Canaanean blades, Khirbet Kerak Ware) (Richard, 2003:286-290; Greenberg & Goren, 2009:130). Craft specialisation has also been identified in the same EB II-III industries (Shimelmitz, Barkai & Gopher, 2000; Zuckerman, Ziv & Cohen-Weinberger, 2009). This is likely the result of centralised involvement in these industries. Despite the involvement of centralised administration in various economic industries, household production and decentralised distribution also occurred as people took advantage of their local resources (Ben-Shlomo, Uziel & Maeir, 2009:2265).

### 3.3.2 Core-periphery model

The involvement of centralised power or elites in the production and distribution of commodities has generated a complex model of market exchange commonly described as a world-systems network (Chase-Dunn & Hall, 1993; Richard, 2003:286). In this situation, there is an exploitation of commodities and services from the peripheral communities by the centralised cores (Chase-Dunn & Hall, 1993:863; Peregrine, 2000:60; Richard, 2003:286).

This core-periphery model of exchange may be applicable to the economic relationship between Egypt and the EBII-III southern Levant (Shai & Uziel, 2010:70), as the movement of commodities between the two regions appears unidirectional, from the southern Levant to Egypt (Ben-Tor, 1992:96-97; de Miroschedji, 2014:312). On a smaller scale, this relationship is also hypothesised to exist among the large urban centres of the EB II-III southern Levant and their surrounding villages (Richard, 2003: 286).

## 3.4 Historical texts and exchange

The evidence for the movement of commodities is discovered in two forms: historical records (e.g., cuneiform tablets, iconography, written texts) and artefacts (e.g., lithics, metal, pottery) (McCorriston, 1997:518; Masson, 2005:135-138). The artefactual evidence for exchange is discussed in greater detail later in the chapter, while the potential of historical texts for reconstructing exchange, both in general and the EB II-III southern Levant, is discussed in the following two sections.

### 3.4.1 Historical texts as evidence of exchange in early complex societies

The appearance of early complex societies often coincided with the development of a written language (Maisels, 1990:155). Historical texts, such as the Hebrew Scriptures and Egyptian Execration texts, demonstrate that early complex societies participated in long distance interaction with each other, often mentioning exchange indirectly (Adams, 2001:346). While myths, king lists, and military conquests are most prominently featured in the content of historical records of early literate societies (Snell, 1997:18), others recorded the types of commodities imported or exported and their value (Atici *in press*). This is exemplified by the *Story of Sinuhe*, which was composed for an Egyptian monarch during the 12$^{th}$ Dynasty (ca. 20$^{th}$-18$^{th}$ century BCE) (Pritchard, 1958:5; Cline,

2003:361). Although mentioned indirectly, this text describes the nature of commodities that were exchanged (e.g., wine, olive oil, fruits, timber) and their corollary exchange partners (Pritchard, 1958:5; Cline, 2003:361). There are also depictions of exchange between Egyptians and southern Levantine inhabitants in paintings in Egyptian tombs that date to the 19$^{th}$ century BCE (Cline, 2003:361). Further examples of recorded exchange in early complex societies are Mesopotamian cuneiform tablets. These etchings on dried clay slabs, discovered at Mesopotamian sites from the 3$^{rd}$-1$^{st}$ millennia BCE, describe the exchange of various commodities (e.g., silver, textiles, tin) (McCorriston, 1997:518). It is important to consider such texts as they frequently describe perishable or reused commodities that go unseen in the archaeological record (Atici *in press*: 242).

### 3.4.2 Historical texts and exchange during the EB II-III of the southern Levant

While the inhabitants of the EB II-III southern Levant were aware of written language, they did not develop their own script (Shai & Uziel, 2010:69). The EBA of the southern Levant is essentially a preliterate period as there are no local historical texts (Ben-Tor, 1986:1; Shai & Uziel, 2010:69). Yet, its neighbour to the west, Egypt, has a rich documentary history from the same period that provides written evidence of interaction and exchange between the two regions (Ben-Tor, 1986:1; de Miroschedji, 2001:465).

Although the Egyptian historical texts are useful for identifying what commodities were exchanged (e.g., Abydos ware, copper, olive oil, timber) from the southern Levant to Egypt, it is difficult to establish with which southern Levantine settlements they exchanged (Mazar, 1990:136; Esse, 1991:104). This is due to the vagueness and generality in which the southern Levant is referenced in Egyptian records

(Ben-Tor, 1986:1; Esse, 1991:104). However, it is from these historical texts that a fuller picture of inter-regional exchange between Egypt and the southern Levant may be inferred. For example, it is plausible that the same perishable commodities were exchanged for several millennia, but are now invisible in the archaeological record due to their poor preservation or consumption.

### 3.5 Exchange systems of the EB II-III southern Levant

In pre-literate and proto-literate societies, there is often a reliance on artefactual evidence to reconstruct the nature of exchange. The absence of written texts in southern Levantine remains has forced archaeologists to examine artefact assemblages in order to understand their production, distribution and consumption (Savage, 2011:119; Milevski, 2013).

The artefactual evidence indicates that exchange occurred on a local, intra-regional, and interregional basis during the EB II-III of the southern Levant. Exchange was orchestrated through both large urban centres and local distributers, occurring in a variety of forms of exchange (Milevski, 2011:198). It is important to identify the sites of procurement and the settlements of production in order to understand the movement of the commodities.

The sections below discuss the local, intra-regional, and inter-regional exchange of commodities during the EB II-III of the southern Levant. These commodities include chipped stone artefacts, pottery, and metal. Ground stone artefacts have been excluded from this discussion as their exchange is discussed in greater detail in the next chapter. The review of the exchange of non-ground stone artefacts assists in establishing the models of exchange present during the EB II-III of the southern Levant. Furthermore, it

provides the economic context and framework of exchange routes into which the movement of ground stone artefacts may fit.

### 3.5.1 Local exchange of the EB II-III southern Levant

Local exchange, represented archaeologically as a high frequency of commodities discovered near their original sources, is known to have occurred during the EBII-III in the southern Levant. Several commodities, most notably Golanite cooking pots and Canaanean blades, emphasise the exploitation of local resources and distribution within local sub-regions. The exchange of these commodities is discussed in the following sections in an effort to illustrate the scale and nature of exchange systems of the EB II-III southern Levant.

#### *3.5.1.1 Golanite cooking pots*

A recently identified EBII-EBIII industry, Golanite cooking pots, has been discovered at a various settlements around the Sea of Galilee, and within the sub-regions of the Jordan Valley, Jezreel Valley and Galilee. Bet Yerah and Raqat in the Galilee sub-region contained a small assemblage of Golanite cooking pots that were produced in the Golan (Paz & Iserlis, 2009:104). Settlements furthest west and south, namely Har Haruvim and Baraqet respectively, revealed sherds of Golanite cooking pots that also originated in the Golan (Paz & Iserlis, 2009:104). Though they crossed the artificial borders of the sub-regions outlined in Chapter 2, the Golanite cooking pot industry can be considered a local industry as it was exchanged to settlements proximate to the sources, roughly within a days journey (Paz & Iserlis, 2009:104).

Traced via petrography to brown basaltic clays in the western Golan, these cooking pots were exchanged on a small scale. Smaller settlements within the Golan,

including Leviah, Bardawil, and Yitzhaki, acquired their clays within the immediate vicinity (Paz & Iserlis, 2009:104). These settlements may have served as the both the production and distribution centres, operating as decentralised workshops that identified a need for specialised cooking pots in the existing typology. It is likely that these pottery vessels radiated out from the three settlements as they were exchanged to neighbouring settlements.

#### *3.5.1.2 Canaanean blades*

Canaanean blades have been identified as a trademark of the EBA of the southern Levant. They are nearly ubiqutious at settlements of the Levant. Although not confined to one subregion, it is hypothesised that their production and distribution occurred on a local level (Rosen, 1997; Milevski, 2013). It should be pointed out that no provenance studies conducted through geochemistry have been undertaken on the flint assemblages of the EBA southern Levant. As Canaanean blades from many settlements have been macroscopically sourced to flint outcrops in close proximity to the settlements, it is likely that there were multiple producers and distributers (Rosen, 1983; Milevski, 2011).

As Canaanean blades served agricultural needs, it is expected that they are found in higher quantities in rural settlements than in urban centres. In addition it can be further extrapolated that workshops are discovered in residential and domestic contexts. A comparable Canaanean blade workshop has been discovered in a suburban section of Titriş Höyük in Anatolia where production was focused on agricultural consumers (Shimelmitz, Barkai & Gopher, 2000:21; Milevski, 2011:105). An analogous example in the southern Levant is the chipped stone workshop at Har Haruvim (Shimelmitz, Barkai & Gopher, 2000). Har Haruvim, situated close to grey-beige and brown flint outcrops in

the Jezreel Valley, is considered to be a large production centre of Canaanean blades during the EB II-III (Rosen, 1997:108; Shimelmitz, Barkai & Gopher, 2000). Other potential centres of production include Tell Halif and Gezer, where debitage, cores, and close proximity to sources provides evidence for this hypothesis (Seger *et al.*, 1990:22). Tel Yarmuth is also a candidate to be a production centre and distributer of Canaanean blades to the Shephelah as indicated by the presence of brown flint blocks (Milevski, 2013:207). However, with the abundance of flint sources within the southern Levant, it is suspected that there were multiple production centres within each sub-region (Rosen, 1983:19-23). It should be noted that the production of Canaanean blades probably passed through different stages at separate settlements (Rosen, 1984: 504-505).

With production centres located in each sub-region, it is likely that they distributed Canaanean blades to neighbouring settlements. In general, the macroscopic observations, based on the colour of flint, have linked the Canaanean blades of most settlements to their most proximate sources (Milevski, 2013:207). For example, the Eocene formation adjacent to the settlement of Gezer is considered to be the procurement site of brown flint Canaanean blades discovered at the majority of settlements within the Shephelah (Milevski, 2011:94). Similarly, Canaanean blades were likely exported from Har Haruvim to settlements within the sub-region of the Western Galilee, such as Qiryat Ata and Megiddo (Bankirer, 2003:172). Bab edh-Dhra was supplied by several sources within the Dead Sea Plain during the EBA, but lacks a significant quantity of Canaanean blades (Rosen, 1997:108; Milevski, 2013:207). This settlement marks the furthest eastward distribution of Canaanean blades in the southern Levant (Milevski, 2013:207).

It is argued that a degree of centralisation may have influenced the exchange of Canaanean blades as the dominant urban centre or primary workshop in each sub-region would have organised the movement of these flint commodities (Milevski, 2011:226). This control would have existed on a sub-regional level or possibly at the workshop level, through a distribution to the immediate agriculturalists.

### 3.5.2 Intra-regional exchange of the EB II-III southern Levant

The intraregional exchange, occurring among sub-regions within the southern Levant, is evidenced by the visibility of various commodities within the many sub-regions of the southern Levant. Additional evidence is indicated by the presence of workshops and the provenancing of artefacts. In specific, intraregional exchange is best represented by the distribution of pottery industries (e.g., Khirbet Kerak Ware, Northern Canaanite Metallic Ware (Milevski, 2013:69). The exchange of these wares, along with that of tabular scrapers of the flint industry, is examined below in order to continue to establish the nature of exchange during the EB II-III of the southern Levant.

#### *3.5.2.1 Khirbet Kerak ware*

Khirbet Kerak Ware, a distinct pottery industry, was originally identified at Bet Yerah and is defined by its distinct features that reflect Anatolian pottery (Greenberg *et al.*, 2012). A large two-story kiln constructed in the courtyard of the Circles Building (granaries) was discovered surrounded by Khirbet Kerak Ware sherds at Bet Yerah (Greenberg *et al.*, 2012). The location of the kiln (in a public complex) and its large size indicate it must be proportional to the volume of vessels it can produce (Rice, 2005:158). The resulting interpretation is that this workshop may have served as a primary location for the production of Khirbet Kerak Ware (Mazar, 1990:140; Zuckerman, Ziv & Cohen-

Weinberger, 2009:137). It should be noted that Khirbet Kerak Ware was also manufactured from local clays around the settlements of Bet Shean, Shuneh, and Hazor, that suggests that these settlements also served as production centres (Zuckerman, Ziv & Cohen-Weinberger, 2009:136). The presence of multiple large production centres is cited as evidence of decentralised production with specialised artisans operating in cooperation with middlemen (Milevski, 2011:74). Further evidence of their production in Galilee and their distribution outward from these settlements is observed through the distance decay concentration of Khirbet Kerak Ware. As the distance from Bet Yerah increases, the volume of Khirbet Kerak Ware decreases (Greenberg *et al.*, 2012:96).

This pottery industry quickly became widespread across the sub-region of Galilee, reaching as far north as Hazor (Amiran, 1969:74; Greenberg *et al.*, 2012:96). Khirbet Kerak Ware was also distributed in high volumes into other sub-regions, including the Jezreel Valley (Megiddo), Jordan Valley (Bet Shean), and the Central Hill Country (Jericho) (Mazar, 1990:133). Minimal traces have been discovered in the Shephelah as sherds have been found at Tell es-Safi/Gath and Tel Yarmuth (de Miroschedji, 1999:12; Shai *et al.*, 2014:44). A small amount of has been recovered at settlements in the east side of the Jordan Valley, with the largest assemblage from Tell Shuna (Philip, 2008:168). It is assumed that middlemen would transport Khirbet Kerak Ware through Megiddo and Bet Shean, then southwards into the Coastal Plain, Central Hill Country and Shephelah (Zuckerman, Ziv & Cohen-Weinberger, 2009:165).

#### *3.5.2.2 Northern Canaanite Metallic Ware*

In the northern half of the southern Levant, Northern Canaanite Metallic Ware dominated pottery assemblages during the EB II and the beginning of the EB III (de

Miroschedji, 2009:108). Despite the volume of Northern Canaanite Metallic Ware in assemblages, there has been an insufficient amount of provenance studies to determine origin of the clay procurement and vessel production (Mazar, 1990:133; Greenberg & Porat, 1996). Through petrographic analysis, Greenberg and Porat (1996:18) hypothesise the procurement site of clays to be in north-eastern Galilee (between Hazor and Dan), and that the main production centres to be in isolated locations on the slopes in the Naphtali Hills and around Galilee (Greenberg & Porat, 1996:19). It is assumed that there is a concentration of production centres within the Galilee sub-region. A Northern Canaanite Metallic Ware production centre has been identified at Bet Yerah from the presence of pottery workshop elements surrounded by Northern Canaanite Metallic Warevessels and sherds (Eisenberg & Greenberg, 2006:354). Its semi-residential location coupled with the observed craft specialisation suggests that production was conducted on a large scale. Within the Galilee sub-region, the large scale of production, distribution pattern (discussed below), and high degree of standardisation is indicative of centralised organisation (Greenberg *et al.*, 2012:95). This centralised organisation is assigned to workshop level decision-making authorities rather than a centralised ruling governmental administration (Milevski, 2011:87).

It is difficult to determine how Northern Canaanite Metallic Wares were intra-regionally distributed, though it is plausible that larger urban centres, such as Bet Yerah and Dan, were the main distributors (Milevski, 2011:54). The distribution of NMCW expanded south and west, since they are recovered as far south as the Shephelah (Dalit), Central Hill Country (Ai) and the northern edge of the Negev (Arad) (Greenberg & Porat, 1996:11). It should be pointed out that there is a high typological consistency among the

pottery assemblages of the northern settlements (Amiran, 1969:58-66). Eventually this industry became common throughout the Galilee, Golan, Jezreel Valley and the Jordan Valley, reaching several settlements on the east side of the Jordan River as well (Greenberg, 2003:20; Philip, 2008:169). Northern Canaanite Metallic Ware was distributed both as a primary commodity and as secondary commodity. The former is inferred from the high quantity of bowls and platters at Qiryat Ata and Qashish in the Jezreel Valley, as these would have been poor containers (Greenberg & Porat, 1996:20). Consequently, these commodities were transported from northern Galilee south into the Jordan Valley, and south through the Jezreel Valley into the Shephelah (Milevski, 2011:56).

#### *3.5.2.3 Tabular scrapers*

Although tabular scrapers have been discovered in several neighbouring regions to the southern Levant, they were mainly distributed within the southern Levant through intra-regional exchange. As with the Canaanean blades, no provenance studies involving geochemical fingerprints have been undertaken on tabular scrapers of the EBA southern Levant. The reconstruction of exchange is based on macroscopic characteristics.

The sources of these flint tools are thought to be from two separate locations: Har Qeren, on the border of the Negev and Southern Shephelah, and the El-Jafr basin in the Dead Sea Plain (Milevski, 2013:213). Prior to the EBA, an exchange network of tabular scrapers had been in operation exploiting these sources and it is hypothesised that the exploitation of these same sources continued during the EBA (Rosen, 1997:109; Milevski, 2013:213). The frequency of Canaanean blades is greater in the northern half of the southern Levant than in the southern half. This lies in contrast to the distribution of

tabular scrapers where the reverse is true. This pattern supports the hypothesis that the main procurement sites were located in or close to the southern region (Rosen, 1997:109).

The high volume of debitage and cores at Har Qeren suggest there may have been a production centre located at this settlement (Milevski, 2013:211-213). A large quantity of tabular scrapers, manufactured from several different sources, was discovered at Mitzpe Shalem in the Southern Hill Country and at Tel Yarmuth in the Shephelah (Rosen, 1988; Milevski, 2013:211). It is plausible that Tel Yarmuth and Mitzpe Shalem were inter-regional recipients and distributers of tabular scrapers arriving from the southern production centres (Rosen, 1988:141; Rosen, 1997:109).

In general, the movement of tabular scrapers is thought to be from the south to north, through the Shephelah in the west and the Jordan Valley in the east (Milevski, 2011:102). Middlemen are assumed to have conducted this intra-regional distribution of tabular scrapers through down-the-line exchange as they passed through each large settlement (Harrison, 1993). As they move north, the volume of tabular scrapers in assemblages decreases, which explains the greater visibility of this industry in the southern half of the southern Levant. However, it is difficult to accept that the tabular scrapers of the southern Levant were fashioned from southern sources and transported to the northern sub-regions as Milevski (2011; 2013) and Rosen (1984: 504-505; 1997) put forth, rather than being locally produced.

### 3.5.3 Inter-regional exchange of the EB II-III southern Levant

The nature of inter-regional exchange between the southern Levant and foreign regions is difficult to establish (Ben-Tor, 1986:1; Esse, 1991:15). Exchange between

settlements of the southern Levant, Sinai and the Negev was steady throughout the EBA. For example, pastoralists, such as those at the Camel Site, were able to access resources from urban centres in the north, probably in exchange for raw material from the isolated sources (Rosen, 2011).

By the MB, the overland exchange routes were formalised, such as the "Way of Horus", passed through the Sinai gateway, while maritime routes followed the coast of the Mediterranean (de Miroschedji & Sadek, 2001; Milevski, 2011:130). It is assumed (in the absence of historical records) that these same exchange routes have their origin in the EB and earlier periods. It is possible that EB II-III maritime exchange had grown more common than overland, but the evidence for significant EBA urban centres along the coast is lacking, either absent or destroyed by later building activities (e.g., Ashqelon, Ashdod) (Stager, 2000:631). However, the large villages around Ashqelon-Afridar and in southern Gaza (Tell es-Sakan) all imply the presence of major urban centres along the coast that operated as ports.

The artefactual evidence signals a largely unidirectional exchange system between Egypt and the southern Levant, possibly in the form of tribute (Shai & Uziel, 2010:70). The southern Levant bears much less evidence of imported Egyptian commodities than that imported into Egypt (Ben-Tor, 1991:4). Metal (e.g., copper, tin, gold), as a raw material or jewellery and ornaments, was exported from mines in regions such as Jordan and the southern Negev to urban centres in the southern Levant and as far away as Egypt (Philip, 1988: 190-208; Adams, 2006: 137-144; Levy, 2007:85).

There is evidence for inter-regional exchange between the southern Levant and points further north (Anatolia). A few prestige items (e.g., decorative mace heads)

(Rosenberg, 2010) are brought from as north as Anatolia to settlements in the southern Levant (Cline, 2003: 360). However, there is no evidence for the type of materials that may have been sent northwards.

One of the most discussed inter-regional connections inhabitants of the southern Levant maintained was that with Egypt (Esse, 1991:104; Shai & Uziel, 2010:69). The inter-regional exchange of these commodities is addressed in greater detail below.

#### *3.5.3.1 Abydos Ware*

Pottery commodities, specifically Abydos Ware (a sub-set of Northern Canaanite Metallic Ware), from the sub-regions of the southern Levant that surround the Sea of Galilee, were exchanged to Egypt (Braun, 2009:28; Greenberg *et al.*, 2012:95). This is evident from the presence of Abydos wares in Egyptian tombs and burial contexts, further suggesting they were also prized commodities.

Abydos Ware was exchanged to the Upper Kingdom of Egypt during the First Dynasty Egypt not only as containers for oils, grain and wine (Kafafi, 2011:139), but for the vessels themselves (Greenberg & Porat, 1996:19). In return, inhabitants of Bet Yerah received Egytian vessels that probably served as a container for other commondities (Greenberg *et al.*, 2012:96). Consequenlty Bet Yerah can be considered as the starting point for at least one node in the long distance inter-regional network. This is supported by provenance analyses based on geochemical evidence (Kafafi, 2011:140). However, Bet Yerah is not the sole receipient of Egyptian pottery, as Tell es-Sakan, Tel Yarmuth, Tell es-Safi/Gath, Megiddo and Arad also contain Egyptian imports in their assemblages (Amiran 1968:317; de Miroschedji and Sadek 2000:42). It should be noted that a greater

amount of Egyption pottery is discovered in the Shephelah than in the northern sub-regions, which implies that it was the locus of greater intensity of exchange with Egypt.

Despite the limited presence of Egyptian artefacts in the southern Levant, Abydos Ware is arguably the most significant indication of interaction during the EB II-III between these two regions (Mazar, 1990:135; Braun, 2009:28). This industry was transported to ports in coastal cities, such as Ashqelon-Afridar and Tell es-Sakan, where intermediary middlemen would organise the shipments to Egypt (de Miroschedji & Sadek, 2000; Milevski, 2011:130). Alternatively, the Way of Horus may have been in use with commodities transported by foot to Egypt. The involvement of a centralised authority is unknown, but likely due to the scale of organisation.

#### *3.5.3.2 Metal*

In general, metals discovered in EB II-III southern Levantine contexts include bronze, tin, copper, sliver and gold and have been sourced to Egypt, Sinai, Negev, Anatolia and Mesopotamia (Mazar, 1990:135; Genz, 2000:56). However, evidence for copper working is more visible across the EB II-III southern Levant during the EBA than any other metal (Mazar, 1990:134). Like other materials, metals can be transported in raw form to a smelting (production) centre, before being exported as a finished commodity. While the source of a metal object can readily be established, it is difficult to determine where it was produced.

Mines or procurement sites containing evidence of exploitation have been discovered at Timna in the southern Negev, Wadi Feinan in the north-eastern Negev, and several scattered locations in the Sinai. While the Timna deposits date from the LB and

later, Wadi Feinan yielded significant evidence for EBA copper exploitation (Levy, 2007).

At the Camel Site in the Negev, Barqa el-Hetiye near the mines of Wadi Feinan, Lod and Arad, there is evidence of smelting activities (Amiran, 1978:56; Genz, 2000:59-61). The settlements of Numeria in the Dead Sea Plain, Khirbet Hamra Ifdan located near the Feinan mines, and Megiddo display evidence of smelting (Genz, 2000:60-61; Levy & Najjar, 2007:103). Khirbet Hamra Ifdan is considered to be the largest metallurgical production centre of the EBA Near East (Levy & Najjar, 2007:103; Levy, 2007:85). Although production typically occurred at settlements proximate to the mines (e.g., Timna, Khirbet Hamra Ifdan), a notable exception is Megiddo where metal objects may have been fashioned for cultic purposes in the temples (Greenberg, 2003:19; Milevski, 2011:124). This suggests that copper was probably exported from the southern Levant to Egypt both as a raw material and a finished product.

Collections of metal knives, chisels, and axes have been found in small quantities at numerous settlements across the southern Levant (Golani, 2003:215). Despite the exchange of metal originating in the southern Levant, its distribution eventually reached the northern boundaries of the southern Levant. The largest settlements contain the greatest volume of metal objects, with assemblages frequently composed of ornaments and jewellery (Philip, 1988:200; Philip, 1989; Genz, 2000). Metal appears as a prized luxury or prestige possession, possibly signally the presence of elite groups.

Exchange occurred between Egypt and the production centres surrounding Feinan (Milevski, 2011:130). It is likely that initially the metal objects were imported inter-regionally and overland to the southern Levant at Ashqelon-Afridar and Tell es-Sakan

before being transported by boat to Egypt (de Miroschedji & Sadek, 2000: 123-144; de Miroschedji *et al.*, 2001: 75-104), or across the Sinai by donkey caravan (Greenfield, Shai & Maeir, 2012:24). It is likely that this long distance movement of metal involved middlemen, although MB texts from Egypt suggest that Egyptians were also directly involved in the management of the caravans.

### 3.5.4 Summary of EB II-III exchange in the southern Levant

Any discussion of exchange during the EB II-III of the southern Levant is rooted in the visibility of artefactual commodities. The exchange of perishable commodities is difficult to address in the absence of archaeological evidence.

All forms of exchange may arguably have experienced the involvement of some level of centralised decision-making authority, albeit only at the workshop level (Milevski, 2011:226). At the lowest level, the distribution of certain industries (e.g., pottery, chipped stone), whose remains are confined to individual settlements, would have needed nothing more than a very local level of decision-making in order to meet the needs of their immediate occupants. In such a situation, there was not a reliance on imported commodities for subsistence since the assemblages were produced and consumed from resources within the vicinity of the settlements (de Miroschedji, 2000; Ben-Shlomo, Uziel & Maeir, 2009).

The artefactual commodities exchanged intra-regionally would have needed to be organised on a higher level since they were distributed beyond their local catchment. There were two main directions for the distribution of such goods, either north-south (e.g. Khirbet Kerak Ware), or east-west (e.g. copper). It is likely that these commodities were exchanged through the same routes. The goods would have moved between the various

sub-regions of the Shephelah, Jordan Valley, and Central Hill Country from where production occurred to where they were consumed. It is plausible that middlemen were required to facilitate the movement of commodities over long distance (e.g., more than one day's journey).

For the most part, distribution seems to revolve around and through the urban centres of each sub-region. The dominant pattern is that commodities from the surrounding villages and landside were congregated at urban centres and further transported over long distances to other urban centres for further distribution. The radiation of commodities outward from the large urban centres developed as either 1) settlements that took advantage of their neighbouring smaller settlements, or 2) settlements that took advantage of their situation, such as encompassing a port on the coastline or being located near significant resources (Milevski, 2011:235). This suggests that a core-periphery set of relationships existed between the large urban centres and their surrounding villages, permitting the urban centres to accumulate wealth in the form of excess commodities (Ben-Tor, 1992:96-97; de Miroschedji, 2014:312). In turn, this accumulation of wealth provided the basis for increasing societal complexity and stratification (Greenberg, 2014:861).

## 3.6 Conclusion

Economic systems can be divided into three stages: production, distribution, and consumption. From the information presented, it is apparent that Economic systems and exchange are important aspects of everyday life and were prevalent in early complex societies of the Near East and the EB II-III southern Levant. In early complex societies, economic systems and exchange experienced the involvement of centralised authorities

and existed at three geographic levels: local, intra-regional, and inter-regional. The discussion demonstrates that small and large-scale exchange networks were present during the EB II-III in the southern Levant. Both prestige and domestic commodities were exchanged within and among the various sub-regions and between the southern Levant and distant regions. This review of economic systems and exchange is used to investigate the production, distribution, and consumption of a specific commodity, ground stone artefacts, in the following chapter.

# Chapter 4. Literature review: life-history of ground stone artefacts

## 4.1 Introduction

In order to more fully understand the importance of ground stone artefacts found in an excavation, it was necessary to examine their life-history. The life-history of an artefact is its journey from production to deposition in the archaeological record, encompassing the stages in between these events (e.g., distribution, consumption). These stages are potentially visible through a thorough analysis of an artefact and the larger context of the settlement and region, solidifying them as a means to reconstruct and understand the associated human behaviour.

The majority of studies that examine ground stone artefacts of the EB II-III southern Levant have focused on their typology and distribution within and between settlements. However, this literature rarely addresses where the artefacts were procured, the mechanisms of their movement, how they were used, and where they were ultimately discarded.

To fully understand the exchange and life-history of ground stone artefacts of the EB II-III of the southern Levant, it is necessary to review ground stone literature in general and studies from the Chalcolithic to the EBA of the southern Levant. A review of the Chalcolithic and EB I periods is included as it provides the foundation for understanding the development and maintenance of the ground stone industries and the relationship between people and their environment during periods of socio-political change. This chapter is an effort to describe the theory behind ground stone artefact analysis in detail and to provide the background for basalt ground stone artefacts of EB III Tell es-Safi/Gath and those of the EB II-III southern Levant.

## 4.2 Ground stone artefacts: general overview

The sections below discuss the current state of ground stone studies, focusing on their definition, typology and classification, and analytical potential.

### 4.2.1 Definitions of ground stone artefacts

While chipped stone artefacts have long been the subject of extensive discussions in the literature that have resulted in a set of standardised definitions for their shape, manufacture, and use, the same has not been true of ground stone tools until recently. The most efficient way to distinguish them from chipped stone tools has been through the function of the artefact or the technique used in its reduction. Consequently, they are denoted as any stone artefact modified by or for crushing, pecking, pounding, grinding, or incising (Wright, 1991:21; Adams, 2014a:2). Variations of the aforementioned definition often serve in describing particular ground stone assemblages that contain a more limited range of such artefacts (e.g., those of abrasive wear) (Rowan *et al.*, 2006:577).

### 4.2.2 Classification and typology of ground stone artefacts

*Classification* and *typology* are two concepts that are all too frequently used interchangeably by archaeologists. However, an effort is made to distinguish between classification and typology as they are two separate concepts.

*Classification* is a set of formal criteria by which a particular collection of data is organised (Rouse, 1960:313). This assessment is performed according to attribute similarities among artefacts and most commonly results in the classification of artefacts by raw material (e.g., basalt, sandstone), form (e.g., jars, jugs, platters), or by function (e.g., pounding, grinding) (Rouse, 1960:313-315; Rowan, 2014:917). The latter two

classifications, form and function, are related and a "form equals function" approach is often adopted in their construction (Adams, 1999:476). However, form is often indicative of the intended function, but is not necessarily reflective of the actual function (Adams, 2010:132).

By comparison, a *typology* is a theoretically oriented classification that has been imposed by the analyst in order to solve specific problems (Gifford, 1960:346; Clarke, 1968:205). It is an ideational arrangement of data that has been organised through a classification system (Rice, 2005:276). Artefacts that compose a typology have been classified into different types due to the selection of various attributes (Rouse, 1960:315; Hill & Evans, 1972:233).

Unfortunately, ground stone artefacts are often overlooked in the chronological determination of a site, as their form typology remains static over long periods of time (Rowan & Ebeling, 2008a:2-3). This also may be due to inconsistent classification systems that result in poorly produced typologies and ultimately an unnecessary dearth of knowledge in the archaeological record (Adams, 2014b:4).

Adams (2014b:3) organises ground stone artefacts into one of five main types based on their function: 1) processing tools, 2) manufacturing tools, 3) paraphernalia, 4) pigments and minerals, and 5) pecking stones. Additional types, briefly acknowledged by Adams (2014:5) may be also be added. These include cooking stones, structural stones, and ecofacts (e.g., concretions and fossils). The many types identified above can be further divided into a range of sub-types (e.g., processing – slabs, querns). These sub-types are usually based on a secondary classification system by form or function. The

sections below describe several function types of the most common ground stone artefacts found in assemblages of the southern Levant.

#### *4.2.2.1 Lower grinding stones*

Lower grinding stones are the bottom half of a two-part grinding or food processing operation with the other half being an upper grinding stone. As lower grinding stones are anchored and typically rest on an installation or a floor they fall under the category of *netherstones*, stationary ground stone artefacts that are too large to be manipulated by hand (Adams, 2014b:150). Lower grinding stones are often referred to in North American archaeology as *metates* while in the Old World they are known as *slabs* or *querns* (Adams, 2014b:103). The terms *slab* and *quern* reflect how the consumer uses the lower grinding stone, although there is a fuzzy boundary between their distinctions. Slabs bear a rectangular use surface and display lateral wear striae (Wright 1992:63). Conversely, querns exhibit an oval use surface with rotary wear striae (Wright 1992:63). They are recognisable because of their large size, often exceeding 50cm in length, and flat use-face. The dorsal side of the grinding stone will often be smooth as a result of interaction with the floor while the face will wear quickly from interaction with the upper grinding stone. Ground stone fragments are best diagnosed as originating from lower grinding stones if they retain a shallow, concave curvature on their use-face (Rowan, 2014:921).

#### *4.2.2.2 Upper grinding stones*

Upper grinding stones are the top half of the grinding operation and interact with the lower grinding stone. They are considered a sub-category of *handstones*, ground stone artefacts that are hand-held, and are often referred to as *manos* in North American

archaeology (Adams, 2014b:148). These tools are often oblong in shape and small enough for the consumer to manipulate with one or both hands. As they interact with the lower grinding stone, their edges become worn faster than the middle of the use-face. This produces a convex curve on the use-face and creates a diagnostic feature for identifying these artefacts (Rowan, 2014:919). Upper grinding stones appear as bifacial and unifacial tools where the dorsal side will often display additional cultural polish from interaction with the palms of the consumer.

#### *4.2.2.3 Mortars*

Mortars are another category of netherstones used for processing food. However, they are often paired with a pestle or pounder and undergo crushing, rotary grinding, or pounding (Wright, 1992:65). The use surface include a deep, circular depression where processing occurs (Dubreuil, 2004:1613). This depression is distinct from vessels in that it is separated from the exterior edge of the artefact by a thick wall (Rowan, 2003:189). Other than the concave depression, little manufacture is given to the rest of the stone (Adams, 2014b:132). Mortars can range in size from small hand sized pebbles to large boulders.

#### *4.2.2.4 Perforated stones*

Perforated stones appear as a variety of separate sub-types, including weights, whorls, disk, and maceheads (Wright, 1992:74). They are characterised by a perforation through the artefact that connects the two exterior faces of opposite ends of the artefact. The perforation of the artefact is cylindrical in cross-section and circular in plan (Wright, 1992:74). The artefact itself is typically circular in form and mildly polished. Ropes, strings, straps, hafts, or other materials are fed through the perforation in order to use.

Although the artefact is manufactured through drilling, the interior of the perforation may appear polished from interaction with the material passed through it (Rosenberg, 2010:204). The size of the artefact can vary depending upon its intended function but will typically be fist-sized or smaller. The function of most perforated ground stone artefacts is often speculative as there are rarely found with the material that ran through the perforation (Rowan, 2003:189). Weight, thickness, and diameter have been important measurements that have sought to establish a relationship between these values and the type of ground stone artefact (Rowan *et al.*, 2006:593). For example, maceheads are considered to be circular perforated objects that exceed 10mm in diameter and 150g in weight (Rosenberg, 2010:204). However, weight is an inconsistent measurement as it is indicative of the density and type of material, rather than the size of the artefact.

#### *4.2.2.5 Pounders*

Pounders, as the name indicates, function as pounding substances or material. Despite the similar form and occasional synonymous use of the terms, pounders are frequently distinguished from hammerstones by function (Rowan *et al.*, 2006:602; Rowan, 2014:928). While hammerstones are used in the reduction of other tools, pounders are associated with food-processing, similar to that of pestles. These hand-held stones are typically spherical or cuboid in form with cultural polish that covers the exterior (Wright, 1992:70).

#### *4.2.2.6 Pestles*

Pestles are often paired with mortars to accomplish the rotary grinding or crushing for food preparation (Ebeling & Rowan, 2004:110). Their size is often related to the type of action they perform and/or the type of material on which they are performing (Adams,

2014b:144). Pestles used for crushing will often be large, elongated stones and operated with two hands. The inverse is true of rotary grinding where a short but elongate stone, often held with one hand, is used. As they are elongated and manipulated by hands, pestles are typically oval in cross-section (Wright, 1992:69). Their used surface will often be convex with many scars.

#### *4.2.2.7 Vessels*

Ground stone vessels (bowls, platters, vases, goblets) use similar terminology to describe their parts as pottery vessels. They appear in the archaeological record in a variety of forms and sizes and are the only ground stone artefact considered chronologically distinct (Rowan, 2003:183). Additionally, vessels may be decorative with incised motifs, fenestrated handles, or pedestalled stands (Braun, 1990:89). The accepted function of ground stone vessels is a container for food or drink, but also as a ritual object (Ebeling & Rowan, 2004:110; Rowan *et al.*, 2006:576). This is enabled by the large concave depression in the centre of the artefact and the rims and bases are usually well-defined (Wright, 1992:75). The interior and rim of a vessel is often smoothed and the walls are much thinner than those of a mortar.

### 4.2.3 Analytical potential

It has often been expressed that ground stone artefacts have been insufficiently researched, often being placed in the "other" artefact category in site reports (Rutter & Philip, 2008:343; Rowan & Ebeling, 2008a:2). Within the past few decades, there have been attempts to rectify this by standardising the terminology (Wright, 1992; e.g., Adams, 2014b), examining exchange (Rutter, 2003; e.g., Milevski, 2008), and reconstructing domestic subsistence (Wright, 1994b; e.g., Hamon, 2008). Such efforts has

sought to bring this subfield of archaeology on par with that of pottery and lithics and to ultimately provide additional information on human behaviour (Sparks, 2007; Rowan & Ebeling, 2008b).

## 4.3 Life-history of ground stone artefacts

As mentioned above, the life-history of ground stone artefacts encompasses the stages associated with human behaviour. The sections below discuss the various stages of life-history (production, distribution, consumption, and discard).

### 4.3.1 Production of ground stone artefacts

Similar to other industries (e.g., pottery, chipped stone), the exchange of ground stone artefacts is dependent upon the scale and nature of their production (Wright, 1993; Abadi-Reis & Rosen, 2008:113; Milevski, 2008:125). As previously mentioned, production involves raw material procurement and manufacture as well as the organisation through which these tasks are performed. A *chaîne opératoire* of ground stone production can be extracted from Adams (2014b:4) who outlines 1) the selection of material, 2) the decision to modify the selected raw material based on a preconceived idea of the finished commodity and intended function, and 3) the modification and re-modification of the raw material to form the desired shape. The following sections address the broad stages of the *chaîne opératoire* and the decisions of the artisan. The first stage in this process is procurement and the second is manufacture. Both are described in this order below.

#### *4.3.1.1 Procurement*

Contrary to Rutter and Philip's (2008) terminology, *procurement* is not used synonymously with *acquisition*, as the former will refer to the direct extraction of a raw

material from its parent source, and the latter refers to the general obtainment of something. The selection of raw material in the procurement process is arguably the most vital step in ground stone production (Stone, 1994:690; Carter, 2008:67). The decisions regarding raw material selection have implications for the amount of energy expended in the manufacture stage and the resulting function and durability of the tool (Andrefsky Jr., 1994; Carter, 2008:67). These decisions are often influenced by geological and environmental constraints as well as the demand by consumers (Stone, 1994:691; Schneider & LaPorta, 2008:19-21). For example, a notable preference may be for a fine-grained material (e.g., basalt) over a conglomerate rock (e.g., beachrock) due to the durability of the former.

It has been observed that in hunter-gatherer societies that members will travel up to 7km access "local" sources for their own acquisition of ground stone artefacts (Fratt & Biancaniello, 1993:376) and carrying loads of 45-55kg (Schneider & LaPorta, 2008:30). This distance is similar to that of potters acquiring clay based on the synthesised observations of Arnold (1985:51-52) though most rarely exceed 1-3km (Fowler, Fayek & Middleton, 2011:767). A round trip of this nature permits procurement to occur within a single day.

The procurement of raw material is often accompanied by social behaviour. It has been observed in pottery and chipped stone studies that craftsmen will bypass available sources for others of poorer quality on the basis of ritual, preference, or reverence for the source (Rice, 2005:115-117; Andrefsky Jr., 2009:75-78). Similar behaviour regarding the procurement of ground stone material is difficult to observe through ethnoarchaeology as

ground stone artefacts have a long use-life and the replacement of a stone may be prolonged (David, 1998:55).

The negatives in quarries or outcrops where craftsmen pry blocks free constitute the best evidence for procurement behaviour (Abadi-Reis & Rosen, 2008:111; Gluhak & Rosenberg, 2013:1613). The presence of repeatedly exploited quarries represents evidence for intentional procurement (Abadi-Reis & Rosen, 2008:112).

#### *4.3.1.2 Manufacture*

The reduction of raw material, or manufacture, may occur impromptu at the quarry or within the settlement, such as in a household or formal workshop (Masson, 2005:1143; Carter, 2008:73). Typically, quarried blocks will undergo an initial reduction of large chunks, often occurring at the quarry and resulting in a preform or blank (Wright, 1992:56). After transport to the workshop, the reduced block receives further modification through secondary flake reduction and/or finishing to achieve the desired form (Abadi-Reis & Rosen, 2008:113). As somewhat informal tools, most ground stone artefacts may not receive finishing treatment.

As addressed in Chapter 3, the manufacture stage is where craft specialisation is most visible. A skilled artisan will likely produce a morphologically consistent ground stone typology through repetitive manufacture techniques (Costin, 2005:1066). For example, they may produce bifacial planoconvex grinding slabs of similar dimensions beginning with battering and followed by pecking. The various techniques and the order in which they are used may be visible on the finished ground stone artefact. Consequently, a similar morphology, or standardisation in artefact type, produced by a

consistent *chaîne opératoire* can serve as the identification of the artisan and imply craft specialisation (VanPool & Leonard, 2002).

Ground stone workshops or production centres, similar to those of chipped stone, are identifiable by the presence of debitage, cores, specialised tools, and unfinished artefacts (Wright, 1993:103; Sparks, 2007:180; Carter, 2008:73). This is exemplified by an Iron Age workshop at Hazor in the southern Levant where debitage, metal tools and unfinished basalt vessels were discovered (Ebeling & Rosenberg, In press). The size and type of workshops are proportional to the scale of the industry. For example, households may produce ground stone artefacts for themselves, leaving little surplus.

### 4.3.2 Distribution of ground stone artefacts

Ground stone tools are one of the many artefact types that are commonly cited for evidence of exchange (Weinstein-Evron, B & Ilani, 1999; Milevski, 2008; e.g., Milevski, 2011). Unfortunately there are few studies generated on the precise model of distribution (e.g., tribute, market exchange) (Milevski, 2008:116). While exchange may be evident based on the given distribution of such artefacts, it is exceedingly difficult to reconstruct the nature of this distribution, often limiting their discussion to the general term "exchange". This is due to the small volume, in comparison to other industries (e.g., pottery), of ground stone commodities exchanged. In turn, the small volume is based on several factors, mainly their long use-life, heavy weight, and low consumption per user (2-4 stones of each type per life of user) (David, 1998:55).

Similar to many distribution studies, the first step is to identify the source from which the ground stone originates, often performed through a provenance analysis (Weiner, 2010:36; Gluhak & Rosenberg, 2013). As the location and context of deposition

are identified through excavation, it is the reconstruction of this middle step that is of importance. How did the artefact get from *A* to *B*? This is investigated based on what is known about the two ends of the use-life spectrum: production and consumption. This question has frequently gone unanswered and can only be speculated based on theoretical models (discussed in the previous chapter).

One avenue for investigating distributional behaviour is a comparison of the raw material with the distance that it has travelled (Fratt & Biancaniello, 1993). There is often a direct correlation between the quality of the raw material and the distance from the procurement site. Although poorer quality materials are locally exploited, it is often found that if ground stone assemblages contain imported artefacts used in domestic functions, that these artefacts are typically of higher quality material than what is locally available (Stone, 1994:690-691; Schneider & LaPorta, 2008). It is often observed that the volume of ground stone artefacts often decreases with an increased in distance from the source (Ebeling & Rowan, 2004:111).

The involvement of middlemen is hypothesised in a number of distribution models (e.g., Renfrew, 1975:42), few of which have been applied to ground stone artefacts. From the workshops, ground stone commodities are distributed to consumers through various modes of distribution for further use in domestic, ritual, elite, and/or industrial activities. These modes of distribution are difficult to identify archaeologically and are rarely observed ethnographically. Household production often results in direct access to raw materials and the sole consumption as is observed with the Homol'ovi of the southwestern USA (Fratt & Biancaniello, 1993). However, imported ground stone artefacts are not obtained so easily and the scale of exchange is such that it often requires

centralised organisation. This is apparent in the exchange of ground stone artefacts by the Olmec and Maya in Mesoamerica. An exchanged network, organised by the centralised authority of the lowlands, brought ground stone artefacts from the highland sources to the lowland residents (Rathje, 1972:371-389). Middlemen, likely related to the centralised authorities, facilitated these transactions. This was performed by first bringing the ground stone artefacts from the highlands to the centralised authority in the lowlands, then secondly by establishing a centralised market for the households to acquire them (Rathje, 1972:371). This economic system connected producers in one region with consumers in another through centralised redistribution (Rathje, 1972; Milevski, 2008:117).

The movement of ground stone commodities over distances greater than a single day round trip (the standard procurement time for household procurement) occurs more frequently in complex societies (Milevski, 2011:118-119). As household production decreased and specialised craft production increased, it is assumed that middlemen were able to traverse these distances in place of the producers (Rutter, 2003:154). In addition, the domestication of the donkey and other beasts of burden would have facilitated this long distance exchange (Greenfield, Shai & Maeir, 2012:24). Although ground stone artefacts are an appropriate means to establishing the occurrence of exchange, they have been somewhat enigmatic in the reconstruction of the nature of their distribution.

### 4.3.3 Consumption and discard of ground stone artefacts

Consumption research on ground stone tools often focuses on subsistence strategies (e.g., hide working, fishing) and food preparation (e.g., cereal grinding) (Ebeling & Rowan, 2004:108). Many studies that focus on ground stone consumption have centred on assemblages of southwestern United States aboriginals (e.g., Adams,

1993; Adams, 1999). Such studies, among others, have produced significant information on the analysis of consumption of ground stone artefacts. The sections that follow discuss how consumption is categorised through use and the relationship it maintains with the function of artefacts.

#### *4.3.3.1 Viewing consumption through use*

As noted above, there is a divide between the intended use and the actual use of a ground stone artefact: the former is theoretical while the latter is practical. The consumption of ground stone artefacts is divided into two categories of actual use-life stages: primary and secondary. The primary use-life stage is described as the original function of an artefact (Adams, 2014b:24), such as the discovery of a lower grinding stone in an installation with the worn side up. Meanwhile, the secondary use-life stage, whether sequential or concomitant, involves any additional usage of the artefact beyond the primary use-life (Adams, 2014b:24-25). This recycling suggests long-term habitation and/or a restriction of resources (Adams, 2014b:24-25). Artefacts found in situ or in a primary context have not undergone intentional disposal.

The limitation of space in households and neighbourhoods often contributes to regular maintenance and recycling (Arnold 1994:916). As consumers, households will often organise the space within the residential complex to suit certain activities. This is evident at the Neolithic settlement of Jilat 7 in the Sinai where caches of large, complete grinding tools were demarcating areas of food preparation and storage (Wright, 2008:134-135). Finding *in situ* grinding stones is rare due to their value for secondary use, such as in a wall, or their regular discarding because of the space a dead grinding stone will occupy. As a result the involvement of a ground stone artefact in an activity

area is often inferred through residue and wear analysis and the presence of other finds (e.g., debitage, phytoliths) associated with the activity area (Adams, 2014b:46). Although the typology of a ground stone artefact is indicative of its function, Wright (1994b:242) identifies the difficulty in assigning a ground stone typology to a specific substance being ground.

#### *4.3.3.2 Relationship between function and consumption*

It is apparent that the nature of consumption is linked to the function of each ground stone artefact. While the functions of ground stone artefacts may appear to be self evident, use-wear analysis, residue analysis, and ethnographic analogy has been useful in understanding the correlation between ground stone artefacts and their role in subsistence practices and food preparation (David, 1998:60; Hamon, 2008:1516). This "form equals function" approach (Adams, 1999:476) has served to categorise these artefacts, including the popular ground stone vessels used in the serving or storage of food, as indicative of traditionally domestic tasks (Adams, 1999:475). As a result, they are often associated with the role of women in the household (Ebeling & Rowan, 2004:113). This sexual division of labour may be incorrect as historical texts (e.g., Judges 16:21-22; Lamentations 5:13) and statuette representations (e.g., see late 18$^{th}$ Dynasty Egyptian statuette in Ebeling & Rowan 2004:109) depict men also performing tasks that involve ground stone artefacts (Ebeling & Rowan, 2004:109-114). Consequently, it is evident that the predominant consumers of ground stone artefacts were households (Kadowaki, 2008:252; Wright, 2008:138), although the elite were a minor consumer of ground stone artefacts, using vessels and maceheads as ritual objects and in burials (Rosenberg, 2010:214).

From a broad perspective, ground stone artefacts enable the establishment of the local economy as use-wear analysis and residue analysis permit the identification of the agricultural products consumed. Within a house, the collective function of a ground stone assemblage is designed to forward the economic status and well-being of the household (Wilk & Rathje, 1982:631-632). As instruments so important to subsistence and daily life and so prevalent in domestic assemblages (David, 1998:23; Adams, 1999), it is apparent that the acquisition of ground stone artefacts was a high priority (Wright, 2008:130). Therefore, ground stone artefacts have the potential to illuminate domestic practices and the organisation of activity areas by the household.

## 4.4 Ground stone research on the Chalcolithic and EBA of the southern Levant

Despite being under-studied, the potential of ground stone artefacts to reconstruct and understand behaviour has been realised in research on the southern Levant. The following sections summarise the ground stone literature from the southern Levant. Two major periods are considered in this review: Chalcolithic and EBA. Although this thesis focused on the EB II-III, the preceding Chalcolithic and EB I were included in the review in order to demonstrate long-term patterns relevant to the increasing urbanisation of the region.

### 4.4.1 Chalcolithic

The Chalcolithic (ca. 4500-3300 BCE) was a period of change from the preceding Neolithic (ca. 8500-4500 BCE), not only culturally, but also economically (Rowan & Golden, 2009:1). During this period there is evidence of increased specialised craft production and long distance exchange networks, including those of ground stone artefacts (Levy, 2003: 263). A discussion of ground stone artefacts, both basalt and in

general, is entailed in the sections below. This discussion contributes to establishing and understanding the development of ground stone industries over time in the southern Levant.

#### *4.4.1.1 Ground stone artefacts: general*

A variety of raw material was exploited in the production of ground stone artefacts, including basalt, limestone, and sandstone (Rowan *et al.*, 2006:577). This range of material, present in most assemblages, represents the utilisation of both local sources and imported commodities (van den Brink, Rowan & Braun, 1999:164). The majority of settlement assemblages contain ground stone artefacts manufactured from sources proximate to the settlement.

An absence of workshops with a secure Chalcolithic context limits studies on ground stone production (Rowan & Golden, 2009:41). Though many ground stone artefacts bear fine craftsmanship, there is little discussion of assemblage standardisation or specialised craft production (van den Brink, Rowan & Braun, 1999:163; Rowan & Golden, 2009:41).

The limited analyses of settlement assemblages, e.g., Shoham (Rowan, 2005) and Gilat (Rowan *et al.*, 2006), offers insight into the typology of ground stone artefacts used during the Chalcolithic. Ground stone typologies remain static over long periods of time and exhibit little variation throughout the Chalcolithic period of the southern Levant (Rowan & Ebeling, 2008a:2-3). As the majority of ground stone artefacts discovered are those associated with domestic activities, it follows that the primary consumers were domestic units or households. Wright (1992) has generated a detailed classification system based on the typologies of Chalcolithic settlements into which the majority of

ground stone artefacts fit. These include mace heads, slabs, pounders, mortars and vessels. Mace heads are a distinct industry as they were not used for military functions, but used as ritual or prestige items (Bourke, 2008:139; Rosenberg, 2010:214).

#### *4.4.1.2 Ground stone artefacts: basalt*

Basalt ground stone artefacts are present in assemblages in a variety of form. However, basalt vessels emerge as a trademark of the Chalcolithic and have received the majority of attention in Chalcolithic ground stone studies (van den Brink, Rowan & Braun, 1999; e.g., Philip & Williams-Thorpe, 2000; Rutter, 2003). Wright (1992:75-76) includes a number of subcategories into which the basalt vessels fall. The most abundant in the archaeological record are V-shaped vessels that are typically plain with a polished open cavity, and zoomorphic/anthropomorphic vessels that bear decorative representations of animals or people on the exterior (Rutter, 2003:136; Bourke, 2008:135). Variations of the basalt vessel industries are decorated with fenestrated or pedestalled support structure (e.g., van den Brink, Rowan & Braun, 1999). These popular basalt vessels are considered to be ritual or prestige items as they have been recovered from Egyptian tombs and Proto-Canaanite burials (Mallory-Greenough & Greenough, 2004:707). Their significance to the afterlife or their role in a mortuary context other than grave goods is not yet known. However, this evidence suggests that households were not the sole consumers of ground stone artefacts (Rutter, 2003:137).

As no workshops have yet been discovered, evidence of the production of these vessels is scarce (van den Brink, Rowan & Braun, 1999:164). Remnants of basalt debitage were discovered at Tell Abu Hamid, Jordan, but were thought to be associated with retouching (van den Brink, Rowan & Braun, 1999:164). The large settlement of

Teleilat Ghassul, Jordan was originally assumed to be a production centre due to its prominence and large assemblage of basalt vessels (Bourke, 2008:135). However, this hypothesis was overturned by provenance studies that showed that the majority of basalt vessels originated from Jordanian outcrops to the south and Golan outcrops to the north (Philip & Williams-Thorpe, 1993; Philip & Williams-Thorpe, 2000).

Basalt was clearly a prized material as ground stone artefacts of this material are discovered at the majority of settlements, including those great distances (>200km) from their sources (Ebeling & Rowan, 2004108). Though more heavily concentrated at settlements near basalt outcrops, basalt vessels were distributed across the southern Levant, being nearly ubiquitous at Chalcolithic settlements, including Sal, Jordan, Shiqmim, Israel, and as far north as Dan, Israel (Philip & Williams-Thorpe, 1993:53; van den Brink, Rowan & Braun, 1999:168). An example of the distance that basalt ground stone artefacts were distributed is that many basalt vessels discovered in Egypt have been provenanced to western Jordan. These are the end-results and representatives of an inter-regional exchange network that existed between Egypt and the southern Levant (Mallory-Greenough & Greenough, 2004). This movement of basalt commodities may have occurred via the King's Highway as a high number of vessels were discovered at Maadi, Egypt (Mallory-Greenough & Greenough, 2004; Savage, 2011). However, basalt bowls that were sourced to Mt. Hermon in northern Israel were discovered at Jordanian settlements (Rutter, 2003:233). This demonstrates that even though basalt outcrops were locally available, Jordanian settlements exchanged basalt commodities with groups in the northern sub-regions of the southern Levant. This may have been for socio-political factors or a preference for the craftsmanship or material (Rutter, 2003:233)

The exchange of basalt artefacts during the Chalcolithic is widespread throughout the southern Levant and into Egypt. Local exploitation of resources is practiced. The limited provenance studies demonstrate that there does not appear to be a reliance on a specific sub-region for basalt commodities. It is further important to note that exchange of basalt commodities was facilitated by factors other than necessity.

### 4.4.2 Early Bronze Age I

The EB I of the southern Levant is distinguished from the Chalcolithic by the appearance of new cultural trends, particularly those of agricultural-intensive villages and new wide spread pottery industries (Mazar, 1990:92). Despite these alterations, there are minor changes in the ground stone industry. This observation may stem from an inadequate amount of EB I ground stone studies (Philip, 2008:205). The few ground stone studies of the EB I have focused on recording typologies based on the assemblages from settlements and reconstructing exchange networks through a provenance analysis of the raw material (Milevski, 2008: 116). The results of the aforementioned studies are discussed in the sections that follow and in reference to basalt and ground stone artefacts in general.

#### *4.4.2.1 Ground stone artefacts: general*

Occupants of EB I settlements exploit their local raw material sources for ground stone production, a trend that was present in the Chalcolithic. This is evident at the settlements of Bab edh-Dhra, Jordan, and Bet Yerah, Israel, where basalt was procured and at Hazor, Israel, where beachrock was procured (Milevski, 2008:118).

An insufficient amount of research has been conducted on the standardisation of assemblage typologies impeding inter-settlement comparisons (Rowan, 2003:200). The

ground stone typologies of the EB I are derived from assemblages on excavated settlements, such as Qiryat Ata, Israel (Rowan, 2003) and Yiftaḥ'el, Israel (Braun, 1997). Utilitarian tools, such as slabs, hand stones, and pounders, dominate the ground stone assemblages (Rowan, 2003:200). They display little change from those of the Chalcolithic period and are similarly fashioned for subsistence practices and domestic activities (Philip, 2008:205).

#### *4.4.2.2 Ground stone artefacts: basalt*

The basalt industry of the Chalcolithic continues during the EB I. However, a notable alteration is that the vessels of the EB I exhibit cruder manufacturing marks (Rutter, 2003:150). In addition, it has been put forth that decorative patterns on the vessels may be due to regional variances produced by multiple individual artisans (Gophna, 1979; Braun, 1990:93). A provenance study conducted on vessels from several Jordanian settlements demonstrates that they were produced from several procurement sites spread across western Jordan and the Jordan Valley (Philip & Williams-Thorpe, 1993). This provides support for the hypothesis that regional variations were present in the vessel industry (Braun, 1990:93).

The reconstruction of exchange routes has been the primary theme of EB I ground stone studies in the southern Levant. Similar to the Chalcolithic, this is achieved through distribution and provenance analyses conducted on basalt artefacts. The distribution of basalt ground stone artefacts encompasses the majority of southern Levantine settlements. The networks of this distribution are depicted in Figure 7.1 of Milevski (2008:119) where both the Jordanian sources and northern sub-regions are assumed to be the main suppliers of basalt. Many basalt ground stone artefacts, vessels in particular,

have been discovered at settlements within distant regions from basalt sources, including settlements within the Coastal Plain, Shephelah and Southern Hill Country (Braun, 1990:88; Rowan, 1998:56). The volume of basalt vessels wains as the distance from sources increases. Provenance investigation of basalt vessels has shown that they were also exchanged as far away as Egypt, as the Chalcolithic networks continued to operate in this sub-period (Mallory-Greenough & Greenough, 2004). Basalt vessels continue to be found in elite mortuary contexts which implies that they may have been prestige items or served a ritual function (Rowan 1998:55). These artefacts were not limited to households and domestic activities, as the elite also considered them to be commodities of value (Rutter, 2003:148).

Additional EB I connections between the southern Levant and Egypt are discussed by Savage (2011). While a provenance study is not included, the distribution of basalt spindle whorls within Egypt, Mesopotamia, and the southern Levant is examined. With a high concentration of typologically similar basalt spindle whorls appearing in the central southern Levant and lower concentrations in Egypt (Maadi) and Mesopotamia (Hama, Judaidah), it is hypothesised that Levantine middlemen controlled the movement of these commodities (Savage, 2011:131). The movement of basalt spindle whorls could have occurred via overland routes (see Figure 1 in Savage 2011:120), specifically the Way of Horus, the King's Highway, or via the coastal road (Savage, 2011:128).

It should be pointed out that there is a higher volume of basalt artefacts discovered in Jordanian settlements that are provenanced to Mt. Hermon and the northern sub-regions than during the Chalcolithic (Rutter, 2003:235). The exchange between these

two locations represents a growing preference for socio-political relations rather than simple economic subsistence (Rutter, 2003:235).

### 4.4.3 Early Bronze Age II-III

The southern Levant during the EB II-III was a period of socio-political transformation, experiencing the emergence and regional domination of urban centres. Ground stone artefacts appear to be ubiquitous during the EB II-III at southern Levantine settlements and are recovered from urban centres as well as peripheral villages (Ebeling & Rowan, 2004). However, the small corpus of ground stone literature from this period and region is limited to a cataloguing of their assemblages by typology in site reports (Gopher & Eisenberg, 2001; e.g., Rowan, 2003), or exchange studies through an analysis of their distribution (e.g., Milevski, 2011). The sections below discuss this literature, specifically in relation to basalt and ground stone artefacts in general.

#### *4.4.3.1 Ground stone artefacts: general*

The consistency of assemblage typologies with Wright's (1992) classification system demonstrates how ground stone typologies can remain static over long periods of time with little variability (Rowan & Ebeling, 2008a:2). The ground stone assemblages of the EB II-III display a high variability of raw material as settlement occupants participated in an exploitation of local sources, possibly through household production (Philip, 2008:205). Occupants of settlements of all sizes, such as Arad, Bab edh-Dhra, Gezer, accessed their local sources of sandstone, basalt, and beachrock respectively (Milevski, 2011). Milevski (2005:118) describes the EB II-III exchange of ground stone artefacts as consisting of a "localised net of distribution" and a "non-homogenous market", where local acquisition and distribution primarily occurred.

The typologies of the EB II-III ground stone assemblages, composed of grinding slabs, weights, pounders, and other artefacts that fit into Wright's (1992) classification, reflects the function of these artefacts. Similar to assemblages of the Chalcolithic and EB I the assemblages of the EB II-III are indicative of the subsistence strategies and domestic practices of the consumers. This is evident at Bet Yerah where grinding stones and pestles were discovered near food storage areas and weights were discovered in broad rooms and courtyards where one might repair fishing nets (Paz, 2012:416). The consumption of artefacts has not been systematically investigated on assemblages of the EB II-III of the southern Levant.

#### *4.4.3.2 Ground stone artefacts: basalt*

There are significant changes between the EB I basalt ground stone artefacts and those of the EB II-III. The most notable alteration is the discontinuation of the basalt vessel industries, former hallmarks of the Chalcolithic and EB I, that disappear at the beginning of the EB II-III (Rutter, 2003:148). However, similar to the EB I and the Chalcolithic, no basalt ground stone workshops or quarries have been discovered with a secure EB II-III context (Milevski, 2008:121).

Because the EB II-III assemblage typologies are very static, it is the raw material of the artefacts that is indicative of exchange (Rowan & Ebeling, 2008a:2-5). Basalt ground stones have been the focus of these investigations (e.g., Milevski, 2008; Milevski, 2011:107) based solely on their distance from the nearest sources. However, there are no provenance studies from the EB II-III that systemically identify where these artefacts originate (Rutter & Philip, 2008:343). The basalt ground stone distribution in the southern Levant during the EBII-III can be divided into local and long distance exchange.

The frequency of basalt artefacts is highest at north-eastern settlements where the high availability of basalt flows in the Golan and Galilee sub-regions seemed to dictate the material composition of the assemblage. This is most evident at Bet Yerah where occupants participated in an exploitation of their local basalt sources (Greenberg, 2011:46). This may imply that Bet Yerah was a prominent consumer of basalt artefacts since they were locally produced and relatively inexpensive (Greenberg, 2011:46-48; Greenberg *et al.*, 2012). In contrast, the evidence from southern settlements shows that the frequency of basalt ground stone artefacts declines with the greater distance from the Golan and Galilee sources. Few basalt artefacts (e.g., tournettes) have been found within the Southern Hill Country and the Shephelah (Roux & de Miroschedji, 2009:160). It is assumed that these were fashioned at Bet Yerah and exchanged south via the Jordan Valley or through Megiddo (Roux & de Miroschedji, 2009:160). At sites further south and more distant from basalt sources, such as Nahal Tillah, Israel, there is an even lower frequency of basalt grinding stones (Milevski, 2008:124).

Based on macroscopic analysis, it is argued that basalt artefacts from the Jezreel Valley, Golan and Galilee sources were accessed and distributed more than those of the Jordanian sources (Milevski, 2008:119). This may represent a shift in which settlements were the leading producers and exporters as urban centres within the Jezreel Valley, the Golan and the Galilee sub-regions, such as Bet Yerah and Megiddo became dominant socio-economic players throughout the EB II-III (Greenberg *et al.*, 2012). Additionally, the widespread exchange from north-eastern sub-regions to the rest of the southern Levant may continue the trend experienced during the EB I where even settlements with ready access to basalt resources were acquiring these imported commodities.

## 4.5 Conclusion

The information presented in the preceding sections demonstrated that ground stone artefacts are under-studied and have the potential to provide a greater contribution to the understanding of human behaviour. As an important domestic commodity they can be analysed through the stages of their life-history, namely their production, distribution, and consumption. Most studies of ground stone artefacts in the southern Levant have focused on one aspect of the life-history.

The economic systems revolving around basalt ground stone artefacts of the Chalcolithic-EB III of the southern Levant were quite similar. There was a high reliance on local production and proximity to a source dictated the volume of basalt artefacts in a settlements assemblage. The quality of production, particularity that of basalt vessels, decreases from the Chalcolithic to the EB I. Inter-regional exchange of basalt commodities to Egypt decreases from the EB I to the EB II. However, the distribution of basalt artefacts is widespread across the southern Levant during both periods.

The discussion presented above and in the previous chapters demonstrates what domestic commodities, namely basalt ground stone artefacts, can reveal about daily life and economic systems. In the next chapter, this cumulative information is synthesised into hypotheses and applied to an examination of the basalt assemblage of Tell es-Safi/Gath.

# Chapter 5. Hypotheses, methods, and techniques

## 5.1 Introduction

Many issues in archaeology require the structured inquiry of the Scientific Method in order to provide a full understanding of behaviour. The issues pertaining to this thesis are no exception.

This thesis used the information presented and the models discussed in the preceding chapters concerning economic systems, ground stone analysis, and early urban societies of the southern Levant to generate questions and testable hypotheses about the life history of basalt ground stone artefacts. The hypotheses were investigated and tested through the methods and techniques that are discussed in the sections that follow. This chapter describes the systematic steps involved in the investigation of the life history of basalt ground stone artefacts of EB III Tell es-Safi/Gath their implications for exchange in the southern Levant.

## 5.2 Questions and hypotheses

The discovery and recovery of basalt ground stone artefacts at Tell es-Safi/Gath gave rise to a unique set of questions. These questions were composed to address the following topics: geological and social provenance, production, distribution, and consumption and discard. They are presented below:

- 1) Geological and social provenance: from which geological source(s) and sub-regions(s) did the basalt ground stone artefacts originate?
- 2) Production: what was the organisation of production associated with the basalt ground stone artefacts?

- 3) Distribution: what was the nature of distribution associated with the basalt ground stone artefacts?
- 4) Consumption and discard: what were the consumption and disposal strategies of basalt ground stone artefacts?

These questions were designed to flesh out information regarding the life-history of basalt ground stone artefacts in the EB II-III southern Levant.

In order to answer the questions, it was necessary to address them in the form of testable hypotheses. The testing of hypotheses is essential to archaeological inquiry and the generation of knowledge. As tentative explanations for phenomena, hypotheses serve as the focal points of investigation. The validity of each hypothesis holds implications for constructing more complete theories regarding the nature of production, distribution, and consumption of ground stone artefacts, both in general and during the EB II-III of the southern Levant. Hence, the examination of the basalt artefacts was guided by a combination of questions and hypotheses. These are expanded upon below in respect to the basalt ground stone artefacts of EB III Tell es-Safi/Gath.

### 5.2.1 Provenance

- Question 1: From which geological source(s) and sub-regions(s) did the basalt ground stone artefacts originate?

  Hypothesis 1: *If a basalt ground stone artefact originated from a specific source, then based on the provenance postulate, both the artefact and the source should bear the same geochemical fingerprints.*

Establishing the source of the basalt ground stone artefacts was vital to understanding their life-history. Knowledge of the geological source(s) provided

information on the distance of their movement. Although knowledge of the source(s) or procurement site proves valuable, further investigation was necessary to identify the people supplying the basalt commodities. Identification of the source(s) allowed associations to be made between the procurement site (geological source) and the nearest settlement (Rutter & Philip, 2008: 343). Local exploitation of a basalt source was a common practice in the southern Levantine settlements. Basalt artefacts provide evidence that settlement occupants interacted with their local environment and exploited the sources for subsistence and economic gain, most likely out of availability and convenience (Jacobson, van der Westhuizen & de Bruiyn, 1995:381; Neff, 2012: 829). Further interaction, in the form of exchange, was essential for the acquisition of the basalt ground stone artefacts.

The provenance investigation of these hypotheses was accomplished through a combination of several methods: provenance analysis (Method 1 – all methods are discussed further in the chapter), trace element analysis (Method 2), and a meta-analysis (Method 3). The trace element analysis was performed on the basalt ground stone assemblage while the meta-analysis was performed on the basalt sources. The results of the trace element analysis and meta-analysis were compared through the encompassing provenance analysis. Energy dispersal x-ray fluorescence (ED-XRF) was the technique that provided data for the trace element analysis.

Hypotheses 1 would be verified if the following condition is satisfied:

- a) The geochemical fingerprint of an artefact matches that of the geological source (Neff, 2001:107-108).

### 5.2.2 Production

- Question 2: What was the organisation of production associated with the basalt ground stone artefacts?

Hypothesis 2.1: *If the neighbourhood at Tell es-Safi/Gath was comprised of non-elite residential houses, then it is expected that the occupants engaged in household production of ground stone artefacts.*

Hypothesis 2.2: *If the EB II-III of the southern Levant was a period of growing social complexity and increased specialised craft production, then it is likely that the basalt ground stone industry was also produced through specialised craft production*.

The production stage in the life-history of the basalt ground stone artefacts is arguably the most important stage. Energy expenditure through the reduction of raw material produces a finished commodity of value. It was important to reconstruct this transformation from a useless chunk of rock to a tool used in most households as it revealed information about the artisan. The skill of the artisan may be discerned by studying the ground stone artefacts.

Hypothesis 2.1 was tested through field excavation and documentation (Method 5). Techniques included the sieving of material in an attempt to discover basalt debitage. Documentation during excavation identified the areas of spatial densities of basalt debitage within the neighbourhood, alleyway, and/or households. This provided information on where manufacture or lithic refuse discard occurred.

The hypothesis above would be verified if the following expectations are met:

- a) Basalt debitage is discovered in high quantities within the neighbourhood area.

Hypothesis 2.2 was tested through a qualitative analysis (Method 6) and a morphometric analysis (Method 4). A qualitative analysis was conducted through macroscopic observations in an effort to organise the basalt ground stone assemblage into a working typology. Typologies assist in categorising the basalt artefacts in preparation for a morphometric analysis. The morphometric analysis of the basalt ground stone assemblage attempted to identify the degree of standardisation through measurements of the ground stone artefacts.

The hypothesis above would be verified if the following expectations are met:

- a) Basalt ground stone artefacts of the same type display little to no variation in their dimensions (Blackman, Stein & Vandiver, 1993:61; Schneider & LaPorta, 2008:32).

**5.2.3 Distribution**

- Question 3: What was the nature of distribution associated with the basalt ground stone artefacts?

Hypothesis 3: *If Tell es-Safi/Gath was a large urban settlement, then it is likely that a centralised authority obtained imported commodities (e.g., basalt artefacts) for redistribution to the settlement occupants.*

Distributional behaviour facilitates the movement and ownership changes of commodities. The commodities at Tell es-Safi/Gath are no exception. Redistribution through a centralised authority involves the accumulation of commodities, the movement of those commodities to a central location, and a further reallocation of those

commodities to consumers (Masson, 2005:1142). This form of exchange is often facilitated between distant regions by middlemen (Renfrew, 1975:42).

This hypothesis was tested through a combination of methods. These methods entailed a provenance analysis (Method 1), a trace element analysis (Method 2), a meta-analysis (Method 3), field excavation and documentation (Method 5), and a qualitative analysis (Method 6). The geochemical results of Hypotheses 1, performed through ED-XRF and a meta-analysis, provided data for this inquiry. An assessment of the basalt ground stone typologies in each house through a qualitative analysis and a distributional analysis would reveal the similar types of artefacts among households. This further highlights what groups had access to certain commodities.

This hypothesis would hold true if the following conditions are met:

- a) The basalt artefacts were imported from a non-local producer.
- b) Each household not only contains basalt (imported) artefacts, but a similar assemblage of basalt ground stone artefacts.

### 5.2.4 Consumption and discard

- Question 4: What were the consumption and disposal strategies of basalt ground stone artefacts at Tell es-Safi/Gath?
- Hypothesis 4: *If the neighbourhood at Tell es-Safi/Gath housed non-elite residents, then it is likely that the households performed traditionally domestic tasks and engaged in the recycling of commodities.*

The local economy of a settlement was often related to its political standing in its sub-region. It further reveals whether a settlement relied on various external producers for their commodities or whether they were self-sufficient.

This hypothesis contains two different but related components of investigation. It was tested through a qualitative analysis (Method 6) and field excavation and documentation (Method 5). The qualitative analysis involved a construction of a typology and macroscopic observations, providing information on its intended function for the consumer. Field excavation and documentation provided information on the location of the ground stone artefacts to establish the context and use-stage of the artefacts and how they came to be there.

Hypotheses 4 would be verified if the following condition is satisfied:

- a) The basalt ground stone assemblage contains artefacts that were used in traditional household activities (e.g., food processing, subsistence strategies) and bears evidence of use of their intended function (e.g., use-wear polish).
- b) The basalt ground stone artefacts are found in secondary use-life stages (Adams, 2014b:46).

## 5.3 Methods and techniques

A method is the plan or organisational steps involved in investigating a problem while a technique is the instrument or application used to accomplish those steps or a specific task. The methods and techniques employed in this thesis were conducive to answering the research questions and testing the hypotheses. The sections that follow outline the various methods and their related techniques utilised to generate data.

### 5.3.1 Method 1: Provenance analysis

In order to establish the nature of movement of the basalt ground stone artefacts from the EB III strata of Tell es-Safi/Gath, a provenance analysis was applied. Embodied

within any provenance analysis is the identification of a materials source or origin. In archaeology this investigation is regularly performed for a range of artefacts where ceramics, chipped stone artefacts, and metal are among the most commonly examined (Neff, 2001).

This thesis applied the same principles to basalt ground stone artefacts and their potential source(s). The provenance analysis compared the results of the trace-element analysis performed on the basalt ground stone artefacts with the results of the meta-analysis performed on the fingerprints of various geological sources in the Near East. In specific, this provenance analysis was based on the comparison of geochemical fingerprints and was supported by the provenance postulate.

#### *5.3.1.1 Geochemical fingerprints*

Accurate and successful provenance analyses are performed through the generation and comparison of mineralogical and/or elemental fingerprints (Lambert, 2005:482; Weiner, 2010:37). Such fingerprints, including isotopic profiles (e.g., Hull *et al.*, 2008), major and minor elements, as well as trace elements, serve as the unique composition by which a material may be identified at the geochemical level (Neff, 2012). Of these, trace elements are arguably the most defining criteria (Weiner, 2010:68), as they are identified as those elements present in concentrations of less than 1000 parts-per-million (ppm) by weight of a rocks composition (McSween Jr., Richardson & Uhle, 2003:248).

The criteria for selecting a type of geochemical characterisation upon which to base the provenance results depended on the elements or minerals that offered the best discrimination between sources. Various elements (major and trace) were used to obtain

matches between the geochemical fingerprints of the geological sources and the basalt artefacts. For basalt, the elements $SiO_2$, $Na_2O$, $K_2O$, Rb, Y, Sr, and Ni were used. $SiO_2$, $Na_2O$, and $K_2O$ allowed a total alkali vs. silica graph to be created (discussed in section 5.3.3), while Rb, Y, Sr, and Ni appeared as trace elements whose proportions characterise volcanic flows.

#### *5.3.1.2 Provenance postulate*

Early studies of exchange lacked concrete scientific evidence to connect a certain location or group of people to an artefact (Glascock, 2002:1). As scientific techniques advanced they were adopted into archaeological research. A pioneer in this avenue was Shepard (1948; 1956) who incorporated a petrographic analysis into her provenancing of ceramic material. Since then, archaeologists have focused on using mineral and chemical characterisation methods and techniques for establishing the source of an artefact. In effect, this association between the artefact and a source became described as the *provenance postulate*. First described by Weigand et al. (1977:24), the provenance postulate is the underlying principle of this trace element analysis (Rice, 2005:413). Simply stated, the provenance postulate maintains that differences between the fingerprints of separate raw materials are analytically identifiable and that any compositional variations will be smaller within sources than between sources (Glascock, 2002:2; Rice, 2005:414). It has been further expanded by Neff (2001:107-108) to note that identifying the parent source is possible "as long as there exists some qualitative or quantitative chemical or mineralogical difference between natural sources that exceeds the qualitative or quantitative variation within each source." Consequently, data generated from the mineralogical and elemental studies demonstrate the superior methods

of identifying the source of an artefact and provide the opportunity for replicable and precise results (Glascock & Neff, 2004:1516; Lambert, 2005:478). Hence, provenance studies serve as a bridge between the hard sciences and social sciences.

### 5.3.2 Method 2: Trace element analysis

The trace element analysis was performed on the basalt ground stone artefacts from the EB III levels at Tell es-Safi/Gath. The most common techniques utilised in trace-element analyses are x-ray fluorescence (XRF) (Lambert, 2005; Pollard *et al.*, 2007), neutron activation analysis (NAA) (Neff, 2001), and various forms of inductively coupled plasma mass spectroscopy (ICP-MS) (Neff, 2012). The application of these techniques provides statistical amounts of geochemical constituents of a material. The technique used in this trace element analysis was energy dispersal x-ray fluorescence (ED-XRF) spectrometry and is expanded upon below.

#### *5.3.2.1 Technique: energy dispersal x-ray fluorescence*

There were three integral parts to obtaining the geochemical signatures of the basalt ground stone artefacts: selection of a sample, sample preparation, and the actual analysis. Each of these is discussed, in turn, in the sections that follow.

5.3.2.1.1 Selection of sample

A total of nineteen basalt ground stone artefacts from the EB IIII ground stone assemblage of Tell es-Safi/Gath were subjected to ED-XRF analysis (Table 5.1). These were not selected at random. For the most accurate results, all basalt ground stone artefacts found in a primary context were selected. Because the total number of artefacts discovered in a primary context is small, artefacts from secondary contexts were also selected. As there were a number of artefacts in a secondary context it is necessary to

select them based on their spatial organisation, tensile strength, and surplus of material. Thus, it was attempted that an artefact be selected from each room in an effort to obtain a geochemical profile of an artefact from every area of the neighbourhood. Furthermore, some artefacts could not be fractured with a hammer (e.g., 746060) due to their density and tensile strength, and some were too small too to use (e.g., 84011, 16E83C087).

5.3.2.1.2 Sample preparation

The sample preparation for the trace element analysis using ED-XRF mirrored that of Eliyahu-Behar *et al.* (2012). To begin, a small piece (ca. 20g) was snapped off of each of the basalt ground stone artefacts used in the analysis. This trace element analysis required a minute amount (5-10g) of material. This was a negligible amount in comparison to the size of the artefacts, rendering little damage to them. The small pieces were then crushed into smaller fragments (ca. 0.5mm in diameter) and submersed in ethanol ($C_2H_6O$) in a plastic vial. The vial was sealed and floated in a vibrating sonic bath for 20 minutes in order to sift clinging sediment material and residue off the basalt fragments. Upon removal from both the sonic bath and vial, the basalt fragments were placed under a heat lap to dry. Once dry, the fragments were further crushed in a Retsch MM 400 mixer mill with agate containers and balls resulting in a powder. Because basalt is a strong and dense material, it was necessary to further crush the powder down to particle sizes smaller than 125µm using an agate mortar and pestle. For each sample, 4g of resulting fine powder was mixed with 0.9g of FluXana HD Elektronik BM-0002-1 licowax micropowder. The new mixture was placed in a Specac crusher and pressed under 12 tons of pressure into a 32mm diameter pellet. The solid pellets were then placed in a Spectro-XEPOS XRF instrument for analysis. The Spectro-XEPOS XRF instrument

measured the fluorescence with a palladium (Pd) anode and secondary targets while Spectro-XEPOS HE software recorded the data (Eliyahu-Behar *et al.*, 2012:258).

5.3.2.1.3 ED-XRF analysis

ED-XRF involves the bombardment of a sample, in pellet or powder form, with x-rays in order to discover the samples elemental constituents. At the atomic level, x-rays target electrons in the valence orbits around the nucleus of atoms (Rollinson, 1993:10). The result is an ionisation of the atom and the ejection of an electron from the lower valence orbits resulting in the instability of the structure of the atom (Rice, 2005:393). This instability is resolved by the transfer of an electron in a higher valence orbit to the former place of the aforementioned ejected electron (Rice, 2005:393). With this electron transfer energy is expelled as electromagnetic radiation. The intensity of this radiation is characteristic of the specific element to which that atom belongs (Rollinson, 1993:10). This radiation or fluorescence is absorbed by sensors and measured, permitting the identification of the element (Pollard *et al.*, 2007:101).

These measurements are performed and recorded on a range of elements in the XRF instrument. This exposure to x-rays does not damage the samples (Shackley, 2011:8), allowing them to be reused in future analysis. In addition, XRF analysis is cost effective and quick, as the machine does not require an operator to monitor it once the test has begun (Shackley, 2011:9).

### 5.3.3 Method 3: Meta-analysis

A meta-analysis of geochemical data as undertaken in this thesis. A meta-analysis consisted of a new analysis on existing data combined from separate studies in order to further understand the significance of those studies in relation to each other. The

statistical conversion of existing data to uniform units of measurements enabled this method. The meta-analysis embodied in this thesis involved the extraction and manipulation of the values of various geochemical fingerprints of multiple basalt sources in the Near East in order to make them statistically meaningful. It allowed the combination and comparison of the results from these previous studies. The sections below describe the location and fingerprints of the geological sources used in the meta-analysis.

#### *5.3.3.1 Geological sources*

Near the eastern boundary of the southern Levant and along the current Israel-Jordan border resides an earthquake fault line. This fault line, commonly referred to as the Great Rift Valley, Levantine Fault, or Dead Sea Fault, is the northern most meeting of the Sinai Sub-Plate with the Arabian Plate. As a tectonically active location, eruptions from volcanoes in this geographic region have resulted in periodic flows of lava, culminating in plateaus or strata of igneous rocks (Al-Malabeh, 1994:519). Several flows resulted in strata of basalt, described as a dark-coloured, fine-grained, extrusive igneous rock (Allaby, 2013).

At an approximate distance of 120km from Tell es-Safi/Gath, the closest basalt outcrops are located in the Jezreel Valley, Galilee and Golan (see Figure 1 of Weinstein *et al*. 2006:3) (Ebeling & Rowan, 2004:108; Citron-Katz, 2012:495). Other more distant sources (>120km) are located in the southern Negev and Jordanian regions (see Figure 1 in Mallory-Greenough & Greenough 2004:701), extending from the eastern Dead Sea Plain into western Jordan (Ebeling & Rowan, 2004:108). Additional sources, though

sparse, are located in Egypt over 500km to the west (see Figure 2 in Mallory-Greenough & Greenough 2004:702).

#### *5.3.3.2 Geochemical fingerprints of sources*

It was necessary to acquire geochemical fingerprints of each available source in order to compare them to the fingerprints of the artefacts in an effort to find a match with the basalt artefacts. Due to the difficulties encountered in collecting field samples of each source, comparative data sets were obtained from published literature. This collection of literature included both archaeological and geological studies. The geochemical data in the literature included fingerprints from several strata located in the Near East. A data comparison served to confirm or eliminate certain fingerprints in order to establish where the basalt ground stone artefacts were procured or where they were not procured.

To begin, the data from geochemical profiles were extracted from the literature and converted into an *iNumbers* file as a separate database. The data was then organised by site, sub-region and/or geological source, site average and source average, total alkali vs. silica categorisation, and a discrimination of elements. These steps are outlined in the sections below.

##### 5.3.3.2.1 Site

Many of the samples were extracted from the same site. These are grouped together by their site in the database and separated from samples of different sites.

##### 5.3.3.2.2 Geological source and sub-region

The averaged geochemical fingerprints were further grouped together by the similar geological stratum based on the age (e.g., Miocene, Early Pliocene, Late Pliocene) of the flow. These are simultaneously organised by sub-region (Figure 2.1). It

should be noted that some geological strata could be located in more than one sub-region. This provided a range of geochemical fingerprints for each geological source in each geographic sub-region.

5.3.3.2.3 Site average and source average

As the database contains numerous samples per site, it was necessary to average the element values of the samples from each site. These calculations created general geochemical fingerprints for each site. Separately, the total average and one standard deviation of all the samples of each source in each sub-region was calculated in an effort to further consolidate and organise the data.

5.3.3.2.4 TAS categorisation

A unique aspect about basaltic rocks is that they may be distinguished based on their ratio of total alkali ($Na_2O + K_2O$) to silica ($SiO_2$) content (Le Maitre, 1984; Zanettin, 1984; Le Bas *et al.*, 1986). This geochemical discrimination uses major elements to produce the following categories (and others) based on the classification presented by Le Bas et al. (1986): foidite (nephelinite), basanites-tephrite, alkali-basalt, and trachy-basalt (hawaiite).

Fiodites have the lowest content (ca. 35-40 wt%) of $SiO_2$ but a wide range of $Na_2O + K_2O$ content (ca. 0-15) (Le Bas *et al.*, 1986:747). Following this, basanites-tephrites have a wider range (ca. 37-47 wt%) in $SiO_2$ as well as a moderate range (ca. 3-9 wt%) of $Na_2O + K_2O$ (Le Bas *et al.*, 1986:747). Typically, a direct relationship exists between the total alkali and silica values in fiodites and basanites-tephrites. Alkali-basalts have a high $SiO_2$ content (ca. 45-55 wt%) to low $Na_2O + K_2O$ content (ca. 0-5 wt%) and contain olivine and pyroxene titanaugite (titanium-rich augite) (Walther, 2005:257-258).

Trachy-basalts contain a similar range of $SiO_2$ co (ca. 45-52 wt%) as alkali-basalts, but a higher content of $Na_2O + K_2O$ (ca. 5.5-6.5 wt%) (Le Bas *et al.*, 1986:747).

Plotting the geochemical fingerprints of the comparative basalt sources on a TAS diagram enabled a categorisation of the sources by proportional values of constituents generated when the rock was magma. This also allowed cross-referencing of the TAS categorisation of the averaged geochemical fingerprints with the TAS categorisation of the original individual samples from the literature. Both the site averages and sources averages were plotted through this data arrangement.

5.3.3.2.5 Discrimination of elements

In order to further discriminate between sources, it was necessary to perform several statistical calculations with the values of the elements prior to plotting them against each other. These calculations involved the addition of major elements $Na_2O$ and $K_2O$ in order to find the total alkali value of each sample. The iron content of sources is often presented as FeO or $Fe_2O_3$. In order to convert the amounts of these major elements into manageable values, the following formula is applied: FeO x 1.11 = $Fe_2O_3$. Additionally, the ratios between several trace elements (Ni, Rb, Sr, and Y) were calculated as Y/Rb, and Sr/Ni. The statistical conversion of these data enabled a more efficient comparison of the geochemical sources and was an effort to further distinguish what element proportions are characteristic of each source.

**5.3.4 Method 4: Morphometric analysis**

The morphometric analysis of the basalt ground stone assemblage attempted to identify the degree of standardisation in production. Artefact standardisation is indicative of craft specialisation and is identified by the similar morphology of ground stone types

(Costin, 2005:1066). This is supported by the standardisation hypothesis and conducted through measurements of the artefacts dimensions.

#### *5.3.4.1 Standardisation hypothesis*

The identification of specialised artisans through the analysis of artefacts is posited through the *standardisation hypothesis* (e.g., VanPool & Leonard, 2002). The standardisation hypothesis maintains that the commodities of specialised artisans will appear more standardised than those of non-specialists (VanPool & Leonard, 2002:712). Standardisation is described as both an outcome and a process (Rice, 1996:179) and is exemplified in the morphology of artefacts and the *chaînes opératoires* involved in their production (Shafer & Hester, 1986:159).

A close range of morphology suggests that the artefacts were manufactured according to a similar rubric. This close range is further indicative of standardisation, pointing to the behaviour of a single artisan. There should exist a high degree of standardisation in the ground stone assemblage typology had manufacture of the basalt ground stone artefacts occurred by a specialised artisan (Blackman, Stein & Vandiver, 1993:61; Schneider & LaPorta, 2008:32). Conversely, a large variation in the morphology of an artefact type suggests standardisation. This absence of standardisation within the basalt artefact typology is indicative of multiple artisans, possibly representing different households and using different manufacture techniques (Rice, 1981).

#### *5.3.4.2 Technique: measurements*

In order to investigate the morphology of the basalt ground stone artefacts of the EB III levels of Tell es-Safi/Gath, measurements of the artefact dimensions were taken. The guidelines for which measurements were taken and in which locations of the

artefacts were found in Figure 3 of Wright (1992:59). Each type of artefact received measurements in specific locations in order to obtain a system of standardised dimensions.

Measurements were taken using a standard measuring tape and recorded in centimetres. Values were rounded to the nearest 0.0 or 0.5 cm. Length was recorded as the longest dimension on the worn surface with the width perpendicular to the length and also taken at the longest point. Thickness was measured at the thickest point and orthogonal to the previous two dimensions. Diameters and circumferences were also measured. Weight was recorded to the nearest 0.0 or 0.5 gram.

### 5.3.5 Method 5: Field excavation and recovery

Great care was undertaken to ensure maximum efficiency in the excavation and recovery of material remains from Tell es-Safi/Gath. These operations are described in detail below, including archaeological remains in general, basalt artefacts, and their associated context.

#### *5.3.5.1 Excavation and recovery of archaeological remains*

Area E of Tell es-Safi/Gath has been and is being excavated through a combination of the stratigraphic and architectural tradition. The basic archaeological provenance framework was the Wheeler-Kenyon technique of excavating in 5m x 5m squares and leaving an unexcavated baulk of 1m in order to monitor the stratigraphic sequences.

All remains were organised into loci where each represented a natural or cultural depositional unit that had discrete and definable boundaries. Each locus, a three-dimensional unit of analysis, received its own identification number. Within every locus,

there was an assortment of baskets (e.g., pottery, fauna, charcoal) that were opened and closed daily. Features, such as walls, hearths, and pits, were also assigned the equivalent of a locus number to serve as their identification.

In relation to this thesis, field excavations and documentation allowed the recovery of artefacts and the establishment of an artefacts context and use-life stage. These three exercises are expanded upon below.

The systematic recovery of artefacts was a necessary precondition toward the analysis of the spatial distribution of remains. Different techniques of sieving were practiced in order to recover minute material that would normally be dumped and go unstudied. Dry sieving occurred through dual screens at 0.5 cm and 1.0 cm at a sieving ratio of approximately one bucket out of every ten. As a result, there was considerable attention paid to the micro-debris and small remains. Even very small basalt remains could be collected and included in the analysis.

In addition, all occupational deposits, supra-floor material, and floor surface material underwent wet sieving and heavy fraction picking to maximise the chance of basalt debitage recovery. The remains from the heavy fraction recovery activities were not included in this analysis since they were not ready at the time that this thesis was being conducted.

#### *5.3.5.2 Excavation and recovery of basalt ground stone artefacts*

During excavation, the x, y, and z provenance of each basalt ground stone artefact was recorded for each identified specimen in the field. Once removed from its archaeological context, the elevation of the bottom of artefact is measured at the lowest point of the cavity left by the artefact. Only those that were discovered in the sieves or

buckets after they were removed from their *in situ* position do not have their x, y, and z provenance recorded. Under both conditions, each artefact was given its own basket number that serves as its identification.

During recovery, each artefact was placed in a separate plastic bag with two identification tags for redundancy; one on the interior of the bag and one on the exterior. Once excavation ceased at the end of the day, the artefact was brought back to the temporary field laboratory at Kibbutz Revadim, Israel. In the field laboratory, the ground stone artefacts were sorted and stored in boxes in preparation for movement to the post-excavation season short-term storage location.

Upon conclusion of the excavation, the artefacts were brought to Bar Ilan University, Israel, and organised for short-term storage. Long-term storage was accommodated by the Israel Antiquities Authority upon the conclusion of the Tell es-Safi/Gath project. Additional cataloguing occurred at Bar Ilan University where the basket numbers of the ground stone artefacts were matched to the corresponding locus for further analysis.

#### *5.3.5.3 Context of artefacts*

The context was the most important factor when assessing the distribution of artefacts within a site. By definition, the context entails the three-dimensional position of an artefact within a site and is commonly referred to by several means, including a series of coordinates, locus or basket number, or by the description of the stratum that encompasses it (Glassow, 2005:135-137). Context appears in one of three forms:

- Primary context: where an artefact is found in the location where it was first deposited by human behaviour (e.g., refuse discarded in a pit, sealed burial).
- Secondary context: where an artefact enters the archaeological record by means of indirect action from where it was first deposited by human behaviour (e.g., artefacts on a floor that fell off a bench, collapse of a wall or ceiling).
- Tertiary context: where natural forces or later anthropogenic activity has removed all traces of initial depositional behaviour (e.g., removed by animals, erosion, material removed by intrusive robber's trench, fill material used for building material or to level surfaces/floors).

Establishing the context of an artefact is paramount to understanding its disposal and the depositional processes involved in situating it into its position of discovery. This establishes the security of the archaeological provenance in which an artefact or feature is discovered.

### 5.3.6 Method 6: Qualitative analysis

Qualitative analyses provide an organisation and description of data that cannot be subjected to numerical values. Such analyses are frequently used in artefact analysis (e.g., Milevski, 2013) to provide a more complete understanding of the artefact assemblages. Two techniques used in this thesis fell under the umbrella of a qualitative analysis: classification and typology, and macroscopic observations. The sections below discuss the nature and application of these techniques.

#### *5.3.6.1 Technique: classification and typology*

As discussed in Chapter 4, artefact typologies are theoretically oriented classifications, designed to investigate specific issues that relate to the artefact types (Gifford, 1960:346; Clarke, 1968:205). Typologies rely on consistent classification systems to organise their attributes and enable site-to-site comparisons of artefact types. Such a classification system is found in Wright (1992). The criteria of Wright's (1992) classification system organises artefacts into categories based on function. As a result, this classification, when employed as a typology, allows the archaeologist to analyse the function of the artefact types within that typology.

Although designed for the Upper Palaeolithic through the Chalcolithic of the Levant, Wright's (1992) classification system has been applied to the analysis of ground stone assemblages from other periods, including the EB I (e.g., Ashqelon-Afridar – Rowan 2004), EB I-II (e.g., Qiryat Ata - Rowan, 2003), and Iron Age (e.g., Hazor - Ebeling & Rosenberg, In press). This is possible due to the chronologically static nature of ground stone typologies (Rowan & Ebeling, 2008a:2-3). As a result, this system has become a standard within ground stone analysis in Near East studies (Rowan, 2003:183; Rowan, 2004:85; Schneider & LaPorta, 2008:21).

A functional typology of the basalt ground stone assemblage from the EB III levels of Tell es-Safi/Gath was constructed in order to obtain a greater understanding of their consumption and production. The typology was obtained through the application of Wright's (1992) classification system. A similar terminology is used to describe the artefact attributes. Several types of ground stone artefacts have been described in Chapter

4, but the diagnostic attributes that characterise to their function(s) are reiterated in the paragraphs below.

5.3.6.1.1 Lower grinding stones

Lower grinding stone appear large in size (>30cm in length) and often stationary *in situ*. These artefacts typically have one use-face that is well worn and polished. The dorsal side of a grinding stone bears a moderate amount of smoothness due to contact with the ground during use. As grinding wears away the surfaces, the measureable thickness of these tools appear thinner in areas of greater use (Wright 1992:63). In lower grinding stones this is evident between the edges and the middle of the use face, where the latter is thinner than the former (Wright 1992:63). As a result, a concave curve occurs in the cross section of the grinding stone (Rowan 2014:921; Wright 1992:63).

Lower grinding stones are further divided as slabs and querns. The terms *slab* and *quern* reflect how the consumer uses the lower grinding stone, although there is a fuzzy boundary between their distinctions. Slabs bear a rectangular use surface and display lateral wear striae (Wright 1992:63). Conversely, querns exhibit an oval use surface with rotary wear striae (Wright 1992:63). In the absence of these features, they appear indistinguishable.

5.3.6.1.2 Upper grinding stones

Upper grinding stones (handstones) appear in several forms, but are typically elongated tools with a flat use surface (Wright, 1992:67). They are small and light enough to use with one or two hands and can be unifacial or bifacial (Wright, 1992:67). Tilting the edges upward during interaction with the lower grinding stone produces a convex curve to the use surface of the lower grinding stone (Wright, 1992:67; Rowan,

2014:919). While the flat surface designates these artefacts as grinding stones, it is the manipulation by hand and the convex use surface that identify them as upper grinding stones (Wright, 1992:67).

5.3.6.1.3 Pounders

Pounders are spherical or cuboid in appearance and are accompanied by a smooth, polished exterior due to use (Wright, 1992:70). Their size is such that they can be encased in one hand and wielded with ease (Wright, 1992:70). Any irregular edges appeared dulled with use and battering marks are often visible on the surface (Wright, 1992:70).

5.3.6.1.4 Perforated stones - weights

The identification of a perforated stone is straightforward and based on the presence of a perforation through the artefact. The perforation is circular in nature and connects the exterior sides of the artefact. The artefacts are of a circular or ringed form and the exposed perforation is often polished from the material that was fed through it.

This section addresses perforated stones that plausibly functioned as weights, namely spindle whorls and loom weights. These two types of ground stone artefacts are similar in form, but are differential based on diameter and thickness (Wright, 1992:75; Rowan *et al.*, 2006:593). Spindle whorls are approximately 30-60mm in diameter and 5-15mm in thickness and appear discoidal in form (Wright, 1992:75). In contrast, loom weights are larger at 40-80mm in diameter and 15-25mm in thickness and appear spherical or biconical in form (Wright, 1992:75).

5.3.6.1.5 Vessels

Ground stone vessels are categorised by several criteria, many of which are applicable to pottery vessels. Vessels must have a well-defined, uniform rim and base (Wright, 1992:75). They are often discovered with a gradual thinning wall from the base to the rim (Wright, 1992:75). Exterior finishing is also a requirement and distinguishes vessels from the unfinished exteriors of mortars (Wright, 1992:75).

***5.3.6.2 Technique: macroscopic observations***

The basalt ground stone artefacts from EB III Tell es-Safi/Gath fall into several distinct qualitative categories based on their macroscopic characteristics. These qualitative categories were: colour, polish, and condition. As these categories were qualitative in nature, they only served to differentiate among the basalt ground stone artefacts in the Tell es-Safi/Gath assemblage. The following sections discuss the categories into which the basalt ground stone artefacts fall.

5.3.6.2.1 Colour

Colour is useful as a discriminating agent as it often distinguishes between different material types of rocks and different raw material sources (Bonsall *et al.*, 2010). As basalt ranges in colour from dark-green to black (Allaby, 2013), this criterion can distinguish basalt artefacts from artefacts manufactured from the red shades of various conglomerate rock or the pale-brown shades of limestone. By extension, the various colours of the basalt artefacts can serve to distinguish between their originating sources. For example, a black basalt artefact would not share the same geological stratum with a dark-green basalt artefact as the different geochemical compositions produce different colour matrices.

The initial collection of basalt artefacts was based on the assessment of colour. This was performed by eye. This sorting technique was applied to the ground stone assemblage of Tell es-Safi/Gath in order to identify basalt artefacts. Although this was a subjective assessment, it was sufficient to distinguish between potential basalt artefacts and those that were plausibly not basalt.

5.3.6.2.2 Cultural polish

As it is likely that the basalt ground stone artefacts of EB III Tell es-Safi/Gath were used as tools, it stands to reason that they would display evidence of use. This would be evident through the presence of cultural polish. Such polish must be discernable from polish caused by natural forces (e.g. water, wind). Cultural polish on ground stone artefacts is caused by human behaviour and differentiated from natural polish in that it occurs on specific locations (e.g., face, handle) where an artefact has been grasped or has repeatedly interacted with another material (Valado, 2008:174). Unlike natural polish, which appears uniform across the whole of an artefact, such as a water-rolled pebble, cultural polish is often present in various degrees in different places on an artefact (Valado, 2008:173-175).

Furthermore, cultural polish is typically most evident on artefacts that undergo grinding. The consequences of these actions are visible as tribological polish or use-wear polish on the surface that received interaction with another stone (Valado, 2008:175). *Sheen*, the chemical oxides and film that accumulate on the use faces are a result of this surface-on-surface interaction (Adams, 2014a: 129-138:5). This microscopic residue occurs through abrasive, fatigue, or adhesive wear, and, in combination with a levelled

surface topography of the ground stone surface, forms a smooth and shiny surface (Dubreuil, 2004:1614; Adams, 2014a: 129-138:5).

Intended function does not always equate to the actual function of an artefact and the appearance of cultural polish signals the actual function of the artefact (Adams, 2010:132). It is reasoned that a direct relationship exists between the amount of use a tool receives and the amount of cultural polish it displays (Sussman, 1985). This principle was applied to the ground stone assemblage of the EB III Tell es-Safi/Gath in an effort to identify how the artefact was used and to what extent artefacts received this use. The identification of the intensity of cultural polish was conducted through a visual assessment and was based on a scale that ranges from low to high as illustrated in Table 5.2. This scale is characterised by several visual criteria. An artefact surface that bears a low amount of polish intensity reflects a moderate amount of light, but grit friction, the visibility of individual grains, is present. A high polish intensity displays a glossy appearance, reflects light off its polished surface, and grit friction is negligible. Medium polish intensity falls in the middle of the two extremes and is mostly void of grit friction and reflects considerable light.

5.3.6.2.3 Condition

Information regarding the recycling and use-life stage of the basalts ground stone artefacts may be obtained from an examination of their condition (Adams, 2008:214). The aspect of the condition of the artefacts that was examined is the age of their fractures: ancient or modern. Modern or fresh fractures typically occur through excavation and are discerned by differences in colour and weathering patterns on the fractured face from the other surfaces. The faces of ancient fractures appear as the same colour as the rest of the

artefact and display the same weathering patterns as time and the depositional forces make their appearance uniform. This examination was undertaken by eye and described by the terminology found in Wright (1992).

## 5.4 Conclusion

The methods and techniques presented in this chapter were selected in an effort to efficiently and effectively test the hypotheses. These assorted forms of investigation analyse different aspects of the life-history of the basalt artefacts of Tell es-Safi/Gath. In the following chapter, the results of the analyses are applied and discussed to validate or negate the hypotheses.

# Chapter 6. Data description and analysis

## 6.1 Introduction

This chapter provides a description and analysis of the data utilised in this thesis. The data were obtained through the application of the methods and techniques outlined in the previous chapter. Furthermore, these data are a combination of quantitative and qualitative values and are used to test the hypotheses later in the chapter. Analyses specific to this thesis were performed at the University of Manitoba, Bar Ilan University (Israel), and the Weizmann Institute of Science (Israel). These were conducted in an effort to reconstruct the life-history of the basalt ground stone artefacts from the EB III levels of Tell es-Safi/Gath.

## 6.2 Data description

The data described in this thesis derived from the excavation seasons between 2004 and 2013, a total of ten seasons. During this period of time, the uppermost horizon of several EB III houses and associated archaeological remains were uncovered and recovered in Area E of Tell es-Safi/Gath as illustrated in section 2.5 of Chapter 2. Among the recovered remains was an assemblage of basalt ground stone artefacts. These basalt artefacts, 31 in total, were the primary source of data for the thesis. Table 6.1 presents the archaeological provenance that was recorded upon the recovery of each artefact and the sections draw the information in this table into their discussion.

Despite the efforts of the excavation, no basalt debitage was discovered (Greenfield 2014; Shai 2013). Debitage would appear as flakes or chunks of basalt rock that was not been retouched to form tools. These would have been identified not only by their dark colour (black-dark green), but by a number of diagnostic features including

bulbs of percussion, conchoidal fractures, or striking platforms (Shott, 1994). The size range is highly variable, but likely from 30-1cm. The sections that follow provide a detailed description of the basalt ground stone assemblage from the EB III levels of Tell es-Safi/Gath.

### 6.2.1 Colour and raw material of basalt artefacts

Colour was the initial variable used to categorise the artefacts in the entire EB III assemblage into raw material types. The intention was to separate the basalt artefacts from non-basalt artefacts based on macroscopic observations conducted visually by eye. Basalt is frequently described as a dark material, ranging from dark-green to black in colour (Allaby, 2013). Hence, all ground stone artefacts that fell into the dark-green to black range were categorised as basalt. There were no artefacts of a dark-green colour in the EB III ground stone assemblage. In fact, all the artefacts selected as basalt were of a similar colour: pale black. Chalky dirt from the excavation sediment left a perception of dark grey. Washing and drying sections of the artefacts revealed their true colour to be pale black. This exercise allowed the separation of a small collection of artefacts from the rest of the assemblage, but they could not be further sub-divided by their colour, as significant variations do not exist.

For the most part, this initial categorisation by colour proved to be straightforward with the exception of artefact 845008. Artefact 845008 was originally categorised as basalt as it was pale black in colour. However, it was not dense or of a fine-grained texture as is most basalt. Instead, it had a soft and flaky texture and was light in weight in comparison to other basalt stones of a similar size. The geochemical composition of 845008 (Table 6.2) indicated that it was not basalt as its $SiO_2$ content was considerably

low (6.79) in comparison to the standard range for basaltic rocks (ca. 35-55), and its CaO was much higher (49.59) than that of basaltic rocks (ca. 8-12) (Le Bas *et al.*, 1986:747). As a result of these values, artefact 845008 was excluded from the basalt ground stone assemblage. This misidentification of a calcite-rich rock as basalt exemplifies the difficulty in distinguishing rock types of similar appearance without the aid of geochemical characterisations. It further suggests that categorisation of material by colour is neither always perfect nor sufficient. Consequently, one must examine other aspects of an artefact (e.g., density, texture) and consider these in addition to colour.

### 6.2.2 Typology of basalt artefacts

As discussed in section 5.3.6.1 of the previous chapter, the types of basalt artefacts from Tell es-Safi/Gath were arranged into a typology based on function attributes through the application of Wright's (1992) classification system. Although theoretical in nature, the typology permitted a detailed examination of the collective and individual function of the types. At times, it was difficult to assign a specific type to several artefacts based on Wright's (1992) classification system, as they were heavily fractured and absent diagnostic features. This is a common issue experienced by many attempting to compose assemblage typologies (e.g., Rowan, 2003:183). As a result, these artefacts could not be assigned to a type with full confidence and often fell under the category of "fragment". The size of the artefacts and the extent of use they display suggest that they are not debitage, but rather fragments of larger ground stone artefacts. As none of the fragments could be put together to form a larger stone, it should be noted that each fragment is representative of one "complete" artefact. A detailed description of the assemblage typology is outlined below and is organised by the various types present.

Table 6.3 provides a breakdown of the typology and each paragraph will refer to it. Drawings of each stone artefact can be found in Appendix 2 and photos in Appendix 3.

#### *6.2.2.1 Lower grinding stones*

Lower grinding stones (n=21) were assigned to a type based on several criteria: concave use-face in cross section, large size, and an inability to manipulate the artefact by hand (Rowan 2014:921; Wright 1992:63). Comparisons of the types in Table 6.3 demonstrate that lower grinding stones are the most abundant type of basalt artefact at the settlement. Artefacts 16E94A011, 745050, 941057, 1143031, and 16E84C012 are too large to manipulate by hand and displayed a concave use-face in cross section. The remaining 16 lower grinding stones were fragments, but retained concave use-faces in cross section, which is a defining characteristic of lower grinding stones.

The lower grinding stones were further classified as slabs and querns based on the shape of their use-surface, where oval use-surfaces are associated with querns and rectangular use-surfaces are associated with slabs (Wright 1992:63). Table 6.4 provides a comparison of the lower grinding types. The fractured nature of 16 lower grinding stones did not permit them to be classified as either a slab or quern fragment and they fell into the general type of slab/quern fragment. This type composed the majority (76.2%) of the lower grinding stones (Table 6.4) and holds implications for depositional behaviour (discussed later in the chapter).

Three lower grinding stones (748114, 941057, and 1143031) were classified as saddle–shaped querns due to the oval nature of the use-surface, the absence of ridges around the perimeter of the use-face, and the concave profile in cross section. As a result, saddle-shaped querns compose 14.3% of the total lower grinding stone types (Table 6.4).

Another identifiable type of lower grinding stone was a basin quern (16E84C012). This large artefact not only contains an oval use-surface, but thick and well-defined ridges that demarcated the extent of the use-surface. This sole basin quern constitutes 4.8% of the total lower grinding stone types, as seen in Table 6.4.

The last type of lower grinding stone that was present in the basalt assemblage of Tell es-Safi/Gath is a boulder quern/slab (16E94A011). Classification of this artefact is problematic, as it does not display significant rotary or lateral striae. In addition, its oval use surface is due to the shape of the stone rather than where it interacted with an upper grinding stone. However, it lacks a stable base and its use-face extends to the edge of the artefacts. This suggests that this expedient artefact is a boulder quern or boulder slab.

#### *6.2.2.2 Upper grinding stones*

Upper grinding stones (n=7) were the second most abundant type of artefact in the basalt ground stone assemblage from Tell es-Safi/Gath (Table 6.3). These artefacts can be manipulated with one or two hands and were elongated to accommodate the grip of the consumer. The convex use-face in cross section was the most defining characteristic of the upper grinding stones, particularly of the fragments (Wright, 1992:67; Rowan, 2014:919).

Table 6.5 provides a comparison of the upper grinding stone types. Three handstone fragments were recorded, as they could not be further identified, composing 42.9% of the upper grinding stones (Table 6.4).

A complete, bifacial rectilinear/flat handstone (746060) was also identified and represents 14.3% of the upper grinding stone types (Table 6.5). This rectangular artefact

displays two use-faces on opposing parallel flat sides. A similar basalt artefact was recorded at Jemmeh (Rowan, 2014:922).

Three unifacial loaf handstones (745098, 748093, and 16E84A007) were identified in the assemblage, composing 42.9% or the upper grinding stone types. Each artefact displayed a distinct convex use-face in cross section and a single use-face. The round curvature of the exterior sides gives these artefacts the signature "loaf" form, a common type that appears chronologically throughout the southern Levant. Additional examples have been recovered from Jemmeh (Rowan, 2014:920) and EB II-III Beth Shean (Mazar and Rotem 2012:380).

#### *6.2.2.3 Pounder*

Within the Tell es-Safi/Gath basalt ground stone assemblage is a single pounding stone (n=1) (84011) (Table 6.3). This artefact is of a size that can be easily encased in one hand. Its shape is characteristic of a pounder as it is mostly spherical, but faint, dulled edges also give it a cuboid appearance (Wright, 1992:70). As a result, it is a spheroid-cuboid pounder. Comparable basalt pounders were discovered at EB II Te'o (Gopher & Eisenberg, 2001:143) and Jemmeh (Rowan, 2014:922).

#### *6.2.2.4 Perforated stone – weight*

A single perforated stone (n=1) (16E83C087) was discovered in the basalt ground stone assemblage from Tell es-Safi/Gath (Table 6.3). The perforation was complete and connected one side of the artefact to the other and was located in its centre. In addition, the perforation is circular and the artefact is ringed and discoidal in form. It is described as a weight and is further differentiated between a loom weight and a spindle whorl based on its measurements (Wright, 1992:75; Rowan *et al.*, 2006:593). In section 5.3.6.1.5

spindle whorls are described as approximately 30-60mm in diameter and 5-15mm in thickness and appear discoidal in form while loom weights are larger at 40-80mm in diameter and 15-25mm in thickness and appear spherical or biconical in form (Wright, 1992:75). Artefact 16E83C087 measures 35mm in diameter and 15mm in thickness, classifying it as a spindle whorl. Basalt spindle whorls are known across the southern Levant and comparable examples have been discovered at EB I-II Madaba, Gat Hefer, Megiddo, and Jericho (Savage, 2011:124-129).

#### *6.2.2.5 Vessel*

A rim fragment of a vessel (n = 1) was identified among the assemblage of basalt artefacts from Tell es-Safi/Gath and composes a small proportion of the typology (Table 6.3). The artefact (1143010) displayed a well-defined plain rim with gradual thinning from the base to the rim, notable characteristics of ground stone vessels (Wright, 1992:75). The vessel fragment contains parts of the walls but nothing of the base. Significant exterior and interior finishing is also present, distinguishing it from small mortars (Wright, 1992:75). Because of the fractured nature of the artefact is cannot be classified further than as a rim fragment. However, based on the rim alone, comparable vessels can be identified at EB II Qiryat Ata (Rowan, 2003:185) and EB I Bir Safadi (Braun, 1990:89).

## 6.3 Data analysis

The data described in the section above, the basalt ground stone assemblage from EB III Tell es-Safi/Gath, will be used to investigate the aspects of the life-history of these artefacts. This is conducted through the methods and techniques outlined in the previous

chapter. Consequently, the sections that follow examine the provenance, degree of standardisation, function, neighborhood distribution, and condition of the basalt artefacts.

### 6.3.1 Source provenance of basalt artefacts

The investigation of the geological provenance of the basalt artefacts from Tell es-Safi/Gath involved a comparison of the results from the meta-analysis and the trace element analysis discussed in Chapter 5. The meta-analysis was performed on the geochemical fingerprints from basalt sources in the Near East in order to make the data statistically significant and comparable. The trace element analysis was performed on 19 of the 31 basalt ground stone artefacts to identify their geochemical constituents. The provenance analysis compared the results of the two methods to each other in an attempt to test whether a match exists between the two sets of fingerprints. Any match suggests that the artefact was procured from that source (Lambert, 2005:478; Weiner, 2010:36).

Major and trace elements were cross-referenced in order to discriminate between geochemical fingerprints. These associations were established through the provenance postulate that maintains that differences between the fingerprints of separate raw materials are analytically identifiable and that any compositional variations will be smaller within sources than between sources (Glascock & Neff, 2004:1516; Lambert, 2005:478-479; Rice, 2005:414). The following sections analyse the results of the meta-analysis and the trace element analysis and discuss the comparison of the two data sets.

#### *6.3.1.1 Results of meta-analysis*

As pointed out in Chapter 5, the most proximate basalt sources to Tell es-Safi/Gath are discovered within several sub-regions of he southern Levant and in the more distant regions of western Jordan and Egypt. The meta-analysis was performed on

the geochemical fingerprints of many of these basalt sources and was enabled by a limited repertoire of previous work by several analysts. Sources in the Golan have been analysed by Weinstein (1994; 2000) and Weinstein et al. (2006). Sources in the Galilee have been analysed by Weinstein (2000; 2012) and Weinstein et al. (2006). In northern Israel, sources around Mt. Hermon were analysed by Wilson et al. (2000). Sources in the Jezreel Valley have been analysed by Weinstein (2000) and Gluhak and Rosenberg (2013). Sources within Harra el-Jabban have been analysed by Al-Malabeh (1994). Sources within Egypt have been analysed by Mallory-Greenough and Greenough (2004) and Greenough et al. (2001). Geochemical fingerprints of these sources were extracted from the literature and complied into an *iNumbers* database. The geochemical fingerprints of Near East sources were arranged through the steps (site, geological sources and sub-region, site average and source average, total alkali vs. silica (TAS) categorisation, and discrimination of elements) outlined in section 5.3.3.2 of Chapter 5. The results of these steps are discussed below.

6.3.1.1.1 Averaged geochemical data of sources

The data for the averaged geochemical fingerprints of the sources of Near East are located in Appendix 4. The $SiO_2$ and $Na_2O + K_2O$ values were plotted on a TAS graph in Figure 6.1. This TAS graph (Figure 6.1) displays the categorisation of basaltic rocks types where two types emerge. The sources of the Golan, Jezreel Valley (JV), and Harra el-Jabban (HJ) are shown to be composed of basanites-tephrites basalts. Northern and southern Egyptian sources (NE and SE), as well as sources in the Hulah Valley (HV), southeastern Lower Galilee (SELG) Mt. Hermon (MH), and Korazim–Sea of Galilee (K-SG) are composed of alkali-basalts. This discrimination was used further when plotted

against the basalt artefacts. Unfortunately, no $SiO_2$, $Na_2O$, or $K_2O$ values have been presented for sources discovered around the Dead Sea. This leaves an absence of the potential sources for the Near East.

The graph (Figure 6.2) presents the averaged geochemical data of Near East sources with the error bars, indicative of one standard deviation. These error bars often intersect with those of other sources. This served to further demarcate which basalt artefacts fall within an appropriate range of the average and will be discussed below.

6.3.1.1.2 Averaged geochemical data of sites within sources

The data for the averaged values of the elements in the geochemical fingerprints of the sites within sources are located in Appendix 5. The geochemical data from each site within each source was averaged to provide additional points of data to plot. This serves to cross-reference the results of the averaged geochemical data of the sources and allows the identification of outliers. First, the data were plotted on a TAS graph, as seen in Figure 6.3. This enabled the identification of different basaltic rock types. Information presented in Figure 6.3 indicates that, not only are there site outliers, but there are also individual sources that may be distinguished. Furthermore, the data distribution in Figure 6.3 demonstrates that the sampled sites of the Near East sources fit into three basaltic rock types: basanites-tephrites, alkali-basalts, and trachy-basalts. Sites from the Jezreel Valley and the Golan are mostly composed of basanites-tephrites basalts. The Hulah Valley, Harra el-Jabban, and southeastern Lower Galilee sub-regions each contain a site composed of basanites-tephrites. In addition, some sites of the Golan and Mt. Hermon fall under trachy-basalts. However, the majority of Mt. Hermon, southeastern Lower

Galilee, and Hulah Valley sites, as well as Korazim-Sea of Galilee and Egyptian sites are composed of alakali-basalts.

The TAS categorisation of the averaged data per site aligns with that of the averaged data per source. With the exception of the outliers each group of sites is clustered within the TAS categorisation of the source average. The sources and sampled sites of the Jezreel Valley, Golan, and Harra el-Jabban are composed of basanites-tephrites basalts. The sources of Egyptian, the Hulah Valley, southeastern Lower Galilee, Mt. Hermon, and Korazim-Sea of Galilee are comprised of alkali-basalts. As a result, the sources fall under one of two basaltic rock types: basanites-tephrites or alkali-basalts.

In Figure 6.4, which is a $SiO_2$ vs $Na_20 + K_2O$ plot, it is evident from the data distribution that the basanites-tephrites sources (JV, Golan, and HJ) are distinct from each other and require no further discrimination amongst one another. Sites in northern Egypt are separated from the rest of the plotted points, save for an outlier of Mt. Hermon. The main cluster of Mt. Hermon sites is noticeably distinct. Several sources composed of alkali-basalts (HV, SE, K-SG, MH, and an outlier of SELG) are much more clustered and require further discrimination. Harra el-Jabban sites are included in this discrimination, as they may be considered proximate to the cluster. This is conducted by a plotting several trace and major elements ($TiO_2$, Pb, Rb, Y/Rb, and Sr/Ni) against each other as outlined in section 5.3.3.2.5 in Chapter 5. This generates four plots, to be described next (Figures 6.5-6.8).

Figure 6.5 creates two groups and an outlier of Mt. Hermon by contrasting $TiO_2$ and Y/Rb. One group is composed of southern Egyptian sites, a Harra el-Jabban site, and

Mt. Hermon sites, and the other of Korazim-Sea of Galilee, Hulah Valley, a Harra el-Jabban site, and southeastern Lower Galilee sites.

Similarly, the distribution in Figure 6.6 creates the same two groups, but brings the outlier of Mt. Hermon more proximate to the group of Korazim-Sea of Galilee, Hulah Valley, a Harra el-Jabban site, and southeastern Lower Galilee. This is accomplished by using $TiO_2$ and Rb.

Figure 6.7 contrasts Pb and Rb data distributions and generates three groups. Southern Egypt and Mt. Hermon are two of the groups that are distinct from the others. The third group, composed of Korazim-Sea of Galilee, Hulah Valley, southeastern Lower Galilee, and an outlier of Mt. Hermon, is larger and encompasses a greater range of values. As the points in the third group are still proximate to each other, they cannot be sub-divided. There are no Pb values given for Harra el-Jabban sites.

A fourth plot, Figure 6.8, uses Rb and Sr/Ni as discriminators and produces several groups and several outliers. The southern Egyptian sites are well separated from the other sites. The Mt. Hermon and Harra el-Jabban sites appear sporadic and do not fit into groups. While the Korazim-Sea of Galilee and Hulah Valley sites are somewhat distinct from each other, their range is too proximate to fully be considered separate groups.

For the most part, these plots serve to discriminate between basalt sources of the Near East, if only to a small degree. However, as described above, there is often overlap between the values and ratios of the elements from different sources. The most notable feature of the graphs is that the sites from sources in southern Egypt are distinct and separated from those of the southern Levant.

#### *6.3.1.2 Results of trace element analysis*

The trace element analysis involved an examination of the basalt artefacts through the technique of energy dispersal x-ray fluorescence (ED-XRF). The ED-XRF analysis occurred at the Weizmann Institute of Science, Israel, under the direction of Dr. Adi Eliyahu-Behar. It was performed through the procedure outlined in the previous chapter on a sample selected from the EB III basalt ground stone assemblage of Tell es-Safi/Gath.

The ED-XRF analysis produced a breakdown of the geochemical constituents of each artefact that are found in Table 6.7. From this table, it is shown that the data from the ED-XRF analysis includes a range of major elements ($SiO_2$, $Na_2O$, $K_2O$, $P_2O_5$, CaO, $TiO_2$, $Fe_2O_3$, MgO, $Al_2O_3$ and Mn) and trace elements (Ni, Cu, Zn, Rb, Sr, Y, Zr, Nb, and Pb). Additional element calculations consist of $Na_2O + K_2O$, Y/Rb, and Sr/Ni. These are calculated for further discrimination in later sections. The amounts of each element vary among basalt artefacts, but are all within a range that suggests they are all basaltic rocks. For example, all artefacts bear a high amount (35-50%) of $SiO_2$ that is a defining geochemical feature of basalt. Within this range of $SiO_2$, there are different types of basalt that can be identified when plotted on a total alkali ($Na_2O + K_2O$) vs. silica ($SiO_2$) graph (Figure 6.9). The TAS diagram is generated in an effort to categorise the types of basalt that make up the ground stone assemblage. This further separates them into geochemical groups and assists in identifying their source.

Four types of basaltic rocks constitute the sample of the EB III Tell es-Safi/Gath assemblage and were identified on the TAS diagram (Figure 6.9) and depicted in the last column of Table 6.7: foidites (745019, 1144013), trachy-basalts (745029, 16E93A049),

basanites-tephrites (745050, 745047, 1346093, 16E93B070, 1143031, 745098), and alkali-basalts (748093, 748114, 1042042, 16E84A007, 16E93B081, 941057, 16E94A011, 16E84C012, 16E93A050). This is not to say that there are four sources from which the artefacts originate, but that this organisation of data assists in narrowing the potential sources for each artefact.

#### *6.3.1.3 Synthesis of meta-analysis and trace element analysis results*

A combination of the meta-analysis and the trace element analysis contrasts the geochemical profiles of the basalt artefacts with the plots of the potential sources presented in section 6.3.1.1. To begin, the averaged geochemical data of the sources ties the artefacts that fall closest to the average and within the range of one standard deviation to the source as demonstrated in Figure 6.10. As a result, most of the sampled artefacts can be connected to a source. These connections are recorded in Figure 6:10 and Table 6.8. From the available information four artefacts (748093, 748114, 1144013, and 745019) could not be connected to a source. Three artefacts (745050, 1346093, and 1143031) are tied to the Jezreel Valley and three artefacts (745047, 745029, and 16E93B070) are tied to the Golan. Two artefacts (16E93B081 and 745098) are sourced to Harra el-Jabban in modern Jordan and two other artefacts (16E84A007 and 16E93A050). Five artefacts (1042042, 16E93A049, 941057, 16E94A011, 16E84C012) are connected to Mt. Hermon and two (16E84A007 and 16E93A050) are sourced to the Hulah Valley. No artefacts were sourced to southeastern Lower Galilee, Egypt, or Korazim-Sea of Galilee based on the available data.

The above results (that at least five sources exist for basalt artefacts at Tell es-Safi/Gath) are supported by a comparison of the averaged sites with the basalt artefacts

(Figure 6.11). However, one artefact of contention is 941057. This falls into the range of several sites and, by extension, several sources (denoted by the red circle). Further discrimination, found in Figures 6.12-6.15, demonstrates that artefact 941057 cannot be confidently categorised as originating from any of the potential sources. It is most closely associated with Korazim-Sea of Galilee as seen through the Rb vs. Sr/Ni plot (Figure 6.15). However, it should be noted that artefact 941057 does not fall near the southern Egyptian sources. Its proximity on the plotted graphs (Figure 6.12-6.15) to Mt. Hermon, Hulah Valley, and Korazim-Sea of Galilee suggest that it should be considered as originating from the northern sub-regions (Table 6.8).

Results from the provenance analysis demonstrate that basalt artefacts originated from multiple sources and several sub-regions. Table 6.8 outlines several corresponding EB II-III settlements that are within or proximate to the sub-regions and sources. None of the geochemical fingerprints of the artefacts align with those of Egyptian sources. This corresponds to the observed decrease in exchange between the southern Levant and Egypt during the EB II-III (Shai & Uziel, 2010:68-69). Although the importation of basalt artefacts via inter-regional exchange does not seem to have occurred, intra-regional exchange occurred on a large scale. The majority of basalt artefacts were procured and likely also manufactured in the north-eastern sub-regions of the southern Levant (Table 6.8). These discoveries are similar to those of Milevski (2008; 2011). The production of basalt artefacts does not appear to have occurred solely within a sub-region or at a centralised location. In addition, there does not seem to be a preference for a basalt source or exchange for basalt commodities from a certain sub-region (Figure 6.8). These commodities were transported over great distances, over 120km to the north-eastern sub-

regions and as far north as Mt. Hermon (ca. 300km away) and as far east as Harra el-Jabban (ca. 150km away) (Ebeling & Rowan, 2004:108). It should be further noted that there is no correlation between the type of basalt ground stone artefact and the source of procurement as both upper grinding stones and lower grinding stones appear to originate from the same sources.

### 6.3.2 Degree of standardisation in basalt assemblage

The degree of standardisation in the EB III basalt ground stone assemblage from Tell es-Safi/Gath was assessed in an effort to understand the organisation of production associated with the artefacts. This assessment was conducted through a morphometric analysis described in section 5.3.4. In this analysis, it is expected that artefacts of the same type and the same measurements suggest craft specialisation (Costin, 2005:1066). This exemplifies the standardisation hypothesis that states that the commodities of specialised artisans will exhibit a more standardised morphology than those of non-specialists (VanPool & Leonard, 2002:712).

Because over 90% of the assemblage is fractured and most of the artefacts are fragments of a larger ground stone artefact, it is difficult and to estimate the original size and dimensions of the ground stone artefact from which the fragments originate. Due to the fractured nature of the basalt ground stone assemblage, many measurements of the artefacts are not of their original dimensions, such as those established via manufacture.

Measurements of the dimensions of the basalt artefacts from Tell es-Safi/Gath were taken with a standard measuring tape and recorded in centimetres. These were taken of the dimensions outlined by Wright (1992:59). These are depicted in Table 6.9 which includes 1) the length, width, and thickness of grinding stones, 2) the diameter and

thickness of perforated stones, and 3) the circumference of pounding stones. These measurements are further described below in relation to upper and lower grindings stones as they contain more than one artefact of that type.

#### *6.3.2.1 Lower grinding stones*

Most (n=20, Table 6.3) of the basalt lower grinding stones are represented by fragments of the original tools. This means that the measurements that involve a fractured dimension cannot be used in the analysis of standardisation. As a result, the length and width of lower grinding stones cannot be considered. This impedes the analysis of craft specialisation through standardisation.

However, some information may be gleaned from the measurements of intact dimensions. This is apparent in the thickness of the basalt artefact and is recorded in Table 6.10. With the exception of one artefact (1141073), the remaining 20 lower grinding stones retain intact thickness (Table 6.10). As such, artefact 1141073 was excluded from further assessment. Artefact 16E94A011 is complete and identified as a boulder quern/slab which suggests it was an expedient tool or was unfinished upon exchange. It was excluded from further assessment, as it did not display the degree of finish found in the rest of the assemblage and appeared as an outlier. The 19 lower grinding stones display an average thickness of 3.79cm and a one standard deviation (ca. 67%) of 1.08cm (Table 6.10). This means that 12 of the 19 artefacts fall within ±1.08cm range (2.71-4.87cm) of the average measurement (Table 6.10). This implies that the thickness of these basalt artefacts is fairly uniform. Minute variations in the measurements are explained as representing fragments that originate from different parts of the artefacts (e.g., edge, middle). It is well known that the middle of a lower grinding

stone recedes in thickness quicker than the edges due to greater use. While this explanation is plausible, it only accounts for why there is variation within the ca. 2.5-5cm range. It does not address why these measurements are of a similar thickness overall (e.g., ca. why they are 2.5-5cm and not 2-12cm). Based on these observations, two compatible interpretations can be made, as described next.

The first interpretation suggests that the thickness of lower grinding stones was often manufactured to a certain measurement of roughly 4-7cm. 4-7cm is the addition of the average and 1-3cm as use-wear will often remove 1-3cm of grains. This does not mean standardisation existed in terms of craft specialisation, but that there was a common desire or demand for lower grinding stones of this thickness. As the lower grinding stones were provenanced to different sub-regions (e.g., 16E93A049 – Mt. Hermon, 16E93B070 – Golan) (see Table 6:8), it is plausible that multiple artisans participated in manufacturing these artefacts to this thickness (Shafer & Hester, 1986:159). This would provide a suitable use-life while keeping the commodity sufficiently durable, relatively light, and transportable.

The second interpretation addresses the behaviour of the consumer to a greater degree. It posits that the once the lower grinding stone reached a certain thickness (e.g., 2-4cm) it became useless to the consumer. This may be for a number of reasons, including structural instability, susceptibility to fracture, or the central depression was too great to grind sufficiently (Adams, 2008:224-225). As a result, most basalt lower grinding stones fractured or were intentionally fractured in order to facilitate discard (Wright, 2014:16).

#### *6.3.2.2 Upper grinding stones*

A parallel situation to the lower grinding stones is discovered when assessing the nature of the upper grinding stones in the basalt assemblage. The measurements of the upper grinding stones (n=7) are outlined in Table 6.9. The information in Table 6.9 indicates that there are few intact dimensions of the original artefact. As a result, the length and width measurements cannot be considered and craft specialisation of the complete morphology cannot be assessed through standardisation. In addition, artefact 1046004 must be left out of consideration, as it does not retain any intact dimensions (Table 6.9).

However, the thickness dimension of 6 of 7 upper grinding stones is intact as presented in Table 6.11. The thickness of these 6 upper grinding stones ranges from 4.0-5.5cm, a spread of 1.5cm (Table 6.11). Meanwhile, the average thickness of these artefacts is 4.67cm (Table 6.11). The 1.5cm spread appears negligible and may even be subject to measurement error. The ideal thickness for upper grinding stones appears to be between 4-6cm, or if 1-2cm is budgeted for use-wear, the thickness may be considered 4-7cm. This consistency in thickness may be explained through a consideration of consumption rather than specialised craft production, as the upper grinding stones have been provenanced to separate sub-regions (e.g., 745029 – Golan, 745098 – Harra el-Jabban) (see Table 6.8). Handstones are by definition those stone tools manipulated by hand and, upper grinding stones, a sub-type of handstones, are no exception. This requires the movement and energy of the consumer. There is a necessity to grasp and lift artefacts of this nature in order to perform their intended function. A similar range (average of 5.28cm) in the thickness of upper grinding stones is observed in the EB II

ground stone assemblages of Qiryat Ata (Rowan, 2003:186). Consequently, upper grinding stones, and handstones in general, must be manufactured to an appropriate size and weight that is suitable for the consumer (Adams 2014:48). Thus, it is likely that uniform thickness of the basalt upper grinding stones of Tell es-Safi/Gath represent a standard thickness (4-6cm) for upper grinding stones that suits the needs of the consumer. Southern Levantine artisans may have been manufacturing their upper grinding stones through a similar rubric in order to conform to the needs of the consumer (Rice, 1996:179).

### 6.3.3 Function of basalt assemblage

The function of the basalt ground stone assemblage from Tell es-Safi/Gath is investigated here in order to provide information on the nature of their consumption. This is accomplished through an identification of the typology and a visual analysis of the use-wear polish displayed on the artefacts. It should be noted that the typology has been described in section 6.2.2 of this chapter and will be referenced in the following sections. However, it does not necessarily mean that the object functioned in a certain manner just because the form of an artefact classifies it under a specific type (e.g., lower grinding stone may have been used not only as a grinding stone, but also as a mortar). This issue addresses the intended function of the artefact versus the actual function and both are discussed in reference to the basalt artefacts (Adams, 2010:132). An excellent indicator of actual function is cultural polish. The examination of cultural polish is discussed below.

#### *6.3.3.1 Cultural polish on basalt artefacts*

Polish appears on artefacts in two forms: natural and cultural. To paraphrase from the previous chapter, cultural polish is typically found on isolated or discrete locations of an artefact, where it has repeatedly interacted with another surface through human behaviour (Dubreuil, 2004:1614; Adams, 2014a: 129-138:5). In contrast to cultural polish, natural polish is generally uniform across the exterior of an artefact, as the forces of nature will not solely interact with a specific location of the artefact (Valado, 2008:173-175).

The basalt ground stone artefacts from the EB III levels at Tell es-Safi/Gath were inspected for polish. This was to determine what parts of the artefact experienced use and how much use each artefact received. As noted in section 5.3.6.2.2 and outlined in Table 5.2, the examination was carried out by eye and the degree of polish intensity was described on a scale from low to high based primarily on the amount of light reflected off that surface. All of the basalt ground stone artefacts from the EBIII levels of Tell es-Safi/Gath display some cultural (use-wear) polish, but significant natural polish was absent. This is not to say that natural forces did not contribute to the overall polish on the artefacts. Rather, due to the intensity and extent of the cultural polish, any locations of natural polish were over worn, as is common with ground stone artefacts due to their forceful wear (Adams, 2014a:8). The location and intensity of the cultural polish are outlined in Table 6.12 and are further discussed in the paragraphs that follow.

6.3.3.1.1 Lower grinding stones

Information in Table 6.12 indicates that, of all the basalt artefacts, lower grinding stones displayed the highest intensity of cultural polish. Table 6.13 provides a concise

breakdown of the location and intensity of cultural polish on lower grinding stones. The majority of lower grinding stones (16 of 21) display a high intensity of polish on their face while others (5 of 20) exhibit a medium intensity on this location (Table 6.13). Additionally, most of the lower grinding stones (12 of 21) displayed a low intensity of polish on their dorsal side in comparison to 7 of 21 that exhibited a medium intensity (Table 6.13). The face interacts with the face of the opposing stone (upper grinding stone in this case), while the dorsal side of lower grinding stones interacts with the ground or floor. Interaction with another artefact produces higher intensities of polish quicker than interaction with a floor or ground. This is likely because the lower grinding stone is often anchored and stationary. However, the intensities of polish discovered on the lower grinding stones indicate that they all experienced a large amount of use through grinding.

6.3.3.1.2 Upper grinding stones

Upper grinding stones displayed similar patterns of cultural polish to lower grinding stones, as Table 6.12 indicates. The dorsal sides and faces of the artefacts exhibit considerable amounts of polish. This is detailed in Table 6.14 as 6 of 7 upper grinding stones that display a high intensity of polish on their face and the remaining artefact bears medium polish on the same location. 5 of 7 upper grinding stone exhibit a medium intensity of polish (Table 6.14). While 1 upper grinding stone (745098) displays a low intensity of polish on the dorsal side, another artefact (745029) could not be assessed due to its fragmented nature (Table 6.14). The interaction between the face of an upper grinding stone and the face of a lower grinding stone produces the medium-high amount of polish on the face. The dorsal side of upper grinding stones interacts with the palms of the user that produces a similar result. It is apparent that the former interaction

wears and polishes surfaces of grinding stones more efficiently than the latter. Based on their polish locations and intensities, it is apparent the upper grinding stones experienced considerable use through grinding.

6.3.3.1.3 Pounder

The lone pounding stone (840111) contained a medium amount of cultural polish across its entire exterior surface as noted in Table 6.12. Despite the uniformity of the polish on the artefact, other factors suggest that the polish is due to cultural interaction rather than natural forces. This is because of the archaeological provenance of discovery and the way in which the artefact was manufactured and used. Having been discovered buried by occupational debris in a residential neighbourhood, it is likely that the pounder received daily use by the residents. When pounding stones are manufactured, the rough out is finished with excessive smoothing to provide it with a spherical appearance. In addition, the interaction with the palm of the user and the opposing durable surface of which the pounder contacted would also serve to produce polish.

6.3.3.1.4 Perforated stone – weight

The perforated weight, identified as a spindle whorl (16E83C087), displays cultural polish across its sides and perforation (Table 6.12). This polish appears in a medium intensity and does not appear on the fracture scars. It is difficult to distinguish whether the polish was acquired through consumption or manufacture. Finishing, general handling, and interaction between the artefact and material in the perforation may all have contributed to the polish (Rowan, 2003189; Rosenberg, 2010:204).

6.3.3.1.5 Vessel

Similar to the pounding stone, the vessel (1143010) displays a medium amount of cultural polish across the interior, exterior, and rim surfaces as described in Table 6.12. The exception is the rougher fracture scar. It is reasoned that this polish is the result of cultural interaction as opposed to natural forces. This is due to the standard appearance of basalt vessels in the southern Levant. Basalt vessels were finished on all surfaces with smoothing and this vessel appears to be no exception (Philip & Williams-Thorpe, 1993:51; van den Brink, Rowan & Braun, 1999:180). Consequently, the intensity of polish is probably indicative of manufacture rather than consumption.

***6.3.3.2 Functional attributes of basalt assemblage***

The strong presence of cultural polish exhibited on all the basalt artefacts provides significant information on their actual function. The intensity of cultural polish displayed on the basalt artefacts suggests that they were used extensively as indicated in Table 6.15. The greatest degrees of polish intensity are high and medium which indicates that the artefacts experienced regular use (Table 6.15). Polish appears primarily on the face (Table 6.15). As a result, the location of cultural polish indicates that each artefact was used in a manner that reflected its intended function (e.g., grinding with grinding stones). Hence, there is a strong correlation between the intensity and location of cultural polish and the intended function, as cultural polish appears where one would expect it on such artefacts (e.g., face – grinding stones).

Figure 6.16 outlines the number of types by percentage to demonstrate how the assemblage is dominated by upper and lower grinding stones. Over 90% of the assemblage are grinding stones, with 67.8% of them being lower grinding stones and

22.6% upper grinding stones (Figure 6.16). The typology of the basalt ground stone artefacts of Tell es-Safi/Gath is somewhat homogenous in that it is composed primarily of grinding stones. In addition, it can be stated with confidence that all of the basalt artefacts, with exception of the vessel, were used for their intended function. As a result, the functional attributes of the typology point to the utilitarian nature of the assemblage, as these artefacts participated in domestic activities, including food processing and weaving (Wright, 1992; Adams, 1999; Rowan *et al.*, 2006:578). The Tell es-Safi/Gath basalt assemblage is reflective of typical domestic assemblages found at other settlements within the southern Levant that also contain high quantities of grinding stones (e.g., Qiryat Ata, Ashqelon-Afridar, Tel Yarmuth) (Rowan, 2003; Rowan, 2004).

Although negligible in quantified terms, the basalt vessel can be considered a prestige item (Braun, 1990:94; Rowan, 1998; Rowan, 2003:17). From what little can be assessed, it is important to note that this artefact is well-finished and manufactured from a prized material (basalt), that was valued for its durability, workability, and possibly colour (Ebeling & Rowan, 2004:108; Schneider & LaPorta, 2008). Further evidence is gathered from the fact that the manufacture of these vessels is labour intensive and Tell es-Safi/Gath is far removed from sources of basalt. Consequently, this prestige artefact was imported and likely represents a continuation of the extensive basalt vessel exchange network that existed during the EB I.

### 6.3.4 Neighbourhood analysis of distribution of basalt artefacts

The basalt ground stone artefacts of Tell es-Safi/Gath are distributed within Area E not only horizontally across the various rooms and buildings, but also vertically throughout the EBA phases. As a result there is a chronological and spatial distribution of

the basalt typology. These will be discussed in turn below in an effort to identify the concentrations of artefacts and which buildings had access to these commodities.

#### *6.3.4.1 Chronological distribution of basalt ground stone typology*

The basalt ground stone artefacts were recovered from Strata E6 and E5 in Area E. A chronological breakdown of the number and type of each artefact is presented in relation to each stratum below.

##### 6.3.4.1.1 Stratum E6

The earliest excavated EBA stratum at Tell es-Safi/Gath is Stratum E6. It is only partially excavated in Area E as the uppermost horizon has not been removed yet across the entire area allowing E6 to be reached. Three basalt artefacts (3 lower grinding stones) were discovered in Stratum E6 as outlined in Table 6.16. As this stratum has received limited excavation, the basalt artefacts from this stratum are not representative of a final E6 basalt assemblage. Rather, they are included because it is important to note that the occupants possessed these artefacts and that domestic activities were performed during this time frame.

##### 6.3.4.1.2 Stratum E5

The majority of EB III basalt artefacts (n=28) from Tell es-Safi/Gath are recovered from Stratum E5 in Area E as depicted in Table 6.17. In addition, basalt artefacts were discovered in each of the three architectural phases that compose Stratum E5, Phases E5a, E5b, and E5c (Table 6.17). However five basalt artefacts (3 lower grinding stones, 1 upper grinding stone, 1 vessel) could not be confidently assigned to an architectural phase and remained categorised under Stratum E5 (Table 6.17).

Phase E5c contains the fewest artefacts in the E5 stratum: one artefact, which is a fragment of a lower grinding stone (Table 6.17). This phase has not received as extensive excavation as later phases and does not yet have a full representative basalt assemblage. It is the smallest area of excavations for this stratum (5x10m) as indicated in Table 6.18 that provides the associations between the size of phases that have been excavated and the number of basalt artefacts discovered in those phases.

The frequency of basalt artefacts within Phase E5b is in between that found in E5c and E5a. They are a mix of lower (n=5) and upper (n=3) grinding stones (Table 6.17). The occupants of this architectural phase received a considerable supply of basalt artefacts, given these were found in an excavation area that was only 10x20m (Table 6.18).

By comparison, Phase E5a contains the highest quantity of basalt ground stone artefacts (n=14) (Table 6.17). It was also the stratum that was excavated over the largest area (15x20m) (Table 6.18). These are represented as 1 pounder, 1 weight, 3 upper grinding stones, and 10 lower grinding stones and collectively form the most diverse assemblage of the three phases (Table 6.17).

While it would seem that the occupants of Phase E5a had access to more basalt objects than the previous two E5 strata, it could just as well be possible that this is a reflection of size of excavated area for each stratum as outline in Table 6.18. In general, it can be observed that the occupants of the area were well connected to the exchange networks of basalt artefacts as they received a considerable amount of basalt commodities.

### *6.3.4.2 Spatial distribution of basalt ground stone typology*

In this section, the spatial distribution of the basalt ground stone artefacts recovered from Strata E6 and E5 in Area E will be analysed by type. The number and type of each artefact is presented in relation to its spatial provenance within each stratum and presented below.

6.3.4.2.1 Stratum E6

As very little of Stratum 6 has been excavated, the spatial distribution of the three basalt artefacts in it is difficult to establish. Artefact E15AQ179 is considered to be located in Alleyway 104306 that divides the neighbourhood as illustrated in Figure 6.17 and Table 6.19. This is based on the building tradition observed in the EBA levels of Tell es-Safi/Gath where much of the Stratum E5 architecture is constructed on top of Stratum E6 architecture, likely utilising the same alleyway (Shai *et al.*, 2014:28). The other two artefacts are probably located in a residential room as they were discovered in an installation (16E93B06) (expanded upon in later sections). Because the these two artefacts are located below the foundation walls of Building 104311 (Stratum E5), it likely that they are associated with Stratum E6 that has yet to be fully excavated. Basalt artefacts are then located inside and outside residential structures (Figure 6.17).

6.3.4.2.2 Stratum E5

The basalt artefacts contained within Stratum E5 are divided amongst the buildings and rooms of the three architectural phases: E5a, E5b, and E5c. As discussed in section 2.5.4 of Chapter 2, each phase represents a shift in the architectural composition of the neighbourhood. This means that the layout and organisation of buildings and rooms alters throughout the EB III. To date, seven buildings have been uncovered in Area

E (Shai, Uziel & Maeir, 2012; Shai *et al.*, 2014). The distribution of basalt artefacts within these buildings and their rooms are discussed in the paragraphs that follow.

*6.3.4.2.2.1 Phase E5c*

Of the three buildings of Phase E5c, only Building 134307 contained a basalt artefact as illustrated in Figure 6.18. This artefact (134307) is shown to be the fragment of a lower grinding stone and is located in Room 114602 (Figure 6.18). This room was the central courtyard of its parent building and due to the abundance of additional ground stone artefacts and installations (Figure 2.3), it is plausible that this are functioned as a food preparation locale. By extension, it is likely that artefact 134307 also participated in the activities associated with this area. The absence of basalt artefacts in Buildings 114805 and 134817 (Figure 6.18) is likely due to the limited excavation they have undergone.

*6.3.4.2.2.2 Phase E5b*

The majority (7 of 8) basalt artefacts found in Phase E5b are located in Building 74512 as depicted in Figure 6.19. The heaviest concentration of basalt artefacts (n = 5) and ground stone artefacts in general is in Room 74512, the courtyard of Building 74512 (Figures 2.6 and 6.19). This solidifies the likelihood that the courtyard continued to function as a multipurpose food preparation area. Rooms 84405 and 104604 each contained a lower grinding stone fragment (Figure 6.19). Their lower concentration of basalt artefacts and ground stone artefacts in general (Figures 2.6 and 6.19) suggests these two rooms were not important areas of food preparation and served other functions. The other basalt artefact, a lower grinding stone, is located in Room 134803 of Building 84309 (Figure 6.19). While this building had access to basalt commodities, only Room

134803 contained ground stone artefacts (Figure 2.4). However, in comparison to ground stone artefact count of Room 74512, it is not likely that Room 134803 functioned as the food preparation area for this building.

*6.3.4.2.2.3 Phase E5a*

Phase E5a boasts a considerable amount of basalt artefacts (n = 14) that are spread amongst the two buildings, 114206 and 104311, and the alleyway that divides them, as shown in Figure 6.20. Aside from upper and lower grinding stones that dominate the typology in this phase, a pounder and weight are present (Figure 6.20). Room 104113 of Building 114103 contains a lower grinding stone (Figure 6.20). It is unclear why this artefact appears in a near empty Room 114103 as an adjacent room (104108) contains two installations that likely served in food preparation (Figures 6.20 and 2.7). In building 114206, Rooms 104207 and 114402 contained one and two grinding stones respectively (Figure 6.20). Room 94413 in Building 114206 contains the most basalt artefacts, composed of one upper grinding stone and three lower grinding stones (Figure 6.20). This room may be primary locale of food preparation as other ground stone implements that include a pounding stone were also discovered. The largest room of Building 114206, Room 114206, has a low ground stone count (n = 3) and two mortars and only one basalt artefact: a pounder (Figures 6.20 and 2.7). Based on the distribution of ground stone artefacts, there appears to be a divide between areas of different food preparation tasks in Building 114206. In Room 94413 grinding activities occur while in Room 114206 crushing and pounding take place. Four fractured basalt artefacts, consisting of three lower grindings stones and a weight, are discovered in the refuse of Alleyway 104306 (Figure 6.20). Their fractured nature attests to their likelihood of being discarded

in the alleyway (expanded in 6.3.5) among other artefacts (fauna, pottery, metal, asphalt) (Figure 2.5).

*6.3.4.2.2.4 Summary of spatial distribution*

Several basalt artefacts (n=5) could not be assigned to a specific phase and remained assigned to Stratum E5 in general (Figure 6.21). While they are not included in the count of basalt artefacts associated with the buildings in each phase, it is important to note several aspects about them. Two lower grinding stone fragments are found in the matrix of walls and a rim fragment of a vessel is discovered in one of the rooms that likely belongs to Building 114206 or 74512 (Figure 6.21). From Figure 6.22 it is apparent that most excavated buildings, 114206 and 7412, contain the most basalt artefacts at nine and seven respectively. This count is followed by the alleyway (104306) with four basalt artefacts and Building 104311 with two artefacts. Buildings 134307 and 84309 both contained one basal artefact. Consequently, within Stratum E5 there is an unequal distribution of basalt artefacts among both buildings and rooms (Figure 6.23). Figure 6.23 illustrates the overall distribution of Stratum E5 basalt artefacts through the combination of each phase. From this diagram (Figure 6.23), it is apparent that not every room contained basalt artefacts. However, every well-excavated building contained basalt artefacts and seems to have accessed to these imported commodities. The exceptions are Buildings 134817 and 114805 (Figure 6.18). But as basalt artefacts are discovered in Stratum E6, it is likely that further excavation of Phase E5c will recover more basalt artefacts.

### 6.3.5 Use-life and deposition of basalt assemblage

The use-life stage and deposition of basalt artefacts provide information about consumption, recycling, and discard strategies of the EB III Tell es-Safi/Gath residents. It should be noted that use-life stage is not the equivalent of context, for example primary context ≠ primary use-life stage as described in section 4.3.3. The use-life stage and deposition of basalt ground stone artefacts is investigated through a macroscopic analysis of the physical condition of the artefacts in accordance with their archaeological provenance. The physical condition of the basalt ground stone artefacts was conducted through a visual examination of fracture scars and an estimation of the remaining percentage of the original artefact. Each artefact was inspected individually and the results were recorded in Table 6.19. The paragraphs below will describe this table in greater detail.

#### *6.3.5.1 Complete artefacts*

Three artefacts, 746060, 840111, and 16E94A011, are complete and bear no fractures (Table 6.19). This suggests that significant depositional forces did not act upon them. Rather, they were likely to have been swiftly buried by sediment or other remains.

Artefact 16E94A011 was found on an E5a surface and *in situ*, beside a pebble installation in Room 114402 (Table 6.1). This lower grinding stone resides on its dorsal face with the grinding face exposed and was probably used in this location and position. This archaeological provenance suggests that the artefact had not moved from its position of last use. As such, it had not undergone discard, but rather abandoned and later buried by other remains in its primary use-life (Adams, 2014b:24-25).

Artefact 746060 was found in occupational debris within Room 104207 (Table 6.1). It is composed of a dense basalt matrix with no major vesicles giving it more durability over vesicular basalt artefacts. In addition, it is likely that this artefact was still in use, as it had not been actively discarded (e.g., thrown in a refuse pit). However, as this upper grinding stone was not discovered next to or on top of a complete lower grinding stone, it cannot be stated that this artefact belongs to a secondary or primary use-life (Adams, 2014b:24-25).

Artefact 840111 was recovered from Room 114206 and was associated with a pebble hearth (Table 6.1). Similar to the other complete artefacts, 840111 was likely still useable when it was abandoned and buried. Given its proximity to a food preparation locale, it is plausible that this artefact was utilised on the main floor of the building and did not experience a fall from another floor. This pounder was likely in its primary use-life stage (Adams, 2014b:24-25), but as pounders often do not have an accompanying netherstone, it is difficult to confirm this assessment. Two proximate mortars may have acted as netherstones.

#### *6.3.5.2 Fractured artefacts*

Visible fracture scars on artefacts were categorised as of ancient or modern origin in order to distinguish the time of fracture. Modern fracture scars appear "fresh" as the interior of the rock is exposed and not covered in the surrounding sediment. Ancient fracture scars blend with the uniform exterior of the artefact. The presence and quantity of these two scar types on the basalt artefacts are discussed below.

6.3.5.2.1 Modern fractures

Modern fractures on artefacts typically occur during excavation, usually when a large tool with a metal head, such as pick or shovel, makes forceful contact with an artefact. Ground stone artefacts are very durable, but often receive significant blows. Other ways to deliver modern fractures occur during transport or storage and will involve dropping the artefact or dropping something on the artefact. Five artefacts display one modern fracture each as described in Table 6.19. In relation to the number of artefacts that exhibit ancient fractures and the number of fracture scars, the modern fracture count is low (Table 6.19). As a result, the modern fractures did little to reduce the overall size of the artefacts. This suggests that the current condition of the artefacts is primarily due to ancient depositional activity rather than modern interaction.

6.3.5.2.2 Ancient fractures

While it is most plausible that the remaining basalt assemblage bears ancient fractures with exception of the complete artefacts, there are five basalt artefacts (745019, 745047, 745050, 748110, and 16E93B070) that could not be assessed (Table 6.19). This lack of assessment was due to the ability to distinguish with confidence a modern fracture from ancient. Unfortunately, these basalt artefacts had been soaked in water and scrubbed clean. These actions removed any traces of fresh breaks. It should be noted that artefact 16E93B070 was discovered in the alleyway and represents direct discard behaviour of the Tell es-Safi/Gath residents. The other four artefacts were discovered in secondary contexts of occupation debris (Tables 6.1 and 6.18) and their use-life stage cannot be determined.

Most (n = 23) of the basalt ground stone assemblage bore evidence of ancient fractures. Figure 6.24 provides a breakdown of the number of ancient fractures seen on each artefact. The distribution of fractures per artefact are as follows: three artefacts are complete, five artefacts bear one ancient fracture, two artefacts bear two ancient fractures, five artefacts bear three ancient fractures, seven artefacts bear four ancient fractures, one artefact bears five ancient fractures, and three artefacts bear eight-ten ancient fractures (Figure 6.24). This breakdown indicates that, overall, the basalt ground stone assemblage is heavily fractured. This conclusion is further supported by Figure 6.35 that depicts the estimated percentage of the amount that remains of the original artefact. The pie graph demonstrates that most of the artefacts (38.7%) represent approximately 5% of a full sized artefact (Figure 6.25). 22.6% of the artefacts represent 35% of the parent artefact and 19.4% represent roughly 10% of the original artefact (Figure 6.25).

The fractured nature of the basalt assemblage suggests that most of these artefacts underwent depositional forces that damage their morphology. The archaeological provenance provides information on the nature of discard of these artefacts. For example, the four of the artefacts discovered in the alleyway that display ancient fractures are heavily fractured and represent <50% of their parent artefact with three artefacts representing 5% (Tables 6.1 and 6.18). Their archaeological provenance in the alleyway (Tables 6.1) suggests that they were purposefully located there after fracturing. This indicates active discard on the part of the residents of Tell es-Safi/Gath. Other active discard occurred in the form of a cultural fill on which to construct a surface. Artefact 1143031 was heavily fractured (35% of the original artefact) and placed in a sub-floor matrix to provide stability for the surface. Recycling was also practiced at Tell es-

Safi/Gath after basalt artefacts fractured. This is evident from artefacts discovered in secondary use-life stages. For example, it is probable that two basalt ground stone artefacts (16E93A049, 16E93A050) may have experienced secondary-sequential use. These artefacts are two pieces of fragmented lower grinding stones and lined the interior of concave pebble installation (Tables 6.1 and 6.18). They had received considerable intended use, as can be extrapolated from their high intensity of cultural polish on the face. The function of the installation is unknown, but could have been a hearth, storage location, or food processing area. Other fractured basalt artefacts were discovered in a secondary-sequential use-life stage as well. Three artefacts (941057, 944090, 16E93B081) bear evidence of extensive primary (intended) use, but were found as part of the matrix used to construct the stone foundations of mud-brick walls. These artefacts were used to fill gaps between larger field stones. Other secondary-sequential uses included the matrix of pebble installations (artefacts 840111, 16E84A007) and the matrix of pebble floors (artefact 1141073). The residents of Tell es-Safi/Gath actively recycled and reused fractured basalt artefacts after their primary use life had ended, possibly due to fracturing (see section 6.3.3.1 on how use-wear contributes to fracturing). It is worth noting that intentional fracturing has been observed at other settlements (e.g., Çatal Höyük) in order to construct installations or serve other secondary purposes (Baysal & Wright, 2005:321). It is plausible that Tell es-Safi/Gath occupants also engaged in this behaviour.

The use-life stage of many artefacts discovered in secondary contexts of occupational debris could not be determined due to the ambiguity of their archaeological provenance. A case could be made that the artefacts discovered as possible cultural fill in

the alleyway were in a secondary-sequential use-life stage, possibly used as material to level certain areas (e.g., the alleyway). While discard and secondary use-life are not mutually exclusive, the artefacts have been labelled in this analysis as discarded, since this behaviour is more probable.

## 6.4 Testing of hypotheses

The above analyses will be used to test the hypotheses outlined in Chapter 5. Each hypothesis is presented below along with the conditions that may or may not verify it. Conditions that are met assist in providing evidence for a true hypothesis.

### 6.4.1 Provenance

The first hypothesis addresses the geological and social provenance from which the artefacts were procured. It was tested through a provenance analysis (Method 1), a trace element analysis (Method 2), and a meta-analysis (Method 3).

- Hypothesis 1: *If a basalt ground stone artefact originated from a specific source, then based on the provenance postulate, both the artefact and the source should bear the same geochemical fingerprints.*

The hypothesis above holds true if the accompanying condition is met:

- a) The geochemical fingerprint of an artefact matches that of the geological source (Neff, 2001107-108).

The results of these analyses were divided (Table 6.8). Some basalt artefacts displayed a similar geochemical fingerprint as various sources and were matched together as depicted in Table 6.8. Approximately 80% of the sampled artefacts were given a match. In the northern sub-regions of the southern Levant, three artefacts are sourced to the Jezreel Valley, three artefacts are sourced to the Golan, five artefacts are sourced to

Mt. Hermon, and one is sourced to the Hulah Valley. Two other artefacts are sourced to the Harra el-Jabban region in western Jordan. Other artefacts (n=4) did not have a match (Table 6.8). As a result, the condition is considered to be satisfied for the majority of the sampled assemblage.

It is equally important to note from where the artefacts are not originating. Of the 19 artefacts sampled, none of them matched the geochemical fingerprints from Egypt. The lack of comparative geochemical fingerprints from western Jordanian sources is unfortunate and hinders the extent of this analysis. The geochemical data provided by Philip and Williams-Thorpe (1993) and Mallory-Greenough and Greenough (2004) that includes sources in western Jordan is incomplete and could not be used as it does not provide major elements. Because of this dearth in comparative data, it cannot be conclusively stated that the artefacts are not originating from this sub-region.

### 6.4.2 Production

The hypotheses related to the second research question inquire into the organisation of production of the basalt ground stone artefacts. These hypotheses were tested through a morphometric analysis (Method 4), field excavation and documentation (Method 5) and a qualitative analysis (Method 6).

- Hypothesis 2.1: *If the neighbourhood at Tell es-Safi/Gath was comprised of non-elite residential houses, then it is expected that the occupants engaged in household production of ground stone artefacts.*

The above hypothesis would be verified if the following expectation was met:

- a) Basalt debitage is discovered in high quantities within the neighbourhood area.

The results (section 6.2) showed that no basalt debitage has been discovered in the neighbourhood of Tell es-Safi/Gath. This indicates that material reduction of preforms did not occur within the neighbourhood and that the residents did not engage in the household production of basalt ground stone artefacts. Alternative behavioural explanations suggest that the absence of debitage may be due to reduction occurring off site or that people actively removed debitage from their neighbourhood. The latter explanation would be plausible had basalt debitage been discovered only in the alleyway. However, this was not the case and no concentration of basalt debitage has been found elsewhere on the EB III excavated parts of the site to date (H. Greenfield, pers. comm.). It should be noted that natural, environmental processes might have contributed to the absence of basalt debitage at Tell es-Safi/Gath and at other settlements in the southern Levant. $SiO_2$ poor rocks, such as basalt, are subject to heavy weathering from exposure to water and wind erosion at geologically rapid rates (Eggleton, Foudoulis & Varkevisser, 1987:162; Navarre-Sitchler & Brantley, 2007). Fragments of debitage, particularly those reduced from vesicular basalts, may have been degraded to grains that fell through the sieve screens (Eggleton, Foudoulis & Varkevisser, 1987:169; Navarre-Sitchler & Brantley, 2007). While it is theoretically possible that this process occurred, it is unlikely to be the case since it would have occurred across the region and not be limited to Tell es-Safi/Gath. The absence of basalt debitage is more likely a result of production decisions to finish objects at or close to the quarries in order to reduce the cost of their transport.

- Hypothesis 2.2: *If the EB II-III of the southern Levant was a period of growing social complexity and increased specialised craft production,*

*then it is likely that the basalt ground stone industry was also produced through specialised craft production*.

This hypothesis would be verified if the following expectation was met:

- a) Basalt ground stone artefacts of the same type display little to no variation in their dimensions.

Results of the analyses (Tables 6.9-6.11) attempted to establish the degree of standardisation in the assemblage. However, due to the fractured nature of the stones that constitute the assemblage, the degree of standardisation cannot be accurately ascertained. The only intact dimension from which information could be extrapolated was the thickness of upper and lower grinding stones. The similar dimensions may be due to the gradual reduction of material on the face through extended use. Alternatively, the similar dimensions of upper grinding stones may be the result of a size preference for the artefact to fit in the palms of a consumer. The range of 4-7cm may have been ideal as it kept the artefact at a manageable size and weight while maintaining a long use-life and sturdy structure. As a result, it is plausible that the minute degree of standardisation in the upper grinding stones was not the result of specialised craft production. As similar artefacts were provenanced to separate sub-regions, it is implausible that the same artisan manufactured such artefacts. Consequently, this condition is not met nor fully rejected, as there is faint evidence that some specialised production may have occurred in the form of a standard rubric among ground stone artisans. However, as the evidence is weak, the notion of craft specialisation must be dismissed.

### 6.4.3 Distribution

The third hypothesis examines the nature of distribution that brought the basalt artefacts from their location of production to the occupants of Tell es-Safi/Gath. It was tested through the following methods: provenance analysis (Method 1), trace element analysis (Method 2), meta-analysis (Method 3), field excavation and recovery (Method 5), and qualitative analysis (Method 6).

- Hypothesis 3: *If Tell es-Safi/Gath was a large urban settlement, then it is likely that a centralised authority obtained imported commodities (e.g., basalt artefacts) for redistribution to the settlement occupants.*

For the hypothesis to hold true, the following conditions must be met:

- a) The basalt artefacts were imported from a non-local producer.

As basalt is not discovered within ca. 120km distance of Tell es-Safi/Gath and the artefacts originate from several separate geological sources and sub-regions of the southern Levant, it can be asserted with certainty that the artefacts were imported from a non-local producer. Thus, this condition is met.

- b) Each household not only contains basalt (imported) artefacts, but a similar assemblage of basalt ground stone artefacts.

The households of Tell es-Safi/Gath are designated by the different buildings in the neighbourhood. These buildings are delineated by their architectural boundaries. The spatial distribution of basalt artefacts indicates that, if each fractured artefact is counted as representing a former whole, each E5 household does contain a similar assemblage of basalt ground stone artefacts to an extent. While the number of basalt artefacts per building (household) fluctuates, the typologies of the assemblages are similar. This is

because they are mainly composed of upper and lower grinding stones. However, there does not appear to be a building that was socially or economically prohibited from the acquisition of basalt artefacts. As a result, the condition is considered to be met.

### 6.4.4 Consumption and discard

The fourth hypothesis addressed the nature of consumption and discard of the basalt ground stone artefacts at Tell es-Safi/Gath. It was tested through field excavation and recovery (Method 5) and a qualitative analysis (Method 6).

- Hypothesis 4: *If the neighbourhood at Tell es-Safi/Gath housed non-elite residents, then it is likely that the households performed traditionally domestic tasks and engaged in the recycling of commodities.*

This hypothesis would hold true if the following conditions were satisfied:

- a) The basalt ground stone assemblage contains artefacts that were used in traditional household activities (e.g., food processing, subsistence strategies) and bears evidence of use of their intended function (e.g., cultural polish).

Analyses performed on the basalt ground stone assemblage confirmed that the artefacts were both heavily used and used for food processing and subsistence strategies (Tables 6.12-6.15). The assemblage was mainly (>90%) composed of grinding stones that were used in the preparation of food. In addition, all artefacts displayed a high-medium amount of cultural polish. This polish appeared where expected (e.g., faces, dorsal side, perforation), which suggests that they were all initially used for their intended function. As a result, this condition is successfully met.

- b) The basalt ground stone artefacts are found in secondary use-life stages (Adams, 2014b:24-25).

The results (Table 6.19) of the analyses demonstrate that roughly a fourth of the basalt artefacts were discovered in a secondary use-life stage. These artefacts were found in walls, intentional fills, and installations. Because they display extensive use-wear polish that they would not have received from their context of discovery, it is likely that they served a separate (primary) function prior to be placed in the walls, fills, and installations. This condition is considered to be satisfied.

## 6.10 Conclusion

This chapter was divided into three main parts: data description, data analysis, and hypothesis testing. Each of these produced a greater understanding of life-history of the basalt artefacts from Tell es-Safi/Gath and the economic systems that revolved around them. At times, the fractured nature of the assemblage was observed to be an obstacle in the acquisition of a sufficient analysis.

Nevertheless, significant results were obtained. For example, the basalt artefacts were shown to compose a standard domestic assemblage with a typology made of upper and lower grinding stones. The degree of craft specialisation could not be determined. It was also demonstrated that the artefacts originated from several separate sub-regions, mainly in the northern half of the southern Levant. All the basalt artefacts were shown to have experienced extensive intended use through their location and intensity of cultural polish. In addition, the five hypotheses regarding provenance, production, distribution, and consumption were tested with varying results. These discoveries are carried over into

the next chapter and discussed in relation to the life-history of basalt artefacts in the southern Levant and the economic standing of Tell es-Safi/Gath.

# Chapter 7. Conclusions

## 7.1 Introduction

Now that the data has been presented and explained, it can be placed into the larger context of the life-history of basalt ground stone artefacts, EB III Tell es-Safi/Gath, and the EB II-III southern Levant. Combining the results obtained in the previous chapter and the information presented in Chapters 2-4 permits a reconstruction of the life-history for the basalt ground stone artefacts. It further addresses the significance of this research, analytical considerations, and avenues of future research.

## 7.2 Reconstruction of life-history of basalt artefacts at Tell es-Safi/Gath

The cumulative analyses conducted on the basalt ground stone assemblage combined with information from the literature allow reconstruction of the life-history of basalt artefacts. This systematic reconstruction involves putting together the various pieces of data presented in Chapter 6. It focuses on parallel studies and draws on previous discoveries, theoretical perspectives, and working hypotheses to help paint a clearer picture of domestic life at Tell es-Safi/Gath and in the southern Levant. The life-history is divided into sections that constitute an economic system: production, distribution, use, and disposal. In each case, the most plausible scenario is provided and discussed in an effort to understand the associated human behaviour.

### 7.2.1 Production

The production of the basalt ground stone artefacts can be further subdivided into procurement and manufacture. Procurement addresses the location of raw material extraction, while manufacture involves the act of raw material reduction. These serve to

identify the organisation of production in the EB II-III southern Levant and are also discussed below.

#### *7.2.1.1 Procurement*

The provenance data has indicated that the majority of basalt ground stone artefacts were procured from sources in the northern sub-regions of the southern Levant and to a lesser extent from the Harra el-Jabban region of the Harra Ash Shamah basalt terrain. As previously mentioned, it is assumed that the settlements nearest to these sources participated in their exploitation (Jacobson, van der Westhuizen & de Bruiyn, 1995:381; Neff, 2012: 829). Artisans took advantage of their proximity and made a convenient decision to utilise what was locally available (Stone, 1994:691; Schneider & LaPorta, 2008:19-21). The exceptions to this assumption are inhabitants of Jordanian settlements, possibly at Batrawy (Nigro, 2010; Nigro, 2012). The distance from this easternmost settlement in Jordan to the Harra el-Jabban is roughly 25km. The scarcity of EB III settlements in central Jordan makes it difficult to pinpoint what settlement truly accessed this source. The multiple locations of procurement indicate there was no preference by artisans for one source in the region over another (Rice, 2005:115-117; Andrefsky Jr., 2009:75-78). All local exploitations and allowed for minimum energy expenditure, something that is commonly witnessed in the archaeological record (Andrefsky Jr., 1994; Carter, 2008:67). Therefore, it is likely that basalt artefacts were procured within a distance of a days journey, likely under 7km, similar to the observations Arnold (1985:51-52) made of potters. Artisans may have used donkeys to assist in the transportation of procured blanks (Fratt & Biancaniello, 1993:376; Schneider & LaPorta, 2008:30). Unfortunately, no negatives have been found, as this is the best

evidence of procurement (Abadi-Reis & Rosen, 2008:111; Gluhak & Rosenberg, 2013:1613). Clusters of many negatives would indicate the best evidence of repeatedly accessed quarries (Abadi-Reis & Rosen, 2008:112). It is possible that some artefacts were made from altered boulders representing an opportunistic procurement that may have occurred during other activities (Abadi-Reis & Rosen, 2008:112). Artefacts 941057 and 16E94A011 appear to be of this kind of procurement due to the lack of manufacture on their sides and dorsal side.

#### *7.2.1.2 Manufacture*

Information on the manufacture of basalt ground stone artefacts in the southern Levant is lacking due to the absence of workshops and locales of manufacture (Milevski, 2008:121). This thesis was subject to that dearth of information. It cannot be stated where manufacture specifically occurred, but it is likely that it took place within the same sub-region that the provenance analysis identified (e.g., Jezreel Valley, Mt. Hermon). Further evidence from the lack of debitage at Tell es-Safi/Gath suggests manufacture took place exterior to this neighbourhood. Standard models of ground stone production, based on ethnographic and archaeological research, involve the procured blocks undergoing an initial reduction at the quarry before being transported back to a workshop for further secondary reduction and finishing (Wright, 1992:56; Masson, 2005:1143; Abadi-Reis & Rosen, 2008:113). This has been described at the Camel Site in the Negev where occupants would sporadically but intentionally exploit local sandstone sources (Abadi-Reis & Rosen, 2008:112). Large amounts of debitage, both chunks and flakes, were discovered at these quarries located approximately an hours walk from the Camel Site (Abadi-Reis & Rosen, 2008:111-112). It is not uncommon to finish manufacture at the

quarry in order to reduce the weight of the artefact. Such a condensed *chaîne opératoire* may apply to the basalt artefacts discovered at Tell es-Safi/Gath.

The fractured nature of the basalt artefacts left little to discover about manufacture techniques. Some indications of smoothing or finishing can be discerned on the sides of several artefacts representing that, despite the domestic and often informal nature of the tools, some were given aesthetic treatment. Because the majority of basalt artefacts from Tell es-Safi/Gath were manufactured by artisans in the north-eastern sub-regions of the southern Levant, it is anticipated that they display similarities with the north-eastern settlements. The basalt assemblage from Tell es-Safi/Gath does not stand out from other assemblages (e.g., Te'o, Bet Yerah) within the southern Levant, neither by typology nor morphology.

It does not appear that the basalt ground stone artefacts were fashioned by specialised artisans. As craft specialisation is most discernable through a consistent *chaîne opératoire* and a standardisation of the same type of artefact (Shafer & Hester, 1986:159; Blackman, Stein & Vandiver, 1993:61; VanPool & Leonard, 2002; Costin, 2005:1066; Wright, 2008:151). Although the basalt artefacts of Tell es-Safi/Gath are highly fractured, there was one intact dimension that could be analysed for standardisation: the thickness of upper grinding stones. However, it was demonstrated that the similarity in dimensions was likely due to the finishing of artefacts according to the same functional rubric: the need to fit comfortably into the hands of the consumer. More evidence is provided through the provenance analysis as some of the upper grinding stones originate from separate locations, which would make it unlikely that same artisans manufactured the same artefacts. It should also be noted that the quality of

some artefacts (746060, 16E84C012, 1143010) which suggests that some artisans were proficient at this craft. Other artefacts (16E94A011, 745019, 941057) display asymmetrical dimensions and little effort in manufacture save for the flattening of the face.

#### *7.2.1.3 Organisation of production in the EB II-III southern Levant*

The production of basalt ground stone artefacts does not appear to be a large-scale endeavour arranged through centralised workshops located in the large urban centres. Rather, based the provenance results, it appears that many artisans from separate sub-regions participated in the basalt ground stone industry. This lies in contrast to the large-scale production of other contemporary industries (e.g., Canaanean blades, Northern Canaanite Metallic Ware, Khirbet Kerak Ware) where the large-scale involvement of a centralised administration, particularly at Bet Yerah, is suspected (Mazar, 1990:140; Shimelmitz, Barkai & Gopher, 2000; Greenberg *et al.*, 2012).

The scarcity of EB II-III ground stone studies makes establishing the organisation of production difficult. The data presented in this thesis were also not sufficient to fully describe the organisation of production in its totality. Many of the assertions are based on the absence of evidence. The presence and analysis of workshops is essential to understanding the organisation of production. Although these are absent in the EB II-III, an attempt is made to understand the organisation of production by applying the parameters of production specified by Costin (1991) and discussed in Chapter 3.

##### 7.2.1.3.1 Context

The context of production addresses the degree of control over production, which raises the issue as to whether there is involvement of a centralised authority in

production. In the EB II-III southern Levant, there is no clear-cut evidence for any category of artefact that artisans operated under the direct control of a centralised authority, be it a temple or palace (de Miroschedji, 2003; Greenberg, 2003; Greenberg *et al.*, 2012). This is particularly true of ground stone tool production where the craftsmanship is relatively poor and ground stone workshops have not been discovered in or associated with large public/administrative structures (e.g., Tel Yarmuth, Bet Yerah, Megiddo) (Milevski, 2008:121). The same situation is witnessed with the analyses of EB I basalt artefacts (Rowan, 1998:327).

7.2.1.3.2 Concentration

The provenance results suggest that artisans were dispersed throughout the various sub-regions of the southern Levant and manufacture occurred at multiple locations. This attests to the unlikelihood that artisans were nucleated only in specific areas, such as within large urban settlements (e.g., Bet Yerah, Dan).

7.2.1.3.3 Scale

The scale of production cannot be discerned with confidence. Assumption 1 (see section 3.3.1.2) cannot be assessed as no EB II-III basalt workshops have been discovered. The low number of basalt artefacts within the southern Levant suggests that the scale of labour organisation in production was not extensive, nor organised by a centralised source. In accordance with Assumption 2, the low output is indicative of few artisans. Household production was likely the main source of ground stone production and would be taught from parent to youth. It is also important to bear in mind Assumption 3, where the size of the surrounding community does not indicate the size of

output. If this assumption is applied to the southern Levant, it fits that the high EB II-III population of this large region does not suggest that there was a high number of artisans.

7.2.1.3.4 Intensity

The intensity of basalt ground stone production can be described as part-time. This is based on the low quantity and quality of the artefacts, as well as their longevity (David, 1998:55). Grinding stones are known to last months and years, which eliminates any urgency for their replacement and thus little requirement for many full-time artisans (Rathje, 1972:387).

7.2.1.3.5 Synthesis

From the limited data, a tentative breakdown of the organisation of production of basalt ground stone artefacts during the EB II-III southern Levant results in independent, dispersed, part-time artisans. These are more sufficiently summed up as *individual specialisation* where households or individuals will engage in production for their own consumption and the distribution of any surplus (Costin, 1991:8). It has been noted in complex societies of Mesoamerica that the demand for ground stone artefacts was rarely high at any time and households often had multiple tools (Rathje 1972:387; Roya 1943:106; McBryde 1945:47).

Despite the complex nature of urban society in the EB II-III southern Levant, the EB II-III basalt ground stone industry appears to differ little from that proposed for the EB I. The frequent sloppy manufacturing and low amount of aesthetic finishing that existed in the EB I are all present in the EB III assemblage at Tell es-Safi/Gath (Braun, 1990:94). Additionally, there does not seem to be a strong relationship between specialised ground stone production and social complexity (Rowan, 1998:329).

### 7.2.2 Distribution

The distribution stage of the life-history of the basalt ground stone artefacts is difficult to reconstruct as there is no direct evidence of it. As a result the information presented below relies on previous models of exchange discussed in Chapter 3 and the analysis from Chapter 6. This section is divided into two sub-sections that describe two facets of distribution: 1) the transportation of the artefacts from the production centre to Tell es-Safi/Gath and 2) the redistribution of the artefacts to the residents of Tell es-Safi/Gath upon their arrival at the settlement.

#### *7.2.2.1 Middlemen and the transportation of artefacts*

As previously mentioned in Chapter 5, the most proximate basalt sources to Tell es-Safi/Gath lie outside an approximate 120km radius. It follows that the basalt artefacts were transported by anthropogenic means to Tell es-Safi/Gath. The provenance analysis assists in establishing that the artefacts originated from a variety of sources in the north-eastern sub-regions of the southern Levant and indicates how connected the sub-regions were to each other.

The most plausible scenario to explain the transportation of basalt commodities into the Shephelah and to Tell es-Safi/Gath involves middlemen. Middlemen are known to operate during the EBA of the southern Levant (Milevski, 2011:232). Many of them travelled inter-regionally on the Kings' Highway or the Way of Horus from Egypt through the Levant and into Mesopotamia (Savage, 2011:120). During the EB I, the exchange of basalt vessels and spindle whorls from western Jordan to Egypt along these routes was well established (Mallory-Greenough & Greenough, 2004; Savage, 2011). Since these middlemen operated inter-regionally, it is plausible that they also operated

intra-regionally during the EB II-III (Milevski, 2008:232). It is not known whether they were related to the artisans or commissioned by a centralised authority. Within the centralised societies of the EB II-III southern Levant, it is assumed that they had connections to the elite (Milevski, 2011:232).

It is known that basalt ground stone artefacts were not the only commodity that was exchanged intra-regionally (see Chapter 3). To maximise their efficiency, middlemen transported more than one commodity at a time. For example, it is probable that middlemen with a load of basalt artefacts received from one artisan from the Golan would stop in Bet Yerah to collect Khirbet Kerak Ware to further distribute south. Of course, this is a simplified model, but it may likely be how middlemen operated. It is thought that they regularly moved between and stopped at the largest urban centres of each sub-region of southern Levant, since this would be the most likely route of travel. This model is suggested for Khirbet Kerak Ware and Northern Canaanite Metallic Ware (Milevski, 2011:56,69) and is applicable to the basalt ground stone artefacts of Tell es-Safi/Gath (Figure 7.1). For example, basalt artefacts from the Jezreel Valley may have been collected at Megiddo and sent south via merchants in the Central Coastal Plain (Figure 2.1). Those originating in Golan, Korazim, Mt. Hermon, or south-eastern Galilee may have been gathered at Bet Yerah, then transported south through Bet Shean and the Jordan Valley to Jericho, where they made their way west into the Shephelah. This route may have been more popular during the EB II given the prominence of Ai and Arad. An alternative route would have been to travel southeast from Bet Yerah to Megiddo and continue south on the first route. However, it cannot be established whether middlemen went directly to Tell es-Safi/Gath with their basalt commodities or stopped at one

settlement to exchange with other middlemen who continued the same trend until the commodities reached Tell es-Safi/Gath. This latter possibility is described as down-the-line exchange (Renfrew, 1975:42) (Figure 3.1). Although this thesis examines unidirectional exchange (from the north-eastern sub-regions of the southern Levant to Telles-Safi/Gath), it is expected that the Shephelah was also a producer of exchange commodities. These may have included tabular scrapers or perishable commodities (e.g., grain, olive oil, fruits) of which could be acquired and exchanged to the north-eastern sub-regions by middlemen on the return trip from Tell es-Safi/Gath and other settlements in the Shephelah (Milevski, 2013:214). It is likely that, in the absence of an exchange medium, such as cash (coinage of gold, silver, or other metals), commodities were exchanged for other commodities or even labour (Masson 2005:1149; Silver 2007:93).

As a result of the involvement of middlemen, basalt ground stone artefacts received a wide distribution despite the limited production. One factor assisting the wide distribution of remains over long distances was the introduction into the region of the use of beasts of burden, mainly donkeys, during the EBA. The domestication of the donkey toward the end of Chalcolithic enabled new socio-economic conditions and technologies to be implemented during the EBA of the southern Levant (Milevski, 2011:191; Greenfield, Shai & Maeir, 2012:24). Not only did this event hold implications for agricultural production, but allowed people to conduct exchange over longer distances and on a larger scale. The exploitation of donkeys as beasts of burden may also have contributed to a rise in urbanism as they facilitated large-scale long distance exchange and more intensive agricultural practices (Postgate, 1986; Jans & Bretschneider, 1998; Grigson, 2012). Old Kingdom hieroglyphic texts attest to the use of donkeys as the major

caravan transport animal between Egypt and neighbouring regions (Midant-Reynes, 2000:55; Sowada, 2009:162-163; Greenfield, Shai & Maeir, 2012:24). Middle Bronze Age cuneiform texts attest to donkeys transporting commodities from Assyria to Cappadocia as carrying around 75 kg (Larsen, 1967:141-155). This weight is over double what an average man could transport. But, they were also used to pull carts, wagons, and chariots (Bar-Oz *et al.*, 2013:1-5). The combination of wheeled transport and the exploitation of these animals provided an efficient means for moving large and heavy ground stone artefacts quicker and with relative ease. Caravans of donkeys loaded with commodities would be utilised as a foremost mechanism of exchange (Sowada, 2009:163; Milevski, 2011:178-197). The domestication and use of donkeys was essentially a technological innovation that allowed for the large-scale distribution of large and heavy objects.

An additional and under-recognised means of exchange during the EB II-III was that of naval transport. This was conducted by large maritime boats or by small rafts walked along tributaries (Stager 2000:630). This latter technique has been verified through experimental archaeology which has demonstrated that one person can steer a load of approximately 300 pounds of ground stone material on a *tule* raft, or reed boat, with relative ease (Schneider and LaPorta 2008:31). This would be useful for transporting commodities along the Jordan River and south through the Jordan Valley (Schneider and LaPorta 2008:31).

#### *7.2.2.2 Distribution within the Shephelah*

On the way to the Shephelah, it is likely that middlemen stopped in each successive settlement or node of the southern Levant. Pausing at the large urban centres,

in particular, allowed the exchange of commodities with that specific settlement. There is good evidence that all of the major urban settlements were connected to the intra-regional southern Levantine exchange system (Milevski, 2008:118-120; Milevski, 2011:109-113). For example, Tel Yarmuth, Arad, and Ai (as well as Tell es-Safi/Gath) received basalt artefacts. Tel Yarmuth boasts two sets of tournettes originating from the Galilee-Golan sub-regions (Roux & de Miroschedji, 2009). However, the supposed "political dominance' of Tel Yarmuth raises the question as to whether Tell es-Safi/Gath was a competing urban centre or a secondary centre to the Tel Yarmuth political core (Shai *et al.*, 2014:44). The distribution of basalt commodities in the Shephelah must be considered under these two possibilities. The following paragraphs describe the plausible models of the distribution of basalt artefacts at Tell es-Safi/Gath based on whether Tell es-Safi/Gath was a secondary or competing settlement.

7.2.2.2.1 Mode 1: Tell es-Safi/Gath as a secondary urban centre

Tel Yarmuth has long been regarded as the dominant settlement in the Shephelah (de Miroschedji, 1988; de Miroschedji, 2003; de Miroschedji, 2006; de Miroschedji, 2009). Under this assumption, Tell es-Safi/Gath can be considered as the sub-regional node the basalt ground stone exchange network. A likely distribution scenario views the movement of commodities to Tell es-Safi/Gath as a peripheral distribution from Tel Yarmuth. Evidence for Tel Yarmuth as the dominant centre in the Shephelah is found in the large EB II-III palace complexes. Evidence for Tel Yarmuth's potential to be the central distributer or redistributor for goods in the region is the large storerooms in the palaces that contain numerous large storage jars (de Miroschedji, 1999:12; de Miroschedji, 2003; de Miroschedji, 2006:64). This may constitute evidence of either

stockpiling for personal consumption within the palace or centre. Conversely, it may have been to control the flow of commodities by a centralised authority into and out of Tel Yarmuth as a central place and for redistribution (de Miroschedji, 1999:12; de Miroschedji, 2006:64). As a secondary centre, Tell es-Safi/Gath would have received a redistribution of commodities through Tel Yarmuth. Tell es-Safi/Gath residents may have made their way to Tel Yarmuth to acquire foreign commodities on their own or a group of middlemen may have operated between the two settlements. However, no evidence of stockpiling basalt artefacts at Tel Yarmuth has been reported, which suggests that redistribution was an unlikely relationship between Tel Yarmuth and Tell es-Safi/Gath.

The economic relationship between the two urban centres may be characterised by a centralised redistribution network (mode 5 Figure 3.1). At the settlement level, the elite at Tell es-Safi/Gath conducted centralised redistribution with the non-elite residents of the city (mode 5 Figure 3.1). The non-elite residents contributed a portion of their own commodities to the centralised authority at Tell es-Safi/Gath as a form of taxation or even tribute (Wright, 1994a:71). The elite would forward these on to Tel Yarmuth through middlemen and in return would receive and redistribute basalt ground stone artefacts, among other foreign commodities, to the non-elite residents. This redistribution could be performed through centralised markets (Masson, 2005:1142). The presence of basalt artefacts within each household indicates that each had access to this commodity and no household was socially or economically isolated or prohibited from obtaining them. The examination of basalt artefacts does not provide evidence of social stratification within the neighbourhood through differential access to this commodity.

7.2.2.2.2 Mode 2: Tell es-Safi/Gath as a competing urban centre

Recent excavations at Tell es-Safi/Gath and an analysis of its EBA material culture have prompted an alternative model to the one previously described. Given its size of approximately 24 hectares (Uziel & Maeir, 2005; Shai *et al.*, 2014:21), Tell es-Safi/Gath can be considered a large urban centre of the Shephelah. This new model views Tell es-Safi/Gath as an equally important settlement to Tel Yarmuth. From the data recently presented for the nature, extent, and scale of EB III occupation at Tell es-Safi/Gath, it is possible that it was a primary centre in the Shephelah sub-region.

In this mode, the role of Tell es-Safi/Gath in the basalt artefact exchange system is different. Commodities may have been brought directly to Tell es-Safi/Gath from other nodes in the north-eastern sub-regions (e.g., Megiddo, Bet Yerah). Because Tell es-Safi/Gath was dependant on Tel Yarmuth, it was able to generate its own demand for basalt commodities. Tell es-Safi/Gath would be seen a primary consumer rather than an extension of Tel Yarmuth's consumption. In relation to the basalt artefact producing north-eastern sub-regions, Tell es-Safi/Gath and Tel Yarmuth may have been perceived as periphery consumers to the core of north-eastern urban settlements.

The limited evidence for centralised redistribution within Tell es-Safi/Gath has been discussed in the previous chapter. Similarly to the previous model, the stockpiling of basalt artefacts in elite and administrative complexes at Tell es-Safi/Gath would provide additional and more indicative evidence of centralised redistribution of these commodities within the city. While Tell es-Safi/Gath received basalt artefacts from the north-eastern sub-regions of the southern Levant, these commodities may have been distributed to residents through centralised redistribution or market exchange. In a

centralised redistribution system the elite assumed responsibility for the exchange of basalt commodities (Mode 5 Figure 3.1). Middlemen might act as the intermediaries between a distant supplier and the elites of Tell es-Safi/Gath in an effort to acquire basalt artefacts. Within Tell es-Safi/Gath, the elite conducted centralised redistribution with the non-elite residents of the settlement (Mode 5 Figure 3.1). In order to receive these imported commodities, the non-elite residents supplied the centralised authority with tribute or taxation (Wright, 1994a:71). Given the spatial and temporal distribution of the artefacts within the neighbourhood, it is apparent that each household had access to these commodities.

The above scenario mirrors the model of ground stone distribution practiced among Mesoamerican (Maya and Olmec) complex societies (Rathje 1972) (see Chapter 4). An analogous system operated in the Mesoamerican lowlands where pre-Columbian middlemen, relatives of the ruling elite, would deliver ground stone artefacts collected from the highlands to ruling elite of the lowlands (Rathje, 1972:371). The ruling elite would then redistribute the ground stone artefacts to lowland households.

In contrast, it is possible that the occupants of Tell es-Safi/Gath may not have been overly dependant on the basalt exchange. A reliance on the elite for centralised redistribution may not have been as heavy at Tell es-Safi/Gath as the local non-elite had other local sources of ground stone artefacts. Indeed, basalt artefacts (all of which are of non-local origin) constitute ca. 30% of the entire EBA ground stone assemblage at Tell es-Safi/Gath. The majority of ground stone artefacts are manufactured from local limestone material that is found in abundance around the settlement (Ackermann & Bruins, 2012:124). Basalt artefacts have been acquired through market exchange from

free-lance middlemen (Mode 7 – Figure 3.1), rather than redistributed by elite authorities. In this model each individual, including the middleman, is intent on benefiting from the transaction in the form of payment or a basalt artefact (Renfrew, 1975:45; Hodder, 1978:205-211; Masson, 2005:1151). The occupants of Tell es-Safi/Gath may then view basalt artefacts as a rare commodity or luxury.

#### *7.2.2.3 Involvement of a centralised authority in exchange systems*

The many fortified settlements of the EB II-III southern Levant attest to the presence of some socio-political unrest between urban centres (Greenberg & Paz, 2005). This may have been in response to competition for resources or military advancements. Socio-political competition among settlements may have put a strain on the access to resources. This would serve to segregate the sub-regions politically and socially. However, the involvement of a centralised authority in the distribution of resources would be beneficial to residents of Tell es-Safi/Gath. Negotiations between centralised authorities of urban centres would facilitate the movement of certain commodities where access by commoners was prohibited (Rathje, 1972:371). This would provide residents with security against commodity shortages and import foreign commodities (Bates & Lees, 1977:833).

### 7.2.3 Consumption (use and discard)

The last stages in the life-history of the basalt ground stone artefacts of Tell es-Safi/Gath are use and discard. These are grouped together as they are often intertwined. The known recipients of these commodities were domestic households. Each household contained basalt artefacts in their assemblages. The various functions of the artefacts and the nature of discard reflect the behaviour of the resident. These facets of the life-history

are expanded upon below in an effort to further illuminate and understand daily life at Tell es-Safi/Gath.

#### *7.2.3.1 Use and function of basalt artefacts*

The collective function of the basalt artefacts, based on their typology, is a reflection of domestic activities, specifically food preparation and subsistence (Adams 2014:102). All the basalt artefacts were extensively used, possibly until they fractured. The cultural polish and high amount of sheen on the grinding stones implies that they were utilised regularly and with force. The grinding stones and pounder were important tools in food preparation activities as they processed grain products through abrasive and compacting forces, minimising the quantity of grit in the meal (Ebeling & Rowan, 2004:108).

Each household conducted similar food preparation activities based on the typology. Some areas seem reserved for these activities. For example, the courtyard of Building 114206 is littered with basalt ground stone artefacts during Phase E5b. This may be the central locale of food preparation. Additional evidence is provided by the presence of non-basalt grinding stones, cooking vessels, and a large stone platform installation (Shai *et al.*, 2014:40). During Phase E5a, food preparation activities occurred in Room 94413 of Building 114206. This is attested by the presence of basalt grinding stones, both upper and lower ones. As many artefacts are in secondary contexts, it is difficult to identify pairs of grinding stones. This kind of domestic space use was not uncommon in settlements of the southern Levant. An analogous example of the use of a courtyard for food preparation with ground stone artefacts is at Bet Yerah (Paz, 2012:416).

#### *7.2.3.2 Discard of basalt artefacts*

The majority of the basalt ground stone assemblage is fractured, with less than 50% remaining of most artefacts. While some were discarded in the alleyway, others were re-used and experienced a secondary use-life stage. The alleyway appears as a location for disposal, whether for levelling purposes or simply to dispose of trash. The basalt artefacts discovered in the alleyway are all highly fractured (many representing 5% of the original artefact) and most likely of little use. For instance, the weight (16E83C087) was fractured across the centre, a common breakage pattern for ringed objects. The cause of the many fractures cannot be determined, however. They may have been broken on purpose or dropped when moved by residents or post-depositional forces, such as the collapse of the roof and walls.

The alternative to discard was re-use. Some artefacts were placed in the matrix of walls, probably not for their basaltic nature, but simply because they were the right size of stone needed to fill a gap. Still others (16E93A049, 16E93A050) were place on edge so that their face with the smooth sheen was exposed and could line the concave interior of an installation. The artefacts were not used to the brink of exhaustion and those that were discarded or re-used may have fractured by accident. Ultimately, this use beyond the primary function represents the recycling nature of the household.

#### *7.2.3.3 Value of basalt artefacts*

It is often cited that there is a direct relationship between the value of a commodity and its distance from the originating source and an inverse relationship between value and volume of artefacts distributed (Earle & Ericson, 1977:6; Renfrew 1977). Low value bulky artefacts have been documented as retaining a high frequency

near the source and a significant decrease in frequency at locations over a day's journey away (Orton 1980). Although basalt artefacts are reported in higher frequencies at settlements most proximate to the sources, such as Bet Yerah (Eisenberg & Greenberg 2006; Paz 2012) or Beth Shean (Mazar & Rotem 2012), in the case of Tell es-Safi/Gath, it would appear that, despite the distance from basalt sources, basalt artefacts still constituted a large percentage (ca. 30%) of the entire ground stone assemblage. This would suggest that Tell es-Safi/Gath was well connected to the north-eastern sub-regions and a significant consumer in the basalt ground stone economic system. The relative excess of these commodities would have decreased their exchange value. In addition, the acquisition of basalt ground stone artefacts does not appear to be entirely out of necessity. As basalt commodities appear available to each commoner household, this would suggest that there were with no social or financial restrictions based on differential access for basalt grinding stones. Because basalt artefacts were common imported commodities within the southern Levant and were widely distributed, it is likely that their exchange value was low.

Basalt artefacts were not the only source of ground stone implements for Tell es-Safi/Gath residents. Among the large assemblage of ground stone artefacts were beads, upper and lower grinding stones, weights, vessels, mortars, pounders, and pestles manufactured from other geological materials. For the most part, the residents obtained ground stone artefacts from locally available limestone sources. However, raw material aspects of basalt likely made them a valuable household commodity. For example, basalt is durable, sheens and smooth's well, and leaves considerably less grit in the processed meal in comparison to other materials (Ebeling & Rowan, 2004:108-111; Schneider &

LaPorta, 2008:20). In addition, they were probably more valued than ground stone artefacts of local materials. The possession an imported commodity, particularly one so efficient for daily activities, was an attractive economic opportunity. While this may have added to the demand to maintain the basalt exchange network, it more importantly increased the use value of the basalt artefacts. It can be surmised that while their cost of acquisition (and exchange value) may have been of little expense, their use value was high.

## 7.3 Significance of research

The intent of this research was to investigate and reconstruct the life-history of the basalt ground stone artefacts from the EB III levels at Tell es-Safi/Gath. This was an attempt to discover the organisation of production, the nature of distribution, and the consumption and discard strategies associated with the artefacts. This inquiry held implications for the increasing our understanding of the socio-economic environment of Tell es-Safi/Gath and the role economic systems play in the sustenance of the early complex societies (EBA) of the southern Levant. The results of this investigation provide significant information on all of the above facets. These are discussed below in turn.

### 7.3.1 Life-history of basalt ground stone artefacts

In this thesis, the life-history of basalt ground stone artefacts was reconstructed in an effort to understand the three components of economic systems in which this industry was rooted. The examination was divided into the stages of economic systems: production, distribution, and consumption. This permitted a *longue durée* perspective of the manufacture, transportation, use, re-use, and value that the artefacts received from the

moment they were conceived in the artisans' minds to the movement they were discovered by archaeologists.

The information provided in this thesis contributed in the following ways to the growing field of ground stone research:

- It demonstrated that the procurement of basalt artefacts predominantly occurred from the basalt sources in the north-eastern sub-regions of the southern Levant that range from the central Galilee in the west to the basalt plateau of the Golan Heights and Mt. Hermon in the east. This was a shift away from the procurement strategies for basalt vessel industries of the EB I and Chalcolithic that exploited many of the basalt sources in western Jordan around the Dead Sea (e.g., Philip & Williams-Thorpe, 1993; Rutter, 2003).
- The production of these commodities does not appear to be performed by specialised artisans, unlike other contemporary commodities (e.g., Canaanean blades, Khirbet Kerak Ware, Northern Canaanite Metallic Ware).
- Basalt was shown to continue to be one of the most, if not the most, valued material from which to produce and consume ground stone artefacts.
- The distribution of ground stone artefacts was accomplished through long-distance exchange networks organised by middlemen and centralised authorities.

- These commodities underwent intentional discard and/or recycling by consumers.
- This research further solidifies the working hypothesis that ground stone artefacts were primarily related to domestic activities.
- As a whole, it was a unique approach that examined the complete life-history of a group of artefacts rather than focusing on a single stage of their life.

### 7.3.2 Socio-economic environment of Tell es-Safi/Gath

As the basalt ground stone assemblage was recovered from the EBA levels of a non-elite domestic neighbourhood at Tell es-Safi/Gath, a considerable amount of information was gained on the occupants of this neighbourhood and their socio-economic state. For example, the participation of Tell es-Safi/Gath in economic systems shows how the settlement was connected to the rest of the southern Levant. This settlement was not socio-economically isolated during the EB IIII.

The discrete nature of architectural units in Area E (4 spatially, but 7 temporally so far) and their associated debris suggest that this was a neighbourhood of non-elite domestic residences. There is no evidence of industrial or other specialised activities (H. Greenfield, pers. comm.). Within this neighbourhood, the primary domestic unit was the household. Each household possessed a small quantity of basalt ground stone artefacts indicating that each household had access to these imported (and probably relatively expensive) artefacts. There is no evidence for any social or economic differentiation between the households in the neighbourhood based on differential access to basalt ground stone artefacts. The relatively even distribution between households is analogous

to modes of ground stone distribution where a centralised authority or elites controls the exchange and redistributes the commodities to the residents (e.g., Hayden, 1987). On the other hand, there are several indications that the occupants of this neighbourhood were not the urban poor. Based on the high amount of imported artefacts, including basalt, it is possible that this neighbourhood housed several key players in the movement of commodities and may be a merchant quarter (Greenfield, Shai & Maeir, 2012:44).

The distribution of basalt artefacts within the houses enables identification of the locus of domestic (including food processing) activities. The courtyard contained the highest concentration of basalt and other ground stone artefacts, implying that the majority of domestic activities may have occurred in this area. The same spatial organisation of domestic activities is found at Bet Yerah. This is significant as it represents a similar domestic practices and cultural continuity with inhabitants in other sub-regions. The value of basalt ground stone artefacts and efficient nature of the domestic residents is further exemplified by the secondary use the artefacts received.

### 7.3.3 Economic systems in an early complex society

The EBA of the southern Levant was a period of societal rise and collapse. It cannot yet be determined if increasing urbanism led to or was a result of the rise of the first complex societies in the region and secondary state formation. The mechanisms that generated these complex societies are not yet fully understood. However, one mechanism in particular, exchange, served to connect producers with consumers over long distances and various areas, facilitating the movement of commodities (Greenberg & Porat, 1996; Milevski, 2008; Milevski, 2011; Savage, 2011).

The relationship between exchange and elites groups is considered to be a causal factor in the emergence of complex societies (Wright & Johnson, 1975; Brumfiel & Earle, 1987). In such complex societies, the movement of commodities involved not only the elites, but many other participants, including artisans, middlemen, and non-elites (Milevski, 2011:232). The control of these economic systems was an opportunity in which both middlemen and elite took advantage in an attempt to raise their social and economic standing (D'Altroy & Earle, 1985: 187-206:197-202; Kafafi, 2011:139; Savage, 2011:120). Economic systems, represented in this case by the movement of basalt ground stone artefacts, facilitated interaction among the various sub-regions of the southern Levant (Brumfiel & Earle, 1987:3; de Miroschedji, 2006:74-75; Rutter & Philip, 2008). This permitted greater economic prosperity, the formation of alliances, and the development of a ruling elite class that controlled the movement of commodities (Rathje, 1972:386; Gottwald, 1976; Runnels, 1988; Wattenmaker, 1994:197). In order to receive these imported commodities, it is likely that Tell es-Safi/Gath households had to forfeit some autonomy (Sahlins, 1963:300; Rathje, 1972:371). As basalt artefacts were not the only material of imported commodities (e.g., beachrock, ivory, faience) (Maeir, Shai & Horwitz, 2011; Shai *et al.*, 2014), the households of Tell es-Safi/Gath were subject to a degree to their settlement elite and sub-regional elite. By extension, Tell es-Safi/Gath was moderately dependent on external producers and middlemen for certain commodities, and possibly even on Tel Yarmuth. As a result, a co-dependent relationship may have been sustained in tandem as the elite class organised exchange, while the non-elite residents created the demand for commodities and reinforced a reliance on the elite class (Trigger, 1993:163; Wattenmaker, 1994:197; McGuire, 2008:74-76). The presence of an elite class

is taken as an indication of complex societies in the southern Levant (Wright, 1977:381; Trigger, 1996:533-534; Earle, 2002:43; de Miroschedji, 2009:119). The scenario described above is one that has been applied to the EB II-III of the southern Levant (Milevski, 2011) and is most supported by this thesis. However, this continuation of centralised exchange lies in contrast to the hypothesised "return to decentralisation" that Milevski (2011:226) proposes economic systems experienced during the EB III.

The scale of the basalt ground stone exchange was large, given the amount of material found across the region and reaching from sources in the north into the Shephelah and Coastal Plain. It should be pointed out that while the quantity of basalt artefacts increased from the EB I, the distance decreased between intra-regional settlements with the rise of more settlements and urban centres. While intra-regional exchange increased, inter-regional exchange appears to have undergone a significant decline after the EB I (Mazar, 1990:136; Shai & Uziel, 2010:68-69). The exchange of basalt vessels and spindle whorls to Egypt appeared to have ceased, for example.

Intra-regional economic systems were well developed and in operation by the EB II and continued to develop during the EB III. They continued to supply commodities to elite and non-elite as well. The intensification of intra-regional exchange is significant as it represents the pinnacle of social complexity during the EBA.

## 7.4 Analytical considerations

When conducting research and analysing data, it is likely that one will encounter analytical problems. This thesis is no exception. Several analytical issues must be acknowledged when considering the results of this thesis. Four notable issues are listed below.

### 7.4.1 On-going excavations

The most apparent may be that excavations at Tell es-Safi/Gath are on-going and new information is obtained each season. Not only does this add to the growing basalt ground stone assemblage, but it adjusts as loci are lump/split with various architectural phases. This is why it is important to also consider the basalt ground stone assemblage by occupational stratum. The presented information is subject to change given all of the above.

### 7.4.2 Site-wide generalisations

Generalisations regarding the entire tell from the remains in Area E must be made with a great deal of caution. Only a small fraction of the entire EB III occupation at the site has been excavated. It is doubtful whether such a small proportion will be representative of the whole site. Area E contains a residential neighbourhood from which little can be extrapolated regarding much more than the lives of non-elite residents. Elite residences are likely to be at the peak of the tell on the western edge and buried under metres of later occupation. For all we know, it may be that only non-elite residents utilised basalt artefacts. This is unlikely given the presence of basalt artefacts in the repertoire of elite structures at other sites in the region (de Miroschedji, 2003; Greenberg, 2003; Greenberg *et al.*, 2012). As a result, it may be some time before a full understanding of the EBA at Tell es-Safi/Gath is obtained. However, it should be noted that all the basalt artefacts available (those that were discovered in the neighbourhood) were included in this thesis. Consequently, this sample, despite being low in number overall, can be considered representative of the EB III domestic neighbourhood at Tell es-Safi/Gath.

### 7.4.3 Condition of the assemblage

The basalt ground stone assemblage from Tell es-Safi/Gath is highly fractured. Although most fractures are ancient, it was difficult to determine whether they occurred prior to or post-deposition. Fracturing prior to deposition has been identified in several artefacts as they are found in secondary use-life stages.

It should be pointed out that each fractured basalt artefact was counted as representing a whole (e.g., 7 upper ground stone fragments = 7 upper grinding stones). This was due in part to the fact that, with the exception of artefact 1141073, no ground stones could be made to match. Although it is possible that some artefacts may have been fragments of the same original ground stone artefact, those that were included in the provenance analysis originated from separate locations. This suggests that each ground stone artefact may represent one original basalt commodity. As a result, they are treated as separated objects.

The fractured nature of the assemblage hindered the classification of artefacts by morphological type. As a result, several artefacts were simply classified as fragments.

### 7.4.4 Basalt provenance

Another relevant consideration is the level of confidence associated with the basalt provenance, particularly the reliance on a meta-analysis. The geochemical fingerprints of basalt sources were obtained from previously published literature. While this does not imply they are useless, it does mean that basalt outcrops were not accessed by the same analyst studying the basalt ground stone artefacts, nor were the outcrop samples run with the same instrument. Unfortunately, this could not be accomplished due to several constraints. A more efficient provenance analysis would be to obtain a range of

samples from basalt outcrops across the Near East and run them under the same conditions with the same instrument. This would include those sources located around the Dead Sea and along the Jordan Valley.

## 7.5 Directions for future research

This thesis opens several avenues for further research. Many of which will improve upon the accuracy and scale of the results. Four avenues that stand out are outlined below.

### 7.5.1 Regional comparison of ground stone artefacts life-histories

The life-history model from this thesis can be used in comparative studies of other basalt ground stone assemblages. These could include intra-site comparisons (between elite and non-elite houses) and inter-sites comparisons (between Tell es-Safi/Gath and other settlements). These studies can investigate the nature of the industry and how consistent typologies are across sites and sub-regions. Any discrepancies between two locations will require an explanation, one that may be rooted in socio-political factors, differential access to commodities, or tool function.

### 7.5.2 Basalt geochemistry

The raw geochemical data of the basalt ground stone artefacts adds to the small collection of basalt geochemistry conducted on artefacts in the southern Levant. Consequently, it may be utilised to inquire whether additional settlements were obtaining their basalt artefacts from similar sources. This will solidify or usurp further hypotheses regarding the basalt exchange within the southern Levant. Additional methodological studies might include testing the geochemical fingerprints of the basalt ground stone samples using an alternative technique (e.g., ICP-MS, thin-section petrography). As

previously mentioned, obtaining samples from geological outcrops around the southern Levant will expand the comparative basalt geochemistry library.

### 7.5.3 Large scale studies of economic systems

Further research needs to be undertaken on the scale of economic systems during the EB II-III southern Levant. This includes studies on energy expenditure, access to particular resources, and the quality and quantity of commodities exchanged. Most literature that addresses economic systems of this region and period simply provides the location of a resource and a list of settlements that contain commodities from this resource. This says little of whether exchange of the commodity increased or decreased over time, who were the main consumers, or the nature of disposal. Exchange is rarely unidirectional and it is important to understand what commodities were being exchanged. Understanding the life-history of artefacts enables a greater understanding of economic systems involved in their industry.

### 7.5.4 Tell es-Safi/Gath in the Shephelah and southern Levant

The political role of Tell es-Safi/Gath during EB II-III in the Shephelah and southern Levant remains elusive. This problem is predicated on its proximity to the close neighbour and slightly larger settlement to the east: Tel Yarmuth, with its large palace complex (de Miroschedji, 1999; de Miroschedji, 2003). The relationship between these two urban settlements is speculative at best (Shai *et al.*, 2014:44). The presence of large-scale fortifications, the size of the settlements, and the volume of finds suggest that Tell es-Safi/Gath may have been a central hub in the Shephelah. Whether it was competing with Tel Yarmuth or secondary to it is unclear. In any case, it is clear that the non-elite residents of Tell es-Safi/Gath were the recipients of a range of imported commodities

indicating that this settlement was not isolated and was included in the exchange of multiple industries. These may have been funnelled through Tel Yarmuth or came directly to Tell es-Safi/Gath from competing polities. What Tell es-Safi/Gath provided in exchange is currently unknown. Additional research is required to illuminate the socio-political nature of the Shephelah sub-region and southern Levant.

## 7.6 Conclusion

This thesis adopted a unique approach in that it reconstructed the life-history of basalt artefacts rather than focusing on a lone aspect of their life. The implications of this study include a more accurate understanding of domestic activities, economic systems, and early complex societies of the EB II-III southern Levant. Knowledge of these facets is paramount to establishing the nature of the societal rise and collapse that characterises this period. In addition, this thesis was an effort to further develop archaeological inquiry into areas of research that have not received significant attention. As a result, the conclusions presented above, however tentative, ultimately contribute to the general disciplines of Anthropology, Archaeology, and Near Eastern Archaeology.

## Figures

**Figure 1.1 The Near East (images from Google Maps)**





**Figure 1.2 The Fertile Crescent (image from Google Maps)**

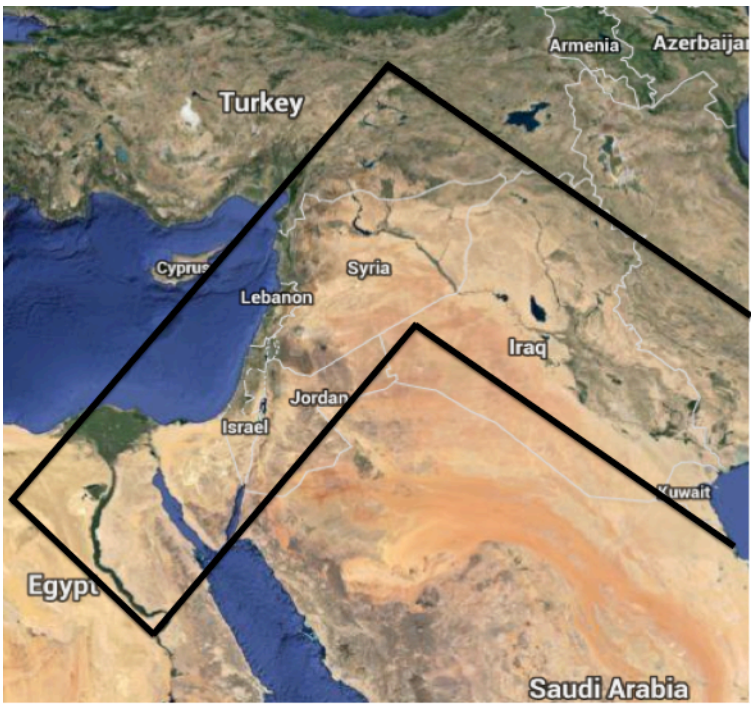



**Figure 1.3 The southern Levant (image from Google Maps)**



**Figure 2.1 Sub-regions of the southern Levant**

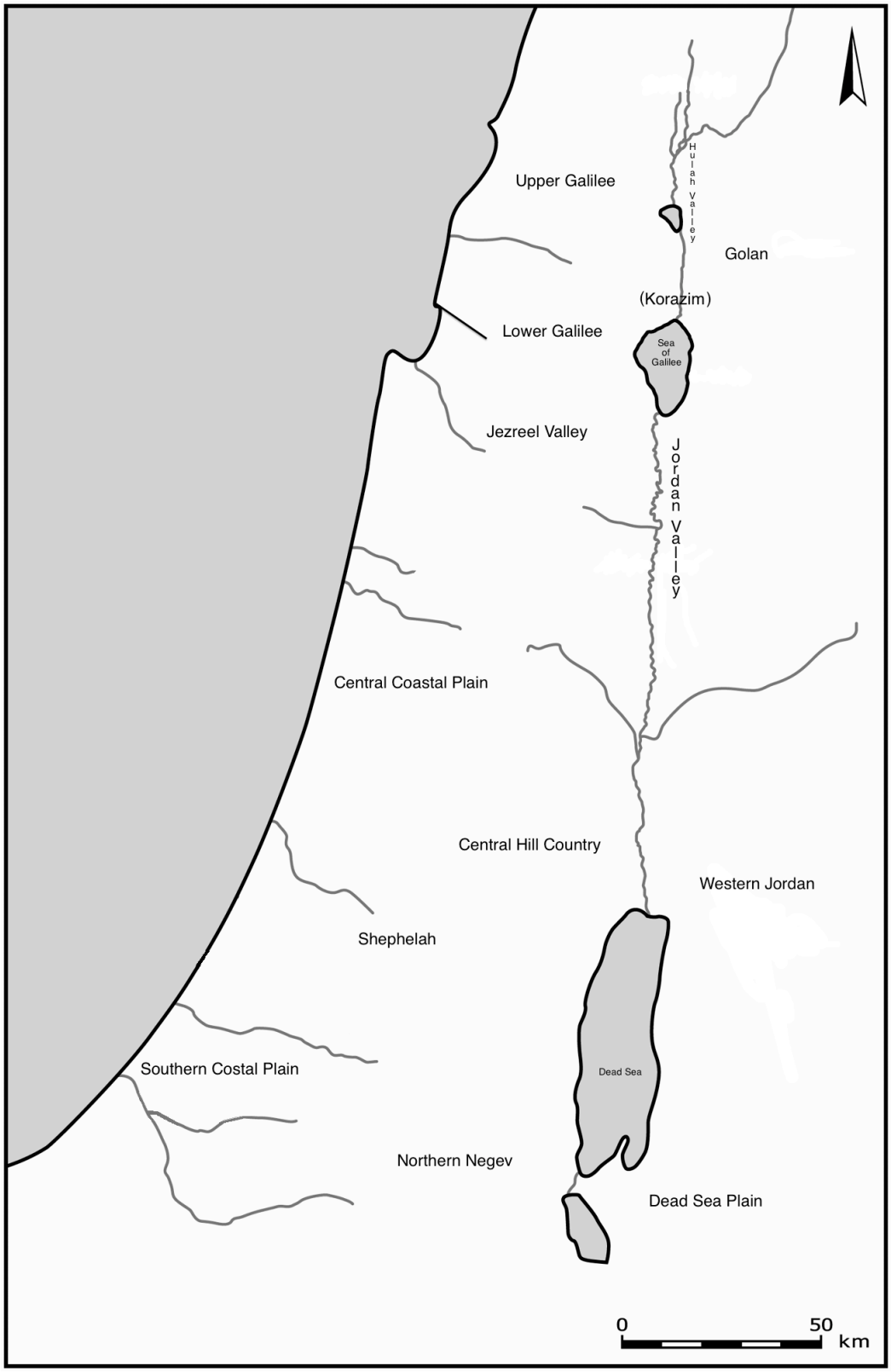


**Figure 2.2 Stratum E5 of Tell es-Safi/Gath**

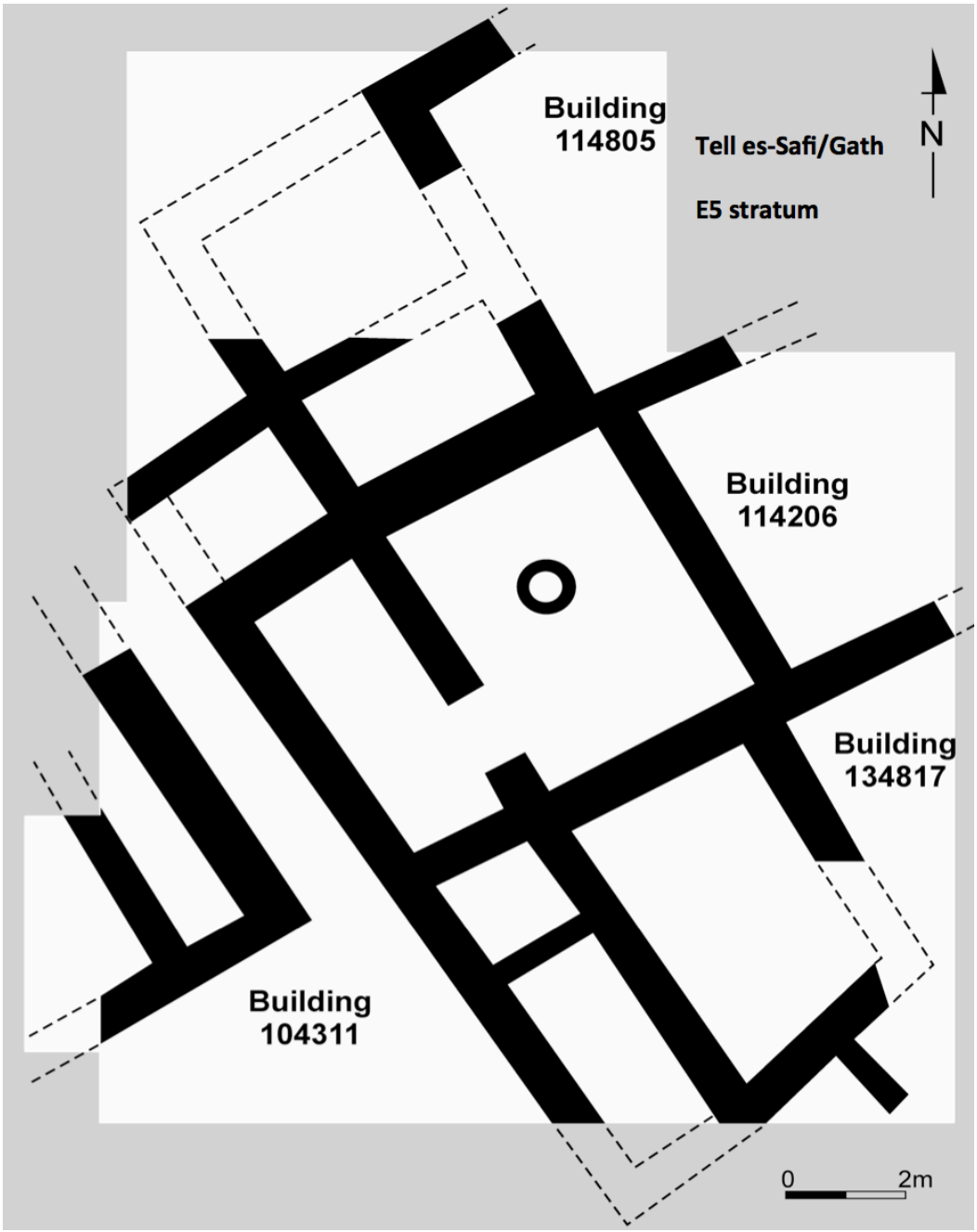


**Figure 2.3 Phase E5c of Tell es-Safi/Gath**

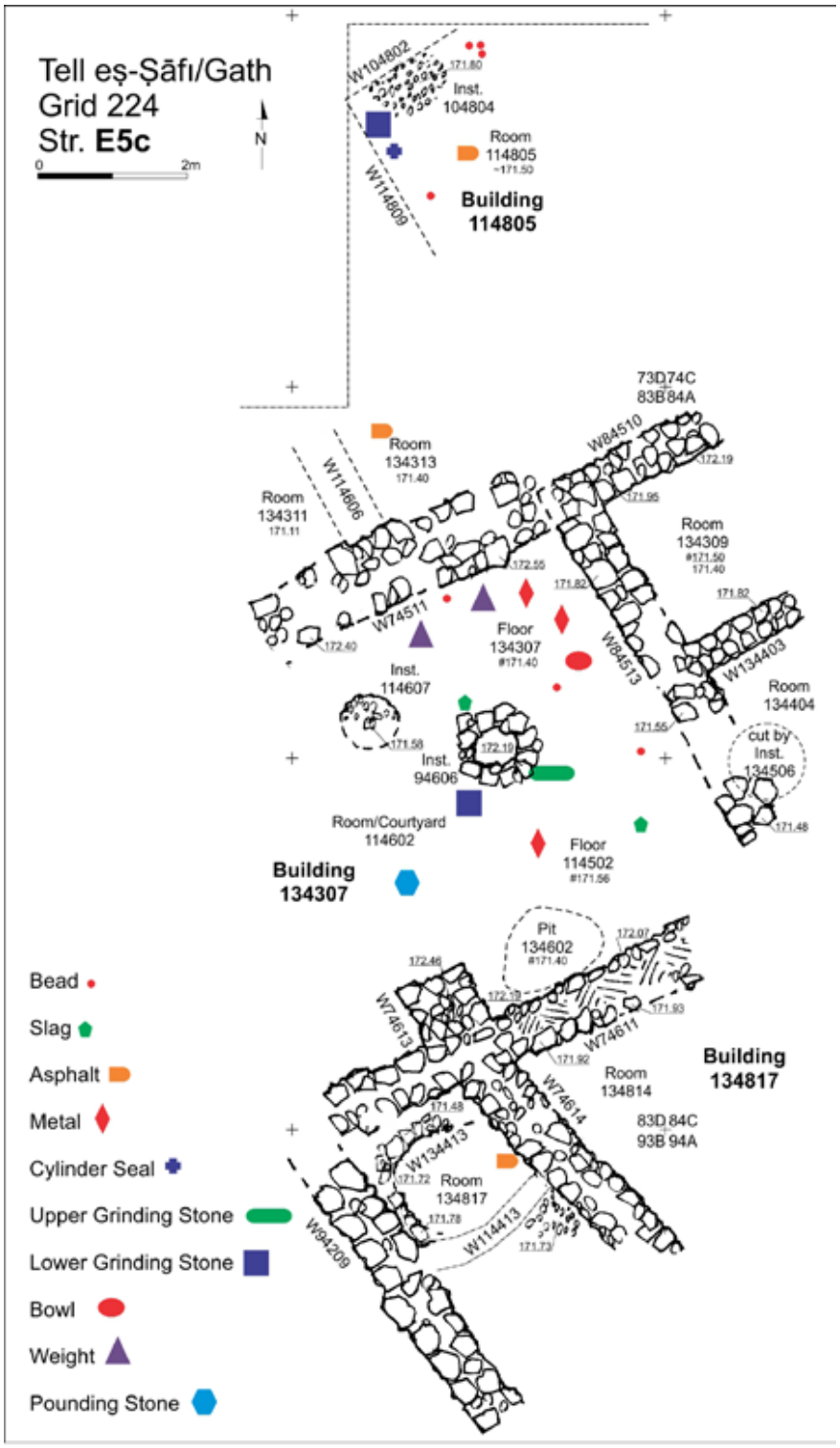


**Figure 2.4 Phase E5b of Tell es-Safi/Gath**

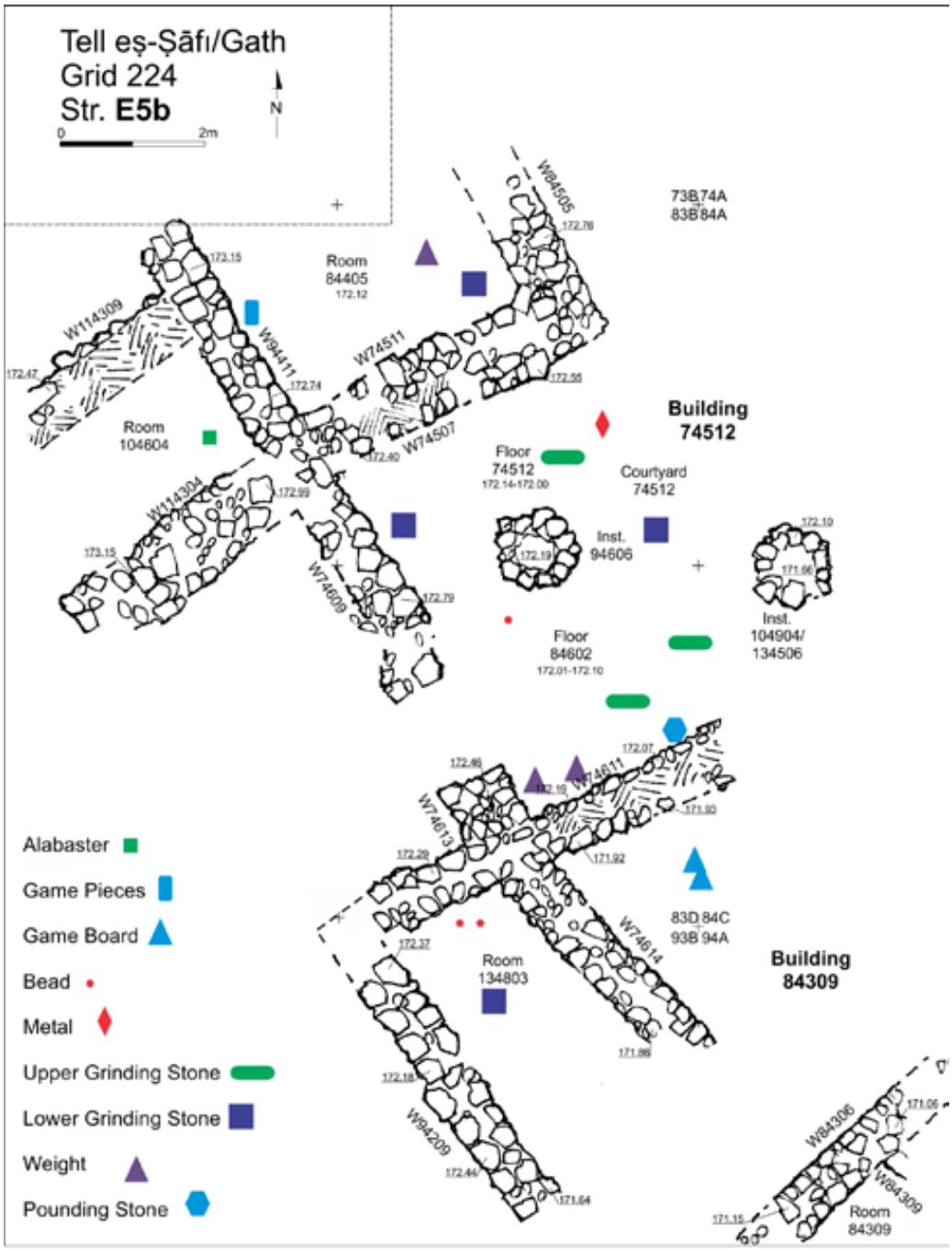


**Figure 2.5 Phase E5a of Tell es-Safi/Gath**

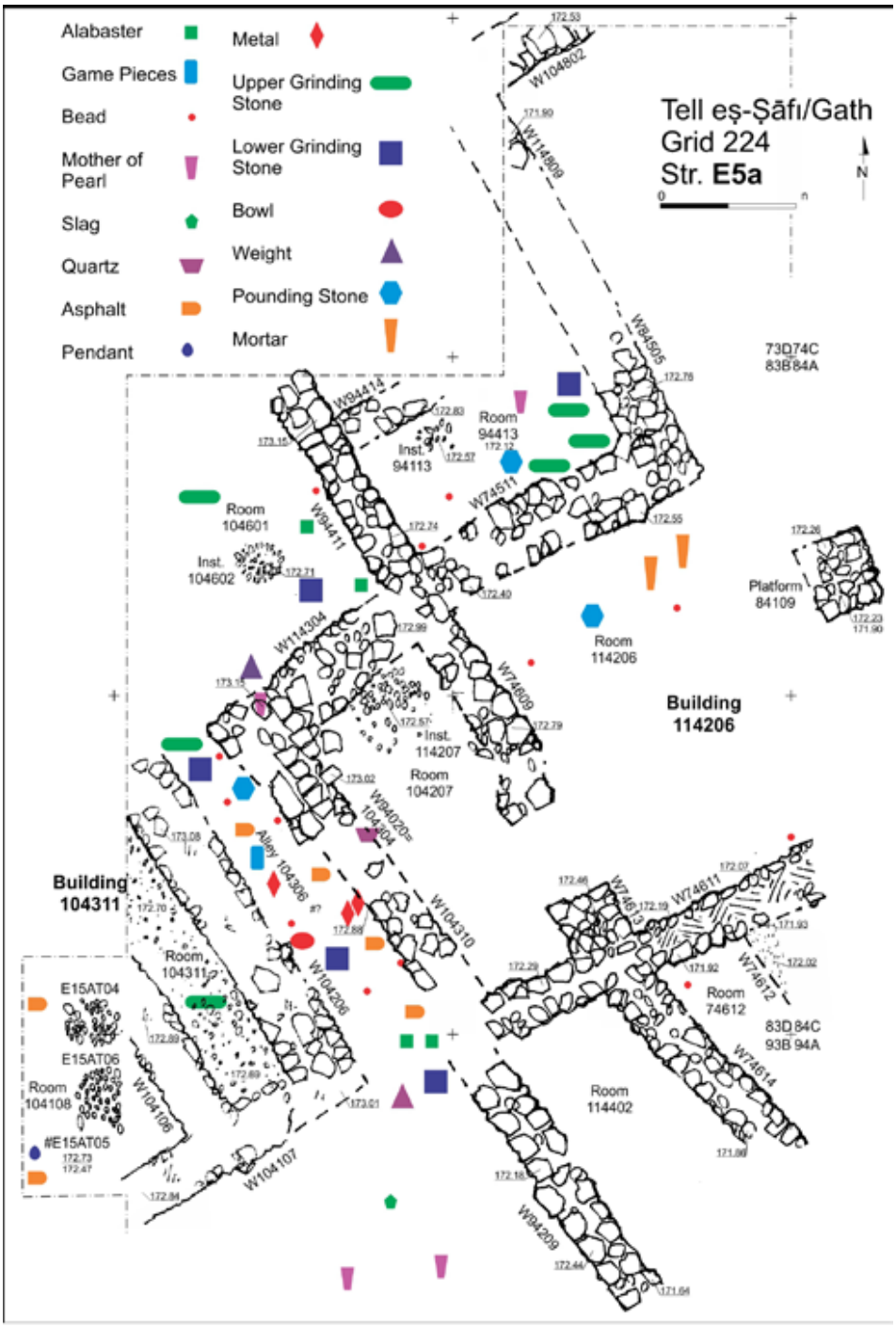


**Figure 3.1 Ten modes of distribution (Renfrew, 1975:42; Harrison, 1993:89)**

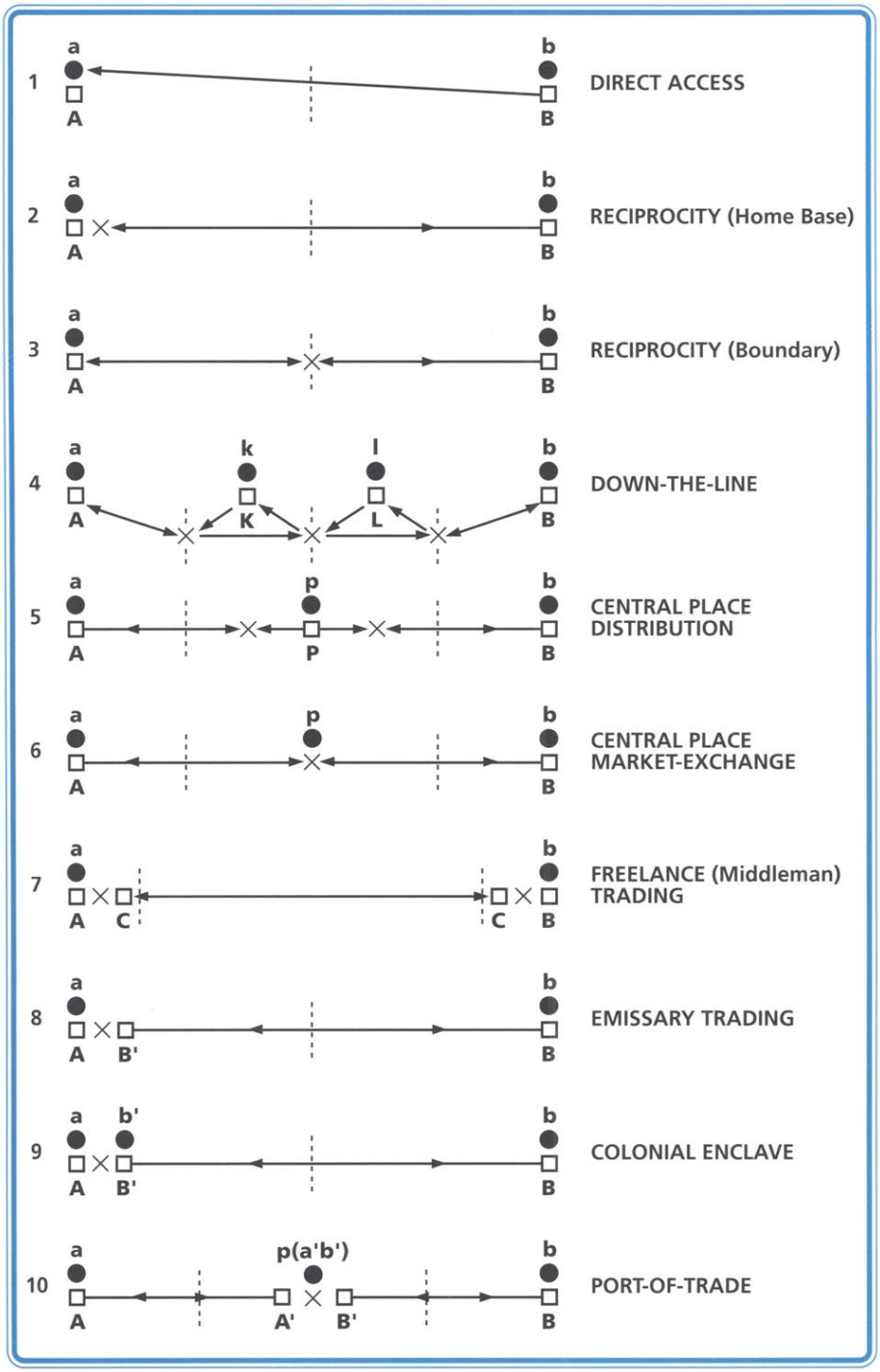


**Figure 6.1 TAS diagram of averaged data of Near East sources**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | × |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

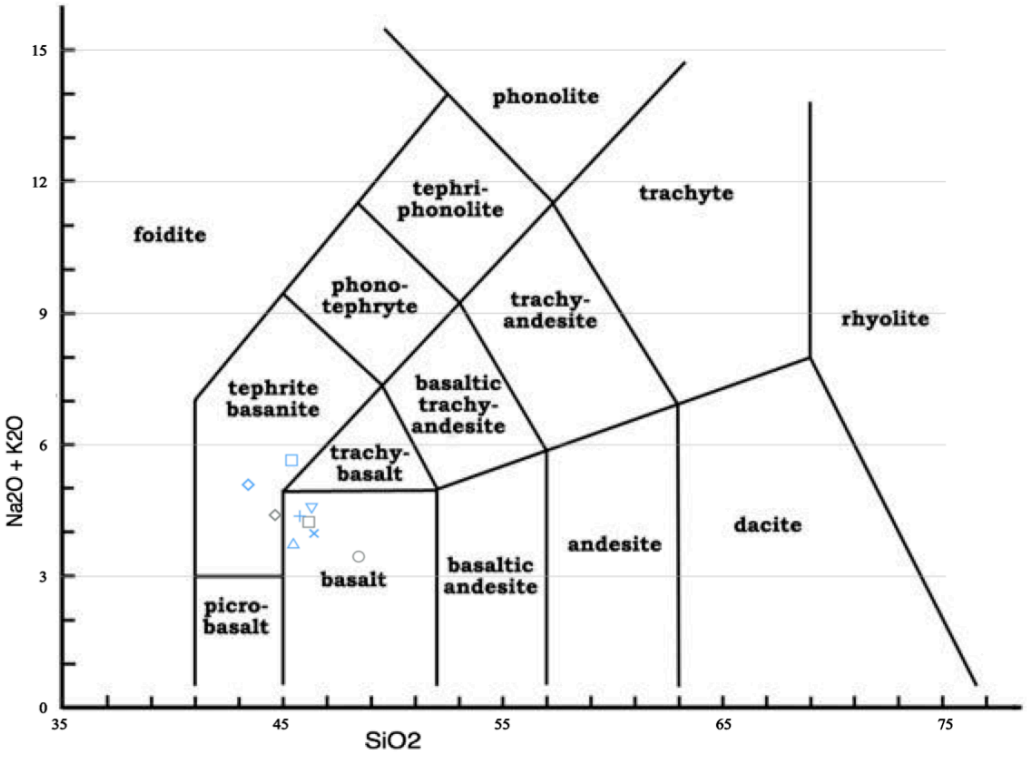


**Figure 6.2 $SiO_2$ vs. $Na_2O + K_2O$ plot of averaged data of Near East sources**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | ✕ |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

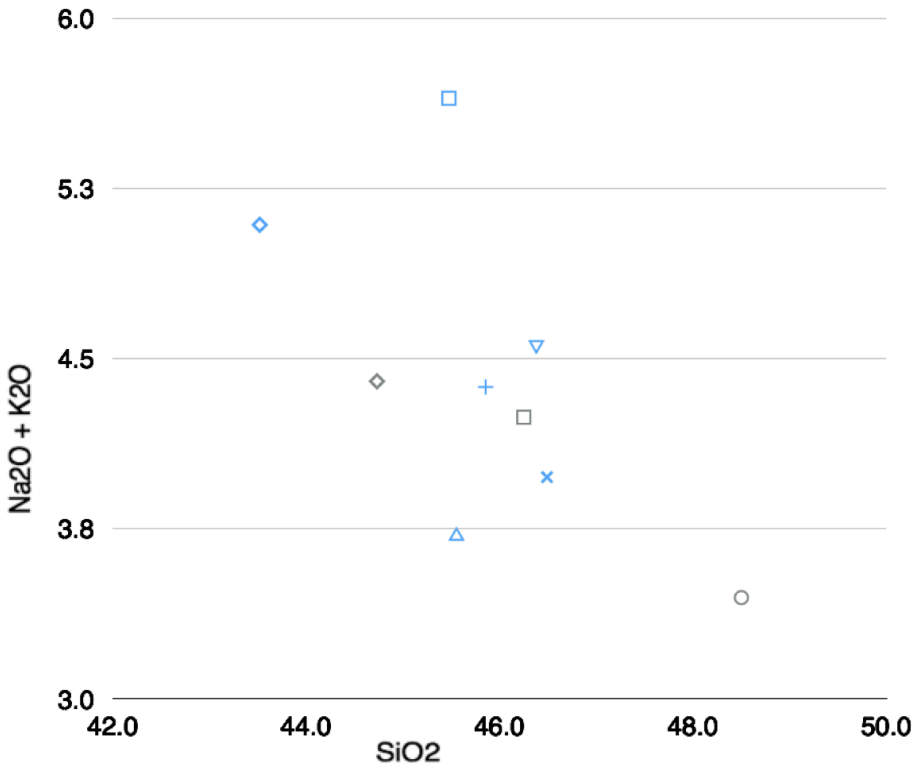


**Figure 6.3 TAS diagram of averaged data of sites within Near East sources**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | ✕ |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

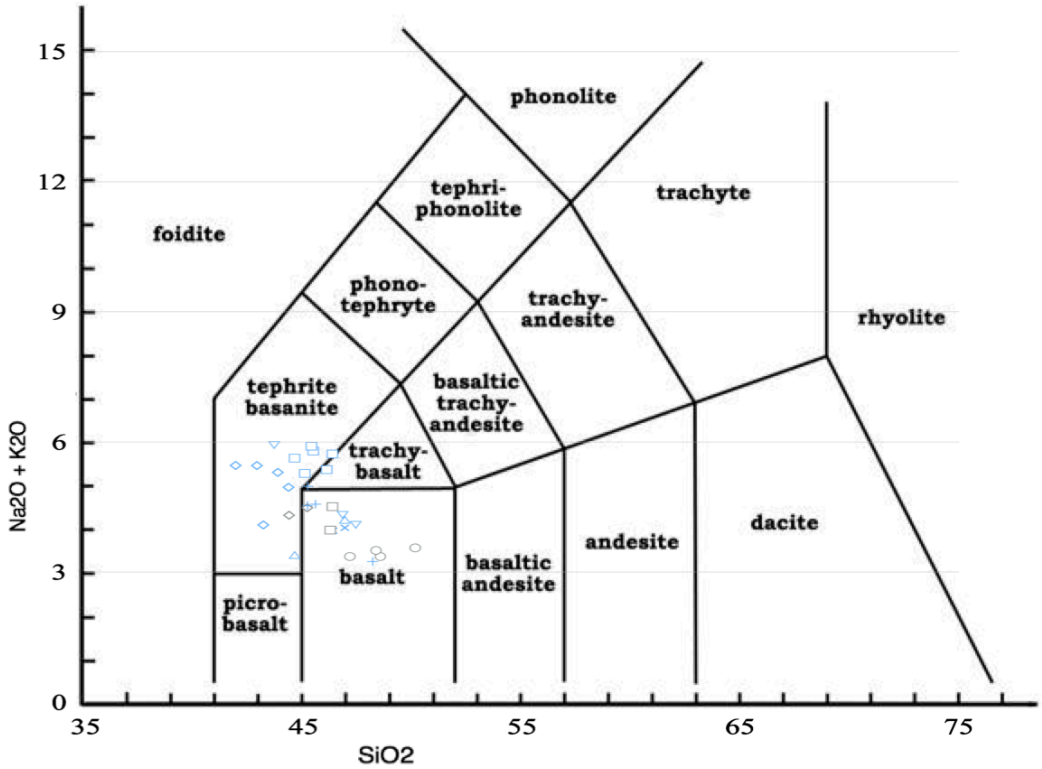


**Figure 6.4 $SiO_2$ vs. $Na_2O + K_2O$ plot of averaged data of sites within Near East**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | × |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

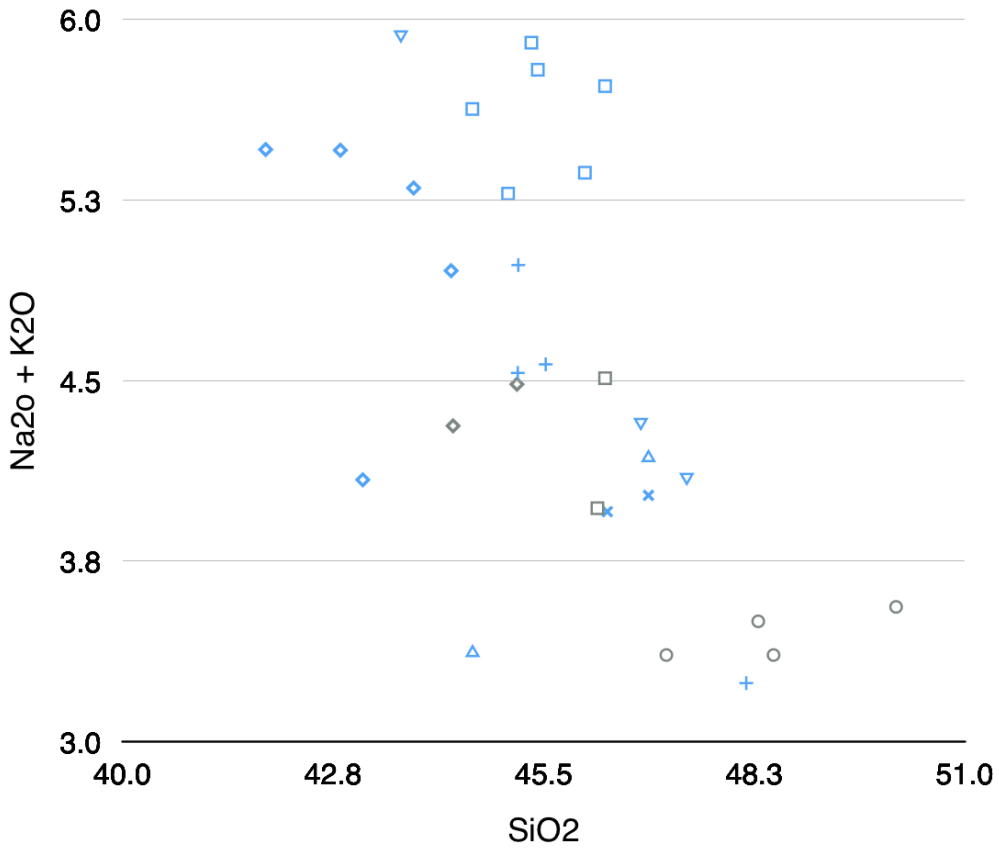


**Figure 6.5 TiO2 vs. Y/Rb plot of averaged data of selected sites**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | × |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

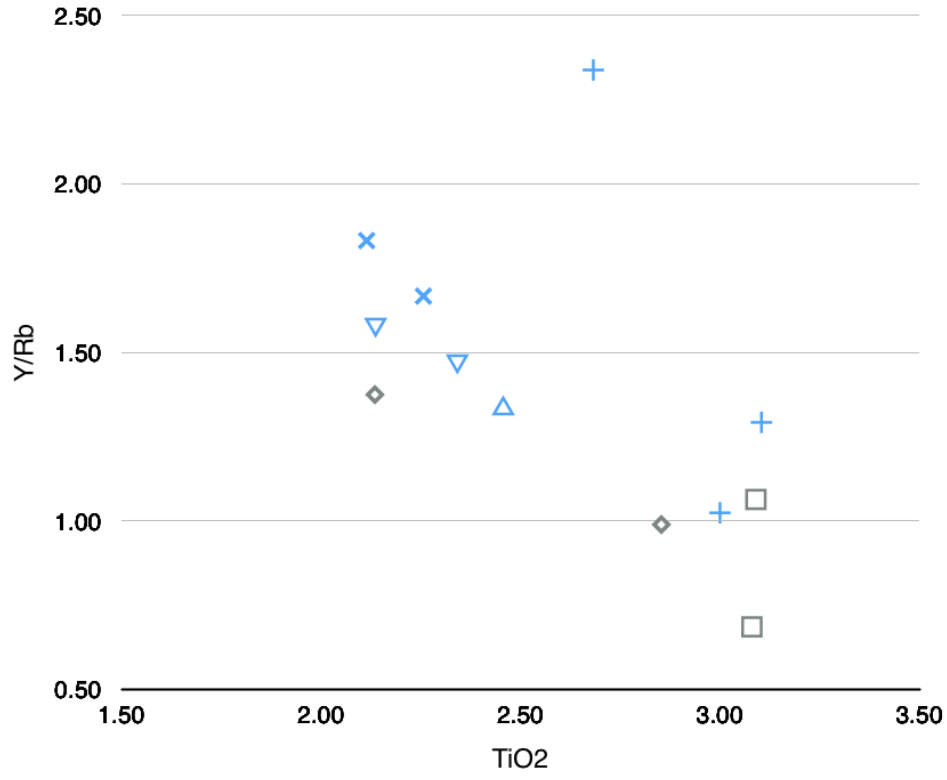


**Figure 6.6 TiO2 vs. Rb plot of averaged data of selected sites**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | × |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

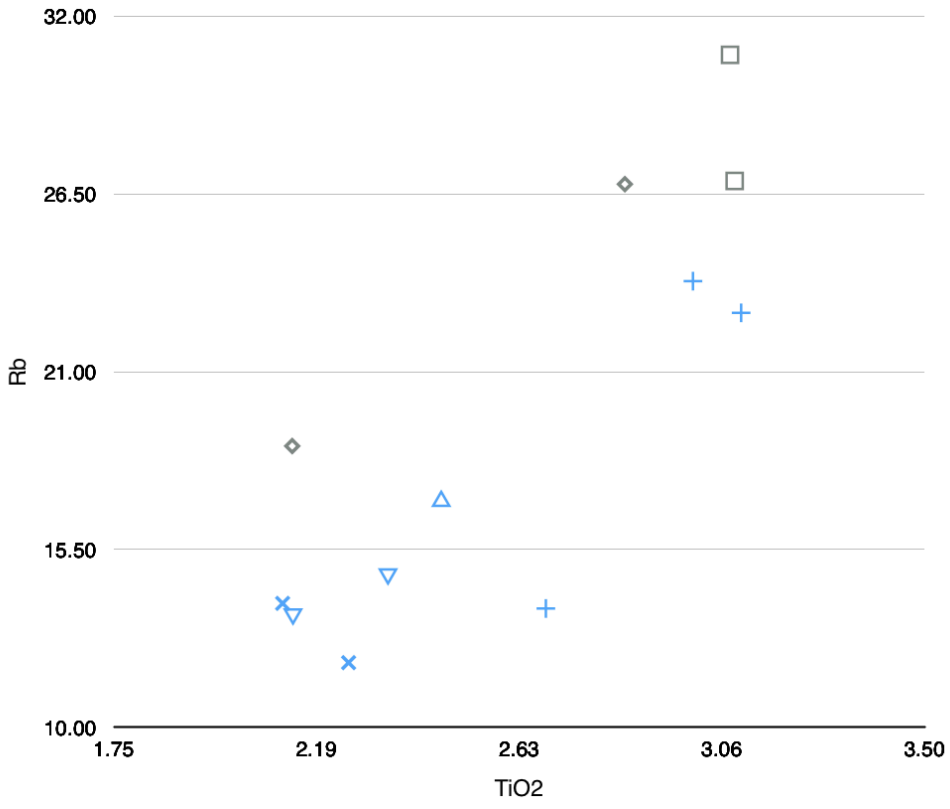


**Figure 6.7 Rb vs. Pb plot of averaged data of selected sites**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | × |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

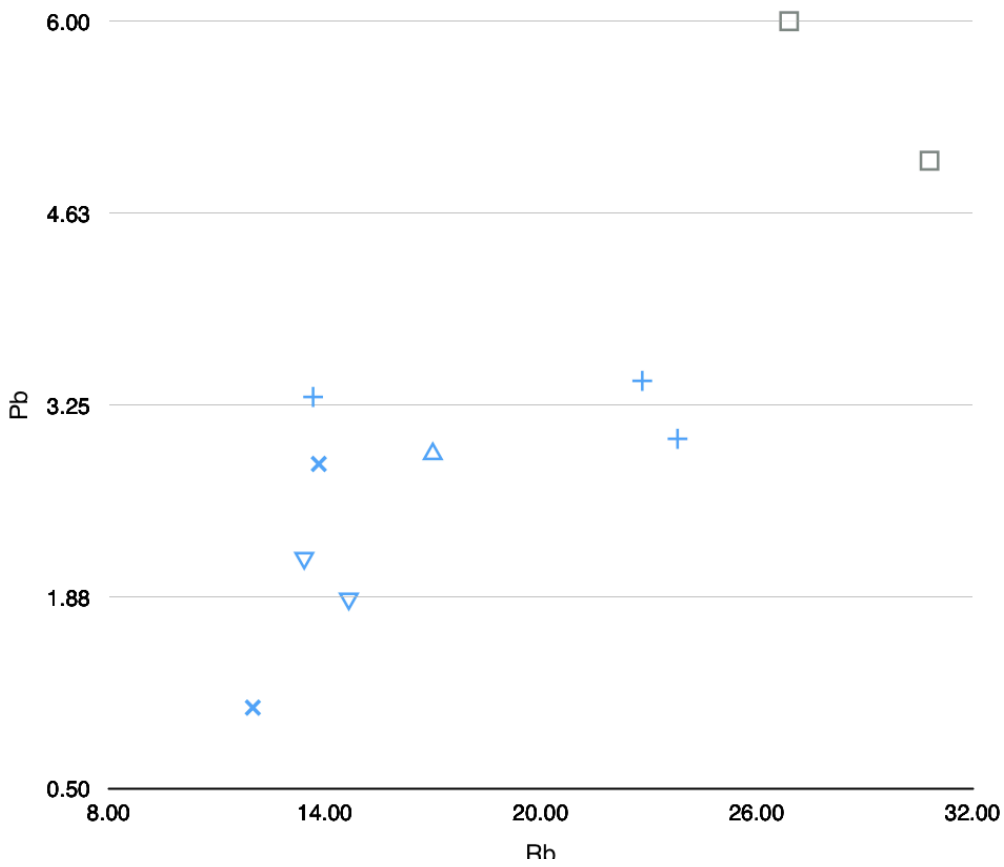


**Figure 6.8 Rb vs. Sr/Ni plot of averaged data of selected sites**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | × |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

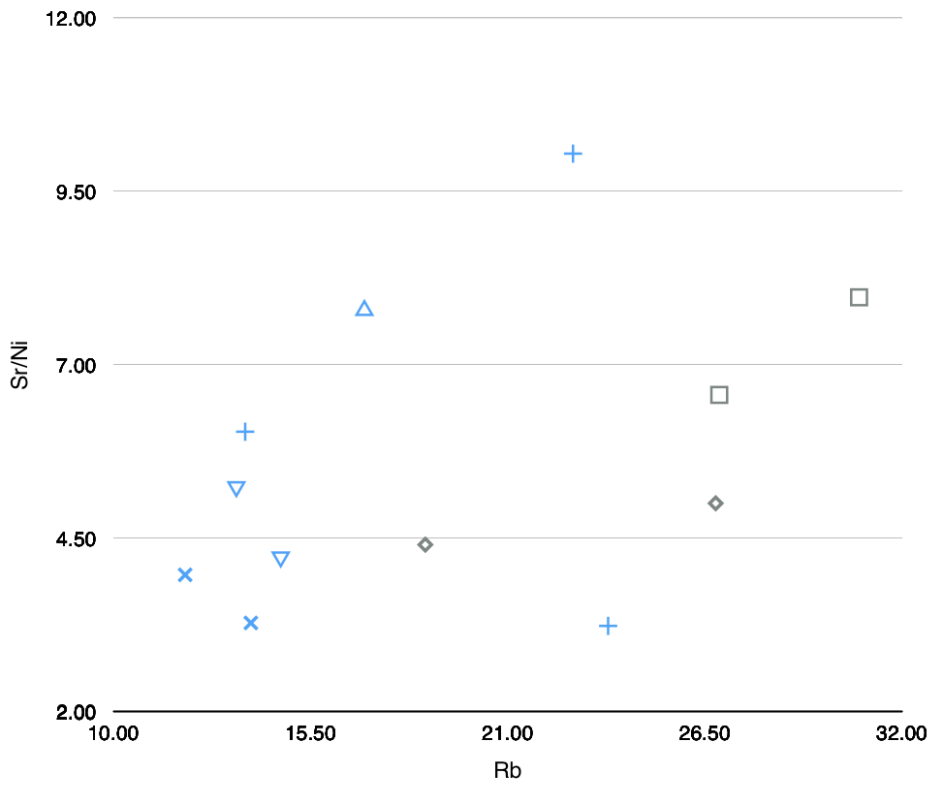


**Figure 6.9 TAS diagram of basalt artefact data**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | ✕ |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

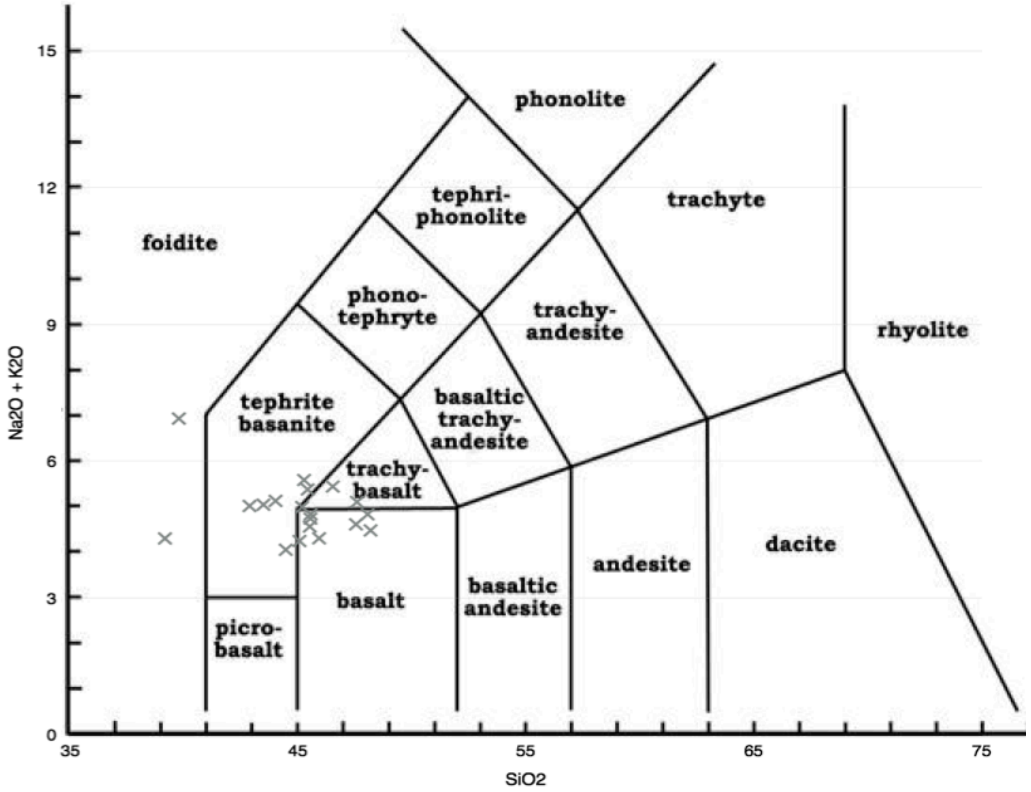
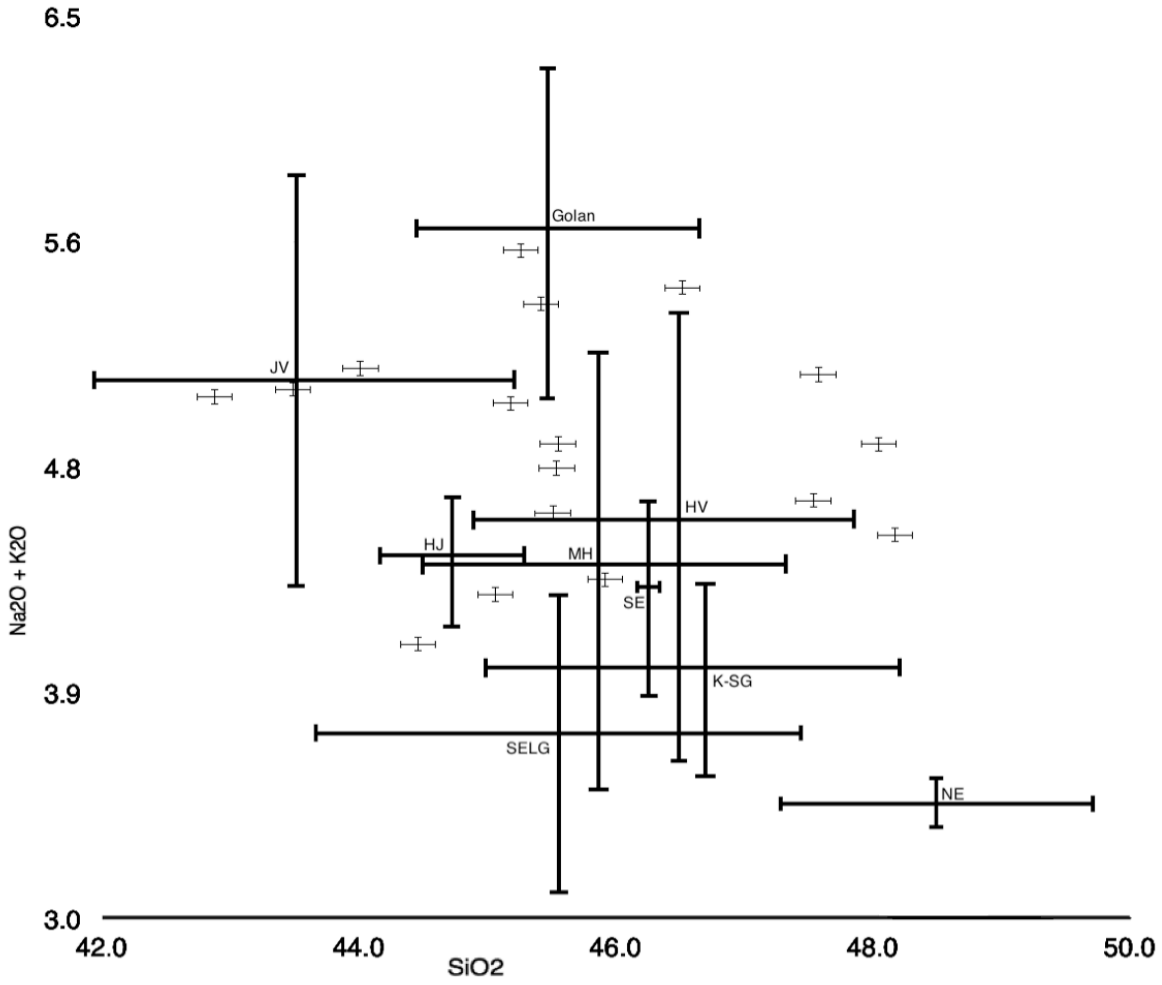


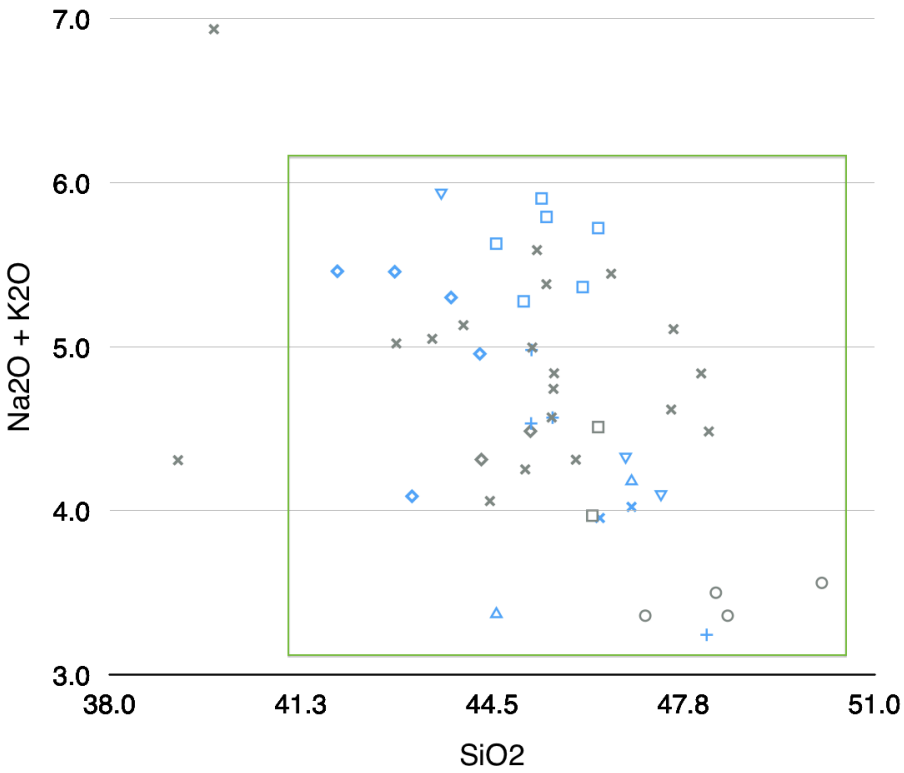
**Figure 6.10 $SiO_2$ vs. $Na_2O + K_2O$ plot of averaged sources and basalt artefacts**

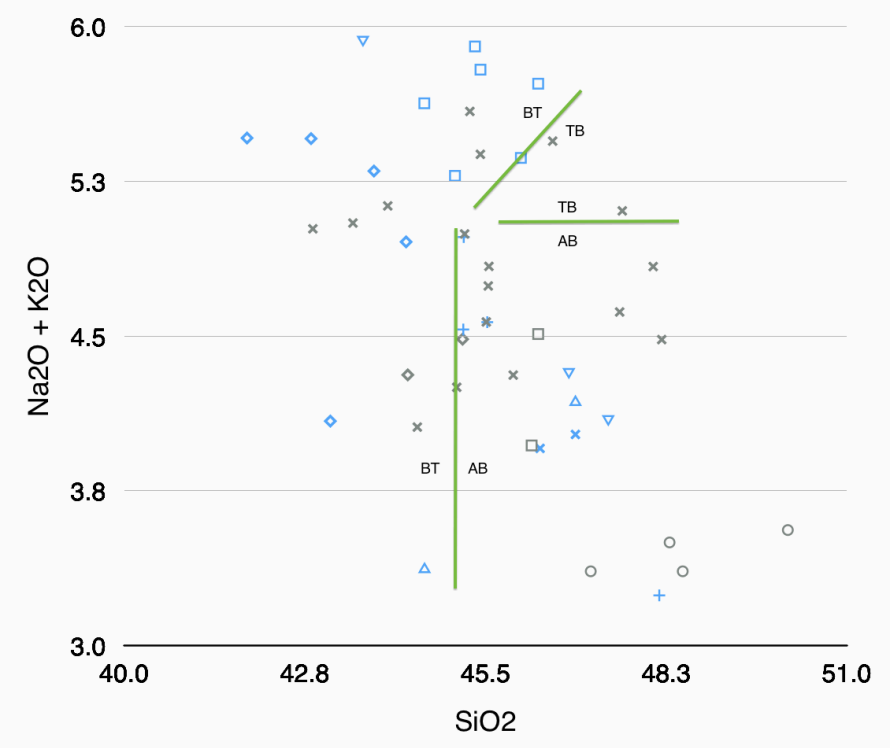



* The error values for each artefact are presented in Table 6.7 and are indicated by the error bars.

**Figure 6.11 $SiO_2$ vs. $Na_2O + K_2O$ plots of averaged sites and basalt artefacts**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | × |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |




6.0
5.3
4.5
3.8
3.0
Na2O + K2O
40.0
42.8
45.5
48.3
51.0
SiO2
BT
TB
TB
AB
BT
AB

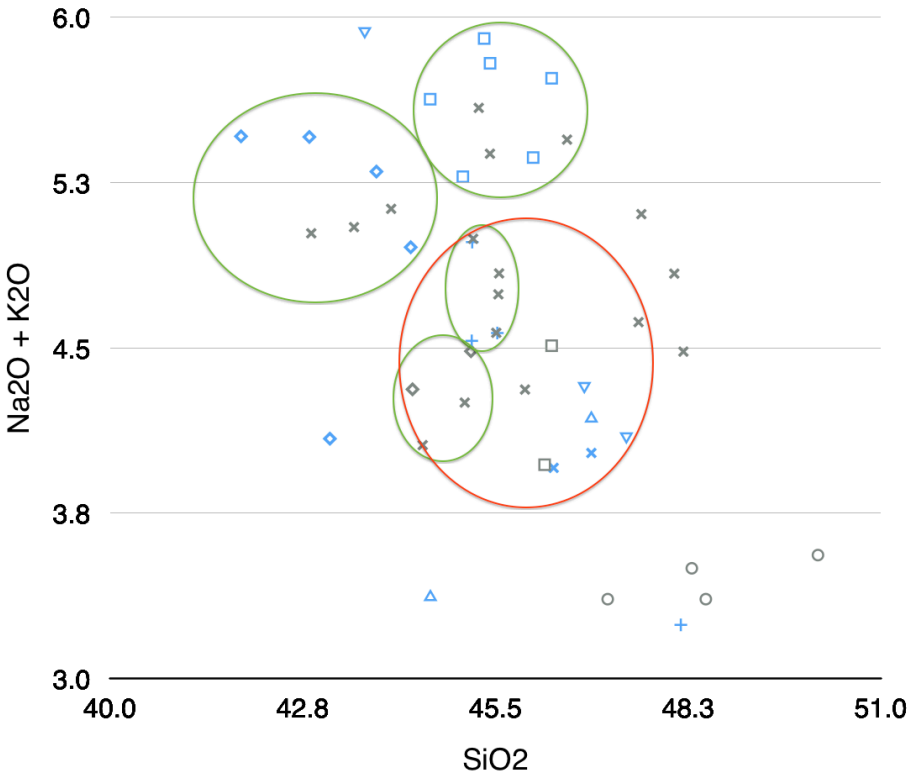

6.0
5.3
4.5
3.8
3.0
Na2O + K2O
40.0
42.8
45.5
48.3
51.0
SiO2

**Figure 6.12 TiO2 vs. Y/Rb plot of selected averaged sites and basalt artefacts**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | × |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

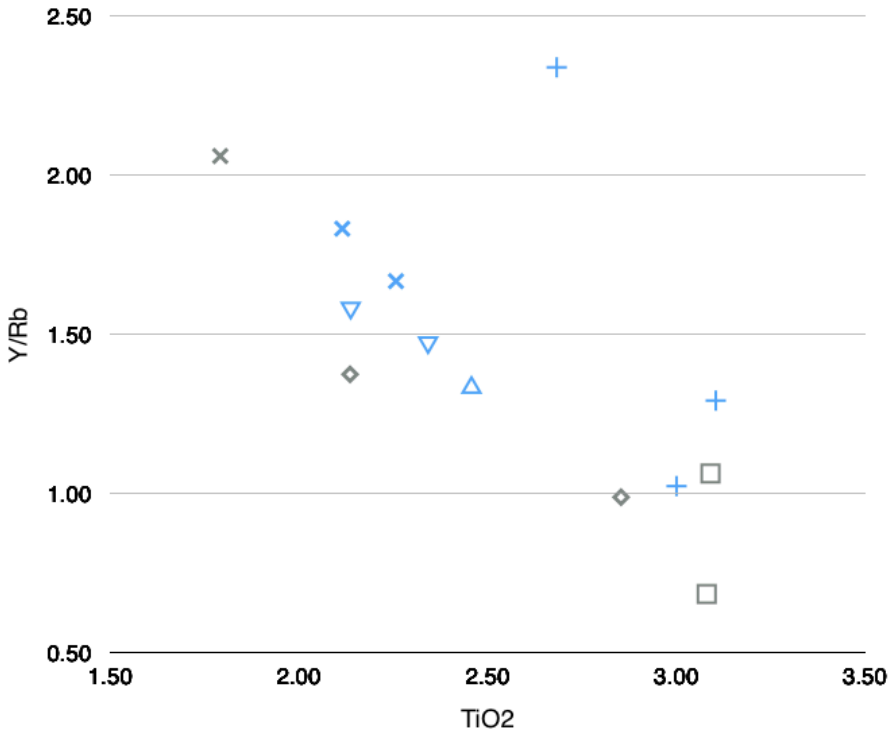


**Figure 6.13 TiO2 vs. Rb plot of selected averaged sites and basalt artefacts**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | ✕ |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

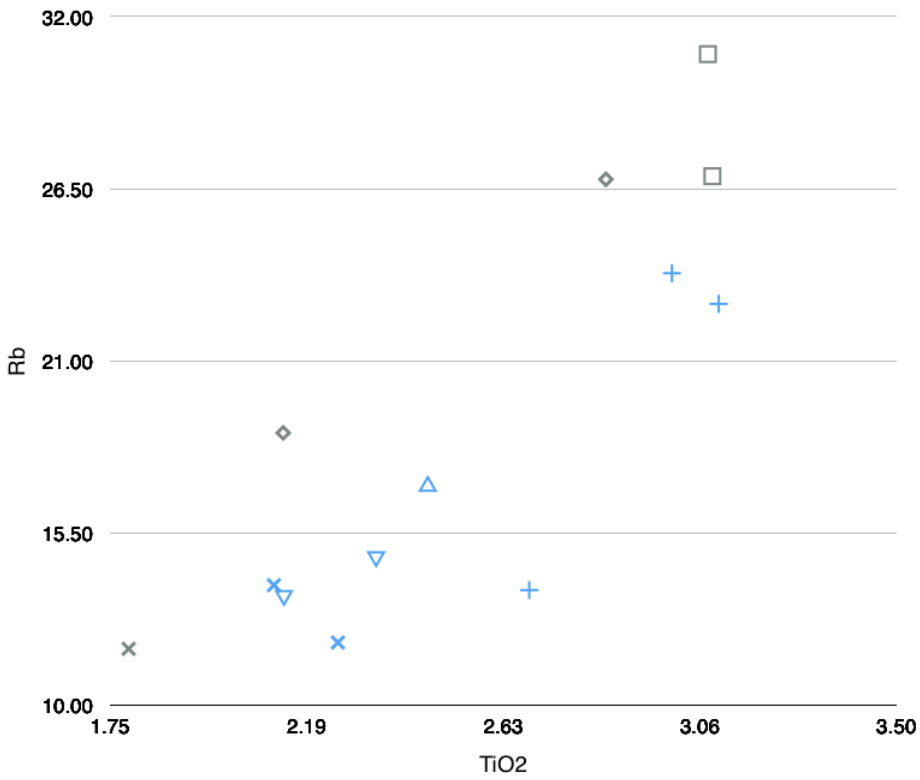


**Figure 6.14 Rb vs. Pb plot of selected averaged sites and basalt artefacts**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | ✕ |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

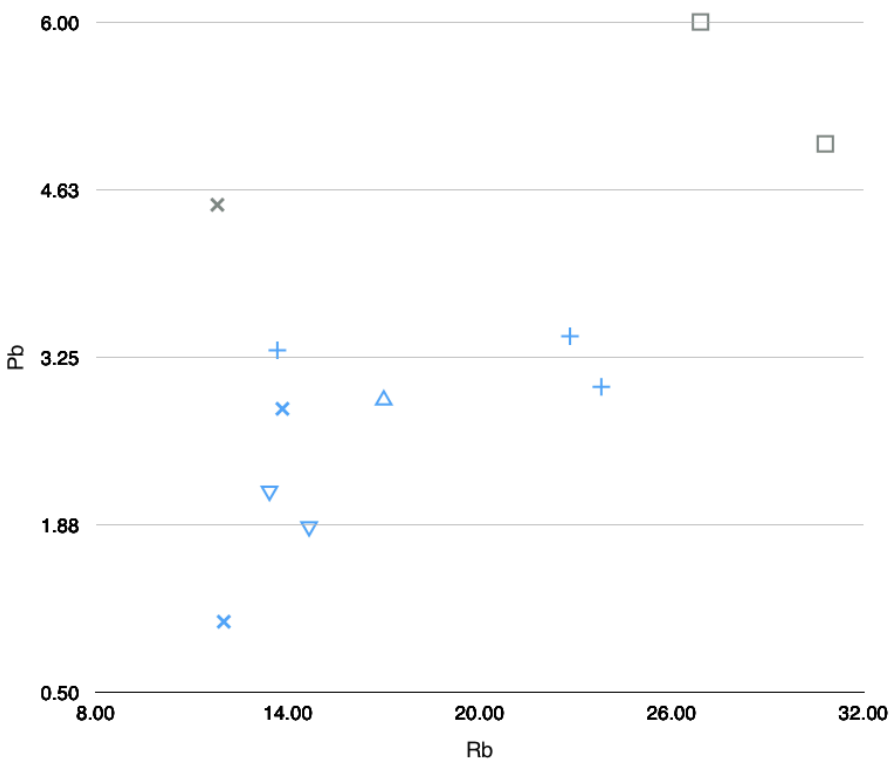


**Figure 6.15 Rb vs. Sr/Ni plot of selected averaged sites and basalt artefacts**

| Legend | | |
|---|---|---|
| **Sub-region/Source** | **Abbreviation** | **Symbol** |
| Jezreel Valley | JV | ◇ |
| Golan | - | □ |
| Korazim-Sea of Galilee | K-SG | × |
| Hulah Valley | HV | ▽ |
| Southeastern Lower Galilee | SELG | △ |
| Mount Hermon | MH | + |
| Harra el-Jabbar | HJ | ◇ |
| Northern Egypt | NE | ○ |
| Southern Egypt | SE | □ |
| | | |
| Tell es-Safi/Gath | - | ✖ |

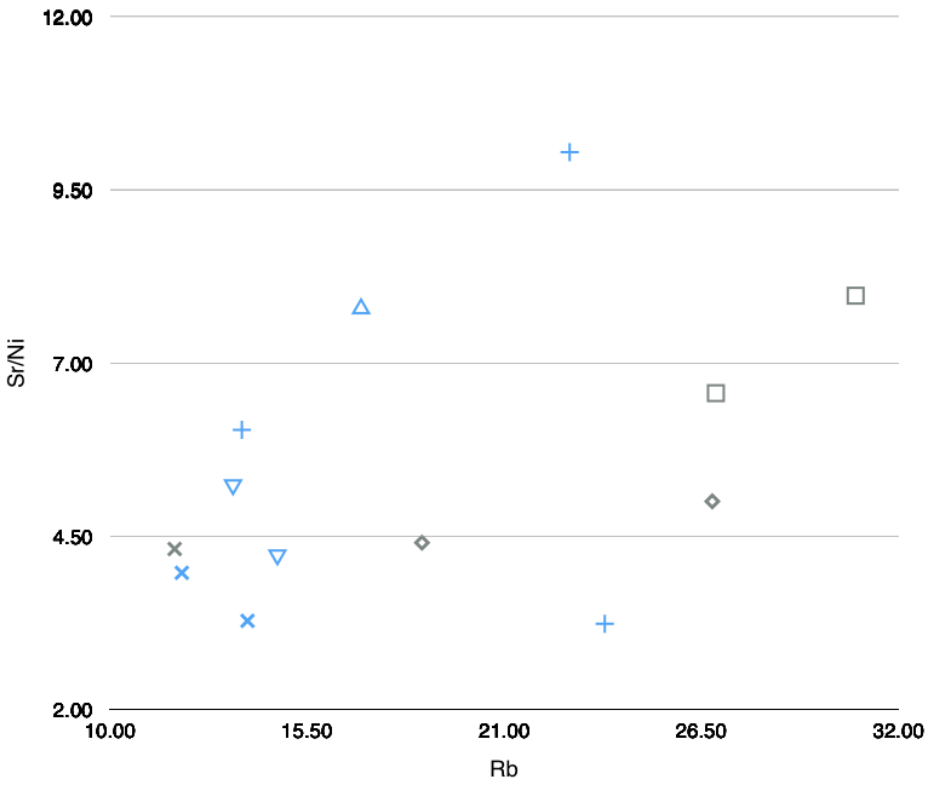


**Figure 6.16 Tell es-Safi/Gath basalt ground stone typology**

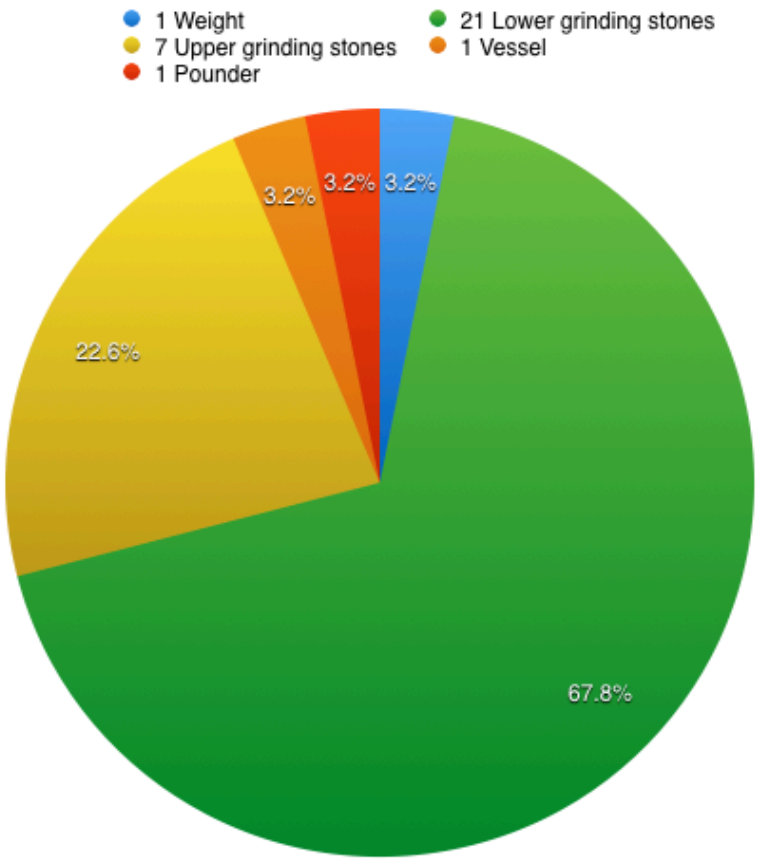


**Figure 6.17 Distribution of E6 basalt artefacts (depicted with E5 architecture)**

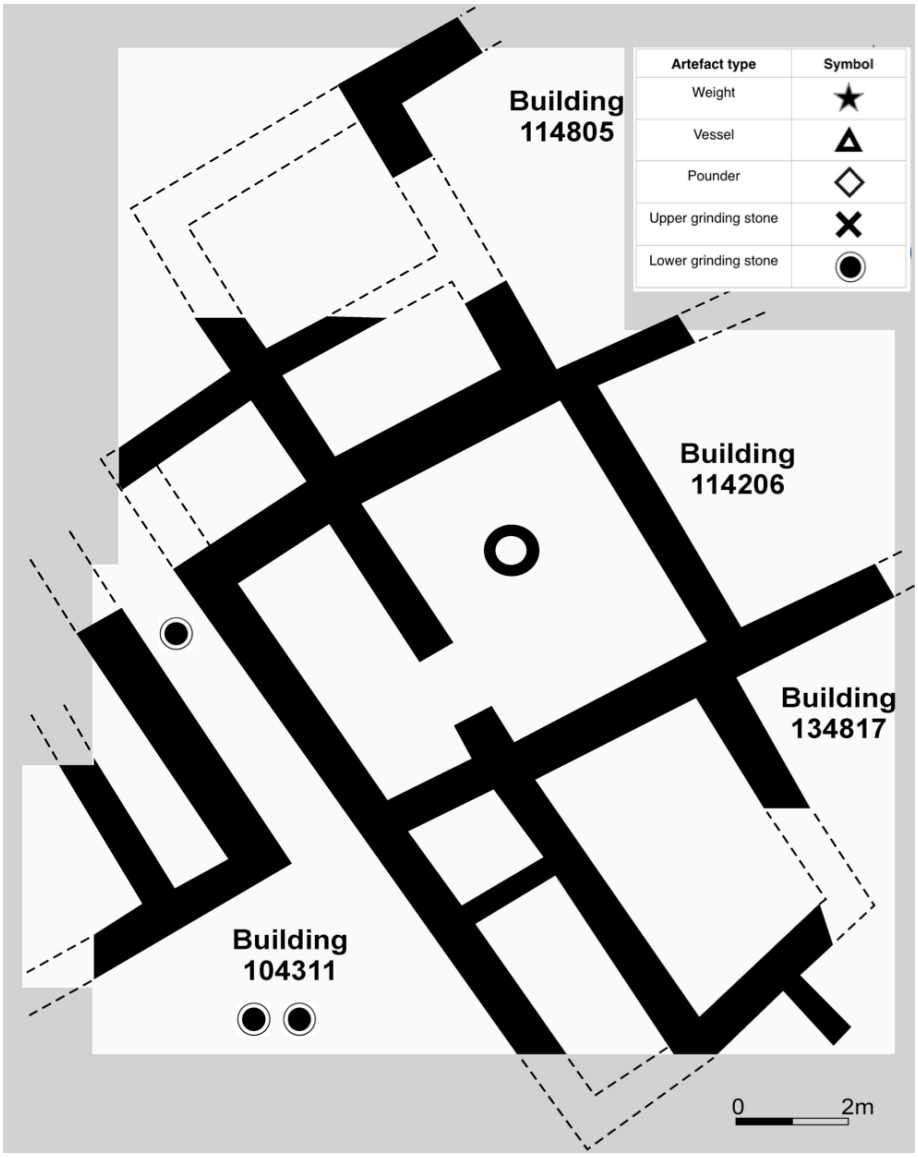


**Figure 6.18 Typology and spatial distribution of E5c basalt artefacts**

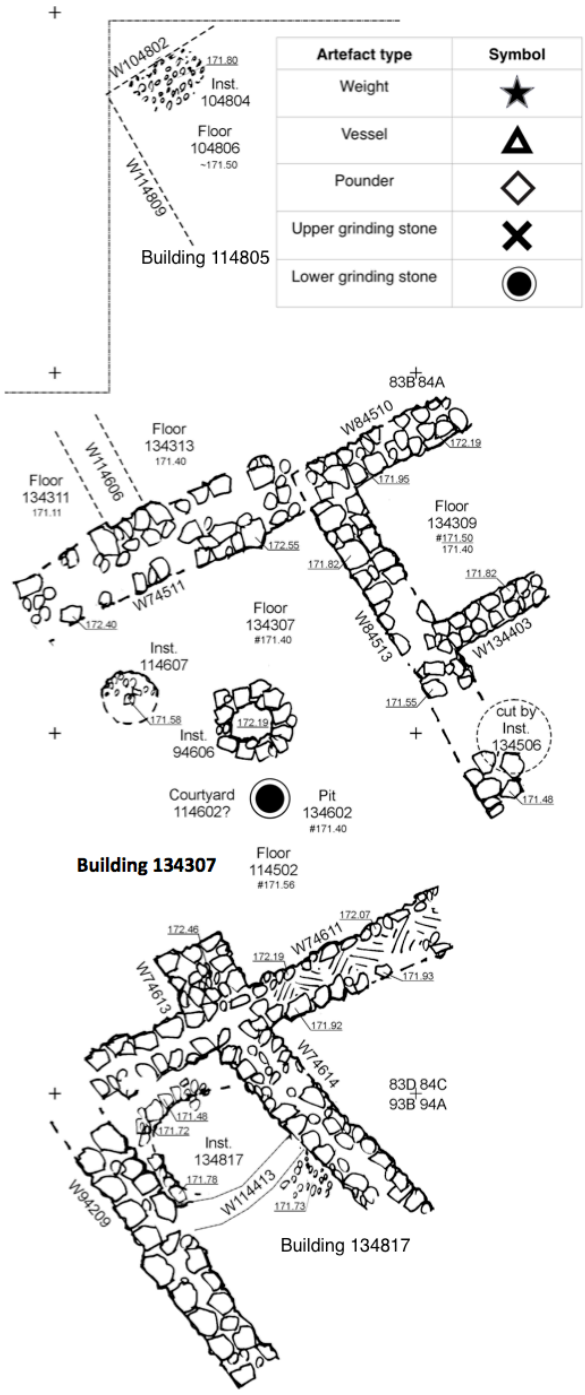


**Figure 6.19 Typology and spatial distribution of E5b basalt artefacts**

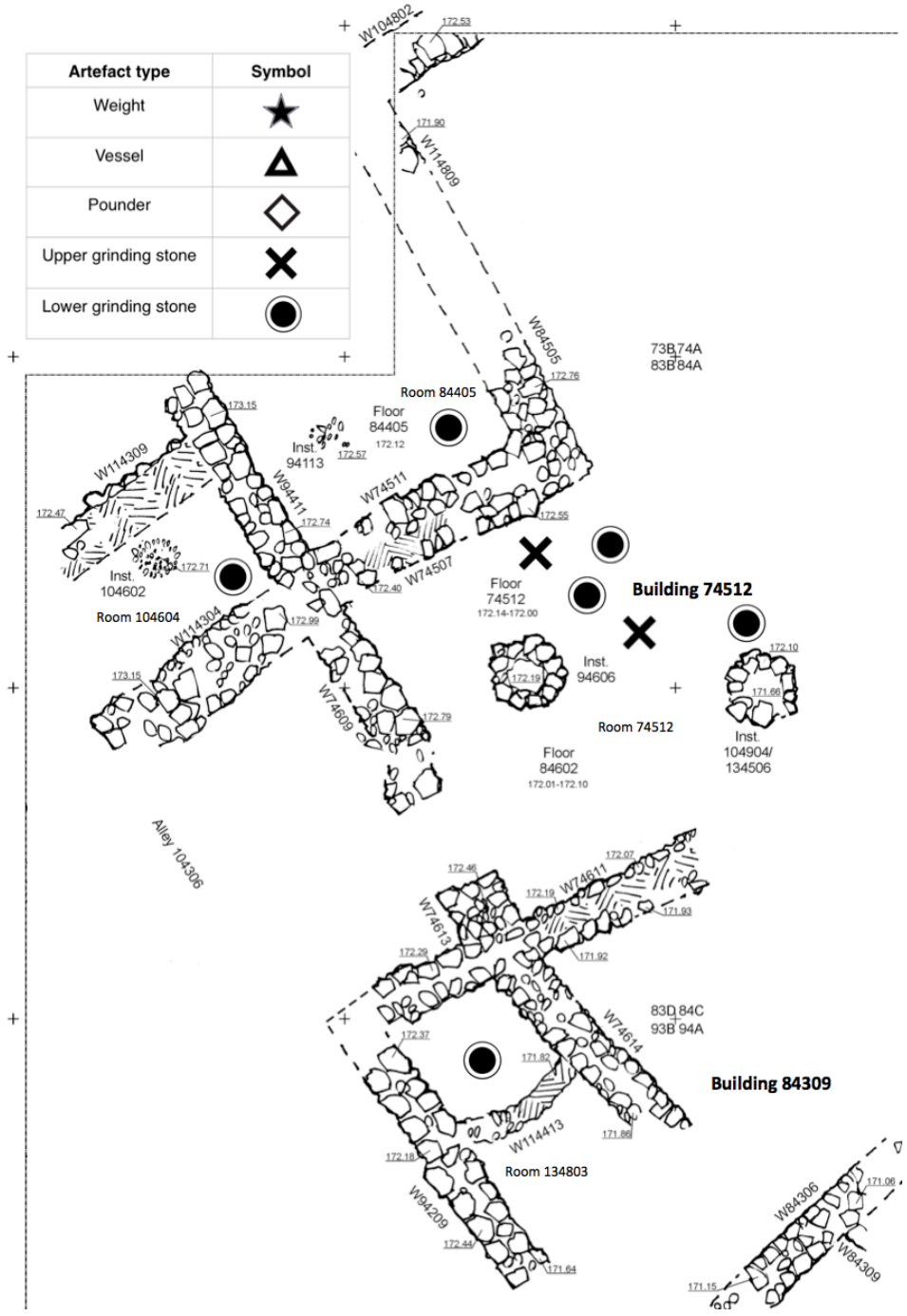


**Figure 6.20 Typology and spatial distribution of E5a basalt artefacts**

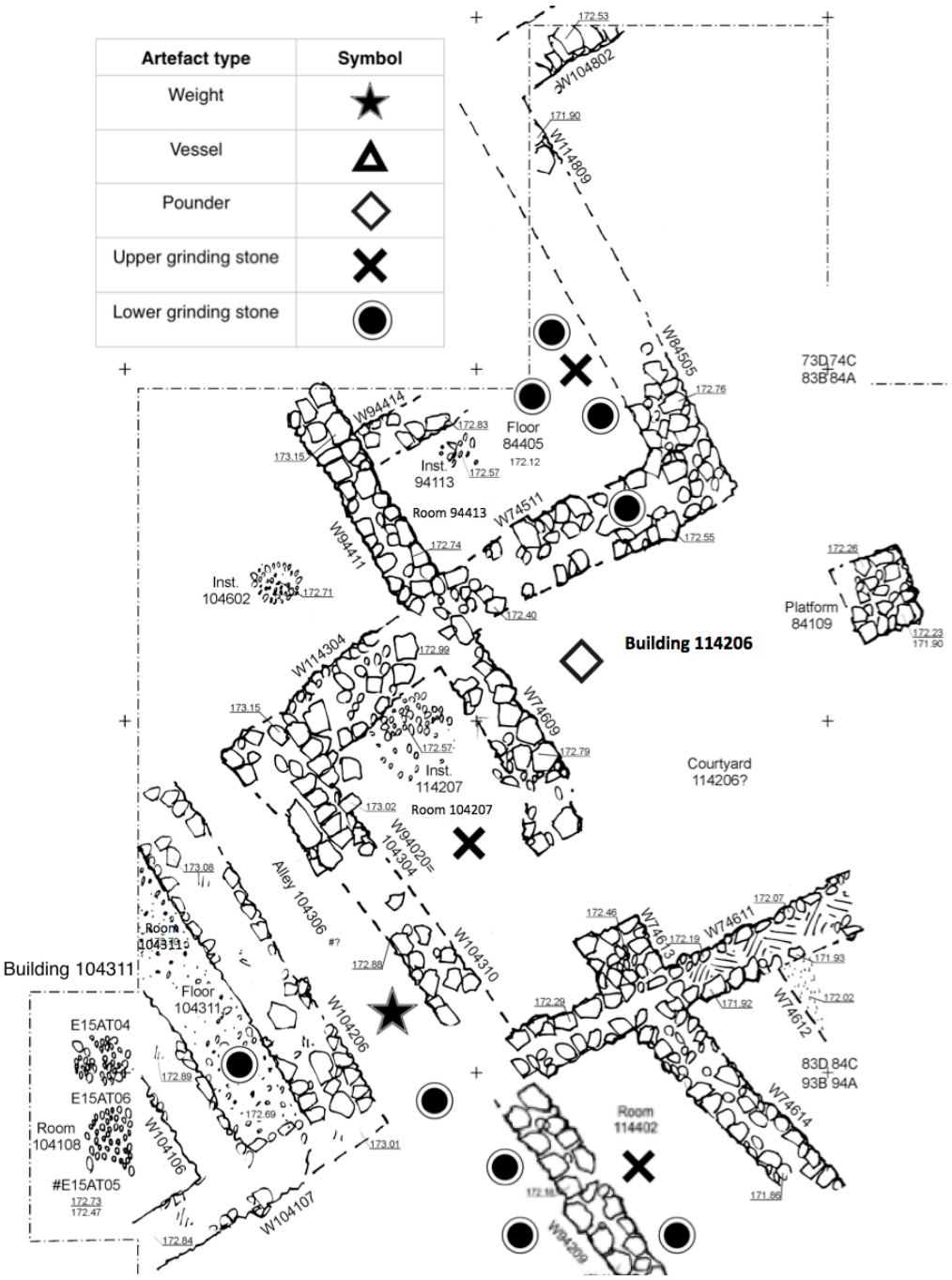


**Figure 6.21 Typology and distribution of E5 basalt artefacts (unknown phases)**

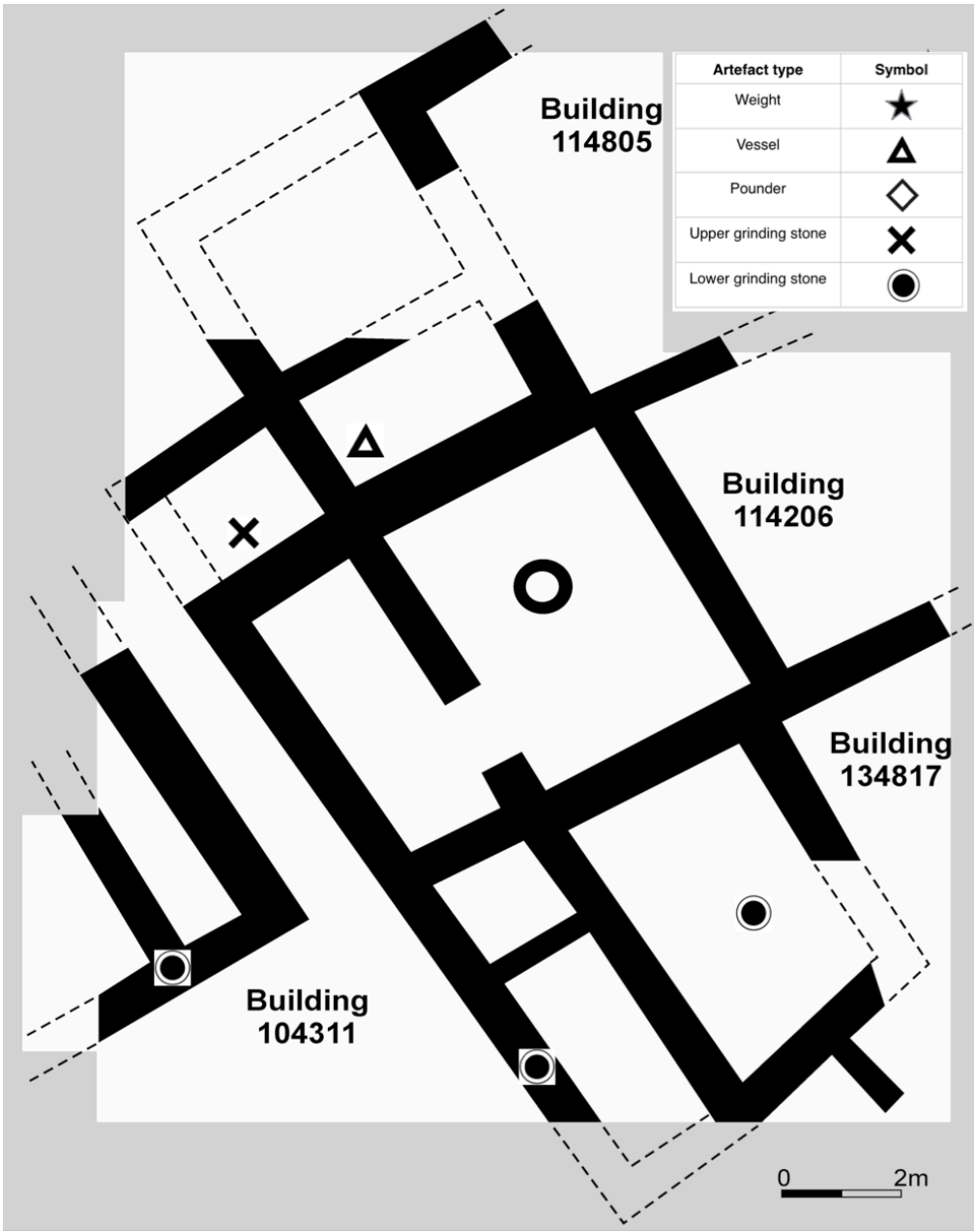


**Figure 6.22 Distribution of all E5 basalt artefacts (depicted with E5 architecture)**

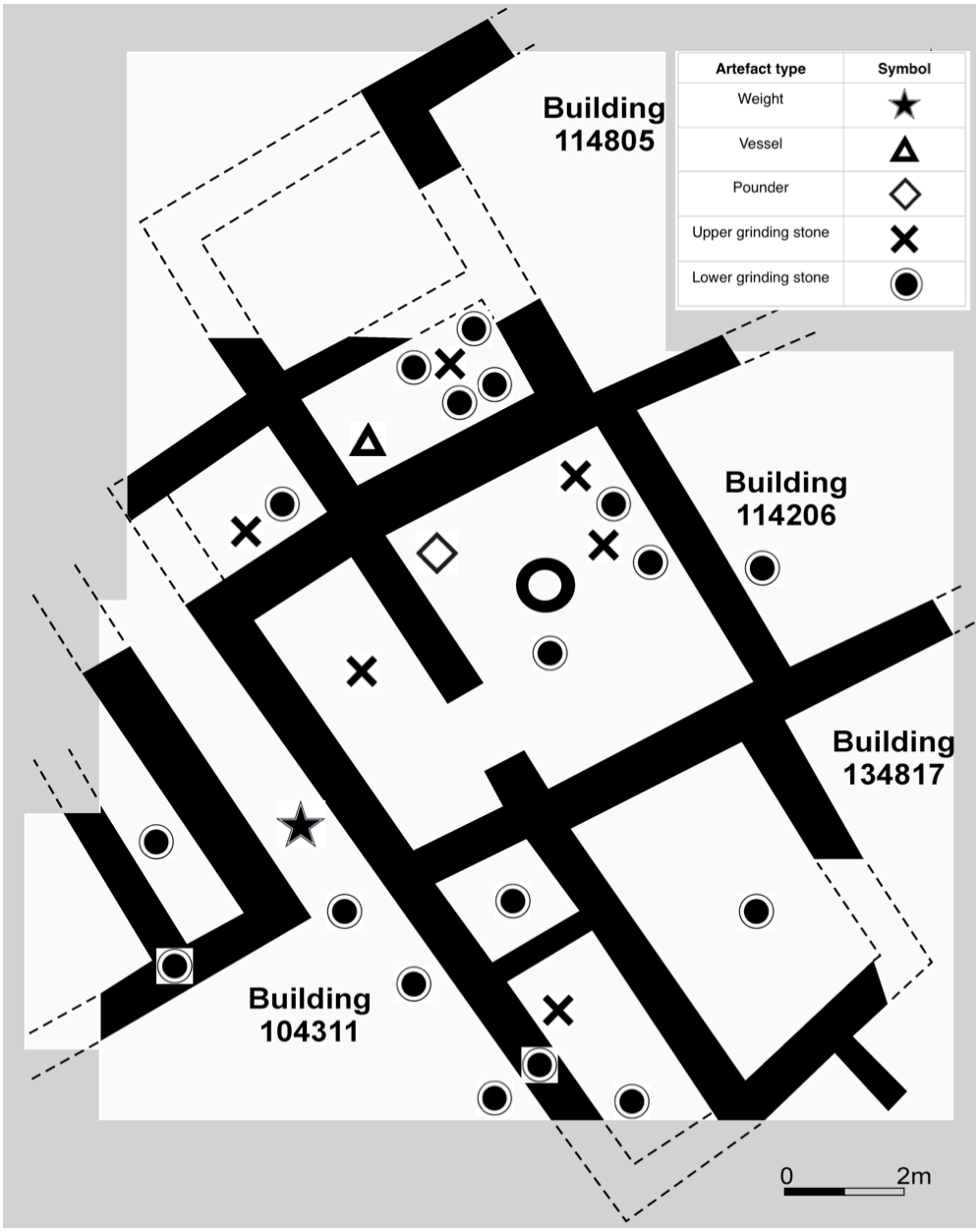


**Figure 6.23 Distribution of E5 basalt artefacts by building**

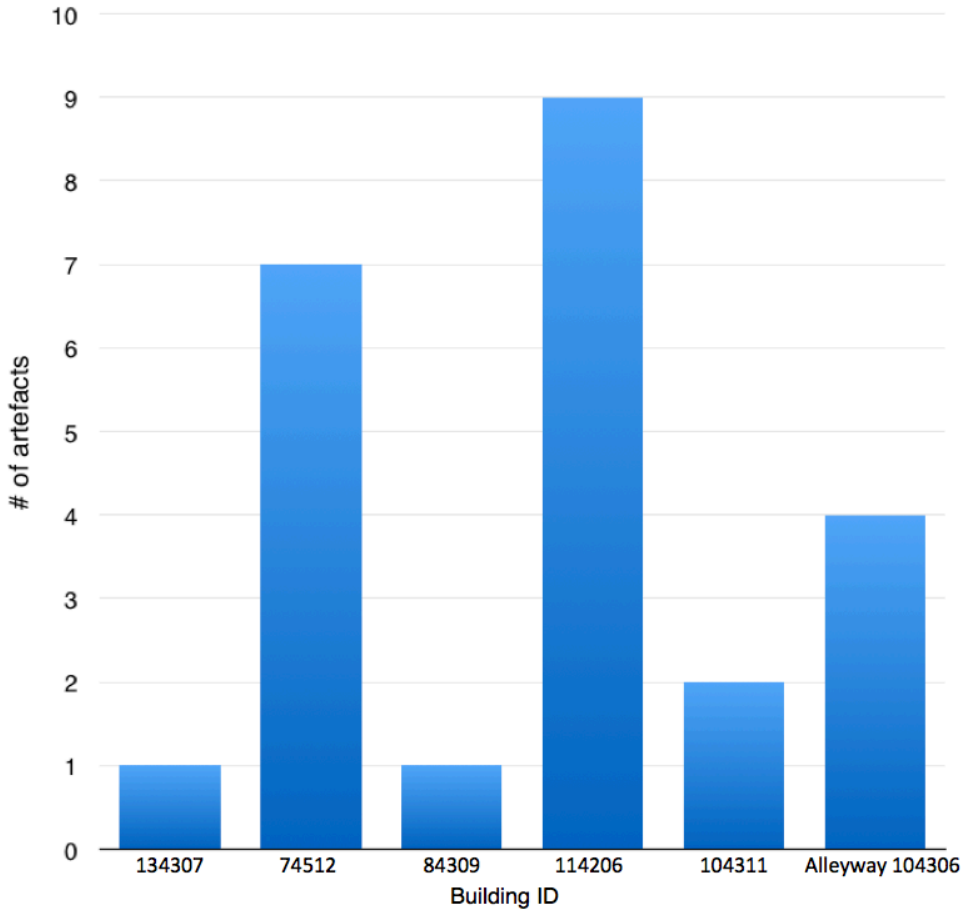


**Figure 6.24 Ancient fractures on basalt artefacts**

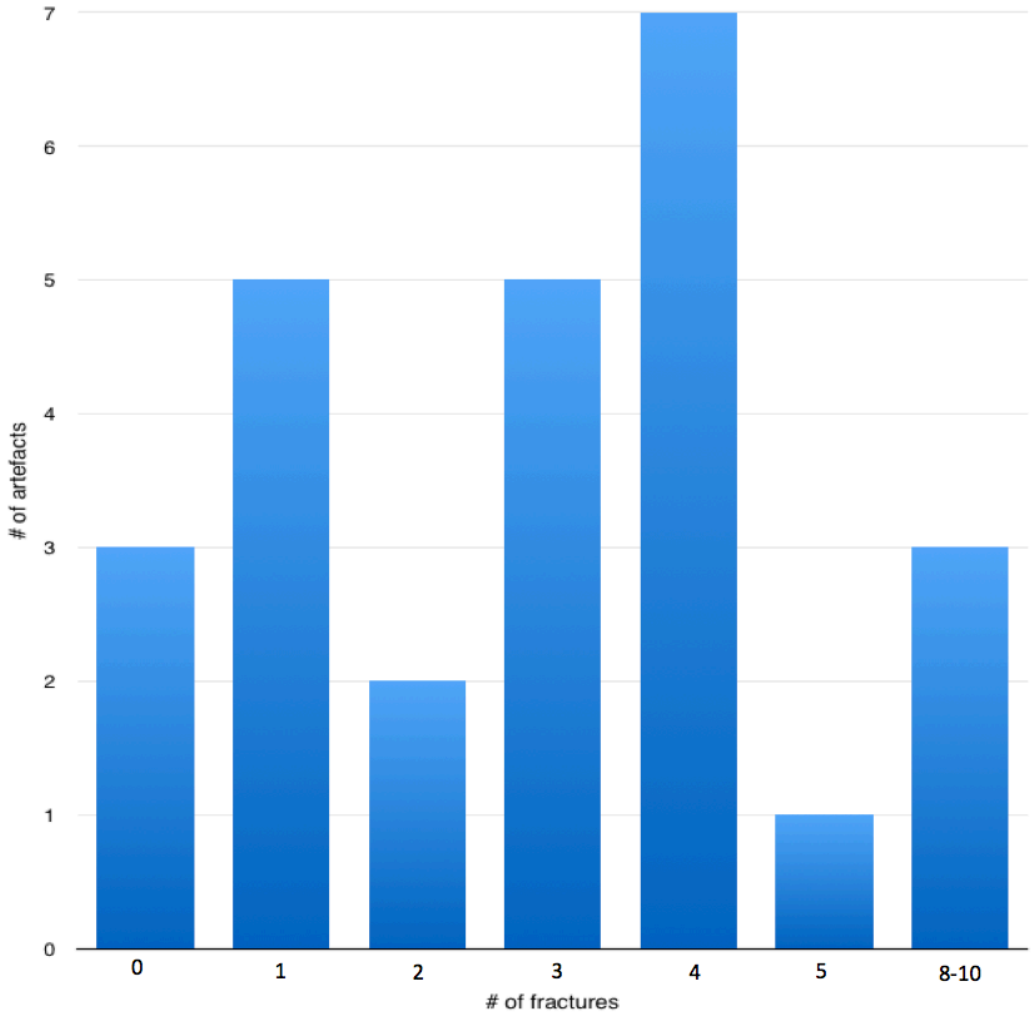


**Figure 6.25 Estimated percentage of original basalt ground stone that remains**

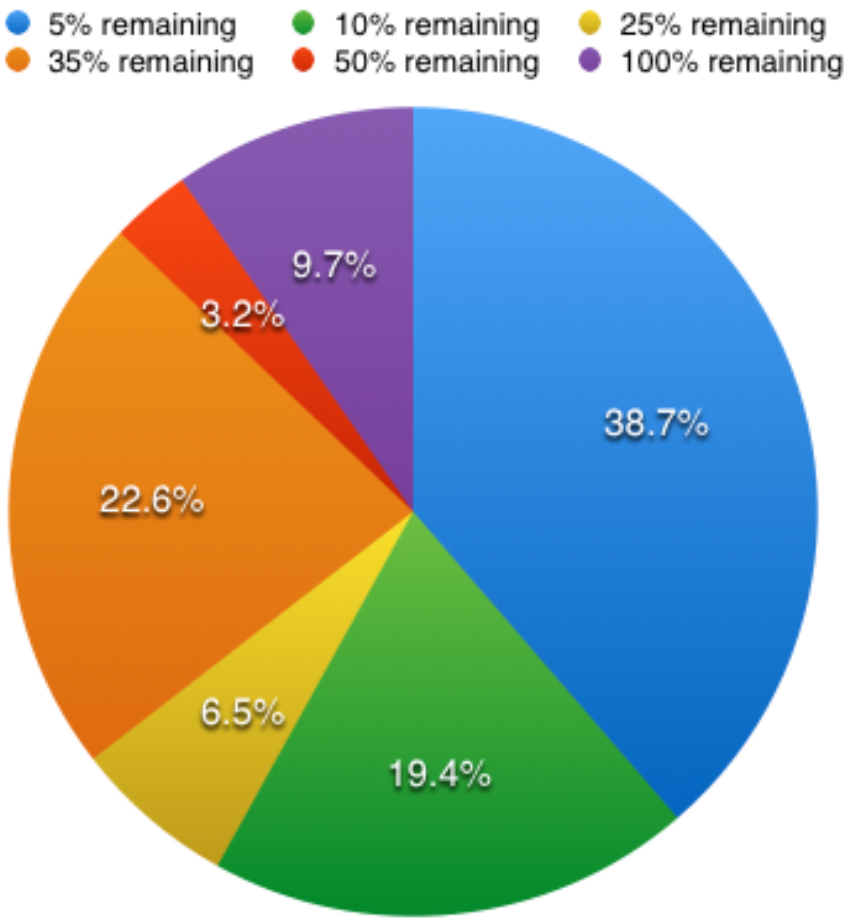
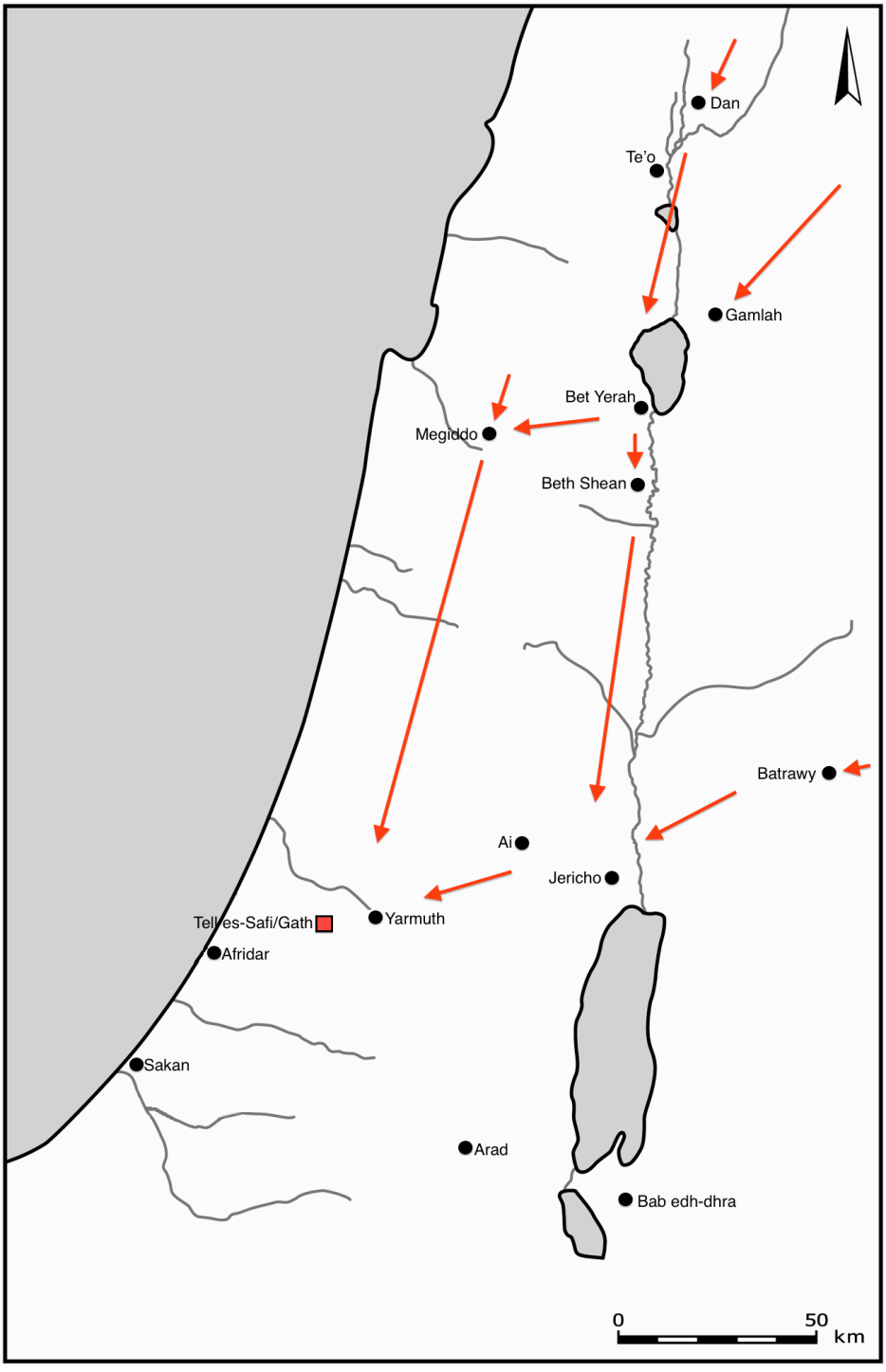


**Figure 7.1 Probable exchange routes of basalt artefacts**



# Tables

## Table 2.1 Chronological synchronisms between EBA-SL and Egypt (BCE)

| EBA Period (Southern Levant) | Mazar 1990 | Dever 2003 | de Miroschedji 2009 | Wright 1936 | Egyptian Period | Egyptian Dynasty |
|---|---|---|---|---|---|---|
| EB I | 3300-3050 | 3500-3100 | 3700-3100/3000 | x - 2900 | Predynastic | Naqada/0 |
| EB II | 3050-2300 | 3100-2650 | 3100/3000-2300 | 2900-2700 | Early Dynastic | I-III |
| EB III | | 2650-2300 | | 2700-2400 | Old Kingdom | III-V |
| EB IV | 2300-2000 | 2300-2000 | 2300-2000 | 2400-2200 | Old Kingdom | VI-VIII |

## Table 2.2 Comparison of south Levantine absolute and relative chronologies

| EBA Period | Relative Chronology (BCE) | Regev et al. 2012 (BCE) |
|---|---|---|
| EB IA | 3500-3050 | x – 3330/3150 |
| EB IB | | 3330/3150 – 3080/3040 |
| EB II | 3050-2600 | 3080/3040 – 2940/2910 |
| EB III | 2600-2300 | 2940/2910 – 2570/2520 |
| EB IV | 2300-2000 | 2570/2520 – x |

## Table 5.1 Basalt artefacts selected for ED-XRF

| Area | Square | Locus | Basket | Phase | Upper level | Lower level | Stratum code | Stratigraphic description | Building | Location | Context | Archaeological provenance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E | 83B | 74505 | 745019 | E5b | 172.38 | 172.12 | 35 | Accumulation on floor | 74512 | Room 74512 | Secondary | Mud-brick debris, accumulated debris on floor 74512 |
| E | 83B | 74505 | 745029 | E5b | 172.38 | 172.12 | 35 | Accumulation on floor | 74512 | Room 74512 | Secondary | Mud-brick debris, accumulated debris on floor 74512 |
| E | 83B | 74505 | 745047 | E5b | 172.38 | 172.12 | 35 | Accumulation on floor | 74512 | Room 74512 | Secondary | Mud-brick debris, accumulated debris on floor 74512 |
| E | 83B | 74505 | 745098 | E5b | 172.38 | 172.12 | 35 | Accumulation on floor | 74512 | Room 74512 | Secondary | Mud-brick debris, accumulated debris on floor 74512 |
| E | 83B | 74506 | 745050 | E5b | 172.54 | 172.28 | 35 | Accumulation on floor | 74512 | Room 84405 | Secondary | Mud-brick debris, accumulated debris on floor 84805 |
| E | 73D-83B | 74808 | 748093 | E5a | 172.55 | 172.24 | 37 | Occupational debris | 114206 | Room 94413 | Secondary | Occupational and mud-brick debris, high volume of restorable pottery |
| E | 73D-83B | 74808 | 748114 | E5a | 172.55 | 172.24 | 37 | Occupational debris | 114206 | Room 94413 | Secondary | Occupational and mud-brick debris, high volume of restorable pottery |
| E | 93A | 94109 | 941057 | E5 | 173.36 | 173.09 | 51 | Decayed mudbrick | 104311 | Wall 104107 | Secondary | EB wall, within mud-brick wall collapse, associated with two complete EB storage jars |
| E | 93B | 104203 | 1042042 | E5a | 172.13 | - | 9 | Street make-up | | Alleyway | Primary | Alleyway debris, probable cultural fill |
| E | 83A | 114306 | 1143031 | E5b | 172.64 | 172.08 | 80 | Brown earth mixed with crushed limestone | 104311 | Room 104604 | Secondary | Subfloor fill containing E5b material on which E5a floor was built |
| E | 93B | 114402 | 1144013 | E5b | 172.08 | 171.72 | 35 | Accumulation on floor | 114206 | Room 134803 | Primary | Ash layer containing cooking pottery ware intermixed with ground stone artefact |
| E | 83D | 134604 | 1346093 | E5c | 171.37 | 171.19 | 74 | Brown earth | 134307 | Room 114602 | Tertiary | Fill of material discovered under E5b/c installation 94606 |
| E | 84A | 16E84A03 | 16E84A007 | E5b | 171.92 | 171.17 | 90 | Cleaning | 74512 | Room 74512 | Primary | Interior matrix of multi-stone installation 104904/13506 |
| E | 84C | 16E84C04 | 16E84C012 | E5 | 170.91 | 170.77 | 74 | Brown earth | 114206 | Room 74612 | Secondary | Fill surrounding multi-stone installation 16E84C08 |
| E | 93A | 16E93A06 | 16E93A049 | E6 | 172.16 | 171.84 | - | N/A | | E6 | Secondary | Installation 16E93A06 containing small pebbles and lined with two ground stone artefacts (16E93A049 & 16E93A050) |
| E | 93A | 16E93A06 | 16E93A050 | E6 | 172.11 | 171.97 | - | N/A | | E6 | Secondary | Installation 16E93A06 containing small pebbles and lined with two ground stone artefacts (16E93A049 & 16E93A050) |
| E | 93B | 16E93B08 | 16E93B070 | E5a | 171.98 | 171.72 | - | N/A | | Alleyway | Primary | Alleyway debris, probable cultural fill |
| E | 93B | 16E93B09 | 16E93B081 | E5 | 172.44 | 171.52 | - | N/A | 114206 | Wall 94209 | Primary | Part of W94209 Stone make up |
| E | 94A | 16E94A03 | 16E94A011 | E5a | 171.72 | 171.36 | - | N/A | 134817 | Room 114402 | Secondary | In situ on E5a surface, beside a pebble installation (probable hearth) |

**Table 5.2 Criteria for assessment of cultural polish intensity**

| Intensity | Description |
|---|---|
| High | glossy look, void of grit friction, reflects considerable light |
| Medium | mostly void of grit friction, reflects considerable light |
| Low | reflects some light, grit friction present, roughing |
| Absent | no indication of smoothing |

## Table 6.1 Archaeological provenance of basalt artefacts

| Area | Square | Locus | Basket | Phase | Upper level | Lower level | Stratum code | Stratigraphic description | Building | Location | Context | Archaeological provenance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E | 83B | 74505 | 745019 | E5b | 172.38 | 172.12 | 35 | Accumulation on floor | 74512 | Room 74512 | Secondary | Mud-brick debris, accumulated debris on floor 74512 |
| E | 83B | 74505 | 745029 | E5b | 172.38 | 172.12 | 35 | Accumulation on floor | 74512 | Room 74512 | Secondary | Mud-brick debris, accumulated debris on floor 74512 |
| E | 83B | 74505 | 745047 | E5b | 172.38 | 172.12 | 35 | Accumulation on floor | 74512 | Room 74512 | Secondary | Mud-brick debris, accumulated debris on floor 74512 |
| E | 83B | 74505 | 745098 | E5b | 172.38 | 172.12 | 35 | Accumulation on floor | 74512 | Room 74512 | Secondary | Mud-brick debris, accumulated debris on floor 74512 |
| E | 83B | 74506 | 745050 | E5b | 172.54 | 172.28 | 35 | Accumulation on floor | 74512 | Room 84405 | Secondary | Mud-brick debris, accumulated debris on floor 84805 |
| E | 83D | 74610 | 746060 | E5a | 172.04 | 171.96 | 37 | Occupational debris | 114206 | Room 104207 | Secondary | Occupational debris, high volume of pottery sherds |
| E | 73D-83B | 74808 | 748093 | E5a | 172.55 | 172.24 | 37 | Occupational debris | 114206 | Room 94413 | Secondary | Occupational and mud-brick debris, high volume of restorable pottery |
| E | 73D | 74808 | 748110 | E5a | 172.55 | 172.24 | 37 | Occupational debris | 114206 | Room 94413 | Secondary | Occupational and mud-brick debris, high volume of restorable pottery |
| E | 73D-83B | 74808 | 748114 | E5a | 172.55 | 172.24 | 37 | Occupational debris | 114206 | Room 94413 | Secondary | Occupational and mud-brick debris, high volume of restorable pottery |
| E | 83C | 84025 | 840111 | E5a | 173.07 | 173.04 | 99 | Other - installation | 114206 | Room 114206 | Secondary | Part of pebble installation intermixed with charcoal and ash (probable hearth) |
| E | 93A | 94109 | 941057 | E5 | 173.36 | 173.09 | 51 | Decayed mudbrick | 104311 | Wall 104107 | Secondary | EB wall, within mud-brick wall collapse, associated with two complete EB storage jars |
| E | 83B | 74511 | 944090 | E5a | 172.54 | 172.28 | 25 | Wall | 114206 | Wall 74507 | Unspecified | Part of stone wall foundation for mud-brick super structure |
| E | 93B | 1042024 | 1042024 | E5a | 172.00 | 172.00 | 80 | Brown earth mixed with crushed limestone | 114206 | Room 114402 | Secondary | Occupational debris, high volume of pottery sherds |
| E | 93B | 1042031 | 1042042 | E5a | 172.13 | - | 9 | Street make-up | | Alleyway | Primary | Alleyway debris, probable cultural fill |
| E | 83A | 1046001 | 1046004 | E5 | 172.73 | 172.58 | 60 | Composite ash layer | 114206 | Room 104601 | Tertiary | Winter wash intermixed with an EB ash pit. Considered associated with surrounding mud-brick debris |
| E | 73D-83D | 1048001 | 1048013 | E5a | 171.95 | 171.75 | 73 | Earth mixed with ash and charcoal | 114206 | Room 94413 | Secondary | Ashy fill |
| E | 93A | 1141112 | 1141073 | E5a | 172.70 | 172.63 | 4 | Stone floor (pavement) | 104311 | Room 104311 | Primary | Mixed with pavement floor 104311 |
| E | 83A | 1143031 | 1143010 | E5 | 172.28 | 172.13 | 46 | Unstratified wash | 114206 | Room 94413 | Tertiary | EB winter wash, same locus as game piece |
| E | 83A | 114306 | 1143031 | E5b | 172.64 | 172.08 | 80 | Brown earth mixed with crushed limestone | 104311 | Room 104604 | Secondary | Subfloor fill containing E5b material on which E5a floor was built |
| E | 93B | 114402 | 1144013 | E5b | 172.08 | 171.72 | 35 | Accumulation on floor | 114206 | Room 134803 | Primary | Ash layer containing cooking pottery ware intermixed with ground stone artefact |
| E | 83D | 134604 | 1346093 | E5c | 171.37 | 171.19 | 74 | Brown earth | 134307 | Room 114602 | Tertiary | Fill of material discovered under E5blc installation 94606 |
| E | 93A | 134709 | 1347085 | E5a | 172.29 | 172.06 | 36 | Accumulation on street | | Alleyway | Primary | Alleyway debris, probable cultural fill |
| E | 83C | E15AQ15 | E15AQ179 | E6 | 172.33 | 172.15 | 36 | Accumulation on street | | Alleyway | Secondary | Alleyway debris, cultural fill. Arguably below E5a alleyway. E6 alleyway? |
| E | 84A | 16E84A03 | 16E84A007 | E5b | 171.92 | 171.17 | 90 | Clearing | 74512 | Room 74512 | Primary | Interior matrix of multi-stone installation 104904/13506 |
| E | 84C | 16E84C04 | 16E84C012 | E5 | 170.91 | 170.77 | 74 | Brown earth | 114206 | Room 74612 | Secondary | Fill surrounding multi-stone installation 16E84C08 |
| E | 83C | 16E83C07 | 16E83C087 | E5a | 172.52 | 172.23 | - | N/A | | Alleyway | Primary | Alleyway debris, probable cultural fill |
| E | 93A | 16E93A06 | 16E93A049 | E6 | 172.16 | 171.84 | - | N/A | | E6 | Secondary | Installation 16E93A06 containing small pebbles and lined with two ground stone artefacts (16E93A049 & 16E93A050) |
| E | 93A | 16E93A06 | 16E93A050 | E6 | 172.11 | 171.97 | - | N/A | | E6 | Secondary | Installation 16E93A06 containing small pebbles and lined with two ground stone artefacts (16E93A049 & 16E93A050) |
| E | 93B | 16E93B08 | 16E93B070 | E5a | 171.98 | 171.72 | - | N/A | | Alleyway | Primary | Alleyway debris, probable cultural fill |
| E | 93B | 16E93B09 | 16E93B081 | E5 | 172.44 | 171.52 | - | N/A | 114206 | Wall 94209 | Primary | Part of W94209 Stone make up |
| E | 94A | 16E94A03 | 16E94A011 | E5a | 171.72 | 171.36 | - | N/A | 134817 | Room 114402 | Secondary | In situ on E5a surface, beside a pebble installation (probable hearth) |

**Table 6.2 ED-XRF results for 845008**

| Sample Name | Na2O | MgO | Al2O3 | SiO2 | P2O5 | K2O | CaO | TiO2 | Fe2O3 | SUM |
|---|---|---|---|---|---|---|---|---|---|---|
| 845008 | 0.46 | 0.69 | 1.58 | 6.79 | 0.31 | 0.50 | 49.59 | 0.20 | 1.02 | 61.38 |

**Table 6.3 Typology of basalt ground stone assemblage of Tell es-Safi/Gath**

| Artefact | Type 1 | Type 2 | Part | Wright (1992) type | Wright (1992) # | Comparative artefacts |
|---|---|---|---|---|---|---|
| 745019 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 745029 | Handstone | Upper grinding stone | Body fragment | Handstone fragment | 63 | |
| 745047 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 745098 | Handstone | Upper grinding stone | Body fragment | Unifacial loaf handstone | 62 | Jemmeh (Figure 23.1-a/b Rowan 2014:920) |
| 745050 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | Beth Shean (Figure 9.12-3 Mazar & Rotem 2012:380) |
| 746060 | Handstone | Upper grinding stone | Complete | Bifacial rectilinear/flat | 52 | Jemmeh (Figure 23.3-n Rowan 2014:922) |
| 748093 | Handstone | Upper grinding stone | Body fragment | Unifacial loaf handstone | 62 | Beth Shean (Figure 9.14-7 Mazar & Rotem 2012:380) |
| 748110 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 748114 | Netherstone | Lower grinding stone | Edge/corner fragment | Saddle-shaped quern | 5 | Beth Shean (Figure 9.12-5 Mazar & Rotem 2012:380) |
| 840111 | Handstone | Pounder | Complete | Spheroid-cuboid | 77-78 | Jemmeh (Figure 23.2-h Rowan 2014:922); Tel'o (Figure 9.1-2 Gophna & Eisenberg 2001:143) |
| 941057 | Netherstone | Lower grinding stone | Half | Saddle-shaped quern | 5 | Yiftah'el (Figure 12.2-7 Braun 1997-99); Beth Shean (Figure 9.13-3 Mazar & Rotem 2012:381) |
| 944090 | Netherstone | Lower grinding stone | End/side | Slab/quern fragment | 13 | Beth Shean (Figure 9.12-3 Mazar & Rotem 2012:380) |
| 1042024 | Handstone | Upper grinding stone | Body fragment | Handstone fragment | 63 | |
| 1042042 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 1046004 | Handstone | Upper grinding stone | Body fragment | Handstone fragment | 63 | |
| 1048013 | Netherstone | Lower grinding stone | End/side | Slab/quern fragment | 13 | Beth Shean (Figure 9.12-3 Mazar & Rotem 2012:380) |
| 1141073 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 1143010 | Container | Vessel | Rim fragment | Rim fragment | 131 | Qiryat Ata (Figure 6.6-4 Rowan 2003:185); Bir Safadi (Figure 2-1 Braun 1990:89) |
| 1143031 | Netherstone | Lower grinding stone | Half | Saddle-shaped quern | 5 | Beth Shean (Figure 9.12-1 Mazar & Rotem 2012:380) |
| 1144013 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 1346093 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 1347085 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| E15AQ179 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 16E84A007 | Handstone | Upper grinding stone | Half | Unifacial loaf handstone | 62 | Jemmeh (Figure 23.1-a/b Rowan 2014:920) |
| 16E84C012 | Netherstone | Lower grinding stone | End/side | Basin quern | 9 | |
| 16E83C087 | Perforated | Weight | Half | Spindle whorl | 108 | Madaba, Gat Hefer, Megiddo, Jericho, and others (see Table 1: Savage 2010:124-129) |
| 16E93A049 | Netherstone | Lower grinding stone | Edge/corner fragment? | Slab/quern fragment | 13 | |
| 16E93A050 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 16E93B070 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 16E93B081 | Netherstone | Lower grinding stone | Body fragment | Slab/quern fragment | 13 | |
| 16E94A011 | Netherstone | Lower grinding stone | Complete | Boulder quern/slab | 3-4 | Qiryat Ata (Figure 6.1-2 Rowan 2003:185) |

**Table 6.4 Lower grinding stone types**

| Type | # of artefacts | % of lower grinding stones |
|---|---|---|
| Slab/quern fragment | 16 | 84.2% |
| Saddle-shaped quern | 4 | 19.0% |
| Basin quern | 1 | 4.8% |

**Table 6.5 Upper grinding stone types**

| Type | # of artefacts | % of upper grinding stones |
|---|---|---|
| Handstone fragment | 3 | 42.9% |
| Bifacial rectilinear/flat | 1 | 14.3% |
| Unifacial loaf handstone | 3 | 42.9% |

**Table 6.7 Geochemical data of basalt artefacts from Tell es-Safi/Gath**

| Site | Sample Name | SiO2 | Na2O | K2O | MgO | Al2O3 | P2O5 | CaO | TiO2 | Fe2O3 | Na2O + K2O |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tell es-Safi/Gath | **745050** | 43.48 | 3.42 | 1.63 | 4.09 | 15.13 | 0.84 | 12.02 | 2.35 | 12.59 | 5.05 |
| Tell es-Safi/Gath | **745047** | 45.42 | 3.77 | 1.62 | 4.35 | 16.35 | 0.95 | 12.28 | 2.39 | 12.57 | 5.38 |
| Tell es-Safi/Gath | **1346093** | 42.87 | 3.78 | 1.24 | 7.80 | 14.05 | 1.05 | 12.67 | 2.30 | 13.93 | 5.02 |
| Tell es-Safi/Gath | **748093** | 48.05 | 3.59 | 1.25 | 5.71 | 16.71 | 0.58 | 10.65 | 2.17 | 12.34 | 4.84 |
| Tell es-Safi/Gath | **745029** | 46.52 | 4.16 | 1.28 | 7.35 | 15.77 | 0.56 | 10.86 | 2.26 | 13.06 | 5.45 |
| Tell es-Safi/Gath | **748114** | 48.18 | 3.56 | 0.92 | 5.34 | 15.43 | 0.42 | 10.56 | 1.91 | 12.92 | 4.48 |
| Tell es-Safi/Gath | **1042042** | 45.54 | 3.39 | 1.35 | 4.13 | 15.56 | 1.28 | 13.60 | 2.45 | 12.40 | 4.74 |
| Tell es-Safi/Gath | **1144013** | 39.16 | 2.94 | 1.37 | 4.89 | 13.29 | 1.11 | 16.07 | 1.83 | 11.70 | 4.31 |
| Tell es-Safi/Gath | **16E84A007** | 47.54 | 3.64 | 0.98 | 4.39 | 16.63 | 0.72 | 12.15 | 2.10 | 12.43 | 4.62 |
| Tell es-Safi/Gath | **16E93B081** | 45.06 | 3.44 | 0.81 | 5.19 | 15.02 | 0.43 | 12.74 | 1.70 | 12.21 | 4.25 |
| Tell es-Safi/Gath | **16E93A049** | 45.18 | 3.60 | 1.39 | 4.36 | 15.75 | 1.14 | 13.25 | 2.10 | 12.07 | 5.00 |
| Tell es-Safi/Gath | **16E93A050** | 47.58 | 3.77 | 1.34 | 4.45 | 16.55 | 1.17 | 12.51 | 2.19 | 12.31 | 5.11 |
| Tell es-Safi/Gath | **16E93B070** | 45.26 | 3.73 | 1.86 | 3.24 | 16.58 | 1.06 | 11.22 | 2.00 | 11.08 | 5.59 |
| Tell es-Safi/Gath | **1143031** | 44.01 | 3.39 | 1.74 | 4.01 | 15.77 | 0.85 | 12.36 | 3.10 | 12.71 | 5.13 |
| Tell es-Safi/Gath | **745019** | 39.77 | 5.75 | 1.19 | 8.08 | 13.17 | 1.32 | 12.10 | 3.13 | 14.02 | 6.94 |
| Tell es-Safi/Gath | **745098** | 44.46 | 2.80 | 1.26 | 5.95 | 14.69 | 0.82 | 12.03 | 2.21 | 12.42 | 4.06 |
| Tell es-Safi/Gath | **941057** | 45.92 | 3.35 | 0.97 | 3.85 | 15.52 | 0.69 | 12.11 | 1.79 | 11.86 | 4.31 |
| Tell es-Safi/Gath | **16E94A011** | 45.51 | 3.58 | 0.99 | 5.96 | 15.30 | 0.56 | 12.66 | 2.16 | 12.96 | 4.57 |
| Tell es-Safi/Gath | **16E84C012** | 45.55 | 3.80 | 1.03 | 4.55 | 15.56 | 0.74 | 12.55 | 2.00 | 12.24 | 4.84 |
| | | | | | | | | | | | |
| | **GBW Ref. Value** | 35.69 | 2.11 | 0.15 | 5.25 | 14.40 | 0.03 | 9.86 | 7.69 | 24.75 | |
| | **GBW 1** | **37.21** | **2.67** | **0.15** | **5.09** | **15.98** | **0.05** | **11.28** | **8.13** | **22.73** | 2.82 |
| | **GBW 2** | **37.01** | **2.71** | **0.15** | **5.06** | **15.96** | **0.05** | **11.31** | **8.16** | **22.70** | 2.86 |
| | **Average** | 37.11 | 2.69 | 0.15 | 5.07 | 15.97 | 0.05 | 11.30 | 8.14 | 22.72 | 2.84 |
| | **Rel. error** | 103.98 | 127.46 | 101.23 | 96.65 | 110.90 | 174.70 | 114.55 | 105.86 | 91.78 | |
| | **Stdev** | 0.14 | 0.02 | 0.00 | 0.03 | 0.01 | 0.00 | 0.02 | 0.02 | 0.02 | 0.0283 |
| | **% stdev** | 0.40 | 0.90 | 1.90 | 0.50 | 0.10 | 2.00 | 0.20 | 0.30 | 0.10 | 1.0 |

| Site | Artefact | Mn | Ni | Cu | Zn | Rb | Sr | Y | Zr | Nb | Pb | Y/Rb | Sr/Ni | TAS categorisation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tell es-Safi/Gath | **745050** | 1418.0 | 83.7 | 26.50 | 118.7 | 13.60 | 604.8 | 24.60 | 206.2 | 34.10 | 6.40 | 1.81 | 7.2 | BT |
| Tell es-Safi/Gath | **745047** | 1499.0 | 86.5 | 54.20 | 109.5 | 15.30 | 738.5 | 27.50 | 212.2 | 36.20 | 5.30 | 1.80 | 8.5 | BT |
| Tell es-Safi/Gath | **1346093** | 1596.0 | 244.9 | 59.90 | 112.1 | 15.40 | 745.8 | 25.10 | 171.6 | 34.40 | 5.80 | 1.63 | 3.0 | BT |
| Tell es-Safi/Gath | **748093** | 1366.0 | 161.9 | 61.40 | 98.7 | 11.50 | 496.9 | 22.40 | 170.0 | 22.50 | 8.60 | 1.95 | 3.1 | AB |
| Tell es-Safi/Gath | **745029** | 1474.0 | 228.1 | 68.00 | 109.1 | 16.00 | 658.1 | 17.90 | 151.1 | 36.10 | 4.00 | 1.12 | 2.9 | TB |
| Tell es-Safi/Gath | **748114** | 1407.0 | 190.8 | 61.30 | 109.0 | 10.10 | 357.0 | 20.80 | 122.9 | 13.20 | 4.90 | 2.06 | 1.9 | AB |
| Tell es-Safi/Gath | **1042042** | 1432.0 | 73.9 | 78.50 | 111.3 | 13.20 | 789.7 | 28.30 | 266.8 | 53.50 | 6.20 | 2.14 | 10.7 | AB |
| Tell es-Safi/Gath | **1144013** | 1315.0 | 114.1 | 40.00 | 104.1 | 9.80 | 643.0 | 22.40 | 154.7 | 25.80 | 4.70 | 2.29 | 5.6 | F |
| Tell es-Safi/Gath | **16E84A007** | 1394.0 | 94.1 | 70.10 | 98.1 | 11.10 | 566.3 | 24.80 | 156.8 | 23.80 | 3.90 | 2.23 | 6.0 | AB |
| Tell es-Safi/Gath | **16E93B081** | 1319.0 | 144.3 | 62.30 | 104.8 | 9.50 | 347.2 | 21.40 | 129.3 | 14.40 | 4.90 | 2.25 | 2.4 | AB |
| Tell es-Safi/Gath | **16E93A049** | 1427.0 | 86.9 | 46.10 | 105.2 | 15.10 | 715.2 | 27.70 | 202.6 | 34.20 | 5.20 | 1.83 | 8.2 | TB |
| Tell es-Safi/Gath | **16E93A050** | 1481.0 | 81.8 | 58.80 | 108.0 | 15.60 | 726.1 | 28.70 | 209.5 | 34.00 | 5.30 | 1.84 | 8.9 | AB |
| Tell es-Safi/Gath | **16E93B070** | 1307.0 | 58.9 | 41.40 | 96.0 | 15.70 | 655.3 | 27.60 | 186.3 | 24.30 | 3.80 | 1.76 | 11.1 | BT |
| Tell es-Safi/Gath | **1143031** | 1437.0 | 59.1 | 51.60 | 106.4 | 14.60 | 673.0 | 24.90 | 184.9 | 33.50 | 3.90 | 1.71 | 11.4 | BT |
| Tell es-Safi/Gath | **745019** | 1594.0 | 291.8 | 32.20 | 124.4 | 12.00 | 987.5 | 22.00 | 231.8 | 69.00 | 6.20 | 1.83 | 3.4 | F |
| Tell es-Safi/Gath | **745098** | 1416.0 | 224.3 | 63.10 | 108.1 | 17.40 | 573.6 | 22.80 | 226.7 | 28.50 | 5.60 | 1.31 | 2.6 | BT |
| Tell es-Safi/Gath | **941057** | 1457.0 | 113.5 | 60.30 | 102.9 | 11.80 | 489.5 | 24.30 | 155.7 | 20.80 | 4.50 | 2.06 | 4.3 | AB |
| Tell es-Safi/Gath | **16E94A011** | 1357.0 | 225.5 | 60.20 | 111.7 | 11.60 | 535.6 | 17.00 | 158.0 | 29.90 | 3.50 | 1.47 | 2.4 | AB |
| Tell es-Safi/Gath | **16E84C012** | 1374.0 | 122.6 | 40.80 | 107.9 | 11.70 | 551.8 | 23.10 | 160.2 | 20.00 | 5.60 | 1.97 | 4.5 | AB |

**Table 6.8 Correlations of sources, settlements, and artefacts**

| Site | Artefact | Type | TAS categorisation | Provenance | Proximate settlements |
|---|---|---|---|---|---|
| Tell es-Safi/Gath | **745050** | Lower grinding stone | BT | Jezreel Valley | Megiddo, Qishyon, Affula |
| Tell es-Safi/Gath | **745047** | Lower grinding stone | BT | Golan | Gamla, Leviah, Rujm el-Hin |
| Tell es-Safi/Gath | **1346093** | Lower grinding stone | BT | Jezreel Valley | Megiddo, Qishyon, Affula |
| Tell es-Safi/Gath | **748093** | Upper grinding stone | AB | | |
| Tell es-Safi/Gath | **745029** | Upper grinding stone | TB | Golan | Gamla, Leviah, Rujm el-Hin |
| Tell es-Safi/Gath | **748114** | Lower grinding stone | AB | | |
| Tell es-Safi/Gath | **1042042** | Lower grinding stone | AB | Mt. Hermon | Dan, Rafid |
| Tell es-Safi/Gath | **1144013** | Lower grinding stone | F | | |
| Tell es-Safi/Gath | **16E84A007** | Upper grinding stone | AB | HV | Hazor, Te'o |
| Tell es-Safi/Gath | **16E93B081** | Lower grinding stone | AB | HJ | Khirbet Batrawy |
| Tell es-Safi/Gath | **16E93A049** | Lower grinding stone | TB | Mt. Hermon | Dan, Rafid |
| Tell es-Safi/Gath | **16E93A050** | Lower grinding stone | AB | HV | Hazor, Te'o |
| Tell es-Safi/Gath | **16E93B070** | Lower grinding stone | BT | Golan | Gamla, Leviah, Rujm el-Hin |
| Tell es-Safi/Gath | **1143031** | Lower grinding stone | BT | Jezreel Valley | Megiddo, Qishyon, Affula |
| Tell es-Safi/Gath | **745019** | Lower grinding stone | F | | |
| Tell es-Safi/Gath | **745098** | Upper grinding stone | BT | HJ | Khirbet Batrawy |
| Tell es-Safi/Gath | **941057** | Lower grinding stone | AB | Mt. Hermon - northern sub-regions | Dan, Rafid |
| Tell es-Safi/Gath | **16E94A011** | Lower grinding stone | AB | Mt. Hermon | Dan, Rafid |
| Tell es-Safi/Gath | **16E84C012** | Lower grinding stone | AB | Mt. Hermon | Dan, Rafid |

## Table 6.9 Morphometric dimensions of basalt artefacts

| Artefact | Weight (g) | Length | Width | Thickness | Circumference | Depth | Height | Diameter | Typology |
|---|---|---|---|---|---|---|---|---|---|
| 745019 | 311.0 | 11.0 | 8.0 | **3.5** | | | | | Lower grinding stone |
| 745029 | 455.0 | 9.0 | 8.0 | **4.0** | | | | | Upper grinding stone |
| 745047 | 657.5 | 12.5 | 6.5 | **5.0** | | | | | Lower grinding stone |
| 745098 | 721.0 | 11.0 | **9.0** | **5.5** | | | | | Upper grinding stone |
| 745050 | 735.0 | 15.5 | 11.0 | **4.0** | | | | | Lower grinding stone |
| 746060 | **1004.0** | **12.0** | **7.0** | **5.5** | | | | | Upper grinding stone |
| 748093 | 497.0 | 10.0 | 8.5 | **4.0** | | | | | Upper grinding stone |
| 748110 | 762.0 | 14.5 | 12.0 | **3.0** | | | | | Lower grinding stone |
| 748114 | 380.0 | 10.0 | 7.5 | **4.0** | | | | | Lower grinding stone |
| 840111 | **221.0** | | | | **17.0** | | | | Pounder |
| 941057 | 2578.0 | 23.0 | **21.0** | **5.0** | | | | | Lower grinding stone |
| 944090 | 640.5 | 11.0 | 10.0 | **3.0** | | | | | Lower grinding stone |
| 1042024 | 62.0 | 4.5 | 3.0 | **4.0** | | | | | Upper grinding stone |
| 1042042 | 327.5 | 9.0 | 5.0 | **3.0** | | | | | Lower grinding stone |
| 1046004 | 174.5 | 9.5 | 5.0 | 4.0 | | | | | Upper grinding stone |
| 1048013 | 418.5 | 13.0 | 10.0 | **3.0** | | | | | Lower grinding stone |
| 1141073 | 157.0 | 5.0 | 4.0 | 3.0 | | | | | Lower grinding stone |
| 1143010 | 112.0 | 6.5 | 6.5 | **2.5** | | | | | Vessel |
| 1143031 | 1292.5 | 19.0 | **18.0** | **4.0** | | | | | Lower grinding stone |
| 1144013 | 469.5 | 11.0 | 7.0 | **3.5** | | | | | Lower grinding stone |
| 1346093 | 104.0 | 5.5 | 4.0 | **4.0** | | | | | Lower grinding stone |
| 1347085 | 182.5 | 4.5 | 4.0 | **4.0** | | | | | Lower grinding stone |
| E15AQ179 | 57.5 | 5.0 | 4.0 | **2.0** | | | | | Lower grinding stone |
| 16E84A007 | 1160.5 | 14.0 | **12.0** | **5.0** | | | | | Upper grinding stone |
| 16E84C012 | 8457.5 | 29.0 | 26.0 | **7.0** | | **3.5** | | | Lower grinding stone |
| 16E83C087 | 14.5 | | | | | | **1.5** | **3.5** | Weight |
| 16E93A049 | 315.5 | 7.0 | 7.0 | **4.0** | | | | | Lower grinding stone |
| 16E93A050 | 139.0 | 6.0 | 6.0 | **4.0** | | | | | Lower grinding stone |
| 16E93B070 | 123.0 | 6.5 | 6.0 | **3.5** | | | | | Lower grinding stone |
| 16E93B081 | 270.5 | 9.0 | 9.0 | **2.5** | | | | | Lower grinding stone |
| 16E94A011 | **17579.5** | **42.0** | **22.0** | **10.0** | | | | | Lower grinding stone |
| | | | | | | | | | |
| *** Intact/original dimensions appear in bold front** | | | | | | | | | |
| *** Dimensions are in centimetres (cm)** | | | | | | | | | |

## Table 6.10 Measurements of lower grinding stones

| Artefact | Length | Width | Thickness | Depth | Type 2 | Wright (1992) typology |
|---|---|---|---|---|---|---|
| 1141073 | 5.0 | 4.0 | 3.0 | | Lower grinding stone | Slab/quern fragment |
| 745019 | 11.0 | 8.0 | **3.5** | | Lower grinding stone | Slab/quern fragment |
| 745047 | 12.5 | 6.5 | **5.0** | | Lower grinding stone | Slab/quern fragment |
| 745050 | 15.5 | 11.0 | **4.0** | | Lower grinding stone | Slab/quern fragment |
| 748110 | 14.5 | 12.0 | **3.0** | | Lower grinding stone | Slab/quern fragment |
| 748114 | 10.0 | 7.5 | **4.0** | | Lower grinding stone | Saddle-shaped quern |
| 941057 | 23.0 | **21.0** | **5.0** | | Lower grinding stone | Saddle-shaped quern |
| 944090 | 11.0 | 10.0 | **3.0** | | Lower grinding stone | Slab/quern fragment |
| 1042042 | 9.0 | 5.0 | **3.0** | | Lower grinding stone | Slab/quern fragment |
| 1048013 | 13.0 | 10.0 | **3.0** | | Lower grinding stone | Slab/quern fragment |
| 1143031 | 19.0 | **18.0** | **4.0** | | Lower grinding stone | Saddle-shaped quern |
| 1144013 | 11.0 | 7.0 | **3.5** | | Lower grinding stone | Slab/quern fragment |
| 1346093 | 5.5 | 4.0 | **4.0** | | Lower grinding stone | Slab/quern fragment |
| 1347085 | 4.5 | 4.0 | **4.0** | | Lower grinding stone | Slab/quern fragment |
| E15AQ179 | 5.0 | 4.0 | **2.0** | | Lower grinding stone | Slab/quern fragment |
| 16E84C012 | 29.0 | 26.0 | **7.0** | **3.5** | Lower grinding stone | Basin quern |
| 16E93A049 | 7.0 | 7.0 | **4.0** | | Lower grinding stone | Saddle-shaped grinding slab |
| 16E93A050 | 6.0 | 6.0 | **4.0** | | Lower grinding stone | Slab/quern fragment |
| 16E93B070 | 6.5 | 6.0 | **3.5** | | Lower grinding stone | Slab/quern fragment |
| 16E93B081 | 9.0 | 9.0 | **2.5** | | Lower grinding stone | Slab/quern fragment |
| 16E94A011 | **42.0** | **22.0** | **10.0** | | Lower grinding stone | Boulder quern/slab |
| | | | | | | |
| | Average thickness = 3.79cm | | | | | |
| | Standard deviation of 1.08cm | | | | | |
| | | | | | | |
| *** Intact/original dimensions appear in bold front** | | | | | | |
| *** Dimensions are in centimetres (cm)** | | | | | | |

## Table 6.11 Measurements of upper grinding stones

| Artefact | Length | Width | Thickness | Type 2 | Wright (1992) typology |
|---|---|---|---|---|---|
| 1046004 | 9.5 | 5.0 | 4.0 | Upper grinding stone | Handstone fragment |
| 745098 | 11.0 | **9.0** | **5.5** | Upper grinding stone | Unifacial loaf handstone |
| 746060 | **12.0** | **7.0** | **5.5** | Upper grinding stone | Bifacial rectilinear/flat |
| 748093 | 10.0 | 8.5 | **4.0** | Upper grinding stone | Unifacial loaf handstone |
| 745029 | 9.0 | 8.0 | **4.0** | Upper grinding stone | Handstone fragment |
| 16E84A007 | 14.0 | **12.0** | **5.0** | Upper grinding stone | Unifacial loaf handstone |
| 1042024 | 4.5 | 3.0 | **4.0** | Upper grinding stone | Handstone fragment |
| | | | | | |
| | Average thickness = 4.67cm | | | | |
| | | | | | |
| *** Intact/original dimensions appear in bold front** | | | | | |
| *** Dimensions are in centimetres (cm)** | | | | | |

## Table 6.12 Cultural polish location and intensity on basalt artefacts

| Artefact | Location of cultural polish | Intensity of cultural polish | Typology |
|---|---|---|---|
| 745019 | Face, dorsal side | Medium, low | Lower grinding stone |
| 745029 | Face | Medium | Upper grinding stone |
| 745047 | Face, dorsal side | Medium, low | Lower grinding stone |
| 745098 | Face, dorsal side | High, low | Upper grinding stone |
| 745050 | Face, dorsal side | High, medium | Lower grinding stone |
| 944090 | Face, dorsal side | Medium, low | Lower grinding stone |
| 746060 | Face, dorsal side | High, medium | Upper grinding stone |
| 748093 | Face, dorsal side | High, medium | Upper grinding stone |
| 748110 | Face, dorsal side | High, low | Lower grinding stone |
| 748114 | Face, dorsal side | High, low | Lower grinding stone |
| 840111 | Entire | Medium | Pounder |
| 941057 | Face, dorsal side | High, medium | Lower grinding stone |
| 1042024 | Face, dorsal side | High, medium | Upper grinding stone |
| 1042042 | Face, dorsal side | High, low | Lower grinding stone |
| 1046004 | Face, dorsal side | High, medium | Upper grinding stone |
| 1048013 | Face, dorsal side | High, medium | Lower grinding stone |
| 1141073 | Face, dorsal side | Medium, low | Lower grinding stone |
| 1143010 | Entire | Medium | Vessel |
| 1143031 | Face, dorsal side | High, medium | Lower grinding stone |
| 1144013 | Face, dorsal side | High, low | Lower grinding stone |
| 1346093 | Face | High | Lower grinding stone |
| 1347085 | Face, dorsal side | High, medium | Lower grinding stone |
| E15AQ179 | Face, dorsal side | High, low | Lower grinding stone |
| 16E84A007 | Face, dorsal side | High, medium | Upper grinding stone |
| 16E84C012 | Face, dorsal side | High, medium | Lower grinding stone |
| 16E83C087 | Perforation, sides | Medium, medium | Weight |
| 16E93A049 | Face, dorsal side | High, low | Lower grinding stone |
| 16E93A050 | Face, dorsal side | High, medium | Lower grinding stone |
| 16E93B070 | Face, dorsal side | High, low | Lower grinding stone |
| 16E93B081 | Face, dorsal side | High, low | Lower grinding stone |
| 16E94A011 | Face | Medium | Lower grinding stone |

**Table 6.13 Cultural polish on lower grinding stones**

| Location of polish | Intensity of polish | # of lower grinding stones |
|---|---|---|
| Face | High | 16 |
| | Medium | 5 |
| Dorsal side | Medium | 7 |
| | Low | 12 |

**Table 6.14 Cultural polish on upper grinding stones**

| Location of polish | Intensity of polish | # of upper grinding stones |
|---|---|---|
| Face | High | 6 |
| | Medium | 1 |
| Dorsal side | Medium | 5 |
| | Low | 1 |

**Table 6.15 Cultural polish breakdown on basalt artefacts**

| Polish type | Location | Intensity | # of artefacts |
|---|---|---|---|
| Cultural | Face | High | 22 |
| | | Medium | 6 |
| | Perforation | Medium | 1 |
| | Entire | Medium | 2 |
| | Sides | Medium | 2 |
| | Dorsal sides | Medium | 11 |
| | | Low | 13 |

**Table 6.16 Basalt artefacts of Stratum E6**

| Square | Artefact | Stratum | Type 2 |
|---|---|---|---|
| 83C | E15AQ179 | **E6** | Lower grinding stone |
| 93A | 16E93A049 | **E6** | Lower grinding stone |
| 93A | 16E93A050 | **E6** | Lower grinding stone |

## Table 6.17 Basalt artefacts of Stratum E5

| Square | Artefact | Phase | Type 2 |
|---|---|---|---|
| | | | |
| 93A | 941057 | E5 | Lower grinding stone |
| 93B | 16E93B081 | E5 | Lower grinding stone |
| 83A | 1046004 | E5 | Upper grinding stone |
| 84C | 16E84C012 | E5 | Lower grinding stone |
| 83A | 1143010 | E5 | Vessel |
| | | | |
| 93A | 1347085 | E5a | Lower grinding stone |
| 94A | 16E94A011 | E5a | Lower grinding stone |
| 83B | 944090 | E5a | Lower grinding stone |
| 93B | 1042024 | E5a | Upper grinding stone |
| 93B | 1042042 | E5a | Lower grinding stone |
| 83D | 746060 | E5a | Upper grinding stone |
| 73D-83B | 748093 | E5a | Upper grinding stone |
| 73D | 748110 | E5a | Lower grinding stone |
| 73D-83B | 748114 | E5a | Lower grinding stone |
| 83C | 840111 | E5a | Pounder |
| 73D-83D | 1048013 | E5a | Lower grinding stone |
| 93A | 1141073 | E5a | Lower grinding stone |
| 83C | 16E83C087 | E5a | Weight |
| 93B | 16E93B070 | E5a | Lower grinding stone |
| | | | |
| 84A | 16E84A007 | E5b | Upper grinding stone |
| 83B | 745019 | E5b | Lower grinding stone |
| 83B | 745029 | E5b | Upper grinding stone |
| 83B | 745047 | E5b | Lower grinding stone |
| 83B | 745098 | E5b | Upper grinding stone |
| 83B | 745050 | E5b | Lower grinding stone |
| 83A | 1143031 | E5b | Lower grinding stone |
| 93B | 1144013 | E5b | Lower grinding stone |
| | | | |
| 83D | 1346093 | E5c | Lower grinding stone |

**Table 6.18 Size of excavated area of each Phase in Stratum E5**

| Phase | Size (m) | # of basalt artefacts |
|---|---|---|
| E5a | 15 x 20 | 14 |
| E5b | 10 x 20 | 8 |
| E5c | 5 x 10 | 1 |

**Table 6.19 Condition and use-life stage of basalt ground stone artefacts**

| Artefact | Condition | # of fragments | ca. % remaining | Ancient fracture? | ca. # of ancient fractures | Modern fracture? | ca. # of modern fractures | Type 2 | Use-life stage |
|---|---|---|---|---|---|---|---|---|---|
| 745019 | Fractured | 1 | 5 | *could not be assessed* | | *could not be assessed* | | Lower grinding stone | Unknown |
| 745029 | Fractured | 1 | 10 | Yes | 4 | | | Upper grinding stone | Unknown |
| 745047 | Fractured | 1 | 10 | *could not be assessed* | | *could not be assessed* | | Lower grinding stone | Unknown |
| 745098 | Fractured | 1 | 25 | Yes | 3 | Yes | 1 | Upper grinding stone | Unknown |
| 745050 | Fractured | 1 | 35 | *could not be assessed* | | *could not be assessed* | | Lower grinding stone | Unknown |
| 746060 | Whole | 1 | 100 | | | | | Upper grinding stone | Unknown |
| 748093 | Fractured | 1 | 35 | Yes | 2 | Yes | 1 | Upper grinding stone | Unknown |
| 748110 | Fractured | 1 | 35 | *could not be assessed* | | *could not be assessed* | | Lower grinding stone | Unknown |
| 748114 | Fractured | 1 | 10 | Yes | 3 | | | Lower grinding stone | Unknown |
| 840111 | Whole | 1 | 100 | | | | | Pounder | Primary |
| 941057 | Fractured | 1 | 35 | Yes | 1 | | | Lower grinding stone | Secondary - sequential |
| 944090 | Fractured | 1 | 10 | Yes | 4 | Yes | 1 | Lower grinding stone | Secondary - sequential |
| 1042024 | Fractured | 1 | 5 | Yes | 5 | | | Upper grinding stone | Unknown |
| 1042042 | Fractured | 1 | 5 | Yes | 4 | | | Lower grinding stone | Discard |
| 1046004 | Fractured | 1 | 10 | Yes | 2 | | | Upper grinding stone | Unknown |
| 1048013 | Fractured | 1 | 10 | Yes | 3 | | | Lower grinding stone | Unknown |
| 1141073 | Fractured | 2 | 5 | Yes | 8-10 | Yes | | Lower grinding stone | Secondary - sequential |
| 1143010 | Fractured | 1 | 5 | Yes | 3 | | | Vessel | Unknown |
| 1143031 | Fractured | 1 | 35 | Yes | 1 | | | Lower grinding stone | Discard |
| 1144013 | Fractured | 1 | 5 | Yes | 4 | | | Lower grinding stone | Unknown |
| 1346093 | Fractured | 1 | 5 | Yes | 1 | | 1 | Lower grinding stone | Unknown |
| 1347085 | Fractured | 1 | 5 | Yes | 4 | | | Lower grinding stone | Discard |
| E15AQ179 | Fractured | 1 | 5 | Yes | 8-10 | | | Lower grinding stone | Discard |
| 16E84A007 | Fractured | 1 | 35 | Yes | 1 | Yes | 1 | Upper grinding stone | Secondary - sequential |
| 16E84C012 | Fractured | 1 | 35 | Yes | 8-10 | | | Lower grinding stone | Unknown |
| 16E83C087 | Fractured | 1 | 50 | Yes | 1 | | | Wright | Discard |
| 16E93A049 | Fractured | 1 | 5 | Yes | 3 | | | Lower grinding stone | Secondary - sequential |
| 16E93A050 | Fractured | 1 | 5 | Yes | 4 | | | Lower grinding stone | Secondary - sequential |
| 16E93B070 | Fractured | 1 | 5 | *could not be assessed* | | *could not be assessed* | | Lower grinding stone | Discard |
| 16E93B081 | Fractured | 1 | 25 | Yes | 4 | | | Lower grinding stone | Secondary - sequential |
| 16E94A011 | Whole | 1 | 100 | | | | | Lower grinding stone | Primary |

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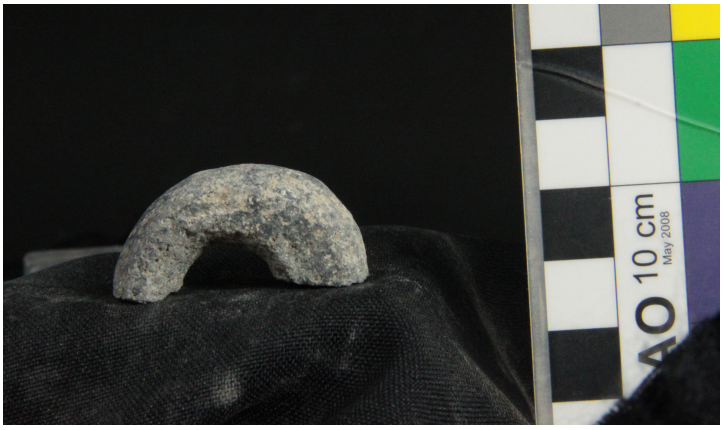
# Appendices

## Appendix 1: List of abbreviations used in thesis

| Abreviation | Term |
|---|---|
| wt% | weight percentage |
| SiO2 | Silicon dioxide |
| Rb | Rubidium |
| Y | Yttrium |
| Sr | Strontium |
| Ni | Nickel |
| KKW | Khirbet Kerak Ware |
| NCMW | Northern Canaanite Metallic Ware |
| TAS | Total alkali vs. silica |
| XRF | X-ray fluorescence |
| ICP-MS | Inductively coupled plasma mass spectroscopy |
| NAA | Neutron activation analysis |
| ED-XRF | Energy dispersal x-ray fluorescence |
| JV | Jezreel Valley |
| HV | Hulah Valley |
| K-SG | Korazim - Sea of Galilee |
| SELG | Southeastern Lower Galilee |
| MH | Mount Hermon |
| HJ | Harra el-Jabbar |
| NE | Northern Egypt |
| SE | Southern Egypt |

## Appendix 2: Basalt ground stone photos

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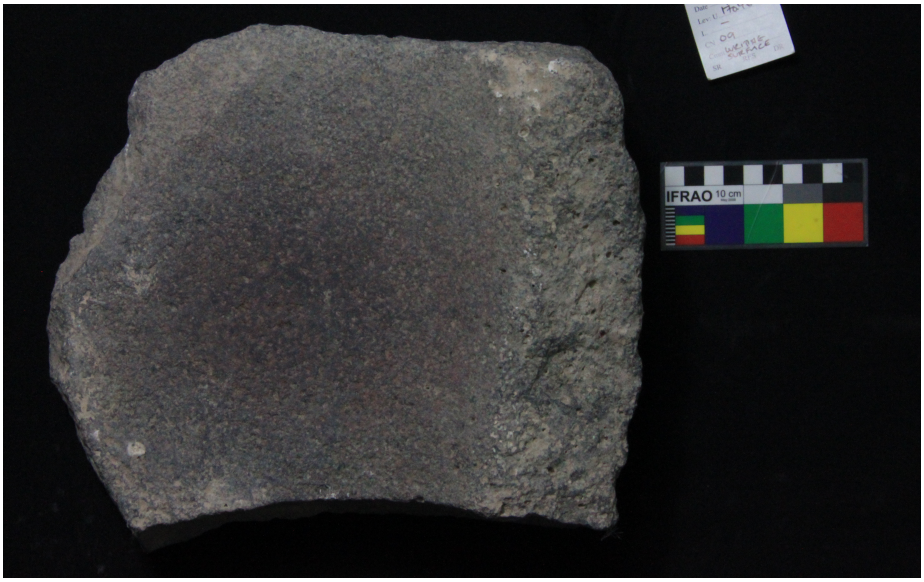



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**16E84C012**





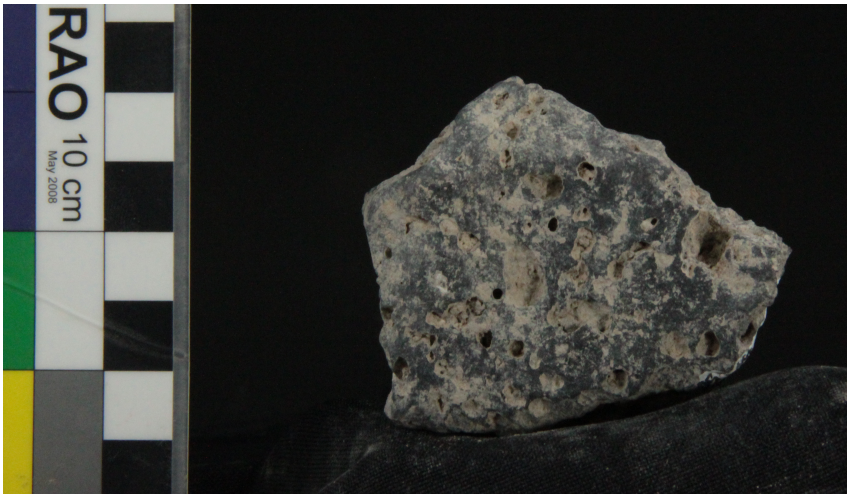

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**16E93A050**



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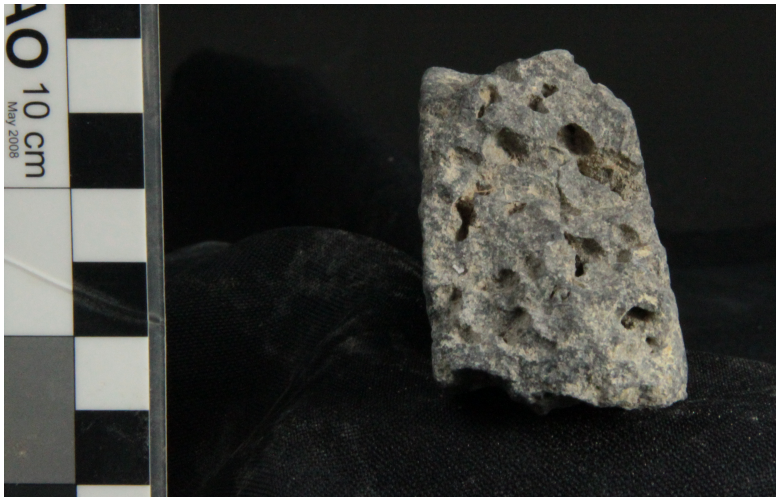

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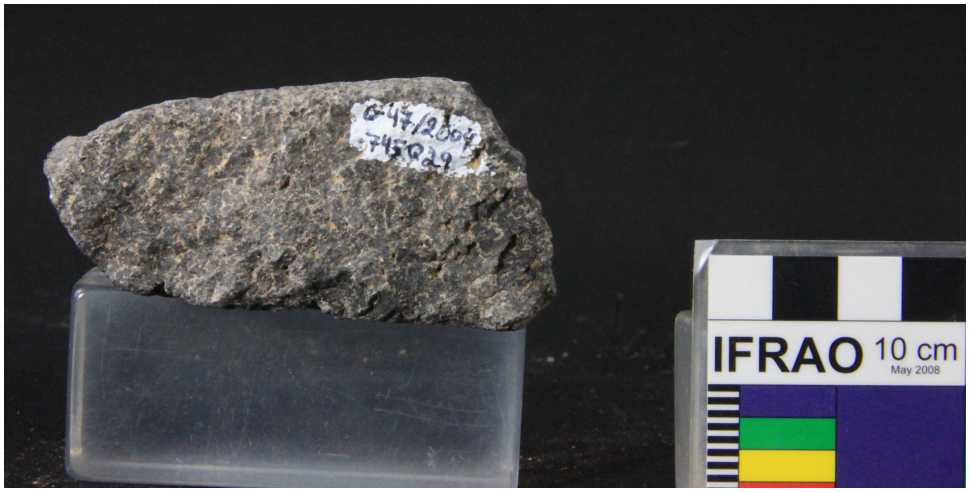
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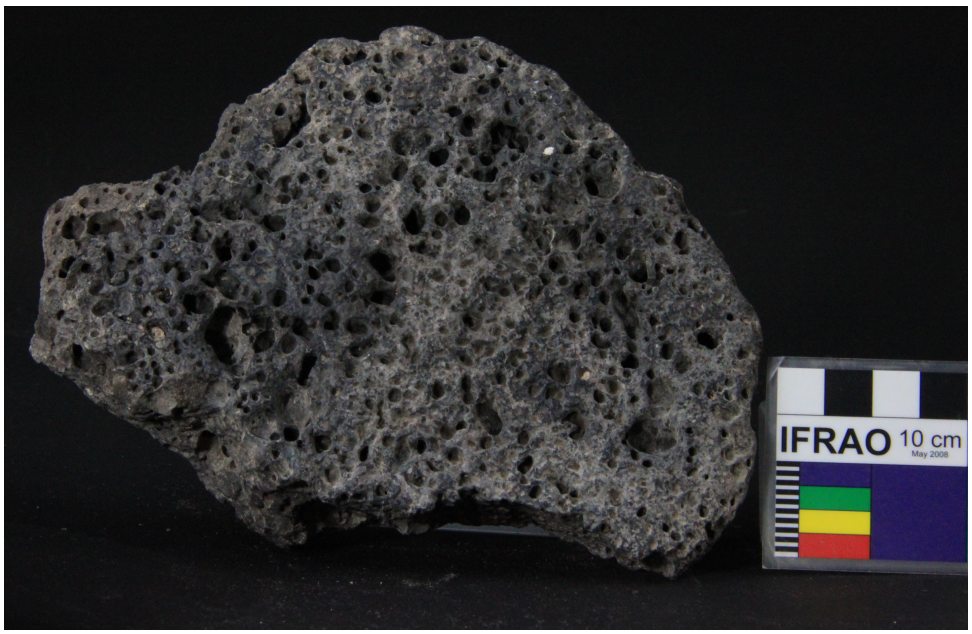



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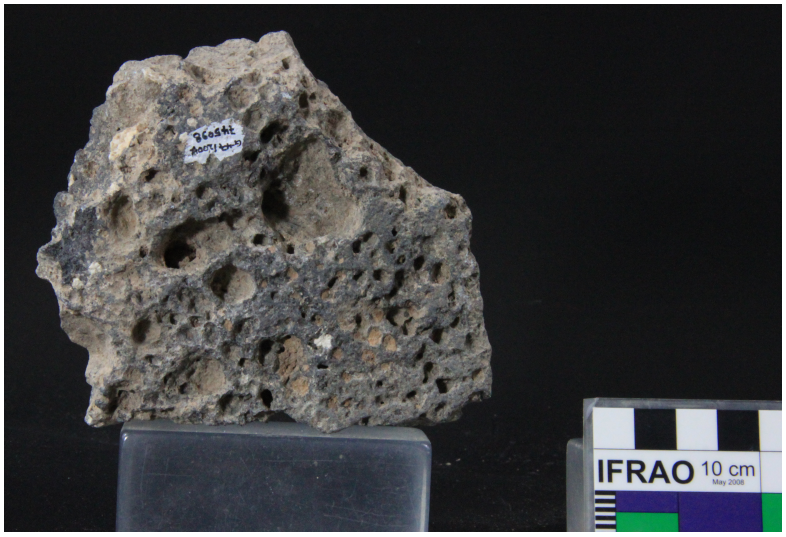



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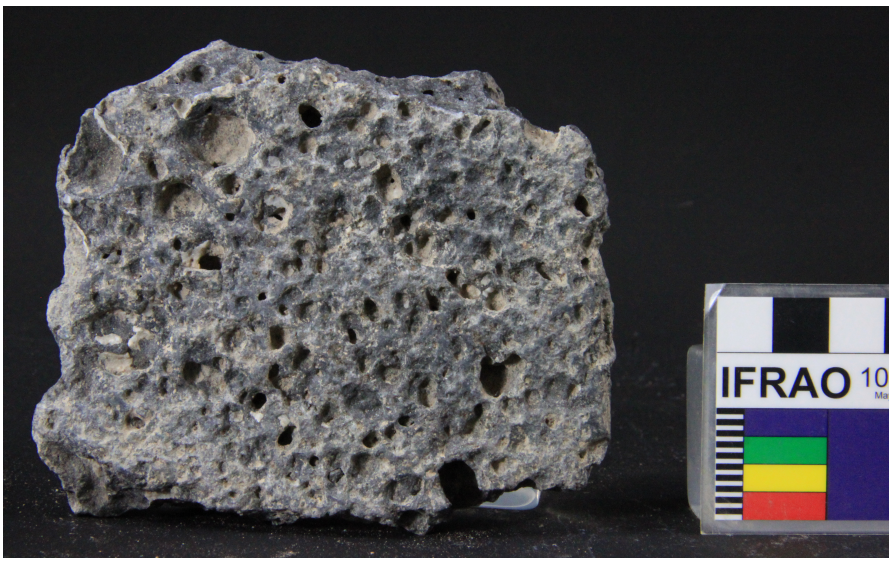


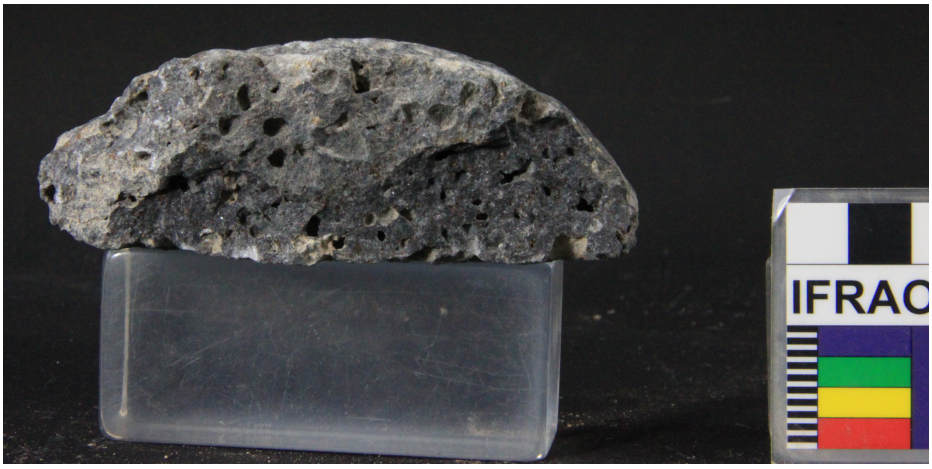

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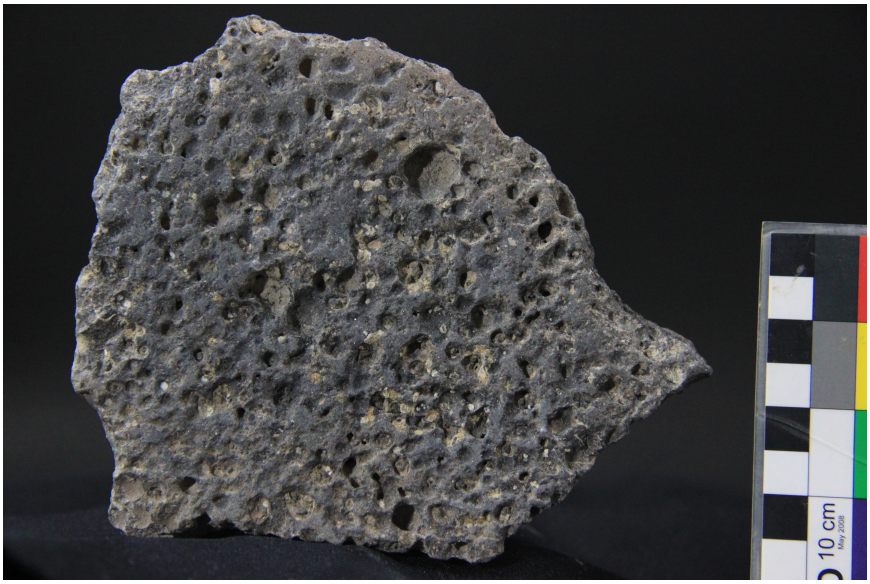



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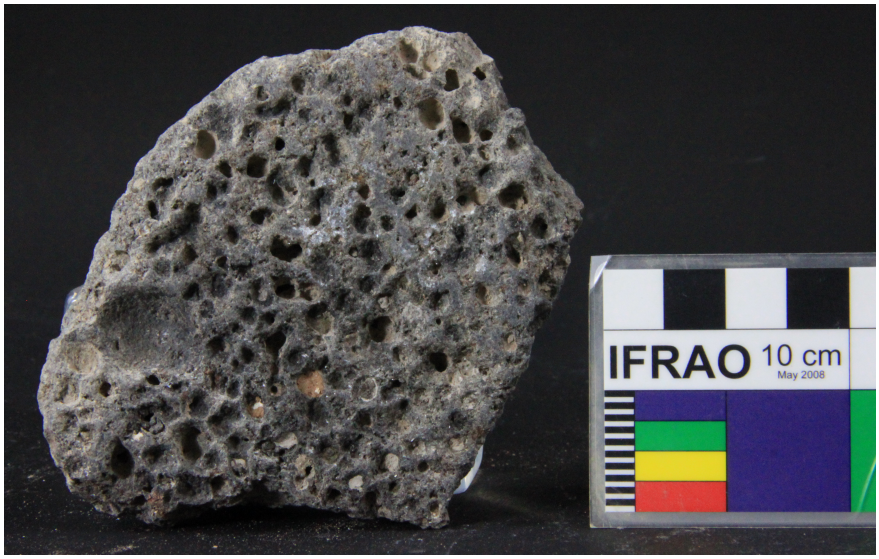



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**748114**







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**941057**






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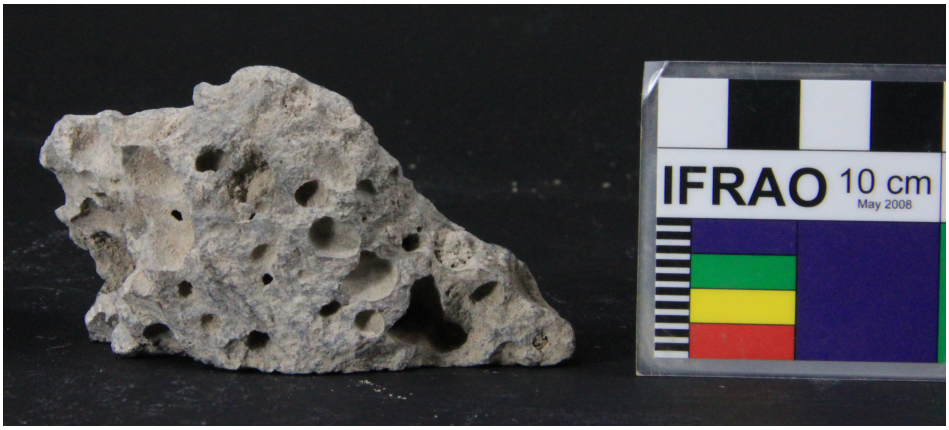
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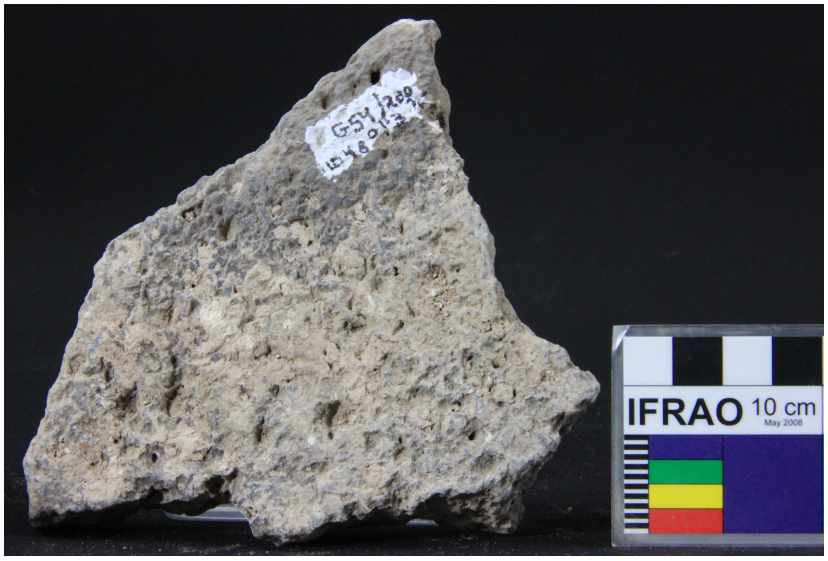
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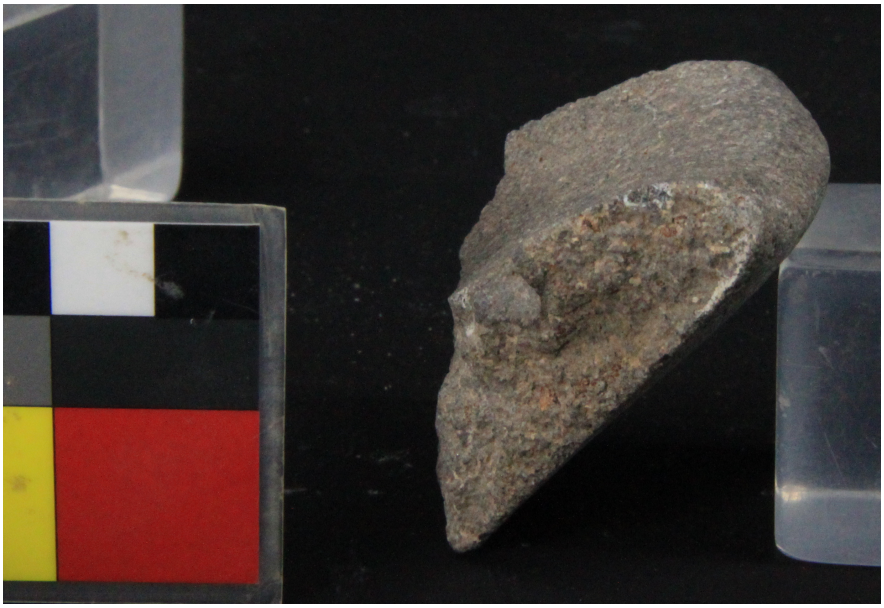




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**1143010**



**E15AQ179**



**1143031**





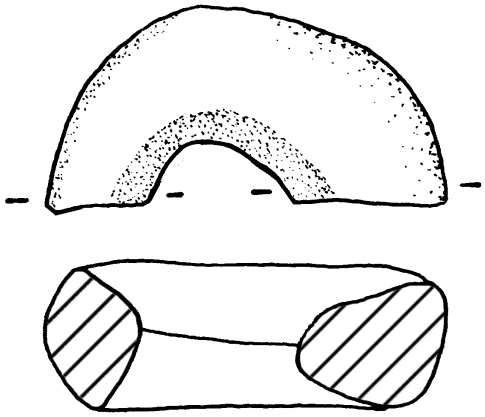

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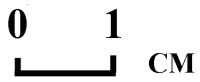




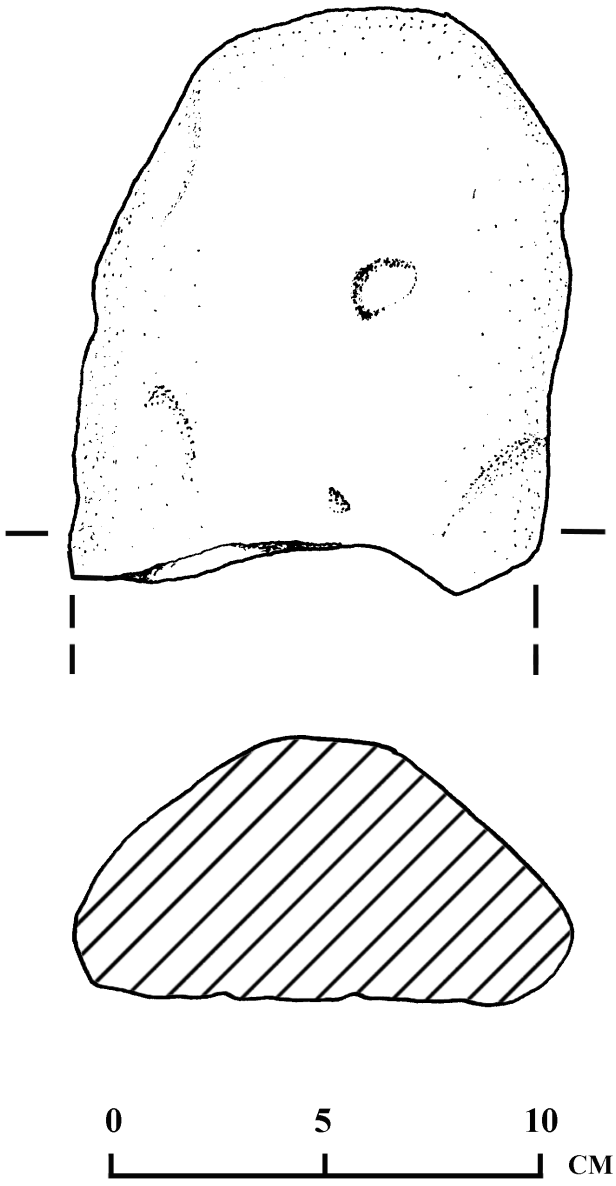

**Appendix 3: Basalt ground stone drawings**

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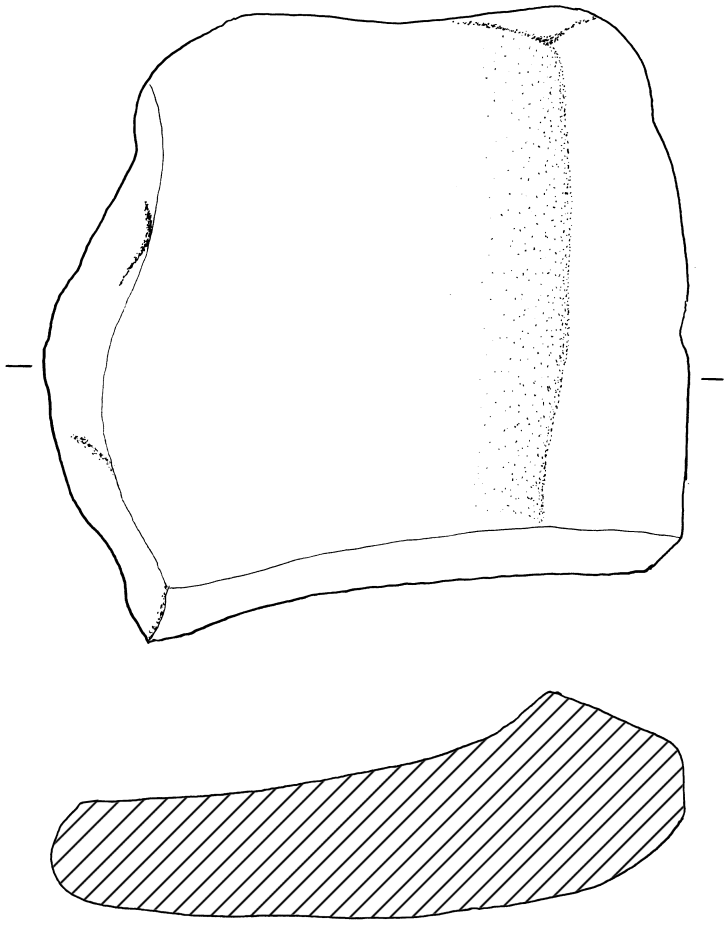




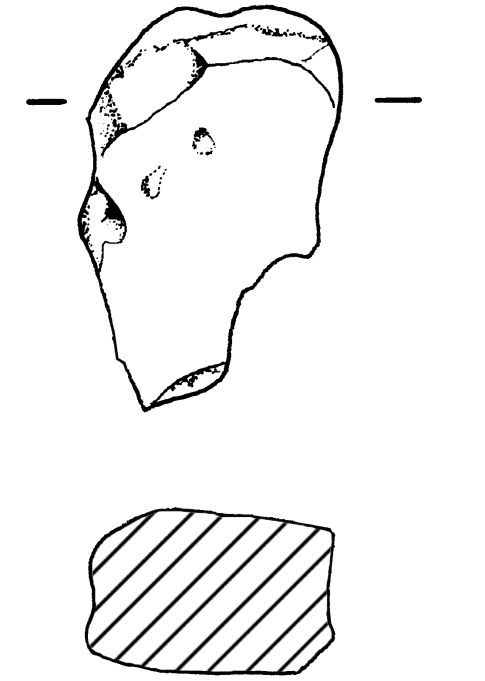
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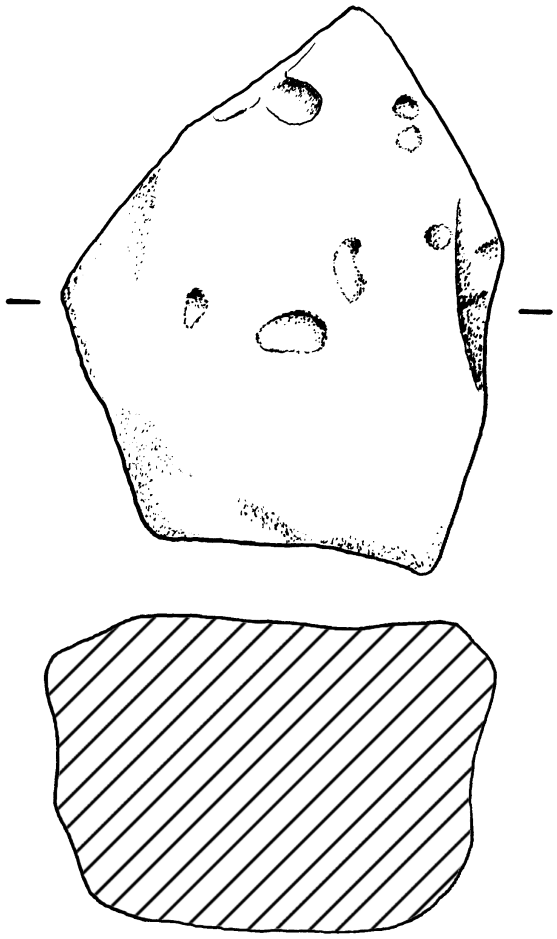
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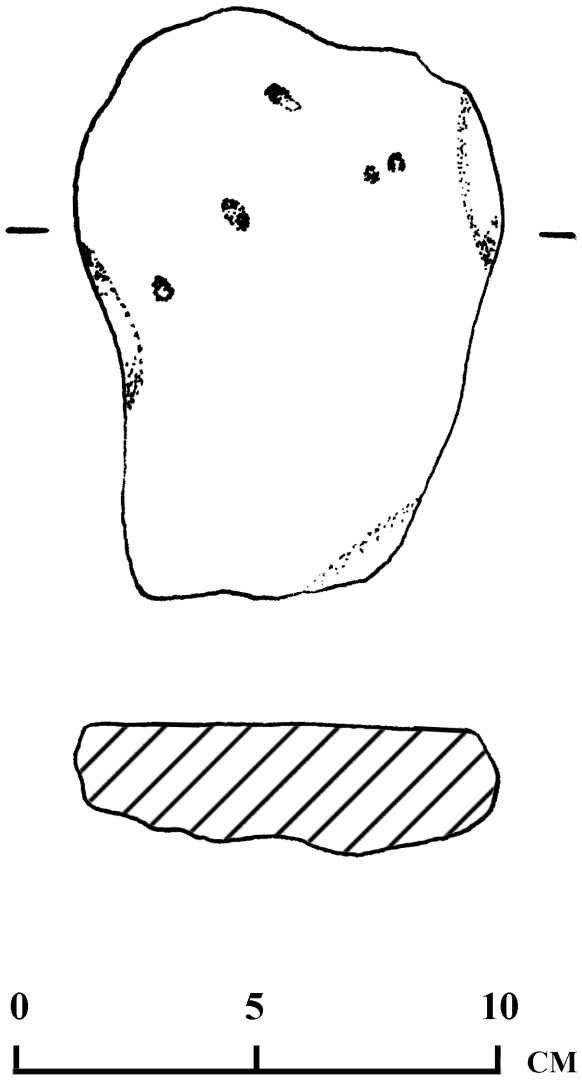
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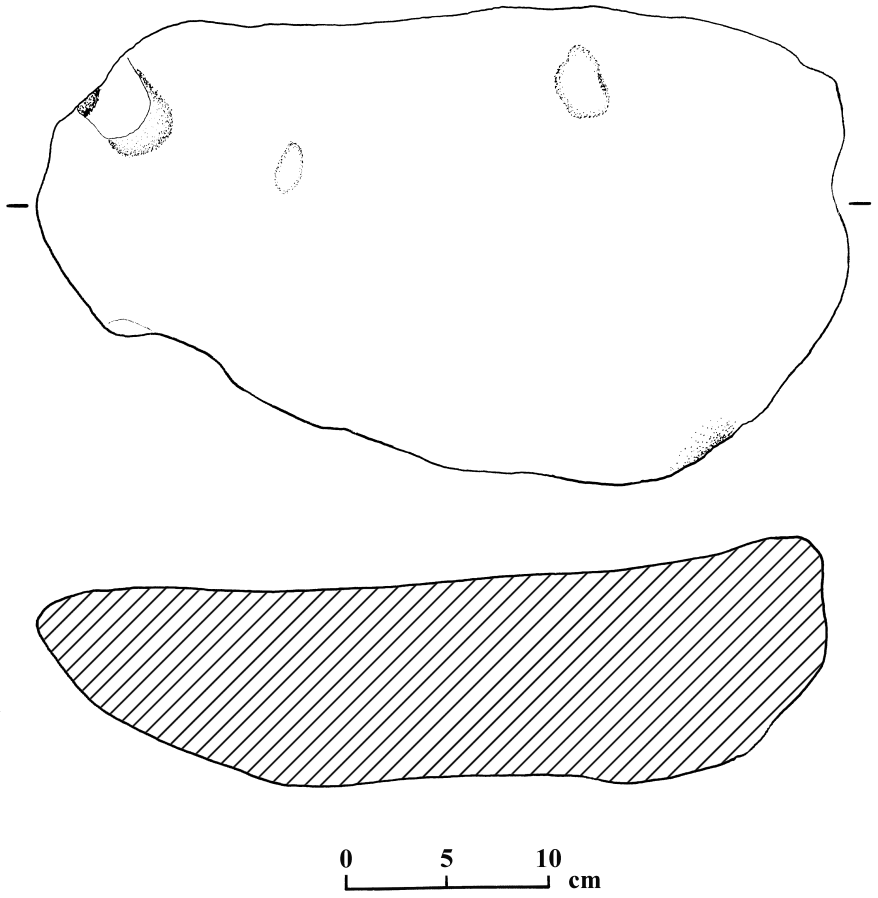
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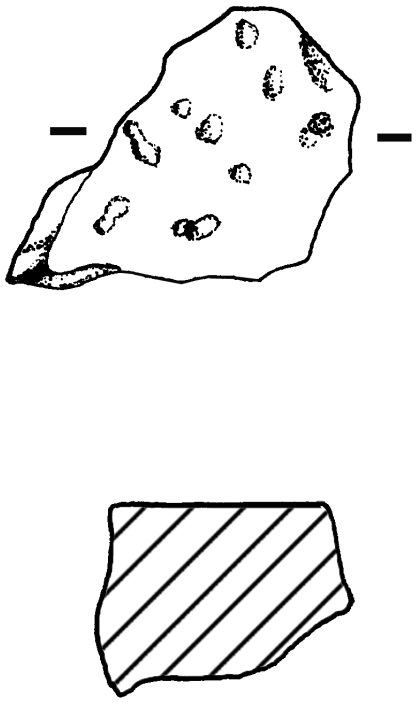
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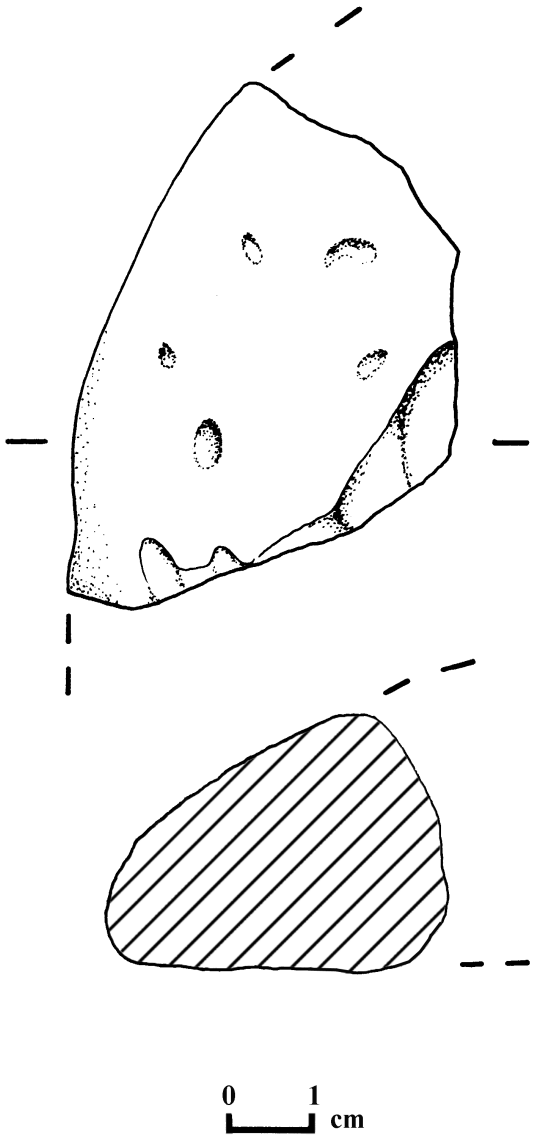


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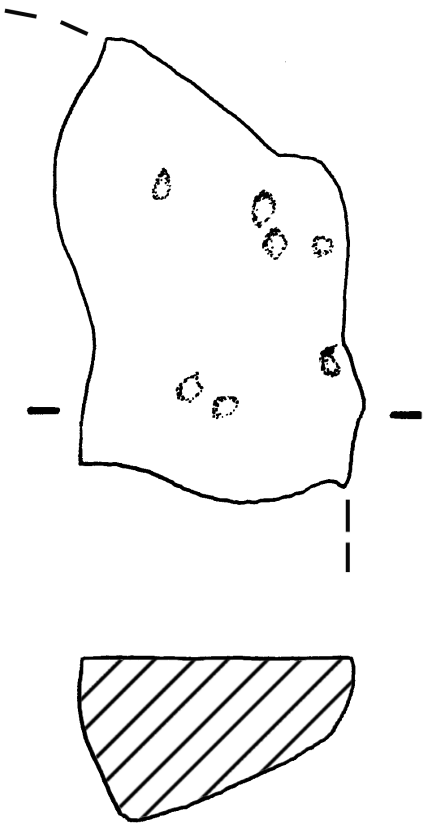


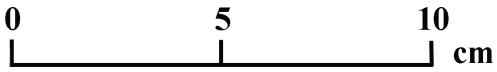


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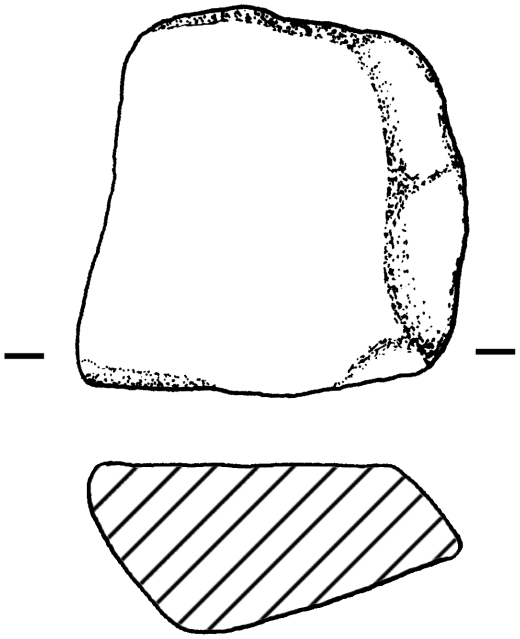


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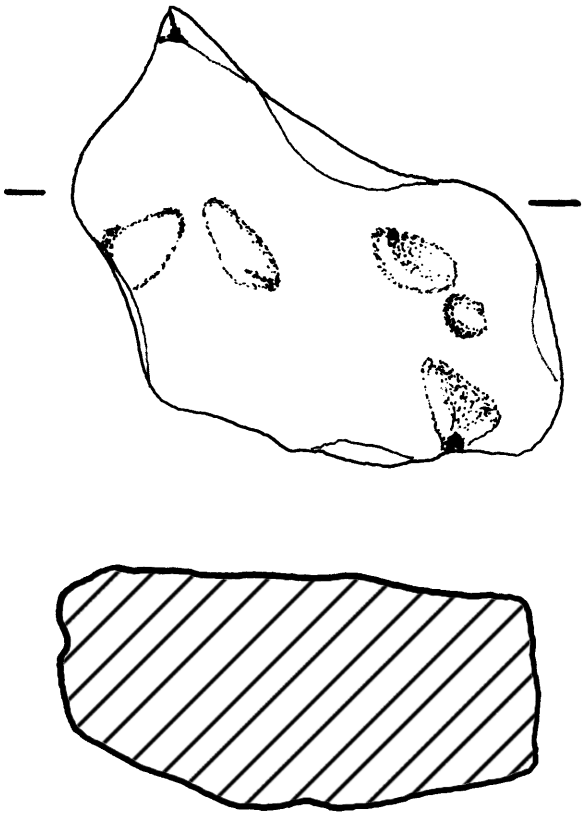


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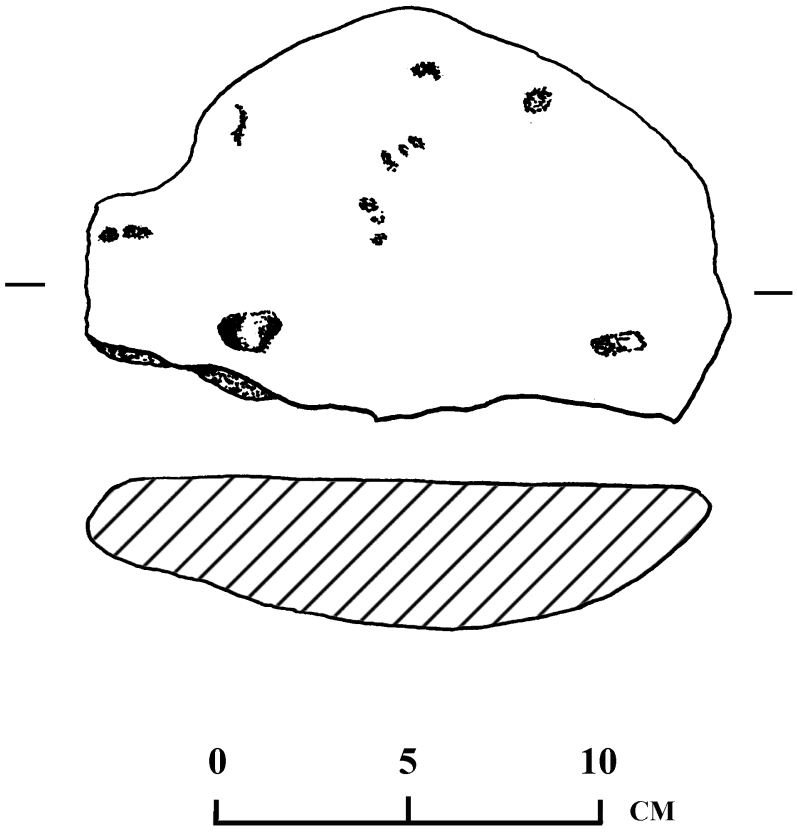




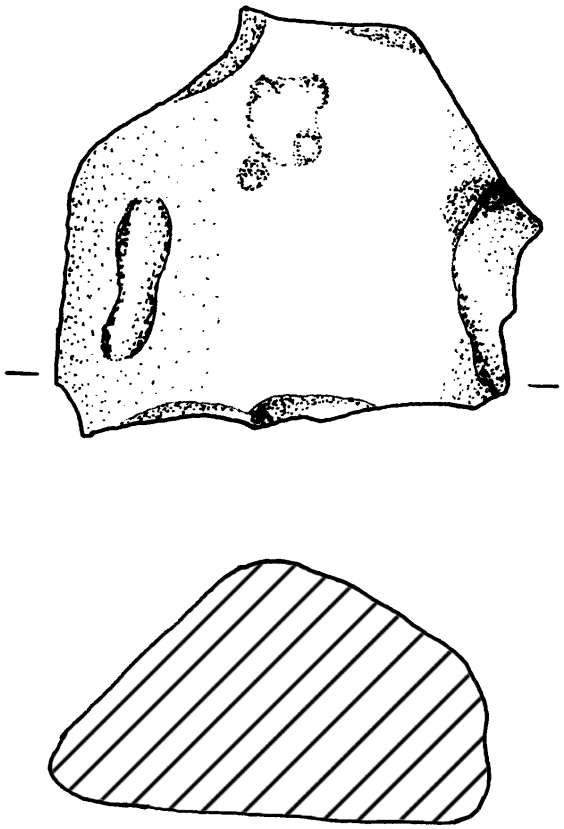
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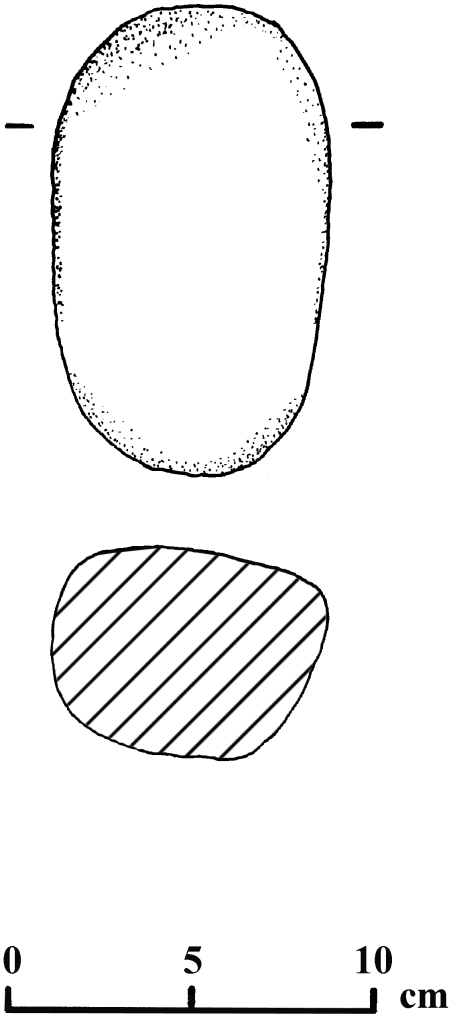
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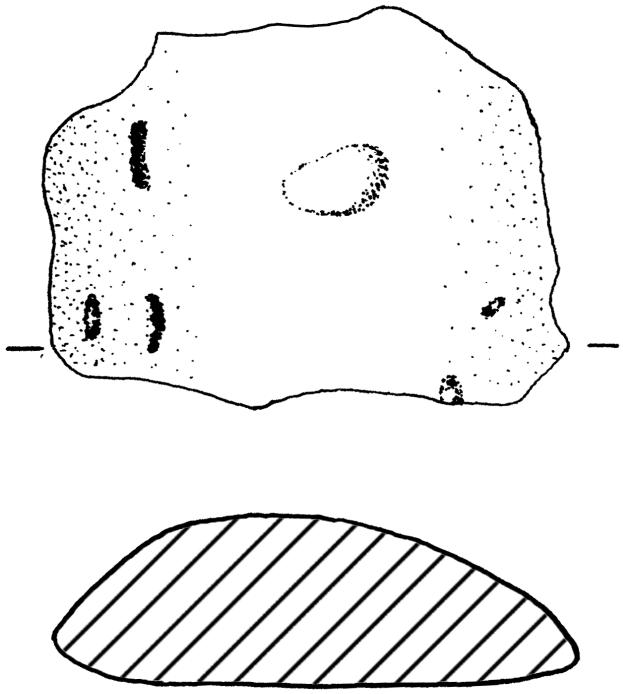
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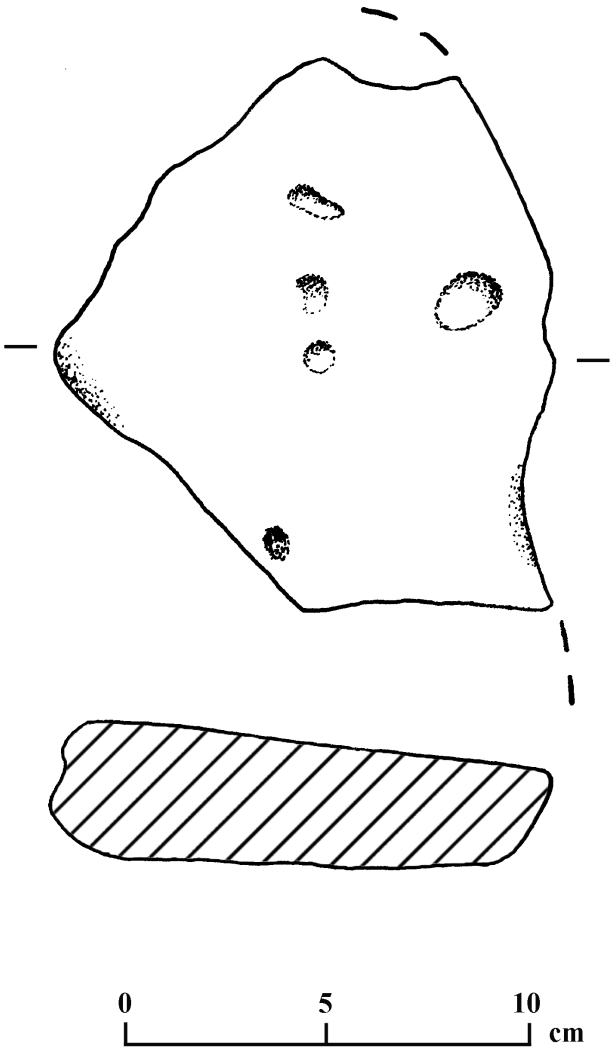
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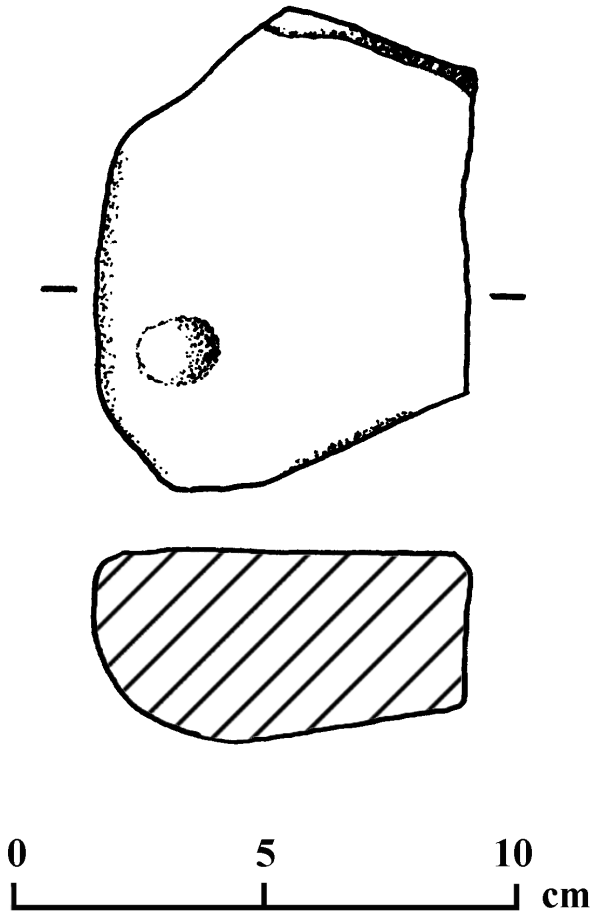
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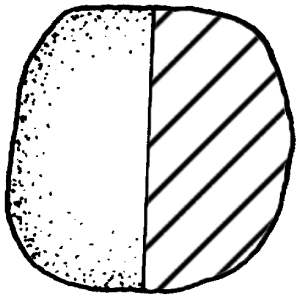
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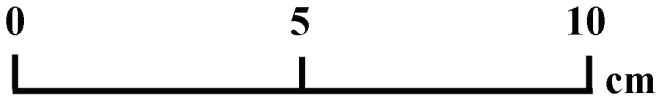


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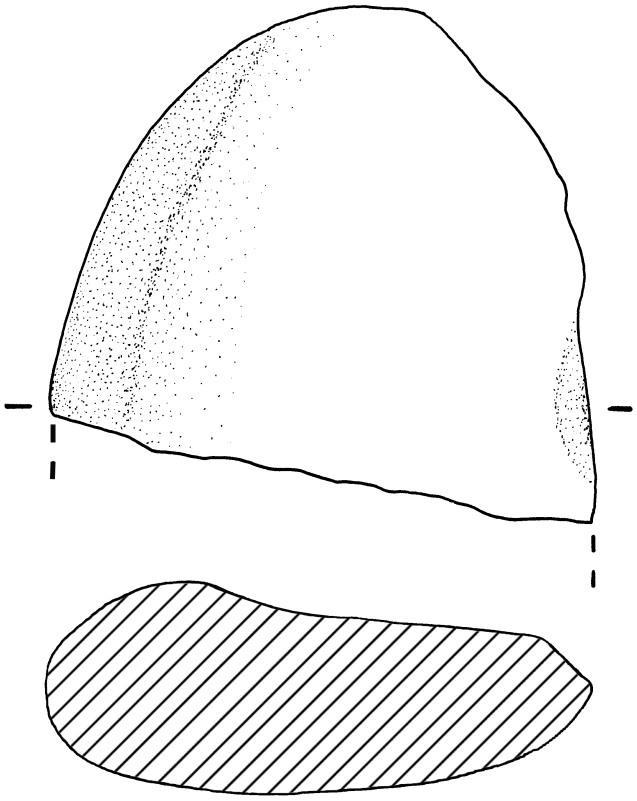


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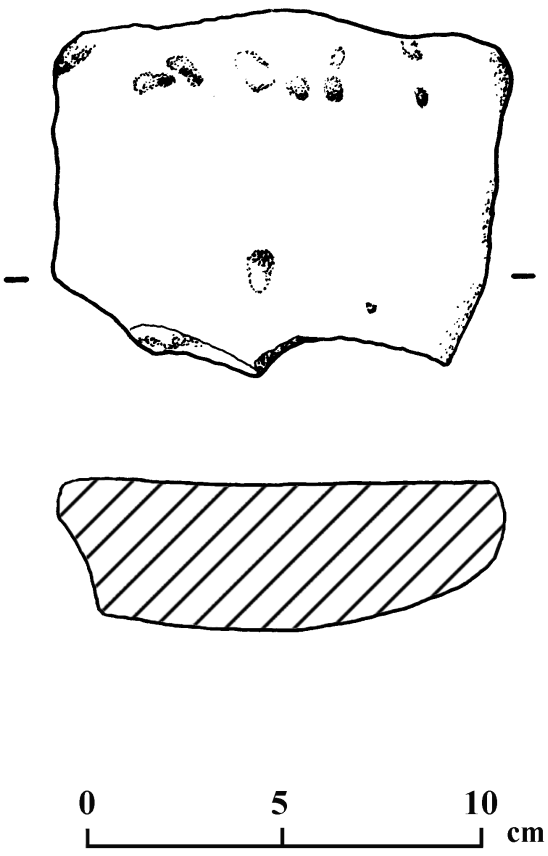




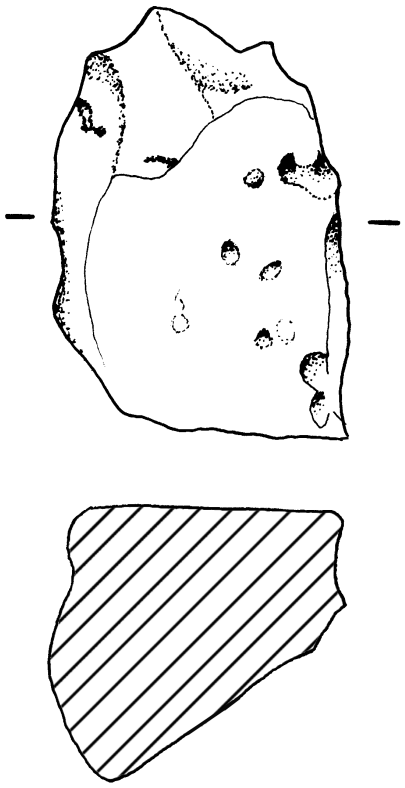
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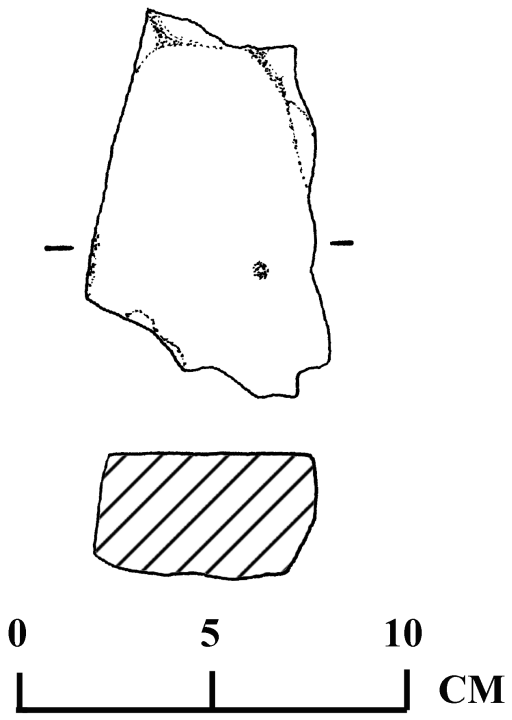
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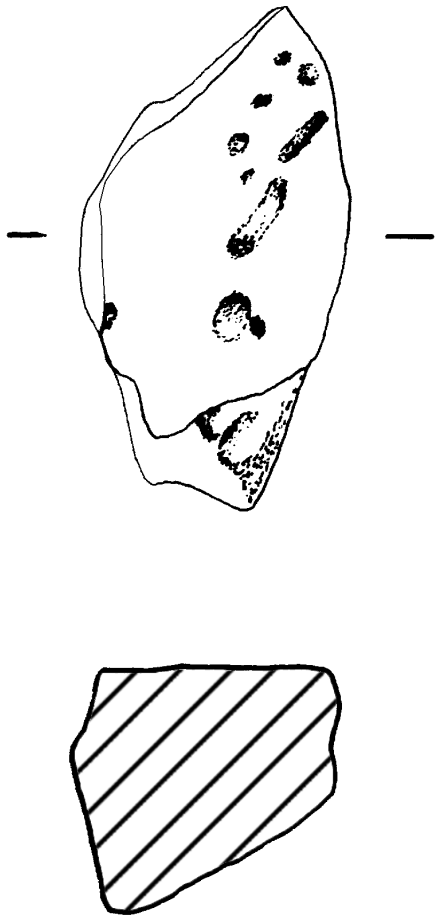
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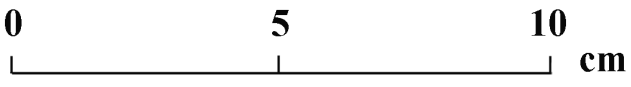


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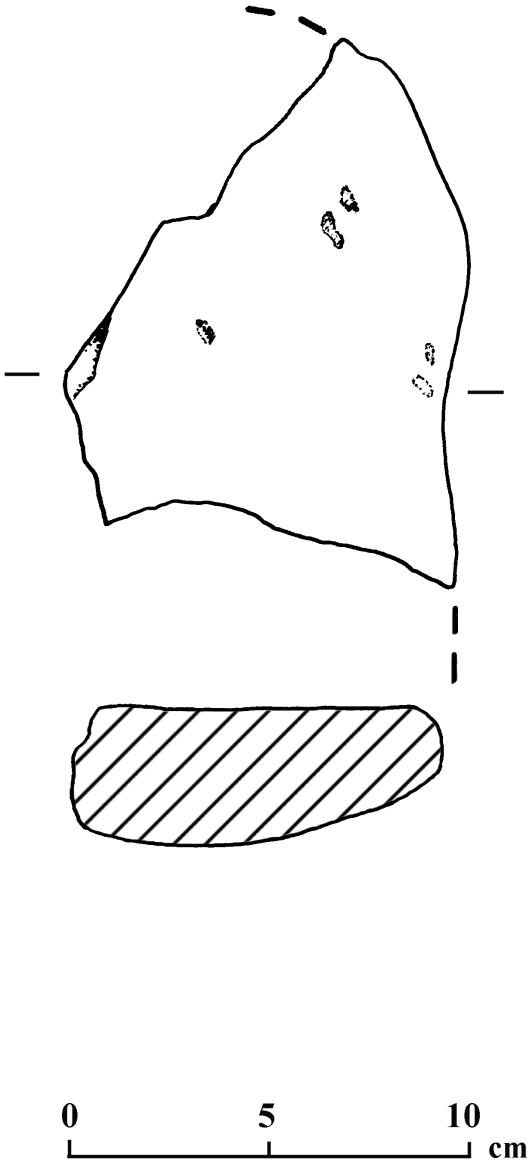


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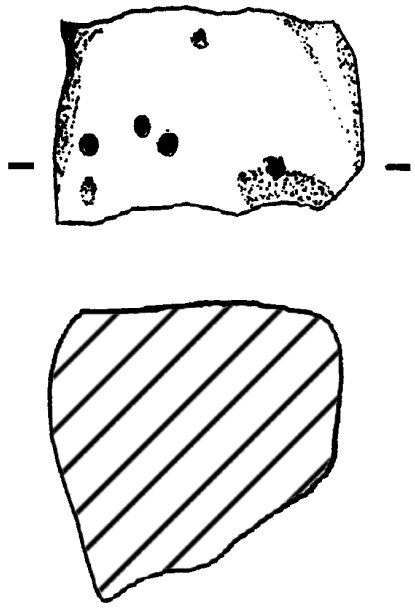


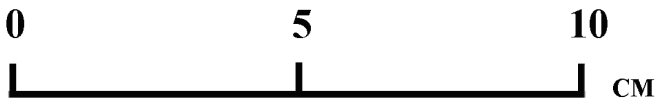


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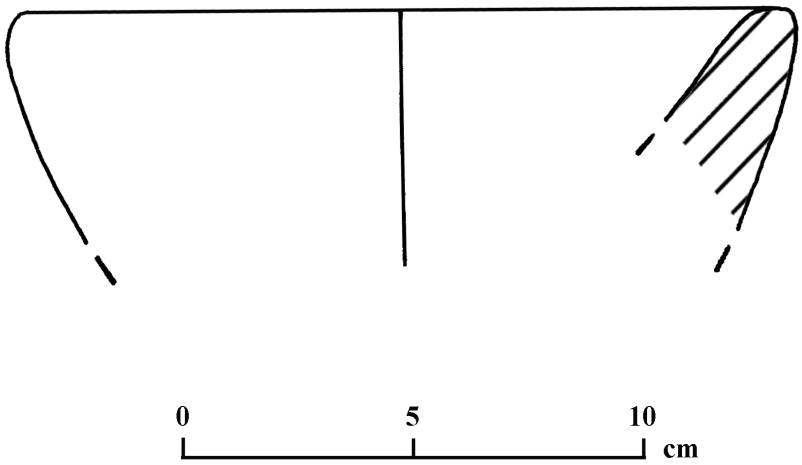


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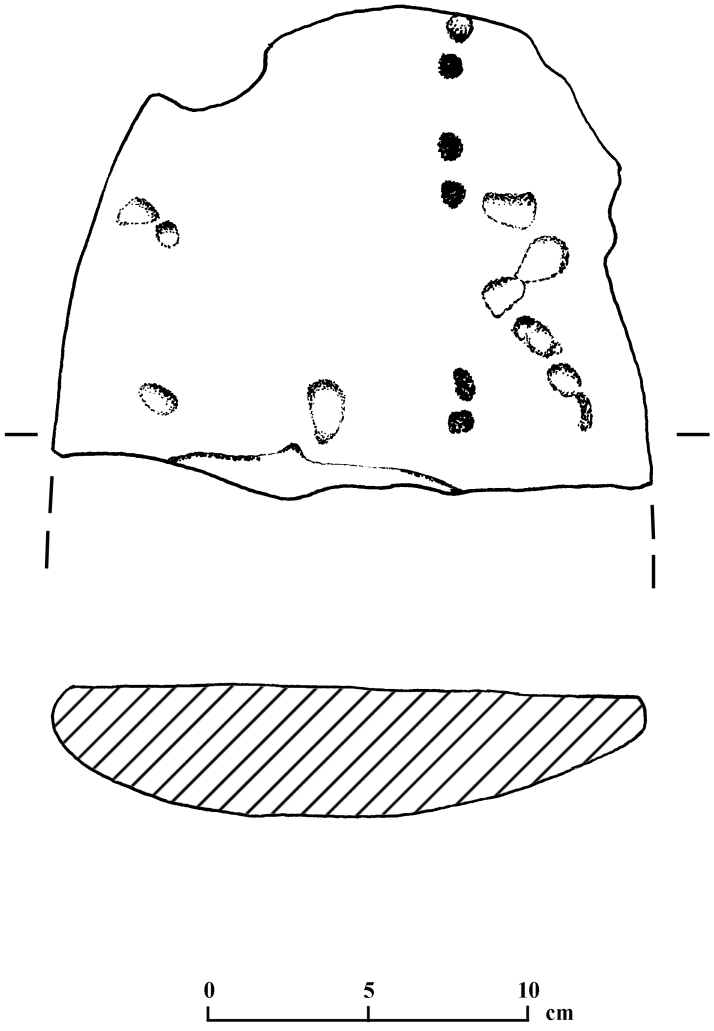




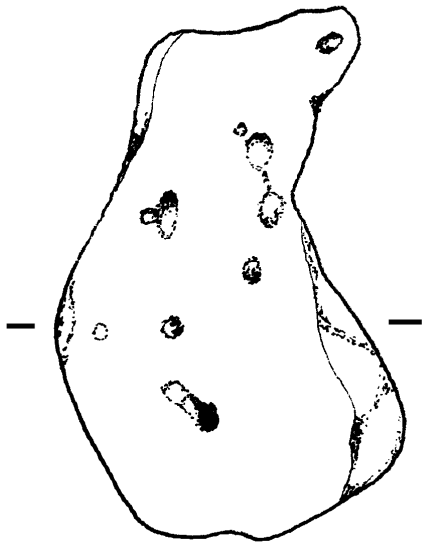
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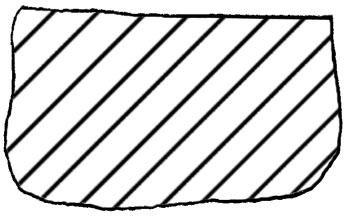


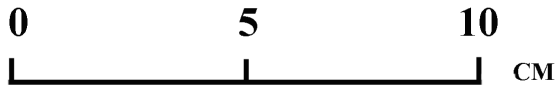
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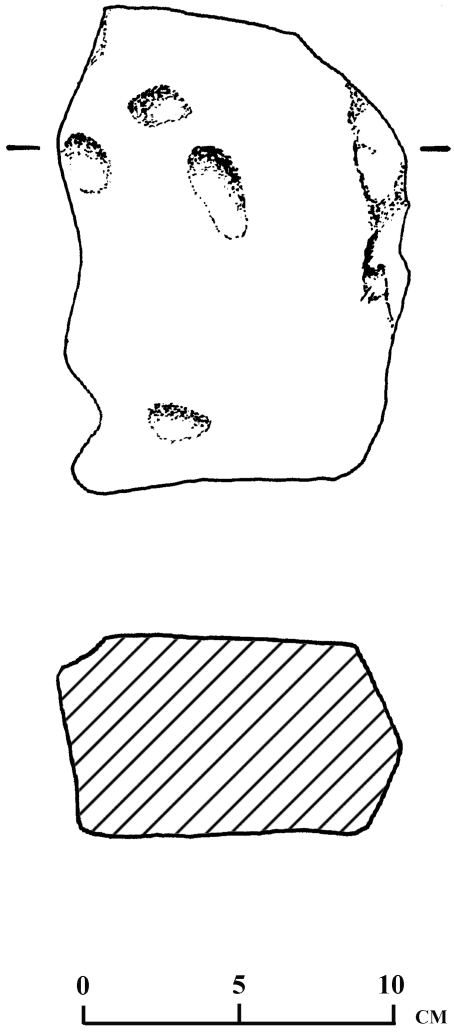
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**E15AQ179**



# Appendix 4: Averaged geochemical data of Near East sources

| Sub-region | Site | Sample | SiO2 | Na2O | K2O | Na2O + K2O | Publication |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **HULAH VALLEY** | HV | Wy-315 | 47.60 | 4.07 | 1.19 | 5.26 | Weinstein 2012 |
| | HV | Wy-317 | 47.90 | 2.97 | 0.68 | 3.65 | Weinstein 2012 |
| | HV | Wy-317a | 47.00 | 2.78 | 0.66 | 3.44 | Weinstein 2012 |
| | HV | Wy-390 | 47.90 | 3.14 | 1.16 | 4.30 | Weinstein 2012 |
| | HV | Wy-394 | | | | | Weinstein 2012 |
| | HV | Wy-395 | 47.20 | 2.50 | 1.10 | 3.60 | Weinstein 2012 |
| | HV | Wy-397 | 46.60 | 3.10 | 1.20 | 4.30 | Weinstein 2012 |
| | W. Golan | Wy-287 | 46.30 | 3.20 | 0.92 | 4.12 | Weinstein et al. 2006 |
| | W. Golan | Wy-282 | 46.80 | 3.06 | 0.76 | 3.82 | Weinstein et al. 2006 |
| | W. Golan | Wy-280 | 47.40 | 3.35 | 1.16 | 4.51 | Weinstein et al. 2006 |
| | W. Golan | Wy-279 | 48.10 | 3.00 | 1.12 | 4.12 | Weinstein et al. 2006 |
| | W. Golan | Wy-278 | 46.00 | 3.58 | 1.15 | 4.73 | Weinstein et al. 2006 |
| | W. Golan | Wy-276 | 46.00 | 3.61 | 1.01 | 4.62 | Weinstein et al. 2006 |
| | Galilee-S | Wy-308 | 43.80 | 5.09 | 0.97 | 6.06 | Weinstein et al. 2006 |
| | Galilee-S | Wy-309 | 43.60 | 4.67 | 0.88 | 5.55 | Weinstein et al. 2006 |
| | Galilee-S | UK-4126 | 43.50 | 5.13 | 1.05 | 6.18 | Weinstein et al. 2006 |
| | | **AVERAGE (n = 16)** | **46.38** | **3.55** | **1.00** | **4.55** | |
| | | **STDEV** | **1.57** | **0.82** | **0.18** | **0.86** | |
| | | **+1** | **47.95** | **4.37** | **1.18** | **5.41** | |
| | | **-1** | **44.81** | **2.73** | **0.82** | **3.69** | |
| | | | | | | | |
| | | | | | | | |
| **KORAZIM-SOG** | Galilee-S | Wy-165 | 44.00 | 2.64 | 1.27 | 3.91 | Weinstein et al. 2006 |
| | Galilee-S | Wy-228 | 48.30 | 3.38 | 0.87 | 4.25 | Weinstein et al. 2006 |
| | Galilee-S | Wy-136 | 48.30 | 3.21 | 0.70 | 3.91 | Weinstein et al. 2006 |
| | Korazim | Wy-293 | 47.50 | 3.03 | 0.90 | 3.93 | Weinstein 2012 |
| | Korazim | Wy-294 | 45.10 | 3.08 | 0.86 | 3.94 | Weinstein 2012 |
| | Korazim | Wy-295 | 45.30 | 3.03 | 0.90 | 3.93 | Weinstein 2012 |
| | Korazim | Wy-296 | 45.10 | 2.46 | 0.84 | 3.30 | Weinstein 2012 |
| | Korazim | Wy-297 | 46.20 | 2.60 | 1.00 | 3.60 | Weinstein 2012 |
| | Korazim | Wy-298 | 46.70 | 3.46 | 1.00 | 4.46 | Weinstein 2012 |
| | Korazim | Wy-311 | 48.40 | 3.58 | 0.95 | 4.53 | Weinstein 2012 |
| | | **AVERAGE (n = 10)** | **46.49** | **3.05** | **0.93** | **3.98** | |
| | | **STDEV** | **1.59** | **0.38** | **0.15** | **0.37** | |
| | | **+1** | **48.08** | **3.43** | **1.08** | **4.35** | |
| | | **-1** | **44.90** | **2.67** | **0.78** | **3.61** | |

| Sub-region | Site | Sample | SiO2 | Na2O | K2O | Na2O + K2O | Publication |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **SE LOWER GALILEE** | Poria | Wy-351 | 43.65 | 2.22 | 1.25 | 3.47 | Weinstein 2000 |
| | Poria | Wy-352 | 44.62 | 2.42 | 1.36 | 3.78 | Weinstein 2000 |
| | Poria | Wy-368 | 46.35 | 2.63 | 0.67 | 3.30 | Weinstein 2000 |
| | Poria | Wy-369 | 43.66 | 1.89 | 1.04 | 2.93 | Weinstein 2000 |
| | Wadi Taylor dykes | Wy-318 | 47.80 | 3.36 | 1.16 | 4.52 | Weinstein 2000 |
| | Wadi Taylor dykes | Wy-320 | 48.20 | 3.39 | 1.18 | 4.57 | Weinstein 2000 |
| | Wadi Taylor dykes | Wy-2001 | 44.60 | 2.09 | 1.36 | 3.45 | Weinstein 2000 |
| | | **AVERAGE (n = 7)** | **45.55** | **2.57** | **1.15** | **3.72** | |
| | | **STDEV** | **1.90** | **0.60** | **0.24** | **0.62** | |
| | | **+1** | **47.45** | **3.17** | **1.38** | **4.34** | |
| | | **-1** | **43.65** | **1.97** | **0.91** | **3.10** | |
| | | | | | | | |
| | | | | | | | |
| **HARRA EL-JABBAN** | Jebal Aritain | A1c | 45.78 | 3.15 | 1.31 | 4.46 | Al-Malabeh 1994 |
| | Jebal Aritain | A3 | 45.55 | 3.44 | 1.18 | 4.62 | Al-Malabeh 1994 |
| | Jebal Aritain | A3b | 44.72 | 3.61 | 1.34 | 4.95 | Al-Malabeh 1994 |
| | Jebal Aritain | A8 | 44.38 | 3.22 | 1.25 | 4.47 | Al-Malabeh 1994 |
| | Jebal Aritain | A9a | 44.50 | 3.44 | 1.22 | 4.66 | Al-Malabeh 1994 |
| | Jebal Aritain | A9b | 44.70 | 3.10 | 1.23 | 4.33 | Al-Malabeh 1994 |
| | Jebal Aritain | A10b | 44.70 | 2.91 | 1.29 | 4.20 | Al-Malabeh 1994 |
| | Jebal Aritain | A20a | 45.10 | 3.16 | 1.28 | 4.44 | Al-Malabeh 1994 |
| | Jebal Aritain | A19 | 46.65 | 3.26 | 1.10 | 4.36 | Al-Malabeh 1994 |
| | Jebal Aritain | A21c | 45.41 | 3.13 | 1.23 | 4.36 | Al-Malabeh 1994 |
| | Jebal Fahem | M3b | 44.72 | 3.68 | 1.09 | 4.77 | Al-Malabeh 1994 |
| | Jebal Fahem | M3c | 44.83 | 3.00 | 1.29 | 4.29 | Al-Malabeh 1994 |
| | Jebal Fahem | M7 | 44.01 | 2.92 | 1.25 | 4.17 | Al-Malabeh 1994 |
| | Jebal Fahem | M10 | 44.09 | 3.09 | 1.15 | 4.24 | Al-Malabeh 1994 |
| | Jebal Fahem | M10c | 44.22 | 3.00 | 1.03 | 4.03 | Al-Malabeh 1994 |
| | Jebal Fahem | M11a | 44.58 | 3.14 | 1.02 | 4.16 | Al-Malabeh 1994 |
| | Jebal Fahem | M12 | 44.13 | 3.07 | 1.21 | 4.28 | Al-Malabeh 1994 |
| | Jebal Fahem | M14 | 44.17 | 3.06 | 1.11 | 4.17 | Al-Malabeh 1994 |
| | Jebal Fahem | M17 | 44.11 | 3.19 | 1.14 | 4.33 | Al-Malabeh 1994 |
| | Jebal Fahem | M22 | 44.29 | 3.63 | 1.05 | 4.68 | Al-Malabeh 1994 |
| | | **AVERAGE (n = 20)** | **44.73** | **3.21** | **1.19** | **4.40** | |
| | | **STDEV** | **0.68** | **0.23** | **0.10** | **0.23** | |
| | | **+1** | **45.41** | **3.44** | **1.29** | **4.63** | |
| | | **-1** | **44.05** | **2.98** | **1.09** | **4.16** | |

| Sub-region | Site | Sample | SiO2 | Na2O | K2O | Na2O + K2O | Publication |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **JEZREEL VALLEY** | Giv'at Kipod | (n = 12) | 43.80 | 3.53 | 1.77 | 5.30 | Gluhak and Rosenberg 2013 |
| | Yizre'el Valley | Wy-324 | 42.06 | 4.18 | 1.56 | 5.74 | Weinstein 2000 |
| | Yizre'el Valley | Wy-325 | 42.19 | 4.01 | 1.54 | 5.55 | Weinstein 2000 |
| | Yizre'el Valley | Wy-327 | 43.83 | 3.64 | 1.85 | 5.49 | Weinstein 2000 |
| | Yizre'el Valley | Wy-329 | 43.63 | 4.34 | 1.62 | 5.96 | Weinstein 2000 |
| | Yizre'el Valley | Wy-322 | 43.01 | 3.84 | 1.89 | 5.73 | Weinstein 2000 |
| | Yizre'el Valley | Wy-332 | 43.85 | 3.45 | 1.63 | 5.08 | Weinstein 2000 |
| | Yizre'el Valley | Wy-333 | 41.33 | 3.85 | 0.80 | 4.65 | Weinstein 2000 |
| | Gavat Hamore (Yizre'el Valley) | Wy-353 | 37.22 | 4.72 | 1.66 | 6.38 | Weinstein 2000 |
| | Gavat Hamore (Yizre'el Valley) | Wy-354 | | | | | Weinstein 2000 |
| | Gavat Hamore (Yizre'el Valley) | Wy-356 | 38.40 | 2.51 | 0.98 | 3.49 | Weinstein 2000 |
| | Gavat Hamore (Yizre'el Valley) | Wy-357 | | | | | Weinstein 2000 |
| | Gavat Hamore (Yizre'el Valley) | Wy-359 | | | | | Weinstein 2000 |
| | Gavat Hamore (Yizre'el Valley) | Wy-360 | 45.84 | 4.14 | 1.60 | 5.74 | Weinstein 2000 |
| | Gavat Hamore (Yizre'el Valley) | Wy-361 | 44.19 | 3.90 | 1.79 | 5.69 | Weinstein 2000 |
| | Gavat Hamore (Yizre'el Valley) | Wy-402 | 43.69 | 4.27 | 1.73 | 6.00 | Weinstein 2000 |
| | Kaukab (Wadi Umm-Sabune) | Wy-149 | 42.10 | 3.42 | 0.83 | 4.25 | Weinstein 2000 |
| | Kaukab (Wadi Umm-Sabune) | Wy-158 | 42.29 | 2.57 | 1.63 | 4.20 | Weinstein 2000 |
| | Kaukab (Wadi Umm-Sabune) | Wy-159 | 42.95 | 2.92 | 0.80 | 3.72 | Weinstein 2000 |
| | Kaukab (Wadi Umm-Sabune) | Wy-164 | 42.63 | 3.00 | 0.76 | 3.76 | Weinstein 2000 |
| | Kaukab (Wadi Umm-Sabune) | Wy-168 | 45.71 | 2.89 | 1.62 | 4.51 | Weinstein 2000 |
| | Kaukab | Wy-172 | 44.91 | 2.79 | 1.17 | 3.96 | Weinstein 2000 |
| | Kaukab | Wy-179 | 43.82 | 4.11 | 1.36 | 5.47 | Weinstein 2000 |
| | Kaukab | Wy-181 | 43.24 | 4.20 | 1.25 | 5.45 | Weinstein 2000 |
| | Kaukab | Wy-182 | 43.92 | 2.67 | 1.30 | 3.97 | Weinstein 2000 |
| | Kaukab | Wy-188 | 46.93 | 4.56 | 1.86 | 6.42 | Weinstein 2000 |
| | Kaukab | Wy-190 | | | | | Weinstein 2000 |
| | Kaukab | Wy-192 | 43.73 | 3.66 | 1.76 | 5.42 | Weinstein 2000 |
| | Kaukab | Wy-193 | 44.10 | 3.41 | 0.93 | 4.34 | Weinstein 2000 |
| | Kaukab | Wy-195 | 46.19 | 3.05 | 1.11 | 4.16 | Weinstein 2000 |
| | Kaukab | Wy-196 | 43.77 | 3.54 | 0.78 | 4.32 | Weinstein 2000 |
| | Kaukab | Wy-199 | 42.60 | 2.75 | 0.65 | 3.40 | Weinstein 2000 |
| | Kaukab | Wy-203 | 47.37 | 4.58 | 2.33 | 6.91 | Weinstein 2000 |
| | Kaukab | Wy-224 | 42.65 | 4.12 | 1.05 | 5.17 | Weinstein 2000 |
| | Kaukab | Wy-226 | 45.63 | 3.97 | 1.74 | 5.71 | Weinstein 2000 |
| | Kaukab - Late Miocene | Wy-218 | 42.24 | 3.75 | 0.85 | 4.60 | Weinstein 2000 |
| | Kaukab - Late Miocene | Wy-214 | 43.24 | 3.71 | 1.34 | 5.05 | Weinstein 2000 |
| | | **AVERAGE (n = 48)** | **43.52** | **3.61** | **1.48** | **5.09** | |
| | | **STDEV** | **1.77** | **0.54** | **0.41** | **0.80** | |
| | | **+1** | **45.29** | **4.15** | **1.89** | **5.89** | |
| | | **-1** | **41.75** | **3.07** | **1.07** | **4.29** | |

| Sub-region | Site | Sample | SiO2 | Na2O | K2O | Na2O + K2O | Publication |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **MT. HERMON** | - | AS 505 | 46.20 | 2.80 | 0.30 | 3.10 | Wilson et al. 2000 |
| | - | SL 103 | 48.80 | 2.93 | 0.41 | 3.34 | Wilson et al. 2000 |
| | - | SL 116 | 49.30 | 2.95 | 0.34 | 3.29 | Wilson et al. 2000 |
| | - | AS 626 | 45.20 | 3.60 | 1.60 | 5.20 | Wilson et al. 2000 |
| | - | AS 628 | 45.50 | 2.60 | 1.30 | 3.90 | Wilson et al. 2000 |
| | - | AS 472 | 46.60 | 4.05 | 1.45 | 5.50 | Wilson et al. 2000 |
| | - | AS 527 | 44.50 | 2.80 | 1.30 | 4.10 | Wilson et al. 2000 |
| | - | SL 114 | 44.00 | 2.90 | 1.06 | 3.96 | Wilson et al. 2000 |
| | - | AS 503 | 46.00 | 3.90 | 1.50 | 5.40 | Wilson et al. 2000 |
| | - | SL 111 | 45.40 | 4.10 | 1.06 | 5.16 | Wilson et al. 2000 |
| | - | SL 120 | 45.60 | 3.10 | 0.51 | 3.61 | Wilson et al. 2000 |
| | - | SL 108 | 45.10 | 3.35 | 0.75 | 4.10 | Wilson et al. 2000 |
| | - | AS 525 | 44.70 | 3.90 | 1.70 | 5.60 | Wilson et al. 2000 |
| | - | SL 119 | 45.60 | 3.30 | 1.54 | 4.84 | Wilson et al. 2000 |
| | - | SL 117 | 45.20 | 3.30 | 1.20 | 4.50 | Wilson et al. 2000 |
| | | **AVERAGE (n = 15)** | **45.85** | **3.31** | **1.07** | **4.37** | |
| | | **STDEV** | **1.46** | **0.50** | **0.49** | **0.86** | |
| | | **+1** | **47.30** | **3.80** | **1.56** | **5.23** | |
| | | **-1** | **44.39** | **2.81** | **0.58** | **3.51** | |
| | | | | | | | |
| | | | | | | | |
| **NORTHERN EGYPT** | Haddadin | - | 50.10 | 2.71 | 0.85 | 3.56 | Greenough et al. 2001 |
| | Cairo-Suez | - | 48.50 | 2.58 | 0.78 | 3.36 | Greenough et al. 2001 |
| | Baharire | - | 48.30 | 2.84 | 0.66 | 3.50 | Greenough et al. 2001 |
| | Middle Egypt | - | 47.10 | 2.86 | 0.50 | 3.36 | Greenough et al. 2001 |
| | | **AVERAGE (n = 4)** | **48.50** | **2.75** | **0.70** | **3.45** | |
| | | **STDEV** | **1.23** | **0.13** | **0.15** | **0.10** | |
| | | **+1** | **49.73** | **2.88** | **0.85** | **3.55** | |
| | | **-1** | **47.27** | **2.62** | **0.54** | **3.34** | |
| | | | | | | | |
| | | | | | | | |
| **SOUTHERN EGYPT** | SW Nubian Desert | - | 46.30 | 3.15 | 1.36 | 4.51 | Greenough et al. 2001 |
| | Wadi Natash | - | 46.20 | 2.88 | 1.09 | 3.97 | Greenough et al. 2001 |
| | | **AVERAGE (n = 2)** | **46.25** | **3.02** | **1.23** | **4.24** | |
| | | **STDEV** | **0.07** | **0.19** | **0.19** | **0.38** | |
| | | **+1** | **46.32** | **3.21** | **1.42** | **4.62** | |
| | | **-1** | **46.18** | **2.82** | **1.03** | **3.86** | |

| Sub-region | Site | Sample | SiO2 | Na2O | K2O | Na2O + K2O | Publication |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| NW GOLAN | 'En Zivan | WY-1 | 46.50 | 3.63 | 1.33 | 4.96 | Weinstein 1994 |
| | 'En Zivan | WY-2 | 46.20 | 3.94 | 1.93 | 5.87 | Weinstein 1994 |
| | 'En Zivan | WY-5 | 46.20 | 4.03 | 1.59 | 5.62 | Weinstein 1994 |
| | 'En Zivan | WY-17 | 47.30 | 3.67 | 1.16 | 4.83 | Weinstein 1994 |
| | 'En Zivan | WY-18 | 43.90 | 4.60 | 1.96 | 6.56 | Weinstein 1994 |
| | 'En Zivan | WY-19 | 44.70 | 4.11 | 1.77 | 5.88 | Weinstein 1994 |
| | 'En Zivan | WY-20 | 44.90 | 4.43 | 2.05 | 6.48 | Weinstein 1994 |
| | 'En Zivan | WY-21 | 46.80 | 4.41 | 1.95 | 6.36 | Weinstein 1994 |
| | 'En Zivan | WY-22 | 44.50 | 4.33 | 2.04 | 6.37 | Weinstein 1994 |
| | 'En Zivan | WY-28 | 44.60 | 4.41 | 1.95 | 6.36 | Weinstein 1994 |
| | 'En Zivan | WY-29 | 44.80 | 4.10 | 1.57 | 5.67 | Weinstein 1994 |
| | 'En Zivan | WY-30 | 43.70 | 3.38 | 1.80 | 5.18 | Weinstein 1994 |
| | 'En Zivan | WY-56 | 45.30 | 4.43 | 1.61 | 6.04 | Weinstein 1994 |
| | 'En Zivan | WY-74 | 46.50 | 3.63 | 1.27 | 4.90 | Weinstein 1994 |
| | Kibbutz | WY-25 | 46.60 | 4.60 | 1.54 | 6.14 | Weinstein 1994 |
| | Kibbutz | WY-26 | 45.60 | 4.20 | 1.25 | 5.45 | Weinstein 1994 |
| | Kibbutz | WY-33 | 46.70 | 4.10 | 1.48 | 5.58 | Weinstein 1994 |
| | Muweisse | WY-9 | 44.50 | 5.06 | 2.24 | 7.30 | Weinstein 1994 |
| | Muweisse | WY-10 | 45.50 | 3.15 | 1.46 | 4.61 | Weinstein 1994 |
| | Muweisse | WY-13 | 44.40 | 4.80 | 1.95 | 6.75 | Weinstein 1994 |
| | Muweisse | WY-16 | 44.00 | 4.54 | 1.82 | 6.36 | Weinstein 1994 |
| | Muweisse | WY-67 | 44.90 | 3.45 | 1.42 | 4.87 | Weinstein 1994 |
| | Muweisse | WY-70 | 46.50 | 4.14 | 1.66 | 5.80 | Weinstein 1994 |
| | Muweisse | WY-71 | 45.70 | 4.39 | 1.87 | 6.26 | Weinstein 1994 |
| | Muweisse | WY-72 | 47.20 | 3.33 | 1.95 | 5.28 | Weinstein 1994 |
| | Dalwe | WY-3 | 46.60 | 4.03 | 1.55 | 5.58 | Weinstein 1994 |
| | Dalwe | WY-4 | 45.20 | 3.53 | 1.43 | 4.96 | Weinstein 1994 |
| | Dalwe | WY-6 | 46.20 | 4.34 | 1.65 | 5.99 | Weinstein 1994 |
| | Dalwe | WY-7 | 45.10 | 4.07 | 1.74 | 5.81 | Weinstein 1994 |
| | Dalwe | WY-8 | 44.60 | 4.19 | 1.77 | 5.96 | Weinstein 1994 |
| | Dalwe | WY-27 | 45.60 | 3.63 | 1.41 | 5.04 | Weinstein 1994 |
| | Dalwe | WY-32 | 46.10 | 3.71 | 1.45 | 5.16 | Weinstein 1994 |
| | Dalwe | WY-65 | 47.40 | 3.59 | 1.17 | 4.76 | Weinstein 1994 |
| | Dalwe | WY-66 | 47.50 | 3.79 | 1.19 | 4.98 | Weinstein 1994 |
| | Dalwe | P-63 | 45.30 | 3.80 | 1.50 | 5.30 | Weinstein 1994 |
| | Dalwe | WY-77 | 46.80 | 4.02 | 1.44 | 5.46 | Weinstein 1994 |
| | Golan | Wy-8 | 44.60 | 4.19 | 1.77 | 5.96 | Weinstein et al. 2006 |
| | Golan | Wy-235 | 45.50 | 3.57 | 1.29 | 4.86 | Weinstein et al. 2006 |
| | Golan | Wy-242 | 45.00 | 3.65 | 1.36 | 5.01 | Weinstein et al. 2006 |
| | Golan | Wy-239 | 45.70 | 3.99 | 1.39 | 5.38 | Weinstein et al. 2006 |
| | Golan | Wy-18 | 43.80 | 4.43 | 1.88 | 6.31 | Weinstein et al. 2006 |
| | Golan | Wy-29 | 44.80 | 4.10 | 1.57 | 5.67 | Weinstein et al. 2006 |
| | Golan | Wy-52 | 43.60 | 3.09 | 1.41 | 4.50 | Weinstein et al. 2006 |
| | Golan | Wy-232 | 45.50 | 3.93 | 1.62 | 5.55 | Weinstein et al. 2006 |
| | Golan | Wy-16 | 44.00 | 4.54 | 1.82 | 6.36 | Weinstein et al. 2006 |
| | | **AVERAGE (n = 45)** | **45.48** | **4.02** | **1.62** | **5.65** | |
| | | **STDEV** | **1.08** | **0.44** | **0.27** | **0.65** | |
| | | **+1** | **46.55** | **4.46** | **1.89** | **6.29** | |
| | | **-1** | **44.40** | **3.58** | **1.35** | **5.00** | |

## Appendix 5: Averaged geochemical data of sampled sites in Near East sources

| Sub-region | Site | Sample Name | Stratum | SiO2 | Na2O | K2O | Na2O + K2O | MgO | Al2O3 | P2O5 | CaO | TiO2 | Fe2O3 | FeO | Fe2O3 + (FeO x 1.11) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| **NW GOLAN** | 'En Zivan | WY-1 | Pleistocene | 46.50 | 3.63 | 1.33 | 4.96 | 9.20 | 14.80 | 0.60 | 8.90 | 2.26 | 1.80 | 10.10 | 13.01 |
| | 'En Zivan | WY-2 | Pleistocene | 46.20 | 3.94 | 1.93 | 5.87 | 9.90 | 14.30 | 1.10 | 8.30 | 2.44 | 1.70 | 9.20 | 11.91 |
| | 'En Zivan | WY-5 | Pleistocene | 46.20 | 4.03 | 1.59 | 5.62 | 7.70 | 15.30 | 1.30 | 8.50 | 2.64 | 1.80 | 10.10 | 13.01 |
| | 'En Zivan | WY-17 | Pleistocene | 47.30 | 3.67 | 1.16 | 4.83 | 7.90 | 14.80 | 0.90 | 9.40 | 2.54 | 1.70 | 9.40 | 12.13 |
| | 'En Zivan | WY-18 | Pleistocene | 43.90 | 4.60 | 1.96 | 6.56 | 8.60 | 14.10 | 2.40 | 10.20 | 2.67 | 1.70 | 9.30 | 12.02 |
| | 'En Zivan | WY-19 | Pleistocene | 44.70 | 4.11 | 1.77 | 5.88 | 8.30 | 14.30 | 1.80 | 9.50 | 2.76 | 1.70 | 9.60 | 12.36 |
| | 'En Zivan | WY-20 | Pleistocene | 44.90 | 4.43 | 2.05 | 6.48 | 8.40 | 14.40 | 1.40 | 9.50 | 2.78 | 1.60 | 8.90 | 11.48 |
| | 'En Zivan | WY-21 | Pleistocene | 46.80 | 4.41 | 1.95 | 6.36 | 9.20 | 14.50 | 1.20 | 8.10 | 2.66 | 1.60 | 8.70 | 11.26 |
| | 'En Zivan | WY-22 | Pleistocene | 44.50 | 4.33 | 2.04 | 6.37 | 8.30 | 14.10 | 1.70 | 9.90 | 2.68 | 1.60 | 9.00 | 11.59 |
| | 'En Zivan | WY-28 | Pleistocene | 44.60 | 4.41 | 1.95 | 6.36 | 8.40 | 14.30 | 2.20 | 10.10 | 2.49 | 1.70 | 9.10 | 11.80 |
| | 'En Zivan | WY-29 | Pleistocene | 44.80 | 4.10 | 1.57 | 5.67 | 9.10 | 14.00 | 1.30 | 10.40 | 2.60 | 1.80 | 9.90 | 12.79 |
| | 'En Zivan | WY-30 | Pleistocene | 43.70 | 3.38 | 1.80 | 5.18 | 8.30 | 14.30 | 1.90 | 10.50 | 2.49 | 1.60 | 9.10 | 11.70 |
| | 'En Zivan | WY-56 | Pleistocene | 45.30 | 4.43 | 1.61 | 6.04 | 8.00 | 14.50 | 1.30 | 9.10 | 2.99 | 1.80 | 10.10 | 13.01 |
| | 'En Zivan | WY-74 | Pleistocene | 46.50 | 3.63 | 1.27 | 4.90 | 7.90 | 15.30 | 1.00 | 9.10 | 2.58 | 1.90 | 10.30 | 13.33 |
| | **'En Zivan** | **Average (n = 14)** | **Pleistocene** | **45.42** | **4.08** | **1.71** | **5.79** | **8.51** | **14.50** | **1.44** | **9.39** | **2.61** | **1.71** | **9.49** | **12.24** |
| | | | | | | | | | | | | | | | |
| | Kibbutz | WY-25 | Pleistocene | 46.60 | 4.60 | 1.54 | 6.14 | 5.10 | 16.50 | 1.30 | 9.80 | 2.70 | 2.30 | 9.10 | 12.40 |
| | Kibbutz | WY-26 | Pleistocene | 45.60 | 4.20 | 1.25 | 5.45 | 5.30 | 16.00 | 1.40 | 10.10 | 2.70 | 2.40 | 9.40 | 12.83 |
| | Kibbutz | WY-33 | Pleistocene | 46.70 | 4.10 | 1.48 | 5.58 | 5.20 | 16.90 | 1.30 | 10.00 | 2.70 | 2.40 | 9.30 | 12.72 |
| | **Kibbutz** | **Average (n = 3)** | **Pleistocene** | **46.30** | **4.30** | **1.42** | **5.72** | **5.20** | **16.47** | **1.33** | **9.97** | **2.70** | **2.37** | **9.27** | **12.65** |
| | | | | | | | | | | | | | | | |
| | Muweisse | WY-9 | Pleistocene | 44.50 | 5.06 | 2.24 | 7.30 | 7.00 | 15.30 | 1.90 | 8.90 | 2.61 | 1.60 | 9.10 | 11.70 |
| | Muweisse | WY-10 | Pleistocene | 45.50 | 3.15 | 1.46 | 4.61 | 9.20 | 14.00 | 0.80 | 8.90 | 2.72 | 1.60 | 9.10 | 11.70 |
| | Muweisse | WY-13 | Pleistocene | 44.40 | 4.80 | 1.95 | 6.75 | 8.50 | 14.10 | 2.20 | 10.20 | 2.66 | 1.60 | 9.00 | 11.59 |
| | Muweisse | WY-16 | Pleistocene | 44.00 | 4.54 | 1.82 | 6.36 | 8.40 | 14.20 | 2.00 | 10.30 | 2.52 | 1.60 | 8.80 | 11.37 |
| | Muweisse | WY-67 | Pleistocene | 44.90 | 3.45 | 1.42 | 4.87 | 10.90 | 13.40 | 1.20 | 9.20 | 2.54 | 1.80 | 9.80 | 12.68 |
| | Muweisse | WY-70 | Pleistocene | 46.50 | 4.14 | 1.66 | 5.80 | 7.30 | 15.50 | 1.30 | 8.30 | 2.69 | 1.80 | 9.80 | 12.68 |
| | Muweisse | WY-71 | Pleistocene | 45.70 | 4.39 | 1.87 | 6.26 | 7.20 | 15.40 | 1.50 | 8.30 | 2.99 | 1.80 | 9.90 | 12.79 |
| | Muweisse | WY-72 | Pleistocene | 47.20 | 3.33 | 1.95 | 5.28 | 7.00 | 15.30 | 1.60 | 8.30 | 2.98 | 1.70 | 9.60 | 12.36 |
| | **Muweisse** | **Average (n = 8)** | **Pleistocene** | **45.34** | **4.11** | **1.80** | **5.90** | **8.19** | **14.65** | **1.56** | **9.05** | **2.71** | **1.69** | **9.39** | **12.11** |
| | | | | | | | | | | | | | | | |
| | Dalwe | WY-3 | Pleistocene | 46.60 | 4.03 | 1.55 | 5.58 | 7.00 | 15.40 | 1.00 | 9.80 | 2.61 | 2.10 | 9.20 | 12.31 |
| | Dalwe | WY-4 | Pleistocene | 45.20 | 3.53 | 1.43 | 4.96 | 6.50 | 15.20 | | 10.10 | 2.69 | 2.00 | 8.90 | 11.88 |
| | Dalwe | WY-6 | Pleistocene | 46.20 | 4.34 | 1.65 | 5.99 | 6.60 | 15.00 | 1.10 | 9.70 | 2.62 | 2.00 | 9.00 | 11.99 |
| | Dalwe | WY-7 | Pleistocene | 45.10 | 4.07 | 1.74 | 5.81 | 6.60 | 15.40 | 1.40 | 10.40 | 2.86 | 2.10 | 9.30 | 12.42 |
| | Dalwe | WY-8 | Pleistocene | 44.60 | 4.19 | 1.77 | 5.96 | 6.10 | 15.50 | 1.40 | 10.20 | 2.89 | 2.10 | 9.30 | 12.42 |
| | Dalwe | WY-27 | Pleistocene | 45.60 | 3.63 | 1.41 | 5.04 | 6.50 | 15.20 | 1.40 | 10.70 | 2.76 | 2.10 | 9.40 | 12.53 |
| | Dalwe | WY-32 | Pleistocene | 46.10 | 3.71 | 1.45 | 5.16 | 6.30 | 15.50 | 1.30 | 10.40 | 2.74 | 2.10 | 9.30 | 12.42 |
| | Dalwe | WY-65 | Pleistocene | 47.40 | 3.59 | 1.17 | 4.76 | 6.00 | 16.30 | 0.80 | 10.10 | 2.46 | 2.10 | 9.20 | 12.31 |
| | Dalwe | WY-66 | Pleistocene | 47.50 | 3.79 | 1.19 | 4.98 | 5.70 | 16.60 | 0.80 | 10.10 | 2.48 | 2.00 | 8.80 | 11.77 |
| | Dalwe | P-63 | Pleistocene | 45.30 | 3.80 | 1.50 | 5.30 | 5.10 | 16.00 | 0.70 | 10.50 | 2.80 | 2.00 | 8.70 | 11.66 |
| | Dalwe | WY-77 | Pleistocene | 46.80 | 4.02 | 1.44 | 5.46 | 6.80 | 15.40 | 1.30 | 9.90 | 2.64 | 2.10 | 9.10 | 12.20 |
| | **Dalwe** | **Average (n = 11)** | **Pleistocene** | **46.04** | **3.88** | **1.48** | **5.36** | **6.29** | **15.59** | **1.12** | **10.17** | **2.69** | **2.06** | **9.11** | **12.17** |
| | | | | | | | | | | | | | | | |
| | Golan | Wy-8 | Early Pleistocene | 44.60 | 4.19 | 1.77 | 5.96 | 6.10 | 15.50 | 1.40 | 10.20 | 2.89 | 1.24 | 10.04 | 12.38 |
| | Golan | Wy-235 | Early Pleistocene | 45.50 | 3.57 | 1.29 | 4.86 | 8.76 | 13.64 | 0.87 | 9.49 | 2.71 | 1.29 | 10.41 | 12.85 |
| | Golan | Wy-242 | Early Pleistocene | 45.00 | 3.65 | 1.36 | 5.01 | 8.23 | 13.88 | 1.02 | 9.76 | 2.78 | 1.30 | 10.56 | 13.02 |
| | **Golan** | **Average (n = 3)** | **Early Pleistocene** | **45.03** | **3.80** | **1.47** | **5.28** | **7.70** | **14.34** | **1.10** | **9.82** | **2.79** | **1.28** | **10.34** | **12.75** |
| | | | | | | | | | | | | | | | |
| | Golan | Wy-239 | Late Pleistocene | 45.70 | 3.99 | 1.39 | 5.38 | 8.33 | 13.94 | 1.00 | 9.62 | 2.68 | 1.26 | 10.23 | 12.62 |
| | Golan | Wy-18 | Late Pleistocene | 43.80 | 4.43 | 1.88 | 6.31 | 8.27 | 13.88 | 1.74 | 10.27 | 2.73 | 1.17 | 9.48 | 11.69 |
| | Golan | Wy-29 | Late Pleistocene | 44.80 | 4.10 | 1.57 | 5.67 | 9.10 | 14.00 | 1.30 | 10.40 | 2.60 | 1.28 | 10.37 | 12.79 |
| | Golan | Wy-52 | Late Pleistocene | 43.60 | 3.09 | 1.41 | 4.50 | 8.80 | 14.70 | 1.90 | 10.20 | 2.61 | 1.20 | 9.72 | 11.99 |
| | Golan | Wy-232 | Late Pleistocene | 45.50 | 3.93 | 1.62 | 5.55 | 5.96 | 15.13 | 0.98 | 10.65 | 2.99 | 1.20 | 9.69 | 11.96 |
| | Golan | Wy-16 | Late Pleistocene | 44.00 | 4.54 | 1.82 | 6.36 | 8.40 | 14.20 | 2.00 | 10.30 | 2.52 | 1.14 | 9.23 | 11.39 |
| | **Golan** | **Average (n = 6)** | **Late Pleistocene** | **44.57** | **4.01** | **1.62** | **5.63** | **8.14** | **14.31** | **1.49** | **10.24** | **2.69** | **1.21** | **9.79** | **12.07** |

| Ni | Cu | Zn | Rb | Sr | Y | Zr | Nb | Pb | Sr / Ni | Y / Rb | Publication |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| 246.00 | 193.00 | 112.00 | 14.00 | 763.00 | 19.00 | | | | 3.10 | 1.36 | Weinstein 1994 |
| 217.00 | 44.00 | 100.00 | 21.00 | 1121.00 | 19.00 | | | | 5.17 | 0.90 | Weinstein 1994 |
| 148.00 | 44.00 | 130.00 | 19.00 | 1129.00 | 21.00 | | | | 7.63 | 1.11 | Weinstein 1994 |
| 155.00 | 48.00 | 113.00 | 15.00 | 922.00 | 23.00 | | | | 5.95 | 1.53 | Weinstein 1994 |
| 158.00 | 52.00 | 128.00 | 27.00 | 1835.00 | 25.00 | | | | 11.61 | 0.93 | Weinstein 1994 |
| 159.00 | 42.00 | 125.00 | 22.00 | 1685.00 | 23.00 | | | | 10.60 | 1.05 | Weinstein 1994 |
| 168.00 | 41.00 | 122.00 | 24.00 | 1698.00 | 23.00 | | | | 10.11 | 0.96 | Weinstein 1994 |
| 266.00 | 40.00 | 129.00 | 22.00 | 1425.00 | 22.00 | | | | 5.36 | 1.00 | Weinstein 1994 |
| 164.00 | 40.00 | 104.00 | 24.00 | 1492.00 | 22.00 | | | | 9.10 | 0.92 | Weinstein 1994 |
| 169.00 | 49.00 | 123.00 | 25.00 | 1765.00 | 25.00 | | | | 10.44 | 1.00 | Weinstein 1994 |
| 213.00 | 58.00 | 126.00 | 12.00 | 1450.00 | 23.00 | | | | 6.81 | 1.92 | Weinstein 1994 |
| 190.00 | 46.00 | 134.00 | 21.00 | 1754.00 | 26.00 | | | | 9.23 | 1.24 | Weinstein 1994 |
| 153.00 | 44.00 | 125.00 | | 1274.00 | 21.00 | | | | 8.33 | | Weinstein 1994 |
| 147.00 | 53.00 | 113.00 | | 913.00 | 19.00 | | | | 6.21 | | Weinstein 1994 |
| **182.36** | **56.71** | **120.29** | **20.50** | **1373.29** | **22.21** | | | **-** | **7.83** | **1.16** | |
| | | | | | | | | | | | |
| 25.00 | 34.00 | 117.00 | 15.00 | 1264.00 | 24.00 | | | | 50.56 | 1.60 | Weinstein 1994 |
| 24.00 | 45.00 | 124.00 | 16.00 | 1424.00 | 26.00 | | | | 59.33 | 1.63 | Weinstein 1994 |
| 40.00 | 48.00 | 136.00 | 18.00 | 1460.00 | 29.00 | | | | 36.50 | 1.61 | Weinstein 1994 |
| **29.67** | **42.33** | **125.67** | **16.33** | **1382.67** | **26.33** | | | **-** | **48.80** | **1.61** | |
| | | | | | | | | | | | |
| 117.00 | 67.00 | 140.00 | 28.00 | 1780.00 | 25.00 | | | | 15.21 | 0.89 | Weinstein 1994 |
| 254.00 | 53.00 | 124.00 | 21.00 | 1481.00 | 21.00 | | | | 5.83 | 1.00 | Weinstein 1994 |
| 155.00 | 44.00 | 120.00 | 25.00 | 1791.00 | 24.00 | | | | 11.55 | 0.96 | Weinstein 1994 |
| 158.00 | 50.00 | 126.00 | 27.00 | 1831.00 | 25.00 | | | | 11.59 | 0.93 | Weinstein 1994 |
| 165.00 | 45.00 | 106.00 | | 1260.00 | 20.00 | | | | 7.64 | | Weinstein 1994 |
| 120.00 | 41.00 | 122.00 | | 1178.00 | 21.00 | | | | 9.82 | | Weinstein 1994 |
| 102.00 | 38.00 | 131.00 | | 1350.00 | 22.00 | | | | 13.24 | | Weinstein 1994 |
| 96.00 | 40.00 | 120.00 | | 1311.00 | 21.00 | | | | 13.66 | | Weinstein 1994 |
| **145.88** | **47.25** | **123.63** | **25.25** | **1497.75** | **22.38** | | | **-** | **11.07** | **0.94** | |
| | | | | | | | | | | | |
| 115.00 | 52.00 | 107.00 | 16.00 | 1116.00 | 23.00 | | | | 9.70 | 1.44 | Weinstein 1994 |
| | | | | | | | | | | | Weinstein 1994 |
| 111.00 | 71.00 | 127.00 | 21.00 | 1173.00 | 24.00 | | | | 10.57 | 1.14 | Weinstein 1994 |
| 100.00 | 60.00 | 139.00 | 21.00 | 1437.00 | 28.00 | | | | 14.37 | 1.33 | Weinstein 1994 |
| 80.00 | 53.00 | 120.00 | 19.00 | 1501.00 | 26.00 | | | | 18.76 | 1.37 | Weinstein 1994 |
| 90.00 | 55.00 | 117.00 | 15.00 | 1569.00 | 24.00 | | | | 17.43 | 1.60 | Weinstein 1994 |
| 100.00 | 57.00 | 109.00 | 16.00 | 1422.00 | 26.00 | | | | 14.22 | 1.63 | Weinstein 1994 |
| 96.00 | 50.00 | 104.00 | | 873.00 | 23.00 | | | | 9.09 | | Weinstein 1994 |
| 58.00 | 47.00 | 103.00 | | 877.00 | 24.00 | | | | 15.12 | | Weinstein 1994 |
| 42.00 | 42.00 | | 9.00 | 1222.00 | 25.00 | | | | 29.10 | 2.78 | Weinstein 1994 |
| 93.00 | 53.00 | 115.00 | | 1090.00 | 23.00 | | | | 11.72 | | Weinstein 1994 |
| **88.50** | **54.00** | **115.67** | **16.71** | **1228.00** | **24.60** | | | **-** | **15.01** | **1.61** | |
| | | | | | | | | | | | |
| 71.00 | 49.00 | 108.00 | 24.00 | 1457.00 | 30.00 | 267.00 | 81.00 | 3.87 | 20.52 | 1.25 | Weinstein et al. 2006 |
| 195.00 | 44.00 | 124.00 | 13.00 | 1695.00 | 24.00 | 236.00 | 55.00 | 2.78 | 8.69 | 1.85 | Weinstein et al. 2006 |
| 193.00 | 40.00 | 122.00 | 13.00 | 1723.00 | 25.00 | 244.00 | 57.00 | 2.70 | 8.93 | 1.92 | Weinstein et al. 2006 |
| **153.00** | **44.33** | **118.00** | **16.67** | **1625.00** | **26.33** | **249.00** | **64.33** | **3.12** | **12.71** | **1.67** | |
| | | | | | | | | | | | |
| 174.00 | 44.00 | 130.00 | 16.00 | 1435.00 | 26.00 | 253.00 | 65.00 | 3.36 | 8.25 | 1.63 | Weinstein et al. 2006 |
| 144.00 | 35.00 | 130.00 | 26.00 | 1809.00 | 27.00 | 317.00 | 96.00 | 5.40 | 12.56 | 1.04 | Weinstein et al. 2006 |
| 192.00 | 51.00 | 113.00 | 14.00 | 1408.00 | 27.00 | 208.00 | 55.00 | | 7.33 | 1.93 | Weinstein et al. 2006 |
| 158.00 | 39.00 | 130.00 | 16.00 | 1789.00 | 28.00 | 322.00 | 98.00 | 4.43 | 11.32 | 1.75 | Weinstein et al. 2006 |
| 56.00 | 49.00 | 121.00 | 20.00 | 1457.00 | 26.00 | 287.00 | 90.00 | 3.00 | 26.02 | 1.30 | Weinstein et al. 2006 |
| 141.00 | 48.00 | 125.00 | 25.00 | 1741.00 | 28.00 | 293.00 | 93.00 | | 12.35 | 1.12 | Weinstein et al. 2006 |
| **144.17** | **44.33** | **124.83** | **19.50** | **1606.50** | **27.00** | **280.00** | **82.83** | **4.05** | **12.97** | **1.46** | |

| Sub-region | Site | Sample Name | Stratum | SiO2 | Na2O | K2O | Na2O + K2O | MgO | Al2O3 | P2O5 | CaO | TiO2 | Fe2O3 | FeO | Fe2O3 + (FeO x 1.11) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| **JEZREEL VALLEY** | **Giv'at Kipod** | **Average (n = 12)** | **Miocene** | **43.80** | **3.53** | **1.77** | **5.30** | **7.86** | **14.26** | **1.28** | **9.91** | **3.12** | **13.31** | | **13.31** |
| | | | | | | | | | | | | | | | |
| | Yizre'el Valley | Wy-324 | Miocene | 42.06 | 4.18 | 1.56 | 5.74 | 8.27 | 13.53 | 1.61 | 9.86 | 3.15 | 1.36 | 11.01 | 13.58 |
| | Yizre'el Valley | Wy-325 | Miocene | 42.19 | 4.01 | 1.54 | 5.55 | 8.43 | 13.61 | 1.61 | 9.93 | 3.12 | 1.32 | 10.67 | 13.16 |
| | Yizre'el Valley | Wy-327 | Miocene | 43.83 | 3.64 | 1.85 | 5.49 | 7.67 | 14.08 | 1.11 | 9.55 | 3.13 | 1.27 | 10.24 | 12.64 |
| | Yizre'el Valley | Wy-329 | Miocene | 43.63 | 4.34 | 1.62 | 5.96 | 5.99 | 13.76 | 1.14 | 9.98 | 3.62 | 1.38 | 11.16 | 13.77 |
| | Yizre'el Valley | Wy-322 | Miocene | 43.01 | 3.84 | 1.89 | 5.73 | 7.91 | 13.90 | 1.00 | 9.79 | 3.24 | 1.31 | 10.62 | 13.10 |
| | Yizre'el Valley | Wy-332 | Miocene | 43.85 | 3.45 | 1.63 | 5.08 | 6.99 | 14.31 | 0.94 | 9.32 | 2.83 | 1.32 | 10.71 | 13.21 |
| | Yizre'el Valley | Wy-333 | Miocene | 41.33 | 3.85 | 0.80 | 4.65 | 7.00 | 13.28 | 1.68 | 11.33 | 3.48 | 1.33 | 10.74 | 13.24 |
| | **Yizre'el Valley** | **Average (n = 7)** | **Miocene** | **42.84** | **3.90** | **1.56** | **5.46** | **7.47** | **13.78** | **1.30** | **9.97** | **3.22** | **1.33** | **10.74** | **13.24** |
| | | | | | | | | | | | | | | | |
| | Gavat Hamore | Wy-353 | Miocene | 37.22 | 4.72 | 1.66 | 6.38 | 10.85 | 10.95 | 1.93 | 12.71 | 3.44 | 1.49 | 12.03 | 14.84 |
| | Gavat Hamore | Wy-354 | Miocene | | | | | | | | | | | | |
| | Gavat Hamore | Wy-356 | Miocene | 38.40 | 2.51 | 0.98 | 3.49 | 9.66 | 11.38 | 1.53 | 13.64 | 3.62 | 1.46 | 11.82 | 14.58 |
| | Gavat Hamore | Wy-357 | Miocene | | | | | | | | | | | | |
| | Gavat Hamore | Wy-359 | Miocene | | | | | | | | | | | | |
| | Gavat Hamore | Wy-360 | Miocene | 45.84 | 4.14 | 1.60 | 5.74 | 5.80 | 15.09 | 1.22 | 8.77 | 2.75 | 1.29 | 10.43 | 12.87 |
| | Gavat Hamore | Wy-361 | Miocene | 44.19 | 3.90 | 1.79 | 5.69 | 6.50 | 14.68 | 1.04 | 9.39 | 3.14 | 1.32 | 10.71 | 13.21 |
| | Gavat Hamore | Wy-402 | Miocene | 43.69 | 4.27 | 1.73 | 6.00 | 7.26 | 14.15 | 1.36 | 10.20 | 2.72 | 1.22 | 9.91 | 12.22 |
| | **Gavat Hamore** | **Average (n = 8)** | **Miocene** | **41.87** | **3.91** | **1.55** | **5.46** | **8.01** | **13.25** | **1.42** | **10.94** | **3.13** | **1.36** | **10.98** | **13.54** |
| | | | | | | | | | | | | | | | |
| | Kaukab (Wadi Umm-Sabune) | Wy-149 | Miocene | 42.10 | 3.42 | 0.83 | 4.25 | 8.10 | 13.25 | 1.54 | 9.93 | 3.20 | 1.23 | 9.92 | 12.24 |
| | Kaukab (Wadi Umm-Sabune) | Wy-158 | Miocene | 42.29 | 2.57 | 1.63 | 4.20 | 8.70 | 13.76 | 1.20 | 9.49 | 3.32 | 1.20 | 9.69 | 11.96 |
| | Kaukab (Wadi Umm-Sabune) | Wy-159 | Miocene | 42.95 | 2.92 | 0.80 | 3.72 | 10.70 | 12.32 | 0.88 | 10.67 | 2.65 | 1.24 | 10.00 | 12.34 |
| | Kaukab (Wadi Umm-Sabune) | Wy-164 | Miocene | 42.63 | 3.00 | 0.76 | 3.76 | 10.60 | 12.18 | 0.82 | 10.48 | 2.60 | 1.24 | 10.02 | 12.36 |
| | Kaukab (Wadi Umm-Sabune) | Wy-168 | Miocene | 45.71 | 2.89 | 1.62 | 4.51 | 7.17 | 13.68 | 0.60 | 9.05 | 2.84 | 1.34 | 10.81 | 13.34 |
| | **Kaukab (Wadi Umm-Sabune)** | **Average (n = 5)** | **Miocene** | **43.14** | **2.96** | **1.13** | **4.09** | **9.05** | **13.04** | **1.01** | **9.92** | **2.92** | **1.25** | **10.09** | **12.45** |
| | | | | | | | | | | | | | | | |
| | Kaukab | Wy-172 | Miocene | 44.91 | 2.79 | 1.17 | 3.96 | 10.00 | 13.71 | 0.72 | 8.85 | 2.55 | 1.25 | 10.11 | 12.47 |
| | Kaukab | Wy-179 | Miocene | 43.82 | 4.11 | 1.36 | 5.47 | 7.88 | 14.11 | 1.19 | 8.88 | 3.01 | 1.30 | 10.55 | 13.01 |
| | Kaukab | Wy-181 | Miocene | 43.24 | 4.20 | 1.25 | 5.45 | 7.85 | 13.93 | 1.24 | 8.73 | 2.95 | 1.30 | 10.53 | 12.99 |
| | Kaukab | Wy-182 | Miocene | 43.92 | 2.67 | 1.30 | 3.97 | 8.18 | 13.67 | 0.65 | 8.69 | 3.05 | 1.37 | 11.08 | 13.67 |
| | Kaukab | Wy-188 | Miocene | 46.93 | 4.56 | 1.86 | 6.42 | 4.49 | 15.43 | 1.00 | 6.50 | 3.20 | 1.25 | 10.11 | 12.47 |
| | Kaukab | Wy-190 | Miocene | | | | | | | | | | | | |
| | Kaukab | Wy-192 | Miocene | 43.73 | 3.66 | 1.76 | 5.42 | 5.59 | 15.08 | 0.99 | 8.55 | 3.39 | 1.39 | 11.22 | 13.84 |
| | Kaukab | Wy-193 | Miocene | 44.10 | 3.41 | 0.93 | 4.34 | 11.29 | 13.26 | 0.74 | 9.04 | 2.52 | 1.31 | 10.61 | 13.09 |
| | Kaukab | Wy-195 | Miocene | 46.19 | 3.05 | 1.11 | 4.16 | 9.91 | 14.06 | 0.40 | 8.32 | 2.16 | 1.29 | 10.44 | 12.88 |
| | Kaukab | Wy-196 | Miocene | 43.77 | 3.54 | 0.78 | 4.32 | 10.38 | 13.49 | 0.96 | 9.60 | 2.71 | 1.30 | 10.52 | 12.98 |
| | Kaukab | Wy-199 | Miocene | 42.60 | 2.75 | 0.65 | 3.40 | 7.12 | 14.16 | 1.20 | 10.18 | 2.92 | 1.37 | 11.10 | 13.69 |
| | Kaukab | Wy-203 | Miocene | 47.37 | 4.58 | 2.33 | 6.91 | 4.60 | 16.03 | 0.78 | 6.52 | 2.46 | 1.21 | 9.83 | 12.12 |
| | Kaukab | Wy-224 | Miocene | 42.65 | 4.12 | 1.05 | 5.17 | 7.14 | 13.73 | 0.94 | 9.71 | 3.37 | 1.33 | 10.77 | 13.28 |
| | Kaukab | Wy-226 | Miocene | 45.63 | 3.97 | 1.74 | 5.71 | 6.67 | 14.83 | 1.00 | 7.49 | 2.49 | 1.20 | 9.73 | 12.00 |
| | Kaukab - Late Miocene | Wy-218 | Miocene | 42.24 | 3.75 | 0.85 | 4.60 | 9.15 | 12.66 | 1.05 | 10.14 | 3.02 | 1.28 | 10.37 | 12.79 |
| | Kaukab - Late Miocene | Wy-214 | Miocene | 43.24 | 3.71 | 1.34 | 5.05 | 8.25 | 13.37 | 1.16 | 8.89 | 3.53 | 1.28 | 10.38 | 12.80 |
| | **Kaukab** | **Average (n = 16)** | **Miocene** | **44.29** | **3.66** | **1.30** | **4.96** | **7.90** | **14.10** | **0.93** | **8.67** | **2.89** | **1.30** | **10.49** | **12.94** |

| Ni | Cu | Zn | Rb | Sr | Y | Zr | Nb | Pb | Sr / Ni | Y / Rb | Publication |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| **122.34** | **58.09** | **155.33** | **30.97** | **1288.87** | **27.76** | **295.47** | **97.76** | **3.18** | **10.54** | **0.90** | Gluhak and Rosenberg 2013 |
| | | | | | | | | | | | |
| 119.00 | 45.00 | | 22.00 | 1934.00 | 28.00 | 314.00 | 103.00 | 4.43 | 16.25 | 1.27 | Weinstein 2000 |
| 133.00 | 38.00 | | 21.00 | 1646.00 | 28.00 | 312.00 | 102.00 | | 12.38 | 1.33 | Weinstein 2000 |
| 118.00 | 35.00 | | 31.00 | 1265.00 | 27.00 | 299.00 | 93.00 | 3.38 | 10.72 | 0.87 | Weinstein 2000 |
| 103.00 | 38.00 | | 19.00 | 1417.00 | 26.00 | 328.00 | 92.00 | | 13.76 | 1.37 | Weinstein 2000 |
| 107.00 | 43.00 | | 28.00 | 1204.00 | 29.00 | 270.00 | 88.00 | 2.77 | 11.25 | 1.04 | Weinstein 2000 |
| 148.00 | 32.00 | | 22.00 | 1186.00 | 22.00 | 259.00 | 69.00 | 2.54 | 8.01 | 1.00 | Weinstein 2000 |
| 133.00 | 38.00 | | 7.00 | 1490.00 | 32.00 | 282.00 | 112.00 | | 11.20 | 4.57 | Weinstein 2000 |
| **123.00** | **38.43** | | **21.43** | **1448.86** | **27.43** | **294.86** | **94.14** | **3.28** | **11.94** | **1.64** | |
| | | | | | | | | | | | |
| 155.00 | 47.00 | | 26.00 | 1748.00 | 34.00 | 348.00 | 126.00 | 0.43 | 11.28 | 1.31 | Weinstein 2000 |
| 145.00 | 38.00 | | 33.00 | 1326.00 | 28.00 | 309.00 | 97.00 | | 9.14 | 0.85 | Weinstein 2000 |
| 176.00 | 38.00 | | 18.00 | 1453.00 | 30.00 | 327.00 | 125.00 | | 8.26 | 1.67 | Weinstein 2000 |
| 135.00 | 38.00 | | 24.00 | 1121.00 | 23.00 | 291.00 | 70.00 | | 8.30 | 0.96 | Weinstein 2000 |
| 125.00 | 43.00 | | 26.00 | 1195.00 | 25.00 | 297.00 | 72.00 | | 9.56 | 0.96 | Weinstein 2000 |
| 115.00 | 37.00 | | 22.00 | 1282.00 | 26.00 | 332.00 | 87.00 | | 11.15 | 1.18 | Weinstein 2000 |
| 139.00 | 46.00 | | 28.00 | 1165.00 | 24.00 | 279.00 | 76.00 | | 8.38 | 0.86 | Weinstein 2000 |
| 101.00 | 33.00 | | 27.00 | 1602.00 | 31.00 | 346.00 | 104.00 | | 15.86 | 1.15 | Weinstein 2000 |
| **136.38** | **40.00** | | **25.50** | **1361.50** | **27.63** | **316.13** | **94.63** | **0.43** | **10.24** | **1.12** | |
| | | | | | | | | | | | |
| 127.00 | 31.00 | | 10.00 | 1965.00 | 27.00 | 298.00 | 111.00 | | 15.47 | 2.70 | Weinstein 2000 |
| 147.00 | 37.00 | | 22.00 | 1427.00 | 26.00 | 288.00 | 88.00 | | 9.71 | 1.18 | Weinstein 2000 |
| 260.00 | 50.00 | | 11.00 | 1207.00 | 24.00 | 255.00 | 65.00 | | 4.64 | 2.18 | Weinstein 2000 |
| 271.00 | 52.00 | | 8.00 | 1272.00 | 25.00 | 272.00 | 69.00 | | 4.69 | 3.13 | Weinstein 2000 |
| 206.00 | 38.00 | | 26.00 | 1233.00 | 20.00 | 239.00 | 61.00 | | 5.99 | 0.77 | Weinstein 2000 |
| **202.20** | **41.60** | | **15.40** | **1420.80** | **24.40** | **270.40** | **78.80** | **-** | **8.10** | **1.99** | |
| | | | | | | | | | | | |
| 211.00 | 39.00 | | 27.00 | 1268.00 | 20.00 | 242.00 | 61.00 | | 6.01 | 0.74 | Weinstein 2000 |
| 142.00 | 31.00 | | 19.00 | 1239.00 | 24.00 | 274.00 | 81.00 | | 8.73 | 1.26 | Weinstein 2000 |
| 144.00 | 27.00 | | 18.00 | 1264.00 | 24.00 | 281.00 | 83.00 | | 8.78 | 1.33 | Weinstein 2000 |
| 192.00 | 41.00 | | 16.00 | 939.00 | 18.00 | 210.00 | 51.00 | | 4.89 | 1.13 | Weinstein 2000 |
| 66.00 | 31.00 | | 25.00 | 1371.00 | 18.00 | 315.00 | 75.00 | | 20.77 | 0.72 | Weinstein 2000 |
| 150.00 | 14.00 | | 16.00 | 1403.00 | 29.00 | 348.00 | 95.00 | 3.40 | 9.35 | 1.81 | Weinstein 2000 |
| 93.00 | 25.00 | | 23.00 | 1305.00 | 24.00 | 289.00 | 69.00 | | 14.03 | 1.04 | Weinstein 2000 |
| 331.00 | 56.00 | | 9.00 | 886.00 | 21.00 | 180.00 | 48.00 | | 2.68 | 2.33 | Weinstein 2000 |
| 230.00 | 48.00 | | 18.00 | 610.00 | 18.00 | 147.00 | 32.00 | | 2.65 | 1.00 | Weinstein 2000 |
| 268.00 | 53.00 | | 7.00 | 1032.00 | 22.00 | 204.00 | 58.00 | | 3.85 | 3.14 | Weinstein 2000 |
| 234.00 | 42.00 | | 7.00 | 1330.00 | 26.00 | 250.00 | 74.00 | | 5.68 | 3.71 | Weinstein 2000 |
| 87.00 | 36.00 | | 33.00 | 1319.00 | 22.00 | 356.00 | 75.00 | | 15.16 | 0.67 | Weinstein 2000 |
| 117.00 | 39.00 | | 14.00 | 1901.00 | 28.00 | 296.00 | 100.00 | | 16.25 | 2.00 | Weinstein 2000 |
| 138.00 | 33.00 | | 24.00 | 1956.00 | 21.00 | 292.00 | 82.00 | | 14.17 | 0.88 | Weinstein 2000 |
| 175.00 | 51.00 | | 17.00 | 1306.00 | 25.00 | 292.00 | 76.00 | | 7.46 | 1.47 | Weinstein 2000 |
| 140.00 | 36.00 | | 14.00 | 1465.00 | 25.00 | 328.00 | 95.00 | | 10.46 | 1.79 | Weinstein 2000 |
| **169.88** | **37.63** | | **17.94** | **1287.13** | **22.81** | **269.00** | **72.19** | **-** | **9.43** | **1.56** | |

| Sub-region | Site | Sample Name | Stratum | SiO2 | Na2O | K2O | Na2O + K2O | MgO | Al2O3 | P2O5 | CaO | TiO2 | Fe2O3 | FeO | Fe2O3 + (FeO x 1.11) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| **HULAH VALLEY** | HV | Wy-315 | Late Pliocene | 47.60 | 4.07 | 1.19 | 5.26 | 5.17 | 15.84 | 0.52 | 9.11 | 2.37 | 1.22 | 9.87 | 12.18 |
| | HV | Wy-317 | Late Pliocene | 47.90 | 2.97 | 0.68 | 3.65 | 10.94 | 14.05 | 0.18 | 8.27 | 1.80 | 1.29 | 10.47 | 12.91 |
| | HV | Wy-317a | Late Pliocene | 47.00 | 2.78 | 0.66 | 3.44 | 9.35 | 14.20 | 0.29 | 8.30 | 1.88 | 1.24 | 10.07 | 12.42 |
| | HV | Wy-390 | Late Pliocene | 47.90 | 3.14 | 1.16 | 4.30 | 7.45 | 14.98 | 0.40 | 9.71 | 2.27 | 1.22 | 9.88 | 12.19 |
| | HV | Wy-394 | Late Pliocene | | | | | | | | | | | | |
| | HV | Wy-395 | Late Pliocene | 47.20 | 2.50 | 1.10 | 3.60 | 9.50 | 14.10 | 0.40 | 8.60 | 2.00 | 1.24 | 10.04 | 12.38 |
| | HV | Wy-397 | Late Pliocene | 46.60 | 3.10 | 1.20 | 4.30 | 6.40 | 15.30 | 0.80 | 10.00 | 2.50 | 1.18 | 9.56 | 11.79 |
| | **HV** | **Average (n = 7)** | **Late Pliocene** | **47.37** | **3.09** | **1.00** | **4.09** | **8.14** | **14.75** | **0.43** | **9.00** | **2.14** | **1.23** | **9.98** | **12.31** |
| | | | | | | | | | | | | | | | |
| | W. Golan | Wy-287 | Late Pliocene | 46.30 | 3.20 | 0.92 | 4.12 | 9.03 | 14.49 | 0.55 | 9.67 | 2.23 | 1.32 | 10.71 | 13.21 |
| | W. Golan | Wy-282 | Late Pliocene | 46.80 | 3.06 | 0.76 | 3.82 | 9.01 | 14.98 | 0.38 | 9.41 | 2.06 | 1.32 | 10.70 | 13.20 |
| | W. Golan | Wy-280 | Late Pliocene | 47.40 | 3.35 | 1.16 | 4.51 | 8.34 | 14.33 | 0.52 | 9.00 | 2.48 | 1.26 | 10.22 | 12.60 |
| | W. Golan | Wy-279 | Late Pliocene | 48.10 | 3.00 | 1.12 | 4.12 | 6.30 | 16.39 | 0.33 | 10.49 | 2.39 | 1.12 | 9.08 | 11.20 |
| | W. Golan | Wy-278 | Late Pliocene | 46.00 | 3.58 | 1.15 | 4.73 | 8.60 | 14.27 | 0.64 | 9.46 | 2.49 | 1.34 | 10.87 | 13.41 |
| | W. Golan | Wy-276 | Late Pliocene | 46.00 | 3.61 | 1.01 | 4.62 | 8.76 | 14.17 | 0.57 | 9.47 | 2.40 | 1.36 | 10.98 | 13.55 |
| | **W Golan** | **Average (n = 6)** | **Late Pliocene** | **46.77** | **3.30** | **1.02** | **4.32** | **8.34** | **14.77** | **0.50** | **9.58** | **2.34** | **1.29** | **10.43** | **12.86** |
| | | | | | | | | | | | | | | | |
| | Galilee-S | Wy-308 | Late Pliocene | 43.80 | 5.09 | 0.97 | 6.06 | 7.00 | 13.78 | 1.37 | 9.52 | 3.25 | 1.28 | 10.33 | 12.75 |
| | Galilee-S | Wy-309 | Late Pliocene | 43.60 | 4.67 | 0.88 | 5.55 | 7.15 | 13.88 | 1.37 | 9.83 | 3.27 | 1.28 | 10.33 | 12.75 |
| | Galilee-S | UK-4126 | Late Pliocene | 43.50 | 5.13 | 1.05 | 6.18 | 6.83 | 13.84 | 1.42 | 10.49 | 3.10 | 1.25 | 10.08 | 12.44 |
| | **Galilee-S** | **Average (n = 3)** | **Late Pliocene** | **43.63** | **4.96** | **0.97** | **5.93** | **6.99** | **13.83** | **1.39** | **9.95** | **3.21** | **1.27** | **10.25** | **12.64** |
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| **KORAZIM-SOG** | Galilee-S | Wy-165 | Early Pliocene | 44.00 | 2.64 | 1.27 | 3.91 | 10.00 | 13.53 | 0.49 | 9.80 | 2.43 | 1.27 | 10.28 | 12.68 |
| | Galilee-S | Wy-228 | Early Pliocene | 48.30 | 3.38 | 0.87 | 4.25 | 5.78 | 15.34 | 0.29 | 9.40 | 2.47 | 1.29 | 10.48 | 12.92 |
| | Galilee-S | Wy-136 | Early Pliocene | 48.30 | 3.21 | 0.70 | 3.91 | 7.94 | 14.97 | 0.16 | 9.06 | 1.87 | 1.29 | 10.45 | 12.89 |
| | **Galilee-S** | **Average (n = 3)** | **Early Pliocene** | **46.87** | **3.08** | **0.95** | **4.02** | **7.91** | **14.61** | **0.31** | **9.42** | **2.26** | **1.28** | **10.40** | **12.83** |
| | | | | | | | | | | | | | | | |
| | Korazim | Wy-293 | Early Pliocene | 47.50 | 3.03 | 0.90 | 3.93 | 8.49 | 14.68 | 0.35 | 9.78 | 2.12 | 1.27 | 10.29 | 12.69 |
| | Korazim | Wy-294 | Early Pliocene | 45.10 | 3.08 | 0.86 | 3.94 | 10.70 | 12.77 | 0.89 | 11.16 | 2.10 | 1.30 | 10.54 | 13.00 |
| | Korazim | Wy-295 | Early Pliocene | 45.30 | 3.03 | 0.90 | 3.93 | 8.80 | 13.28 | 1.00 | 11.32 | 2.11 | 1.29 | 10.46 | 12.90 |
| | Korazim | Wy-296 | Early Pliocene | 45.10 | 2.46 | 0.84 | 3.30 | 8.53 | 13.37 | 0.85 | 11.25 | 2.18 | 1.33 | 10.74 | 13.25 |
| | Korazim | Wy-297 | Early Pliocene | 46.20 | 2.60 | 1.00 | 3.60 | 9.10 | 13.80 | 0.50 | 10.11 | 2.00 | 1.24 | 10.04 | 12.38 |
| | Korazim | Wy-298 | Early Pliocene | 46.70 | 3.46 | 1.00 | 4.46 | 8.24 | 14.23 | 0.54 | 10.11 | 2.19 | 1.29 | 10.47 | 12.91 |
| | Korazim | Wy-311 | Early Pliocene | 48.40 | 3.58 | 0.95 | 4.53 | 6.62 | 15.40 | 0.36 | 9.66 | 2.10 | 1.26 | 10.19 | 12.57 |
| | **Korazim** | **Average (n = 7)** | **Early Pliocene** | **46.33** | **3.03** | **0.92** | **3.96** | **8.64** | **13.93** | **0.64** | **10.48** | **2.11** | **1.28** | **10.39** | **12.82** |

| Ni | Cu | Zn | Rb | Sr | Y | Zr | Nb | Pb | Sr / Ni | Y / Rb | Publication |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| 37.00 | 28.00 | 109.00 | 16.00 | 788.00 | 22.00 | 214.00 | | 3.12 | 21.30 | 1.38 | Weinstein 2012 |
| 272.00 | 38.00 | 106.00 | 7.00 | 632.00 | 14.00 | 126.00 | | 1.28 | 2.32 | 2.00 | Weinstein 2012 |
| 182.00 | 41.00 | 104.00 | 7.00 | 1187.00 | 18.00 | 135.00 | | 1.60 | 6.52 | 2.57 | Weinstein 2012 |
| 145.00 | 39.00 | 107.00 | 16.00 | 622.00 | 25.00 | 206.00 | | 2.10 | 4.29 | 1.56 | Weinstein 2012 |
| 197.00 | 45.00 | 116.00 | 16.00 | 840.00 | 24.00 | 196.00 | | | 4.26 | 1.50 | Weinstein 2012 |
| 178.00 | 37.00 | 108.00 | 16.00 | 541.00 | 21.00 | 197.00 | | 2.10 | 3.04 | 1.31 | Weinstein 2012 |
| 83.00 | 42.00 | 111.00 | 16.00 | 1085.00 | 24.00 | 241.00 | | 2.60 | 13.07 | 1.50 | Weinstein 2012 |
| **156.29** | **38.57** | **108.71** | **13.43** | **813.57** | **21.14** | **187.86** | | **2.13** | **7.83** | **1.69** | |
| | | | | | | | | | | | |
| 226.00 | 44.00 | 115.00 | 13.00 | 852.00 | 20.00 | 161.00 | 34.00 | 1.64 | 3.77 | 1.54 | Weinstein et al. 2006 |
| 234.00 | 49.00 | 107.00 | 11.00 | 553.00 | 21.00 | 129.00 | 24.00 | 1.11 | 2.36 | 1.91 | Weinstein et al. 2006 |
| 170.00 | 39.00 | 113.00 | 17.00 | 703.00 | 22.00 | 187.00 | 38.00 | 2.03 | 4.14 | 1.29 | Weinstein et al. 2006 |
| 100.00 | 40.00 | 96.00 | 18.00 | 782.00 | 21.00 | 193.00 | 40.00 | 2.01 | 7.82 | 1.17 | Weinstein et al. 2006 |
| 198.00 | 47.00 | 118.00 | 16.00 | 995.00 | 22.00 | 199.00 | 46.00 | 2.15 | 5.03 | 1.38 | Weinstein et al. 2006 |
| 200.00 | 45.00 | 116.00 | 13.00 | 845.00 | 23.00 | 173.00 | 38.00 | 2.11 | 4.23 | 1.77 | Weinstein et al. 2006 |
| **188.00** | **44.00** | **110.83** | **14.67** | **788.33** | **21.50** | **173.67** | **36.67** | **1.84** | **4.56** | **1.51** | |
| | | | | | | | | | | | |
| 154.00 | 31.00 | 136.00 | 16.00 | 1525.00 | 26.00 | 340.00 | 96.00 | 3.32 | 9.90 | 1.63 | Weinstein et al. 2006 |
| 165.00 | 32.00 | 135.00 | 11.00 | 1589.00 | 27.00 | 344.00 | 97.00 | 2.92 | 9.63 | 2.45 | Weinstein et al. 2006 |
| 141.00 | 35.00 | 129.00 | 6.00 | 1742.00 | 28.00 | 316.00 | 95.00 | 3.71 | 12.35 | 4.67 | Weinstein et al. 2006 |
| **153.33** | **32.67** | **133.33** | **11.00** | **1618.67** | **27.00** | **333.33** | **96.00** | **3.32** | **10.63** | **2.92** | |
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| | | | | | | | | | | | |
| 209.00 | 48.00 | 98.00 | 14.00 | 855.00 | 23.00 | 186.00 | 37.00 | | 4.09 | 1.64 | Weinstein et al. 2006 |
| 51.00 | 24.00 | 103.00 | 12.00 | 562.00 | 20.00 | 200.00 | 38.00 | | 11.02 | 1.67 | Weinstein et al. 2006 |
| 195.00 | 50.00 | 101.00 | 10.00 | 388.00 | 17.00 | 128.00 | 19.00 | 1.08 | 1.99 | 1.70 | Weinstein et al. 2006 |
| **151.67** | **40.67** | **100.67** | **12.00** | **601.67** | **20.00** | **171.33** | **31.33** | **1.08** | **5.70** | **1.67** | |
| | | | | | | | | | | | |
| 185.00 | 51.00 | 104.00 | 12.00 | 534.00 | 21.00 | 168.00 | | 1.71 | 2.89 | 1.75 | Weinstein 2012 |
| 303.00 | 57.00 | 108.00 | 13.00 | 860.00 | 27.00 | 194.00 | | | 2.84 | 2.08 | Weinstein 2012 |
| 288.00 | 54.00 | 104.00 | 14.00 | 995.00 | 30.00 | 193.00 | | 2.10 | 3.45 | 2.14 | Weinstein 2012 |
| 312.00 | 62.00 | 110.00 | 12.00 | 890.00 | 29.00 | 194.00 | | 2.61 | 2.85 | 2.42 | Weinstein 2012 |
| | | | | | | | | 2.31 | | | Weinstein 2012 |
| 201.00 | 55.00 | 111.00 | 16.00 | 653.00 | 23.00 | 197.00 | | 6.49 | 3.25 | 1.44 | Weinstein 2012 |
| 95.00 | 38.00 | 99.00 | 16.00 | 599.00 | 22.00 | 176.00 | | 1.74 | 6.31 | 1.38 | Weinstein 2012 |
| **230.67** | **52.83** | **106.00** | **13.83** | **755.17** | **25.33** | **187.00** | | **2.83** | **3.60** | **1.87** | |

| Sub-region | Site | Sample Name | Stratum | SiO2 | Na2O | K2O | Na2O + K2O | MgO | Al2O3 | P2O5 | CaO | TiO2 | Fe2O3 | FeO | Fe2O3 + (FeO x 1.11) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| **SE LOWER GALILEE** | Poria | Wy-351 | Miocene | 43.65 | 2.22 | 1.25 | 3.47 | 9.63 | 13.44 | 0.51 | 9.67 | 3.18 | 1.29 | 10.45 | 12.89 |
| | Poria | Wy-352 | Miocene | 44.62 | 2.42 | 1.36 | 3.78 | 10.93 | 13.26 | 0.51 | 9.42 | 2.78 | 1.25 | 10.11 | 12.47 |
| | Poria | Wy-368 | Miocene | 46.35 | 2.63 | 0.67 | 3.30 | 7.99 | 13.44 | 0.30 | 8.66 | 2.61 | 1.33 | 10.74 | 13.25 |
| | Poria | Wy-369 | Miocene | 43.66 | 1.89 | 1.04 | 2.93 | 10.54 | 13.28 | 0.47 | 10.52 | 2.44 | 1.32 | 10.67 | 13.16 |
| | **Poria** | **Average (n = 4)** | **Miocene** | **44.57** | **2.29** | **1.08** | **3.37** | **9.77** | **13.36** | **0.45** | **9.57** | **2.75** | **1.30** | **10.49** | **12.94** |
| | | | | | | | | | | | | | | | |
| | Wadi Taylor dykes | Wy-318 | Miocene | 47.80 | 3.36 | 1.16 | 4.52 | 6.61 | 15.45 | 0.44 | 8.94 | 2.40 | 1.19 | 9.66 | 11.91 |
| | Wadi Taylor dykes | Wy-320 | Miocene | 48.20 | 3.39 | 1.18 | 4.57 | 4.18 | 15.76 | 0.41 | 9.05 | 2.45 | 1.27 | 10.28 | 12.68 |
| | Wadi Taylor dykes | Wy-2001 | Miocene | 44.60 | 2.09 | 1.36 | 3.45 | 8.93 | 13.63 | 0.62 | 9.48 | 2.52 | 1.37 | 11.07 | 13.66 |
| | **Wadi Taylor dykes** | **Average (n = 3)** | **Miocene** | **46.87** | **2.95** | **1.23** | **4.18** | **6.57** | **14.95** | **0.49** | **9.16** | **2.46** | **1.28** | **10.34** | **12.75** |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **HARRA EL-JABBAN** | Jebal Aritain | A1c | Pleistocene | 45.78 | 3.15 | 1.31 | 4.46 | 9.23 | 14.90 | 0.63 | 8.33 | 2.31 | 4.85 | 7.20 | 12.84 |
| | Jebal Aritain | A3 | Pleistocene | 45.55 | 3.44 | 1.18 | 4.62 | 10.45 | 13.42 | 0.49 | 9.20 | 2.83 | 3.01 | 7.31 | 11.12 |
| | Jebal Aritain | A3b | Pleistocene | 44.72 | 3.61 | 1.34 | 4.95 | 8.77 | 13.73 | 0.21 | 10.43 | 3.18 | 4.64 | 7.76 | 13.25 |
| | Jebal Aritain | A8 | Pleistocene | 44.38 | 3.22 | 1.25 | 4.47 | 8.61 | 14.51 | 0.49 | 9.74 | 3.21 | 3.35 | 7.85 | 12.06 |
| | Jebal Aritain | A9a | Pleistocene | 44.50 | 3.44 | 1.22 | 4.66 | 9.21 | 15.27 | 0.58 | 9.52 | 2.85 | 3.62 | 8.14 | 12.66 |
| | Jebal Aritain | A9b | Pleistocene | 44.70 | 3.10 | 1.23 | 4.33 | 8.81 | 14.93 | 0.47 | 9.72 | 3.05 | 3.25 | 7.90 | 12.02 |
| | Jebal Aritain | A10b | Pleistocene | 44.70 | 2.91 | 1.29 | 4.20 | 8.76 | 14.55 | 0.31 | 10.08 | 2.85 | 3.93 | 7.85 | 12.64 |
| | Jebal Aritain | A20a | Pleistocene | 45.10 | 3.16 | 1.28 | 4.44 | 8.99 | 13.57 | 0.32 | 9.80 | 3.05 | 3.91 | 8.38 | 13.21 |
| | Jebal Aritain | A19 | Pleistocene | 46.65 | 3.26 | 1.10 | 4.36 | 10.25 | 14.30 | 0.53 | 8.74 | 2.55 | 3.89 | 8.12 | 12.90 |
| | Jebal Aritain | A21c | Pleistocene | 45.41 | 3.13 | 1.23 | 4.36 | 8.93 | 14.82 | 0.55 | 9.08 | 2.65 | 3.97 | 7.44 | 12.23 |
| | **Jebal Aritain** | **Average (n = 10)** | **Pleistocene** | **45.15** | **3.24** | **1.24** | **4.49** | **9.20** | **14.40** | **0.46** | **9.46** | **2.85** | **3.84** | **7.80** | **12.49** |
| | | | | | | | | | | | | | | | |
| | Jebal Fahem | M3b | Pleistocene | 44.72 | 3.68 | 1.09 | 4.77 | 10.22 | 14.81 | 0.40 | 9.74 | 2.18 | 4.07 | 6.80 | 11.62 |
| | Jebal Fahem | M3c | Pleistocene | 44.83 | 3.00 | 1.29 | 4.29 | 9.56 | 14.16 | 0.46 | 9.52 | 2.09 | 3.68 | 6.43 | 10.82 |
| | Jebal Fahem | M7 | Pleistocene | 44.01 | 2.92 | 1.25 | 4.17 | 10.45 | 14.49 | 0.27 | 9.47 | 2.15 | 3.97 | 7.11 | 11.86 |
| | Jebal Fahem | M10 | Pleistocene | 44.09 | 3.09 | 1.15 | 4.24 | 10.26 | 15.13 | 0.29 | 9.44 | 2.22 | 4.05 | 7.19 | 12.03 |
| | Jebal Fahem | M10c | Pleistocene | 44.22 | 3.00 | 1.03 | 4.03 | 9.55 | 14.05 | 0.35 | 10.02 | 2.10 | 3.84 | 6.95 | 11.55 |
| | Jebal Fahem | M11a | Pleistocene | 44.58 | 3.14 | 1.02 | 4.16 | 8.29 | 14.42 | 0.21 | 9.90 | 2.13 | 3.88 | 6.88 | 11.52 |
| | Jebal Fahem | M12 | Pleistocene | 44.13 | 3.07 | 1.21 | 4.28 | 10.01 | 14.51 | 0.38 | 9.92 | 2.12 | 3.78 | 6.93 | 11.47 |
| | Jebal Fahem | M14 | Pleistocene | 44.17 | 3.06 | 1.11 | 4.17 | 10.12 | 14.53 | 0.35 | 9.83 | 2.14 | 3.82 | 6.83 | 11.40 |
| | Jebal Fahem | M17 | Pleistocene | 44.11 | 3.19 | 1.14 | 4.33 | 9.16 | 14.13 | 0.35 | 10.26 | 2.21 | 4.09 | 7.15 | 12.03 |
| | Jebal Fahem | M22 | Pleistocene | 44.29 | 3.63 | 1.05 | 4.68 | 9.33 | 13.58 | 0.36 | 10.23 | 2.01 | 3.72 | 6.32 | 10.74 |
| | **Jebal Fahem** | **Average (n = 10)** | **Pleistocene** | **44.32** | **3.18** | **1.13** | **4.31** | **9.70** | **14.38** | **0.34** | **9.83** | **2.14** | **3.89** | **6.86** | **11.50** |

| Ni | Cu | Zn | Rb | Sr | Y | Zr | Nb | Pb | Sr / Ni | Y / Rb | Publication |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| 209.00 | 43.00 | | 12.00 | 1006.00 | 21.00 | 237.00 | 48.00 | | 4.81 | 1.75 | Weinstein 2000 |
| 251.00 | 53.00 | | 24.00 | 655.00 | 21.00 | 194.00 | 42.00 | | 2.61 | 0.88 | Weinstein 2000 |
| 261.00 | 24.00 | | 10.00 | 496.00 | 17.00 | 129.00 | 22.00 | | 1.90 | 1.70 | Weinstein 2000 |
| 274.00 | 51.00 | | 19.00 | 724.00 | 20.00 | 162.00 | 42.00 | | 2.64 | 1.05 | Weinstein 2000 |
| **248.75** | **42.75** | | **16.25** | **720.25** | **19.75** | **180.50** | **38.50** | - | 2.90 | **1.34** | |
| | | | | | | | | | | | |
| 70.00 | 18.00 | | 18.00 | 729.00 | 23.00 | 198.00 | 40.00 | 2.24 | 10.41 | 1.28 | Weinstein 2000 |
| 84.00 | 14.00 | | 17.00 | 656.00 | 22.00 | 195.00 | 38.00 | | 7.81 | 1.29 | Weinstein 2000 |
| 177.00 | 41.00 | | 16.00 | 1192.00 | 23.00 | 230.00 | 46.00 | 3.56 | 6.73 | 1.44 | Weinstein 2000 |
| **110.33** | **24.33** | | **17.00** | **859.00** | **22.67** | **207.67** | **41.33** | **2.90** | 8.32 | **1.34** | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 185.00 | 46.00 | | 26.00 | 1090.00 | 28.00 | 265.00 | 65.00 | | 5.89 | 1.08 | Al-Malabeh 1994 |
| 210.00 | 39.00 | | 22.00 | 960.00 | 27.00 | 247.00 | 53.00 | | 4.57 | 1.23 | Al-Malabeh 1994 |
| 161.00 | 72.00 | | 30.00 | 1048.00 | 26.00 | 265.00 | 68.00 | | 6.51 | 0.87 | Al-Malabeh 1994 |
| 220.00 | 40.00 | | 29.00 | 1064.00 | 28.00 | 258.00 | 64.00 | | 4.84 | 0.97 | Al-Malabeh 1994 |
| 180.00 | 61.00 | | 26.00 | 1010.00 | 27.00 | 249.00 | 58.00 | | 5.61 | 1.04 | Al-Malabeh 1994 |
| 201.00 | 41.00 | | 24.00 | 1015.00 | 25.00 | 251.00 | 61.00 | | 5.05 | 1.04 | Al-Malabeh 1994 |
| 215.00 | 58.00 | | 30.00 | 1120.00 | 27.00 | 260.00 | 62.00 | | 5.21 | 0.90 | Al-Malabeh 1994 |
| 175.00 | 63.00 | | 29.00 | 1083.00 | 24.00 | 260.00 | 62.00 | | 6.19 | 0.83 | Al-Malabeh 1994 |
| 330.00 | 46.00 | | 27.00 | 1084.00 | 26.00 | 253.00 | 59.00 | | 3.28 | 0.96 | Al-Malabeh 1994 |
| 220.00 | 32.00 | | 25.00 | 1010.00 | 27.00 | 248.00 | 58.00 | | 4.59 | 1.08 | Al-Malabeh 1994 |
| **209.70** | **49.80** | | **26.80** | **1048.40** | **26.50** | **255.60** | **61.00** | - | **5.17** | **1.00** | |
| | | | | | | | | | | | |
| 341.00 | 76.00 | | 20.00 | 1040.00 | 26.00 | 224.00 | 36.00 | | 3.05 | 1.30 | Al-Malabeh 1994 |
| 215.00 | 52.00 | | 18.00 | 993.00 | 25.00 | 215.00 | 43.00 | | 4.62 | 1.39 | Al-Malabeh 1994 |
| 216.00 | 48.00 | | 20.00 | 973.00 | 26.00 | 218.00 | 39.00 | | 4.50 | 1.30 | Al-Malabeh 1994 |
| 206.00 | 39.00 | | 19.00 | 957.00 | 25.00 | 212.00 | 46.00 | | 4.65 | 1.32 | Al-Malabeh 1994 |
| 196.00 | 48.00 | | 17.00 | 970.00 | 27.00 | 214.00 | 39.00 | | 4.95 | 1.59 | Al-Malabeh 1994 |
| 195.00 | 67.00 | | 20.00 | 960.00 | 25.00 | 210.00 | 47.00 | | 4.92 | 1.25 | Al-Malabeh 1994 |
| 194.00 | 57.00 | | 21.00 | 990.00 | 26.00 | 209.00 | 45.00 | | 5.10 | 1.24 | Al-Malabeh 1994 |
| 193.00 | 59.00 | | 19.00 | 946.00 | 26.00 | 208.00 | 34.00 | | 4.90 | 1.37 | Al-Malabeh 1994 |
| 189.00 | 45.00 | | 17.00 | 816.00 | 26.00 | 204.00 | 42.00 | | 4.32 | 1.53 | Al-Malabeh 1994 |
| 197.00 | 41.00 | | 16.00 | 785.00 | 25.00 | 196.00 | 34.00 | | 3.98 | 1.56 | Al-Malabeh 1994 |
| **214.20** | **53.20** | | **18.70** | **943.00** | **25.70** | **211.00** | **40.50** | - | **4.50** | **1.38** | |

| Sub-region | Site | Sample Name | Stratum | SiO2 | Na2O | K2O | Na2O + K2O | MgO | Al2O3 | P2O5 | CaO | TiO2 | Fe2O3 | FeO | Fe2O3 + (FeO x 1.11) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| **NORTHERN EGYPT** | Haddadin | Average | Miocene | 50.10 | 2.71 | 0.85 | 3.56 | 6.30 | 14.30 | 0.27 | 9.68 | 2.31 | 13.30 | | 13.30 |
| | Cairo-Suez | Average | Miocene | 48.50 | 2.58 | 0.78 | 3.36 | 5.22 | 15.40 | 0.46 | 9.77 | 2.91 | 14.20 | | 14.20 |
| | Baharire | Average | Miocene | 48.30 | 2.84 | 0.66 | 3.50 | 6.75 | 16.40 | 0.34 | 11.30 | 1.04 | 12.10 | | 12.10 |
| | Middle Egypt | Average | Miocene | 47.10 | 2.86 | 0.50 | 3.36 | 5.63 | 15.60 | 0.39 | 10.10 | 2.97 | 14.60 | | 14.60 |
| | **N. Egypt** | **Average (n = 4)** | **Miocene** | **48.50** | **2.75** | **0.70** | **3.45** | **5.98** | **15.43** | **0.37** | **10.21** | **2.31** | **13.55** | | **13.55** |
| | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | |
| **SOUTHERN EGYPT** | SW Nubian Desert | Average | Miocene | 46.30 | 3.15 | 1.36 | 4.51 | 7.94 | 15.00 | 0.69 | 8.79 | 3.09 | 13.60 | | 13.60 |
| | Wadi Natash | Average | Miocene | 46.20 | 2.88 | 1.09 | 3.97 | 8.32 | 14.20 | 0.61 | 9.40 | 3.08 | 14.00 | | 14.00 |
| | **S. Egypt** | **Average (n = 2)** | **Miocene** | **46.25** | **3.02** | **1.23** | **4.24** | **8.13** | **14.60** | **0.65** | **9.10** | **3.09** | **13.80** | | **13.80** |
| | | | | | | | | | | | | | | | |
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| **MT. HERMON** | Phase 1 | AS 505 | Neogene-Quaternary | 46.33 | 2.80 | 0.30 | 3.10 | 12.10 | 13.70 | 0.10 | 7.30 | 1.32 | 2.82 | 9.78 | 13.68 |
| | Phase 1 | SL 103 | Neogene-Quaternary | 48.80 | 2.93 | 0.41 | 3.34 | 8.80 | 14.20 | 0.25 | 9.20 | 1.78 | 3.28 | 9.72 | 14.07 |
| | Phase 1 | SL 116 | Neogene-Quaternary | 49.30 | 2.95 | 0.34 | 3.29 | 8.20 | 14.40 | 0.25 | 9.20 | 1.75 | 3.25 | 9.65 | 13.96 |
| | **Phase 1** | **Average (n = 3)** | **Neogene-Quaternary** | **48.14** | **2.89** | **0.35** | **3.24** | **9.70** | **14.10** | **0.20** | **8.57** | **1.62** | **3.12** | **9.72** | **13.90** |
| | | | | | | | | | | | | | | | |
| | Phase 2-1 | AS 262 | Neogene-Quaternary | 45.20 | 3.60 | 1.60 | 5.20 | 6.40 | 15.70 | 1.00 | 8.40 | 2.70 | 4.20 | 8.50 | 13.64 |
| | Phase 2-1 | AS 628 | Neogene-Quaternary | 45.50 | 2.60 | 1.30 | 3.90 | 7.40 | 14.90 | 1.00 | 8.60 | 3.30 | 4.80 | 9.00 | 14.79 |
| | Phase 2-1 | AS 472 | Neogene-Quaternary | 46.60 | 4.05 | 1.45 | 5.50 | 5.60 | 15.80 | 0.90 | 7.60 | 2.79 | 4.29 | 8.71 | 13.96 |
| | Phase 2-1 | AS 527 | Neogene-Quaternary | 44.50 | 2.80 | 1.30 | 4.10 | 7.20 | 15.50 | 0.90 | 9.10 | 3.42 | 4.92 | 9.58 | 15.55 |
| | Phase 2-1 | SL 114 | Neogene-Quaternary | 44.00 | 2.90 | 1.06 | 3.96 | 7.90 | 14.90 | 0.80 | 8.80 | 3.31 | 4.81 | 8.69 | 14.46 |
| | **Phase 2-1** | **Average (n = 5)** | **Neogene-Quaternary** | **45.16** | **3.19** | **1.34** | **4.53** | **6.90** | **15.36** | **0.92** | **8.50** | **3.10** | **4.60** | **8.90** | **14.48** |
| | | | | | | | | | | | | | | | |
| | Phase 3 | AS 503 | Neogene-Quaternary | 46.00 | 3.90 | 1.50 | 5.40 | 7.00 | 15.60 | 0.50 | 8.50 | 2.80 | 4.30 | 8.00 | 13.18 |
| | Phase 3 | SL 111 | Neogene-Quaternary | 45.40 | 4.10 | 1.06 | 5.16 | 6.30 | 15.40 | 0.80 | 10.00 | 2.65 | 4.15 | 8.85 | 13.97 |
| | Phase 3 | SL 120 | Neogene-Quaternary | 45.60 | 3.10 | 0.51 | 3.61 | 8.80 | 14.60 | 0.50 | 10.40 | 2.65 | 4.15 | 9.45 | 14.64 |
| | Phase 3 | SL 108 | Neogene-Quaternary | 45.10 | 3.35 | 0.75 | 4.10 | 8.50 | 14.40 | 0.50 | 10.50 | 2.63 | 4.13 | 8.97 | 14.09 |
| | **Phase 3** | **Average (n = 4)** | **Neogene-Quaternary** | **45.53** | **3.61** | **0.96** | **4.57** | **7.65** | **15.00** | **0.58** | **9.85** | **2.68** | **4.18** | **8.82** | **13.97** |
| | | | | | | | | | | | | | | | |
| | Phase 2-2 | AS 525 | Neogene-Quaternary | 44.70 | 3.90 | 1.70 | 5.60 | 6.20 | 16.00 | 0.70 | 8.00 | 3.64 | 4.14 | 9.66 | 14.86 |
| | Phase 2-2 | SL 119 | Neogene-Quaternary | 45.60 | 3.30 | 1.54 | 4.84 | 9.40 | 14.00 | 0.54 | 9.70 | 2.66 | 4.16 | 7.54 | 12.53 |
| | Phase 2-2 | SL 117 | Neogene-Quaternary | 45.20 | 3.30 | 1.20 | 4.50 | 9.40 | 14.30 | 0.70 | 10.30 | 2.70 | 4.20 | 8.70 | 13.86 |
| | **Phase 2-2** | **Average (n = 3)** | **Neogene-Quaternary** | **45.17** | **3.50** | **1.48** | **4.98** | **8.33** | **14.77** | **0.65** | **9.33** | **3.00** | **4.17** | **8.63** | **13.75** |

| Ni | Cu | Zn | Rb | Sr | Y | Zr | Nb | Pb | Sr / Ni | Y / Rb | Publication |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| 51.40 | 59.30 | 93.20 | 20.70 | 355.70 | 33.00 | 224.00 | 25.40 | 8.29 | 6.92 | 1.59 | Greenough et al. 2001 |
| 34.40 | 43.00 | 90.00 | 15.40 | 383.90 | 42.30 | 258.60 | 25.10 | | 11.16 | 2.75 | Greenough et al. 2001 |
| 185.70 | 57.00 | 66.00 | 16.80 | 495.70 | 16.80 | 110.50 | 26.10 | 1.48 | 2.67 | 1.00 | Greenough et al. 2001 |
| 41.00 | 58.50 | 81.00 | 9.90 | 421.30 | 33.60 | 207.30 | 19.80 | | 10.28 | 3.39 | Greenough et al. 2001 |
| **78.13** | **54.45** | **82.55** | **15.70** | **414.15** | **31.43** | **200.10** | **24.10** | **4.89** | **7.76** | **2.18** | |
| | | | | | | | | | | | |
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| | | | | | | | | | | | |
| 133.00 | | 36.33 | 26.90 | 873.00 | 28.60 | 180.50 | 61.40 | 6.00 | 6.56 | 1.06 | Greenough et al. 2001 |
| 89.30 | 54.30 | 57.70 | 30.80 | 711.80 | 21.10 | 214.70 | 43.70 | 5.00 | 7.97 | 0.69 | Greenough et al. 2001 |
| **111.15** | **54.30** | **47.02** | **28.85** | **792.40** | **24.85** | **197.60** | **52.55** | **5.50** | **7.27** | **0.87** | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 220.00 | 41.00 | 93.20 | 7.40 | 171.00 | 13.00 | 68.00 | 6.60 | 1.85 | 0.78 | 1.76 | Wilson et al. 2000 |
| 230.00 | 8.00 | 93.20 | 7.10 | 299.00 | 27.00 | 89.00 | 14.40 | 1.84 | 1.30 | 3.80 | Wilson et al. 2000 |
| 225.00 | 78.00 | 93.20 | 6.90 | 274.00 | 18.00 | 93.00 | 14.90 | 1.19 | 1.22 | 2.61 | Wilson et al. 2000 |
| **225.00** | **42.33** | **93.20** | **7.13** | **248.00** | **19.33** | **83.33** | **11.97** | **1.63** | **1.10** | **2.72** | |
| | | | | | | | | | | | |
| 85.00 | 17.00 | 93.20 | 29.00 | 803.00 | 31.00 | 303.00 | 73.80 | 3.89 | 9.45 | 1.07 | Wilson et al. 2000 |
| 95.00 | 10.00 | 93.20 | 23.00 | 904.00 | 29.00 | 243.00 | 56.40 | 2.76 | 9.52 | 1.26 | Wilson et al. 2000 |
| 55.00 | 34.00 | 93.20 | 22.40 | 810.00 | 37.00 | 318.00 | 67.50 | 3.34 | 14.73 | 1.65 | Wilson et al. 2000 |
| 90.00 | 36.00 | 93.20 | 20.90 | 966.00 | 24.00 | 234.00 | 55.00 | 3.90 | 10.73 | 1.15 | Wilson et al. 2000 |
| 100.00 | 44.00 | 93.20 | 18.80 | 785.00 | 25.00 | 217.00 | 51.40 | 3.22 | 7.85 | 1.33 | Wilson et al. 2000 |
| **85.00** | **28.20** | **93.20** | **22.82** | **853.60** | **29.20** | **263.00** | **60.82** | **3.42** | **10.45** | **1.29** | |
| | | | | | | | | | | | |
| 100.00 | 40.00 | 93.20 | 22.90 | 927.00 | 22.00 | 220.00 | 51.10 | 2.71 | 9.27 | 0.96 | Wilson et al. 2000 |
| 90.00 | 50.00 | 93.20 | 19.50 | 871.00 | 27.00 | 310.00 | 72.40 | 4.59 | 9.68 | 1.38 | Wilson et al. 2000 |
| 180.00 | 68.00 | 93.20 | 6.50 | 765.00 | 22.00 | 197.00 | 46.90 | 2.62 | 4.25 | 3.38 | Wilson et al. 2000 |
| 165.00 | 70.00 | 93.20 | 5.80 | 665.00 | 21.00 | 201.00 | 47.00 | | 4.03 | 3.62 | Wilson et al. 2000 |
| **133.75** | **57.00** | **93.20** | **13.68** | **807.00** | **23.00** | **232.00** | **54.35** | **3.31** | **6.81** | **2.34** | |
| | | | | | | | | | | | |
| 60.00 | 59.00 | 93.20 | 24.10 | 827.00 | 27.00 | 263.00 | 54.90 | 2.80 | 13.78 | 1.12 | Wilson et al. 2000 |
| 320.00 | 66.00 | 93.20 | 27.10 | 670.00 | 22.00 | 245.00 | 60.00 | 3.17 | 2.09 | 0.81 | Wilson et al. 2000 |
| 300.00 | 74.00 | 93.20 | 20.20 | 702.00 | 23.00 | 220.00 | 58.80 | 3.05 | 2.34 | 1.14 | Wilson et al. 2000 |
| **226.67** | **66.33** | **93.20** | **23.80** | **733.00** | **24.00** | **242.67** | **57.90** | **3.01** | **6.07** | **1.02** | |