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Approaches to Production and Distribution in

Anthropological Archaeology:

Views from the Early Bronze Age of Jordan and Israel

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of

Philosophy

in

Anthropology

by

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Professor Paul Goldstein

Professor Falko Kuester

Professor Lisa Tauxe

2016

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Chair

University of California, San Diego

2016

DEDICATION

For my Nanny Jean, who would have loved to have read this dissertation.

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LIST OF ABBREVIATIONS

CV - Coefficient of variation

EBA - Early Bronze Age

EBI - Early Bronze Age I

EBII - Early Bronze Age II

EBIII - Early Bronze Age III

EBIV - Early Bronze Age IV

EVE - Estimated vessel equivalent

ELRAP - Edom Lowlands Regional Archaeology Project

KHI - Khirbat Hamra Ifdan

MoR - Modulus of Rupture

MxNV - Maximum number of vessels

LIST OF SUPPLEMENTARY FILES

Gidding_AnalyzedDiag_Appendix2.csv

Gidding_FinalBulk_Appendix3.csv

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ABSTRACT OF THE DISSERTATION

Approaches to Production and Distribution in Anthropological Archaeology:

Views from the Early Bronze Age of Jordan and Israel

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The Early Bronze Age (3500 BCE – 2000 BCE) signals the start of complex societies across the Middle East. Compared to Egypt and Mesopotamia, sites in the southern Levant developed on a smaller scale. The difference in scale has led to debate about whether it is appropriate to call the settlements of the Early Bronze Age “urban” or “complex” by focusing on ranking, social differentiation, and unequal access to resources to indicate the development of elite structures. This study examines the site of Khirbat Hamra Ifdan (KHI) in the Faynan district of southern Jordan to assess the role of the production of copper on both local and regional social structures. As a significant prestige good, copper could act as a tool of ancient elites to finance and maintain their position of power. Any site involved in the production of

that good becomes an excellent candidate to examine the role of elites in production and unequal access to material wealth. However, the Faynan district is an arid region where dry farming is impossible, making the support of an urban elite difficult. In order to place production at KHI within the dialogue of urbanism in the Levantine EBA, it is necessary to highlight characteristics locally and regionally that indicate aspects of a production and exchange system that suggest ranking, social differentiation, and unequal access to resources. A hybrid approach is used to examine the social structure of KHI and the neighboring region. The ceramic assemblage, comprising over 6.5 tons of sherds is examined in detail according to types and functional equivalents to highlight whether there is evidence of division of activity within the site and tested. To do this a new web application and data infrastructure called ArchaeoSTOR was created. Next, a map of the diachronic changes in the constellation of copper producing and trading sites is developed using paleomagnetic and radiometric dating techniques to indicate contemporaneity along with ceramic correlates. Finally, local and regional data is used to describe a new model for the development and dissolution of specialized copper production during the EBA.

Chapter 1: Introduction to the Research Question

The development of urban centers is one of the most significant achievements in human history. The appearance of cities signals the arrival of a number of other features that can suddenly become archaeologically discernible as a part of a larger state apparatus. Chief among these is the appearance of ranked social organization that can be observed through a number of features that often appear concurrently: differential access to resources, mobilization of large-scale building projects, specialized craft production and mechanisms for a bureaucracy. These features are all important parts of defining a political economy that can be applied in any number of circumstances (Smith 1991). In fact, it is the expansion of these features beyond what might be considered a “home” area that can be used to define the development of pristine states (Spencer 2010). Over time, these features have appeared and disappeared as state apparatuses develop and collapse. One of the primary challenges for archaeologists is to describe the underlying causes for both the appearance and disappearance of these features in order to better understand the full variability of the human experience.

In this dissertation I will analyze the role that a specialized copper manufactory, the site Khirbat Hamra Ifdan (KHI), played in the southern Levantine Early Bronze Age (EBA; 3500-2000 BCE) political economy. The site dates to the end of the EBA and is located in the arid zone of Faynan, Jordan, which also is one of the few sources of copper in the southern Levant (See Figure 1.1, Levy et al. 2002). The ceramic data from KHI will be used to highlight variability in the use of space within KHI, especially in relation to faunal and metallurgical material types. Changes in the overall settlement organization will be contextualized with other sites in the region that were also involved with copper production. Problems in the relative chronology based on ceramics for the Levantine EBA have recently been noted so chronological association is done using radiometric and archaeomagnetic

techniques (Regev et al. 2012). The changes in the settlement patterns related to copper production are noted in relation to changes in the occupation history of KHI. This chapter will outline background to the research question and the organization of the dissertation in order to introduce the themes and data that will be examined. That data will be used to describe the how the political economy of the Faynan region reacted to changes in the structure of other complex societies within the Levant and in neighboring regions. This chapter will outline The political economies that developed in relation to the primary states are called “Secondary States”.

Secondary state formation offers the opportunity to explore how burgeoning states used their developing bureaucracies to influence and exploit nearby areas through the different expressions of social complexity in relation to stronger powers. In the southern Levant the Early Bronze Age (EBA, ~3500 - 2000 BCE) has long been argued to be the first urban period that developed as a secondary state in the shadow of the Egyptian state (Wright 1961, Esse 1991). This is despite the fact that the expression of urbanism in the EBA is at times incomplete and certainly on a different scale compared to its neighbors in Mesopotamia and Egypt (Joffe 1993). Further, recent scholarship has challenged the assertion that the EBA is in fact “urban” at all by focusing on the absence of each of the aforementioned features in such a formation that is indicative of a centralized authority (Philip 2001, Chesson and Philip 2003, Savage, Falconer, and Harrison 2007).

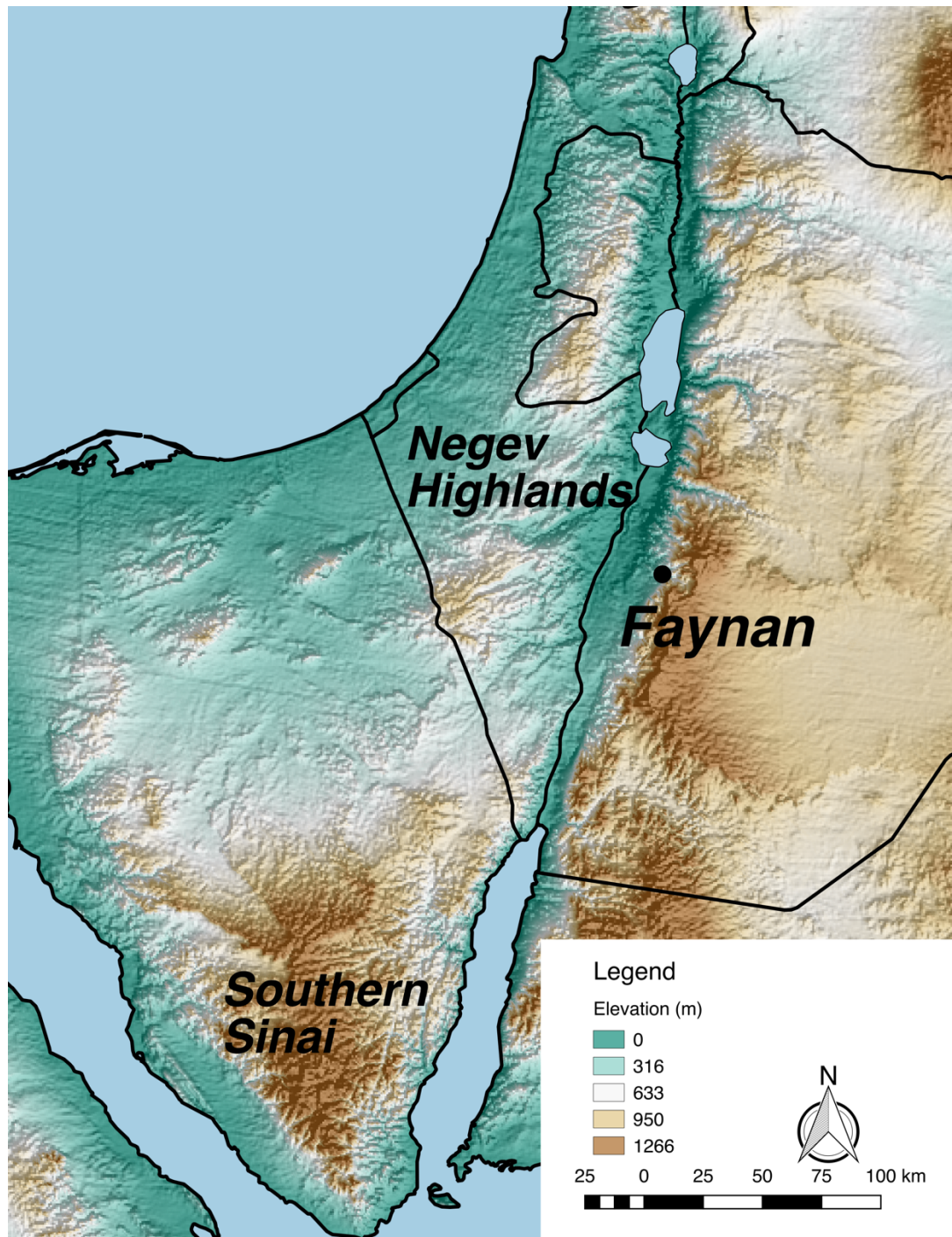


Figure 1.1: Map of the important regions for the copper trade during the Early Bronze Age mentioned in the text (DEM data from Land Processes Distributed Active Archive Center 2001).

One way to examine structural aspects of the political economy within the framework of the southern Levant is through the study of prestige commodity production. The exploitation of commodities at a large scale is a straightforward method to demonstrate complex social organizations. This is in part due to the intricacies of both producing and trading large volumes of goods. The intense production of specialized products requires the mobilization of a labor force in order to develop surpluses. Early in the development of complex social organization, the exploitation of rare materials such as copper is thought to have been one of the key tools of elites to consolidate power (Kristiansen and Earle 2015). This shift would signify the application of more complex means of elite finance beyond subsistence for the appropriation of wealth finance goods, which have their own unique applications within a central ruling authority (D'Altroy and Earle 1985). When the surplus commodity consists of prestige goods, exchange needs to be negotiated between the local elite that was able to mobilize the production of a good and a distant elite that requires the good to help validate power. The negotiations required to maintain elite control of production and to facilitate exchange are predicated on the presence of a bureaucratic apparatus. The bureaucratic apparatus helps to maintain differential access to resources and turn the results of the exchange into capital projects that serve to reinforce elite power. Hence the recognition that these factors occur contemporaneously as a constellation of features that lead to the suggestion that evidence of one feature can be used to identify the others.

Marginal environments are especially useful for highlighting instances where elites were involved in the development of specialized commodity production due to restrictions imposed by environmental factors. An archaeologically recognizable social hierarchy can develop in cases where there is evidence for a non-agricultural surplus based on durable goods. Arid zones offer a useful set of constraints when looking to develop a model for the ancient political economy because the environment is a limiting factor that must be considered

along with other potential influences (Rosen 2008, Pg. 409-410). Without the ability to reliably produce an agricultural surplus using dry agriculture, the type of settlement in arid zones is naturally limited. Typically, pastoralists utilize arid lands as pasture to support the specialized production of pastoral products in exchange with more permanently settled groups (Sherratt 1983, Khazanov 1994). However, the impermanence of settlement for these groups can be difficult to discern archaeologically making it difficult to directly study their political economy. In situations of pronounced settlement growth and intensification in arid zones it is expected to be the result of exchange using the surplus to provide for necessary subsistence in the arid environment. This would follow the Law of Comparative Advantage, which assumes that it is better to trade for a good when it is easier to produce a different good locally in exchange for the first (Ricardo 1817 [2010]). However, the fundamental problem of exchange is that it requires negotiations that make exchange not disadvantageous under the rational conditions of a one-man prisoner's dilemma (Greif 2000, Pg. 254-255). Hence, if such exchange is occurring over long distances, the necessary conditions to facilitate that exchange must occur through development of trust mechanisms that can be found in the bureaucracy of a state's political economy. To validate this process there needs to be evidence of production of a scale that is beyond necessary for basic local subsistence.

The identification of a site that depended significantly on a single resource helps with the study of the EBA political economy by reducing the variables that might influence the development of hierarchical structures. KHI offers such a case (Levy et al. 2002). As a scarce, circumscribed resource, the intense production of copper at KHI implies long distance trade. However, the sites that KHI is most closely associated with are associated with the collapse of both the Egyptian and the EBA urban system (Haiman 1996, Cohen 1999, Adams 2000, Dever 2014). As a result, the most dominant period of copper production in the Faynan region is left out of studies of the urban EBA political economy (Milevski 2009, de Miroschedji

2014). New research of the radiocarbon record from the EBA has indicated significant problems in the old version of the southern Levantine chronology and forces the reevaluation of the relative sequences of sites across the whole of the southern Levant (Regev et al. 2012). As a result, two key contributions will be made through research at KHI. First, a description of the degree of hierarchical control as a part of the local organization of copper production. Secondly, the chronological data from KHI needs to be reevaluated in relation to other EBA copper production sites. This will illustrate the social context that led to the intensification of copper production at KHI. For this case, the copper exchange system this would mean understanding not just what was exchanged and between whom, but what are the mediating factors that make this possible. Examples of questions that need to be asked in order to elucidate this discussion include what were the circumstances of consumption? What were the circumstances of production? Moreover, what values might have been communicated between producers and consumers? The description of social complexity at KHI and the regional setting for KHI will be necessary to identify to answer broader questions regarding the social complexity of political organizations during the EBA and how they responded to external stimuli.

The second chapter, Insights on Urbanism and Social Organization of Production and Exchange will provide theoretical background necessary to situate the research problem. As already discussed identifying components of a developed political economy are an important part of identifying social complexity associated with urbanism. Important consideration will be given to how specialized production is organized and the necessary political conditions that enable different kinds of production systems. The presence of intense production implies exchange and the different models for exchange systems and how they are used as a part of political economy will be reviewed. The concept of property, an important but difficult to identify feature of differential access to resources, will be used to highlight important aspects

of communication that can be implicit in the production process. Due to KHI's location in a Saharo-Arabian desert environment, pastoralism as a subsistence strategy and a means of production will be discussed in light of the treatment of production, exchange and property in settled groups. The transhumance of pastoral groups will lead to the presentation of the concept of an "Industrial Landscape" that can be studied diachronically to understand shifts in the overall demand for copper. Other contemporaneous copper production systems in other parts of the Near East will be discussed as reference for the production seen at KHI. Finally, the way that urbanism and by association social complexity have been dealt with in the context of EBA Levantine research will be reviewed as it has been applied to the structural and economic features of settlements.

The third chapter, Models for the Social and Political History of the Negev and Faynan will use the theoretical models for the development of "urban" settlements as the basis to describe and evaluate models for the organization of settlement in the Negev and Faynan. The two regions are separated by a modern border, but in antiquity evidence supports that the areas were treated as a geographical unit, defined in part by ecology (Bienkowski and Galor 2006). The earliest research that focused on aspects of copper production in the EBA took place within Israel and as a result focused on the Negev and Sinai. The predominant model set by the first research proposed that the copper production system did not persist for the whole of the EBA. Research in Faynan began later and Jordanian data still has not been fully integrated into the synthetic models of the Levantine EBA political economy (e.g. Milevski 2009, de Miroschedji 2014). How the history of research has affected the overall interpretation of copper production in the EBA will be reviewed. Each model will be considered according to aspects of craft specialization, the role of Egypt and local cities for setting demand, the degree of social complexity during each phase of copper production and whether

metalworking was a local development. I will then use the background data provided in the description of models to establish the parameters for the current study at KHI.

The fourth chapter, History of Early Bronze Age Research: The Site of Khirbat Hamra Ifdan and its Environs will elaborate the necessary background information to begin the analysis of ceramic material from KHI. This history of excavations and the previously published literature will be reviewed (Adams 1999, 2000, Levy et al. 2002, Adams 2003, Muniz 2008). The background of KHI will introduce the important recent developments of the revision of the EBA chronology (Regev et al. 2012). A new Bayesian model for the published radiocarbon data from Arad will be presented to validate the new dating scheme for this important site in the northern Negev (See Figure 1.1). Other important background data will include studies of the ancient environment, ceramics, ceramic petrography and more detail on existing research on Levantine copper production.

The fifth chapter, Using Ceramics to Estimate Intra-Site Processes: Statistical Analysis of the Total Assemblage to Understand Craft Production will introduce the methodology used to analyze the total assemblage of 196,591 sherds at KHI. To analyze the sherds a web application built on a new data infrastructure called ArchaeoSTOR was created to manage the data (Gidding et al. 2011, Gidding et al. 2013, Gidding, Levy, and DeFanti 2014). An overview of ArchaeoSTOR is presented along with a case study that includes preliminary analysis of the total assemblage from KHI. That case study provides a preliminary characterization of the formation processes that differentially influenced the deposition across the site. The quantitative analysis of the total assemblage is an important first step to provide a framework before analyzing the diagnostic features of the ceramic assemblage in more detail.

The sixth chapter, Trends in Material Variability and Their Meaning for Modes of Production using Statistical Methods will provide a more detailed analysis of the ceramic record. The focus will be on Stratum III at KHI, the stratum with the most secure contexts for

analysis. A review of the methods for diagnostic analysis will be provided along with justification for the assignment of functions to different forms. The relationship between the distribution of pottery within the site and the distribution according to the form and function of different pots will be an important component to compare the assemblage to both pastoral and urban sites. Based on correspondence analysis, loci of specific activities will be identified by comparing the relative assemblages of ceramics according to function, faunal and metallurgical finds from room to room within the site. The correlation of the KHI material to other EBA sites will allow for the characterization of the local subsistence strategy in relation to other finds at the site.

The seventh chapter, Pottery in Chronological Context: Revising Models of Copper Exchange in the Early Bronze Age Using Chronological Data will revise the chronological context used to understand the occupation of KHI. Based on archaeomagnetic, radiometric and ceramic data a new model will be produced to describe shifts in the industrial landscape over the EBA. Absolute chronological data based on radiocarbon will be used to correlate the phases of the industrial landscape with changes in the political organization of Egypt and the Levant in order to characterize expected demand. The data will provide the chronological context necessary to synthesize a new model for the political economy of copper production during the EBA.

The final chapter, the Conclusion, synthesizes the results from the previous chapters to describe a revised phasing of the EBA industrial landscape as it related to KHI. The phasing established in Chapter 7 is examined using the various lines of evidence presented in the previous chapters to describe the conditions for the development of the specialized copper manufactory at KHI. The data from the revised chronological sequence in Chapter 6 will be applied to the ceramic data in Chapter 5 to provide greater detail of changes in the distribution of copper production sites in response to shifting regional demand for copper. This will take

advantage of the recognized problems in the traditional chronological sequence and seek to revise the interpretation of other nearby sites to fit this new model. As a result, it will be possible to address the circumstances that enabled long-distance trade of copper during the main occupation phase of KHI and how that is distinct from previous and later phases of the industrial landscape of copper during the EBA. This will support evidence for many of the features of a ranked social organization.

Chapter 2: Insights on Urbanism and Social Organization of Production and Exchange

Archaeological theory posits that the development of specialized commodity production is tied to the appearance of urbanism. This is derived from the concurrence of the first cities and the first states. In this context a simple, but challengeable, definition of a city is a settlement that is not self-sufficient in that it accumulates resources from beyond its immediate hinterland. Given that one of the simplest ways for a ruler to generate status through economic means is the generation of surplus, it is natural that increased production, the state and urbanism are connected. Using Marxist theory, V. Gordon Childe developed his theory for the origin of the Urban Revolution, where he associated the appearance of urban spaces with the social transformations that would allow for full time specialized production of crafts which was in part enabled by the growth of surplus agricultural production (1950/2004, 1956). Part of this theory was the acknowledgment of the role of demographics and the physical space of cities, but the focus was primarily on the interplay of power and material production. In this framework the creation of agricultural surplus offered a means to provide for full-time specialized craft production.¹ A number of other interdependent features also feature in this model with the implicit assumption that within urban spaces social differentiation existed based on rank with the highest ranking individuals acting as an authority over the rest of community, effectively eroding kin based relationships that shaped social organization. Childe's (1950/2004, 1956) focus on technological change as a primary stimulus for social change inspired later archaeologists to take up the study of craft production to be discussed later in this section.

¹ In modern economic theory, the period of time preceding the industrial age is often characterized as being agrarian, with developments related to agricultural production being the most important when considering the characterization of economic shifts in that period (Grantham 1999).

One of the problematic elements of the model for the Urban Revolution is the circularity of reasoning for how surplus and elites were supposed to co-generate that does not indicate specific causal factors. Childe's model failed to deal with the major criticism of the Marxist approach; namely that underpinning the Marxist concept of surplus production is the requirement of a market economy that necessitates organizational structure and as result does not adequately define how such structures were generated in the first place (Dalton 1960, Pg. 485-487, 489, e.g. Carneiro 1970, Wittfogel 1974). Rather than looking for a single causal factor, alternative models have sought to explain how power structures and commodity surpluses can develop together in pre-modern societies or where markets are not present (e.g. D'Altroy and Earle 1985, Hirth 1996, Carballo 2013). One of the ways to understand the generation of power in such a situation is through cooperative means that eventually lead to the development of rank. The cooperative model has been advocated by Charles Stanish (2004, Pg. 14) who noted that "...an increase in surplus can be achieved not only by getting more people to work or getting people to work more, but by getting those people to work differently in a more efficient labor organization. The new organization provides the material resources that increase each individual's benefits along with the wealth necessary for the emergence of an elite." Such a model seeks to explain how the development of rank in groups might occur through mutually beneficial strategies rather than exploitative strategies that recognizes that humans do not always act selfishly or rationally (Henrich et al. 2010). Given such expectations, modeling the social aspects of both production and exchange as complimentary systems is fundamental to understanding how structures of authority were generated and maintained.

Besides studying how the economy is linked to political structures, studies of the nature of urbanism have similarly been interested in the contingent role that cities play in legitimizing power. One of the key aspects of this in cross-cultural studies that look at how the

creation of cities reflects aspects of the construction of power within the built environment through design (both to convey social meaning and to structure interaction), use of space, and relative size to other settlements (Smith 2010, Pg. 173-183). In these frameworks, it is the very understanding of how cities are defined, what role they play and how they operate within the context of the hinterland, that offers the opportunity to explore the nature of political structures that operated within different kinds of settlements. This is informed by the rich variety of ways that settlements structure the lives of those that come into contact with them (Emberling, Clayton, and Janusek 2015). After all, the way that different spaces could be utilized changes drastically depending on the context.

An unusual locale for the study of the processes of specialized production is in the arid periphery, where large settlements of familiar physical urban structure are difficult to maintain due to ecological constraints. 1.5-hectare site of Khirbat Hamra Ifdan requires this contextual approach that not only seeks to describe local activities but examines that data within a regional context that at the same time helps to revise the model on which it is based. The historical narrative for the EBA has been in particularly violent flux in the last decade due to new data that has not yet been fully synthesized. It is for that reason that both regional and local models need to be developed cooperatively. Thus defining both the organization of production within KHI and the nature of settlement in the Early Bronze Age will be necessary to describe the history of the site through the EBA. Due to the unique circumstances of the site, located in the periphery of the periphery, the relationship between KHI and a state authority is not immediately clear. Further, surplus production at the site was not agricultural, but based on craft production, which means that some explanation for how labor was organized and supported is required. It is for this reason that identifying different ways of establishing ownership of property in the archaeological record will be necessary to establish a context for the social relationships that are a part of the process of production and exchange.

By treating the processes of production and exchange within the same the study it will be possible to treat the role of KHI in an Industrial Landscape, a multi-scalar approach that is necessary to model both local and regional socio-political structures. The theoretical treatment of the role of different kinds of production, exchange and models of the state will be used to recount how those theoretical ideas have been applied to generate the common narrative for the Levantine EBA in the Third Millennium BCE.

2.1. The Organization of Craft Production/Specialization

The study of the copper trade is by default connected to the study of craft specialization. The production of a commodity such as copper is a complex process that requires specialized knowledge involving resource procurement and technical skill. As a result, it is a craft that would be created only by specialists. The development of craft specialization as a field of research developed from the late 1970s through the present (cf. Costin 1991, Clark 1995, Costin and Wright 1998). The theoretical study of craft specialization as the explicit topic of research is most often associated with the connection between political control and the way that craft production is organized. Such a connection between power and the economy explicitly finds its origins in the work of Childe and by association Marx (Marx 1867 [1990], Childe 1950/2004, 1956). It must be said that much of the reason behind this is the assumed inherent connection between specialization of production and the state, or at least a hierarchically organized society (Patterson 2005). The most common applications of the study of craft specialization focus on a way to indirectly study the ancient political economy of state-level societies rather than other social systems that might be tied up in productive enterprise through the study of technology as in *chaîne opératoire* or a behavioral chain approach (Discussed later in Chapter 2.5, Leroi-Gourhan 1943, Leroi-Gourhan 1973, Schiffer 1975, Schiffer and Skibo 1987). Each approach examines

the social interactions that are tied up in technological systems in order to expand the study of craft specialization. The priority of craft specialization is to identify the setting for production as a part of the larger social system and then attempt to reconcile the context of production with the local organization of production.

The work of craft production is in many ways a response to a perceived over-reliance on studies of distribution (exchange) in archaeology, positing that production is actually easier to study given the nature of archaeological data and archaeological methodologies (Costin 1991, pg. 44). Given that a single researcher is usually capable of either a focus of intense archaeological excavation at a single site or a broad regional survey without strong data resolution, a refocus on production allows for what is perceived to be a more realistic lens of study especially regarding reconstruction of the political economy.

By connecting the artifact distribution across many sites to the organization of production in a number of different social settings (social, political, religious and economic) to craft specialization offers a methodology to specifically address questions otherwise unanswerable. Costin (1986, 1991, Pg. 9, 2007) has provided a comprehensive set of studies that characterize the relationship between kinds of specialization and their relationships to different kinds of political control using fluid parameters to compare the relationship to authority, the concentration of production activities, the amount of material produced and the amount of time dedicated to production tasks. Each of those parameters has its own set of qualifications, but to understand those factors offers a means to organize key aspects of production that relate to the way that a relationship based on differential status can structure production systems and reflects the amount of authority required to generate commodities. Additionally, identifying the arenas for the consumption of goods, specifically to understand aspects of scale, is necessary to compare how production at a single site matches expected demand regionally. Within a site a number of diagnostic techniques can be used as indices to

identify specialization including technological consistency and standardization (Blackman, Stein, and Vandiver 1993). Studies of production and technology explain that (1) the technical task, (2) the environment, and (3) the producing agent all require consideration in order to establish the setting of craft specialization (Roux 2003). The result is a picture of the economic response to different pressures (political, environmental or social) in an attempt to identify an aspect of the economy that is knowable through archaeological research.

As a theoretical model craft production offers a perspective that highlights reflexivity in the analysis between the point of production and the social circumstances of that production. Only by generating an idea of value and consumptive practice for the objects produced can the social system for specialization be fully developed. Given the clearly evident specialization of copper production evident at KHI as a site, the different loci for craft specialization need to be considered on an intra-site basis as well to develop a model of social organization. This can be done through the modeling of how spaces within the site were used. That data, in turn, will also need to be put in context of trading partners in order to develop the context of consumption and how the objects of production ended up in consumer's hands.

2.2. Using Property to Study Political Organization

Although difficult to detect in the archaeological record without access to textual data, a concept of property and a way to evaluate property holdings is an important attribute for any study of exchange. Without a concept of property, all objects would be interpreted as communal. This is an important point as it is the differential access to resources that is the economic foundation of how political organization is derived. Property is necessary for the study of how different kinds of exchange are structured and necessary to develop a context for the consumption of craft products. Without documentary evidence it is difficult to assign property to specific individuals, but the inherent quality of property as a distinction between

“haves and have nots” means that property is a means to assess inequality and power relationships. Property itself can be divided into two categories: landed (dealing more with aspect of agricultural production) and movable (objects that could function as wealth finance) (D'Altroy and Earle 1985). Both categories of property are difficult to identify archaeologically. Nevertheless, a consideration of some of the theory behind the different kinds of property and the associated rights is important to help define the kinds of power relations that are might be active at a site.

The most comprehensive archaeological theory of property for anthropological archaeological research has been put forth by T. Earle and helps to differentiate movable from landed property in order to implicate different power mechanisms that can be used to implicate social structure (2000, Pg. 49-53). Firstly, a diachronically recognized change in the movement of goods and technological sophistication is evidence of property rights as exchange necessitates property rights. In this highly general tool only movable goods are covered archaeologically (cf. Shennan 1999). Secondly, warfare is indicative of consolidation of power which in turn requires a sense of political control/property (cf. Carneiro 1970). This instance covers both movable property in order to differentiate hierarchy through the maintenance of a warrior elite and landed property as the object of conflict. Both the landed and movable property scenarios would also implicate a different kind of mechanism through which to display and enforce power. Thirdly, the differential distribution of settlements and objects provides another way to conceive of property rights; either on a regional scale through calculating space requirements for a given settlement based on ecological constraints, or the differential distribution of objects within a settlement highlighting the settlements/households in control on a local scale (cf. Hodder and Orton 1976). This assumes control of rights to resources within catchment areas or differential access to goods within a site implying rank. Lastly, marking of property is the most direct version of defining ownership of property. For

movable objects this can occur in the form of the direct marking through sealing practices or other means (cf. Wengrow 2008). For landed property, monuments often are used to distinguish property; burials operate as the most commonly discussed monumental marker of property (cf. Saxe 1970, Binford 1971). The control of landed property can in some circumstances be more important than material wealth, especially in contexts of pastoralists or places where access to water is limited (Kramer 1982, Pg. 52). In those contexts, whomever held control of land would also control the means of production for all that used the land. Each of these means to detect aspects of power dynamics will need to be considered when seeking to understand whether and/or how property values are maintained in the case of KHI.

The primary resistance to the model is related issues of fluidity in the marking of property. The marking of movable goods does not seem to encounter significant resistance, instead it is the dynamics of how land claims are mediated that have been critiqued the most. One complaint has to do with the way that Earle's model equates specific terms for property types with levels of social complexity in an overly simplistic manner (i.e. Earle 1998, Pg. 91). In case studies from medieval archaeology it has been shown that ownership of property includes complexity based on fluidity of access to land according to social status that is not covered in the Earle model (Gibson 2008, Pg. 58-60). If data was only available on the local level land access might look to be held in common, but as a system different nobles could control and exchange land in a way that is not archaeologically perceivable. In another case within Neolithic contexts even when burials are discovered in a household context, skepticism is required in order to establish such an act as a marker of ownership due to the question of continuity in societies that might include fluid dynamics of group identity in some social contexts (Kuijt et al. 2011). In the case of KHI property rights will play a role; the key indicator will be movable goods through which landed property can be discussed in order to incorporate the importance of property as a part of social differentiation.

The issue of fluidity is even more amplified in the case of movable goods as the context of discovery does not always lend itself to identifying the individual that owned a good. Even without identifying the individual owner, the processes of diachronic changes of intensity, implementation of warfare, and the marking of goods will all be important to help set the setting for how copper was consumed in the EBA. Within KHI the differential distribution of material will also be necessary to characterize internal social differentiation not just as it relates to copper objects, but also ceramics. This reflexive relationship necessitates that the differential distribution within KHI will need to be put into the context of the larger political dynamics revealed by shifts in regional strategies for copper production. The interpretation will be informed by the implications of diachronic changes in exchange processes of regional strategies on the social and political organization of EBA society in the southern Levant and neighboring regions.

2.3. Social Aspects of Production and Exchange

Following a discussion of production, it is natural to discuss the hard to identify materially the process of exchange. The current popular models for the study of production and exchange as a unit stems from the combination of approaches that systematically illustrate the total life-cycle of archaeological material. The origins of such a complete approach derive from M. Schiffer's (1972, pg. 158) introduction of the concept of the archaeological life-cycle for artifacts: procurement, manufacture, use, maintenance, and discard. What has changed in new approaches are the explicit terms used to focus coherently on more specific and manageable terms for the investigation of the mechanisms that underpin different social processes. For instance, C. Costin (1991, Pg. 2-3) in her already discussed study of craft production offers the similarly linear life-cycle: production, distribution and consumption as complementary, interdependent parts taken independently to identify the related economic,

social and political aspects of a past culture. For the explicit study of exchange A. Bauer (2010) presents a more flexible model that moves beyond the linear description of artifact life cycles uses the concepts of context, communication and consumption concurrently as the terms of study (See Figure 2.1). Breaking up the elements of exchange into those three components is an important reorientation that highlights the need to adjust analysis according to local and historic trends through an understanding of context. Identifying the means of communication informs the interpretation of social behavior as an explicit term for analysis instead of only studying artifacts to identify the social background for the life-cycle of artifacts. In combination the three components describe the locally contingent conditions that would affect the interpretation of the consumption of artifacts or the material record itself. This approach follows from G. Stein's (2002 , pg.904) suggestion to utilize complementary aspects of processual and post-processual research foci offering a broader framework to discuss exchange compared to the traditional division between studies of production and exchange. Thus a framework is set to bridge the methodological gap between studies of exchange and production by using approaches to the archaeological record that utilize material and ethnographic correlates to highlight the social arenas that enable different kinds of production and exchange systems.

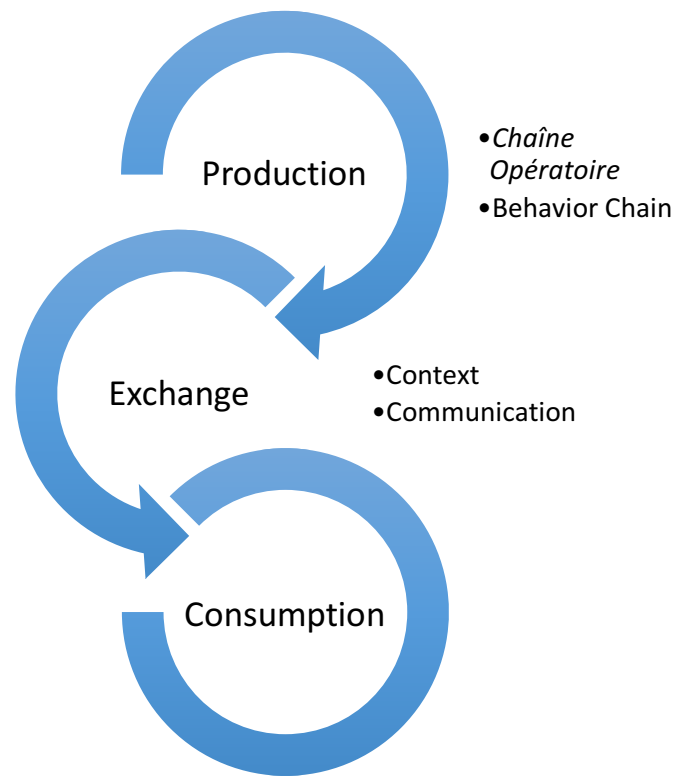


Figure 2.1: The inter-relationship of the components of production, exchange and consumption with methods for detection of features.

Context within this framework provides the basis for providing a description of the ideological, historical and cultural context of exchange activities. This means describing the potential arenas for trading activities. The theoretical framework for such discussions is directly derived from the work started by Mauss, Polanyi and others offering methodological alternatives to the typical assumptions of market based exchange with redistribution and gift-exchange being the other classical categories (See Figures 2.2-2.4, Malinowski 1922, Polanyi 1957, Mauss 1990 [1950]). Later discussions of more complicated alternative trading relationships that specify the variety of social circumstances involved in trading relationships were developed: down-the-line, directional, freelance, or prestige-chain and others (Renfrew 1975). For the Bronze Age generally the most important of these exchange “types” is the idea

of redistribution through a central authority, a palace or temple based economy, in order to finance and mediate relationships between those in power and the commoners (Earle 2011). In the most basic form this operates through the procurement of staple finance goods in order to support the craft specialists that generate goods useful in wealth finance (D'Altroy and Earle 1985, Earle 1987). Additionally, these different trading relationships could and did operate simultaneously, in a nested fashion, offering a wide array of models that can be employed to describe the different contexts of trade and their social dimensions (Knapp and Cherry 1994, Nakassis, Parkinson, and Galaty 2011). It is important to consider how the kind of material that is being exchanged will inform the kind of economic model is appropriate. Locations of source material, production centers, distribution networks, etc. on the landscape are important variables in understanding how the location of production and exchange affects the social behavior inherent to those processes (Grant 1987). The identification of the potential context for exchange on a regional scale offers constraints within which to structure the interpretation of the archaeological data (Discussed in Chapters 4 and 7). Fundamental to any reconstruction of exchange requires first a model for the social context that enabled exchange activities.

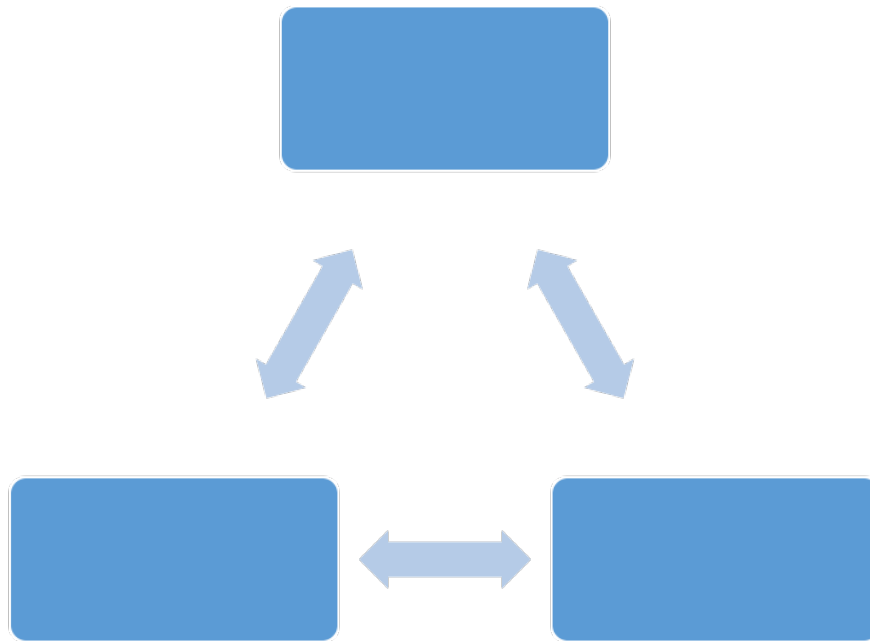


Figure 2.2: Gift exchange occurs between individuals and can include important socially mediating events, but without a single local that regulates the exchange. Rectangles are left blank to highlight relative equality in exchanges.

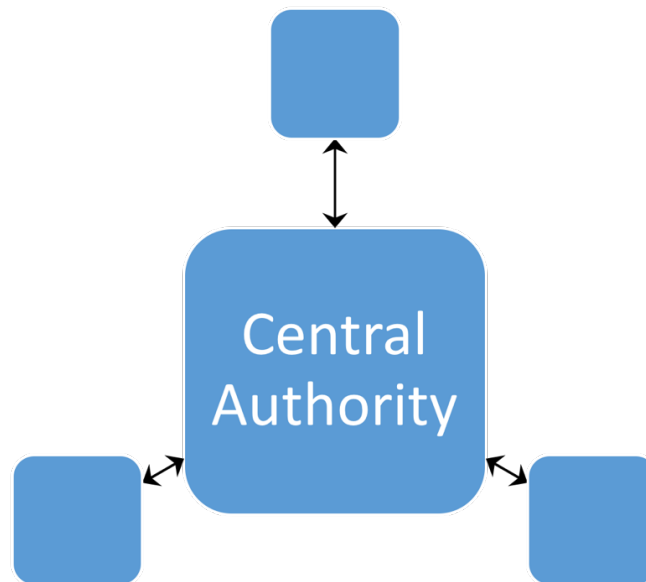


Figure 2.3: Model for redistribution economy. The central authority directly controls the movement of commodities in a way that reinforces political and social dominance, represented by the size of the central square.

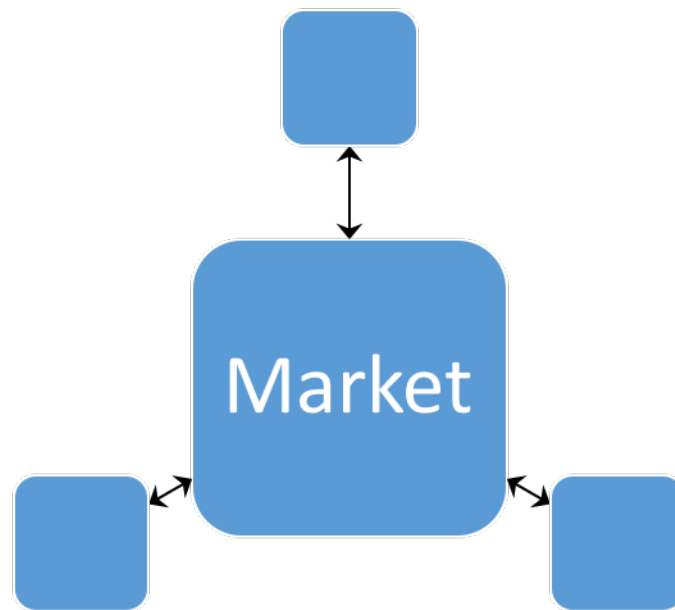


Figure 2.4: Model for Market exchange. Archaeologically would there are similarities to redistribution, but lacks the signature of a single, large, permanent storage place and trade is more fluid. In market the center is not associated with a single place or institution. Market exchange can be more disperse.

The study of communication seeks to identify the “social construction of society” through the trade of more than the physical object, but also significations related to that object. Otherwise invisible forms of communication can be recognized in the archaeological record through the identification of features that identify concepts like property, as discussed above, and also other aspects that might enhance the desirability of an object. In the Levant examples of how changes in the way that objects were consumed between different periods has been used to indicate shifts in identity (Bunimovitz and Greenberg 2004, Sherratt 2010). Another synthetic example of how to understand communication through the material culture would be through the archaeology of “brands” (Wengrow 2008, Bevan and Wengrow 2010). Brands provide a uniform terminological framework for a variety of interpretations of manufactured

goods or some other set of objects that exhibit similar means of communicating an idea that achieves meaning in consumption. Brands mediate consumption in a number of different ways; examples include differential consumption of fakes or replicas and different ways of establishing what is indeed valued or real through the brand. In this sense the brand provides a structure that guides acquisition along a number of restricted avenues, but at the same time it also provides a framework from the producer that establishes a kind of universal guide for interpreting quality, especially without legitimate knowledge of the exact origin or producer. The use of this strategy to understand what was valuable offers insight into the structure of production and exchange by highlighting what was communicated through design decisions. In the case of Faynan this may be evident in the standardization observed in the production of items like copper ingots (Discussed in Chapter 4.5.2) and in other contexts through regularized markings on storage vessels especially in the form of seals.

2.4. Aspects of Economies Based on Pastoralism in the Near East

In order to characterize the productive potential of KHI it will be fundamentally important to define whether KHI was occupied year-round or only for part of the year. The amount of time spent every year at KHI was heavily influenced by the dominant local mode of production. In short, if KHI was seasonally occupied by full-time pastoralists then full-time copper production would be impossible. The theoretical approach to the archaeology of pastoralism has seen considerable changes in the ways that models have been employed. For early researchers, especially for late prehistoric and early historic sites in the Levant, the issue of pastoralism was reduced to a distinction between sedentary and nomadic existence which portrayed pastoralism as the antithetical opposite of urban dwellers and used modern Bedouin as a proxy for ancient behavior (cf. Saidel 2008, Rosen and Saidel 2010). Too often this has led to an overly simplistic application of ethno-archaeological correlations between present

and past versions of pastoralists (Khazanov 2009, pg. 120). The simplest of these analogies are based on the assumption of an opposition between “the desert and the sown”, which was popular at the start of the 20th century and continued to be used until relatively recently to succinctly describe the distinction between the settled and the outside worlds of the EBA (e.g. Bell 1907, Dever 1980, pg. 58). Since the introduction of more ethnographic models for pastoralism a more complex picture has emerged that over time has taken more care to take into account various technological limitations that would affect social behaviors seen in modern pastoralists when making correlations to the past. A key consideration then is the appreciation of technical sophistication in pastoralists approach to production that leads to necessary social differences compared to more sedentary people.

In the Levant, but also generally there was a shift away from cultural historical frameworks through the 1970s and 1980s. This grew from a general dissatisfaction with sweeping a priori explanations for the past and a desire to test a number of different models in order to better depict ancient pastoral activity (Cohen and Dever 1978, Hole 1978). One of the major contributions to this research was that of A. Khazanov (1994, 2009) who utilized his research on nomads of Central Asia to help present a number of expectations for pastoral nomads that would be applicable to the southern Levant. These outlined a number of generalizations about pastoral nomadic behavior that set new restrictions on expectations on pastoral nomadic behavior. First, cultivation is unimportant compared to pastoralism as primary form of economic activity. Second, nomadic pastoralists lack stables or laying fodder. Third, pastoralists have no focus on fixed locations except through the maintenance of natural pasture. Fourth, their economy requires movement within grazing territory. Fifth, all or a majority of the population work only as pastoralists. Sixth, the economy is aimed at subsistence, not for profit in modern capitalist sense, despite exchange being an important function of nomadic activities. Seventh, social organization is based on kinship or other

segmentary systems both real and spurious. Aspects of Khazanov's ideas were generally echoed by other authors at the time and also include the provision that pastoralists often exhibit an asymmetric economically dependent relationship with settled peoples especially in earlier forms (Hole 1978, Tapper 1979, Ingold 1980, Cribb 1991). These seven principles for pastoral nomadic behavior in current periods set an important precedent in order to contextualize the archaeological reality observed for groups assigned the pastoral label. Firstly, the fact that pastoralism was not the antecedent to cultivation, but rather a specialized form of agriculture. Extended from this is that there existed a spectrum of ways that pastoralists both organized and interacted with settled people. Secondly, the ethnographic data highlighted intangible behaviors that are not directly seen in the archaeological record that needs to be further considered when possible via indirect means. As a result, it is no longer possible to assume pastoralism was the opposite of crop based agriculture.

Since the earliest ethnographic studies to synthesize a general set of theory for pastoralists, it has become increasingly clear that a wider set of definitions are required to describe behavior. Many of the generalizations set out by Khazanov were based on highly mobile groups in Central Asia whose social and technological conditions differ significantly from prehistoric societies which would have limited "pure nomadism" (Khazanov 2009, Pg. 120). Recognizing the limitations of models based on modern nomads, continued research has highlighted spectrum of pastoral varieties that include features that might not be mutually exclusive, such as pastoral nomadism, semi-nomadic pastoralism, agro-pastoralism, tethered nomadism, enclosed nomadism, and peripheral nomadism (cf. Barnard and Wendrich 2008). It is not necessary to describe each of these forms except to say that each deals with different variations on the degree of mobility patterns, the dependence on settled groups, the segmentation of hierarchy and order and the dependence on features of the landscape. For the purposes of Levantine pastoralism there are a certain number of features that make it unique to

other regions. The Neolithic antecedents of pastoral activity in the Negev and Sinai highlight behavioral nuances unique to circumstances determined by the local landscape as a crossroads between Africa and Asia and the natural resources present in the region (Betts 2008).

However, the application of modern ethnography in the Levant includes three interpretive constraints: the impact of factors for which there is no ancient parallel, the reliability of modern ethnographic data, and the aforementioned variety of pastoralist strategies lacking archaeologically obvious distinctions making correlations difficult (Rosen 2008a, 2008b). These criticisms are most clearly laid bare by the implications of the technological limitations of ancient pastoralists that hitherto had not been recognized (Saidel and van der Steen 2007, Rosen and Saidel 2010). Although these critiques often challenge the very tools that are necessary for effective comparative research, fully understanding the implications of limitations in the data has been crucial to place a pastoral nomadic groups within their own cultural and historical trajectories.

One of the major issues of concern for the revised definition of pastoral activity is based on their role in the economy. Above Khazanov (1994, 2009) argued that subsistence was the primary economic goal of pastoralists. This assertion has been refuted by Marx (2006) who adds more nuance and fluidity to the generalized model of the political economy of pastoral activity by challenging Khazanov and insisting on the importance of markets for the sale of surplus goods. However, the production of surplus and its relation to value within pastoral economies does not strictly match other market expectations because the production of surplus is not just for market sale but also a risk management strategy (Næss and Bårdsen 2015, Pg. 432-434). The role of surplus as a product and for risk management is reflected in the common “bank/[meat] on hoof” concept for how pastoralists maintain and produce surpluses by growing the herd as much as possible. The interplay of pastoral surpluses with other types of surplus production is fundamental to measuring how different socioecological

systems contend with resilience in the face of external challenges (Carpenter et al. 2014, Pg. 766-767). Despite the fact that studies of pastoralists always focus on pastoral production, they might not only rely on pastoral products for risk management and seek other means of risk management (Marx 2006, Pg. 82). It is important to recognize pastoralism as a specialized form of economic production to help characterize the economic system in which it is situated, but it is also important not to ignore the complexity of how pastoral groups will face challenges by adopting different strategies of risk management.

In the EBA of the southern Levant there is good evidence for both intense production and urban centers in what are now hyper-arid regions. While pastoralism is typically considered the primary means of production for transhumant groups alternative sources of productive enterprise certainly are possible. In the eastern deserts of Jordan there is good evidence for a seasonal, specialized lithic industry that traded with the Levantine core (Quintero 2002, Müller-Neuhof 2014). Additionally, in the arid zone of inner Syria the site of Al-Rawda appears to have been a managed, urban trade hub that helped to service trade caravans from the Euphrates to heavily settled areas nearer to the Mediterranean coast (Castel and Peltenburg 2007). These two examples provide evidence of incentives for settling arid areas in first example to produce objects seasonally, the other more permanent to facilitate important trade, valuable enough to have major stations. Each of these sources of production allowed groups to live longer periods of time in arid zones and to engage in production beyond pastoralism. Compared to lithic production, copper would have necessitated a broader set of resources and knowledge in order to carry out the variety of processes that were involved in the total process of smelting.

The role of pastoralism in the economic structure of KHI is important for characterizing not just whether pastoralism offered a primary means of subsistence, but also the degree of mobility of the occupants of KHI. Already, it has been convincingly argued that

the occupants of KHI depended heavily on goats and sheep for meat and on a limited basis kept animals for specialized secondary products (Muniz 2008, pg 309-310). While the occupants of KHI were pastoralists, they did not engage in intense production of pastoral secondary products. The limitations of ethnographic comparison suggest that some of the previous assumptions of the behavior of pastoralists described above need to be abandoned. Nevertheless, the key point for this dissertation, of degree of sedentary behavior can still be addressed. The range of possible expressions of pastoral behavior allows for sedentary pastoralists (Barnard and Wendrich 2008, Pgs. 7-8). One consideration for the interpretation of KHI as a site that depended on horticulture versus one that relied upon pastoral production is the relative quantity of blades with gloss, evidence of cutting grasses. EBA sites in the Mediterranean zone blades with gloss make up a relatively high percentage of the total assemblage, in the Negev area at pastoral campsites blades with gloss make up a very small percentage of the assemblage (Rosen 1997, Pg 58-60, Vardi 2014, Pg. 96). The best point of comparison will then be a comparison of ceramic assemblages between different kinds of EBA sites. A second consideration related to the organization of food consumption will come from the ceramic data. Cribb (1991, Pg. 76) offers four expectations for the ceramics of nomadic sites: pottery is used less intensively, the range in size and vessels is limited compared to settled sites, there is a bimodal distribution of mostly large and small vessels, and if large pots are used as fixtures average pot size will be skewed up, otherwise it will be skewed down. It follows that the ceramic data from KHI will be important to put in perspective the permanence of the settlement and as a result clarify the nature of the organization of copper production.

2.5. Industrial Landscape Theory: Melding Studies of Production with the Social Context Thereof

One of the challenges of connecting a model of industrial production to transhumant pastoralists is that in the ethnographic record they constitute different type of production. This is in part due to the fact that the very act of being transhumant makes the development of an intense productive enterprise in a single place difficult. Additionally, being labeled a pastoralist is already a definition of the primary means of production for an individual. By contrast, transhumant or itinerant metal workers were mobile in part due to the nature of their work and the high value of metals. In many cases most settlements or centers couldn't support a full-time metal worker and as a result were itinerant but took part in no other form of production (Neaher 1979, Berland 1983). These two kinds of mobile groups might even form sympathetic networks of movement according to trading patterns and needs for pastoral and metal products. In this formulation the pastoralists are transhumant by definition, but their role in relation to metal workers will depend on the itinerancy of the metal workers. Settled metal workers might use the pastoralists as vehicles for exchange. However, exchange would also be a part of the metal worker's production process if they were itinerant. As a result, it is necessary to take a landscape approach to study aspects of the shifts in production as it relates to both pastoral and metal production and exchange through time.

It is possible to define an approach mediating production and exchange as a single field of study under the name "Industrial Landscape Archaeology" especially as it relates to the development of highly specialized production. In order to study industrial production archaeologically, a number of production sites must be considered both on the intra- and inter-site levels simultaneously. Knapp (2000) has outlined a version of the industrial landscape concept focusing on ideational factors that incorporates different stages in the production and

exchange of metals through time on Cyprus. The landscape approach provides the opportunity to focus on describing the social organization of labor at production sites across the study region within a unified theoretical construct and to note changes in locations and functions of sites through time. Important to the explicit use of the term “Industrial” is the theoretical baggage that is associated with the term as a result of the Industrial Revolution and the associated social, economic and political consequences of the shift that occurred when industrial production took hold across Europe in the 18th and into the 19th centuries. An important semantic point to note is the distinction between industry and the process of industrialization: the former describing labor that leads to a physical product, the later describing a system in which a class of owners employ full-time specialists to produce a physical product (Matthews 2003, pg. 52). Certainly when considering ancient societies, questions of the applicability of each term is required.

The inherent problem of the use of modern terms for production like “industry” and “industrialization” within the domain of archaeology is the questionable applicability to ancient societies given the divide traditionally taken a priori of pre- and post-industrial societies and the resulting use of the term “industry” and its derivatives as unique to the Industrial Revolution. Given these constraints, it comes to no surprise that Industrial Archaeology is most commonly practiced in Britain and focuses on post-Medieval Britain. However, Casella (2005) makes the point that Industrial Archaeology is at the core a study of the social interplay of the means for production, distribution and consumption where historical data help to tie together each step in the process. As a result, could be applied to pre-industrial societies where a kind of specialization in production is met, keeping in mind the limitations of a prehistorical setting. Thus in prehistoric settings it can be appropriate to call certain kinds of labor transformations industrial in the sense that the organization of labor takes on a new intensity that highlights a stricter division of space for different labor operations. In this case,

the changes in the setting of labor is used to model social implications for the general system. In other words, mapping changes in the organization of production as indicative of changes in the organization of labor, while being mindful of their own implications for the organization of that labor.

Given the marginalization of workers through the development of the Industrial Revolution, archaeology helps to develop a diachronic story of changes in the social lives of workers and the contexts of production. The earliest attempts by archaeologists to conduct industrial landscape archaeology were made by historical archaeologists in Britain. In this case archaeology was a “handmaiden” to other fields of research providing details of the social lives of the subject that do not exist within the documentary record (Riden 1973). This is the same underlying concept for all archaeology, but in order to apply the industrial concept to pre-industrial activity the relationship between the site of production and its surroundings is fundamental to define. This is in essence what is meant by the use of the term industrial within the context of the EBA, a locus of production that far exceeds any known neighboring production centers for a given commodity. For the region of Faynan, the role of copper as the primary form of production for those that have lived in the region has been illustrative to help model changes in the technology of production over long periods of time with the first major increase in copper production occurring during the EBA (See Table 2.1, Hauptmann 2007, Pg. 217-231). What has not been adequately described are the relationships between a number of the EBA sites that are also related to the production system beyond the Faynan area. In order to apply these techniques, some more general examples of regional approaches to production need to be considered.

Table 2.1: Based on calculations of Hauptmann of the intensity of production in the Faynan region from period to period using estimates from surface slag in the region (Hauptmann 2007, Table 5.3).

Period	Number of Smelting Sites	Amount of Slag	Copper
Early Bronze Age I	4	2 kg	? kg
Early Bronze Age II – III	13	5000 t	300 - 500 t
Iron Age	4	100,000 - 130,000 t	6,500 - 13,000 t
Roman Period	1	40,000 - 70,000 t	2,500 - 7,000 t
Early Islamic Period	2	1,500 t	100 - 150 t

The analysis of the spatial orientation within non-historical systems of production have produced valuable insights into the social organization of groups responsible for the production of metals. For pre-industrial cases the definition of industrial production needs to be reoriented to appreciate differences of scale between modern and pre-modern production systems; for pre-modern systems the appearance of centers specializing in the production of a commodity can be considered “industrial” if the intensity is high enough relative to production of similar sites especially in the case of full-time specialists. Important here is the definition of “industry” as defined above that refers to the overall organization of labor within a highly specialized group of settlements. When considering these sites in a socio-political context it is important to understand the functional limitations that influence the choice of site location based on technological capabilities that assumes rational economic behavior as a baseline. The reality is that ideational and social factors influence the location of a site and also need to be considered (Knapp 2000). Those ideational factors could be based on what would have been perceived as “magical” aspects of copper production (Anfinset 1996, Pg. 45). Studies of sacred landscapes within the Negev region have not excluded the importance of industrial

production as a component of understanding past cultures through time (Avner 2002). In each of these cases a reconsideration of the term industry is required, more along the lines of specialist producers, or evidence of a division of labor. Fundamental to discussing the appearance of specialization of production in one locale is the expectation that specialization occurs simultaneously elsewhere so that each set of specialists can support one another (Shennan 1999). While such an approach offers one guide to the relationship between production and distribution, its application is limited to instances with strong evidence of specialized production; as is evident for copper production at KHI and associated smelting locations.

The application of a spatially connected analysis of locations of production mirrors the aims of the *chaîne opératoire* approach to the study of production. Derived from Mauss' (1990 [1950]) approach to research of total social phenomenon that surrounded the process of gift giving, *chaîne opératoire* focuses on the social gestures that surround production (Leroi-Gourhan 1943, Leroi-Gourhan 1973). *Chaîne opératoire* was initially used to describe the process of lithic production but the approach was expanded upon by Lemonnier (1986) and the associated work of Pfaffenberger (1988, 1992) popularized in the English language literature. Schiffer's (1975) behavior chain analysis that is a part of the larger suite of Behavioral Archaeology was independently developed and very similar to this approach albeit with a more diachronic focus (Bar-Yosef and Van Peer 2009, Pg. 105). The most important aspect of *chaîne opératoire* as an approach is the explication of the social gestures of production in order to map the organization of the production system as a means to infer the sociopolitical contexts of production (Dobres 1999, Pg. 124). In the early work at KHI, a *chaîne opératoire* was applied that focused on the site, more than its integration with the greater Faynan landscape (Levy et al. 2002). The use of the *chaîne opératoire* in the context of a landscape moves away from a focus on the details of the production of the specific objects

and instead the describe the total system in which that production took place. This borrows elements of the approach in order to map types of activity related to the production and exchange of artifacts across a landscape in order to infer the sociopolitical environment that enabled that past landscape.

The application of industrial landscape theory to the region around KHI is to place the variation in distribution of sites related to copper production within the socio-political context of the time. The coincidental changes in distribution of sites, changes in consumer base and occupational history inform the interpretation of organization of labor locally at KHI. Thus it is necessary to consider both the regional chronology for different sites and the organization of production locally in order to model the regional organization of copper production. Further, the identification of the permanence of settlement at KHI is fundamental to the interpretation of the production system; if it was not occupied year-round then it would be necessary to reconsider the copper production system as more opportunistic and part of a suite of goods produced as part of a pastoral-nomadic production strategy. In this later case, the same key indicators of chronological context and local organization are still important, but the description of the social organization of labor shifts to models that fit the scale of production expected for part-time laborers.

2.6. Copper Exploitation in the Early Bronze Age

When the Near East is taken as a whole there are a number of important technological developments that occurred that lead to the increased specialization of production of certain goods. An excellent example of this was the discovery of processes associated with the “Secondary Products Revolution” during the sixth through fifth millennium, which signaled significant changes in range of products derived from animals and an increase in the efficiency of production through the use of animal labor (Sherratt 1983, Levy 1983). Firstly, the

development of an expanded product repertoire created a new set of goods that could be produced and in some cases were limited by ecological constraints. Secondly, those new products often increased efficiency in both the techniques used to manufacture equivalent goods and the renewability of many resources, assuming that production was done by a specialist. Lastly, the opportunity to specialize in these secondary products also created demand for these new products, which eventually influenced changes in trade patterns with long distance trade focusing more on finished or partially finished goods in larger quantities as opposed to raw items or down the line trinkets. In the case of metal production other important changes occur to facilitate increased long distance trade through the spread of common iconographic references and regimes that can facilitate the trade of higher valued commodities (Kassianidou and Knapp 2005, Pg. 239). The archaeological evidence indicates that intensively produced, specialized metal production is closely correlated with the complex social organizations.

This general progression towards specialization led to regionally distinct technological progressions and styles for different material types. For instance, in Iran Thornton (2009, 2009) has outlined a number of striking differences in the overall changes in production techniques between Iran and the southern Levant. The data for Iranian smelting sites has been less intensively studiedly compared to the Levantine examples. At the start of the equivalent of the Early Bronze Age in the Levant two different styles of specialized metal production centers appear. Those two styles eventually merge to coexist within sites and appear to highlight differential production for either elite or utilitarian goods. That organization seems to highlight social stratification amongst the metal producers with the production of luxury goods produced in association with copper, lead and possible silver smelting. Copper by the Third Millennium BCE was produced into disk ingots made of nearly pure copper. By the end of the third millennium copper ingots take on a “bar-shape” developed that has appeared at KHI and

sites in the Negev highlands (Kochavi 1967, Cohen 1999, Levy et al. 2002, Dever 2014). As a result of the standardization and scale of production across such a broad region it is assumed that there was a central, 'elite' authority in control.

Just like in Iran, the development of metallurgy in Turkey highlights a number of important local nuances that make it distinct from the Levantine model. The early work on the Turkish metallurgy traditions challenged models that highlighted the importance of technological innovation in the lowlands of Mesopotamia, instead focusing on independent innovation locally around the mines of Anatolia (cf. Yener 2000, Pg. 6-29). During the Chalcolithic metal production in Anatolia appears to be more complex than what was seen in the Levant or Iran. Based on the site of Değairmentepe where the even distribution of metallurgical debris between different rooms highlights each household working independently or nucleated workshop-level production (Lehner and Yener 2014). While at Arslantepe the presence of a central store room is said to be indicative of centralized control and unlike Değairmentepe there is evidence of long distance interaction with Mesopotamia (Frangipane 1997). Starting in the Third Millennium, the early Bronze Age for Anatolia, the use of tin bronzes becomes more prevalent (Yener 2009). It is in this period that highly specialized production sites for metals, including tin, appear as the result of large-scale interaction networks in order to help manage uncertainty of access to various raw materials (Lehner and Yener 2014). The intense production of alloy components at separate sites for the production of tin highlight a sophisticated hierarchy of specialized sites that allow each to work complementarily to produce highly desirable finished goods. It is worth noting in this case the the major production sites are separate from the major core regions of Mesopotamia.

The model for the development of the copper production in the southern Levant has been well documented with comprehensive data of production sites and copper sources (More

comprehensive discussion of aspects of Levantine copper production follows in Chapter 4.5.2). Copper bearing ores were first exploited for the production of beads (Bar-Yosef Mayer and Porat 2008). The sources of copper ore, Faynan and Timna, have been well described and surveyed (Rothenberg 1962, Hauptmann 1987, Rothenberg 1999, Hauptmann 2000, Hauptmann 2007). The first major production of copper took place in the Beer-Sheva valley where the first evidence of copper production is attested (Levy and Shalev 1989, Shalev 1994, Golden, Levy, and Hauptmann 2001). Over the course of the following EBA the scale and intensity of production progressively increases closer to the ore source of Faynan (Fritz 1994, Adams and Genz 1995, Levy et al. 2001, Adams 2003). Early in the EBA there is reason to believe that copper was a part of a synchronous Mediterranean trading network with Egypt (Stager 1985, Gophna and Milevski 2003). The important element of copper production in the southern Levant was that the two key ore sources were located in the arid southern areas, disconnected from the main areas of settlement.

Within the models for Iranian, Anatolian and Levantine metal production there is a general trajectory towards increased specialization that is complemented by more advanced technologies and longer distance interregional trade. One of the most important steps in this progression is the eventual production of uniform measures or forms of copper for trade which in the Iranian case was seen as evidence of central planning of attached specialists (Thornton 2009). Ingots of a similar plano-convex disc form were also identified in Oman (Weisgerber and Yule 2003). The ingots in Oman are of note because some of them were identified as counterfeit or not being pure copper, but instead filled with slag. Despite the presence of ingots at KHI and associated sites in the Negev, it is hard to prove attached specialization due to the ephemeral nature of the sites involved. This is illustrated by the model for the metal workers of the contemporary Indus civilizations. At sites like Mohenjo-Daro and Harappa there is no evidence for primary smelting of ores, instead it is assumed that metalworkers there

were refining ingots into final products (Hoffman and Miller 2009, Pg. 240-243). In the context of Harappan urban centers metal workers sourced raw copper from other areas in ingot form. At KHI there isn't a clear, nearby, large-scale urban core to be serviced in this manner, but the production of pure copper ingots suggests export for consumption by other metal workers that would finish the product. The peripheral nature of the Levant in relation to the larger core areas of Mesopotamia and Egypt reinforces the need to consider how the concept of urbanism is used within the Levantine context as a potentially distinct model. A core element in the development of metal production in the Anatolian and Iranian cases is the concurrent development of urban trading partners for surplus copper; thus it is important to consider the nature of urban development within the Levantine region to contextualize the EBA copper industry in the Southern Levant in general and in Faynan specifically.

2.7. Ways of Defining Settlement: Urban Theory as it Applies to the EBA in the Levant

The connection of urban centers to the state is fundamental to the Levantine model for urban development. The earliest analyses of the Early Bronze Age in the southern Levant were carried out by the generation of archaeologists who used culture-history models and were based on relatively small data sets to construct grand narratives of florescence and collapse for the period (e.g. Wright 1936, 1937, Kenyon 1957, 1970, Wright 1971, Amiran 1978, Amiran and Gophna 1989). These narratives were heavily influenced by contemporary research in neighboring regions and led to the use of urban to describe the settlement of the Levant starting the EBA. This was despite the fact that compared to Mesopotamia, the Levantine "cities" were not nearly on the same scale in terms of size or other economic features (Joffe 1993, Pg. 60-65, Falconer and Savage 1995). In order to bridge the gap different trends in the analysis of Levantine urbanism have developed that seek to better

contextualize the shift in settlement intensity that occurs in the EBA, but in its proper scalar context that also recognizes the nuances of the Levantine landscape (Paz 2012, Pg. 407). The two foci of the analysis of urban structure in the EBA Levant are the physical space of settlements (size, architectural features, and related interpolation) and the shift in scale of long distance exchange (material studies focused primarily on technology and regional interaction). The two analyses are naturally intertwined, but rely on key differences in data to help build models. The analysis of physical space in urban sites prioritizes the social significance of architecture and derived demographic data (settlement density, settlement size, and subsistence strategies). The study of long distance exchange and related production systems is more interested in specific types of material and the distribution patterns of those items. For the characterization of Levantine settlements as urban, the use of the physical characteristics dominates the history of research with economic determinations being more popular in recent research. This makes it important to first review how physical characteristics of settlements have been used to describe the overall social organization of the southern Levant.

2.7.1. The Application of Urban Theory to Early Bronze Age Sites

The application of urban theory in the EBA is derived from the long assumed rivalry between the “sown and the desert” as a dichotomous and violent opposition. Thus one of the core ways to identify urban settlement was the opposite of a rural or pastoral economic basis. Given that the Levantine Early Bronze Age coexists with the development of the first state level societies in Egypt and Mesopotamia, the same questions that have been asked in order to define those societies have also been asked of the Levant (Childe 1950/2004, 1956, Frankfort 1959, 1965). More recent research that has sought to explain the development of the new “urban” settlement types seen in the southern Levant as a result of secondary state processes that are a derivative of the formation of states in the aforementioned neighboring regions (See

Table 2.2, Esse 1991, Joffe 1993). As a result, the development of the state in Egypt should match aspects of the changes in the political organization of Levantine settlements. The use of “urban” to describe these settlements has been challenged due to the significant scalar difference in settlement size and organization between the Levant and neighboring area (Philip 2001, Chesson and Philip 2003, Phillip, Clogg, and Dungworth 2003, Paz 2012, Wilkinson et al. 2014, Chesson 2015). Thus, in addition to an evolving definition of “urban”, a new definition of “rural” also developed as an important part of the overall trajectory of the EBA (Falconer 1995, Fall, Lines, and Falconer 1998). Over time the interpretation of revolutionary changes between periods for the whole Levantine area within the Early Bronze Age has softened. This is due to the recognition of unique aspects to the development of EBA urbanism that is difficult to compare to other models and regions, in part because of the high degree of regionally circumscribed political shifts within the Levant (Joffe 2014, Pg. 221). Recent research has focused on a reevaluation of the data from the EBA to indicate that the Urban-Rural dichotomy within the Levant may in fact be imagined.

The start of social complexity in the southern Levant has most clearly been identified through changes in economic organization. During the Chalcolithic period increased specialization was a result of the associated increase in capacity for trade and productive agriculture through the exploitation of animal labor that allowed for easier long distance trade (Levy 1986, Ilan and Sebbane 1989, Levy and Shalev 1989, Rosen 1989, Pg. 217, Braun 1990, Pg. 95, Shalev 1994, Yekutieli 2001, Levy 2014). Over time the development of the Chalcolithic spread to more sites across the southern Levant and included increased interaction with Egypt (de Miroschedji 2002, Yekutieli 2004). At its peak during the EBII-EBIII, the EBA in the southern Levant is typified by (1) a village system in which (2) early urbanism develops into a landscape of (3) city-states, especially in the northern parts of the region, with (4) Egypt exerting influence in the southern part of the region. At the tail end of

the period, the EBIV period, many of the urban centers collapse leaving what is commonly identified as a village or pastoral society only to be reoccupied in the next round of intensive urbanization, the Middle Bronze Age. (Dever 1998, Gophna 1998, Palumbo 2001). This interruption was initially blamed on the appearance of “rural” or “desert” pastoral groups that disrupted the established order and settled in new locations. The specialization observed during the EBII - EBIII applies to a number of different productive sectors including groundstone, metals, agriculture (in the form of viticulture), and lithics that were all part of trade systems internal and external to the Levant.

Table 2.2: The general model for the progression of the Early Bronze Age as it relates to Egypt (Yekutieli 2001, de Miroschedji 2002, van den Brink and Levy 2002, Wengrow 2006, Rosen 2011a). The correlations to Egypt have since been revised (Discussed later in Chapter 4.3 along with fixing the chronology to absolute dates).

Canaan/Jordan	Egypt	Description of Events
Early Bronze IA	Late Maadian (Naqada IIa-b)	Early Egyptian expansion; Production of Levantine export goods
Early Bronze IB	Naqada II c-d, Naqada III a-b, Dynasty 0	Colonial exploitation of Southwestern Canaan
Early Bronze II	Dynasty I-III	Development of Canaanite "City-states", Maintenance of connections to Egypt, especially at Arad
Early Bronze III	Dynasty IV-VI	Reorganization of Canaanite urban centers with production centers more dispersed, Egypt bypasses region
Early Bronze IV (Intermediate Bronze Age)	1st Intermediate Period	General urban collapse across the region characterized by ruralism

The initial identification of the Early Bronze I-III as urban was based on a few specific traits of the settlements that agglomerate in the period of time. The first description of the period as urban is often drawn from work by figures such as G.E. Wright who made the initial chronological determinations for the period based on stratigraphic phasing at the site of Jericho (Wright 1936, 1937, 1971). This early determination is important as it highlights that within the Levant significant changes in the organization of settlements occurs during the

EBA, as evident in the stratigraphy, even if it pales in comparison to similar physical features of cities in other regions. The features of EBA settlements that changes most at the start of the EBA included the first appearance of city walls and the overall increase in size of the cities. The increase in size of the settlements being the most important factor for most researchers, seven hectares being the accepted size at sites like Yarmuth, Gezer, Aphek and Arad to be considered a city (Ben-Tor 1992). This is not much in terms of size when compared to sites in Mesopotamia which ranged in the same period from 40 to 400 hectares in size. The “urban” concept was applied given the locally significant degree of population agglomeration that clearly had occurred even if not all of the typical markers of an urban society such as public buildings, social stratification, and a part of the population engaged in non-agricultural production were not met universally at the different large sites. Despite the desire to talk about the settlements of the Levant in the same breath as the cities of neighboring regions, the scale of settlement never truly reached the same intensity, so the many of the indices of centralized organization of power need to be freshly considered within the Levantine context leading to the characterization of that period as not-urban, rural or nomadic.

When the southern Levantine Early Bronze Age system collapses at the end of the EBIII it is the rural population that was believed to have taken over. This battle was characterized as between the “desert and the sown” highlighting the importance of the population based outside the 200 mm isohyet line during the earlier urbanizing period. The very perception of a collapse with the pastoral-rural element replacing the established settlements, was thought to indicate that there was a constant struggle between these elements in the population. That struggle is best initially exemplified by the “Amorite hypothesis” which saw a new group of pastoral nomadic invaders that destroyed the established urban centers displacing them with new cultural traditions (e.g. Kenyon 1966, Kochavi 1967, Cohen 1999). Over time the interpretation of foreign invaders as a local movement developed, but

still the characterization as a battle between the “desert and the sown” was pervasive with the idea that there was a “triumph of the desert over the sown” (Dever 1980, pg. 58) being maintained. By setting up an opposition between settled and rural elements that was characterized not just by different subsistence strategies, but also fierce, violent opponents, it was possible to use that opposition as an important factor in large scale shifts in political organization.

The settled and the sown dichotomy was based on the uncritical use of historical records that date to periods of the Middle and Late Bronze Age. One important source was the Amarna letters of the Late Bronze Age² (Moran 1992). In the letters conflicts are attested between cities and the surrounding territories, and have been interpreted as indicative of the strong difference between urban and rural groups letters (Rowton 1973b, 1973a). The conflation of events attested in the Late Bronze Age with the EBA ignores the significance of the difference of hundreds of years between the Late Bronze Age and Early Bronze Age political systems. This kind of misextrapolation of Bronze Age textual sources into the EBA from later parts of the Bronze Age was common and also done with other Egyptian sources such as the Beni Hasan Tomb painting of the Middle Kingdom (Cohen 2015). The result of the misuse of the historical record in the past has meant that even as the dramatic interpretations associated with an urban and rural dichotomy have been modified, the terminology and associated interpretive baggage were taken for granted in the framework for the EBA that is still a part of the literature today. The challenge of confronting previously accepted “truths” for the EBA in the face of data that contests existing paradigms has been evident in newer anthropological models (Esse 1991, Joffe 1993). While those words didn’t

² The Amarna letters were a cache of correspondence discovered between Late Bronze Age Levantine Rulers and the Egyptian Pharaoh.

revise the model wholesale, they did introduce a number of important new perspectives along an urban to rural continuum.

Researchers working in Jordan in the late 1980s began to challenge the assumption of the EBA as urban and the EBIV as rural. Starting with his dissertation, provocatively titled “Heartland of Villages”, Steven Falconer (1987) has done the most work utilizing settlement pattern analysis methodologies to explore the relationship between “urban” and “rural” settlement. In a series of works comparing the settlement patterns of the EBA and Middle Bronze Age he indicated that in the EBA there was an absence of hierarchical settlement organization, as one might expect for an urban center (Falconer 1994, Falconer and Savage 1995, Falconer 1995, Fall, Lines, and Falconer 1998). Another important contribution was the excavation of the site Khirbet Iskander by S. Richard (1988, 2010) where significant fortification walls highlighted settlement continuity; the walls originated in the EBIII and continued into the EBIV. The combined evidence of continuity of settlement at urban centers, with the inquiry into the validity of urban as a category helped to redefine the discussion of EBA urban archaeology.

The new data introduced by Falconer and Richard was critiqued based on methodological grounds. Falconer and colleagues continued to primarily use the formal elements of settlements to distinguish between urban and rural, their distinction utilized Childe's notion that the estimated self-sufficiency should be one of the key determining factors for analysis. In this definition urban settlements rely on neighboring settlements for agricultural support, whereas rural settlements are self-sustaining by definition. In order to understand the social, economic, and political dependency between settlements one need only look at the relationship of settlement size between settlements and between each settlement and its catchment or sustaining area. The sustaining area is based on a calculation of the sites sustaining area, a site's total population, and a constant based on the area of arable land

required for agricultural subsistence per capita. In many respects this took the already discussed model of Childe, that agricultural surplus was the key to introducing rank, and applied mathematical models to identify rank across a given landscape. Therein lay one of the problems with the analytical method, the model assumes a direct correlation between catchment area and political territory, which is both inconsistent with the general aim of the study and over-reliant on survey data (Smith 2003). The problem in this case is that the underlying data for a survey based approach is difficult to take at face value for much of the Southern Levant (Banning 1996, Haiman 2006). While methodological issues hindered the revision the urban model for the EBA based on structural issues, other lines of evidence proved to be more useful to help develop a more nuanced and complex model for the development of urbanism in the southern Levant.

Without an obvious way to resolve the critiques of the different analyses of the structure of EBA settlement new research began to focus on other data sets in order to enhance the arguments from both sides. A. Joffe (1993) suggested the important notion of scalar difference between the urban phenomenon in the southern Levant compared with the core area of early Near Eastern urbanism in Mesopotamia. This reinterpretation is reinforced by the increasing evidence of autonomous heterarchically³ organized settlement with low level integration during this period, despite differentiation on overall settlement size (Harrison and Savage 2003). This general picture has been observed by other researchers working in Jordan as well (Chesson and Philip 2003, Chesson and Goodale 2014, Chesson 2015). Increasingly it is becoming apparent that when taken on a regional level the integration that would be

³ Heterarchy in this case means a society in which rank is not considered vertically, but along a number of different means that are not necessarily obvious to distinguish in the archaeological record. It is not to say that rank does not exist as much as it implicates the variety of ways that it exists along a variety of social, religious, linguistic, etc. boundaries. In such a scenario ranking exists, but due to the fluidity with which rank is applied does not in an obvious manner in the archaeological record.

expected for a strongly hierarchical society is not present in every region of the southern Levant during the EBA. It is clear that a few settlements in the northern core of Israel such as Megiddo and Tel Yarmouth had features that resonate with later forms of urbanism, such as temples or palaces (de Miroschedji 2006, Adams, Finkelstein, and Ussishkin 2014). Even so those structures are probably not large enough in the first place to support a redistributive economy lead by a central ruler (Chesson 2015). Additionally, there is not clear evidence so far at some of the larger cities of a paramount leader despite the clear reorganization of settlement layout and household organization (Paz 2012, pg. 422). These features are seen as exceptions across the region and not the rule.

The fact that regionally distinct settlement patterns through time are recognized for the EBA means that as an alternative to the physical characteristics of settlement, the distribution of different commodity types both in and between settlements is a more effective way to identify patterns of ranking. As a result, much research for the EBA in the last two decades has slowly shifted to focus more and more on using the distribution of material types of build models of rank and social organization. By shifting focus from the physical organization of settlements to studies focused on aspects of the material record complementary lines of analysis were undertaken that helped to challenge the old models for the EBA (Philip 2001, Chesson 2003, Chesson and Philip 2003, Phillip, Clogg, and Dungworth 2003, Milevski 2011, Paz 2012, Chesson and Goodale 2014, Chesson 2015). In total these reevaluations of the data based on survey and excavations highlights the importance of reconfiguring models of the EBA, especially with more data from areas considered rural or peripheral. This has led to models that focus more explicitly on economic aspects modeling urbanism to draw conclusions. This method has been especially useful given that pastoralism is best understood as an economic choice, as a kind of production, offering a better way to compare archaeological records between the different kinds of sites.

2.7.2. Economic Models for Urbanism

The key aspect of the redevelopment of a model for relations between large settlements and the peripheral areas was the introduction of more sophisticated anthropological models for the behavior of pastoralists. The most important figure in this change was Anatoly Khazanov who had studied pastoral nomads in Central Asia (Khazanov 1994). In his work he outlines a number of core descriptors for pastoral nomadic activity that in earlier research in the Early Bronze Age were often overlooked. Important amongst these are the fact that rather than being perceived as independent of urban centers, nomads are in fact dependent on stratified sedentary societies that are capable of surplus production for exchange. Typically, nomads are not able to produce the full range of products that they depend upon (already a potential challenge to the model developed by Falconer, et al. above). A modern correlate of this can be seen in the modern Bedouin who occupy the same areas being discussed who eat little of the meat and are reliant on grain and other foodstuffs grown by sedentary groups (Marx 1992). With this in mind it would be best to understand pastoral nomads as a kind of hyper-specialist that would play a part within the larger economy of the region. Furthermore, Khazanov's study of pastoral nomadic groups rejected the idea of a battle that might have existed between the "desert and the sown" based on the fact that typically nomads were overmatched technologically.

The revised view of pastoralists as a complementary part of the local development of settlements and not an invasive force was fundamentally important to help look for autochthonous sources to describe the course of the Early Bronze Age. The most important change in this regard was the effort to reevaluate the nomenclature used to describe stratified social organization of the period from the assumption of the connection between "urban" and hierarchical organization. One particularly virulent debate utilized burial evidence from

Jericho to attempt to distinguish whether the inhabitants of EBIV Jericho organized hierarchically or were an egalitarian society (Palumbo 1987, Shay 1989). Important in that case was that the focus was on the EBIV period, when it is assumed that the urban social order had collapsed, and the more nuanced approach used especially by Shay (1989, Pg. 85) to distinguish an array of ways that stratification can occur. These more nuanced debates about the EBIV helped to introduce the need to also use more nuanced methods for the application of models of pastoralist behavior in the EBA.

A key aspect of the shift in the use of modern anthropological correlates for pastoral behavior in the past was the recognition that in many cases ancient pastoralists were most likely not as nomadic as current versions. Khazanov (1994) and others (Cribb 1991, Saidel 2008) identified this variation in the modern anthropological record and warned of its misapplication. The key reason that direct, unqualified ethnographic comparison between ancient and modern societies does not work is due to technological constraints between modern and ancient societies (Rosen 2008a, Wengrow and Graeber 2015). For pastoralists the most important of these technological constraints was the lack of certain domesticated animals for economic exploitation. As just one example, camels are an important feature of pure nomadic Bedouin in the modern era and were only domesticated in 1st millennium BCE (Sapir-Hen and Ben-Yosef 2013). As a domesticate, the camel enabled much longer distance trade routes that also supports different kinds of interaction that would not have been possible in the EBA. Those technological limitations would also affect settlements and structure the relationships of settlements to the rural periphery. Khazanov's early contributions remain an important first step for research in the following two decades where more care has been used for ethnographic comparisons used to describe ancient activity and as a result increased nuance has become much more common when describing the Early Bronze Age.

The revision of how urban spaces operate was also reconsidered to add characteristics that once one would have been associate with pastoralists. The result of the introduction of a more nuanced approach to the range of ways that social stratification could materialize in the archaeological record instigated new models for rural areas that sought to diversify the interpretation of those spaces in a more dynamic light. Claims of rural independence during the later part of the EBA has been described as a result of the continuation of settlement activities despite the collapse of nearby urban centers (Fall, Lines, and Falconer 1998). Similar resilience has been seen in ethnographic models for the modern Bedouin (Marx 2007). In fact, the Bedouin mimic the social organization of urban space on a larger scale. This includes the city's economic specialization and differentiation allowing for quick changes that reflect changes in market conditions, influencing the regional economy, and that are less commonly involved in long distance movement than often thought. These other ethnographic models highlight that present pastoral groups are not as deterministically linked to an urban core as assumed. The identification of modern pastoralists exhibiting urban traits adds more weight to the reconsideration of the urban/rural distinction for the EBA to appreciate an alternative interpretation of the lifeways of pastoral groups that also implicates their existence as distinct from the urban social system.

Over the course of the EBA the quantity of specialized goods produced and traded progressed with the increased adoption of the donkey for long-distance trade and refinements in the processes for the production. Starting with the colonization of Southwestern Canaan by the Egyptians and exploitation of viticulture; progressively the production and distribution system of the Southern Levant slowly developed into what appears to be a self-sustained economic system with different regional production centers providing different commodities (Milevski 2011). Two case-studies can be drawn as examples of different kinds of production systems for this period. First, in the case of ceramics regional variation in ware-types has lead

to difficulty comparing ceramics from site to site, but certain styles such as North Canaanian Metallic Ware (NCMW) and Khirbat Kerak Ware (KKW) offer the ability to identify shifts in the organization of production centers in certain settlements (Discussed in Chapter 4.5.1, cf. Philip and Baird 2000). Secondly, the production of groundstone in the Negev Highlands offers an interesting case study of non-pastoral production by pastoralists outside major settlements that formed an important part of trade between rural and settled areas (Rosen and Schneider 2001, Saidel 2002, Abadi-Reiss and Schneider 2006, Rosen 2011b). The identification of small scale craft production outside of the settlement centers reinforces that in the EBA some craft production was not directly attached to central authority, but instead served as the basis for trading relationships to supplement the needs of each group of people. The presence of simultaneous small-scale production for a common consumer by semi-nomadic pastoral groups indicates interdependence between the settled and pastoral groups for certain kinds of commodities. In part, it would be expected that the impetus for the production of non-pastoral goods by pastoralists would be the result of access to raw materials unavailable to people in settlements.

The role of a competitive advantage in formulating the organization of both interaction and the development of increased scales of production is not enough to explain the underlying social mechanics that enabled ancient long-distance trade. Ricardo's Law of Comparative Advantage states that it is not worth producing commodity "x" yourself if you're better off producing commodity "y" and obtaining commodity "x" in exchange for it (Ricardo 1817 [2010]). In other Bronze Age contexts this has been accepted *prima facie* for the development of a regional division of labor that led to the eventual development of new social institutions (Kristiansen and Earle 2015, Pg 242). In the context of the EBA, copper is usually considered to be emblematic of this process, but the irony is that copper only appears as a medium of exchange and accumulation in the EBIV after the collapse of central institutions

that would arrange production and exchange of valuable commodities (Milevski 2009, Pg 144). Further, it cannot be expected that the simple existence of a comparative advantage is enough to explain how long distance trade of valuable commodities developed. The one-sided prisoner's dilemma game highlights the fundamental problem of exchange; despite the benefit of a trade based on comparative advantage it is always better to not cooperate (Greif 2000, Pg. 254-255). This circumstance is especially true in the case of long distance exchange where familiarity might alleviate inherent distrust. Locally, shared rituals can enable elite to develop cooperative means for the consolidation of power that facilitates exchange (Stanish 2004). The groundstone evidence highlights a system where strong central authority was not directly responsible for the production in the sense of attached specialization, but the exchange system was relatively local to the site of production. The short range of the exchange would have diminished distrust. In the case of long-distance exchange of commodities, like copper, other mechanisms were necessary to facilitate the exchange. The trajectory of the general models for the social organization of production and exchange indicate that long-distance trade and settlement agglomeration went hand in hand due to the development of centralized leadership, but the mechanisms that led to that eventuality are less clear. For KHI it will be necessary to not just show that production was more intense in the EBA, but also to indicate through changes in the industrial landscape what mechanisms led to an intensification of the copper production system.

2.8. Conclusion

The way that the relationship between theories of urbanism and the operations of states are understood to be intertwined is fundamentally important for any study of the EBA in the Levant and in particular the southern Jordan/Israel example presented here. The history of how those two forces have been understood has shaped the way that models were constructed

to describe the development of settlement patterns through the EBA and the eventual collapse of the EBA settlement system. Pivotal has been the progressive shift overtime in the analytical focus of how that system has been described, between a focus on physical structure that shape urban activity to a focus on the material elements of society that imply rank and social complexity. This shift in focus has only started to consider how the application of theories related to the social and political circumstances of production, exchange and consumption can be used to enhance our understanding of the EBA. Most important in this instance is the mechanisms for the generation of surplus production that would form the economic basis for the long distance trade that clearly becomes a more significant part of the EBA economy.

For the southern part of the southern Levant the relationship between the organization of production and the organization of power is the most important consideration to indicate the connection of that region with the surrounding area. The two primary copper ore sources are found in this area, in addition to some of the largest deposits of refined copper. In this period copper was an important commodity that was most often associated with elite structures due to the amount of labor required and the technical difficulty to produce a final product. For the copper production site of KHI it will first be important to consider the way that different activities at the site were organized. For this theory related to craft production and property will be especially important. Secondly, on a regional level, it is also important to consider the diachronic shifts in the location and mode of copper production and transportation within the larger regional context. The description of modes of communication and consumption imbued through the context of exchange will be important to establish to offer a setting for a model of the Faynan industrial landscape. The necessary data to describe the kind of social system that operated during the EBA for the Faynan area will be derived from these local and regional transitions of copper production and exchange. Thus, it is first important to discuss

models for how production was organized in the region of interest before proceeding to a description of the existing knowledge of settlement activity at KHI.

Chapter 3: Models for the Social and Political History of the Negev and Faynan

The review of theoretical considerations for the organization of production and exchange in the Levant indicated a number of key indices that are important to consider when reviewing models constructed for the copper trade in the Southern Levant. Before the copper producing area of Faynan was explored in detail through excavations, the neighboring Negev Highlands offered the most complete picture for the copper trade in the EBA. Today and in the past the Negev Highlands is a marginal zone that only saw periodic population bursts over time (Rosen 1987, Pg. 50). Except for the Byzantine period, the majority of settlements were small (fewer than nine rooms) and are thought to reflect a primarily pastoral population. As a result, a number of features of pastoralists typically form the dominant aspects of any model for the region. The question remains whether it is appropriate to fully conflate Faynan into a model of the Negev. The models from the Negev then must be understood as informative of a part of the copper exchange, but not necessarily representative of Faynan. The most important variables to consider in models of the Negev for the EBA are the degree of sedentarization, the involvement in long-distance trade and the involvement in the production of specialized goods. Different aspects of this includes the characterization of sites in relation to each other and whether the source of change in society was defined as internal or external as each sub-period progressed.

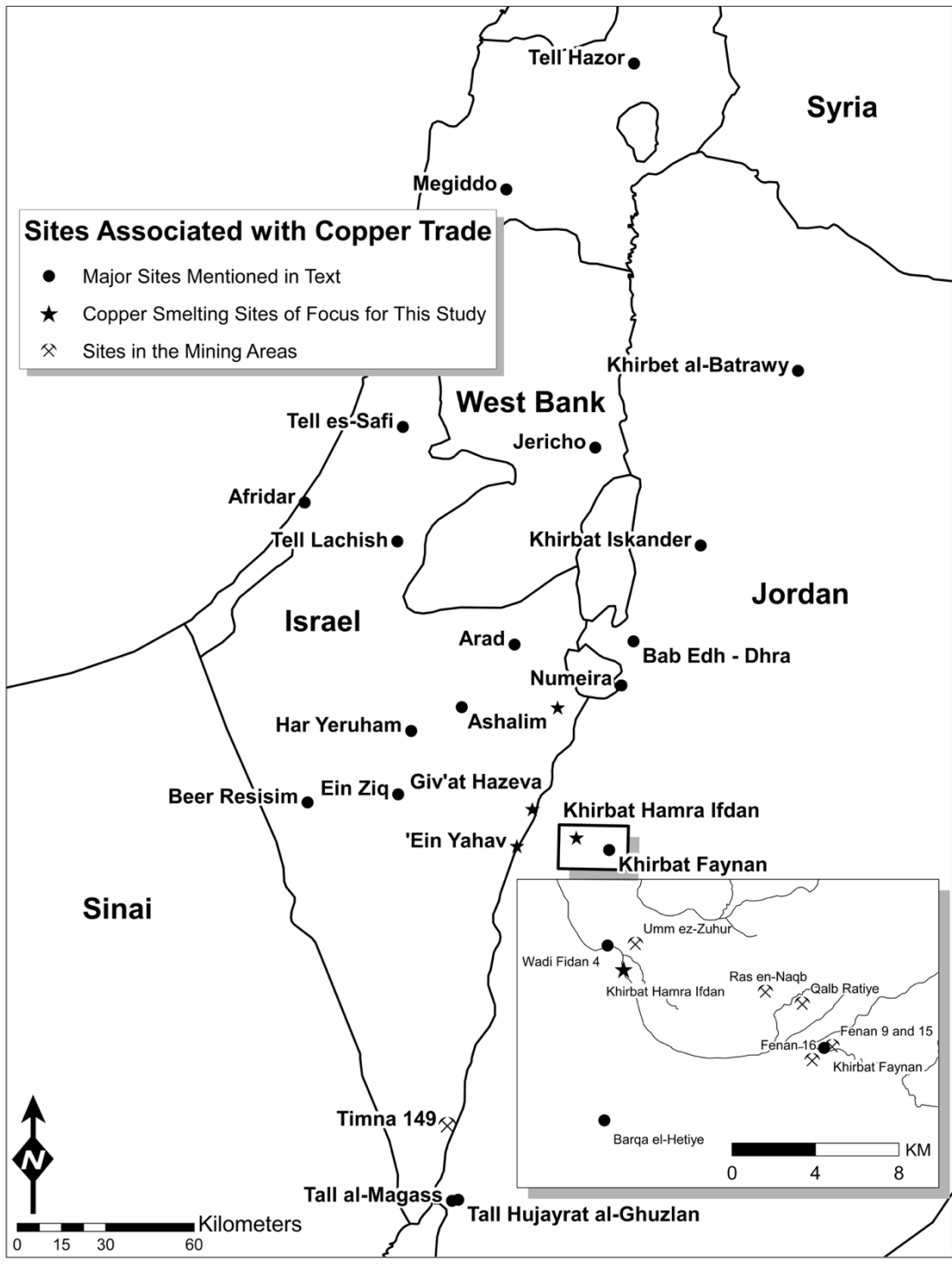


Figure 3.1: Map of sites related to the Early Bronze Age copper trade mentioned in the text.

Before synthesizing the extant models for the later part of the EBA of Faynan and the Negev Highlands it is important to recognize the historical limitations inherent in the methods used to construct the models. Three limitations will be considered that have shaped the conclusions of existing models and limit their applicability given new data for the southern areas of the southern Levant. First, the fact that the Negev is a peripheral study area for the Levant has limited its inclusion in synthetic models of the larger southern Levant. Second, the models rely on insecure survey data from the Negev for which a single interpretation is not set. Third, as a result of the revised chronology the existing framework for those models based on survey no longer applies. It is through the identification of the limitations that the utility of the models for the present study will be considered.

The fact that the region of interest is so peripheral to the major areas of settlement has meant that it has also been relatively poorly studied. This indicates the first concern to be recognized, whether Faynan and the Negev are the central focus of the study or are peripheral to the primary areas of study. Compared to other parts of Israel and Jordan the Negev and Faynan have not been extensively studied and as a result many models for the general EBA of the whole of the southern Levant include these peripheral areas despite the regional distinctions that have troubled research for this period through time (Discussed in greater detail in Chapter 4.5). Importantly, synthetic discussions of the socio-political organization of the southern Levant more often than not leave Faynan and the Negev Highlands sites off the map (literally) and when the area is mentioned it only receives a footnote due to the recognized importance of copper, especially as a part of the urbanization of the region. This is exemplified by all of the models, each show copper as an export without consideration of what was traded in the opposite direction. This precludes discussion of other kinds of exploitation that could indicate evidence of ranking of the peripheral areas.

This has also meant that in some cases the use of older models and data from the Negev and Faynan have been uncritically utilized by researchers focused on the more settled areas leading to inaccuracies in the application of data for model building and *vice versa*. As a result, the second concern is revealed where the continued use of assumptions or data, since been proven incorrect, has led to the preservation of built in assumptions that are in need of inquisition. Historically the methods used to analyze the EBIV were heavily biased toward tell sites (Dever 1992). Tell sites by their nature are settlement conglomerations formed over long periods of time at a single site one on top of the other, constantly reinhabited and growing over time due to their strategic position in the landscape. A focus on these sites will naturally yield results that focus on the centralized nature of settlement as opposed to any other aspects of society, especially the pastoral elements more common in the Negev Highlands. Considering that in modern non-industrial societies the population outside of urban centers far outnumbered that of the population within urban centers an alternative method to analyze these underestimated populations is required (Mann 1986). To combat these biases data based on full coverage survey have become more important in Levantine Archaeology as a means to provide greater knowledge of the landscape and provide better access for archaeologists to the formally marginalized peoples within the literature. This actually produces a different bias in a region like the Negev where sites are highly visible and as a result can be overrepresented relative to other regions (Banning 1996). The problem with the inaccurate data is best understood as a problem of path-dependence that has shaped research when researchers have uncritically used survey data to build regional models.

This issue of the contingency of past models has only become amplified with the third complication. As would be expected, advances in underlying data on which past models have been built. A good example of novel path-breaking research has been the development of a new dating schema for the EBA that has significantly altered how any of the existing models

can be applied in relation to existing cross-regional relative stratigraphy (See Table 3.1). For instance, based on the new dating scheme the Egyptian Old Kingdom is now concurrent with the EBIII-IV instead of the EBII-III as was previously assumed (Discussed in greater detail in Chapter 4.3.3). This has significant ramifications for understanding how the large polities outside the Levant would have formed long distance trading relationships that are a key aspect of understanding the development of settlement agglomeration in the EBA.

Table 3.1: Traditional and revised chronologies of the EBA in the southern Levant; highlights the shifts in relation to both Egypt and Mesopotamia. The traditional model is based on the widely accepted synthetic model of Stager (1992). The revised model is based on new radiocarbon analysis by Regev (2012, 2013).

Levant	Traditional Chronology	Revised Chronology	Egypt - Original	Egypt - Revised	Mesopotamia - Original	Mesopotamia - Revised
Early Bronze I	3500 - 3000 BCE	3500 - ~ (3200 - 2900) BCE	Pre-Dynastic	Pre-Dynastic - First Dynasty	Late Uruk; Jemdet Nasr	Late Uruk; Jemdet Nasr
Early Bronze II	3000 - 2600 BCE	~(3200 - 2900) - ~2900 BCE	First - Second Dynasty	First Dynasty	Early Dynastic I and II	Jemdet Nasr
Early Bronze III	2600 - 2300 BCE	~2900 - 2500 BCE	Third - Sixth Dynasty	Second - Fourth Dynasty	Early Dynastic III; Akkadian Empire	Early Dynastic I and II
Early Bronze IV	2300 - 2000 BCE	2500 - 2000 BCE	Seventh - Eleventh Dynasty	Fifth - Eleventh Dynasty	Third Dynasty-Ur III	Early Dynastic III; Akkadian Empire; Third Dynasty-Ur III

The third concern, especially the total reconfiguration of the EBA absolute chronology, has complicated recounting past models. As will be clear, one of the pivotal aspects of these models is the terminology used for the terminal phase of what is now called the EBA. A number of terms have been used for what I call the EBIV (see following section for discussion of other terms) and the terminology used often reflects the model in use. Where appropriate, a brief discussion of the implications of the terminology will also be necessary to highlight implications for the model. Further, when and where the chronology is based on relative data or correlations with neighboring regions such as Egypt or Mesopotamia must be noted as that data remains correct despite the change. If the data is based on relative chronological markers to neighboring regions, then it is possible to adjust the absolute dates to the new chronology. When a combination of local and long distance correlations was used, the dating question is more complicated and requires extensive reexamination. The issue of the application of the revised chronology is one of the most important factors to consider for the purpose of research at KHI because the radiocarbon dates from KHI primarily date to the period of time that was most affected by the chronological shift (Discussed in greater detail in Chapter 4.3).

When any of the three aforementioned factors worked independently or in combination they will be addressed as a preface for the context of how the models specific to the Negev and Faynan were constructed. With those three considerations in mind it will be possible to take consider each model using the four variables of primary concern for this study: the origins of the disruption at the start of the EBIV, the permanence of settlement, the socio-political organization of settlement, and the role of copper in each of those processes. After covering the models for the southern Levant, a brief discussion on the relationship between large states and peripheral areas will follow.

3.1. Early Models: Cultural History Paradigms and the View from the North

As the basis for the general narrative for the development of the EBA urban system used by future archaeologists, it is important to briefly consider aspects of how early models were developed and their implications for later research on the period. Those earliest descriptions of the social history of the development of the EBA in the southern Levant were directly tied to a small number of key tell sites.⁴ Those sites offered isolated deep trenches that could be used in conjunction with the general stratigraphic sequence to produce a general history for the region (Wright 1937, 1961, Kenyon 1957, Wright 1971). This offered a narrow perspective of the transition from sub-period to sub-period that highlighted the rise and collapse within each site cross-correlated to other transitions in other sites. That progression as it was initially formulated broadly states that in the EBI early village life and limited centralized production gave way to larger settlements in the EBII that included features such as city walls and other features that are part of the suite of material that could be called urban. Through the EBIII many of those cities persisted, but some collapsed and some new cities formed. At the end of the EBIII the older major settlements were broadly abandoned except for some exceptions with a number of new smaller settlements appearing, seemingly associated a pastoral mode of production in the Middle Bronze I (MBI).

The progression that was initially developed in these early models included all of what currently would be identified as the EBA but with three instead of four sub-phases. W.F. Albright and G.E. Wright were the figures that expanded the EBA to include a fourth sub-phase based on the continuity of trends in the ceramic data and split the period currently identified as EBIV (traditionally dated to 2300-2000 BCE) into the EBIV ending at 2100 BCE

⁴ Dever (1973) offers the most detailed history of the minute shifts in absolute chronology over the formative period of research on the Levantine EBA.

with the MBI following (Wright 1937, Albright, Kelso, and Thorley 1944). That split added a period of urban abandonment to the end of the EBA tied to the major changes in the settlement pattern at the end of the EBIII. That shift also meant that the end of the EBIII was associated with the end of the Old Kingdom in Egypt and the start of the First Intermediate Period in Egypt.

Over time a number of other terms besides EBIV and MB I were introduced for the period between 2300 and 2000 BCE that highlight continuity with a slow change in material culture from the Early Bronze Age to the Middle Bronze Age. The other terms used indirectly mirror the terminology used for this period in Egypt: Intermediate EB – MB (Kenyon 1970), and Intermediate Bronze Age (IBA) (Kochavi 1967). Intermediate EB – MB describes the introduction of migratory ethnic groups, often identified as a nomadic group of tribes from Syria called the Amorites, identified through changes in the social aspects of daily life (burial practices, types of objects in use) between the Early Bronze III and Middle Bronze II periods despite material connections to both EB and MB cultures highlighting an intermediary stage (Kenyon 1966, Prag 1974). The name IBA is a slight adaptation of the Intermediate EB-MB term implying that there was a punctuated period between the Early Bronze III and Middle Bronze II sufficiently different from either to require its own term separating it culturally from its predecessor and successor due to its intrusive nature despite clear material connections to both and without the stress of migration. The basis for this term was the fact that many of the sites during the period were founded on virgin ground and often, but not always, single occupation sites (Kochavi 1967). While the origins of the IBA term was in the peripheral areas of the Negev Highlands, currently it is still applied most often in northern areas of the southern Levant (e.g. Bunimovitz and Greenberg 2004). Broadly speaking however, the vast majority of researchers have dropped the IBA terminology in favor of EBIV.

The important contribution of these early models was the general framework that all following researchers were challenged to apply in their own work. That framework set the idea that the transition to the EBIV was the result of invaders from an outside region. The fact that the transition to the EBIV was not recorded evenly across all sites was prescient, but misinterpreted, of the importance of regional variation across the Levantine region during the EBA that has resulting a difficulty synchronizing chronologies. The recognition of the importance of pastoral groups in the period that follows the EBIII instigated the use of survey data in the research that followed to identify sites outside the settled areas.

3.2. Surveying the Negev: Rudolph Cohen and Mordechai Haiman

The work at the major tell sites to establish an expected framework for the overall settlement of the Levant made it possible to use survey data more effectively to fill in the gaps of knowledge regarding overall settlement patterns during the EBA. This was clear in the northern areas where new settlement data based on surveys reinforced general trends regarding the changes in location and size of settlements over the course of the EBA (e.g. Gophna and Portugali 1988). Following peace with Egypt, the Negev in southern Israel was going to transition into military training grounds that led to the Negev Emergency Survey. That survey, led by R. Cohen (1979, 1992, 1999) the director of excavations and surveys for the Negev region for the Department of Antiquities of Israel (now Israel Antiquities Authority), did extensive work on the EBIV, eventually excavating a number of sites in the Negev Highlands, including Ein Ziq and Beer Resisim⁵. Cohen's familiarity with much of the material culture was unrivaled, in part because he prevented many researchers from access to

⁵ W. Dever excavated Beer Resisim and published a more comprehensive report of the excavations (2014). The two researchers had significantly different interpretations of the data and Dever's interpretations are discussed independently in the next section.

the major sites. Cohen's excavation methods at many sites has often been questioned and only recently have organized research projects been carried out to revise our understanding of the large sites in the region (Dunseth 2013). One researcher that was allowed access to many of the sites was M. Haiman (Haiman 1996, 2009, Saidel and Haiman 2014), whose own perspective on the EBA Negev differed from Cohen's, due to his personal focus on smaller sites and more intensive survey. As a result of Cohen's influence on Haiman and their pioneering work together as surveyors in the Negev, the two figures are taken together to highlight the most extensive models of the EBA by Israeli researchers working in the Negev when the region was just beginning to be recognized as an important conduit for the copper trade.

Cohen's model for the settlement pattern of the Negev Highlands relied on data from neighboring regions to prescribe the periods of florescence and nadir. For the EBII, ceramic similarities connected copper mining sites in the southern Sinai with the large walled settlement of Arad, where over 200 copper pins were found (Amiran, Beit-Arieh, and Glass 1973, Amiran 1978b, Beit-Arieh 2003). By comparison no such evidence for major sites related to copper production were found for the EBIV. The sites responsible for copper production were instead found in the Negev itself. Thus, based primarily on the survey data that was collected, Cohen identified the settlement of the Negev Highlands for the EBII a simple occupation system compared to that of the EBIV. In the EBII there was only a single very large site and the organization of sites was believed to be positioned purely as a conduit for the Sinai copper trade that was centered at Arad (See Amiran, Beit-Arieh, and Glass 1973). That assumption was applied to the survey data which was interpreted using the model based on large settlements rather than searching out autochthonous developments in the countryside (Cohen 1985). Although he acknowledged that settlements in the Negev Highlands probably also needed to be assigned to the EBIII, Cohen observed a gap of occupation between the EB

and EBIV, which was reflected in the categorization of sites as a part of the survey efforts made under his supervision (Cohen 1985, Haiman 1986, Rosen 1987, Lender 1990, Haiman 1991, 1993, Cohen 1999). After the gap in settlement during the EBIII Cohen observed the start of a new multi-tier settlement system in the EBIV (Cohen 1999, Pg. 52-54). The appearance of settlement in the EBIV was the result of a “desert and sown” battle with more technologically developed pastoralists invading and settling in the Negev. Cohen’s wiggle-matched model for settlement density was based on the expectation that Levantine data provided the necessary comparative data to match the number of settlements to the intensity of copper production.

Based on Cohen’s interpretation of both the nature of settlement in the Negev and the surrounding region he advocated for a distinction between the EBA and the EBIV with the suggestion that the occupation was intrusive on the EBA. As a result, in many of his publications he maintained the descriptor MBI even after most researchers had dropped the term in favor of EBIV or IBA⁶ (Cohen, Dever, and Caldwell 1981). Cohen’s retention of the MBI name was due to his interpretation of the occupation as a foreign occupation by nomadic invaders, evoking the “Amorite Hypothesis” of Kenyon. The intrusive culture was one that was said to be more advanced, assuming that the population originated in Egypt and invaded Palestine via Transjordan (Cohen 1999, Pg. 56). It was this circuitous route that helped explain the presence of copper ingots at many of the sites. Cohen maintained the invasion hypothesis despite the fact that he has also recognized continuity in architectural traditions at these sites from the EBII-III (Cohen 1992). The use of the strict separation embodied by the MBI nomenclature led by Cohen in the Negev Highlands to maintain a model distinguishing Arad’s position of power during the EBII from the later period of larger settlements in the Negev

⁶ Cohen at this point also assumed that the MBI was contemporaneous with the First Intermediate Period in Egypt or roughly 2300 - 2000 BCE.

Highlands such as 'Ein Ziq and Be'er Resisim (Cohen 1992, 1999). It is important to keep in mind that his theories were all contingent on the historical movement of large groups of people from distant lands and as a result the way that Cohen interpreted the mega-sites reflected the assumption of them being a more organized society.

The new settlement system that started in the MBI was assumed to have been an intrusion of a new population element and reflected their social norms. After excavating many of the large sites Cohen (1999) described the system of settlement as organized on three tiers based on with all settlements assumed to be roughly contemporaneous. The highest tier was called central settlements, measuring 3 to 20 dunams, and the settlements were broadly assumed to have been occupied full-time. Within this tier Cohen identified three classes based on architecture. The first class contain 1-5 rooms dwelling structures with a central pillar to support a stone roof with rare rectangular buildings at some sites and surrounding sites on hill crests there are often cairns. The major sites of this class consists of Ein Ziq, Mashabbe Sade and Beer Resisim (See Figure 3.1). The second class were sites with round or rectangular structures that are built in succession to form an exterior enclosure. There is said to be roof pillars in the interior of rooms that sometimes occur in a row, but no roofing slabs. The settlements are compact with something more akin to neighborhoods forming. Examples of the second class are Har Zayyad and Har Yeruham. The third class is represented by a single site, Nahal Nizzana, which shows dwelling units that are round and irregular with adjoining courtyards that include alleyways between residential units. The site also included a distinct northern and southern block to the settlement and in some rooms had stone pavements that recall the floors of Arad silos. The second tier was called large settlements that share the characteristics of the central settlements but are only up to 2 dunams in size. A handful of settlements in the second tier exist in the Negev Highlands. The settlements of the third tier, or small settlements, were plentiful. Small tier settlements consist of a few residential units.

Lastly, there is also evidence of temporary settlements which were basically just an animal pen and scant evidence for the use of caves. Cohen observed an organization of settlement that included full-time occupations on the larger sites with nomadic populations occupying the smaller sites.

Haiman follows the model of Cohen, organizing the sites in the Negev according to size, but makes changes to details in the structure of the model by asserting that the occupants of the mega-sites were autochthonous specialists in the copper trade. Haiman's (1996) synthesis of the settlement data from the Negev Emergency Surveys illustrates two different levels of settlement, more permanent mega-settlements and smaller peripheral sites, with the same three different architectural distinctions between the different mega-sites as Cohen. The difference was that Haiman left open the possibility that the architectural distinctions were representative of different groups of people occupying the sites diachronically, not just synchronously. This was important as Haiman also noted that the mega-sites were not permanent occupations, but semi-permanent way-stations as a part of a copper trade that started in Jordan and traversed the Negev Highlands on the way to a final destination. This was informed by the presence of hammerstones that might have been used to process copper. He has posited that these merchants could even be considered "wage" laborers within a larger economic system controlled by some outside sites (Egypt or northern areas of the southern Levant). In that capacity the role that the occupants of the Negev Highlands played was not that of the outside invader disrupting the system, but a more autochthonous development of itinerant merchants. This merchant class developed as result of the collapse of the Egyptian Old Kingdom, ~2200 BCE, in response to the demand for copper that the weakened state could not produce on its own.

Haiman's model for the organization of settlement of the Negev in the EBIV is different from the model that he has developed for the structure of EBII settlement. Haiman

reaffirms Cohen's position of a strong distinction between EBII and later EBIV settlement that is defined by the direct chronological association of EBII settlements with Arad (Saidel and Haiman 2014, Pg. 173). Unlike Avner (2001) and Rothenberg (1992), Haiman asserted that the EBII Negev consisted of two distinct settlement patterns in the EBII (Saidel and Haiman 2014, Pg. 173). One settlement pattern was that of the indigenous pastoralists who occupied temporary settlements. The other was that of urban dwellers who were interested a presence in the Negev and Sinai to protect trade routes related to copper production and to supervise the copper production directly. The important distinction from the EBIV model is the role of non-indigenous groups that Haiman asserts are identified through the architectural similarities and ceramic correlations between Arad and settlements adjacent to the mines and Sinai (Aspects of this connection are discussed in Chapter 4.5). As an urban center Arad is assumed to have played a pivotal role in the EBII copper trade (Discussed in Chapter 4.5.2, Amiran, Beit-Arieh, and Glass 1973). The importance of Arad in this system means that when Arad collapsed, so did the rest of the EBII sites in the Negev and Sinai leading to the break unsettlement between the EBII and EBIV.

Despite the advantages that survey brings to help produce a better picture of the extent of settlement over a region, it also important to recognize inherent weaknesses in the method. Banning (1996) has discussed extensively how easily survey in the southern Levant can often miss material remains. Further concerns for the existing survey data come from the methodology used to date the sites, especially over a region as large as the Negev Highlands. The materials typically used to date sites are flints and holemouth rim jars, both long-lived materials but difficult to distinguish chronologically. When such materials were found on the surveys conducted during the Negev Emergency Survey architectural patterns were used as a determining factor to establish chronology in the absence of solid ceramic evidence (M. Haiman Pers. Com.). Such distinctions on surveys can be particularly disturbing especially

given the difficulties present in comparing data of similar architectural features within the outline region between surveys (Haiman 2006). As a result, the typological and chronological distinction of two exclusive periods of occupation, the EBII and EBIV, from the Negev Emergency Survey should be questioned given that the assertion of the periodization is based primarily on circumstantial rather than definite evidence. In fact, a survey of radiocarbon dates from sites in the Negev Region has highlighted the fact that sites from across the region cannot be isolated only to those two periods (Avner and Carmi 2001). Continuity was also seen in the petrographic evidence, especially at the sites of Beer Resisim and Ein Ziq (Goren 1996). In addition to the issue of the permanence of settlement, a clearer discussion of the chronology between Negev sites is still one of the most important issues to be dealt with as a part of any research given the light level of uncertainty that remains.

3.3. Conflicting Views of the Role of Copper and the Permanence of Occupation: William Dever

One of the sites that has both helped and hindered the discussion of the chronology within the Negev Highlands was the site of Beer Resisim. The site only yielded three radiocarbon dates that were performed on ostrich eggshell, a problematic material for radiocarbon dating (Discussed in detail in Chapter 4.3, Vogel, Visser, and Fuls 2001). Excavated with Cohen, W. Dever (1973, 1980, 2014) took primary control of the final publication of the site in addition to having published pioneering work on the ceramics of the EBIV. Dever's work to synthesize the social organization of the EBIV was based primarily on his strong familiarity with the ceramic chronologies of many excavated sites around the southern Levant and an interest in utilizing anthropological theory to model that excavated data (Dever 1992, 1998). Like Haiman, Dever emphasized that the occupants of sites in the Negev Highlands were transhumant and as a result anthropological models of pastoral

nomadism were required to make sense of the data. Unlike Cohen and Haiman, Dever played down the role of copper as the economic basis for settlement in Negev during the EBIV.

In his research on the EBA, Dever wrote many important synthetic works that were important to contextualize the results of his research in the Negev Highlands. His focus was not only the pastoral areas of the south, but the southern Levant more broadly in order to understand the nature of the collapse of the EBIII urban system (Dever 1980, Dever 1998). One of the key distinctions of Dever's work during this phase compared to other scholars was his adoption of the role of environmental collapse as the key explanation for the end of the EBIII (i.e. Weiss et al. 1993, Weiss and Bradley 2001). This model of collapse for the EBIII took on the common assumption that the EBIII ended at ~2300 BCE and identified six key factors. First, overpopulation of cities forced strains on the food production systems. Second, a decline of rural food production further exacerbated the first problem. Third, environmental issues became apparent such as deforestation from overuse of the land. Fourth, food shortages increased as a result of the first three problems. Fifth, the over-centralized settlements could not cope with the sudden crisis. Lastly, Egypt's centralized hierarchy of the Old Kingdom broke down with the regional nomarchs, or leaders, taking more control in Egypt, offering fewer options for organized long-distance trade. This model provided a veritable house of cards with a number of statements that are contingent on the timing of the EBIII collapse, which has since proven to be inaccurate (See Chapter 4.3). The reliance of Dever's inherent assumption on environmental changes must be remembered while discussing his interpretations of the results from the excavations at Beer Resisim and the EBIV more generally.

The major difference between Dever and Cohen was the belief that the subsistence economy of the Negev was based on pastoral nomadism. Based on excavations at Beer Resisim, Dever (Cohen and Dever 1978, 1979, Dever 1980, 2014) has highlighted the reliance

of the inhabitants of Negev sites as pastoralists participating on a limited basis in the trade of copper. It was assumed by Dever that the absence of tools necessary to produce copper and the absence of copper tools indicated that the occupants of the site were not involved in production (contra Haiman 1996). Thus the nomadic character of Beer Resisim, and by association the other major sites in the Negev Highlands, was best understood as a permanent seasonal camp with its occupants moving from the Hebron Hills to the north. His hypothesis was informed in part by the similar material assemblages in each region, including copper ingots found in both areas (Dever and Tadmor 1976). Rather than interpreting that economic behavior as evidence of a distant invasion like Cohen, Dever favored the theory that the development of the central sites in the Negev Highlands were the result of an exodus from the more heavily settled areas of Palestine along the coast and to the north. Complemented by his observations of continuity in the ceramics from the EB into the EBIV, Dever always favored the EBIV term to describe the period after the end of the EBIII (Dever 1973, 1980). The evidence of continuity from the earlier periods in the EBA was an important contribution of Dever, especially in light of the shifts in absolute chronology for the period. Perhaps in anticipation of the shifts in the EBA, Dever (2014, Pg. 227) recognized inconsistency in the chronology of the Negev settlements based on the radiocarbon data. Even though the model that Dever presented was based on a false assumption regarding the collapse of the EBIII, his push for the expanded use of anthropological models and recognition of endogamous forces in the shifts between periods helped to shape future research.

3.4. Synthetic Analysis from Israel: Israel Finkelstein

I. Finkelstein (1995a) was one of the first Israelis to produce anthropologically driven models. His model was presented in a series of publications that provided an explanation for the expansion and contraction of settlement that was driven by social forces internal to the

Levantine socio-political system using long scale change in occupation patterns in highlands regions in Israel through the whole of the Bronze Age and into the Iron Age (Finkelstein 1990, Finkelstein and Perevolotsky 1990, Finkelstein 1995b, 1995a). It was very much the desire to seek explanations for change locally, within the southern Levant, that highlighted a connection to Dever's work. Finkelstein uses the IBA term to describe the EBIV highlighting connections to the EBA, but considering it a distinct period from the EBII "Desert Polity" of Arad and the MBA. The most problematic element of the model was that it relied on contingent factors that were not predictable and contextual to the selective datasets used to develop the model. As already mentioned, the significant occupations in settlement density through the EBA in the Negev area have since been proven false (Avner and Carmi 2001). Similar to Dever, the revised dating scheme for the Levant, which highlights that the EBIII collapse was not as dramatic as once understood, dispels many of the contingent factors on which the model was developed.

The model developed by Finkelstein takes an evolutionary approach that assumes the natural progression of human society is to focus on the development of plant based self-sufficiency and by association resource accumulation, i.e. copper. The model however doesn't wrestle with how to rationalize the changing kinds of copper objects that were found in different periods. Finkelstein explicitly ignored the relevance of environmental data and external factors due in part to the uncertain literature on both, making them unsubstantiated causal factors. Instead, more reliable was the survey and related demographic data that provided the evidence for settlement oscillations (Cohen 1985, Gophna and Portugali 1988, Gophna 1998, Cohen 1999). Focus then was on the settlement structure, thus he assumed the presence of polities based on the size of settlements and the surrounding settlement patterns (Finkelstein 1995b). The oscillations in settlement density were the result of natural processes of a "multi-morphic" society which saw urban and rural ways of life fluctuate in accordance

with the integration or disintegration of urban settlement structures. When the urban centers were most dominant in the archaeological record than the pastoral elements of society became relatively unobservable through archaeological methods of detection. When the urban society fell apart, rural elements were added to the dispersal of urban populations who began to subsist on sheep/goat pastoralism, seasonal agriculture and occasionally metallurgy. The fact that rural groups in periods of urban disintegration could not trade with urban centers for grain meant that they needed to build some settlements and as a result left behind a clearer archaeological record. Also, it is implied that it was the technological expertise of urban dwellers that enabled the production of complex goods, such as copper.

Finkelstein's ideas were not adopted widely in the general literature, but the fact that he introduced a more nuanced approach to the behavior of pastoralists was an important development. Rather than presenting pastoralists in the dichotomous "desert and sown" model that the previous researchers all utilized, he focused on the fact that the occupants in peripheral areas exhibited both "urban" and "rural" traits, even if those traits were derived from migration from urban areas. Like Dever, his focus on looking for local sources of change in social patterns was an important contribution to the orientation of research for the Negev area.

3.5. Local Trends in the Negev: The Timnian Complex and Autochthonous Development

Researchers that work almost exclusively in the Negev Highlands area have focused on the role of endogenous forces for local social change. The Negev Highlands is rich in lithic material and as a result a separate chronological sequence, called the Timnian Complex has been developed based on shifts in the frequency of different lithic forms and production techniques (See Table 3.2, Rothenberg and Weyer 1979, Pg. 114, Ward 1991, Rothenberg and

Glass 1992, Rosen 2006, 2008, 2011a, Rosen and Vardi 2014). Lithic were a focus because as a peripheral area the Negev Highlands is notoriously poor in terms of the variety of ceramic forms. This was in fact one of the problems on the Negev Highlands Emergency Survey when trying to identify the variety of periods of occupation during the EBA. The Timnian Complex was split into a number of phases that are considerably longer than any of the ceramic based EBA periods in the northern complex. This is a reflection of both the difficulty of using lithics as the primary tool in determining cultural sequences and emphasizes a key point of the researchers, the strong continuity seen in settlement observed over the whole of the Timnian period. In fact, a key element of this is the evidence of a progressive split in the stone tool industries between Northern Israel and Southern Israel, interpreted to be indicative of the diversity of cultural processes between the regions (Rosen 1997, 2011a). The combination of continuity of cultural traditions and distinctions in the stone tool production processes from neighboring regions was considered validation of a model for the region that was based on the importance of local self-determination guiding social change that was independent from neighboring forces.

Table 3.2: The chronological relationship between the Timnian periodization in relation to the associated chronological distinctions using the new chronology. (Based on Rosen 2011a, Pg. 72)

Year BCE	Northern Chronology	Desert Chronology	Features
2000			
		Terminal Timnian	Large Cluster Architecture
	EBIV		
	EBIII		
3000	EBII	Late Timnian	
	EBI		
4000			Nawamis
	Ghassulian	Middle Timnian	
			Metal
	Besorian		Ceramics
	Qatafian		
5000	Wadi Raba'	Early Timnian	

One of the key components of the Timnian Complex was the role of different kinds of craft production as a means to define the participants in the system. The earliest descriptions of the Timnian Complex as distinct from the contemporaneous EB system focused on the role of copper as a unique product of the inhabitants of the broader Sinai-Negev regions (Rothenberg and Glass 1992). In this formulation the role of Arad and the associated settlements in southern Sinai are marginalized. This is in complete opposition to the assumptions made by all previous researchers regarding the role of Arad as a polity that managed copper trade. In fact, it is argued that the number and kind of copper finds at these sites doesn't indicate production as much as trade oases that interacted with the local

populations as a means to extract resources during the EBII (Rothenberg and Glass 1992, Pg. 146-151). Thus S. Rosen has expanded Rothenberg's argument to include other economic interests of the inhabitants of the Negev and neighboring regions that make up the Timnian culture (2011a). Rosen's synthetic analysis defines the Timnian complex as a distinct lineage from the areas in northern Israel and Jordan where the EBA and associated nomenclature are used to describe different social tendencies than what are observed in the peripheral arid zones. This is identified in recent excavations of some of the smaller EBII and EBIV settlements of the Negev where evidence of integration in the copper trading network and other kinds of craft production, beads and groundstone, indicated both a trading relationship with and a distinct subsistence economy from the more densely settled areas to the north (Saidel 2002, Rosen 2011b). The separation in subsistence strategies provides further validation for scholars distinguishing the study of the Negev Highlands and the Faynan District as regionally distinct from the areas to the north. The recognition of persistent regional differences lends itself to a reorganization of how to perceive the Southern Levantine landscape with an orientation of closer ties on the East/West axis.⁷ This is reinforced by evidence from later periods, e.g. the Nabateans and Edomites, where a stronger cultural and political connection existed on each side of the Arabah valley (Bienkowski and Galor 2006, Bienkowski 2007). Thus the use of Timnian as a distinct cultural entity in pre-history also has been mirrored in other historical political constructions within the region.

While the term Timnian has been used sparingly in the literature, the utility of the term comes from its use of lithics as the cultural determinant as opposed to pottery due to the dominance of lithic forms in the assemblages of Negev sites. The fact that the Timnian has not

⁷ This is in contrast to the general history of research in the southern Levant that has been limited within modern political borders that emphasized north/south connections within current nation-states as opposed to what is described here are other political orientations that might have been more prevalent in ancient times in line with the Timnian/EBA distinction.

been commonly adopted is as much a function of the sparse number of lithic studies for the region as much as the prevalence of pottery as the traditional material for relative dating (despite its marginal importance for pastoral-nomadic life-ways). Lithics are limited as tools for precise dating of different phases and the fact that the Timnian complex is so long is problematic given the amount of change that is observed in neighboring areas. For the purpose of this work, the observation of greater socio-cultural continuity between regions on each side of the Arabah is the most important contribution of the concept of the Timnian complex. The continued push to focus more and more on factors local to the occupants of the Negev and southern Jordan has been vital to subsequent researchers who have focused more on the copper trade network within a more focused regional framework.

3.6. The Nuts and Bolts (or Ingots and Prills) of Copper Trade Networks: Hauptmann, Levy, Adams and Yekutieli

The four models presented above have focused on the Negev to describe the copper trade through the EBA. Over time research in the southern Levant progressively shifted from an application of exogamous to endogamous explanations for the organization of the exploitation of copper sources in the southern Levant. As seen in the underlying logic behind the development of the Timnian complex, it became increasingly apparent that it was necessary to understand the method of production in order to qualify long term changes of the people responsible for copper production. This mirrors the earlier discussion of how the urban concept has been argued in the Levantine literature. It has long been established that copper ingots and other objects from the EBA utilized a similar smelting and manufacturing process (Dever and Tadmor 1976, Maddin and Wheeler 1976). It was apparent that more significant investigation was necessary at the Faynan ore sources and potential loci for production near those ore sources. Three groups of researchers have studied aspects of the production and

subsequent distribution of copper in the Arava region: A. Hauptmann and a team from the Deutsches Bergbau-Museum examined mines in the Faynan area, Hauptmann was later joined by R. Adams and T. Levy to excavate settlements, and finally Y. Yekutieli participated in or led projects in northern Sinai, on the west side of the Dead Sea valley and at a smelting site, 'Ein Yahay, in the Arava valley. All of the projects used the EBIV term when discussing the end of the EBA highlighting continuation from the previous period.

Hauptmann was concerned primarily with the technological aspects of copper production. As a result, his work focused on two elements of copper production, the ore sources and the methods used to produce the copper (Hauptmann 2000, Hauptmann 2007). These contributions sought to look at shifts in copper production over the *longue durée* by surveying different sources of ore, smelting installations and doing chemical studies of ore sources, slag and final products to determine sourcing and metal composition through time. Hauptmann relied on radiocarbon dates and applied them uncritically to the traditional chronology for the EBA. This model described in detail the distinct processes of mining, smelting and annealing (Najjar et al. 1995). Adjacent to the mines smelting installations were used to produce slag that was crushed to extract copper prills and lumps. Near those installations mortars carved into rocks were identified for the purpose of copper extraction. Further smelting required to finally refine the copper to cast ingots. The results of this work highlighted that the vast majority of objects found in the EBA from within the Levantine area were produced from copper smelted from Faynan ore and not Sinai, even during the EBII (Hauptmann 1987, Hauptmann, Begemann, and Schmitt-Strecker 1999, Hauptmann et al. 2015). Hauptmann used radiocarbon dating of furnaces in combination with similarities of technological features to determine the date of smelting operations (See Table 3.3). He noted that over the course of the EBA the total amount of copper produced increased, with the later part of the period being the height of production. At the start of the EBI, at sites like Wadi

Fidan 4, production still used simple techniques but the beginnings of specialized craftsmanship are clear in the form of crucibles and molds. The site of Khirbat Hamra Ifdan, dating to the end of the EBA, shows the full “industrialization” of the production process with clear divisions of manufacturing operations and a dramatic increase in production capacity due to new technologies (Hauptmann 2007, Hauptmann 2014). With that in mind, it was also clear that the amount of copper finds within the Levantine region was not large enough given the scale of production at Faynan, either a lot of copper was lost or much of it was exported.

Table 3.3: Dates published by Hauptmann of EBA smelting sites in the Faynan Region (Hauptmann 2007, Table 5.1). Dates from KHI are included in Table 4.3.

Calibration Method - Site	Date cal BCE	$\pm 1 \sigma$ years BCE
R_Date Barqa el-Hetiye Haus 1 - 1	-3034	106
R_Date Barqa el-Hetiye Haus 1 - 2	-2877	66
R_Combine Fenan 9 (1-4)	-2480	64
R_Date Fenan 9 - 1	-2710	141
R_Date Fenan 9 - 2	-2501	80
R_Date Fenan 9 - 3	-2491	143
R_Date Fenan 9 - 4	-2264	118
R_Date Fenan 16	-2403	92
R_Date Ras en Naqb	-2482	113
R_Date Wadi Ghwair 4	-2631	110

To complement the work of Hauptmann at the copper smelting sites, T. Levy, R. Adams and M. Najjar carried out the first deep-time social archaeology study of mining and metallurgy in Faynan that included intensive pedestrian survey and the large scale excavation a number of the major production sites in the region, known as the UC San Diego – Department of Antiquities of Jordan Jabal Hamrat Fidan and Edom Lowlands Regional Archaeology Project (ELRAP) (Levy and Najjar 2007). Adams provided the first soundings at a number of sites as a part of research for his doctoral dissertation (Adams and Genz 1995,

Adams 1999, 2000, 2002, 2003, 2005). These projects adopted the traditional EBIV nomenclature. That research highlighted that the Faynan area was first occupied in the EBI at the site Wadi Fidan 4 (WF4), but intensive production did not start until the EBII at the site of Barqa el-Hetiye. Important were the discoveries of EBII ceramic connections to Arad, which was followed by further ceramic evidence of connections to the Negev Highland EBIV sites through a sounding at the site of KHI. This complemented one of the assertions of Hauptmann that discredited the interconnection between southern Sinai and Palestine for the sake of copper exploitation, which countered Cohen's and other earlier models for the EBII in the Negev (Hauptmann, Begemann, and Schmitt-Strecker 1999). T. Levy joined Adams to carry out the first large scale excavations at KHI along with a 100% pedestrian survey of the surrounding Wadi Fidan as a part of the greater UC San Diego ELRAP expeditions (Levy et al. 2001, Levy et al. 2002). The results of those surveys and excavations indicated that KHI was a manufacturing powerhouse in the later part of the EBA.⁸ This echoed the initial work of Hauptmann, indicating that the height of intense copper production in the Faynan region took place in the later part of the EBA. Within the framework of Levy's project, A. Muniz produced a dissertation based on animal bones from sites spanning the whole of the EBA (Muniz 2008). The results indicated that for the sites WF4 and KHI, respectively in the EBI and EBIII, contained evidence of feasting, but at KHI there was not evidence of social differentiation for the kinds of foods that were feasted on. Additionally, the mortality profile of the butchered animals suggested that KHI was self-sufficient, producing both meat and secondary products. In combination with the fact that the excavations highlighted an

⁸ The dating of the primary occupation and period of production at KHI dates to the EBIII using the traditional chronology. The ceramic correlation to Negev sites was an important consideration when reconsidering the radiocarbon dates of Negev Highlands sites traditionally dated to the EBIV using the older chronology. This is an aspect of how interaction is modeled for the EBA that needs further discussion and is addressed in more detail later in Chapter 4.3.

unprecedented scale of metal production compared to any other EBA site, KHI was significantly different from what had been previously encountered at other EBA sites as a locus of intense production often associated with centralized oversight, but with incomplete evidence for an urban center.

The work of Y. Yekutieli complements the research of Hauptmann, Levy and Adams, through a number of projects that explicitly dealt with trade routes by excavating and surveying intermediate sites along routes originating in Faynan. The research spanned the whole of the EBA, starting with a survey conducted with E. Oren of northern Sinai that highlighted a string of small settlements that were assumed to be a conduit for down-the-line trade by agro-pastoralists starting in the EBI and lasting through the EBII with a perceived break in the EBIII, before the trade route started again in the EBIV (Oren 1973, Oren and Yekutieli 1990, Yekutieli 2002). Yekutieli's work continued in the Arava and Dead Sea Valleys where he surveyed and excavated sites related to roadways that connect the east and west sides of the valley. The sites along the roadway produced pottery associated with northern settlements of the EBII-III highlighting trade links throughout the Levantine area (Yekutieli 2009). The location of the sites was situated in such a way that they appear to be outposts designed to protect the road and perhaps act as the extension of local leaders to control the local copper trading network (Yekutieli 2006a, 2006b). Finally, work at a small smelting site called En Yahav, in the Arava valley, provided radiocarbon evidence for copper production at the very end of the EBIV (Yekutieli, Shilstein, and Shalev 2005, Vardi et al. 2008). That site was interpreted to be a part of a tiered system of copper production and object manufacture that saw different zones of activity the further the agro-pastoralists got from the ore sources. Stepwise, mining occurred at the ore source, smelting at the next step, annealing and production of objects and finally distribution through the aforementioned network of agro-

pastoralists in Sinai and beyond. The model for the EBIV as described by Yekutieli is indirectly built on the work of Hauptmann, Levy and Adams in the mining district of Faynan. The basic *chaîne opératoire* proposed by Levy et al (2002) for the mining operation highlights a sequence activity starting near the mines and working away as copper is further refined to a product. The analytical data for connectivity between KHI copper production, Faynan ores and the distribution of EBA III/IV copper objects has been determined by Hauptmann (Levy et al. 2002, Hauptmann et al. 2015). However, the full integration of KHI into this ancient mining and metallurgy landscape has not been explicated or modeled. The study presented here builds on this earlier work by presenting an EBA pan-regional landscape study in anthropological perspective using a variety of datasets from KHI.

The distinct division of labor across the landscape generally used for the total process of copper production and distribution has led all of the researchers outlined to assume that the process itself implies central organization. Despite the absence of a clear central authority in the Faynan area throughout the EBA, the organization of the copper production process required planning. Perhaps the best evidence of this is sought on the roadways, where watch posts indicate an exercise of power over trade routes through taxation or other means. However, that control point is not endogamous to the copper producing area, as the evidence of ceramics from outside the area indicates. The variation in intensity of production through the EBA within the Faynan area would then be explained by variations in organizational capacity of the people within that region, or perhaps shifts in authority from another part of the Levant or beyond.

3.7. Copper Production, Surplus Production and Southern Levantine Models of States

Beyond the Negev and Faynan there have been a number of models that have dealt with copper production during the EBA. In Chapter 2.7 a broad review of the means to model

urbanism highlighted a general shift in the focus of Levantine urban theory from concentrating on the larger forms of urbanism to dealing with how urbanism is reflected in the material record. This was one part of a general trend in archaeological research of the period to make a stronger point that when discussing the EBA Levant the term urban either needed to be used with significant qualification or might have even been inaccurate and should be called a “village-based” system. A key element of this was understanding the production of surplus agricultural products that in theory would enable the production of higher value goods. As was discussed in the previous section, copper is a material that required a lot of resources to produce in large quantities and falls in the category of a material that would only be produced in large quantities. Nevertheless, the propagators of the village model sought to highlight limited differentiation both between and within settlements (i.e. Falconer and Savage 1995, Chesson and Philip 2003, Harrison and Savage 2003). The identification of loci of copper production or artifacts would run counter to these claims, so an evaluation of major copper finds and how they have been interpreted outside of the copper bearing zones is necessary.

G. Philip (1988) conducted one of the earliest surveys of copper hordes found in the whole of the Levant (north and south) for the EBA and MBA. As one of the authors that did not consider the EBA of the southern Levant urban, his work was a significant contribution that aimed to differentiate the social contexts of different copper hordes. A key theme in the research is the apparent absence of apparatus for controlling production. Philip rejected the notion of Haiman and others that the metal producers were independent itinerant merchants due to the complexity of the technology required to produce copper, meaning its very presence assumed a required hierarchy (Philip 1988, Pg. 191). Without evidence for attached specialization in the southern Levantine EBII-III he noted that there is no way for such a system to exist. During what he terms the EB-MB, the EBIV, contains the evidence for metal processing (in the form of the Negev Highlands hordes of utilitarian items), leading to the

conclusion that the dispersal of settlement at the end of the EBIII also led to a dispersal in metal production. A later survey of the EBI-III highlighted the absence of state-features in EB society also included a description of metal production (Philip 2001, Pgs. 212-214). The study highlighted that Faynan was not the only source of copper and absent of evidence of central production, it is not clear how control of copper resources were maintained.

The work of Philip complemented M. Chesson (2014), who excavated at Numayra, a small EBIII on the southern tip of the Dead Sea in Jordan where one of the few assemblages of copper working material was identified in the EBIII outside of Faynan. So far the site is unpublished, but the published studies that have typically pointed to a lack of social differentiation at the site (Chesson and Goodale 2014, Chesson 2015). Civic projects were managed through kin-groups and while staple goods were an important part of the economy, they did not operate in the sense of a staple finance, redistributive economy. That evidence suggests that the copper working only occurred on a household basis.

Other researchers do not share the conclusion that the data for storage facilities in the EBA precludes the evidence of social hierarchies. H. Genz (2003) has argued that the basis of social stratification and the use of palatial or temple storage facilities was not for grains but “cash-crops”, olives, grapes and their secondary products. This would explain why the sites with buildings that look like administrative centers lack the facilities for large scale grain storage, but instead have smaller storage facilities intended for higher value agricultural goods that were a part of an elite regional trading network (Genz 2010). This echoes earlier researchers that have highlighted the importance of olive and grape production as major exports from the Levant to Egypt based on material finds in Egypt (Stager 1985, Marfoe 1987). However Genz actually seeks to downplay the role of long distance exchange of cash-crops and instead highlight their importance for trade within the Levant, which also is why the scale of settlements never quite reaches the state level. Informative of this point of view is the role

of copper production. Genz (2000, Pg. 63) is highly critical of the assumption of the role of copper in the production of social hierarchies in the EBA due to the absence of evidence for metalworking at any urban site. In this case Genz is referring to sites outside of the copper producing areas, he saw those sites as exceptions to the rule, but also sites in the Faynan area lacked the elements of urban spaces seen in the more settled areas to the north. Thus for Genz the source of rank in EBA urban settlements was through high value agricultural production and not staple production or the production of wealth items.

New discoveries have challenged Genz's assertion that copper played a limited role in Levantine displays of power. The site of Khirbet al-Batrawy in northern Jordan, a structure that called the "Palace of the Copper Axes" by the excavator L. Nigro (2010, 2014, 2015). The identification of an EBIIIb⁹ public building in which a cache of four copper objects has led to Nigro identifying the site as part of a large copper trading route that included Faynan based on the typological and chemical studies of the axes.¹⁰ Importantly, in addition to the axes, many other high value items were found that would indicate participation in a long distance exchange network. It is noted that at the palace there is no evidence of large storage facilities or workshops. Oddly, the copper implements were seen to be items both items of power for Batrawy elite and also utilitarian (Nigro 2015, Pg. 82). Nigro assumed due to the complexity associated with the acquisition of copper that elites of the settled areas must have been involved in copper as a part of exhibiting rank.

Another challenge to the model of Genz focused on the high value of copper as a commodity for long distance trade making its very presence an indication of elite presence. L. Stager (2001, Pg. 631 - 633) focuses on the importance of ports of trade in the EBA as a locus

⁹ Using the traditional absolute chronology, but dated using ceramics so perhaps truly c. 2600-2500 BCE.

¹⁰ A fifth axe was found in a different room and has been suggested by Nigro to have been from Anatolia.

of elites that were capable of maintaining relationships to enable long distance trade. The information necessary to maintain long-distance relationships were the basis of the power held by elites in the gateway communities. The maintenance of such large distances allowed for the production of even larger profits. The elites that controlled the exchange relationships could effectively dupe the producers into selling at a low price by shielding exposure to the consumers. In the case of the EBA the consumer was Egypt and the producers were locals to the copper bearing areas of Faynan and southern Sinai. Those producers adopted some characteristics of the material culture of the primary consumer during the EBII, Arad. In the EBIII Egypt takes control of the copper mines in southern Sinai effectively cutting out the Aradian middlemen, leading to fall of Arad. The EBIV is not considered in detail by Stager (2001). The model is useful as one of the only ones to deal with the mechanics of exchange that would have enabled the copper production system by highlighting the role of distance and insulation of exposure on commodity prices.

The arguments of Philip, Chesson, Genz, Nigro and Stager result in an impasse where each of the authors have looked at similar datasets and reached opposing conclusions. The arguments revolve around the interpretation of evidence for differentiated access to storage facilities as one might expect in a system where elites used staple finance to establish rank. Certainly the Nigro model does not address this issue, except to say that the high-value goods appear, although there isn't clear evidence of higher value goods being used to supply labor forces either. The proposition of Genz, that rather than dealing with large stores of staple goods higher value agricultural products were the items identified in the relatively small storage areas, is intriguing. This would work as an extension of one of the original models for the origin of complexity in the EBA as a result of increased viticulture exports to Egypt (Stager 1985). Based on the models two points of agreement offer key elements that must be taken into account when building a model for copper production. First, major sites consumed

and refashioned copper on a limited scale even if it wasn't produced locally. Second, settlements of different sizes in the Levant exhibited a variety of traits that might be urban even if they do not stick to the typical forms as understood in areas such as Mesopotamia. Those two factors will need to be incorporated into any synthetic model for the EBA industrial landscape as it related to KHI.

Table 3.4: Summary of the models for the EBA Levantine Copper trade according to key differences that indicate impressions of the political economy of the southern Levant.

Model	Chronology	Seasonality	Copper Consumption			Character of Settlement		Local Development of Metal Working
			Role of Egypt	Role of Local Cities	EBII	EBIV		
Early Consensus	old	?	?	?	City-states	Nomadic - Social Breakdown	Foreign	
Cohen	old	Full-Time	Not clear	Not clear	Urban	Pastoral	Not clear	
Haiman	old	Part-Time	Consumer	Not a Factor	City-States	Pastoral Nomadic	Local	
Dever	old	Part-Time	Consumer	Consumer	City-States	Rural-Pastoral	Local	
Finkelstein	old	Part-Time	Not Clear	Consumer	City-States	Pastoral Nomadic	Foreign	
Rosen/ Rothenberg	old	?	Consumer	Consumer	Urban	Pastoral	Local	
Levy/Adams	old	Full-Time	Consumer	Consumer	Urban	Pastoral	Local	
Hauptmann	old	Full-Time	Not Clear	Consumer	Urban	Pastoral	Local	
Yekutieli	old	Part-Time	Consumer	Consumer	Urban	Pastoral	Local	
Philip/ Chesson	old	?	Not Clear	Consumer	Villages	Pastoral	?	
Nigro	old	?	Consumer	Consumer	Urban	Not Clear	?/ Foreign	
Genz	old	Part-Time	Not Clear	Minor Consumer	Villages	Not Clear	Local	
Stager	old	Full-Time	Consumer	Minor	Urban	Not Clear	Local	

3.8. The Economic Relationship between States and their Peripheries

The Levantine models for the organization of copper production and EBA state formation presented above (See Table 3.4 and Figure 3.2) rarely deal with a rigorous set of discussions of the relations that exist between different kinds of political systems and the resulting long-distance economy even though the most recent models for the EBA economy have been able to synthesize larger amounts of data. An approach that is multivalent when discussing the Levant en masse is especially important in light of the consensus opinion that settlements across the southern Levant took different forms. Despite the differences in form for large scale urbanism between Mesopotamia and the Levant, it is worth reviewing how similar issues regarding the means of extracting different kinds of commodities from the periphery for the use of an elite entity have been modeled in Mesopotamia (Algaze 1993, Stein 1999, Algaze 2005). Understanding the organization of the larger sites of the southern Levant is beyond this dissertation, but it is necessary to consider the general political landscape even beyond the Levantine region. An example of this is the distinction between unitary and segmentary states using how Mann (1986, 2008) has described the organization of social power from different kinds of state structures and how those structures interact with marginal areas such as the Levant. As Stein (1994, Pg. 17) has summarized:

Segmentary states will have a low level of rural productive specialization because of their smaller scale, less centralized structure (lower complexity), and weak control over their hinterlands (lower level of integration). In unitary states, the volume and consistency of demand by centers for rural goods can generate strong incentives for villages to produce surplus agricultural and pastoral products for exchange. At the same time, the degree to which centers can exercise coercive control over their hinterlands can also push the hinterlands toward production of large-scale surpluses in the form of tribute. In either case the scale, complexity, and high levels of integration in unitary states will elicit a higher level of rural productive specialization; however... village specialization will

generally be limited to those commodities, such as food surpluses, for which there is high demand by the center.

As a result, the kinds of states that exist in the areas surrounding the southern Levant will also have an influence on how to interpret the economic activity of peripheral areas whether or not they exhibit clear interaction with large political centers.

Many of the cross-cultural models for craft specialization and the political organization thereof in peripheral regions, especially in relation to larger states, focus on staple surplus production, and not items of wealth finance (Earle and D'Altroy 1982, D'Altroy and Earle 1985). This is in part because specialized production of goods that would be considered a part of a wealth finance system require protection from rival states and elite connections to maintain trade contacts (Earle 2011, Pg. 242). Given the scarcity of copper ore, the distribution of copper goods would have had to come through an elite capable of facilitating and protecting the exchange of some goods for the copper. When we consider the current evidence used for the models of the EBA of southern Levant copper is not ever-present. It might be due to the high recyclability of copper, but when we consider the data used to model the consumption of metal in the southern Levant, it must be said that the data is sparse in the settled areas with limited evidence for copper production or consumption (Philip 1988, Rothenberg and Glass 1992). This view is reinforced by supplementary evidence of tool use at sites indicating that metal tools were used sparingly for cutting bones at EB sites (Greenfield 2008). As will be discussed in the following chapter, the evidence from KHI highlights production that outpaces the Levantine demand as understood by existing excavations. Based on the accepted assumption that elites played a significant part of the process of consuming copper it is necessary that a large, centralized, elite system to coexist with the Faynan production center. Old Kingdom is the best candidate and Faynan has been suggested as a source of copper by other researchers (Bárta 2006, Pg. 62). Egypt factored into

the general outlines of trade for Haiman and Yekutieli, but one of the problems for their models is that it is based on chronology that would make the height of the copper trade contemporaneous with the First Intermediate Period in Egypt, a period where the Egyptian state apparatus generally accepted to be highly fractured (See Figure 3.2).

The necessity of a large state like Egypt for such a copper system to exist leads to the final point to keep in mind about these past models, the correlations for the regional data schema have completely changed since their development. This is especially important because the most important synchronism between the EB I-III Levant and Egypt was based on stratigraphic comparisons that provided the means for the absolute dating of the EB. The revised chronology challenges those pottery comparisons and introduces a new set of chronological standards. Most important in this argument would be when the Old Kingdom starts in relation to the Levantine chronology (See Table 3.1). In the old Levantine chronology, the Old Kingdom started at the end of the EB II. In the new chronology the Old Kingdom starts near the end of the EB III. This makes a huge difference when one considers the general trends for the EB transition into the EB IV. After all, the EB IV is the period of collapse when the Levantine state system disappears. Additionally, it means that chronologies that used relative dating, like that of Arad, reported to end contemporaneously with the start of the Old Kingdom would now end closer to the end of the EB III (See Chapter 4.3.3, Amiran 1968, 1978a, 1978b, 1986). In short, a few major changes in the timeframe for the transitions within the EBA introduces the problem that the narrative for the interactions implicitly assumed in the old model for regional political interaction sphere require significant alteration. One of the preconditions for the presentation of a model of copper consumption in Faynan is the local chronology will be harmonized to the regional chronology.

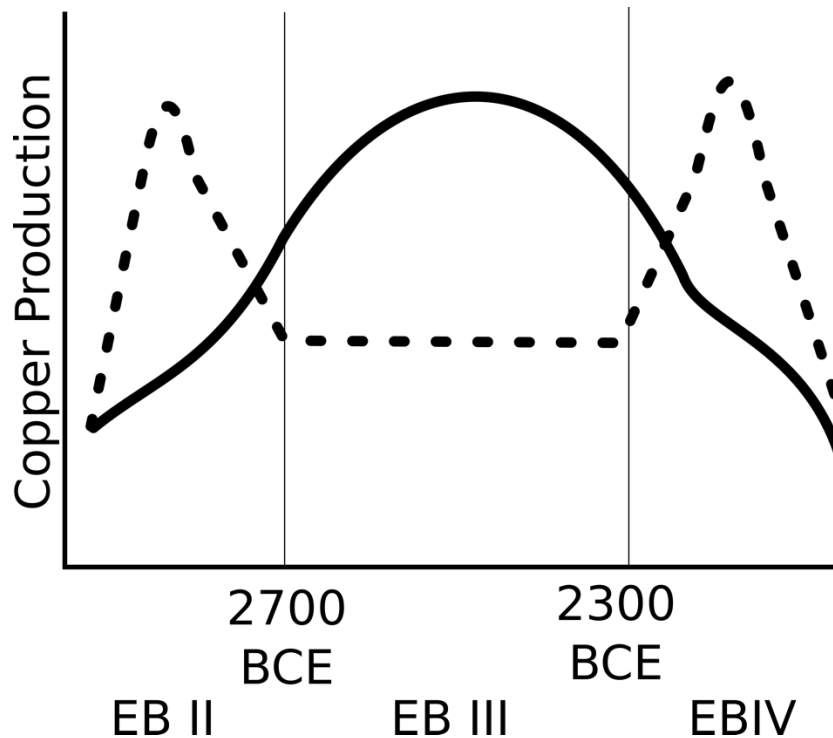


Figure 3.2: Comparison of models for expected copper demand. The dotted line represents the model based on data from Dever (2014), Finkelstein (1995a), Haiman (1996, Saidel and Haiman 2014), and Cohen (1999). The solid line represents the assumption that the height of demand corresponded to the Old Kingdom. Chronological periods are identified using the traditional chronology.

3.9. Conceptualizing the EBA Copper Trade at the Source

It is necessary to develop a new approach that takes into account both local and external factors that can be used to identify how social rank was structured as it related to copper production at KHI as a result of the conflicts between the models outlined above and the implications of the revised EBA chronology. The early focus on settled sites and the surrounding areas has led to the marginalization of the Faynan-Negev areas in the literature except as a source of copper. The details of how copper production was organized has been based on speculation using material data from the process of exchange or consumption (Haiman 1996, Cohen 1999, Kochavi 2009). Nevertheless, the appearance of copper was

always an important part of understanding EBA economic development, but the focus has been the end of the EBA after major hoards were found in Israel in the 1970s (i.e. Dever and Tadmor 1976). The fact that the largest copper deposits were associated with the terminal phase of the EBA meant that its role in earlier phases has been contested, especially in revised narratives that describe the EBA as a heterarchically organized society (Chesson 2003, Chesson and Philip 2003, Harrison and Savage 2003, Savage, Falconer, and Harrison 2007). This can be seen in the contested interpretation of the importance of that trade, as measured by material value (Genz 2000, Stager 2001, Nigro 2015). Both the regional context of consumption and exchange as well as the the context for the different kinds of activity at the source of production need to be taken into account in order to analyze the social factors related to copper production and provide reflexive conclusions for lifecycle of copper objects. This bidirectional reasoning is important as it is only through inferential data derived from a description of the total system that a fully realized model for a local area can be achieved.

3.9.1. Model to Be Examined - Regional Context

In order to articulate the *chaîne opératoire* of copper production observed in the ancient industrial landscape it is necessary to elaborate on the processes of consumption. Where and when did they happen? The production of copper is a laborious exercise. Metal smelting requires both large quantities of materials and technical knowledge in order to make the process work on a large scale. It is for this reason that both the production and the consumption of metals has long been associated with central organization. In this sense, as any product does, it requires a consumer that can organize material in order to trade for such a highly valued commodity. If the scale of production is large and it certainly is at KHI, then it is assumed that the consumer must be similarly structured in order to be able to organize production of goods in exchange.

It is during the end of the EBIII and into the EBIV that a significant increase in copper objects begin to appear across the southern Levant including bronzes that chemically seem to have included Faynan copper (Philip 1988, Phillip, Clogg, and Dungworth 2003). The copper that was being produced in Faynan was very pure and no evidence of the manufacture of bronze has been found at KHI or in the region at large. This leads to the necessary question, were smelting operations conducted by attached or independent specialists?

The description of the kind of specialists that operated the mines of Faynan is in part tied up in the chronology of each production site, the scale of production at the site and the kind of production at the site. This is due to the interaction of the description of specialization with the chronological synchronization between neighboring polities. The chronological correlation is important to establish the amount of demand for luxury goods, such as copper. It follows that the chronological data has a direct implication for the kinds of relationships that specialists could have with elites and it sets up a way to correlate actual production with the kinds of consumers that would be expected. This results in a circularity of logic, the interplay of the chronological variation of active sites for copper production with the synchronization of the implicit variation in intensity of production is instructive of the correlating consumptive needs of the surrounding region. A further consideration is whether the production is primary smelting or secondary recasting at the different sites with evidence of production. As primarily a recasting site, secondary smelting at KHI implies a local industry producing a refined product for export (Discussed in following chapter). It follows that intensities of production in the Faynan region would have been responding to regional and inter-regional demand given the larger scale long distance trade that was evident in the EBA. Logically then the overall production of Faynan copper should peak during the Old Kingdom of Egypt and as a result data from Egypt explains the political relationships that are possible (See Chapter 4.5.2). Smelting and other sites that are associated with the copper trade that fall outside the

timeframe of the Old Kingdom were responding to other local demand that should be of a lower order. If the peak at KHI doesn't match the Old Kingdom, the Levant must be the primary consumer and a larger than expected amount of material that was consumed at Levantine sites was recycled or lost to the archaeological record.

What happens after the initial smelting on a regional scale has typically been ill defined for the whole of the Early Bronze Age with most researchers concatenating all of the processes of copper production as if they necessarily occur in the same place. The evidence from KHI indicates that this is not necessarily true, so far only illustrated by Yekutieli based on his research at the smelting site in the Arava valley at 'Ein Yahav which was already discussed in the background for the final part of the Early Bronze Age (Yekutieli, Shilstein, and Shalev 2005, Vardi et al. 2008). His model breaks down the production processes into a four-part division of labor: smelting, tool production and a buffer zone before hitting "foreign markets". For the sake of a regionally distinct division of labor for copper production the model of Yekutieli is a good one. What remains to be discussed is whether and if so how this regional *chaîne opératoire* changes through time or is static to the whole of the EBA as Yekutieli indicates. This is where an analysis of the sequence of occupation at KHI and an in depth discussion of the phasing at the site is necessary.

The analysis of the regional picture will be highly reliant on new chronological data that will establish a relative chronology for the regional division of labor seen for copper production. To do this the application of archaeomagnetic dating techniques to some smelting sites will build of the pioneering work of Erez Ben-Yosef (2008). Using that data in reference to the new chronological framework and a more descriptive description of the organization of KHI will build a model for regional copper production in the Faynan-Negev area. Important here is the relationship of the ephemeral smelting sites compared to KHI especially during the height of copper manufacturing. Unlike KHI, the smelting sites that were tested ('Ein Yahav,

Hazeva and Ashalim) have no evidence for manufacturing beyond the primary smelting of copper to produce prills. Two models would be expected based on whether operations at KHI are contemporaneous with other ephemeral smelting sites or if there is evidence of different operations over time.

If all of the smelting sites were operating roughly contemporaneously then the overall system through the EB is likely organized loosely. The model that was proposed by Yekutieli (2006a, 2006b) couldn't work because rather than having a division of labor for copper production based on distance from the ore source evidence for the primary production of copper is dispersed. The basic assumption would be that all sites operating contemporaneously implies that copper production was performed opportunistically, with KHI operating as a unique specialization center for certain kinds of finished goods.

If there are differences in when different smelting sites operated in relation to KHI an interpretive framework needs to be built to explain why and when those ephemeral sites were operating and how that is related to the operations at KHI. In this case, the expectation is a multi-modal system that fluctuated over time. This is a clear example of exploring aspects of circular and cumulative causation in the role of specialized copper production on larger political systems, but from the perspective of the periphery (Algaze 2008, Chap. 3). This will test two issues. First, how do the various kinds of production sites that surround KHI relate chronologically? And the question that follows, how does the constellation of production sites generate different industrial landscapes through shifts in the regional cultural chronology of the Levant? The data itself will be related to knowledge of the Egyptian record as it relates to copper consumption. A model like Yekutieli's might work for one period in the EBA, but other periods will yield other regional production systems that need to be explored based on the archaeointensity data.

3.9.2. Model to Be Examined - Khirbat Hamra Ifdan as a Manufactory

When approaching a detailed analysis for the site of KHI within a regional model, the key features that need to be addressed are all aspects of the degree of specialization observed. In some respects, this is tied to the broad expectations for the relationship between subsistence strategies and the kinds of archaeological assemblages that are assumed to have been associated with those strategies (See Table 3.5). The combination of these effects is all directly tied to how ranking will be considered at the site. The issue of specialization can be broken down into whether the occupants were independent or attached and full-time or part-time specialists. Standard theory would assume that full-time specialists would be attached, while part-time could be either independent or attached (Brumfiel and Earle 1987, Pg. 5). As a result, in order to determine the degree of specialization the permanence of occupation, the organization of production, the organization of other rank-determining activities (i.e. feasting), and chronological determinations that would shape the interpretation of KHI within the larger regional economy all must be considered. The key determinants then for the site of KHI will be a description of the ceramic data, the relationship of the ceramic data to aspects of copper production, and the establishment of how that data fits into the regional evidence for the copper trade. The ceramic evidence will provide a necessary proxy to estimate aspects of specialization and the permanence of the occupation at KHI (See Table 3.5).

Table 3.5: The relationship of subsistence strategies and their relationship to other forms of production.

Subsistence Strategy	Metal Production	Ceramic Assemblage	Lithic Assemblage	Faunal Assemblage
Pastoralism	Limited	Limited with Functional Redundancies for Forms	Blades make up small percentage of assemblage or are wholly absent	Kill off rate focuses on old to enhance secondary product production
Horticulture	Intense	Wide variety of forms	Focus on Blades - Should have gloss	Kill off rate focuses on young for meat

Just like many of the models that have already been outlined, the place of KHI within the regional economy will be a determining factor for how to interpret local data. This is especially true for how to contextualize the kind of copper production that occurred at KHI due to the recognized importance of the Negev Highlands as a vector for the distribution of copper (Levy et al. 2002, Hauptmann et al. 2015) and the similarity of ceramics between the regions (Adams 2000). The models that have been recounted for the Negev Highlands have a number of contingent factors that need to be reconsidered. All of the outlined models for the Negev Highlands system have been extrapolated to Faynan with a single homologous group operating the copper trade because extensive excavation at KHI has only taken place in recent times and has yet to be fully published, (e.g. Dever 2014, Saidel and Haiman 2014). Despite radiocarbon dates that point to the EBIII and architectural evidence showing continuity, the dating of the Negev sites has remained culturally with the EBIV (See Chapter 4.3). Exactly how KHI would have interacted with the traders that occupied Negev sites is dependent on the seasonality of those sites with current evaluations pointing to temporary instead of permanent occupations at all sites (Dever 2014, Dunseth, Pers. Com.). In order to articulate the relationship of KHI to the Negev system, seasonality and its relationship to hierarchies are the core data points to be tested at KHI.

The EBA context for the organization of specialized production at KHI has highlighted a mixture of interpretations for the degree of political centralization of production. The analysis of the pottery and its distribution across KHI will provide the means to classify differential access to resources and different kinds of activities within the site. Preliminary research has already been conducted regarding the deposition of metallurgical remains and the animal bones, illustrating evidence for homogeneous access to high quality food during the EBIII and EBIV (Muniz 2008, Pg. 310). However, that data left open the possibility of

organized feasting, a potential indicator of a local redistributive economy and as a result is not yet conclusive. A study of the pottery using a classification of the functional variation of the pottery within the site will help resolve still open issues. The functional variation will provide data regarding the distribution of storage areas, food preparation and food consumption. Additionally, the quantity of certain kinds of serving vessels for food consumption in conjunction with the animal bones will be suggestive of different practices that would have been associated with feasting. The identification of any other evidence for social stratification within activity areas at KHI has implications for the interpretation of the related sites within the copper distribution system. Evidence for the uneven distribution of serving, food preparation or storage vessels would highlight one of the many behaviors expected as a part of early redistribution economy. With or without these indicators, the ceramic data will have to be reckoned with the other key indicators for rank at the site.

The very fact that copper was produced at such a large scale is indicative of political organization. Understanding the dates as a means of verifying interaction or at least potential for interaction is fundamental to understanding the development of specialization as contingent on exchange to support a division of labor. Ricardo's Law of Comparative Advantage (Discussed in Chapter 2.7.2) requires that we would expect that the intensity of production at KHI of finished goods was influenced by local needs responding to outside demands. This is especially the case of ingot production. "These [ingots] only mattered in societies where quantitative exchange equivalences, including those based on labour, were of central importance. In this light the fact that ingots only seem to play a role outside the production area also makes sense because it was here that exchanges were open; ... the producers themselves had far fewer exchange opportunities" (Shennan 1999, Pg. 362). The development of a distinct ingot form as a communication device of authenticity over long

distances indicates one way to mitigate the problem of the one-sided prisoner's dilemma (Greif 2000). Utilizing classical and neoclassical economic theory one could build on the sudden appearance of distinct ingot types in the second half of the Early Bronze Age to be indicative of increased efficiency in specialization and exchange. As a result, the use of archaeointensity data from slags at KHI will be an important anchor to compare timeframes of production at KHI with the surrounding region, especially as it related to production systems that either used or did not use a distinctive ingot form. That data will be important to help synchronize the different kinds of sites in regional *chaîne opératoire* of the Faynan copper production to the organization of KHI during the period of greatest production at the site.

Thus the final analysis will look to test models for Faynan copper production based on specific variations on distinct lines of evidence: ceramic and chronological markers. At KHI the primary concern is with the nature of the pottery distribution and what can be said about how the functional variety and specificity of different vessel types vary across the site for the primary occupation stratum. Other aspects of pottery to be considered will be based on the detailed inventory of material that will also draw out other aspects of quantification based on aspects of breakage, weight and counts. Each of these factors will be considered in relation to each other according to the degree of variation seen across the excavation area. An even distribution will be interpreted to indicate less political integration. An uneven distribution can be interpreted as indicating more integration, but how will depend on what aspects of the ceramic assemblage shows significant variation. This analysis is a fundamental first step to understand how KHI fits within the regional landscape of production.

3.10. Conclusion

The appearance of large numbers of ingots at KHI and related sites signifies a new form of production that is more closely associated with modern concepts of commodities,

capital and money, through the standardization of the shape and weight. The production of such instruments, as opposed to non-utilitarian specialized goods with a deeper set of values (mean more complex and other interpretations), signifies a change in the degree of specialization. Based on Adam Smith (1776 (1976), Section 1.4.7) the expectation is that when an increase in specialization occurs it will be accompanied by an increase in market size. Related is that the adoption of ingots as a method to trade metals signals a centralized authority as the institution that provides a means of guarantee for the standardized trade. The Adam Smith proposition has been reiterated by modern archaeologists that deal with the issue of craft specialization to highlight the correlation between increased specialization as indicative of increased consolidation of political authority (Costin 1991, Peregrine 1991, Costin 2007). A market based incentive has never before been suggested for the Faynan/Negev copper system. Because the older models place the copper trade in the old EBIV (2300 BCE - 2000 BCE) it was impossible to define a large consumer given the fact that the surrounding region was experiencing a decrease in the centralization of authority. However, the revised dating schema places much of the EBIV during the Old Kingdom in Egypt opening up an obvious long distance consumer of large quantities of standardized, unfinished copper. Rather than seeing this development as one to satisfy local markets, it just as easily could have been a result of relations with the developing state in Egypt. From the start the earliest models for the EBA in the southern Levant incorporated the rise of the Egyptian state and its influence on the constellations of settlement that reacted to the changing relationship with the Egyptian state (van den Brink and Levy 2002, Barta 2010). The efforts outlined in existing models to depict the relationship between “urban” and “rural” settlements have blurred the traditional dividing lines between settlement types making it harder to define a settlement dichotomously as urban or rural during the Levantine EBA.

Chapter 4: History of Early Bronze Age Research: The Site of Khirbat Hamra Ifdan and its Environs

The initial models for the organization of settlement in the Early Bronze Age focused on structural aspects of settlements in order to define the period as urban. The most important features that appear include the growth of overall settlement size with indications of planning, the appearance of massive city walls and some larger settlements include public buildings. However, the most important development of the Early Bronze Age in the southern Levant is a significant increase in the intensity of long distance trade. Compared to the previous Chalcolithic, more material travels further indicating an interaction sphere that included Egypt and Mesopotamia. It is for this reason that studying the organization of production at the source of a rare, valuable commodity like copper will be particularly important. This early development of long distance contacts was just the start of a trend that continues into the following Middle Bronze Age when sophisticated trade networks crystalize into a broader Mediterranean interaction sphere.

In the Levantine EBA Khirbat Hamra Ifdan is the best-preserved copper production site. According to Levy et al (2002, Pg. 425), the uniqueness of KHI is a result of an earthquake that occurred at the end of the EBIII that caused most of the mudbrick superstructures of the site to collapse, thereby sealing artifacts connected to copper production and subsistence at the site in a “Pompeii effect”. Thus, KHI offers an important opportunity to explore the organization of the production of copper in relation to everyday functions at the site reflected in the ceramic record, such as cooking, storage and serving. These are important aspects of how staple resources would have been allocated within the site and contribute to the detection of ranking. Importantly, uneven distribution of different kinds of archaeological

remains can be used in conjunction to infer activity areas highlighting unequal access to resources and divisions of labor within the site.

Ricardo's Law of Comparative Advantage (Discussed in Chap 2.7.2) highlights the importance of regional considerations for commodities that determine economic opportunity. No where is this truer than in marginal spaces such as the area of Faynan. The site of KHI is located along the eastern edge of the Wadi Fidan drainage down the Wadi Faynan. This position is a moderate distance down the wadi from the copper mines on the way to the Wadi Arava, close to the spring 'Ayn al-Fidan. The location near the spring is significant as currently the lowland areas around Faynan only receive 100 mm of rainfall on average annually, with seasonal flooding of the wadis in the winter (Markaz al-Jughrāfī al-Malakī al-Urdunī. 2001). Although much of the EBA was wetter than today, Faynan was likely still a marginal environment (See Chapter 4.4). It is in this region that both the copper ore bearing Dolomite-Limestone-Shale (DLS) rock formations are found, in addition to tamarisk and acacia trees that were used as fuel for domestic and metal production (Hauptmann 2007). In the steppe area, between 300 masl and 600 masl, the rainfall increases to as much as 300 mm per annum and the variety of trees increases to include juniper, pistachio and others (Barker, Gilbertson, and Mattingly 2007, Pg. 38). Only above the steppe zone is dry agriculture possible. As a result of the marginal environment in the Faynan lowlands intense copper production and trade would be the one way to support permanent occupation in the area. In fact, the only other area in the southern Levant with copper ore is further south at Timna. Thus when taken in whole, these factors imply that the region must have been part of a larger trading network during periods of continued occupation, supplying copper to different polities in return for other subsistence staples.

Interaction with neighboring regions in the EBA helped to structure the way that researchers have interpreted the overall organization of society. The early periodization for the

southern Levant was based on what were assumed to be simultaneous changes associated with phases in the Egyptian chronology (Wright 1936). This matching was done using material, especially ceramic, correlates. Over time the exact dating of the transitions between sub-periods has been called into question, however the overall cultural trends contained within each phase of the EBA have not been questioned and material cultures belonging to the different phases are accepted as valid (Stager 1992). In the last few years, problems with the absolute chronology have become increasingly apparent and as a result a reevaluation of radiocarbon data has led to a complete revision of chronological correlates between the Levant and neighboring areas (See Table 3.1, Regev et al. 2012). Despite the fact that the new model introduced new synchronization with the outside world that would affect how the progression of urbanization in the Levant matches the chronologies of Egypt and Mesopotamia, in most cases the relative sub-periodization of the southern Levant is still valid. Where the phases of occupation at KHI fit in the Levantine chronology will be fundamental to contextualizing the local data of production.

One of the challenges in order to develop a coherent model situating research at Khirbat Hamra Ifdan stems from the disparate variety of model. As already discussed, the EBA is a period of regionally defined settlement areas and the fact that KHI is in a peripheral part of the Levant with fewer points of comparison makes it harder to fit into larger scale regional models despite its importance in the copper trade. This perspective is illuminated by earlier models for regional interaction that were obviously ignorant of more recent developments archaeologically, but have not been updated (Discussed in Chapter 3). At the same time the specificity of the *raison d'être* for KHI allows for a more narrowly defined model of interaction isolated to interactions based on copper.

The basic building blocks for a modern model of the socio-political organization at KHI are derived from the assumption that the presence of pastoralism and metallurgy are

broadly indicative of complex socio-political structures that play a role in the organization of copper production and exchange during this period. The already discussed new developments in the radiocarbon chronology also need to be applied to any new model of EBA copper production. This is a very important as from site to site and meta-study to meta-study different means have been used to establish a chronology but not revised as a part of the new story for the EBA in the Southern Levant. This is especially important for the story of the relationship of the EBIV to the rest of the EBA. More often than not, the EBIV was given its own section within synthetic studies (e.g. MacDonald, Adams, and Bienkowski 2001, Levy 1998). This certainly made sense when the continuity of social organization between Egypt's Old Kingdom and the Levant in the EBA were linked. However, with the revised dating the EBIV was actually primarily a contemporary of the Old Kingdom and long assumed economic linkages for the EBA need to be reevaluated (For early attempts to reconcile chronological issues between Egypt and the Levant see Sowada 2009, Pg. 122-127).

The archaeological data from KHI will play a significant role in the revision of the model for interaction between Egypt and the southern Levant. Some of the reevaluation will feed into how I generate both my model for testing and some alternative options. The core of this is understanding the regional chronological data in reference to local activities at KHI. This is necessary not just to understand power dynamics local to KHI, but also how to fit the different periods of activity at KHI with the regional power structure.

4.1. Excavation History of Khirbat Hamra Ifdan

The most immediately striking feature of KHI is the site location on a naturally defensible 3.25-hectare inselberg, with the site taking up approximately 1.5 hectares (See Figure 4.1). The site was first visited by F. Frank (1934), and later N. Glueck (1935) also reported to visit the site but probably was at a different location nearby. More recent surveys

have also described the site noting dates for the EBIV, Iron Age, Roman Period and Islamic Period (Raikes 1980, Knauf and Lenzen 1987, MacDonald 1992). The first probes were carried out by R.B. Adams in 1990 and 1992 in association with the Deutsches Bergbau Museum. That work was followed by the UC San Diego – Department of Antiquities of Jordan expedition led by T. E. Levy, R. Adams and M. Najjar in 1999 and 2000. Finally, the last UC San Diego – Department of Antiquities of Jordan probes were carried out by Levy and Najjar in 2007 and 2011 illustrating that the site was primarily occupied in the EBIII and EBIV (Levy et al. 2002, Levy et al. 2012). Adams later excavated a probe at the site to obtain samples for an ancient pollution study (Corbett et al. 2014). Over the course of the UC San Diego – Department of Antiquities four excavation seasons six and a half tons of ceramics, in addition to hundreds of copper objects, ingots, and other mold fragments were found. Additional archaeometallurgical finds collected during the 2007 season show a brief Iron Age occupation, involved in ad hoc copper production, highlight the variety of occupations at the site (See Table 4.1). The importance as a metal refining and casting manufactory is based on the large number of molds and other implements found related to the processing of copper items (See Table 4.2). The scale of copper production and overall quantity of artifacts is surprising given that the site was only about 1.5 ha in size. The small size highlights the degree of specialization for the site towards a single product. The focus of production on copper was the *raison d'être* for the site's position on the margins of EBA settlement in the southern Levant.



Figure 4.1: Aerial photograph of Khirbat Hamra Irdan. Photo taken by Thomas E. Levy.

Table 4.2: The distribution according to stratum of objects related to secondary copper smelting at KHI from the 1999 and 2000 seasons (Based on Levy et al. 2002, Table 2). The vast majority of objects were found within Stratum III highlighting the role in that period of the transformation of already smelted copper into products for trade.

Artifact Category	Stratum II	Stratum III	Stratum IV
Metal Objects			
Metal Axes	0	3	0
Metal Chisels	0	0	0
Metal Pins	12	47	0
Metal Ingots	2	58	0
Metal Lumps	15	169	3
Casting Molds			
Molds – Axes	1	25	0
Molds - Chisels	0	58	0
Molds – Chisel w/butt	0	29	0
Molds – Pins	1	25	0
Molds – Blade	0	15	0
Molds – Indeterminate Final Product	0	76	0
Molds – Ingots	16	345	0
Molds – Indeterminate ingot	51	366	1
Smelting Facility Remains			
Crucible Fragments	40	625	6
Lady Fingers	2	117	0
Furnace Fragments	8	44	0
Total	148	2002	10

The excavations at KHI revealed four major strata with Stratum III being the most substantial period of metal production (See Table 4.2). In the field Stratum III was associated with the EBIII. Radiocarbon dating from different strata and areas of the site was used to determine chronology. Stratum I is associated with any period after the Iron Age and the depth of the stratum was unevenly observed across the site. In some areas the Iron Age period dominated especially in the form of slag heaps. Other parts of the site showed surface architecture with shallow deposits associated with the later Byzantine and early Islamic

periods (See Table 4.1). Stratum II was considered to be a short term EBIV occupation at the site with limited evidence of new construction along with the reuse of the existing Stratum III architecture. Stratum II was not observed in every area of the site. Stratum III was prevalent in all areas of the site and made up the predominant part of the remains excavated where visible. The distinction between Strata II and III is made by what appears to have been the sudden destruction of many buildings across the site in an earthquake. This made for a kind of “Pompeii effect” with huge numbers of vessels and other objects left seemingly in the middle of productive processes (For example see Figure 4.2). Stratum III in some parts of the site saw multiple phasing with as many as four evident within a limited number of rooms. The architecture from Stratum III reveals the organization of structure at the site into a number of complexes, three of which were completely excavated (See Figure 4.3). One complex is contained within what was termed Area H and two structures were split within Area Y with interior courtyards splitting the buildings. Stratum IV was also unevenly observed across the site. The finds from Stratum IV typically date from no earlier than the EBI.



Figure 4.2: Partially melted copper from Locus 2518 in Area Y with small copper ingots still in place. The fact that this object was found unfinished suggests that the copper melting process was abandoned abruptly (Photograph A. Gidding, UC San Diego Levantine and Cyber-Archaeology Lab).



Figure 4.3: Map of the 1999 and 2000 excavations from Khirbat Hamra Ifdan with room numbers labeled. Map made by Ian Jones, UC San Diego Levantine and Cyber-Archaeology Lab.

The site is significant in the story of copper production due to the unprecedented density of copper molds. The location of the site is in the marginal Faynan region away from settlement in the northern part of the southern Levant, in an area that lacked enough annual rainfall to support dry farming. The lithic assemblage has not been published or analyzed in full, but anecdotally blades with gloss are not a significant percentage of the total lithic assemblage. This matches other sites in the Negev Highlands where horticulture was not a significant part of daily substance activity (Vardi 2014, Pg. 96). In the future this is an important assemblage to study to see how it compares to sites like Bab edh-Dhra where there are more blades than sites in the Negev, but seemingly less than sites in the Mediterranean settled zone (Rosen 1997, Fig. 3.17, Rast and Schaub 2003, Pg. 500). Nevertheless, there is an unusual density of artifacts, especially related to secondary copper processing and ceramics. Those two features are not expected in combination. Therefore, it is necessary to review the excavation history of KHI to provide more detail of the material culture of the site, and the characteristics of each excavation area. Two of the excavation areas, Areas H and Y, excavated entire buildings to completion making it possible to compare the function of rooms both within and between buildings.

Table 4.3: Radiocarbon dates from KHI.

Name	1-Sigma		2-Sigma		Mean	±	Publication
	from	to	from	to			
Khirbat Hamra Ifdan - Adams							
R_Date HD-16533	-2621	-2490	-2848	-2470	-2585	88	(Adams 1999)
R_Date HD-16534	-2471	-2342	-2564	-2214	-2394	69	(Adams 1999)
Khirbat Hamra Ifdan - Levy							
R_Date AA99137 - 6601 - Basket 60272	-2867	-2635	-2878	-2583	-2737	83	(Unpublished)
R_Date Beta-143811	-2834	-2465	-2865	-2342	-2575	124	(Levy et al 2002)
R_Date Beta-143813	-2569	-2350	-2581	-2295	-2464	82	(Levy et al 2002)
R_Date Beta-143810	-2569	-2461	-2579	-2346	-2490	65	(Levy et al 2002)
R_Date AA68210	-2565	-2348	-2579	-2289	-2444	85	(Unpublished)
R_Date AA68206	-2482	-2347	-2565	-2297	-2422	65	(Unpublished)
R_Date AA68207	-2481	-2346	-2566	-2294	-2418	70	(Unpublished)
R_Date AA68212	-2451	-2210	-2467	-2153	-2323	82	(Unpublished)
R_Date Beta-143812	-2133	-1942	-2201	-1884	-2031	86	(Levy et al 2002)
R_Date AA69203	-1191	-1023	-1225	-979	-1104	65	(Unpublished)
R_Date AA68208	773	880	689	950	822	58	(Unpublished)

4.1.1. Excavations of Adams

The excavations conducted in 1990 and 1992 by Russell Adams (1999, 2000) provided the first evidence of the role of KHI as a secondary copper smelting site. His work identified architectural features and a number of important pottery varieties that highlighted interaction with the Negev Highlands based on typological similarity. While his data is not a part of the corpus included in this dissertation, the ceramic correlations identified by Adams provide the framework from which this project began. Rather than use strata Adams identified six phases of occupation at the site (See Table 4.1). This included a number of occupations directly underneath the architectural features that were identified. Phase six was dated to after the main occupation for which there was evidence for continued metallurgical activity at the site. This phase would be associated with Stratum I for the rest of the site. Stratum II was not recorded but likely would have been part of phase one as well. Finds associated with Stratum III were recorded for Phase five through two. Phase five is associated with the building and collapse of the architectural features identified in the probe. The collapse of the structure was dated to ~2400 BCE based on radiocarbon, which straddles both sides of the EBIII/IV boundary depending on which chronology is being used (Stager 1992, Regev et al. 2012). Phases four through two were all different phases within the EBIII with evidence of metallurgical activity. Finally, phase one was directly on the bedrock with some evidence of EBII occupation.

4.1.2. Area C

Unfortunately, the UCSD excavations in Area C (75 m²) (see Figures 4.4 and 4.5) were not recorded properly and a lot of spatial data was lost. The area was excavated under the supervision of C. Bardsley (1999) in 1999 and partially excavated again as a part of Area Y (See Area Y below). The maps made during the season are poor and as a result it is difficult to

fully utilize all of the data. Despite this obstacle the area offers some of the more unique ceramic forms found at the site and includes what might be a copper production courtyard. Additionally, the area yielded all four of the identified strata at KHI. The evidence for Stratum IV was sparse, but the distinction between Stratum IV and III isn't always clear in the excavation notes, without any evidence of a clear break in occupation, as in a floor or architectural changes. Stratum III in Area C shows much evidence of copper production and storage. The end of Stratum III was clearly delineated by the appearance of many collapsed walls with well preserved mud brick. However, the mud brick collapse is not consistent across the site and as a result it is unclear whether the whole of Area C stopped activity. Stratum II lacked definitive floors in Area C so it is difficult to fully ascertain activity during the occupation, except to say that copper finds are not as prevalent. Additionally, a new structure was build on top of the existing Stratum III architecture that constitutes Room 1 and subsidiary structures. However, the room lacked identifiable surfaces and the function of the building is unclear. Stratum I was represented by a mixed fill and possible burials. The burials lack detail due to the actions of tomb robbers.

The initial observations of the excavators for the primary EBIII occupation, Stratum III, suggest a limited number of activities in this area of the site. Room 2 was assumed to have served primarily as a store room. Rooms 4, 17, 16, 15 and the central courtyard seem to have been used for copper production based on the ash deposits and implements identified with copper production. Rooms 3, 5 and 6 are indeterminate of function due to the absence of any determining features. Many of the Stratum III rooms included evidence of multiple surfaces indicating occupation at the site over multiple generations. However, those surfaces were not distinguished as a part of the excavation procedure, with most Stratum III rooms consisting of a single locus. As a result, it is difficult to ascertain how the multiple surfaces articulated with different large storage vessels found as installations in many of the rooms. In some cases,

these vessels were left and backfilled given their massive size. The adjoining Area D identified four phases in the courtyard space and can be used as verification of the reuse of this area of the site.



Figure 4.4: Area C final photograph after the UC San Diego – Department of Antiquities of Jordan 1999 excavation season looking at Area C. Photograph by Thomas E. Levy, UC San Diego Levantine and Cyber-Archaeology Lab.

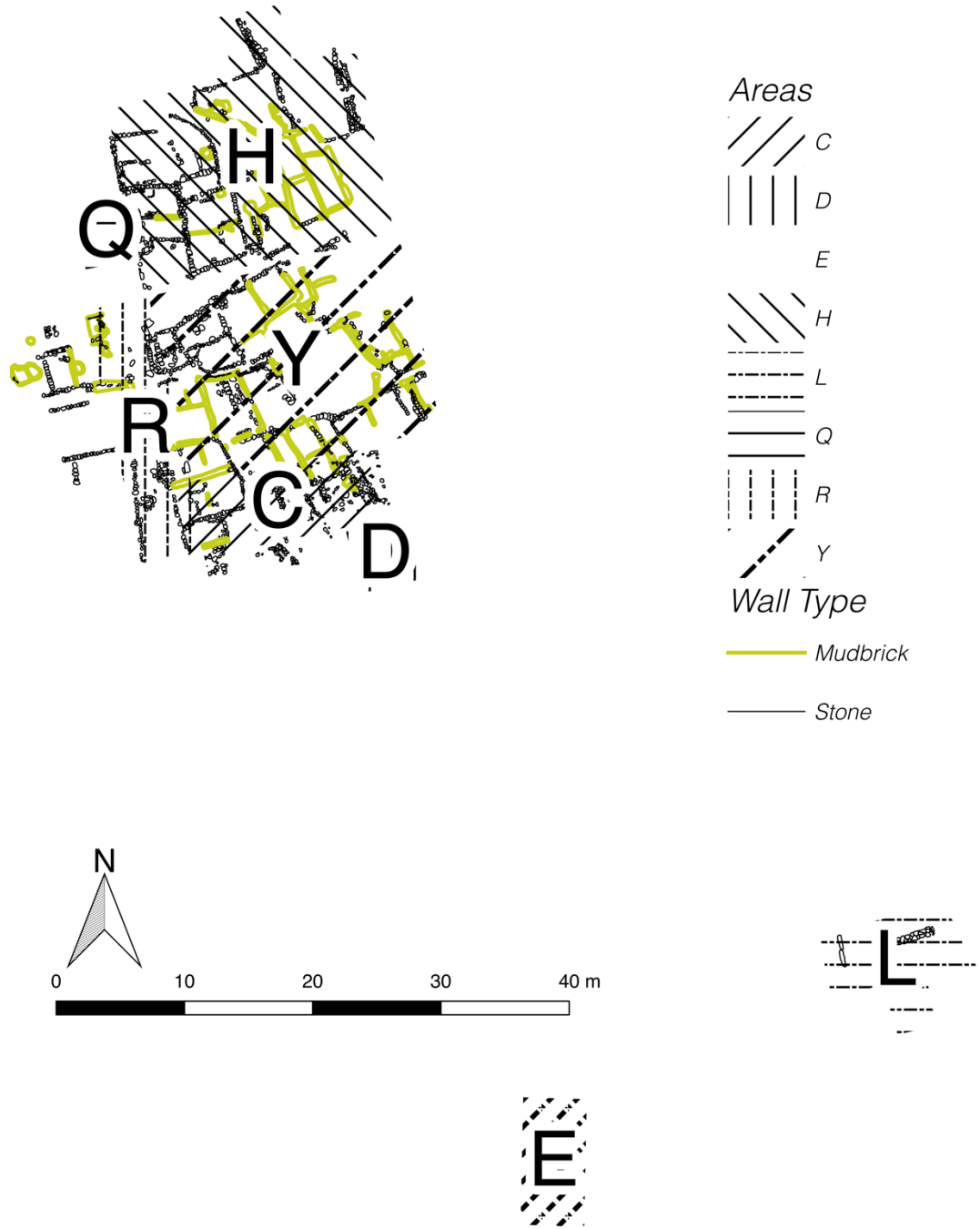


Figure 4.5: Map of Areas excavated at Khirbat Hamra Ifdan

4.1.3. Area H

In Area H (325 m. Sq.) only three of the four strata identified at the site were identified. M. Homan (1999-2000) supervised the excavations over the 1999 and 2000 excavation seasons (See Figures 4.5 and 4.6). The completeness of the excavations and the range of finds in Area H made it one of the two areas that will be focused on for room-by-room analysis. Within the area, subphasing was noted within Stratum I and III. In both, two phases were identified unevenly across the area. Stratum IA was the upper most layer with a single curvilinear wall being the major feature. Just below, in Stratum IB was evidence of a number of Byzantine structures and associated deposits associated with copper production. The Byzantine furnaces, associated slag and structures were in some cases intrusive on the Stratum III layers. In total six structures were identified from the EBIV occupation and the finds in those structures highlight occupation floors in some instances. Stratum II was only marked by five walls with varied construction that in two cases was a reuse of existing walls from Stratum III. The distinction within Stratum III between phases A and B is not clearly articulated in the report based on changes in site activity. The excavator suggests that there is more metal production and raising of livestock in Stratum IIIA, however on a floor in Stratum IIIB the largest ingot horde was found indicating the large scale of copper production in that period. The assertion of the raising of livestock might be due to the preponderance of animal bones in rooms 36, 43, and 48. The later research of Adolfo Muniz highlighted that those rooms in fact contained the refuse from consumption and as a result were thought to be places of feasting (Muniz 2008).

The consistent identification of two different phases for the EBIII in Area H highlights the longevity of occupation during that period. A similar range of functions were assigned to the rooms as in Area C, however because Area H was excavated over two different seasons

the detail of the data is often more comprehensive. The majority of the rooms were given the same number across the two phases. The exception to the continuity of naming was rooms 50 and 64. 64 contained a taboon and was above 50. So given that rooms 50 and 64 were the same, 18 rooms were identified within Stratum III. Structures 36, 37, 38, and 47 were all identified as store rooms based only on the large relative quantity of ceramic vessels. Structures 39, 42, 44, 46, 50, 63, 65, 82, 83, 84 and 85 were all considered mixed utility. The rooms that were associated with metalworking were 43 and 48 due to the number of complete molds identified in situ. Despite the assertion of fixed utility for many rooms, the majority of the rooms contained a mixed assemblage of objects that ranged from storage to domestic production to copper production. For example, the presence of mortars and grinding slabs are ambiguous given the potentially dual role as a food processing device, ore processing device or both. Without testing mineral content and flotation of nearby soils it is impossible to make the distinction.



Figure 4.6: Area H final photograph after the 1999 excavation season. Photograph by Thomas E. Levy, UC San Diego Levantine and Cyber-Archaeology Lab.

4.1.4. Area R

Of the different excavation reports that of Area R (100 m²) is most difficult to follow. The excavations were led by Richard Lee (1999) during the 1999 excavation season (See Figures 4.5 and 4.7). Like the probe from Area Y (Described in the next section), the excavations were meant to help connect the excavations of 1999 and 2000 to Adams' excavations. The excavation report speaks little of the finds that might be associated with Stratum I or Stratum II. The primary feature of the areas is a passageway that split the excavations of Adams from Areas C and Y. The deposit that had the most cultural remains was associated with Stratum II, however the excavation report reveals that in fact the locus was primarily collapse material from neighboring walls. Based on the amount of wood found in that collapse deposit along with other finds it is possible that the passageway was actually roofed. Interestingly, this number of finds in this section of the passageway are much greater than what was found in the northern extension of the same passage, Area Q (Discussed in Chapter 4.1.9, Gidding 2011). This leads to the assumption that some, if not all, of the material was actually collapse from upper stories of neighboring buildings. There is no indication of phasing in the Stratum III deposits. This area will not be discussed in significant detail in the dissertation due to the fact that the area was predominantly outside of the buildings and as a result does not offer information on the organization of space within buildings.

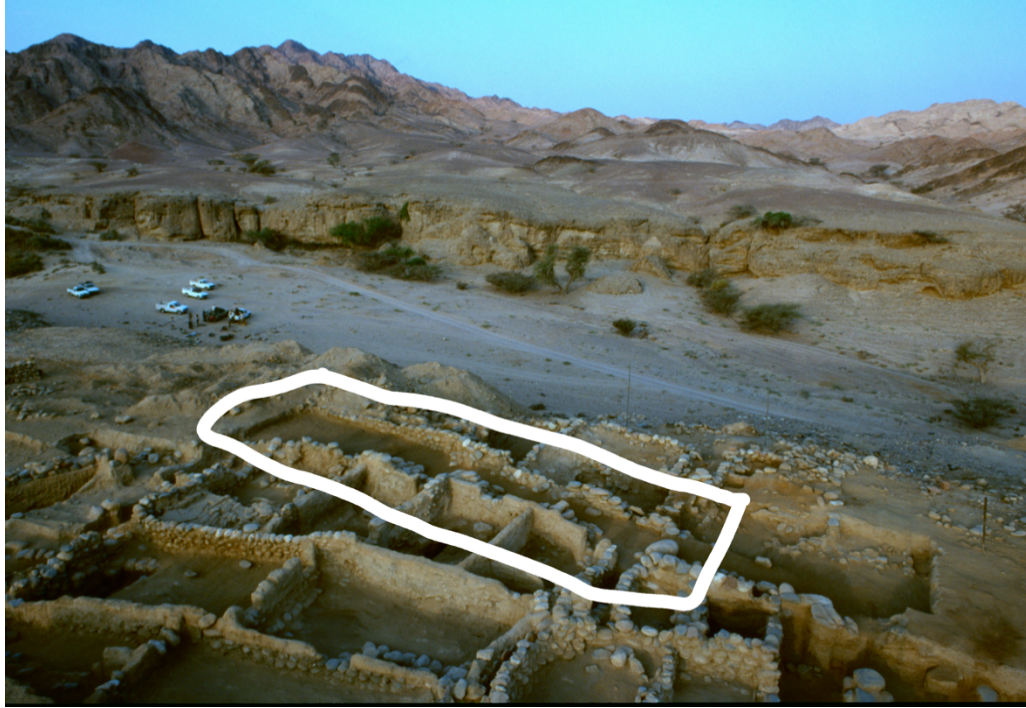


Figure 4.7: The passageway adjacent to Area Y is clear on the west side of the excavation, noted by the white outline. The passageway narrows as it progresses north along Area Y. Photograph by Thomas E. Levy, UC San Diego Levantine and Cyber-Archaeology Lab.

4.1.5. Area Y

Like Area H, Area Y (650 m. Sq.) was excavated both in the 1999 and 2000 seasons. The excavations at Area Y led by Yoav Arbel (1999-2000) revealed all four of the major strata identified across the site (See Figures 4.5 and 4.8). Also, the 2000 excavations in the area extended into what had been Area C, presumably to finish those excavations. For the analysis of the ceramics, Area Y will be an important counterpoint to the detailed description of ceramics from Area H. The fact that the area was excavated in a way that recorded multiple phases clearly in many rooms offers the ability to draw comparisons to Area H.

The phasing in Area Y was slightly different from the phasing observed in neighboring Area H, the only other area to be excavated over two seasons. For instance, the excavator of Area Y did not make the same two phase distinction within Stratum I. However,

for most structures in Stratum III it is clear that the same two phases were present across the excavation area. Additionally, it is worth adding that in some rooms more than two phases were identified. The same curvilinear structure observed on the surface of Area H continues into Area Y. The exact date of that structure is unknown, but in the nearby shallow soil a burial dated to the Islamic period and loci containing not-EB slag were found. Stratum II like Areas C and H lacked much in the way of definable structures except for the occasional wall and evidence of reuse of the existing EBIII walls. There was scant evidence of copper production activities in the Stratum II fills, but the intensity of production is unclear. In Stratum III the remains of 36 rooms were excavated, five of them partially. The general plan in Area Y seemed to be a series of courtyards or open air rooms surrounded by smaller enclosed structures. Like Areas C and H almost all of the rooms showed evidence of activities relating to copper production. The excavator describes the earlier phase of activity at the site being primarily domestic, the later phase being entirely based on metal production with no evidence for domestic use. Stratum IV was observed periodically with unarticulated walls that were buried beneath the foundations of Stratum III. As in the other areas there was little evidence of copper production in Stratum IV. Finally, an extra probe was excavated in square C11 as a part of Area Y adjacent to Area R from the 1999 season and the earlier excavations of Adams.

The excavator's assertion that within Stratum III there were two unique phases of occupation differentiated by function requires further elaboration. The assumption of major shifts in the function of each room from phase to phase isn't necessarily expected given that the architectural configuration does not seem to change with a rebuilding phase and aspects of copper production are found in both phases. Overall the structure of the buildings in this area appear to be courtyards with ancillary rooms for storage. In this configuration Rooms 17, 16, 15, 18, 19, 21, 29, 11, 12, and 55 were all assumed to have been primarily used for storage.

Rooms 22, 14 and 54 were all courtyards, the loci of primary metalworking activities with up to six surfaces identified within each. Structures 20, 22, 23, 25, 28, 60, 59, 58, 56, 53, 52, and 62 were indeterminate of function. Structure 57 was a passageway. Structure 26 was unique for the density of copper molds in association with large stone implements that were assumed to have been associated with copper manufacture.



Figure 4.8: Overview of Area Y after the 2000 excavation season. Note the vats *in situ* near the bottom of the photograph and the still standing sections of mud brick wall on top of the stone foundations. Photograph by Thomas E. Levy, UC San Diego Levantine and Cyber-Archaeology Lab.

4.1.6. Area L

The excavations at Area L (75 m²) were significantly different from other excavation areas because surface architecture clearly indicated the existence of a large, later period structure (See Figures 4.5 and 4.9). The excavation was supervised by Lisa Soderbaum (2000) and was only excavated during the 2000 excavation season. As a result of the later period

structure the stratigraphy in Area L differed significantly from the other areas. For Area L Stratum I was the surface collection of mixed assemblages primarily identified as Roman or Byzantine, but some EB sherds intruded. Stratum II unlike the other areas was associated with only a Roman/Byzantine occupation. Two phases were identified based on reconstruction of walls identified at the site. Two phases were also identified for Stratum III, however in this case Stratum IIIA is identified with the EBIV and thus Stratum II in the rest of the site. Stratum IIIB was identified as EBIII and thus contemporaneous with Stratum III proper in the rest of the site. Stratum IV was identified only as bedrock below Stratum III. Due to the dominance of later period occupation at this area of the site, and the EBIII exposure being relatively small, this area was not included as a part of the detailed analysis of diagnostic sherds.

The overall phasing of occupation during the EBA in Area L matches the rest the site well. Local Stratum IIIA was only recognized by a few loci identified as EBIV by pottery, but no evidence for new architecture. Despite the limited exposure, the material from Stratum IIIB is particularly interesting in reference to what was discovered in Areas C, H, R and Y during the 1999 and 2000 seasons. Two walls were discovered allowing the excavator to delineate two structures. One was mostly devoid of finds, but the base of the other was a pavement of large slab stones that were plastered over to presumably be used for the storage of water. In the locus just about the plaster floor a large quantity of rubbish was found in what is termed Locus 3037 (Room 72). The pottery and other ceramic finds from this locus were typically worn and very broken compared to other excavation areas. What is slightly unclear is whether the water basin ceased to function as such while also being used for waste from ceramics. The fact that the ceramics are both heavily broken and worn hints at the basin functioning as both a store of water and a dump for trash.



Figure 4.9: Finished excavations at Area L highlighting the later architectural style that didn't include mudbrick. The deep trench in the bottom left corner was the only segment to probe in the EBA. Photograph by Thomas E. Levy, UC San Diego Levantine and Cyber-Archaeology Lab.

4.1.7. Area D

The excavation in 2007 of Area D (25 m. Sq.) was led by Muniz (2007) to test some of the assertions of the excavators of Area C regarding the potential presence of a more significant EBIV layer in Stratum II (See Figures 4.5 and 4.10). Instead only evidence of Stratum I and Stratum III were identified and Stratum III was divided into four phases (See Table 4.1). The excavation delineated some architecture, but no distinct structures. On the north there might be a wall that would separate Area D from what seemed to be a courtyard involving rooms 4, 5, 6 and 7 in Area C, but it is impossible to know without further excavation if the wall would fully bound both areas. The finds in Area D were reminiscent of the courtyards of Area Y with benches and complete vessels found in situ along with large stones with evidence of pounding. The complete vessels were found in different phases of the

Stratum highlighting the repeated use of the area. Interestingly, the density of pottery in this area is significantly less compared to Areas H and Y.



Figure 4.10: Area D Final Photograph after the 2007 excavation season looking at Area C. Photograph by Thomas E. Levy, UC San Diego Levantine and Cyber-Archaeology Lab.

4.1.8. Area E

The excavation of Area E (50 m. Sq.) in 2007 by Muniz (2007). Area E was twice the size of Area D with the primary intent of the excavation being a stratigraphic sample of the slag on the surface (See Figures 4.5 and 4.11). After a surface scrape defining the first phase, the slag indicated two more phases within Stratum I, an Iron Age and Byzantine Islamic Phase. The slag was deposited directly on top of Early Bronze Age walls, with no evidence for Stratum II in this area. The Stratum III deposits featured three rooms and two courtyards, none excavated to completion and there was no indication of phasing as in Area D. Like Area D, the quality of the in situ finds were unusual and the ceramic density was smaller. In the first room

this included a basalt mortar, a lance head on the surface, and a lidded cooking pot with the lid still in place. The second room had a plaster floor and limited finds, with a roofing beam. This perhaps could have been another water basin as in Area L. The third room was barely excavated, as a result little can be said about it. One of the courtyards appeared to have a domestic function based on the two taboons found near bench installations with grinding stones. The second courtyard included a large pit with evidence of having been used to produce lime plaster.

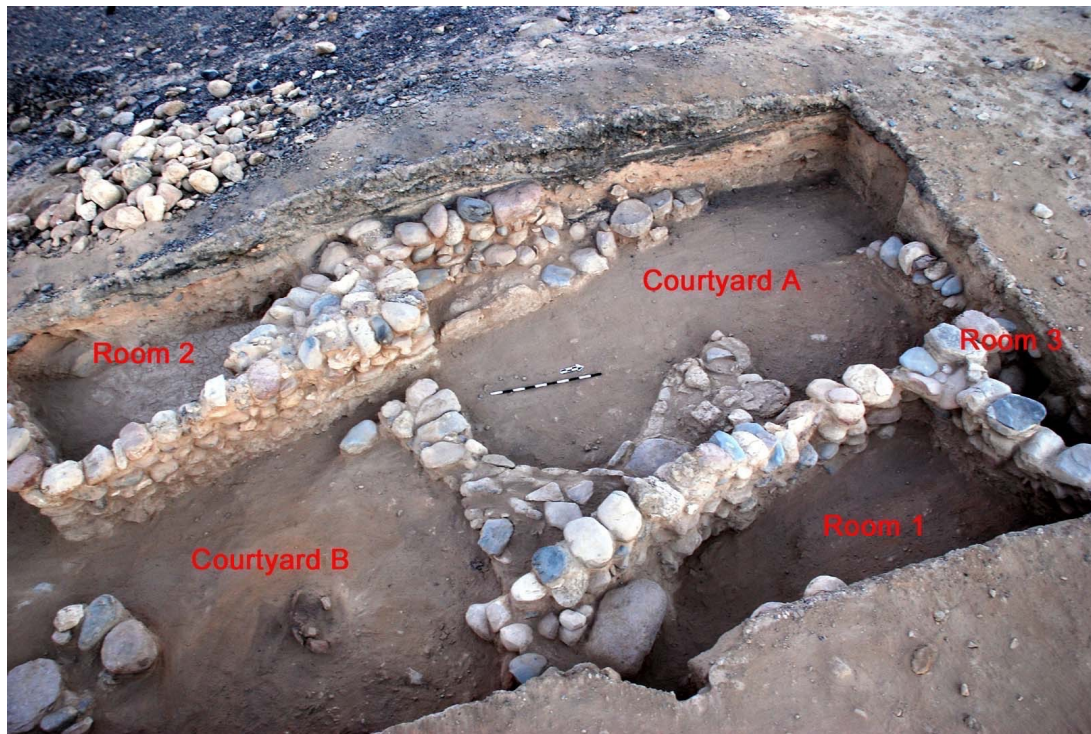


Figure 4.11: Area E Final Photograph after the 2007 excavation season. Photograph by Thomas E. Levy, UC San Diego Levantine and Cyber-Archaeology Lab.

4.1.9. Area Q

The 2011 season at KHI excavated Area Q (25 m. Sq.) to reveal the continuation of an alley-way identified in Area R during the 1999 and 2000 excavation seasons (Gidding 2011, See Figures 4.4 and 4.11). The alley-way runs roughly north to south and is the dominant

feature of the excavated square. The excavation revealed parts of rooms and the whole of the outer wall of the rooms of Area H. The purpose of the excavation was to continue to examine the overall stratigraphy of the site, especially the multiple phasing of Stratum III. Within Area Q all four strata were identified, with collapse from a mudbrick wall helping to delineate the difference between Stratum II and III. As in other areas of the site Stratum II was identified only by the presence of a few wall lines that lay above the collapse of a Stratum III mud brick wall. Evidence of multiple phases of construction for the Stratum III buildings were revealed in the section that was bounded by Area H. This includes bins that are built against the exterior walls of the building in Area H that are similar to walls built out from the walls of Area Y into the alleyway of Area R. Stratum IV lays beneath an ash layer that is found in varying concentrations across the excavated area, the heaviest areas being in the northern half of the square. The data from this excavation was important in order to understand the stratigraphy of Area R and it provides the best date from Stratum IV. Like Area R, as primarily an alleyway the material remains do not lend themselves to a room to room analysis.



Figure 4.12: Area Q final photograph after the 2011 excavation season. Photograph by Aaron Gidding UC San Diego Levantine and Cyber-Archaeology Lab.

4.2. Past Published Research from Khirbat Hamra Ifdan: Adams, Levy and Muniz

The publications on the excavations at KHI have all focused on excavations from the 2000 excavation season and earlier. The only peer-reviewed publication was spearheaded by T. Levy (Levy et al. 2002) and focused on a preliminary description of the organization of metal production. Two researchers that worked on that project have also published large scale syntheses based on the early excavations of KHI in the form of dissertations and book chapters. R. Adams (1999, 2000, 2002, 2005) published a number of articles and produced a dissertation that focused on the ceramic material from KHI. A. Muniz (2008) produced a dissertation based on the faunal remains of the 1999 and 2000 excavations. No additional publications have been produced using data since 2000. The new data that has been produced since the initial excavations offers the opportunity to build on the basic framework set up by the previous researchers to refine the model for the organization of copper production at KHI.

The important work of Adams introduced the initial framework with which to contextualize the occupation at KHI. The key finds from the initial probes included the identification of mold fragments that would have been used for the production of copper objects and ceramics with clear correlations to sites in the Negev Highlands (Adams 2000). The ceramic correlations had been predicted by earlier research on petrography and ceramic forms that anticipated Faynan as the source of copper found at Negev Highland sites, but only with the excavations at KHI were those assumptions proven (Discussed later in Chapter 4.5.1 Dever 1973, Goren 1996). Incorporating the preceding work of Hauptmann (1987) at the copper mines in the Faynan area, Adams determined that the production at KHI must have been an attachment to a larger political entity that managed production at the site. However, the site that managed production remains unknown. Importantly, Adams always discussed the occupation at KHI as an EBIII/IV phenomena based on the radiocarbon dates that were

collected by earlier researchers despite the clear ceramic correlation to Negev EBIV sites (Adams 2000). Adams' initial work was only a probe and as a result it was only through the later excavations in 1999 and 2000 that exposed a much larger space that questions of internal hierarchies within the site began to be addressed.

Following the 1999 and 2000 excavations a single publication highlighted the impressive collection of artifacts associated with copper production at the site. Led by Levy (2002), this paper offered tantalizing new data regarding the production of secondary copper objects at KHI. Importantly it identified a significant number of complete molds to complement the earlier data from Adams and to reinforce the role that KHI might have had in a larger copper trading network with the Negev. While the new data reinforced the probably role of elites in the production of copper at the site, the details for how that might have operated in practice were not yet fully understood.

One of the key ways to understand differentiation within a site is through the unequal access to resources, especially food. Muniz (2008) in his dissertation focused on the animal bones that were consumed at different sites in the Faynan region throughout the Early Bronze Age to highlight variations in animal consumption patterns through time. The results of Muniz were highly influenced by the earlier research of Adams from which he took the assumption that a central authority helped to manage the production of copper. Based on the distribution of bones at KHI, concentrations of large meat bearing bones being in certain rooms, it followed that the distribution pattern reflected feasting and as a result reinforced the assumption of redistribution as an important part of the local economy (Muniz 2008, Pg. 305-314). In this sense it was assumed that elites had to be playing an important part in the overall organization of the site, even if the evidence didn't point to an elite locus of occupation. In an Iron Age context, in Timna, the even presence of meat bearing bones within a copper production site has been used to argue that the copper workers must have been elites, in part

due to their specialized knowledge (Sapir-Hen and Ben-Yosef 2014). The important interplay in feasting on pastoral products as a part of the production of metal objects is fundamentally important to the interpretation of the modes of production that either existed concurrently both in and around KHI.

An important challenge for the description of elite activity at KHI has been the identification of contemporaneous economic systems with which to exchange such a valued commodity as copper. The initial research at KHI predated the reconfiguration of the EBA chronology that expanded the EBIV by 200 years and has significantly altered the way that various aspects of the environmental, political, and economic data can be interpreted (Regev et al. 2012). Using the old chronology, KHI existed through the time of the EBIII to EBIV transition that has long been described as a complete collapse of the EBA social order (See Chapter 3 for different models on the collapse). In order to contextualize the copper production system at KHI then it is first important to review the implications of the revised chronology on other important sites related to copper production. Now KHI dates primarily to the EBIV, which within the common narrative for the southern Levant would not have had many sites with the social hierarchy for which the accumulation of large amounts of copper would be necessary or possible. As a result, it is necessary to review relevant datasets produced and interpreted before the revision of the chronology and apply revised interpretations where possible. After reviewing each of those core components of the archaeological record (environment, regional settlement, ceramic and metallurgic) as it relates to new chronology, it will be possible to address the relationship of KHI to an elite driven copper production network and understand how local activity at KHI might fit within such a network.

4.3. The Chronological Problems of the Early Bronze Age: Challenges of Radiocarbon Dating to the Cultural Chronology

As an important feature of early urban societies, the question of when long distance trade was organized offers insights into when EBA society developed mechanisms of economic control that enabled exchange with the more powerful neighbors of the Levant (See discussion in Chapter 2). This is where the issue of dating becomes especially important as there are ceramic linkages that indicate direct connections to Egypt and were used to make the initial chronology of the Levant (Wright 1936). The fact that neighboring states used written language and other markers such as seals with kings' names allows for the refinement of the synchronization of chronologies between regions (See Table 3.1, e.g. Ben-Tor 1981, Hendrickx and Bavay 2001, Braun 2009, Knoblauch 2010). However, at most sites such correlations didn't exist, especially in the Negev. The result of the revised dating scheme requires a reevaluation using radiocarbon to clarify the internal social organization of the southern Levant in relation to its neighbors.

Radiocarbon dating offers an excellent, independent method to date archaeological remains for the purpose of chronological association. Rick (1987) was the first to use radiocarbon as an independent data point for chronological analysis. The key utility of radiocarbon data is that it provides absolute dates that are simpler to cross-reference between sites than other archaeological techniques, such as pottery or other material comparisons. This quality is important for regional comparisons of sites, especially at sites that have scarce material records for relative dating. However, radiocarbon is not a "silver-bullet" for producing an absolute chronology. Other considerations are required to ensure confidence in the material analyzed. For example, the number of samples collected, variation in lab treatments, the contexts from which the samples are taken and the type of material used in the

measurement all are factors that affect the confidence of a radiometric measurement (Summarized in Wiener 2012). Each of these issues have been a problem in the history of radiocarbon dating in the EBA.

For the initial application of radiocarbon dating to the construction of the EBA chronology the problematic aspects of acquiring and handling samples led to distrust of the data. In the Negev Highlands, the rejection of radiocarbon dates in favor of other tools to determine the relative chronology was especially important due to the lack of stratified sites to anchor a ceramic chronology. More often than not in these cases relatively few samples were taken and the radiocarbon dates didn't match expectations leading to the use of different excuses to explain why the radiocarbon didn't fit the established model used for the rest of the southern Levant (Amiran 1978b, Cohen 1999). Only a few Levantine researchers were willing to trust the radiocarbon data as a relevant, reliable independent method to test the regional chronology and indicate the need revise the model for the most settled areas and the Negev (Avner and Carmi 2001, Bruins and van der Plicht 2001). Despite radiocarbon evidence in favor of revision, the distrust in radiocarbon as a method meant that the EBA chronology for the Levant remained in place, in synchronization with the rise and collapse of the Egyptian state¹¹. This reflexive reliance on the chronologies of neighboring regions had significant impacts on the chronological interpretation of sites in the peripheral desert areas (See models in Chapter 3.1 - 3.7).

¹¹ For this section I will use the cultural chronological associations appropriate for the time of research. In other words, I will not make an attempt to correct for the new chronology. This is done in order to maintain logical consistency with intentions of the original authors. Later in the dissertation when possible some of the temporal assignments will be changed in light of new interpretation.

4.3.1. The First EBA Radiocarbon Dates in the Negev Highlands: Unreliable Indicators of the Past

Without stratified sites in the Negev Highlands there are two ways to date settlement patterns: fitting the data to models or using radiocarbon as an index to develop a regional picture of occupation. The vast majority the published research for the region relies on the Procrustean fitting the data to an expected model of settlement patterning rather than using the data to revise existing models. This is reflected in the conflicts relating to the nomenclature of the EBIV¹² in different regions across the Levant due to the variation in the material record (See Chapter 3.2-3.5). For the Negev Highlands, Cohen (1999, also see Chapter 3.2) held on to the MB I terminology for the EBIV and as a result the EBIII period disappeared from the site counts represented in his and other surveyors' data. The residual effect was that the dating of many of the sites in Negev to the EBII period reflects the expected settlement pattern based on Cohen's opinion that human presence in the Negev was most apparent during the period when Arad was the main center of power, concurrent with the ascendancy of Arad and the Sinai metal trade. This view is reflected in many of the subsequent synthetic works on the EBA that ignore the potential for settlement in the Negev region during the EBIII (i.e. Philip 2001, Milevski 2009). In the absence of radiocarbon, the best way to describe settlement was to assume that the collapse of Arad led to the end of Negev settlement that only resumed in the following period and the absence of settlement meant that the following period should not show continuity with the previous settlements in the radiocarbon data.

At sites that lacked multiperiod stratigraphy, the data from Arad was necessary to contextualize occupational data. This was especially true at sites such as Ein Ziq and Beer Resisim, which were identified as the central sites in the Negev Highlands during the EBIV

¹² Also identified as Middle Bronze I, Intermediate Bronze Age and Intermediate EB-MB

(Haiman 1996, Cohen 1999). In most cases the radiocarbon samples were derived from wood and charcoal, however the dates from Beer Resisim are derived from ostrich egg shell. For the dates derived from wood sources there is the typical problem of old wood, providing dates that are older than they should be with a short lived sample (Schiffer 1986). Ostrich egg shell also has the problem of offering dates that are 180 ± 120 years too old (Vogel, Visser, and Fuls 2001). For both Ein Ziq and Beer Resisim the material used for radiocarbon dating was easy to blame for dates that placed the sites in the EBIII instead of the EBIV (Dever 2014, Pg. 227). Because the EBIII radiocarbon date conflicted with the expected narrative based on Cohen's MBI model, the dates were assumed to be affected by the affect of old wood and ignored in favor of the cultural chronology that saw a break in settlement after the EBII informed by ceramics and data from Arad (Cohen 1992, 1999). Dever saw the situation differently where continuity existed from the EBII, but still left the EBIII out of the model (See Chapters 3.2 and 3.3 for review). The limits of the reconstruction of the Negev-Faynan economic system without well defined stratigraphy and as a result later researchers have emphasized the need to collate larger radiocarbon assemblages for testing (Saidel 2002b, Pg. 191). With only a handful of dates from each of the major Negev sites it is impossible to determine whether the EBIII dating is due to problems in sampling or the identification of a different reality compared to what the model of Cohen would allow.

The building of the model for the the organization of settlement in the EBA was justified for its reliance on cultural chronological techniques in lieu of absolute techniques due to the problems with the reliability of radiocarbon data in that era of research. The material sampled from the Negev Highlands suffered from the problems of small sampling size and poor selection of material to make the sample. As a result, the surveys relied on a cultural chronology anchored by inter-regional ceramic and other material correlations anchored by Arad (Saidel and Haiman 2014, Pg. 173). There Amiran built the majority of her model on

ceramic correlations with Egypt, especially Abydos Ware and the identification of a serekh identified as Narmer) (Amiran 1978a, Braun 2009). As the only well stratified site in the Negev area known in the 1970s and 1980s, Arad offered the data necessary build a model for the rest of the Negev.

Beyond the Negev region the exact chronology has long been debated, with different authors suggesting a number of different interpretations for the dating of different time periods within the EBA (For an excellent early review see Dever 1980). In the northern areas there are many more stratified sites but the data from those sites has revealed variations in the relative settlement abandonment dates (Regev et al. 2012, Figure 11). These variations however have been ascribed to the regionalism noted below and typically were the result of nuances in the kinds of regional interaction (See Chapters 3.5 and 4.5). Despite much larger collections of radiocarbon compared to the Negev, radiocarbon was not believed to be a great solution to resolve the variations in EBA chronologies in part due to the lack of calibration, samples yielded wide errors, and did not match expectations based on Egyptian synchronization (e.g. Aharoni 1967, Pg. 238, Callaway and Weinstein 1977, Table 2 , Weinstein 1984, Pg. 314-361). This was true for early uncalibrated dates that also do not use Bayesian modeling to refine the range of expected dates (Bronk Ramsey 2009, Buck, Litton, and Smith 1992). Without trust in the radiocarbon dating other means were sought to model the absolute chronology in sync with the cultural chronology.

4.3.2. Using Radiocarbon as a Datapoint: The Utility of Radiocarbon to Revise the Model of Interaction during the EBA

Over time a number of key factors enable the use of radiocarbon as an independent dataset to revise the model for the occupation of the Negev Highlands. The radiocarbon methodology has progressed to produce higher resolution dates using calibration curves to

correct the data and Bayesian analysis to add precision to the analysis (Taylor 1997, Bronk Ramsey 2009). Additionally, the progressive acquisition of dates from a large number of different sites has meant that it is possible to collate all of the data into a region-wide model. A summary of all the radiocarbon samples taken in the Negev area does in fact point to the densest period of occupation being in the EBIII as opposed to the EBII with a significant drop-off in number of sites in correlation with the EBIV dates, using the old absolute chronology (Sebbane et al. 1993, Avner, Carmi, and Segal 1994, Avner and Carmi 2001, Avner 2006). This analysis is not without criticism. Even though there are a lot of samples used to make the model, the source is still typically single occupation sites and is a survey of published results without rigorous selection criteria. Additionally, it has been criticized for a bias towards the Uvda Valley. Whether the Uvda Valley can be applied to the rest of the Negev is questionable due to a relative lack of available dates (Haiman 1996). This critique however ignores the fact that the sites that are dated traditionally to the MB I by Cohen, especially Ein Ziq and Beer Resisim, have actually yielded dates that are predominantly from what would have been identified as the EBIII in the past (See Figure 4.13 and compare with Table 3.1). Despite the problems with his sampling, Avner's assertion that we cannot expect the Negev area to have sudden periods without occupation is valid. That data point needs to be taken *prima facie* for research devoid of prejudice seeking to use new data to enhance models. Instead of major breaks in occupation, near continuous occupation in the desert is the more likely model with the more likely reason for a lack of evidence being issues in archaeological methods that cannot identify all evidence for past human activities with absolute chronological certainty.

Recent analysis of radiocarbon data in regions outside of the Negev vindicates the position that the old occupational model for the Negev was inaccurate. The first revisions to the radiocarbon chronology came as a result of the decision to sample more short-lived samples in order to verify the old chronologies. One of the first analyses to this purpose

utilized short-lived samples to indicate that there were problems with the old chronology highlighted inaccuracies in the stratigraphic sequence at Jericho and used that data to suggest that the Egyptian chronology was older than previously assumed (Bruins and van der Plicht 2001). The extension of the Levantine chronology onto the Egyptian chronology has proven to not be applicable based on an effort to use radiocarbon to correct the for any errors in the accepted chronology of Egypt (Bronk Ramsey et al. 2010, Dee et al. 2013, Manning et al. 2014). This is not surprising given the fact that the Egyptian and the traditional Levantine chronology loses cultural synchronism after the 4th Dynasty with the 5th and 6th Dynasty material absent in EBIII strata throughout the southern Levant (Höflmayer 2014b, Pg. 139-140). The fact that later Old Kingdom material doesn't appear in the southern Levant supports the revision of the EBA chronology to a "high chronology" that changes the absolute dates of the Levantine EBA phases, but makes no significant changes to the chronologies of neighboring regions (Regev et al. 2012, Regev 2013, Lebeau 2015). As a result of this revised chronology it is necessary to reevaluate some of the key components that were used to help anchor the chronology of the Negev Highlands and by extension the copper trade routes that originated in Faynan.

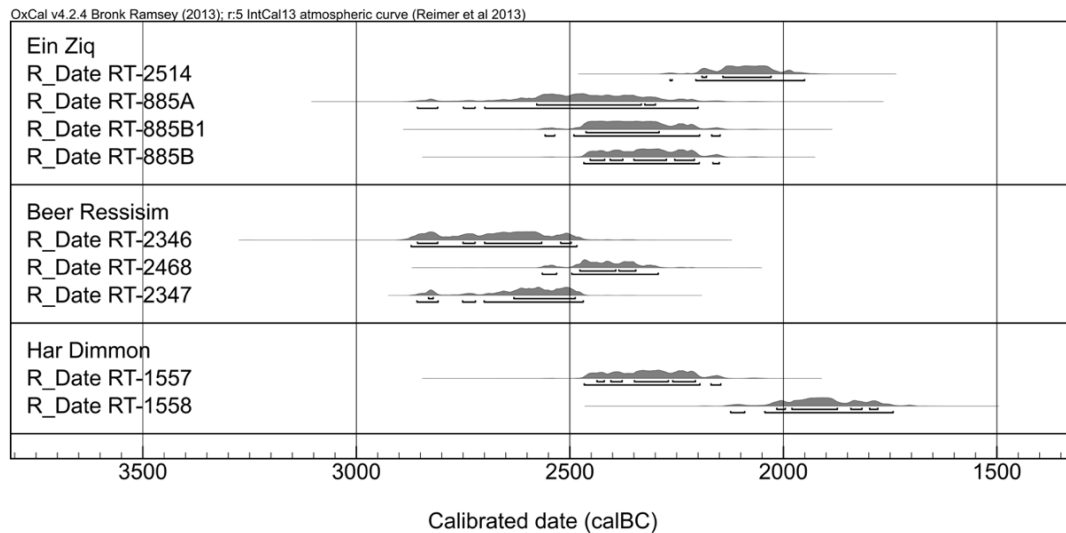


Figure 4.13: Plotted radiocarbon dates from sites in the Negev Highlands (Cohen 1999, Pg. 338-339).

4.3.3. Revised Regional Chronologies and the Revision of Arad: Changing our Perception of the Anchor

Starting in 2011 the Associated Regional Chronologies for the Ancient Near East and the Eastern Mediterranean (ARCANE) project began to reevaluate the relative chronologies across the Near East and Eastern Mediterranean during the same periods as the Levantine EBA (Lebeau 2011, Regev, de Miroschedji, and Boaretto 2012, Regev et al. 2012, Regev 2013, Lebeau 2015). The failures of radiocarbon dating and its ability to be synchronized to the relative chronology based on pottery typologies indicated the need for revision of the chronological framework. This project reinforced that it is necessary to consider independent means of dating, such as radiocarbon, as means to ground the general changes observed in occupational history at sites that contain stratigraphic phasing due to site-specific variation in site evolutions. Since this work has been produced A. Joffe (2014) provided a good summary of the problems regarding the dating by highlighting the regional dependence of transitions between periods of the long accepted EBI through EBIV chronology. In short, radiocarbon has

helped to better synchronize strata between different sites using an absolute metric, but has also introduced and highlighted asynchronisms that were only just being revealed in recent synthetic studies (Philip and Baird 2000b). The complete reconfiguration of the EBA chronology in relation to the chronologies of neighboring states brings into question the validity of the assumed importance of cultural chronological markers (EBI, EBII, EBIII, EBIV, etc.) as legitimate terms with which to describe meaningful socio-political shifts. If the EBII doesn't correspond with the start of the Old Kingdom models of old models of secondary state formation must be rethought and reconfigured (see Chapter 3.7). It also means that the challenges of making correlations using results and models from older publications is more challenging. If the chronological correlations were made using pottery correlations within the Levant the revised chronology needs to be applied. On the other hand, if independent methods such as ceramic correlations between the Levant and Egypt and radiocarbon were used then a shift in terminology might be necessary, a site that was EBII might now be EBIII, etc. In many cases much of the older data from the EBA needs to be evaluated along these lines to reconfigure the relative chronologies according to the new data. More challenging is applying these shifts to sites where the chronology was set using both Levantine and interregional correlations.

As the anchor for much of the chronological determinations for the Negev and by extension Faynan, Arad is very important to reconfigure the chronological story of the EBA and is one of the sites that used both local and regional correlations to anchor the chronology (See Map of sites). Excavated by R. Amiran (1978b), the excavations revealed five Strata initially dated by the excavators as ranging from the Chalcolithic and ending at the end of Dynasty I (c.2900 BCE) in the middle of the traditional dating for the EBII, with Stratum II representing the primary occupation of the site as a fully urbanized, fortified, copper-trading center. Amiran (1978a) later made a small revision using a number of different material

sources to make inter-regional chronological correlations. Especially important were a serekh depicting Narmer in Stratum IV, ceramic correlations in Stratum II with Megiddo Stratum XVIII, Abydos Ware found in Egyptian contexts, and other correlations led to the revision of the end of Stratum I to coterminous with the end of Dynasty II in Egypt (c. 2680 BCE).¹³ However, newly modeled radiocarbon data from Megiddo dates Stratum XVIII to ~3050 - ~2900 BCE (1-sigma) (Regev et al. 2012). That result predates the assumed correlation of Amiran to Arad's Stratum II (2850 - 2650 BCE) based on Egyptian synchronism (Amiran 1978a). Further, accepting the local Egyptian synchronism over the similarity of Arad vessels to Megiddo would place Stratum II in the EBIII using the revised chronology. This creates a challenge for the data from Arad where Stratum II could either be Early, based on the data from Megiddo, or late based on the data from Egypt

The difficulty applying material correlations reaffirms the necessity of using the radiocarbon as an independent anchor. As an extra, independent data source radiocarbon dating can confirm the dating of Stratum II at Arad to the EBII or EBIII. Amiran in her assessment of the ceramic correlation conceded that the ceramic type that is the primary basis of the chronological determination of Stratum III is a long-lived type that is prevalent into the EBIII, only highlighting the difficulty of using ceramics to definitively determine inter-site chronology in the EB (Amiran 1978b, pg. 183). This issue is further complicated by the few radiocarbon determinations published for the site (See Figure 4.14). The initial determinations were very poor in terms of resolution and did nothing to distinguish the periodization of the site (Aharoni 1967, pg. 238). New radiocarbon data for Stratum II reveals problems with the intrasite dating, but implies that Stratum II probably dates in the range of ~2900 BCE - ~2600

¹³ It should be noted that in the revised chronology of Regev (2012) this would make Arad collapse sometime in the EBIII not the EBII, as is supported by the radiocarbon data reevaluated here.

BCE (See Figure 4.13, Callaway and Weinstein 1977, Table 2, Amiran and Ilan 1996, Table 1). This is informed by the assertion by Braun (2009) that the Narmer Serekh found at Arad is from Stratum III and not Stratum IV as assigned by Amiran. This actually matches the dates better from Callaway at least for the EBI/II transition and would make sense taking into account the revised chronology (Callaway and Weinstein 1977, Regev et al. 2012, Dee et al. 2013).¹⁴ The implication of the radiocarbon is that the settlement of Arad post-dates the EBII culture and as a result the ceramics from the site should in fact date to the EBIII as well (See Table 4.4). This position is reinforced by evidence of EBII and EBIII forms found near each other nearby at the site of Har Hemar, a site assumed to have been a kind of watch post on the road to the Dead Sea (Yekutieli 2009). The combination of Egyptian parallels, radiocarbon and data from nearby sites significantly changes estimates on the date of the collapse of Arad and by extension would affect the model of Cohen and others that used data from the Negev Emergency surveys to assume a large gap in settlement in the Negev (See Chapter 3).

¹⁴ Braun's analysis provides the *terminus post quem* for Stratum III for the model of radiocarbon dates from Arad. The assigned range for Narmer is based on the conservatively estimated period of Dynasty 0 leading into Dynasty 1 in Egypt (Yekutieli 2004).

Table 4.4: Revised correlations for Arad based on new radiocarbon analysis.

Levant	Egypt - Original	Egypt - Revised	Arad - Original	Arad - Revised Chronology	Traditional Chronology	Revised Chronology (Regev 2012)
Early Bronze I	Pre-Dynastic	Pre-Dynastic - First Dynasty	Stratum IV		3500 - 3000 BCE	3500 - ~ (3200 - 2900) BCE
Early Bronze II	First - Second Dynasty	First Dynasty	Stratum III-I	Stratum IV - III	3000 - 2600 BCE	~(3200 - 2900) - ~2900 BCE
Early Bronze III	Third - Sixth Dynasty	Second - Fourth Dynasty		Stratum II-I	2600 - 2300 BCE	~2900 - 2500 BCE
Early Bronze IV	Seventh - Eleventh Dynasty	Fifth - Eleventh Dynasty			2300 - 2000 BCE	2500 - 2000 BCE

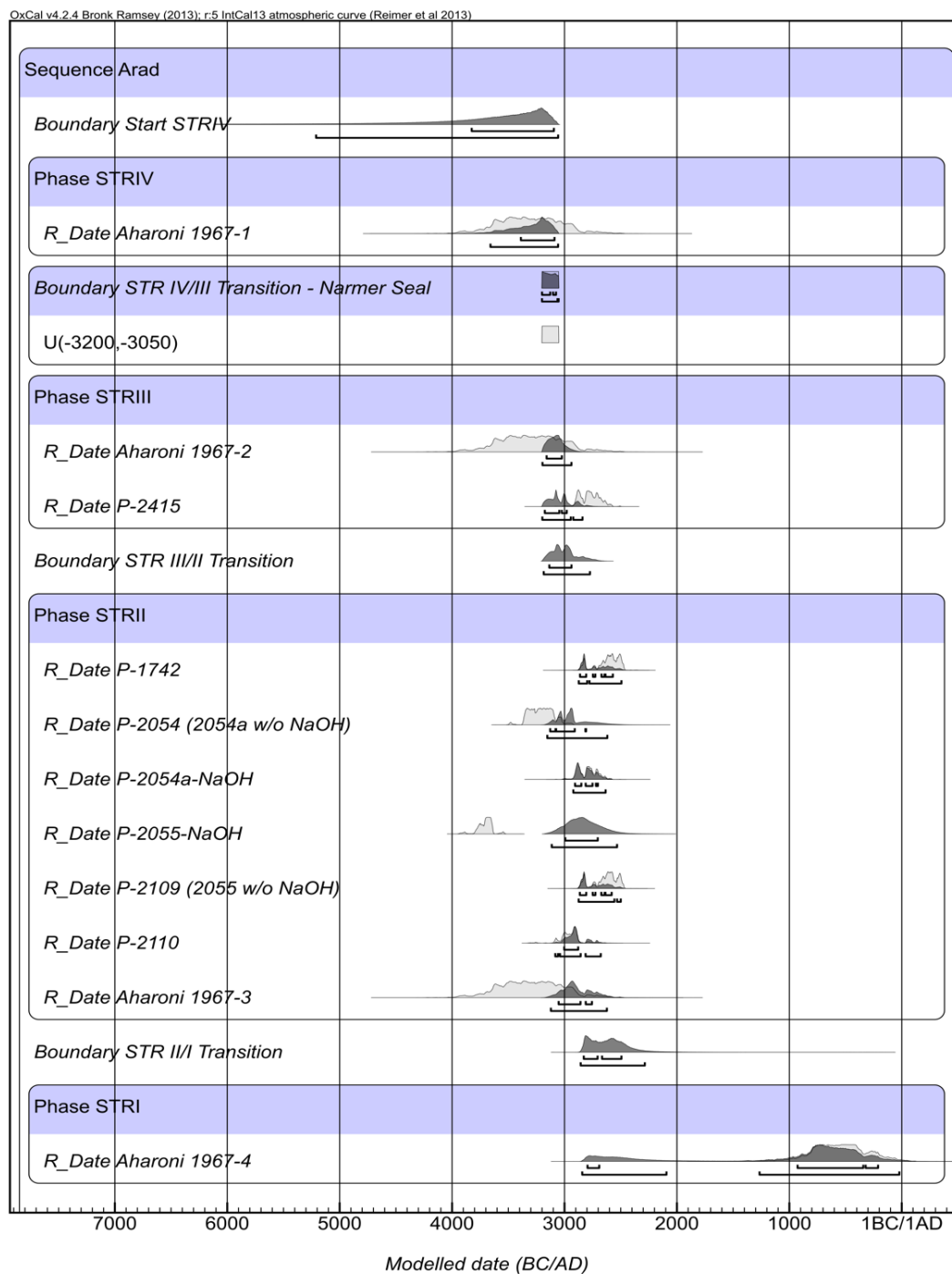


Figure 4.14: Radiocarbon data modeled using Bayesian methods and applying a limit to the Narmer *terminus post quem* as assumed by Braun (2009) to set the boundary between Stratums IV and III. Unless noted as an Aharoni (1967) date, all of the dates published by Callaway and Weinstein (1977).

While radiocarbon is very important in the context of Negev archaeology, in the absence of a good ceramic chronology, northern areas also need chronological revision. The recent work by both the ARCANE project and J. Regev has indicated that the end of the EBIII was about 200 years earlier than previously identified using ceramic correlations (See Figure 4.15, Lebeau 2011, Regev, de Miroschedji, and Boaretto 2012, Regev et al. 2012, Regev 2013, Lebeau 2015). Moving the start of the EBIV back to 2500 BCE completely changes the way that sites in the whole of the southern Levant are interpreted: both as a coherent region and in relation to neighboring regions. Most important is that the old assumption that the EBII-III was contemporary with the Old Kingdom has been ruled out and as a result changes the interpretation of the nature of the long distance exchange associated with the EBII-III Levant (Höflmayer 2014a, 2014b, Höflmayer et al. 2014). Additionally, implicated is the need for reevaluation of the geo-political explanation for the transition from the EBIII to the EBIV in the southern Levant. Important reevaluation of the ceramic data highlights that the Egyptian correlates in excavated EBIII contexts ended before the end of the 5th Dynasty in Egypt or roughly contemporaneously with the revised end of the EBIII (Sowada 2009, Pg. 251-255). The theory of a region wide environmental collapse that led to the end of the Levantine EBIII also has to be reevaluated based on the radiocarbon data (Höflmayer 2014b). As a result of environmental data not being a relevant explanatory factor to explain the shift from the EBIII to the EBIV in the Levant non-environmental explanations for the shift in settlement patterns at the end of the EBIII. This fact however doesn't repudiate the necessity of understanding how the environment in the EBA was different from what can be observed currently across the Levant.

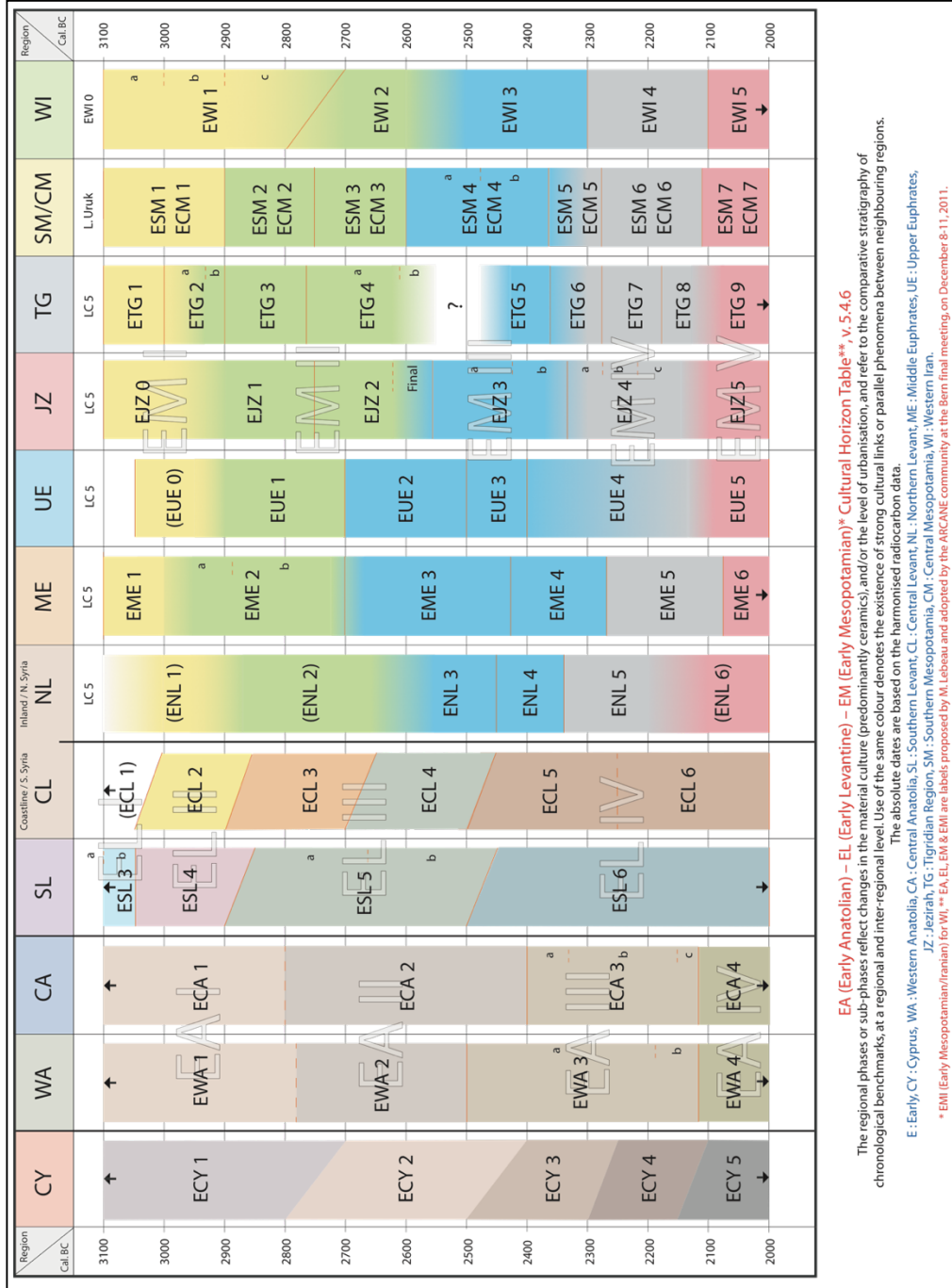


Figure 4.15: Arcane Revisions by the ARCANÉ Project highlighting the interactions between different Near Eastern regions (Source: http://www.arcane.uni-tuebingen.de/EA-EM-EL_phasing_v5-4-6.pdf, Dec 23, 2015).

4.4. The Paleo-Environment of the Early Bronze Age

Environmental data is typically derived from non archaeological contexts using radiocarbon to provide chronological context. The absolute chronology is then often wiggle-matched to the cultural chronology on the assumption that human action will either affect or be affected by natural factors. Using that method environmental data has proven to be an important factor to help explain the different variations in settlement and economy throughout the EBA. Simplistically, wet periods are associated with period of growth and dry periods are associated with collapse. However, environmental data needs to be considered with considerable care in order properly use it to build a context for changes observed in the archaeological record. Taken to the extreme, environmental data has been criticized due to its regular use as a determining factor in the devolution of EBA society at every transition including collapses after the Chalcolithic, EBI, EBII and EBIII (Discussed by Finkelstein 1995, Pgs. 31-37). The very fact that environmental data was used to explain a wide variety of events implicated it in its own undoing as an overused explanatory factor for changes in society during the EBA that fail to recognize the importance of human agency. Environmental data also offers methodological challenges. It is inherently multivariable and requires a large number of proxies ranging from lake bed coring to isotope analysis to palaeoentomological studies each with unique limitations. Compounded with limitations of dating techniques, preservations issues and regional variability it is difficult to derive conclusions that are linked precisely to historical events (Robinson et al. 2006, Rambeau 2010, Pg. 5227-5230, Finné et al. 2011, Pg. 3154). As a result, the environmental data proves to be a useful tool to establish the general context for archaeological data, but its application to specific events has to be taken with care.

The prevailing environmental conditions of the EBA were slightly different than what is observed in the southern Levant today. Between 200 and 300 mm of precipitation per annum is considered the “zone of uncertainty”, where dry agriculture is unstable and pastoral production preferred as a way to generate surplus subsistence (Wilkinson et al. 2014, Pg. 53-54). KHI and most of the sites that were part of the EBA copper production system are outside of the modern zone of uncertainty, in an even more arid space (See Figure 4.16). Broadly speaking at the start of the urban period of the EBA, around 3000 BCE, the Levant saw a significant wet period that over the course of the EBA that progressed to a significant desiccation around 2200 BCE (Frumkin et al. 1991, Pg. 198, Finné et al. 2011, Pg. 3166). The exact timing of the period of wetness is not precise, for instance speleothem data from Soreq Cave on the Dead Sea suggests that the wet period was ~2800~2700 BCE, which in the old chronology would have been around the time of the EBII-III transition (Bar-Matthews and Ayalon 2011, Pg. 169). The sediment data from cores taken at three locations around the Dead Sea confirms that from ~3000 - ~2000 BCE the level of the Dead Sea was relatively high (Migowski et al. 2006, Pg. 427). Pollen analysis was carried out on the same cores and confirms the general consensus that the EBA was generally wetter and cooler than the current environment (Litt et al. 2012, Pg. 103). Data based on oxygen isotopes from land snails has been used to indicate that the northern Negev was likely in the 200 mm area from 6500 - 3000 B.P., effectively moving the zone of uncertainty south about 20 km, but still excluding areas involved in copper production (See Figure 4.16, Goodfriend 1990). The data indicating high amounts of precipitation has been used to postulate that the reason for demographic shift along the Mediterranean coast between the EBII and EBIII was due to the inundation of water (Faust and Ashkenazy 2007). The challenge with the connection of the environmental data to the historical data in such a case is the assumption that the historical chronology is accurate. As discussed in the previous section the end of the EBII has been revised back 300 years and has

been interpreted as a regionally variable and potentially insignificant cultural “break” (Joffe 2014, Pg 221). The result of the revision of the EBA socio-political chronology is that the full urban phase of the EBA is probably associated favorable (wetter) conditions, but changes between the EBII and EBIII phases are not climatically connected. As a counterpoint, archeologists have used environmental data as an explanatory factor for the end of the EBIII, but this application of the data also needs further revision based on the new chronology.

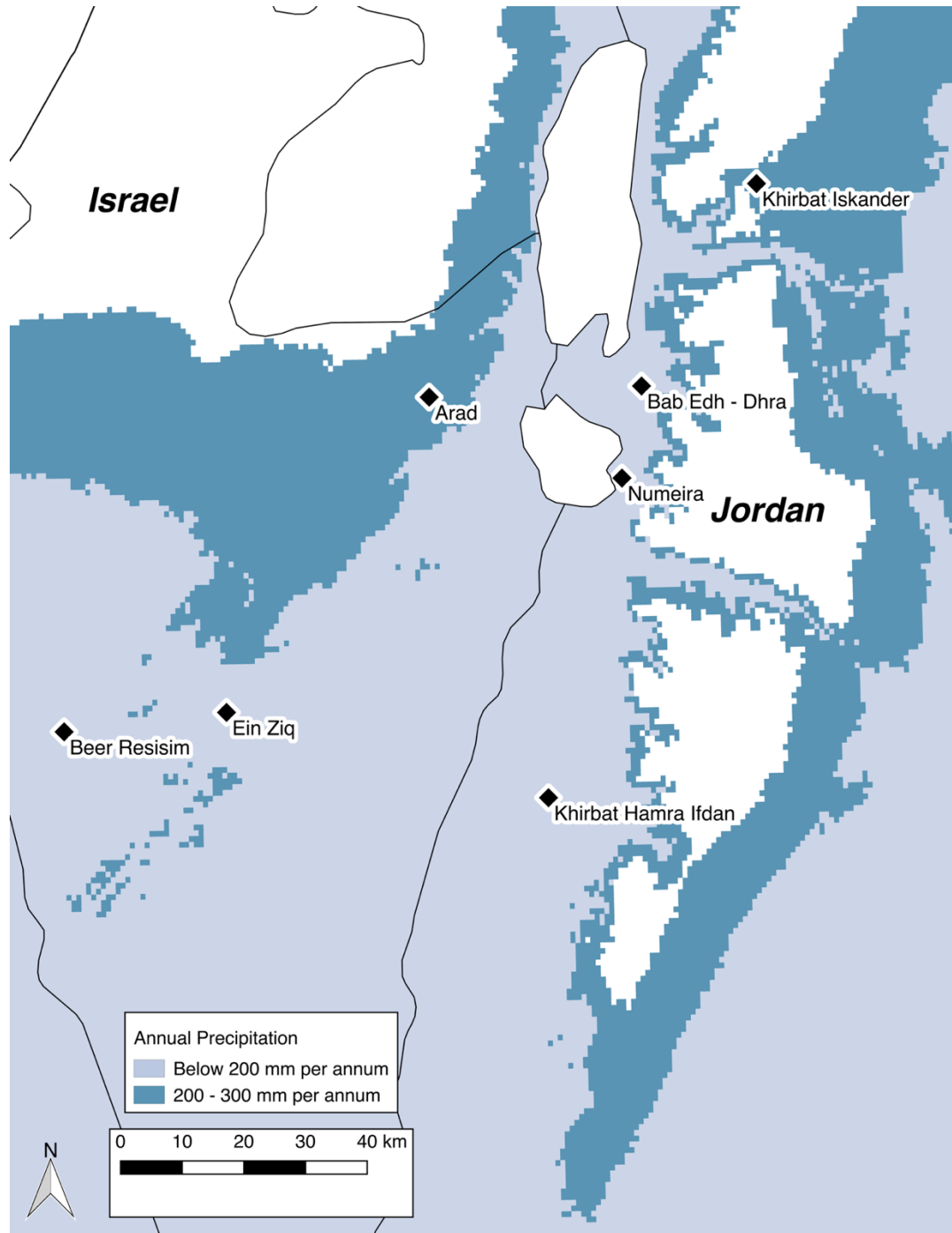


Figure 4.16: Map that illustrates the modern “Zone of Uncertainty”, 200 - 300 mm of precipitation per annum (Based on data from Hijmans et al. 2005).

Environmental determinism played a significant role in the explanation of the collapse of the EBA urban system through environmental degradation. Around 2200 BCE, roughly at the traditional start of the EBIV there is a severe desiccation across the whole of the Near East leading to geomorphological changes that still exist in the region and reflect a change to the harsher environmental conditions similar to those today (Hunt, Gilbertson, and El-Rishi 2007). Explicitly discounting social, economic and political factors, Weiss and Bradley (2001) have said that these conditions caused the downfall of the Akkadian empire of Mesopotamia, the pyramid-constructing Old Kingdom civilization of Egypt, the Harappan 3B civilization of the Indus valley, and the Early Bronze III civilization. The results of a significant desiccation play a role in all six causes for the end of the EBIII according to Dever (1998). However, as mentioned earlier, new archaeological data from the Levant does not support a full-scale collapse at the end of the EBIII, but instead significant regional variation. Evidence from Egypt points to the fact that over the course of the Old Kingdom (2700 - 2200 BCE) there was a slow desiccation contrary to the assumption of a sudden event (Bárta 2013). In the southern Levant the revision of the absolute dates of the transition from EBIII to EBIV to ~2500 BCE precludes a dramatic collapse to end the EBIII (Previous Section, Regev et al. 2012). Of the different applications of environmental determinism, the transition from the EBA into the EBIV environmental collapse has been the best established. Across the Middle East and Eastern Mediterranean, the so-called 4.2 k BP desiccation event was a primary means of explaining significant cultural shifts, especially in the peripheral regions (Höflmayer 2014a). Hardline environmental determinism, exemplified in the Levant by Harvey Weiss (1993, 2001), has typically been avoided due to the implicit assumption that all human beings share a common response to environmental stimuli with man as a machine rather than operating within unique social systems with unique forms of agency. Additionally, there is also the danger of

relying too heavily on the environmental data as the singular explanatory mechanism for social change. This only adds to the significance of earlier attempts to look beyond a simplistic use of significant environmental changes to explain the end of the EBIII and consider local factors under which different areas “collapsed” (Rosen 1995). That attitude has progressively changed into the recognition that environment is merely a potential constraint, but shouldn’t take such a central role in the analysis of the ancient social systems of the Southern Levant (Rosen 2008). As the environmental data has pointed out in the case of the Negev, humans influenced the progressive change of the ancient landscape and as result it is also important to understand aspects of the ancient social organization that would have been a factor in the eventual collapse of EBA society.

Nowhere is this truer than in the case of extractive industries that would rely heavily on natural resources to fuel production. For instance, in Faynan the interplay of the need for wood to fire the furnaces that smelted copper could be related to the observed desiccation trend in the region (Kaufman 2013). This is an important factor when reconstructing not just the environment, but also the local economy. With an estimate of 1:20/40 for the ore to charcoal ratio to make copper with the inefficient technology of the EBA and an average loss of 15% total weight during charcoal production 100,000 tons of wood would have been harvested over the period of production during the EBII-III; likely transported from the Jordanian plateau (Hauptmann 2007, Table 5.3, Horne 1982, Pg. 12, Hunt, Gilbertson, and El-Rishi 2007, Pg. 1329, 1331). But that event is estimated using the old chronology and thus would be distinct from the current EB chronology, which is why the radiocarbon data collected from smelting facilities is so important (See discussion in Chapter 4.5.2). As the effect of environmental change “varies according to technological development, social organization, and perception of this change” (Rosen 2007, Pg. 8), it is important to maintain

climate change as a factor, but place primacy in analysis on how aspects of socio-political organization, economic production processes, and perception to the environmental changes might have worked in combination to effect change.

One final consideration that must be taken into account is what environmental studies can tell about the past geomorphology as it might have influenced farming. The consensus indicates that the Negev Highland landscape would have looked very different during the Early Bronze Age. A Rosen (2007, Pg. 86-88) describes this landscape as being different in the past compared to today where floodplain agriculture would have been possible. Instead of the barren hills present today, lighter loess soils covered by steppic vegetation were common. The nature of flooding was also very different due to the different geo-morphology. Rather than deep channels with dry summers and winter flashfloods more regular flows of water may have existed. The wadi beds present today would not have been as deep, with regular low energy floods in the winter that may have overflowed over the banks and may have been perennial. Even with generally wetter conditions there was still a lot of variability in rainfall from year to year that would require planning for surpluses. These wetter conditions started as early as 5500 BCE and would have allowed for people to inhabit the Negev Highlands. Although highly controversial, Hendrik Bruins (Pers. Com.) believes that he may have evidence of wadi terrace farming utilizing floodwater in the Negev Highlands dating back to the Neolithic. Even if this were not the case, we can assume the habitation potentials of Early Bronze Age landscape to differ significantly from today. As a result, when reconstructing the environmental potential of the EBA landscape it is important not to assume limitations of the current landscape. It should be remembered that KHI is situated near the 'Ayn Fidan, one of the few perennial springs in the Faynan region and that even today this micro-environment in the Wadi Fidan river bed is characteristic of a Mediterranean environmental zone with significant irrigated farming from water run-off and spring water. During the peak of EBA

settlement at KHI these conditions would have been even more favorable to human settlement in the region.

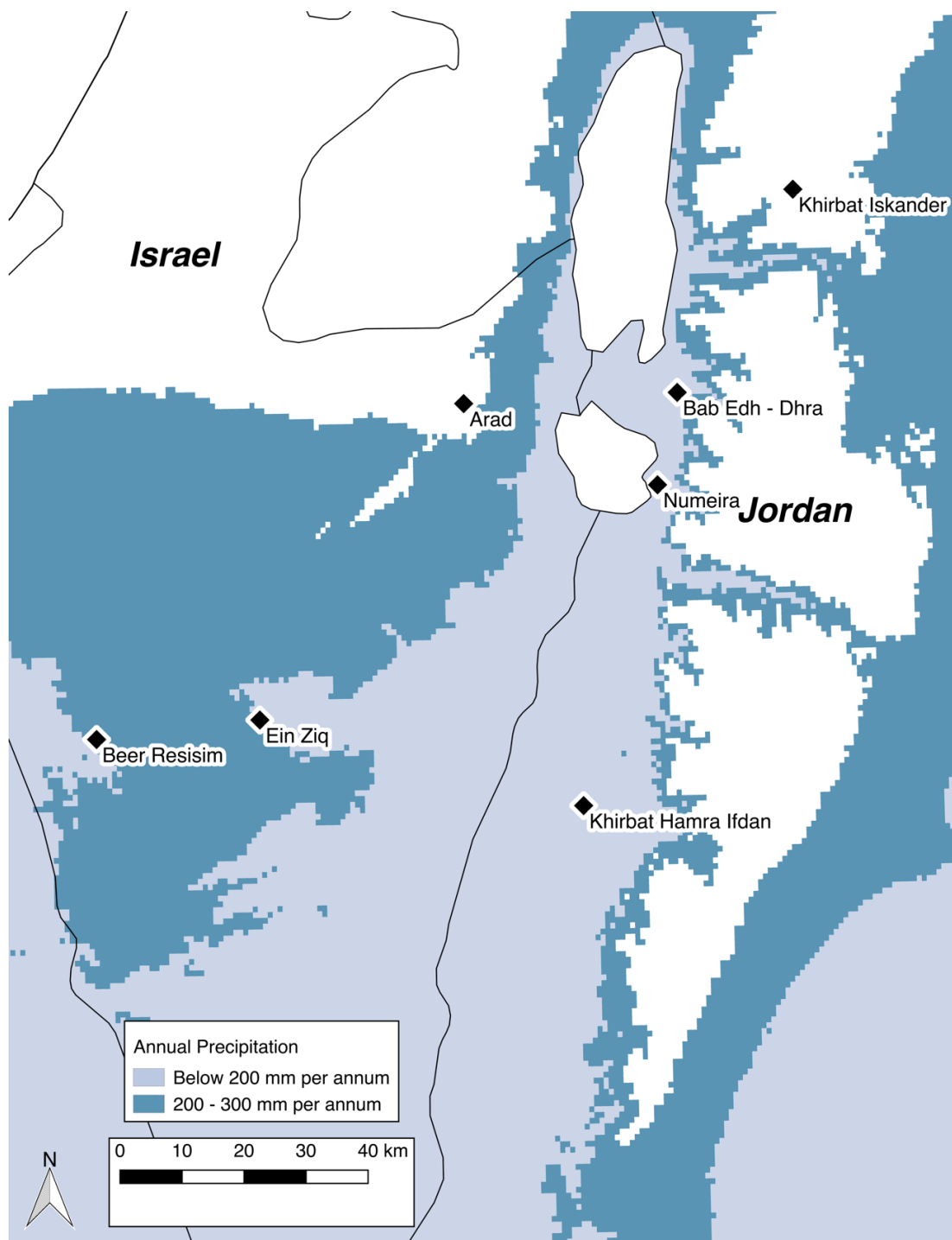


Figure 4.17: Model of isohyets from the Middle Holocene for the northern Negev based on land snail data estimating that the mean annual rainfall shifted to around the modern 150 mm per annum isohyet (After Goodfriend 1990, Hijmans et al. 2005)

4.5. Regional Distinctions in Settlement Patterns and Datatypes

The synthetic characterization of the social, political and economic organization of the Levantine Early Bronze Age is difficult due to semantic differences from region to region (Aspects of this are seen in the nomenclature for the period, discussed above in Chapters 2.7 and 3). The fact that within the archaeological literature there are a number of methods using a variety of datatypes is one component of what makes a uniform model for the sociopolitical organization of the EBA complicated (cf. Smith 2007, 2010). This might seem counterintuitive given the earlier discussion of how inter-regional trade is the best evidence for the development of complex social hierarchies during the EBA. It would be expected that the high volume of trade would offer clear chronological synchronism that allows for synthetic descriptions that agree on the character of the EBA political and economic system. The revised EBA chronology based on new use of radiocarbon data indicates a difference of hundreds of years for the end of the urban phases at different sites making it difficult to identify stratigraphic correlations between tell sites used to define the EBA (Confer Chapter 4.3.3 and Regev, de Miroschedji, and Boaretto 2012, Regev 2013, Regev et al. 2014, Höflmayer et al. 2014).

It follows that the history of how, where and why archaeology was done in the past affects the possible conclusions that can be drawn about past societies. The archaeological truism, “The absence of evidence is not evidence of absence” is based on this principle, regions that go largely ignored will also be absent in the larger narrative of archaeological history. This is evident in the example of the Arad - Sinai copper connection that typically ignored the possibility of Faynan being the source of copper, due to the absence of evidence (i.e. Amiran, Beit-Arieh, and Glass 1973, Porat 1989). There is a difference in the nature of

archaeological research between the northern part of Israel/Jordan and the southern part of Israel/Jordan that affects the interpretation of regional settlement data.

The fact that the northern areas have tell sites with deep occupation histories offers a different set of questions and motivations for archaeological investigation compared to the relatively short-lived occupations of the arid sites in the southern regions. The early excavations in the Levant tended to occur at the larger tell sites in the northern part of Israel and it is in the stratigraphy of the excavated trenches at sites like Jericho and Megiddo that the story of the ancient Levant began (Lamon, Shipton, and Loud 1939, Kenyon 1957, 1965, 1970, Harrison 2004). By comparison most of the sites in the South tend to only be single occupation sites with preservation that made them comparable to a museum. However, the narrower period of occupation made them less suitable for early archaeological work that sought to better understand historical sites noted in the bible and able to tell a longer story through stratigraphy. Archaeology of the southern part of Israel was largely ignored until a series of major expeditions in the late 1970s and early 1980s, a reaction to the development of the Negev as a training area for the Israeli Defense Forces, after which the material of this region became better known (Cohen 1985, Haiman 1986, Lender 1990, Haiman 1991, 1993). Once the Israel Defense Forces were in place, research in southern Israel became difficult due to limited access. The structural issues that influenced the differences between the northern and southern sections of the Southern Levant led to a clear distinction in how well represented each region was in the archaeological literature. A clear example of this is the EBIV where the vast majority of sites known are in the Negev Highlands which led, in part, to the characterization of the periods as rural. However, the identification of so many sites as EBIV was based on the questionable dating of sites during the surveys of Cohen and many of those sites probably should be reassigned to less specific periodization (See discussion above in Chapter 4.3). Also, in recent publications and the southern part of the southern Levant is

almost totally ignored when making maps or discussing the major themes of the period. This is most evident in maps made of the region when discussing regional trends (e.g. Milevski 2009, de Miroschedji 2014, Fig. 22.1). However, the neglect seen in the history of archaeological excavation has not totally abated where there still exists a bias towards sites in the northern part of Israel, often the whole of the Negev being left off the map.

Despite the structural issues in the history of archaeological research that have separated research in the southern and northern parts of the southern Levant, the artificially imposed distinction between north and south does not belie socio-political differences that substantiates a rift in the material culture between the regions. In recent years there has been an effort to highlight the importance of East-West relations across northern and southern regions of the southern Levant throughout history with a special emphasis on the relationship between sites in the Negev and Edom (Bienkowski and Galor 2006). It is suggested that the East-West connection might have taken primacy when considering the extent of ancient polities throughout history. This research emphasized that the modern border between Israel and Jordan has only introduced an unnatural boundary for research (Bienkowski and van der Steen 2001). In the EBA evidence for roads that connected both sides of the Arava in a trade network during the EBII and EBIII hint at the antiquity of connections between Faynan and the Negev (Yekutieli 2006a, 2006b, 2009). The importance and primacy of East-West connections over North-South within the archaeological record is best talked about in terms of the exchange, after all it is long distance trade that makes the argument for social hierarchies in the EBA.

One of the important defining features already mentioned for the southern Levantine EBA was the clear increase in the amount of trade in different kinds of commodities in increased volumes. The fact that there is strong evidence for distinct interaction spheres within the southern Levant also plays a role in how the chronologies are constructed and interpreted

between the two different regions. One element of this is the variation of different fossil ceramic types that go in and out of fashion during each phase of the EBA. However, the absence of pottery is a problem at many of the Early Bronze Sites in the Negev Highlands where pottery is often very sparse, the forms are often not terribly diagnostic and instead lithics dominate (e.g. Saidel 2002b, Saidel et al. 2006, Rosen 2011b). This has led to the development of an alternative chronology based on the lithics that highlights distinctions between cultures in the northern, settled zone and the southern, arid zones based on the longevity of certain forms and different lithic “toolkits” compared to northern ones (See above Chapter 3.5 and Rothenberg and Glass 1992, Rosen 2011a). Lithics are but one item for which regional diversity of resources results in different primary regions of interaction. Another unique material that has been an important part of defining settlement in the southern part of Israel/Jordan is copper. In order to characterize the settlement of KHI it is necessary to discuss what the variations in the distribution of centers related to ceramic production and centers related to copper production throughout the EBA. The differences in the distribution of different key ceramic types in the EBA will reveal primary interaction spheres the conclusions of which are reinforced by the history of copper production.

4.5.1. Regional Pottery Variations in the Early Bronze Age: Production Centers and Petrography

Two kinds of ceramic analyses have been used to describe regional variation within the southern Levant during the EBA. First, ware description has been used to establish regional traditions that vary through time. A ware has been defined for the purpose of the EBA as “a consistent combination of temper, fabric types and manufacturing techniques for a range of forms” (Philip and Baird 2000b, 5). In addition to wares, petrographic studies have been used to model ranges of interaction, implicate trading routes, and refine ware descriptions.

Both of these ceramic datasets offers important contexts to understand the kinds of social interaction that occurred during the EBA.

The ceramic record for the EBA has highlighted regional variation from phase to phase and has been used as the basis for the description of the EBA social and political landscape as regionally varied (Philip and Baird 2000a). Problematically, this will require confronting historical confusion with the pottery sequences used as a proxy to describe the evolution of social power in the Southern Levant with different types corresponding to regional political shifts that no longer match the regional chronology (See Chapter 4.3.3.). In the past these debates for the final phases of the EBA tended to focus on the appearance of “foreign” pottery types as evidence of immigration and pottery “families” based on typological observations that marked regionally defined temporal and cultural shifts (Amiran 1960, Kenyon 1970, Dever 1973, 1980). With the new chronology the relative position of phases in the southern Levant have changed but chronologies of neighboring regions that have not changed as drastically meaning that the appearance of foreign forms is no longer anchored to the same regional political shifts. Petrographic studies have already highlighted problems in the assumptions of temporal and typological coherence in the older chronologies based on “families” used for the EBIII and the EBIV (Porat 1989, Goren 1996). Recent excavations have highlighted even more problems with the family concept due to stratigraphic overlaps in the assemblage that make the assumed chronological and regional assumptions problematic (Richard 2000). This data only lends further support to the fact that the equivalence of ceramic phases to shifts in the political landscape cannot be upheld. The implications of the resulting variety of interpretations of the EBA ceramic assemblage is that the regionalism of the different ceramic varieties contributed to complications in the long-term study of the EBA.

For the EBA two locally produced ceramic wares, Metallic Ware and Khirbat Kerak Ware (KKW), have been used as representative of how ceramic shifts can also represent

changes in political organization. Metallic Ware and KKW are the Levantine type-fossils for the EBII and III respectively, each with a unique production methodology. Recent studies have focused on these wares as a proxy to understand the degree of centralization of production from the EBII through the EBIII, which implies shifts in political organization (de Miroschedji 2000, Greenberg 2000). It is clear that in the EBII Metallic Ware was produced at a single location, and distributed to the surrounding region (Greenberg and Porat 1996). KKW by comparison was produced at a number of sites, but reflects a slightly larger distribution network. What is at question, is the whether from the EBII through EBIII there is a change in the production methods reflected through the shift from Metallic Ware in the EBII to KKW in the EBIII indicating also a change in degree of specialization of production observed at the production sites (de Miroschedji 2000, Greenberg 2000, Greenberg and Goren 2009). However, the EBII might be a phase that only appears at a limited number of sites (Joffe 2014). Additionally, KKW appears to be a migrating technology with origins in the Trans-Caucases and as a result its appearance is connected to socio-political events that transcend the Levantine region (Burney 1989). KKW has been identified as representative in a shift towards a focus towards an increase in aesthetic value over functional value in ceramics. Two arguments derive from this observation. Firstly, it is argued that KKW represents an intruding technology that reflects a change towards a more heterogeneous production system with less specialized production and a number of producers spread through the regions of the Southern Levant (Zuckerman, Ziv-Esudri, and Cohen-Weinberger 2009). Alternatively, this can be interpreted as a standardization in aesthetics, as KKW tends to be distributed over a wider area than the Metallic Ware (Iserlis 2009). The recent identification of Metallic Ware, as a trade item, and KKW, a major part of the assemblage, at Har Hemar, near the Dead Sea, farther south than previously identified, lends credence to the hypothesis of greater regionalization over time (Yekutieli 2009, Greenberg and Goren 2009). However, at Har Hemar there are only

a few representatives of each of these vessel types. The appearance of such vessels so far south points to both KKW and Metallic Ware being a valued trade-good, and point to north-south interaction, but serves little other purpose other than to say that interaction/trade existed at a limited scale. The fact that neither of these material types enters the Negev areas and barely permeates the regions just to the north reinforces the point of a north-south divide.

The divide in the ceramic assemblages that is plainly evident between northern and southern areas of the southern Levant is important for the interpretation and reinterpretation of material found in southern areas of Levant. The distinction between northern and southern assemblages makes ceramic correlations between the northern and southern sequences more complicated. Especially if we take for granted the idea of different chronological formations for the two regions, it becomes more difficult to anchor the ceramics of the EBA in the south using northern settlements.

After the EBIII the predominant model for ceramic traditions reinforces regional distinction over regional interaction. Amiran (1960, Pg. 209-215) was the first to introduce the concept of families introducing a northern, southern and Megiddo group. Dever (1973, 56-59, 1980, 45-49) later expanded the concept to include seven different regional families¹⁵ that in additional regional significance also had chronological significance. Dever's work was followed by later researchers that utilized the family concept to highlight the increased regional distinctions during the period but refined the concept to highlight the contemporaneity of the ceramic families within sites (Palumbo and Peterman 1993, Adams 2000, Richard 2000, Palumbo 2001, Pg. 240-244). The result of the revisions by other

¹⁵ They are the Northern Family (abbr. N), the North-Central Family (NC), the Central-Hill Family (CH), the Jericho-Jordan (J), the Southern Family (S), the Transjordan Family (TR) and the Coastal Family (C).

researchers highlighted the fact that while the families seemed to represent traditions, their geographic isolation was not as clear as initially postulated.

Petrographic research on ceramic material from the Negev region has been especially important to help clarify how the family concept affects all sites related to copper production. Petrography makes the important determination of clay sources for vessels in order to highlight general trading routes and interaction spheres. For the EBII petrography from Arad, sites in the Negev and southern Sinai highlighted interaction between each of the regions and established the assumption of a connection between Arad and copper producers in southern Sinai based on arkosic cooking pots found in both places (Amiran, Beit-Arieh, and Glass 1973, Beit-Arieh 1983, 1986, Porat 1989). That petrographic data highlighted the complexity of the ceramic trade, and by association it is assumed other commodities, around the Negev and Sinai regions. However, it should be noted that the directness of the connection between Arad and Sinai has been called into question due to the presence of the same kind of arkosic clays in the Faynan area. The presence of the same kind of clay source closer to Arad suggests the Arad cooking wares might just as easily come from Faynan (Adams 1999, Pg. 251). That connection would further confirm a connection between the Negev copper trade and Faynan in the EBII that is also evident based on copper lead isotope analysis (Hauptmann, Begemann, and Schmitt-Strecker 1999). Thus the role of Sinai in EBII trade is not well defined. By comparison, the connection between the Negev and Faynan is one that continued into the later part of the EB with the copper trading system evident at sites such as Ein Ziq and Beer Resisim.

The petrographic data from the various Negev Highlands mega-sites associated with copper production highlights the role that sites played in exchange networks within the southern Levant. Y. Goren (1996) published all of the petrographic data from the sites of Har Zayyad, Ein Ziq, Mashabbe Sadeh, Har Dimon, Har Yeruham, and Beer Resisim. All of the

sites had been excavated by R. Cohen (1999). The ceramics from the sites were identified to belong to six petrographic groups from Central and Southern Jordan, the Central and Northern Negev, the vicinity of Biq'at Uvdah, and the Judean Hills. Goren's (1996) analysis found that 80% of the ceramics examined originated from outside the Negev region. Of that 38% were from Jordan with 23% coming from Central Jordan and 15% coming from southern Jordan (See Figure 4.18). An important finding regarding the families was that Dever's families S and TR may in fact overlap, both being made of the same kinds of clay, which would indicate that the assumed geographic separation between the forms was in fact false (Goren 1996, Pg. 59). According to Goren, the traditional distinction between the 'Family S' and 'Family TR' forms is blurred by the petrographic findings, which indicated that a significant number of the 'Family S' forms examined were of Jordanian origin on the basis of petrography. He suggests that, if it were to be found that the geographic distribution of these two families does indeed overlap, then the differences between them may well have chronological implications, and that the assumption that the 'Family S' ceramics may be later development than 'Family TR' may well prove to be correct (Goren 1996: 59). Also at the one smaller site from which petrographic information is available, Rekhes Nafha 396, the pottery shows the same pattern of origin as the larger sites (Saidel 2002a). Similar sourcing of the ceramic materials across the Negev Highlands, independent of site size differentiation deepens the relationship between the Negev Highlands and the Faynan district as being highly integrated parts of an economic system, perhaps even on a more egalitarian basis in which rank-size distribution does not significantly factor into the interpretation of said relationship.

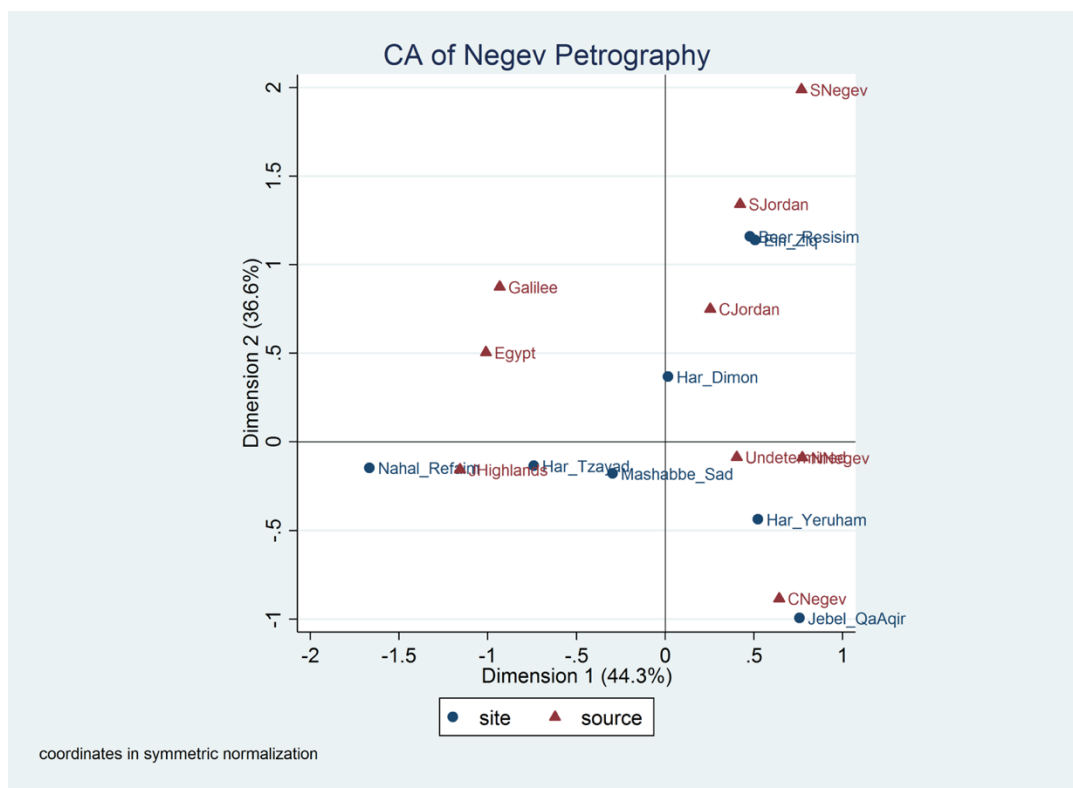


Figure 4.18: Correspondence analysis of region of origin and site of discovery for petrographic data (Uses data from Goren 1996). Most notable is that the assemblages from Ein Ziq and Beer Resisim are nearly identical.

The data derived from the published petrographic data highlights the role of the Negev as a transit zone throughout the EBA. Petrographic studies such as Porat's (1989) and Goren's (1996) allow for the definition of rough boundaries of interaction relating to the copper trade by showing the movement of ceramics within the EBA economic system. First, material for the pottery is sourced and found in a region that goes no further north than Arad. Second, the distribution does not indicate centers and peripheries of pottery production; instead it shows a complex trade network with multiple sources of pottery based on ware-type distributed through the region. Third, there is a strong correlation between a ware-type and the fabric the pot is made from. Either local potters specialized in vessel types or for each type of vessel there was a particular preferred fabric. Fourth, there is intra-regional variation in pottery types with certain types only distributed within confined regions. The appearance of pottery vessels

from so many other locales highlights the intermediary status of the inhabitants of the Negev sites, but the range of interaction is limited to neighboring regions as a part of the exchange of copper and other kinds of trade-goods.

The existing corpus of information from the EBA of the Negev has significant implications for contextualizing the trade of copper during that period. For KHI preliminary and unpublished work has already been carried out by Russell Adams. One of the key ceramic materials were the molds used for copper production that were identified with the Arkosic group, the same as 15% of the ceramic finds in the Negev area (Discussion of molds in the next section, Goren 1996, Pg. 54). The petrographic analysis by Adams (unpublished) of ceramic vessels from his Phase 5 and 6 (Stratum III and IV respectively in this dissertation) showed 82% to be local to southern Jordan, 8% from the Negev and the remaining 10% were unknown with half potentially being long distance trade goods. Adams notes that the best long distance evidence come from one vessel made of coastal sand. Given the existing data, no further petrography was performed as the petrographic evidence clearly shows that the inhabitants of the Negev were active traders with their neighboring regions. Evidence for the few sherds that traveled long distance at KHI highlights connections, but no evidence for direct interaction with Egypt or other larger states is evident based on the ceramic assemblage.

Based on the petrographic data from key Negev sites through the EBA and general history of important ware distribution the general range of interaction during the EBA is exposed. For much of the EBA the more densely settled areas in the north remained separate from the copper bearing areas in the arid south. This is seen in the distribution of the key EBA fossil types, Metallic Ware and KKW, that have not been recorded below the Dead Sea. Additionally, the key trading vector of the Negev Highlands, where petrographic evidence highlights sourcing ceramics from a wide variety of sources, does not have clear evidence of interaction with northern areas. Importantly for Faynan, by comparison to Negev sites the

implications of the petrographic data are that the vast majority of trade didn't involve vessels with their contents, but perhaps just the contents. This offers a context with which to discuss the major resource export of Faynan, copper, which didn't require large vessels to trade over long distances. As a rare resource, access to copper through time highlights complementary aspects of patterns of interregional exchange and regional boundaries during the EBA that complements ceramic data to describe the underlying organization of the EBA exchange system.

4.5.2. Copper Production and Exchange in the Early Bronze Age

The petrographic data from sites in the Negev Highlands and Faynan provides important context for a copper exchange network that operated in that region during the EBA. Significantly, the ceramic data from sites in those regions does not include a lot of archaeological material from areas beyond the immediate neighboring region. The copper production indicates complex organization structures but material culture highlights trade was not of great distance. Knowing the predominant extent of the ceramic trading network confines the expectations for the overall extent of the copper trading network directly associated with sites of production in Faynan (See Figure 3.1). It follows that it is important to compare the extent of the copper trading network to the ceramic network to test whether they overlap. A review of how the locations where evidence of production of copper varies through time indicates important changes in the overall copper production and exchange system and helps to contextualize locations where finished copper objects have been found. When considering archaeological copper deposits, it is also necessary to characterize the different kinds of deposits as they indicate important details of the social and political context of the total copper production system. Thus a regional *chaîne opératoire* of copper production

through the EBA gives context to the significant temporal variation of site locations for the production of copper (Theoretical background discussed in Chapter 2.5).

As a limited resource, the geographical relationship between the different parts of copper processing is an important reference to describe the investment in production. The most important factor for determining the importance of site location is the distance between primary smelting sites and ore sources. In the Early Bronze Age, the location of copper production as a commodity was limited by a number of technological factors most important of which was transportation, which for intense production logically places all aspects of production as close to the mines as possible. It is expected that that when planning to produce large the quantities of metal smelting will occur near the mines due to the mass of ore compared to the final product. If production is further from the site of production the scale of production will often be less (See Figure 4.19). The other constraint for copper production is the availability of resources necessary for smelting, especially charcoal. It has been estimated that the amount of charcoal to ore charge using ancient techniques is 20/40 to 1 (Horne 1982, Pg. 12). If the estimates for copper production during the EBA are correct for Faynan that means an estimate of 9000 t - 15000 t of charcoal (See Table 2.1). While there is good evidence for local availability of trees, it is also suggested that they were being exploited significantly around the time of the Third Millennium (See discussion of environmental constraints in Chapter 4.4, Hunt, Gilbertson, and El-Rishi 2007, Pg. 1323). The acquisition of charcoal would have been a significant step in the production process that would have required considerable time harvesting trees nearby. Plainly, for each of the major processes in the production of copper there are important associated practical constraints that implicate significance for the location of each step in the production process and each combination of processes in a place implies something about the total system. The model fits the EBA where in the beginning a dispersed set of production centers existed across the copper producing

zone. The eventual development of a regional center for copper production closer to the mines coincides with the development of urbanism in the Levantine EBII-III. The following collapse of the urban system in the EBIV sees a return to the dispersed set of production locations. The contextual details of these steps is an important part of interpreting the total copper producing system.

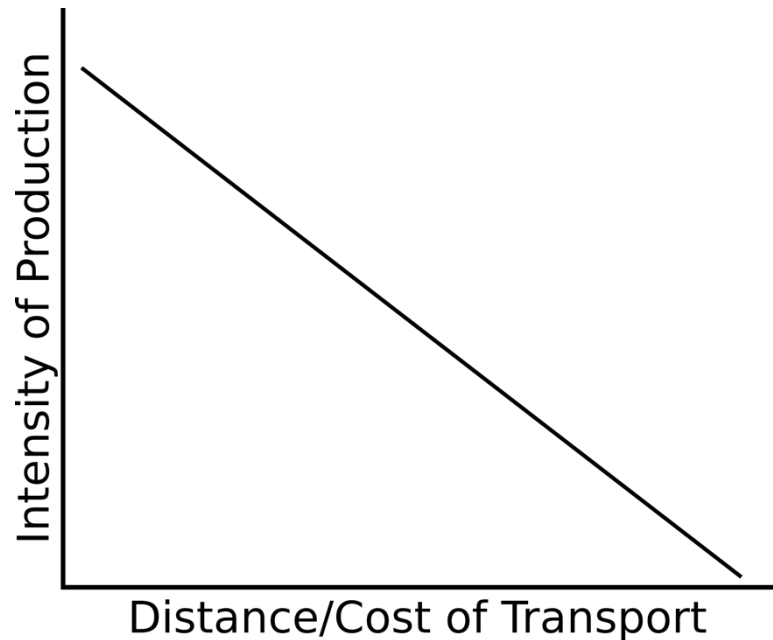


Figure 4.19: Graph highlighting the expected relationship between distance from the mines and the level of production.

At the start of metal production in the Levant the location of smelting was exactly where one would not have expected, often appearing far away from mining centers. In fact, there is a lack of evidence for habitation or smelting in the region of the ore sources for most of the Fourth Millennium (Hauptmann 1987, Hauptmann 2007, Milevski 2009). Rather than smelting near the mines primary smelting of ores from the southern Levant took place in the Beer Sheva valley reflecting the low intensity of production at the start of copper production (Levy and Shalev 1989). This reflects the fact that states had not yet developed in the southern

Levantine Chalcolithic, so the production of large quantities of metal by specialists was not necessary.

Towards the end of the Chalcolithic, leading into the EBI, sites associated with copper production started to appear near the mining centers of Timna (Rothenberg 1999) and Faynan (Levy and Najjar 2007). Near Aqaba, 20 km from the Timna mines the sites of Tall Hujayrat al-Ghuzlan and Tall al-Magass were the first sites in the region to produce ceramic ingot molds in limited quantities and a plain array of shapes (Hauptmann, Khalil, and Schmitt-Strecker 2010, Notroff et al. 2014). Those ingots bear resemblance to other ingots found at Maadi in Egypt highlighting connections between EBI copper producers and the developing Egyptian state (Rizkana et al. 1987, Pl. 4:9-11, Harrison 1993). Evidence for the presence of Egyptian trade was also evident in other parts of southern Israel (de Miroschedji 2002). To support the trade from the ore sources there is an increase in the number of sites along the “Way of Horus” in northern Sinai (Oren 1973). As the first evidence of more intense copper production designed for the export the raw copper, the two sites also represent the first smelting close to the copper mines along the Arava Valley. In Faynan the appearance of the site Wadi Fidan 4, 10 km from the ore sources, indicated an occupation similar to Tall Hujayrat al-Ghuzlan and Tall al-Magass (Adams 1999, Pg. 53). Copper production at Wadi Fidan 4, Hujayrat al-Ghuzlan and Tall al-Magass ended midway through the EBI, but continued at other sites further away from the mines (Shalev 1994). The most important and best known is Afridar, near Ashkelon, on the Levantine coast (Shalev 2003). During the end of the EBI Egypt exerted direct influence over the area of southwestern Israel and engaged directly with the inhabitants of sites in the Negev Highlands (Yekutieli 2004). The fact that Afridar seems to sustain a position as a locus of copper production through the EBI has been suggested to be due to the site’s importance of a hub of trade with Egypt and the Northern Levant (Gophna and Liphschitz 1996, Golani 2004, Golani 2014). After the EBI Egypt played

a less involved role in the southern Levant, but trade with the region continued to be important.

The important change from the EBI into the following EBII was the reconfiguration of the Levantine settlement pattern, with large, independent "urban" settlements appearing. Starting in this period a feature of Levantine trade in the settled areas is the production, exchange and consumption of ores and copper products (Greenberg 2002, Pg. 117-121). Of the large EBII sites Arad, in the northern Negev, showing the greatest density, with 212 copper objects including axes, one adze, chisels, and pins/awls that have been universally sourced to Faynan or Timna (Amiran 1986, Hauptmann, Begemann, and Schmitt-Strecker 1999, de Miroschedji 2002). Pins/awls make up 73% of the assemblage and the objects are widely distributed leading to the conclusion that they were part of regular activity, and not necessarily elite tools (Ilan and Sebbane 1989). Provenience studies of copper objects from areas north of the Negev, at sites like Kfar Monash and Pella, indicate that the objects originated both from Faynan and Anatolia (Phillip, Clogg, and Dungworth 2003, Hauptmann and Schmitt-Strecker 2011). The provenience data reinforces the regional distinctions between the northern and southern areas of the southern Levant but highlighting the different interaction spheres. By comparison to the areas to the north, sites in the Negev continued focus on interaction with Egypt.

During the EBII the Sinai Peninsula was added to Timna and Faynan as an active copper production zones in the southern areas of the southern Levant. Although many locations have been identified in the Faynan area for smelting during the EBII, there is only one, very small site, Barqa el-Hetiye, that has been identified where casting would have taken place (Fritz 1994, Adams 2003, Hauptmann 2007). In Sinai a number of sites appear near the copper mines in the south. Based on ceramic petrographic studies it is suggested that there is a connection between the Sinai sites and Arad which has led some to call the occupation of

southern Sinai “Canaanite” (Discussed in previous section Amiran, Beit-Arieh, and Glass 1973, Beit-Arieh 1986). However, there is some conflict about the direction of influence with the opposite possibility also proposed, that the settlement in Arad had its origins in Sinai via the Negev (Finkelstein and Perevolotsky 1990, Finkelstein 1990). The work of Beit-Arieh in southern Sinai revealed metallurgical installations for finished products on a scale smaller than that of KHI, including casting molds made of sandstone (Beit-Arieh 2003). However, the sourcing of the copper objects from Arad indicates that all of the copper found there did not originate in Sinai (Hauptmann, Begemann, and Schmitt-Strecker 1999). The disconnect between the copper and ceramic data might indicate that while the sites in each area were inhabited by groups within the same sphere of interaction, the flow of copper from Sinai was not back up to Arad, but instead moved to Egypt. It was during the EBII that KHI was first occupied, however, it is not until the following period that large-scale production of copper occurred.

The regional copper trading network in the areas surrounding the Negev Highlands with smelting occurring in Faynan began in the EBII and continued through the end of the EBIV. The revision of the dating schema makes it difficult to take all of the data from Negev sites at face value (as discussed in Chapter 4.3.), nevertheless the general trends in settlement patterns will be used but with known caveats. It is clear that following the EBII the production and distribution of copper played a major role in the settlement of the Negev Highlands and Faynan on a larger scale. A number of sites including Khirbat Hamra Ifdan, Be’er Resisim, Har Yeruham and ‘Ein Ziq have all yielded large deposits of crescent shaped copper ingots. Additionally, the peripheral sites like Rekhes Nafha 396 and the Camel Site have also yielded a copper ingot fragments (Saidel 2002a, Rosen 2011b). In all cases the ingots themselves can be described as roughly triangular with a flat head on the top. The majority of the copper finds from the major later EBA Negev Highlands sites (‘Ein ‘Ziq and Be’er Resisim) have been

sourced to the Faynan region (Segal et al. 1996-1997, Segal and Roman 1999). At KHI a large number of copper ingots along with matching ingot molds have been found (See Table 4.2, Levy et al. 2002). As there is no evidence of smelting to the west of the Araba Valley after the EBII one has to assume that the ingots are being distributed through the Negev Highlands after production at Khirbat Hamra Ifdan or other sites that show evidence of smelting (Levy et al. 2002, Yekutieli, Shilstein, and Shalev 2005, Vardi et al. 2008, Hauptmann et al. 2015). Three sites with evidence of copper production were sampled as a part of this dissertation located to the east of KHI The exact chronology of those smelting sites is one of the primary issues dealt with in this dissertation. However, beyond production, the exact mechanisms of the copper trading network outside of the regions neighboring Faynan are still not well understood or discussed in the literature specific to Levantine EBA copper exchange.

One of the entryways to describe the copper exchange system is through an analysis of how property might have been conceived as a part of the copper exchange network. Recalling the earlier discussion from Chapter 2.2 property takes two forms for the purposes of archaeological analysis: movable and landed. Copper is certainly a movable form of property, but the contexts that it is often found are burials or other monuments often considered markers of landed property (Earle 1998, 2000). These work in combination as a part of copper trade as the protection of trade would have been an important element of trading large quantities of valuable material. The majority of finished copper objects discovered have been a part of hordes that typically contain weapons that seem to be deliberate deposits connected to cultic activity (Philip 1988). These collections of finished products are found in the settled areas north of the Negev located away from copper sources. Unfortunately, graves do not provide the best context to make a connection between use and ownership as it relates to trade due to the disconnect with the object's life-history. For instance, when copper objects are typically found in hordes and graves, they lack direct association with seals or other markings that

could help structure their relationship to social contexts (Beck 1984, Wengrow 2008). However, the objects do indicate spheres of interaction where provenience studies indicate that copper objects found in northern areas highlight connections not just to Faynan but also the northern Levant and Anatolia (Phillip, Clogg, and Dungworth 2003, Hauptmann and Schmitt-Strecker 2011). The evidence of mixed assemblages in the north, compared to assemblies of only Faynan copper in the south indicates that northern areas were probably the consumers of copper objects and hordes found in those cases would not indicate property as a part of trade on the behalf of the producers. While the mechanisms of ownership are unclear based on graves at northern sites, the data highlights long distance trade of copper that is not restricted to the Negev areas.

For the areas of the Negev and Southern Jordan the evidence for cemeteries or using graves as markers is relatively sparse. One of the problems with identifying similar burials in the southern part of the southern Levant is due to the absence of material evidence necessary to assign definite chronological phasing at cairns and other similar markers (Haiman 1992, 1996). Additionally, the cairns are not found in regular proximity of established sites or follow an architectural style that is typologically consistent. Despite the presence of potential territorial markers, it is impossible to determine if cairns or other similar features acted as markers of landed property in the Negev and Faynan EBA.

The difficulty of utilizing data to use landed property to understand the control of exchange processes for copper in the EBA leaves the use of movable properties as the only element to develop the context for copper exchange. The key objects to develop the context are the copper ingots and other copper fragments that have been found at sites across the Negev. The production of these final products has often been related to the activities of itinerant smiths due to the absence of metalworking installations at the larger sites (See Chapter 3.2, Haiman 1996, Cohen 1999, Haiman 2009). The assumption of itinerant smiths

for the whole of the EBA uncritically conflates data from all of the phases of the EBA. The itinerant merchant model directly follows Childe's assumptions about the copper production and distribution as a prime-mover for the "Urban Revolution" (Childe 1950/2004, 1956). However, from a purely theoretical perspective this assumption has been repudiated because it is impossible to take for granted that independent artisans were immune to social and political conditions (Rowlands 1971). Alternative mechanisms for the trade of metals throughout the EBA need to be considered to explain the observed distribution of copper objects that also take into account the larger sphere of power relations of the EBA.

In order to characterize how copper objects acted as property and the exchange that drove the movement of copper across the Negev areas from Faynan it is necessary to look more carefully at how the objects might have been used. One option is to talk about copper and its potential as a development as currency. The use of the currency concept takes advantage of the transitive properties of copper as a trade object. Very soon after the discovery of the first copper ingots, it was already suggested that they may have served as an early form of currency (Balmuth 1963, Kochavi 1967). As Marfoe (1980) notes, "[o]nce the utilitarian character of the metal was established, it provided an interchangeable and measurable resource item that was both abundant enough to be exchangeable and whose production was scarce enough or controllable enough to be valuable." It follows that producers use the process of standardization, as in the production of ingots, to improve transportability or to regularize valuation (Arnold and Santley 1993, Pg. 229). The fact that at the more peripheral sites like Rekhes Nafha 396 and the Camel Site pieces of ingots were also found, presumably split to form smaller measures for trade, might lend some credence to the use of the ingots as currency (Saidel 2002a, Rosen 2011b). The challenge to the currency model is the evenness of weight for the objects, where the only measurable Coefficient of Variation of ingots from KHI is a very high 20% (See Table 4.5 below). Although the appearance of ingots cannot be directly

linked to the sudden development of currency, they do offer an interesting alternative place from which to understand the role of intensely manufactured copper.



Figure 4.20: Fused ingots found as part of a cache in Locus 1010 at KHI, discovered in 1999. Photograph by A. Gidding, UC San Diego Levantine and Cyber-Archaeology Lab.

At the very least the use of regular mold shapes and forms is indicative of specific marking that highlights the intent to communicate certain ideas. The regular reproduction of a shape for ingots is indicative of marking or grading goods allowing for them to be more easily substitutable as in the traditional conception of commodities (See Table 4.5). However, there is also typically an assumption of a political structure that governs those standards, which have been called a kind of “branding”, to facilitate trade over long distances and facilitate the depersonalization of exchange (Wengrow 2010, Kristiansen and Earle 2015, pg 242). That kind of long distance communication would be important for two reasons. Firstly, the lack of Egyptian evidence at KHI and the range of interaction evident based on the petrography suggests some intermediaries in the process of copper exchange. Secondly, long distance

communication of value is necessary to prevent counterfeits and facilitate the trading process especially given the assumption of an intermediary moving the copper from Faynan to Egypt. The concern with quality of copper is evident from two examples in the broader Middle East. Excavations at Al-Aqir in Oman, an important source of copper on the Persian Gulf, revealed planoconvex ingots with slag hidden within to fake the weight (Weisgerber and Yule 2003). Clearly the form of the ingot would be an important indicator of origin of the copper and indicative of purity. The thin KHI form prevents fakes as in the Oman example. The other example highlights the importance of purity describing the nature of trading copper and the issue of purity as discussed in a letter dating to around 1750 BCE:

When you came, you said to me as follows: “I will give Gimil-Sin (when he comes) fine quality copper ingots.” You left then but you did not do what you promised me. You put ingots which were not good before my messenger (Sit-Sin) and said: “If you want to take them, take them; if you do not want to take them, go away!” ... Take cognizance that (from now on) I will not accept here any copper from you that is not of fine quality. I shall (from now on) select and take the ingots individually in my own yard, and I shall exercise against you my right of rejection because you have treated me with contempt. (Oppenheim 1967, Pg. 82)

Although this letter dates to 200 years after the EBA, clearly it was very important for the consumer to be able to trust the source of copper and as a result there was an incentive for a producer to mark the product in such a way that made a guarantee of quality; the technology must co-develop with the social value that it aids (Beinhocker 2006, Pg 15-16). The role of form in communication lessens the negative impact of the absence of well defined standards in weight of ingots at KHI. The alternative interpretations of the ingots as either a form of currency or as a kind of branded object forces a reconsideration of the methods of trade for copper in the EBA.

Table 4-5: Ingot measurements indicating three distinct sizes. Some of the ingots are corroded and the measurements cannot be used. EDM 10611 - 5, 10611 - 6 and 20505 were fused. 31461, 16011-11, and 20505-1 were too corroded to use for thickness. EDM 16011-6A was broken and could not be used for length and 16011-6 was dropped from the weight average as one was broken.

EDM	Sub #	Locus	Basket	Area	Length		Width		Thickness		Weight (g)	
20217		1521	17237	C	4.712	Avg.: 5.7925	0.744	Avg.: 0.8645	0.857		10	
41901		2631	52048	Y	6.873		0.985		0.775		18	Avg.: 14
18479	1	1478	16600	C	12.645	Avg.: 12.836	2.57	Avg.: 2.386	1.066		85	Avg.: 87.5
18479	2	1478	16597	C	13.027		2.202		0.936		90	
31461		2094	56684	H	21.369		2.816		1.667		225	
16011	10	1010	14749	H	22.431		1.108		3.49		240	
16011	4	1010	14749	H	23.793		0.981		3.261		240	
16011	9	1010	14749	H	23.805		1.041		3.185		245	
16011	12	1010	14749	H	21.405		1.039		3.564		255	
16011	3	1010	14749	H	21.242		1.133		3.847		260	
16011	2	1010	14749	H	21.448		1.129		3.748		285	
16011	8	1010	14749	H	22.658		1.116		4.149		315	
16011	7	1010	14749	H	24.809		1.824		3.736	Avg.: 3.18 SD: 0.78	345	Avg.: 299.38 SD: 57.76
16011	1A	1010	14749	H	22.208	Avg.: 21.96 SD: 1.33	1.07	Avg.: 1.12 SD: 0.21	3.584		395	
16011	11	1010	14749	H	21.64		3.573		3.432		410	
16011	6A	1010	14749	H	15.881		0.903		3.354		650	
16011	6B	1010	14749	H	22.299		1.039		2.829		650	
16011	6C	1010	14749	H	22.44		0.958		3.167		650	
20505	1	1318	35899	C	19.219		4.104		1.749		367.5	
20505	2	1318	35899	C	19.584		4.2		1.5		367.5	
16011	5A	1010	14749	H	22.486		1.148		3.677		280	
16011	5B	1010	14749	H	21.266		1.101		2.547		280	
16011	5C	1010	14749	H	21.255		1.278		4.164		280	

The challenge to building a model for the consumption of copper during the EBA is the lack of written data from contemporary Levantine sites or provenance data from Egypt. When looking at neighboring areas, often times data that is used to formulate models is misrepresented as contemporaneous with the model produced. From a similar timeframe of the letter used above, the Middle Kingdom Beni Hasan tomb painting of has been used to build the aforementioned itinerant merchant theory, which is highly problematic due to the contingent nature of the iconography and has led to its misappropriation by researchers of the Levantine copper trade (Cohen 2015). Additionally, only a very limited amount of provenance data has been produced for Egyptian artifacts using x-ray fluorescence and not using lead isotope analysis that would match the copper to the ore source (Hauptmann, Begemann, and Schmitt-Strecker 1999, Hauptmann and Schmitt-Strecker 2011, Hauptmann et al. 2015). The Egyptian data shows that through the end of the Old Kingdom most of the copper artifacts contained less than 1% Arsenic and many were nearly pure copper that would match the typical character copper produced in Faynan (Cowell 1986, Pg. 465). An important distinction within the Old Kingdom tools analyzed was between model tools and full sized axes; between the two the models were mostly pure copper and the full sized tools were mostly arsenical copper (Cowell 1986, Pg. 467). This is interesting due to the role that model tools were thought to have as a representation in the afterlife of a patron-client relationship between the elite and the workers that were given tools to perform tasks and has been seen to be evidence of attached specialization (Odler and Dulíková 2015). That is not to say that these textual and chemical references cannot be used, but they come with the caveat that the data isn't entirely reliable and especially in the Beni Hassan case these caveats are not explained in the accompanying literature.

The data that reflects the consumption of copper in the Old Kingdom Egypt indicates that elites were in direct control of production. All metals were weighed under the supervision of the state administrators before being distributed (Eyre 1987, Pg. 13). The organization of metal redistribution contrasts with the organization of bread and beer distribution, which has been used to indicate a locally determined, informally regulated redistribution system (Warden 2013, Pg. 245-268). It seems that for a more valuable material like copper different mechanisms were used to regulate trade within Old Kingdom Egypt (See Chapter 2.3). For metal redistribution the same general model was also present in Mesopotamia during the Akkadian period. The few texts from the period describe huge quantities of metals that were imported and others reference the metals as being a part of the city's stores and owned by the city (Westenholz 1984, Pg. 27-8). The underlying rationale in both Egypt and Mesopotamia for elite control of metals was that all importation occurred in large quantities and the costs of the metal were too high so that only elites could manage the process of procurement (kings or city as corporate groups). It follows that the trading relationships in that case had to be between individuals that could manage trade with fellow elite groups when trade was at its height. If the textual data is taken at face value, the lack of standards for ingot weight at KHI is even less important. Instead the communication of quality through forms that cannot include fakes would be more important if elites are handling the process of import to Egypt using their own weight system.

Following the EBA the Faynan copper production system collapses with production not to resume again until the Iron Age (Levy, Najjar, and Ben-Yosef 2014). What isn't clear is the exact EBA chronology for the shift from active intense production to a collapse of copper production. This dissertation helps solve this chronological problem that is essential for modeling the social dynamics of EBA copper production. The models already outlined above

for the EBIV would indicate that the end of production was in fact also the height of intense copper production for the EBA, but the correspondence of that production doesn't fit with the expectation for a well organized trading partner with whom to exchange. Two points need more clarification. First, it is necessary to delve more deeply into the organization of KHI in order to develop a more complete model for how production was organized at the site. This is necessary to enhance the current perspective of the copper trading network of the southern Levant by adding data describing the way that copper production was organized in the EBA. Second, it is necessary to clarify the chronology of copper production from the EBII through the EBIV. With those two data points in place will be possible to offer the necessary context to describe the regional *chaîne opératoire* or industrial landscape for copper production and distribution.

4.6. Conclusion

The Early Bronze Age in the southern Levant was the first experiment with urban social complexity for the region. The traditional narrative of a rise and collapse of the urban system that matches the progressions of Egypt and Mesopotamia has been largely proven to be inaccurate. That inaccuracy is the result of enhanced data of the trend, which largely remains but with some important caveats. The most important of the caveats is that the accepted chronology for the whole of the region is inaccurate. In fact, the data indicates that within the southern Levant a number of sub-regions show independent trends that have sometimes made it difficult to make a neat synthetic model for the EBA. One of the primary regional distinctions based on material culture is between the northern, settled areas of the southern Levant and the southern desert areas. Those distinctions are reinforced by trade patterns that

highlight north to south interaction, but smaller primary interaction spheres that focus east to west.

Copper, as one of the most important new, labor intensive commodities in the EBA, is an excellent material to understand aspects of the development of the urban system. During the EBA it is produced in large quantities for the first time. An important element is the communicative element imbued in the regular production of a distinctive ingot form. Copper's durability as a metal and the fact that it is often found in contexts associated with power imply that copper held great value as a trade commodity. This is borne out in the large quantity of copper implements that were likely made from Faynan copper found in Egyptian elite burials that substantiate the power dynamics of the Old Kingdom political hierarchy. However, the organization of production of copper is still relatively unknown. As a result, it is important to consider how production at the site of KHI was organized. As the best preserved copper manufacturing installation of the EBA, an analysis of the distribution of ceramics within the site will offer key insights into the daily activity of the site. With that data it will be possible to contextualize a model for KHI that considers aspects of the revised socio-political chronology for the EBA and clarifies the role that copper played in the development of the urban EBA.

Chapter 5: Using Ceramics to Estimate Intra-Site Natural and Social Processes: Statistical Analysis of the Total Assemblage to Understand Craft Production

In order to develop a model for the development of copper production at EBA KHI it is necessary to analyze the distribution of metallurgical material culture within the site. As discussed in Chapter 2, Costin's (1991) provisions of context, intensity, scale and concentration offer the key variables for the analysis of craft production. Based on the previous work at KHI the most comprehensively published material highlights that production at KHI operated at an unprecedented level of intensity, scale and concentration for the EBA (Adams 2002, Levy et al. 2002). However, the context of production, used to determine attached or independent production has not been defined either through inter-regional or local studies. The prevailing data for inter-regional correlates ties production at KHI to the EBIV in the Negev Highlands, which according to the prevailing models for this period connect that production to the First Intermediate period in Egypt (Discussed in Chapter 3). The lack of centralization in Egypt would suggest independent specialists. However, the revised dating of the EBA for the whole of the southern Levant has made that connection more ambiguous and drawn the data on which the existing model is based into question. The analysis of the distribution of animal bones in an effort to detect the presence of elites at KHI has been considered inconclusive (Muniz 2008). Ceramics offer a complementary study to the data based on animal bones as a means to look at different kinds of processes related to food preparation, storage and consumption in the search of a local elite presence.

One of the challenges of using the ceramic assemblage at KHI for the analysis of site organization is the overall size and density of that material. In total 6033 kg of ceramic vessels were excavated at KHI over four excavation seasons, the largest ceramic assemblage for any site that was a part of the ELRAP. A preliminary sorting to the material was not completed in

the field, as a result significant effort was required to provide the necessary data to produce a general distribution of the pottery across the site.

The large quantity of pottery required a comprehensive data management system in place before analysis could begin. Within the ELRAP data management has become more and more important as a part of a “cyber-archaeology” system that brings together a number of digital technologies for archaeological research (Levy 2015, Pg. 28). To meet the needs of this dissertation and the ELRAP the ArchaeoSTOR project was developed to produce a mechanism by which it was possible to easily collect and link larger quantities of data than was previously possible. ArchaeoSTOR was designed to serve as a data entry tool, repository for meta-data of artifacts, a means to inventory the large number of artifacts, and the subject of my NSF IGERT grant that I received to work on this material. The inventory management was import so that as artifacts were processed it was possible to manage the physical material in addition to the digital data.

With a tool like ArchaeoSTOR and a dataset that had not yet been inventoried offered the opportunity to explore new ways to deal with large ceramic assemblages with methods that took advantage of larger quantities of data used in other archaeological projects. Based on the initial counts, the total assemblage of pottery ended up being 196,591 sherds, with 19,486 diagnostic sherds. Typically, the non-diagnostic sherds are not considered for analysis by researchers. Rather than ignore the non-diagnostic sherds, they were used to understand general trends in how the assemblage was composed, which constituted an important step before more detailed analysis (Discussed in Chapter 6). Throughout the process the goal was to examine different aspects of how material is distributed within the site. Depending on the variables that are measured both even and uneven distributions will offer indications of different social processes that are important to give context to the rest of the data. The characterization of the ceramic material will build indices for different patterns of breakage

within the site that can be interpreted in conjunction with notes from the excavators. Using statistical methods that detect differences in sample variances within the site it will be possible to identify areas of variation that will be useful to guide later analysis. Beyond generating data, the process of recording and storing all of the material in ArchaeoSTOR provided a case-study to test the utility of ArchaeoSTOR for lab management and prepare it to be deployed in the field. Once the broad analysis was complete it became obvious where a more directed analysis of the thousands of sherds that were excavated would be most useful.

5.1. ArchaeoSTOR: A Data Curation System for Research on the Archaeological

While the ArchaeoSTOR project was primarily designed to serve the needs to the preliminary data-entry and data organization necessary for this research project, it was simultaneously intended to provide the data server for future projects within ELRAP. The goal was to meet the challenges for archaeology moving into the 21st century is the application of digital technologies to excavation protocols that have been in place for decades. One aspect of this challenge is understanding where digital technologies help the process of data collection and where digital technology might in fact be a hindrance to excavation processes.

The impetus to adopt a fully digital data management system derive primarily from the expectation that future research will continue to adopt and progressively exclusively utilize digital techniques. Looking both to the future and at present applications, in order to run a complex simulation based on archaeological data, the major immediate hindrance is not the computing power, but the initial data entry on which the simulation is to be based. Storing data digitally from the moment an artifact is taken out of the ground and throughout the process of artifact analysis makes the pipeline that will allow for the application of more robust computational techniques much simpler. The majority of examples from archaeology concerning the adoption of digital technologies highlight test cases that use a small dataset to

investigate a narrow analytical objective, but do not account for the total archaeological process (Kintigh 2006). That means that the full rewards of implementing the system might not be immediately apparent until more data has been digitized a usable way, but in the long term the availability of well-curated archaeological data for analysis will enable new kinds of analytical rewards.

The development of an archaeological data server includes a number of challenges that has prevented the adoption of such systems. Firstly, archaeology is inherently multidisciplinary, practiced inter-regionally, and has developed a number of different schools and approaches to research. That variability has introduced a number of challenges for which there might not be good solution. The development of archaeological databases based on legacy data is not a new process, and early attempts at regional databases for the EBA Levant had well documented challenges due to the unevenness of data (Joffe 1993, Pgs. 8-21). The lack of standards for how data is recorded is compounded by changes in the way that the data has been interpreted over time which means that maintaining the database to keep it up to data requires a long term labor investment. The cost in labor and materials for the development of a data server is the second challenge. Initial costs of computer infrastructures can be high and the programing of applications that can provide the flexibility in archaeological research approaches is challenging. Over time the price of technologies decrease, but also the maintenance of digital systems needs to also be a concern, especially secure, long-term storage. The costs for the development of a data infrastructure and the lack of standards for data recording is not just a problem for archaeology but one that is universally felt by scientists that work in separate work environments. In these situations, it is plain that data is recorded in different ways that suits both the methodological preferences of different groups, the different questions that are being asked and the different subjects of any given study. The fact that data is recorded in ways contingent to the research paradigm used by a research group

means that no data organization system will be perfect and that whatever is produced will not please everyone. Nevertheless, the development of ArchaeoSTOR proceeded using what were the best considered practices based on data models seen in a number of other publications (i.e. Schaub and Rast 1989, Shennan 1997, Rast and Schaub 2003, Greenberg and Keinan 2007, Levy et al. 2010, Kansa, Kansa, and Watrall 2011). The data server described in the following sections was developed and published with the help of Yuma Matsui (Gidding et al. 2011, Matsui et al. 2012a, Matsui et al. 2012b, Gidding et al. 2013, Gidding, Levy, and DeFanti 2014).

5.1.1. Rationale for Development

The primary goal of archaeological research is to tell the story of past cultures using the material record that is left behind. An important part of that process is the construction and testing of theoretical models that are able to compare aspects of cultures both diachronically and synchronically. In order to increase the scale and complexity of data analysis archaeologists have increasingly been turning to more efficient methods within the context of the modern research environment. One way to make data processing more efficient is to improve the way that data is stored and handled by streamlining the data acquisition process. The data management system, ArchaeoSTOR, provides the tools necessary to increase the speed of storing complex archaeological data and delivering that data to novel tools for data visualization. Total digitization of research in archaeology offers a way for archaeologists to meet the challenge of rapidly bringing excavated data to the public and professional communities efficiently. By digitizing the entire archaeological research process, it is possible to provide a means by which archaeological data can be queried and analyzed easily leading to simplified dissemination of data for research and the public. Important for field research, the design of the system allows for the user to generate data in the field, off the grid, using a

remote server and copy data back to a central repository after field research is complete (See Figure 5.1). This approach is essential to archaeological research, which has begun to adopt a number of data intensive research techniques, but can take place in remote locations with unreliable or slow internet access preventing regular access to an off-field-site server.

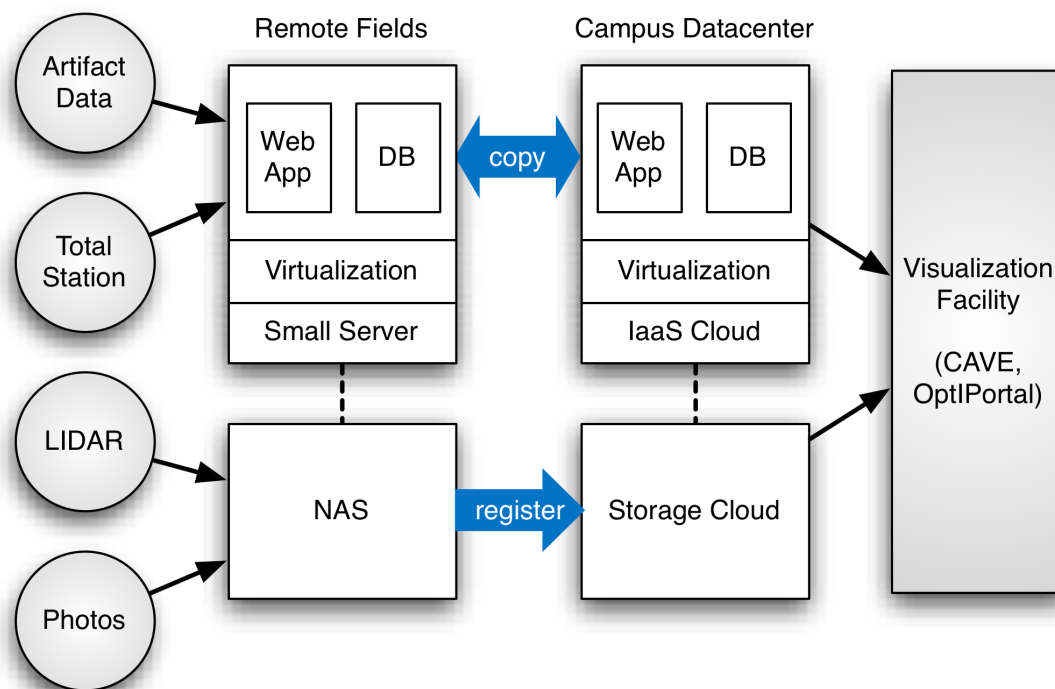


Figure 5.1: Schematic of the processing of data using ArchaeoSTOR (Gidding et al. 2013, Fig. 3).

The initial development of ArchaeoSTOR was to help solve one of the major challenges confronting the ELRAP; the data produced each season was more complex and larger in size continually adding to the large amount of legacy data in both digital and physical form. Before we developed the integrated database ArchaeoSTOR to link the various data collected for the ELRAP there already was a digital infrastructure in place. Total stations are used to map the progress of the excavation itself, digital photography to qualify the excavation and artifacts, and Microsoft Excel to annotate the progress of the excavation and artifact

analysis in digital forms for long term curation (See Figure 5.2, Levy et al. 2010). All of the data from those field seasons was stored in a loosely organized flat file structure that at times made connecting the different aspects of the field excavation time consuming and difficult if a file was not stored correctly. Additionally, changes in data structures occurred as a result of excavating sites that date to a variety of time periods using different archaeological sampling techniques. This was revealed to be a problem when we would want to tie together different datasets as a part of a GIS in order to make a statistical inference to describe different aspects of a site. Year to year the data could be organized slightly differently, which led to a lot of data cleanup. Additionally, even if all of the digital assets were properly organized, connecting all of the digital data to a specific artifact could prove difficult as we collect hundreds of thousands of artifacts year to year, if we need to review a group of artifacts it could be difficult to find a specific artifact within the thousands from each season. With this in mind, ArchaeoSTOR was developed to help manage the “avalanche” of digital and physical assets. Integrating such varied data helped to develop a more robust data structure, applicable to a number of different archaeological situations.

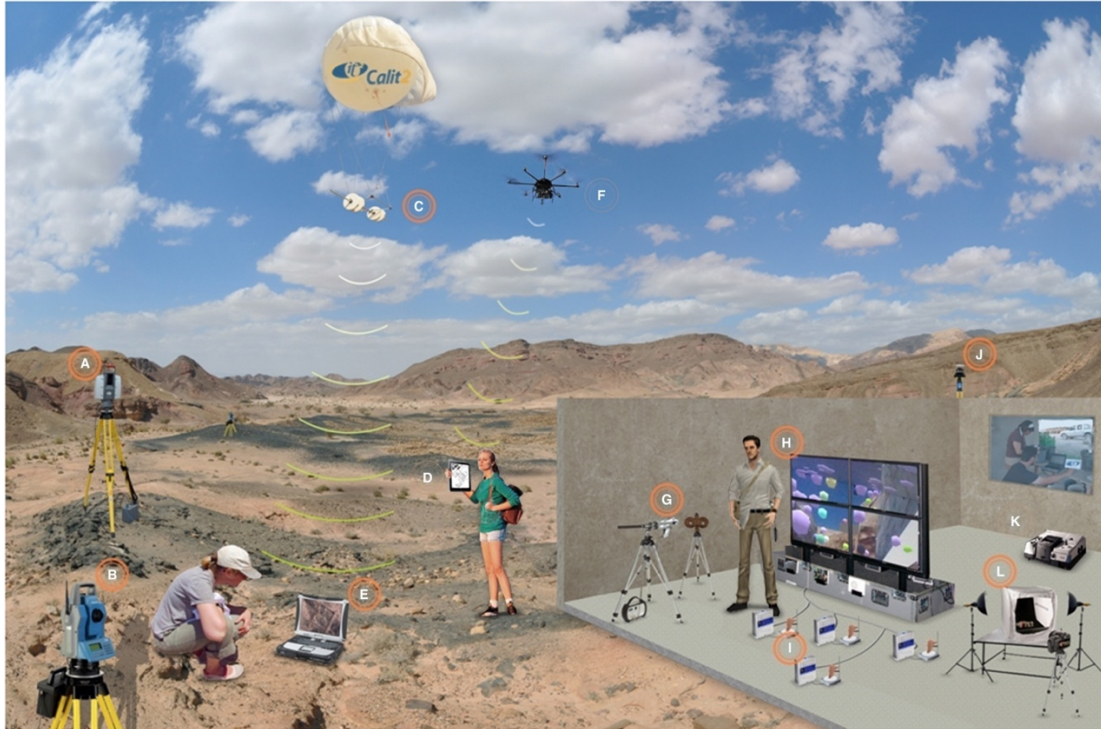


Figure 5.2: A model of the field recording methodology used by the UC San Diego ELRAP expedition. A. LiDAR Scanner B. Total Station (ArchField) C. Aerial photography platform D. Digital Note taking (Opendig) E. Aerial photography platform F. Octocopter imaging platform G. XRF H. Nexcave display I. Nextengine 3D scanners J. dGPS K. FTiR L. Digital photography. (Gidding et al. 2013, Fig 1)

5.1.2. Archaeological Data Management

Archaeological data management takes many different forms from excavation to excavation. Every project has its own methods that are used to archive the excavation process. Nonetheless, there are congruencies between the kinds of data that are collected at all excavations. Various researchers have worked on ontological issues to describe these similarities in methodology and as a way to bridge the gap between the different methodologies between researchers (Isaksen et al. 2009, Jeffrey et al. 2009). For instance, excavators will always map site horizontally to capture occupation levels and vertically to observe changes between occupation levels. Additionally, the site is always divided up into sections in order to give better context to artifacts collected. Artifacts are collected within

these spatial partitions in order to maintain contextual integrity and important finds are recorded as individual points. Similarities between archaeological excavations allow for the identification of facets of archaeological data collection strategies that offer lowest common denominator data types necessary to begin using digital data management.

Managing complex data sets has always been one of the most difficult aspects of archaeology. Archaeological data is nuanced both in its recording and subsequent presentation. This is inherent to the nature of archaeological data, which is drawn entirely from artifacts that present a 'silent' record of human activity for which multiple interpretations are possible. Building such a narrative for archaeology has traditionally meant spending countless hours analyzing and comparing material from a variety of sources, derived through different methodologies. Additionally, data is generated in remote and harsh environments, without the ability to connect to a central server. The best way to process this varied data is to link the methods of data collection through a manageable data system that uses a common denominator to relate findings. Not only does the data need to be well managed, but the system should also allow for on-the-fly recovery of the data as it is being excavated to facilitate different visualization environments to aid in the excavation and real-time analytical processes. Finally, data that is added in the field needs to be rectified with a central storage server that is used for high performance computing when not in the field.

The challenge for adoption of a system like ArchaeoSTOR is the adoption of a standard set of operating procedures that are flexible enough to be applicable to the variety of archaeological circumstances. A factor in universal adoption is that the discipline of archaeology has been slow to adopt digital techniques that encompass every facet of their excavation methodology. Using digital data structures forces the development of standard recording practices that doesn't exist with paper records. Although archaeologists have been using computers for archaeological research since the first personal computers became

available, there is no universal software or organizing principle for archaeological data storage and a result communication between projects has been historically difficult. This is especially true in reference to other fields that have been able to mobilize large-scale efforts to organize data management strategies (i.e. Geosciences Professional Services 2001). Over the last two decades a number of disparate archaeological projects have shown increased interest in developing digital excavation strategies. Volumes describing applications of digital technologies in archaeology have been published through the years but have not attracted widespread appeal (McPherron and Dibble 2002). Conferences like Computer Applications and Quantitative Methods in Archaeology have discussed many of these issues over the years and presented different ways of handling these problems (e.g. Frischer, Crawford, and Koller 2009, Earl et al. 2013). Applications have recently been developed commercially to help guide archaeological research from excavation through publication and digital dissemination, such as the Archaeological Recording Kit (ARK) (<http://ark.lparchaeology.com>) and the Center for Digital Archaeology (<http://codifi.org/>). While it would be good if many researchers adopted ArchaeoSTOR, unlike other data management projects we are not looking to use ArchaeoSTOR to ingest data from other projects. Instead the goal is to allow the data produced to be organized in a way that it is readily accessible for other users and archaeological data services.

5.1.3. Archaeological Data Recording

Typically, archaeology seeks to create a narrative from three sets of data: the material record, its spatial context and the temporal setting that allows for comparison of records between sites. Over the years and inter-regionally, archaeologists have used a number of methodologies to record artifacts and their spatial context to answer different questions about the past. The application of different methods has meant that comparing archaeological data is

difficult and fraught with complexities of melding different research methodologies established for dissimilar research objectives. This variation can even exist within a single project making the integration of ‘legacy’ data with newly derived data difficult. In order to deal with this problem a digital research environment that is flexible enough to handle multiple interpretive frameworks and offers a framework that allows for easier comparison and integration of data with a well-defined ontology is necessary.

Within the UC San Diego ELRAP expedition we have considerable experience with various facets of collecting archaeological data digitally. As noted above, the excavations led by Levy were among the earliest adopters of digital recording of archeological field sites and KHI was featured as the first test case in 1999 (Levy et al. 2001). All of ELRAP’s work has been focused in the area of the southern Jordan known as Faynan – one of the largest southern Levantine copper ore resource zones exploited in antiquity. Our research has focused on a ‘deep-time’ study of social change as it relates to ancient mining and metallurgy from Neolithic to Islamic times (~8700 BCE - ~1700 CE). The changes in digital recording methods that have been employed over the years have been outlined recently (Levy and Smith 2007, Levy et al. 2010). However, over that decade of digital data collection it has become increasingly clear that maintaining an organized flat file structure was not a long-term solution given the increasing complexity and size of data collected season to season.

For ELRAP, digital recording was initially adopted to aid the laborious mapping of archaeological surveys and excavations. Over time this basic goal has evolved using different technologies and methods as they became commonly available, feasible and affordable. The technologies we have adopted are varied in application and data output; to date we have published using high-resolution digital imaging, light detection and ranging (LiDAR) scanners, airborne imaging platforms fitted with high-resolution digital cameras, high-resolution desktop 3D artifact scanners, portable x-ray fluorescence (XRF), differential GPS

(dGPS), Fourier transform infrared spectroscopy (FTiR) and different absolute dating techniques (high precision radiocarbon and paleomagnetic dating; see figure 1). These new sources of data offer a number of challenges over time: they need to be integrated into existing data acquisition channels; they all use different data types/formats that are often incompatible effectively partitioning their use to discreet aspects of analysis; they represent a digital ‘data avalanche’ with increasing density/complexity that has become difficult to manage; and new technologies that use these data-sources are constantly being developed and applied which use already collected data in their own novel ways (Petrovic et al. 2011).

A good example of how a single type of data has transformed in utility for archaeology through the years is the photograph. Before digital photography, images were taken with great care of valuable finds and to document excavated site features of interest. The number of images in a season rarely exceeded 1000. These images were highly prized and primarily served a single purpose, publication. The early adoption of digital photography mirrored that process in archaeological research. Now we photograph every artifact multiple times, with more comprehensive images of interesting features on site, and have added aerial and GigaPan photography. The photographs also come from multiples photographers, each with different intentions for the image. We generate images by the tens of thousands each season in a raw format that takes up over a terabyte of data. Not only are these images used for publication, but they are streamlined into many different analytical functions for scientific visualization including the creation of structure-from-motion point clouds, display in three-dimensional models of the site, and guiding the illustration of features of the site (See Table 5.1). Thus, the increased complexity of how we deal with photography represents a subset of the exponential growth of data in terms of size, management complexity, and processing power need for applications using the data that we collect each field season.

Table 5.1: Changes in kind of photography and their most common uses as a part of the excavation. As a result of the ease of digital photography and the size of raw images it is possible to take a hundred thousand images in a multi-month season, all that need to be inventoried so that they can be found, and would require approximately 2 terabytes of storage space.

Type of Photography	Subject	Post-Excavation Uses	Quantity
Film	Site	Publications, Visual Analysis	Thousands
Film	Objects	Publications, Visual Analysis	Thousands
Digital	Site	Publications, Visual Analysis, Giga-Pan, Structure from Motion	Tens of Thousands
Digital	Objects	Publications, Visual Analysis, Structure from Motion	Tens of Thousands
Digital	Aerial	Publications, Visual Analysis, Structure from Motion, Geo-Rectification, Site Plan Drawing	Tens of Thousands

Two other data systems are used by the ELRAP to record data in the field and are complementary databases used by ArchaeoSTOR to describe the archaeological excavation. Firstly, there is data recording software called ArchField (Smith and Levy 2014). The advantage of ArchField is that all spatial data is stored in a PostgreSQL database, which makes connections between the databases simpler. This also facilitates rapid data entry through barcodes assigned to artifacts and contexts. OpenDIG, developed by Mathew Vincent,

is a piece of software that allows for digital site description and note taking (Vincent, Kuester, and Levy 2014). The three systems work together in order to provide the necessary recording of field excavations.

Other data organization systems have been built within the archaeological community over the years to try to deal with some of these problems. All of these focus on three different levels of analysis: macro-scale, micro-scale, or something in between. On the macro-scale the most common databases store information regarding individual site locations and some basic details as opposed to comprehensive data regarding the excavated materials examples of these types (see Digital Archaeological Atlas of the Holy Land (DAAHL) (Savage and Levy 2014) and Pleiades (<http://pleiades.stoa.org/>)). Other systems have been designed to help organize single-site level data focusing primarily on the basic spatial recording of artifacts and their contexts (see ARK (<http://ark.lparcology.com>), Online Cultural Heritage Research Environment (OCHRE) (<http://ochre.lib.uchicago.edu/>), Reconstruction and Exploratory Visualization: Engineering meets Archaeology (REVEAL), Integrated Archaeological Database (IADB) (<http://iadb.org.uk/>)). More recently there has also been a push to create digital repositories that can accept any kind of data, with coding sheets provided, in order to provide a central place for broad access to research (see the Digital Archaeological Record (tDAR) (<http://www.tdar.org/>), Archaeological Data Service (ADS) (<http://archaeologydataservice.ac.uk/>), or Open Context (<http://opencontext.org/>)). However, none of the systems mentioned above deal with the combination of intra- and inter-site analysis that includes a number of diagnostic tools for material analysis such as XRF and FTIR.

The most significant differences between ArchaeoSTOR and the aforementioned systems is the explicit focus on artifacts rather than contexts and independence from the internet for daily usage. As one might expect, the majority of the different archaeological data

management systems have some capability to input data regarding artifacts. What many lack, however, are tools that complement the digital record with the physical nature of artifacts. ArchaeoSTOR offers a system to manage the location of artifacts and to build inventories for shipping, museum loans, and other common occurrences. Our focus on tightly integrating microscopic and diagnostic methods from material science offers a method for artifact characterization within the database. Additionally, the data input mechanism relies on digital context records established during excavation in order to build the artifact records. Rather than relating context and artifact during data entry, relationships between the two are defined from the start. Importantly, all of this data is recorded in the field without a connection to a central server. These relationships have been drawn out in a system map that illustrates the data transfers within the system and establishes a set of standard descriptors used for each class of artifact.

5.1.4. System Map

In order to develop our system, we identified the most basic units of analysis and expanded workflows in order to maintain analysis at the lowest common denominator possible to establish a well-defined ontology. This was necessary to make sure that there was no redundant data within the system making the data immediately usable for later analyses. The primary data that all archaeologists deal with are artifacts and all data types collected are essentially annotations for artifact description (See Figure 5.3). ELRAP field workers collect artifacts in two ways simultaneously using an on-site GIS recording system. One collection strategy collects artifacts in bulk within a predefined spatial unit. These “bulk” artifacts are then sorted and processed as a part of later analysis. The second strategy records the precise location that an important find is located along with an on-site diagnostic description with a wide variety of different designations possible. The metadata that is stored as a part of

annotation provide the means to anchor artifacts in space and time, to characterize digital data assets beyond brute force recorded data and reevaluate the data and its validity at a later time. We distinguish within the data two different ways of identifying difference between artifacts: material difference and meaningful difference. The concepts of material difference and meaningful difference are modeled on the idea of genotype and phenotype in genetics. This model works to show how archaeologists evaluate the meaning behind observed variation in archaeological material.

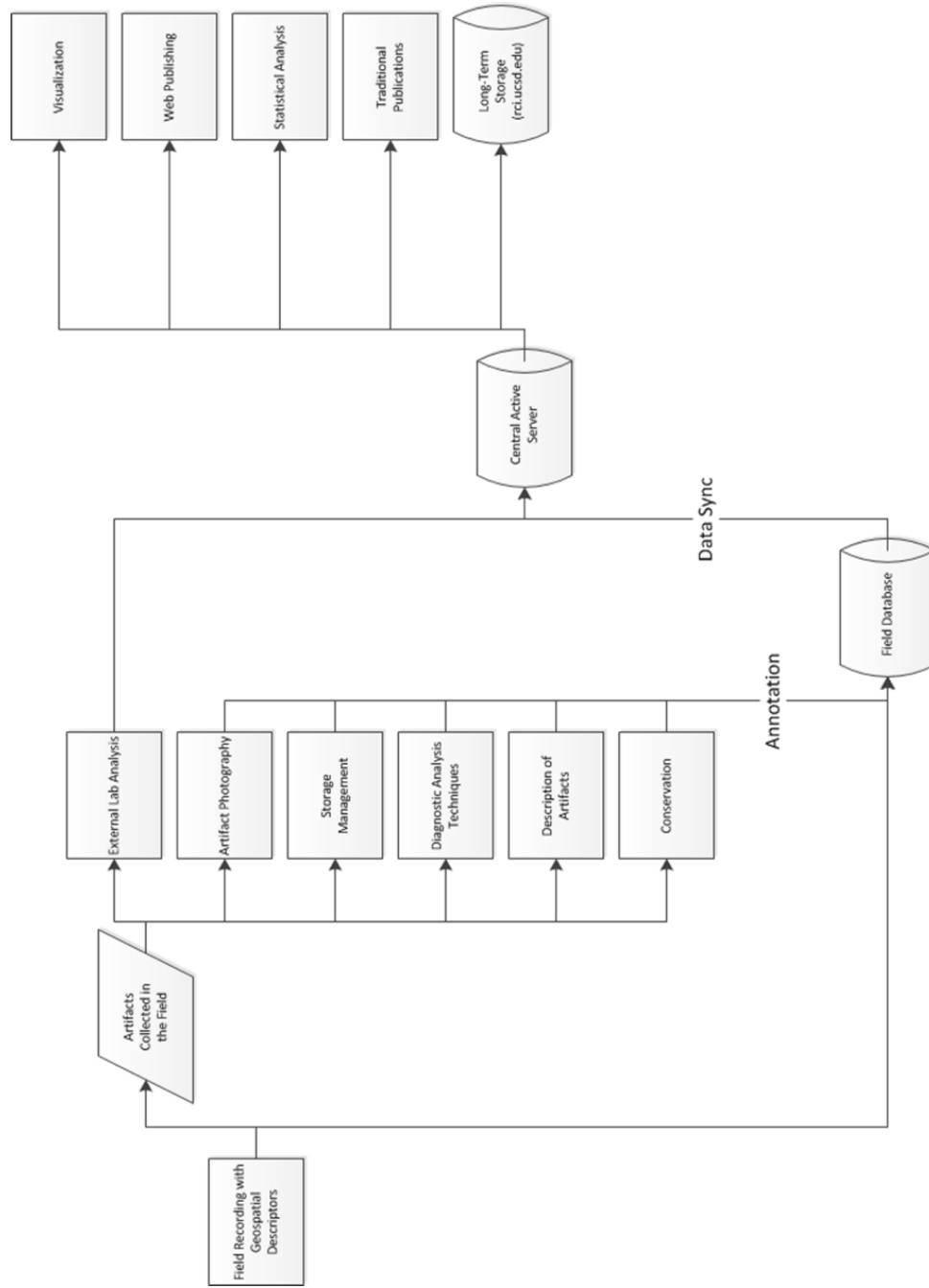


Figure 5.3: A simplified flowchart illustrating how artifacts are recorded and stored in the database for later retrieval (Gidding et al. 2013, Fig. 2).

Material difference is derived by analysis that represents a distinct set of operations using microscopic and diagnostic tools (i.e. XRF, FTIR) that provide objective metrics for differentiating between objects. The results from such tools provide objective results that are directly comparable using mathematical functions. For instance, using XRF analysis the relative elemental composition of any given material can be represented and compared to other samples allowing a variety of conclusions to be drawn regarding materials used to produce a given archaeological sample. Chronological variation in material composition can be observed by comparing the materials from different strata or layers from a given site. Additionally, the provenience of archaeological material can be detected by comparing materials with their sources. This kind of analysis follows a methodology that looks only at abstract traits of materials in a quantitative way, but ignores other important features of any object that inform qualitative comparison of archaeological material. This could include comparing formal or stylistic similarities between artifacts made of different materials that might not be obvious using mechanistic techniques.

The identification of meaningful difference between artifacts that cannot be captured digitally is also taken into account within the database. Meaningful difference is constructed of features that are derived and most efficiently characterized through human interaction and observation representing multiple dimensions of any given artifact. This would include an understanding of functional description, formal-typological description, and other contextual information that is meant to help lead diagnostic analysis. Using annotations based on meaningful difference we can be sure that we are always comparing apples to apples as opposed to apples to pears. Given the aforementioned variety in interpretation of ancient material culture, flexibility in understanding what makes material difference significant is important, and it is assumed that difference observed through diagnostic analysis should

validate any conclusions. In this way observations of difference and meaningful difference work as a part of a reflexive system bridging different ways of understanding the ancient past.

The material difference and meaningful difference distinction could be compared to the semiological etic and emic distinctions; however, this would ignore two important mediating data types fundamental to the system: time and geography. By tying our data to objective dating and geographical data our data organization system is able to create a framework for interpreting more than conventional classificatory structures by providing a web-based application to visually query based on geography in addition to other traditional text based queries.

Spatial annotation is fundamental to how we deal with these aspects of difference. Over the course of an excavation, while unique finds are individually recorded, there are too many “bulk” artifacts (large numbers of bones, lithics, pottery sherds, etc.) collected to give each one its own spatial context. Thus, we divide the artifacts into two categories: classes and singularities. A class is a group of artifacts taken from a similar spatial context and grouped according to basic material and functional category. This means that artifacts that are made of ceramic are grouped together while artifacts that are made of flint are given their own grouping and so on. Artifacts within classes are broadly categorized according to features deemed important and some artifacts may be separated and analyzed as diagnostic based on formal or constructive markers. Additionally, in the field, artifacts can also be identified as having unique attributes and despite belonging to a class are identified as singularly important finds and are recorded as such in order to maintain tighter contextual control for those artifacts. These artifacts identified as diagnostic either in the field or as a part of lab analysis of the “bulk” artifacts are singularities. These singularities are the artifacts that are the primary source of descriptive diagnostic description to characterize ancient social activity (i.e. mining, exchange, etc.). By isolating material into defined spatial units we are able to help guide the

understanding of what constitutes meaningful difference and make further distinctions in other dimensions and the broader categories.

5.1.5. Technical Aspects of the System

In the technical architecture of our system, a data repository server to aggregate our data plays a central role. The server components consist of a database server, application server, and web application (See Figure 5.1). Various open source software was used to make our system independent of proprietary technologies. The database server is PostgreSQL with PostGIS extension, which is a reliable relational database software and can handle spatial data – critical for archaeological research. Additionally, it allows us to have multiple users accessing and manipulating the data at once, necessary given the interoperability of each dataset. The application server is Jetty, and it is common for running Java-based web applications. We implemented the data system as a web application to efficiently interact with the database through the web interface provided by the application server. Additionally, this provides a ready application for sharing our data with other researchers in the future. We use the Grails web application framework to realize maintainable and productive software development. It provides a way to define database schema with a simple object-relational mapping model and auto-generate templates of application to manipulate database. The client components consist of any web browsers, GIS clients that can connect to the database, and other visualization environments. We are currently using QGIS (<http://qgis.org>) as a GIS client for intensive GIS applications because it is both open source and user friendly.

One of the major challenges that we faced in developing the system was dealing with implementation for field use. We cannot access our servers on campus in California while at our remote Jordanian field site. The ability to sync months of collected data seamlessly upon return is fundamental to our operating objectives. Therefore, portability of the system and the

ability to sync with any data left behind has been stressed as a fundamental organizational part of the system. The present system is running on virtualized Linux environment (CentOS), but any operating system that supports the software components described above will work. We employ virtualization technology to use the data system both on the campus and excavation sites. By using virtualization technology, the whole environment of the data system can migrate from a computer to another computer with just copying the disk image. This is useful for field research because we can carry the virtualized server environment anywhere loaded on portable computer hardware, while it runs on larger-scale server hardware on the campus. By effectively using the same server both on campus and in the field, despite no internet connectivity, allows us to use a single map for how our data is organized through the system (see Figure 5.1). When we return from the field we can take the virtual machine and sync it back with the data on campus. Currently this synchronization is one way from the field server to the campus server because new data is not added during excavation. One of our planned projects is to make synchronization between the field system and the system that remains in San Diego possible.

5.1.6. Current Use of the System

When building our database, we needed to be sure to develop around anticipated pipelines for data ingestion in field-like conditions. One aspect of this was to begin initial testing of the data system with the narrow goal of showing the feasibility of incorporating datasets that show both difference and meaningful difference. For this we decided to incorporate a traditional artifact analysis methodology (sorting pottery from KHI according to formal variation), with one of the newer diagnostic technologies that we have adopted, XRF. When we began our field tests we also included a utility to visualize and query spatial data and other associated data. The benefit of this tool (discussed in the next section) is that

archaeologists can instantly grasp visual overview of sites and artifacts after coming back from excavations. It is also advantageous that archaeological data stored then can be directly published and shared on the web using spatial and Structured Query Language (SQL) interfaces.

When dealing with every assemblage of material there are a number of organizing principles used to classify the data. In the case of pottery, basic descriptive categories are assigned based on formal and general characteristics. However as already mentioned, the categories that are important to a ceramicist vary according the spatial context of where the material was found within the excavation. For the purpose of class based analysis there are standards that are employed for the purpose of analysis and form an easy to identify lowest common denominator for the purpose of the database. In order to manage each individual data type within these different structures is a unique Id is assigned that can be tracked through the system; not only within the database, but also physically using a barcoding system. The barcode is linked to the unique ID so that it is possible to rapidly recall the associated metadata for any given object for updates and reference.

The implementation of data collected from XRF is a much greater challenge to fit into the database. XRF is an important tool for identifying the relative quantity of different elements that constitute a given material. However, different settings on the XRF machine are required to measure different element groups, which results in varied results derived from methodological differences. Any time a material is analyzed using different settings the parameters for recording the relative frequencies of elements changes. This means that depending on what aspects of a given material are being analyzed the results can vary considerably. While XRF is useful for a variety of analytical purposes, we need to be very careful to record the methods used for analysis in order to maintain data consistency. Additionally, consistency in how samples are analyzed is important as the software calculates

quantities of a given sample differently according to the total samples run. In order to deal with these problems, we have broken down data storage into two different components, the raw data and processed data, both of which we can pull from depending on the analysis that is desired.

Additional consideration has to be made for the manufacturer of the machine used for analysis. Each manufacturer has different specifications for how data is recorded, stored and processed. These specifications apply both to technical differences in the quality of the data and the data formats used to store the raw data. As a result, the raw data created by different manufacturer's instruments is not readily interchangeable until full processing to ppm measurements is performed. Given our aim of using the XRF data before PPM calculations are made, we account for this problem by specifying the machine used and the methods implemented to process the data. However, currently we organize the data specifically for Bruker, the brand of XRF that we employ.

By processing the XRF data in two stages we can better use the data as it is processed. The uptake of data at two different points of collection for the XRF introduces another problem due to the variety of file types and variability in how data is collected. The files used by the software associated with the XRF are proprietary and need to be converted to a format that can be easily stored in an open-source PostgreSQL database. This is a process that is not difficult, but it means that as a part of the recording/import process care needs to be taken to make sure that all of the settings are also recorded as metadata for data consistency (See Figure 5.4). The software embedded in the data system can parse the XRF data file, store parsed data in the database, and export the data in its original XRF data format. Assuming that consistency is maintained then the database will benefit users by allowing the ability to query for similar samples in order to calculate results from larger groups of material that may have been scanned for many different projects. Other archaeological data including site

information, survey feature information, and artifact information can be manually input with data entry web forms that our new system provides (see Figure 5.5 and Figure 5.6).

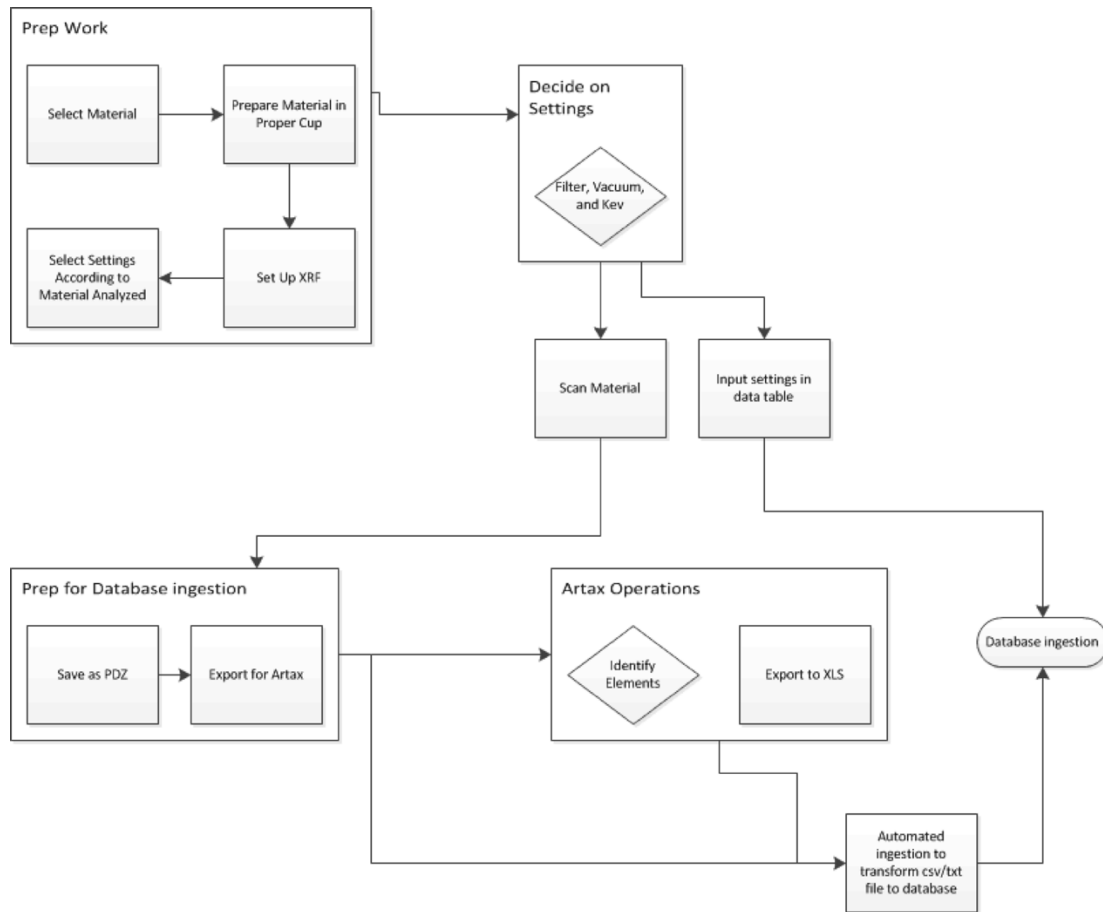
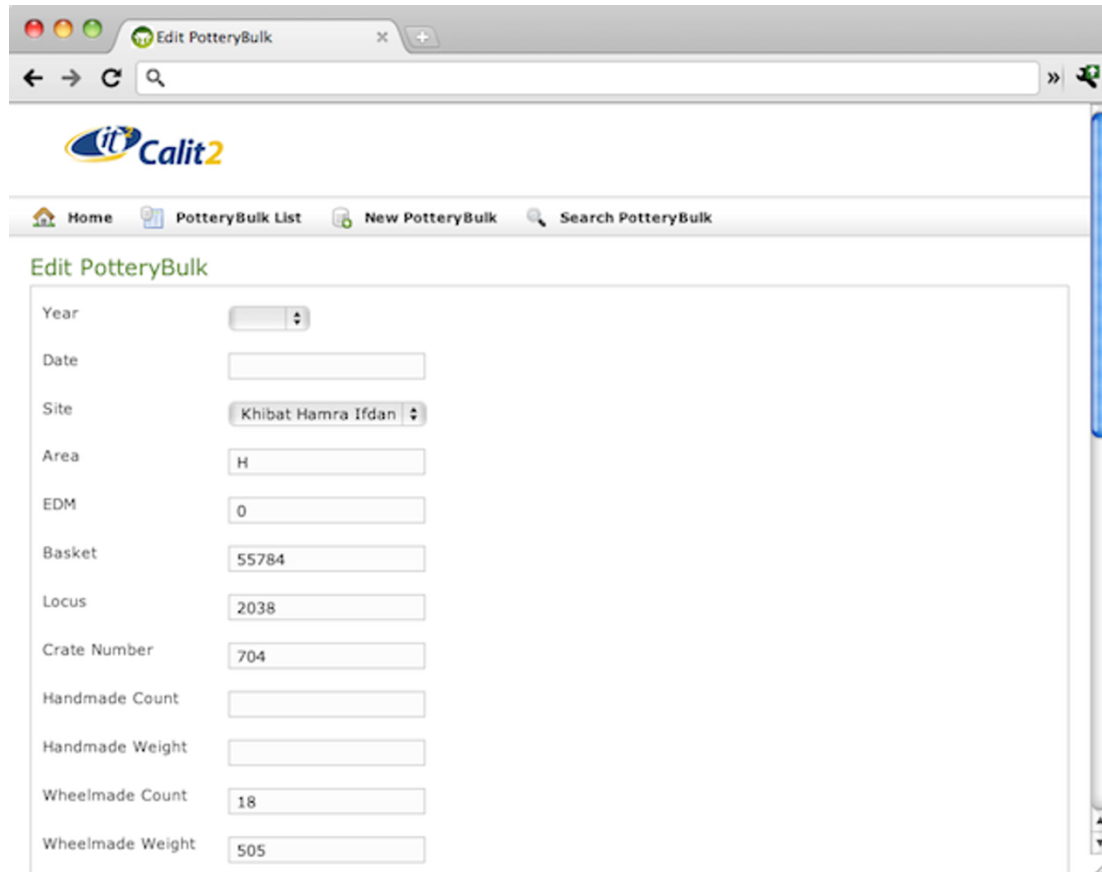


Figure 5.4: The workflow for processing XRF data for ingestion into ArchaeoSTOR (Gidding et al. 2013, Fig. 4).



Year

Date

Site

Area

EDM

Basket

Locus

Crate Number

Handmade Count

Handmade Weight

Wheelmade Count

Wheelmade Weight

Figure 5.5: Basic web interface for data input. Most data input takes place using a form designed for the different material types. Contextual data is automatically entered into the database by relating the table to geospatial data as it comes in from the field (Gidding et al. 2013, Fig. 5).

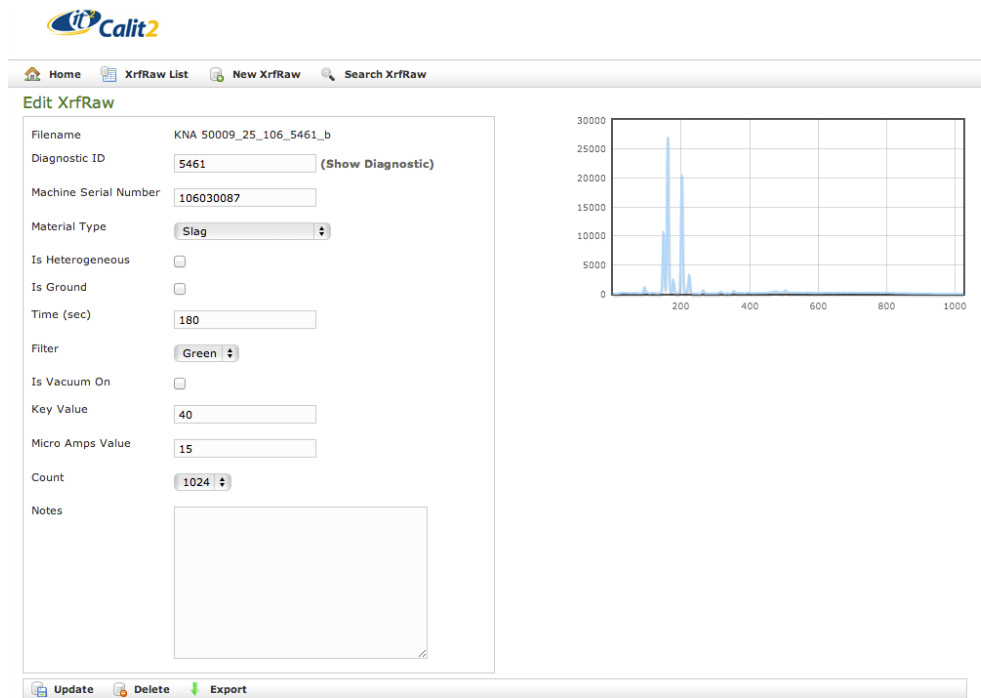


Figure 5.6: XRF data input interface with graphic showing XRF sample spectrum (Gidding et al. 2013, Fig 6).

Within the server several workflows are in place to put field data into the database system according to different typological categories. Regarding geospatial data, measuring devices like total stations produce shape files, which are standard geospatial vector data format for geographic information systems, and others like dGPS devices produce raw data in their original format. Our data system can import shapefiles into the PostGIS database by converting their formats. For the data collected with the dGPS we preprocess the raw data into shape files for import. This function is more important for dealing with ingesting either legacy or outside research groups' data. For our field collection we use our own program that can sync directly with our server after returning from the field site.

It is with the goal of testing the database system in 'field-like' conditions that the application of our database management system was applied and tested with ceramics from the

ELRAP site Khirbat Hamra Ifdan (KHI) in southern Jordan (Levy et al. 2002). The important thing was to test the functionality of the data collection system, process it using the built web interface and then visualize it within the interface of a GIS program like QGIS. Each of these components came together over time to the point that visualizing the data collected was not a problem. As the organization of the data became a seamless process, by scaling the database to larger numbers of artifacts and other data-types, we have put in place an integrated database system capable of handling the full range of artifacts to be recorded in our next field season.

5.1.7. Spatial Data Queries

One new feature that we have begun to implement in the data organization system is the ability to query the data spatially using a web application to visualize the data. Already we noted our use of QGIS to generate maps used to illustrate relationships between data at sites. However, GIS programs, like QGIS, offer static interactivity as a feature of design as a powerful map-making tool, but without dynamic interactivity for data sharing or rapid queries connecting the spatial data to the artifact data. For more interaction with spatial data while performing other tasks, a click-and-use interface is preferable. This tool has a number of applications for archaeological research that transcend traditional GIS applications. Firstly, it allows for rapid recall of the spatial relationships between excavated units. Additionally, archaeological data is visual by nature so spatial queries are a more natural way to interact with data over the course of research in and out of the field. Lastly, we can associate other kinds of visual metadata, like photos, as a part of the query tool enhancing the abstract geospatial data collected for rapid recall.

In order to visualize the data within a web browser we are using a program called GeoServer (<http://geoserver.org>). As an open source software server, GeoServer allows us to publish a wide variety of data types and implement some of our own tools for outputs that are

useful for the needs of archaeologists from a web-based server outlined above. We also use OpenLayers (<http://www.openlayers.org>) to visualize geospatial data. OpenLayers is an open-source JavaScript library that allows web applications to communicate with geospatial data servers and to render map data on web browsers.

The ability to spatially query data is an important part of archaeological research to help match the excavated material record with the space from which it came. The importance of maintaining spatial relationships in the metadata has already been discussed especially in the contexts of using GIS to visualize that data. The process of opening up a GIS program and loading all of the data for that space is inappropriate in some instances due to the extra time it would take to access data in a GIS program. For instance, often times when doing material analysis using the data management system, the ability to click on an archaeological context and see a set of images and other associated data instantly is exactly what the researcher needs while working with material, in addition to then being able to visually query neighboring contexts (see Figure 5.7).



Figure 5.7: Map produced in ArchaeoSTOR from 2011 KHI excavation data along with photographs taken during the excavation. In the figure, lines form shapes of excavation areas (loci), and points represent locations where artifacts were found. When artifact points are clicked on the map, detailed artifact metadata and photos are retrieved and shown (Gidding et al. 2013, Fig. 7).

This application of spatial queries also offers a great platform for sharing archaeological data with the general public and other researchers. Researchers can share a fully interactive map by generating a curated set of data specifically for public consumption, accessed directly on the web without using a stand-alone GIS program or special plug-ins beyond Java. The experience of directly selecting relevant data on a map is particularly useful in the context of collaboration that otherwise would require sending large datasets, over which there might be copyright issues.

5.1.8. The Pilot Study: Bulk Pottery Sorting KHI Pottery and XRF

In order to test the system, we used it first in one of the active laboratories at UCSD and then deployed the system during the 2011 field season in Southern Jordan. For the

preliminary test of the new data ingestion and visualization system we decided to use legacy data from a previous excavation at KHI. KHI was a great option because there is a large collection of unpublished artifact data that has only undergone preliminary analysis. In using the material from this site we were able to test two intended applications of the system in development: ingesting legacy spatial data while taking inventory of excavated material and using the legacy data as a model for ingesting outside data. Based on how labor intensive it was handling legacy data we decided to limit our current goals to the ingestion of legacy data. From the data stored in the database we created a map (see Figure 5.8) using QGIS that illuminates how data might be used to analyze datasets in the GIS environment to illustrate the feasibility of the project going forward.

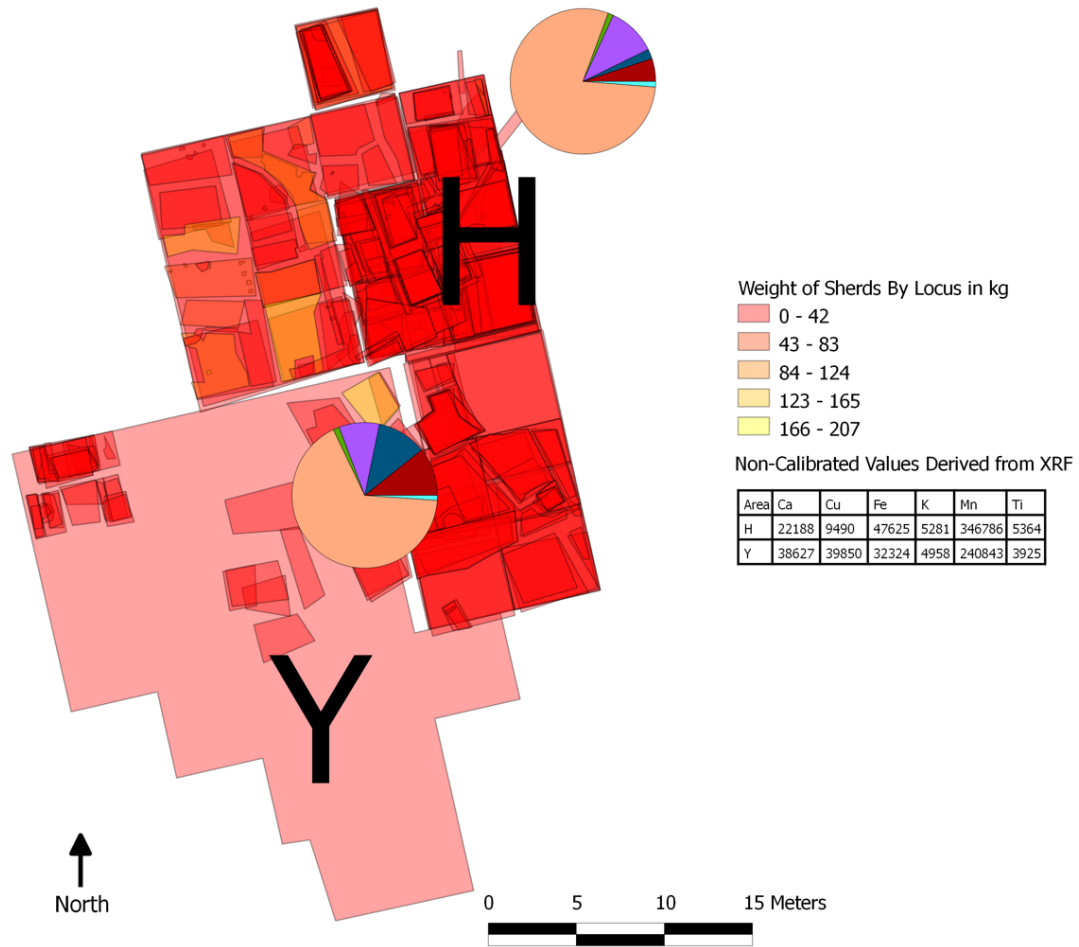


Figure 5.8: A map of two adjoining excavation areas at KHI using open source QGIS (Team 2016), to visualize the relative quantity of pottery and an XRF measurement of a slag sample. The pie chart shows the relative measurements of different elements in an ancient metallurgical slag sample (Gidding et al. 2013, Fig. 8).

The large quantity of legacy data produced by ELRAP at KHI needed to be ingested into the integrated database described here. Dealing with legacy data is a time consuming process because over the years the methods for data collection changed with the implementation of new technologies. This means that applying the old data to new standards takes some time to manipulate into a format that is workable. The most time consuming part of this process is making sure that the spatial data collected in the past can adequately be used in the new system and then correlated with other types of data within GIS software.

For field archaeology projects, taking inventory of daily-excavated material is one of the most fundamental activities. Therefore, we decided to simulate the inventory of material stored in San Diego as though we were in the field in Jordan. The original inventory of the artifact material was never adequately stored digitally during the earlier excavations, so we were able to explore how the workflow could be best managed with the new digital inventory system. We approached the method of analysis as would be expected in the field to evaluate issues of performance and usability, adding and moving features as we became aware of changes needed. Over time we added a number of features that helped functionality while looking at the data. These include: easier export of data, querying ability, and bar-coding for rapid recall of data that has been processed.

Our work with XRF data consisted primarily of making sure that the import/export feature worked seamlessly with the proprietary software provided by the manufacturer. Once the database was capable of ingesting and exporting data for raw processing we queried the data from previous analysis using the new system and processed it for storage in the new data system. This storage mechanism allows for us to have clear metadata describing the circumstances for any processing of the raw XRF data when used for future comparison. After making necessary adjustments to workflow and other problems that were apparent during initial testing we loaded the virtual machine on a Mac Mini Server for use in our field laboratory.

The field application of the data system allowed us to test a number of functions beyond Early Bronze Age Pottery. The most significant changes that we made to the workflow for field use were reactions to the quick recognition of missing data elements in the database. We refined the data management protocols and fields to materials beyond pottery and to time periods beyond the Early Bronze Age. This meant adding a number of material classes that we had not previously thought of, and refining how we consider diagnostic materials to include

ecofacts (ancient ecological remains), which are always collected for diagnostic analysis to help build contextual analysis of excavated units. The technology most responsible for the recognition of ecofacts was our new implementation of a workflow for storage of FTiR raw data. This was the first season that we used FTiR as a part of the excavation process and more work remains to be done in order to fully integrate it into our excavation workflows. Lastly, we connected ArchaeoSTOR to a new system developed to record geospatial data for this past field season. This new system stores all of the field data in a PostgreSQL database with its own set of barcodes. We linked the databases to make data entry move faster, compared to the manual entry currently required for legacy data.

In short, we have been able to show the functionality desired from the data management system described. By using this new database, we were able to ingest spatial data used to describe the context of the finds, describe the artifacts and associated materials and finally, query the results for publication. For every process we were able to have multiple clients manipulating the same data allowing for real-time observation of the data as it was being produced.

The new database allows for easier compliance with current data sharing protocols that are now becoming common for the social sciences. The scope of this project will facilitate fulfillment of the National Science Foundation's data sharing initiative. It is important to note that while we are trying to use language that is broadly relevant to archaeological research, international researchers use different terminology to describe archaeological phenomena around the world. Our Levantine data is structured in a way that is not meant to be universalizing, but it will allow for quick intake into the other larger data sharing initiatives specific to archaeology that are designed to help mediate differences in ontology. Examples of these data sharing initiatives already mentioned are the DAAHL and tDAR.

5.1.9. Legacy Data and Long Term Storage

Developing a low-cost data management system that facilitates adherence to the guidelines set out by funding agencies for research has been one of the underlying driving points for our research. Developing efficient workflows for ingesting legacy data into our data system, especially to facilitate public access to completed research, remains one of the hurdles that we are actively seeking to pass as a part of our research. Not only is public access to our data important for other researchers, but it also fundamental to archaeological research to have this data readily at hand for comparative analysis.

The implementation of the digital archaeology database system presented here illustrates a step towards a new frontier in data interoperability within archaeology. Our project is one of many that signify the beginning of efforts to take the material culture record and digitize it without loss of fidelity. The process of data transformation described here facilitates comprehensive analysis rather than intuitive assumptions and basic descriptions of material culture that are typically made in archaeological investigations. The new database provides the diagnostic tools to objectively understand the complexities in the material record. The logical next step in this process is to create a portal through which other researchers can interact with our data freely to test our conclusions and to allow them to freely draw on the full breadth of the data that we have collected. This can be achieved through a number of avenues including the DAAHL project and the associated Pottery Informatics Query Database (Levy et al. 2010, Smith et al. 2012) that our team is actively developing. This ‘portal science’ approach has been successfully developed by the NSF GEON project for geosciences (<http://www.geongrid.org>). In combination these tools offer a powerful suite to generate, process, and disseminate data digitally.

One way that we are looking to develop alternative models for data sharing and long term storage is through a program, UCSD Library's Research Data Management and Curation Pilot Program, at UCSD in conjunction with the San Diego Supercomputer Center and the UCSD library system (<http://rci.ucsd.edu>). We see this model of data sharing as complementary to using other data sharing initiatives specific to archaeology by using the library's platform to share our data with a wider public. The UCSD library's data sharing program is linked directly to other digital repositories that hold digital material from other disciplines. We hope that these kinds of connections of digital data will allow for future interdisciplinary research using archaeological data. Additionally, by using the UCSD library to share our digital data, we are able to take advantage of digital object identifiers (DOI) to maintain appropriate copyright control of our data (See: <http://dx.doi.org/10.6075/J0WD3XHP>).

In the near future we plan on adding a number of other technologies to the database. Firstly, we need to continue to expand the toolkit to the full range of archaeological materials. As already mentioned, in regards to ecofacts, there are still archaeological material and data types that we have not had a chance to fully integrate into the system. Constructing the kinds of data tables that specialists of different material cultures can find useful is a long and difficult process because all material culture elements are represented differently from sub-discipline to sub-discipline. After we feel comfortable that we have accounted for the basic kinds of data that are a part of archaeological excavation we will begin to implement other tools for diagnostic analysis.

Data from photography from the site and three-dimensional scanning of artifacts are our first priorities for diagnostic tools. We look to develop a number of workflows in conjunction with our work with LiDAR in order to enhance the usability of the LiDAR dataset

as a skeleton on which to layer the images. Additionally, we want to integrate the results from analysis of three-dimensional scans of artifacts into our framework (Gilboa et al. 2004).

More immediately, this project operates as the back-end that allows for more complex scientific visualizations that take advantage of the three-dimensional recording of data collected in the field using the GPS and total station methods described above by providing necessary metadata to provide meaningful analysis. As we begin to integrate other sources of diagnostic data into the visualization system in development by our colleagues we anticipate using our framework to generate dynamic visualizations of the archaeology as it is excavated. These more complex visualizations can be used both analytically and to better communicate our research as it is in motion (Petrovic et al. 2011). The ability to easily disseminate results in a systemic fashion is a step forward for archaeological research away from publishing long form monographs that only provide a select picture of excavation results and methodologies.

The last step for the data infrastructure is the need to eventually move data to long-term storage. This process is to be achieved through the aforementioned Research Cyber-Infrastructure (RCI) initiative through the UCSD Libraries. This initiative will aid in both preserving the data collected for long-term, safe storage and giving a public web portal for dissemination of different materials associated with the data collection. The data will all be stored using Chronopolis, which will replicate all of the data across three repositories for safe storage (Minor et al. 2010). The data will also be presented as a part of the University of California Libraries' digital collection and the Online Archive of California (<http://oac.cdlib.org>). One of the goals for the future of the ArchaeoSTOR project has been to enable a streamlined data-flow into the RCI system in order to ensure long term preservation of the data and to help with the public dissemination of the research.

5.2. Macro-Ceramic Analysis: Extracting Data from Basic Materials

The pilot study of ArchaeoSTOR produced an inundation of data about the general assemblage of ceramic material that the majority of excavations ignore. This was the result of the unconventional methodology employed for quantifying the total assemblage, including non-diagnostic shreds. Such rigorous data collection, a hallmark of the ELRAP expedition, was in part a means to test ArchaeoSTOR, but also it provided a means to characterize details of the assemblage that did not exist in the excavation notes. This was essential in order to develop models for the different patterns of deposition within the site. Beyond simply describing the quantity of material, statistical means to qualify variation in the distribution of the assemblage were used to help direct future research of the diagnostic material. This informed the later analysis by providing a way to compare the assemblages from different contexts based on differential patterns of breakage and deposition.

The use of statistics for the study of ceramics has been commonly done using the diagnostic sherds, usually not the non-diagnostics as described in this dissertation. Statistical inference is necessary for archaeological analysis; the archaeological record is by definition incomplete and requires inference to help fill in the gaps. Early in the history of archaeology typologies were developed for the analysis of archaeological material based on vertical stratigraphy at sites, statistical techniques are important to refine those types and extend those categories to other archaeological situations. The earliest example of this was the use of seriation by Petrie (1899) that introduced the utility of statistical methods in order to reveal data that might otherwise have not been accessible in the archaeological record, in that case imposing vertical stratigraphy on graves based on the relative abundance of specific traits across grave goods.

Since Sir Flinders Petrie's time much work has been done developing other ways to statistically model different aspects of archaeological inquiry. For the analysis of pottery some of the most original work has been performed by C. Orton (1993, 1993) problematizing many of the collection methods used by archaeologists. In many ways, developing good standards for data collection is one of the core concerns when trying to develop relevant statistical analysis. Without a good grounding in the potential limitations of measured variables entire analyses can fall into question. A number of different statistical tools can be used for various kinds of pottery analysis including classification, quantification, chronology, and distribution depending on the the types of variables measured (cf. Sinopoli 1991, Orton 1993, Orton, Tyres, and Vince 1993, Drennan 1996, Shennan 1997, VanPool and Leonard 2011). The methods practiced for this study are not normally discussed in the archaeological statistics text book as they might be considered over-analysis for most archaeological applications. In this case taking advantage of the data collection methodology allowed for a more comprehensive set of analyses that are useful and could be altered to speed up processing.

Statistical analysis in archaeology is usually performed exclusively on diagnostic ceramic forms. Diagnostic forms are prioritized by collection methods because they reveal the most data about the total vessels present in an assemblage. Sherds identified as not diagnostic are usually thrown away at many sites that see very large numbers of ceramics because independently they contain the least amount of information. As a result, the focus of analyses is on frequencies and relationships between different descriptive variables both measured and described of the diagnostics (Examples from South and Central Jordan include Rast and Schaub 2003, Richard 2010). C. Sinopoli (1991) introduces a number of simple statistical tests typically used for basic description of collections and examples of hypothesis testing with the χ^2 test to check expected versus observed frequencies of specific traits or a students t-test to test the relationship between sample means. Drennan (1996), Shennan (1997) and VanPool

and Leonard (VanPool and Leonard 2011) go into more detail regarding multivariate modeling, which was used in the next chapter on diagnostic forms. For the purpose of describing the entire assemblage univariate statistical tools were used.

The literature that includes the most complete analysis of pottery from the Early Bronze Age in the Levant is noteworthy for the paucity of statistical means in order to test claims about stratigraphic variation and activity areas. The study presented here will use the ceramic data collected from KHI to illustrate a methodology to describe intra-site ceramic variation. To date, the majority of Levantine EBA reports tend to follow the traditional model of describing finds and correlates, not necessarily using data gathered about the pottery in order to make hypothesis about social organization using statistical methods, including providing simple descriptive statistics about quantities and types identified despite in some cases using excavation methods that should make such data readily available such as the reports from Be'er Resisim, Hazor and Megiddo, to name a few (e.g. Yadin 1958, 1960, 1961, Yadin, Ben-Tor, and Geva 1989, Ben-Tor and Bonfil 1997, Finkelstein, Ussishkin, and Halpern 2006, Adams et al. 2013, Dever 2014). Additionally, it resonates with the fact that the basis for the early models for the "urban" EBA were based on the physical characteristics of settlements and not the local economy (See Chapter 2.7). The absence of intra-site ceramic studies highlights one of the most prominent problems in EBA pottery analysis, where the high degree of regionalism of pottery types obscures many researchers' attempts to make cross-regional connections (Philip and Baird 2000a). Nevertheless, even in what may be the most comprehensive effort to ameliorate that problem the majority of the research presented, barring the chapter by Mazar, statistical methods to make assertions about the pottery assemblage are absent in favor of making typological descriptions (Philip and Baird 2000b, Mazar, Ziv-Esudri, and Cohen-Weinberger 2000). Notwithstanding the absence of statistical

methods, there is great value in work done to make typologies and comparative chronologies to build the framework for regional interaction in the EBA.

By comparison to the state of Early Bronze Age pottery publication for the greater Levant, the use of statistics for the study of pottery in the region surrounding Faynan is mixed. For instance, site reports from the Negev Highlands do not report any numerical data about the amount of pottery found unless it is a particularly small assemblage (e.g. Rosen 2011, Dever 2014). By comparison, the area around the Dead Sea provides access to more comprehensive numerical data from the excavations. The reports from the site of Bab edh-Dhra only give some basic descriptive statistics offering relative quantities of material, but importantly includes the database and coding sheets for diagnostic sherds described from the site (Schaub and Rast 1989, Rast and Schaub 2003). Unfortunately, it is not clear from the publication whether that data is a sample of the total assemblage and misses the opportunity to use that data to compare areas within the site. A good examples of the use of the ceramic data in order to help validate assertions about the excavated contexts is the site of Khirbet Iskander (Richard 2010). In the Khirbet Iskander report variation in quantitative, qualitative and variety/richness factors are used to help model temporal determinations for both stratigraphy and single period grave sites. The data is useful in helping to make determinations of similarity between occupation levels based on determinations beyond formal similarities. The work at KHI builds off of the models from the aforementioned sites for the methodology to record traditional typological description, and will add the statistical application of that data towards the total assemblage to highlight where statistical methods can be used to understand social interaction within the site (Gidding, Levy, and DeFanti 2014). Before reviewing the diagnostic data in Chapter 6, the first place to apply basic statistical analysis is with the non-diagnostic data in order to clarify where to best apply more specific analyses of the material.

5.2.1. The Methodology Used for Bulk Data Processing

The pottery assemblage from KHI is unique because of the total size and the high level of preservation. Compared to other projects of the ELRAP the total volume of ceramics excavated at KHI and the total number of complete vessels is larger. It is assumed that one of the major factors in the excellent preservation of the assemblage is due to what might have been the sudden abandonment or destruction of the site due to an earthquake introducing a kind of “Pompeii effect” (Levy et al. 2002). Indeed, in many contexts the artifacts seem to have been found as they were left by the original occupants, with complete vessels sunk into the ground and in some cases metalworking implements seemingly stopped in the middle of production (See Figure 4.2). Based on the assumption that the primary EB contexts at KHI were sealed it was decided that a more comprehensive than normal analysis of the material would be warranted.

The largest scale excavations of KHI took place in 1999 and 2000, but the majority of material was never completely sorted or analyzed. Some paper records had been kept, along with scattered digital copies of those records, but it was clear that they were incomplete. Even a cursory glance at the tons of material that remained in storage highlighted that it would be necessary to revisit the material for a more comprehensive analysis using ArchaeoSTOR. ArchaeoSTOR offered a united way to securely store all of the associated data from the ceramic assemblage and organize it for future analysis while providing a means to manage the inventory of the assemblage in order to quickly find artifacts after they had been stored (The data is in Appendix 3).

The development of ArchaeoSTOR and the process that was used to describe the ceramic assemblage from KHI advanced together so that each process reflexively made the other more efficient. When the process of inventory of the bulk sherds began ArchaeoSTOR

was a simple form that allowed for data entry, but full functionality had not yet been implemented. This is important to consider because many of the features that eventually made it into the final design were a response to the need for greater efficiency during the sorting process. At the same time the experience of data entry also slightly altered the way that data was being sorted and counted to increase efficiency through a division of labor; different students responsible for sorting, counting, and weighing. The process of counting and sorting was also influenced by the way that the material was initially excavated and subsequently stored.

The method of excavation is important to the recording system because it influences the way that artifacts are parsed in the field, which also has an effect on how they can be recorded. The ELRAP uses a modified version of the Kenyon-Wheeler method of excavation that was derived from the excavations at Tel Gezer (Dever and Lance 1978). The key units in this method are the Locus and the Basket. A locus is assigned as a subset of the stratum to distinguish soil layers and is associated with a single archaeological deposit. A subset of that is the basket, which is assigned to each locus daily and to special artifacts. This means that when we approached the pottery, in principle each basket would have its own bag of pottery, except in cases where the amount of pottery from a basket was so great that multiple bags were needed. When the legacy data from the 1999 and 2000 seasons was stored, it was not organized according to a schema that reflected the location of origin, i.e. every basket from a locus was not stored together. As a result, when each bag was sorted it constituted its own record and each basket was added up later to constitute the full locus count. Additionally, for the sake of the statistical consistency the site was divided up into different “rooms” according

to the different strata (See Figure 4.3).¹⁶ Despite the fact that rooms could constitute different activity areas, all of the loci for a given room were further combined in order to offer a category of comparison. The other major category of comparison is the stratum. Stratum I constitutes Iron Age or later material, Stratum II is Early Bronze IV, Stratum III was Early Bronze III/IV and Stratum IV is Early Bronze II and earlier. Stratum III was the primary occupation level at the site.

The sorting of material was done according to a hierarchical classification system according to where on a vessel any sherd was derived. The system that was put in place was believed to be the best at providing relevant, but coarse data regarding the overall assemblage at the site. The primary categories for the sherds were diagnostics, handles, bases, decorated, cooking and general body sherds. The diagnostic category consisting of any sherd that could provide definitive knowledge about the type of vessel or offer chronological data through ceramic correlations. In practical terms and most cases diagnostics were rims, but in some cases they could include special handles or decorations that were considered unique enough to provide relevant information in order to make inter-site comparisons. The categories however are not always mutually exclusive. In the case of the sherds that would overlap as non-rim diagnostics, the quantities are small enough that it has a negligible effect on the overall data. Sherds that fit in categories that were not diagnostic are split into two further categories (formal and standard) in order to give a hierarchy that should provide a basic sense of parity for bulk statistical analysis (See Table 5.2). Diagnostics, handles and bases were all considered formal categories, all of which were given precedence over the standard category of decorated and body sherds. So if a sherd fit into a formal category it would be considered for

¹⁶ The majority of the loci constituted a single room except in unique circumstances. The variation in recording meant that in order to maintain statistical consistency it made sense to reduce spatial variability according to a lowest common denominator in most cases.

that formal category, and if there was anything about it considered diagnostic then it was by default diagnostic. In practical terms, if a sherd was both decorated and a base, the fact that it was a base would take precedence and it would be counted as a base. As a result of this the core categories for analysis of the bulk sherds the three formal categories consisted one unit, the standard or body-sherds consisted another. Then only within these reduced categories could the more granular data be applied.

Table 5.2: Table indicates priorities for the two categories of sherd types. Formal always is more important than standard, within each category importance is organized from top to bottom.

Formal - High priority	Standard - Low Priority
Diagnostics (Rims)	Decorated
Bases	Cooking
Handles	Wheelmade/Handmade

What this data should help to provide is a general idea of the variation of distribution of the non-diagnostic assemblage. That variation in distribution is important to help describe areas where different processes were involved in the deposition of the ceramics. This follows from the basic idea of different kinds of “transforms” that would influence depositional patterns at the site and as a result different preliminary tests of homogeneity across the site are used (Schiffer 1975). Variation in the deposition of the pottery can offer a number of new pieces of information that can help with understanding different ways that site was organized. For instance, a locus with a high number of bases will be able to provide a good idea of where likely surfaces would have been, especially when correlated against the degree of breakage for a group of sherds. The data from the statistics, especially such a coarse grained analysis, will not yield definite answers, but it will offer provisions for how to approach the finer grained data at a later date. The degree of breakage would be indicated by the relative quantity of

sherds against mass. The same index (the relationship of quantity to mass) also is indicative of the relative size of vessels. At a later date this data can be normalized against measurements of the full corpus of diagnostic material as well, but in the meantime rough estimation is required.

5.2.2. Description of Statistical Methods Used in this Study

The statistical analyses performed for this study aimed to look at different factors regarding the variety of distribution of pottery at KHI in relation to aspects of copper production. These factors are meant to help identify the indices of kinds of “transforms” on the pottery in order to differentiate different kinds of depositional patterns that will affect the interpretation of other artifacts in each excavation context (Schiffer 1975). The primary aims of the statistical methods employed were to test the homogeneity of pottery distribution for different areas strata from the excavations during the 1999 and 2000 seasons. Beyond the basic descriptive statistics, for this study two categories of variation will be tested using count and weights: the evenness of distribution of material and the variation of breakage. There are a number of ways to describe the evenness of distribution of material at the site, each with their own significance. The first set of tests examine the direct correlation of relative quantities of weights and counts within a given context. The second test uses χ^2 to compare groups of variables in order to test the degree of homogeneity of a suite of traits. Each set of tests provide useful data about the relationship between the different contexts and provide a means to verify statistical significance of the observations. The second set of tests for homogeneity are used to examine the material on different scales of site distribution, horizontally between rooms and then vertically across the strata. Importantly, the second set of tests also allow us to isolate the degree of statistical significance of the findings, unlike the first set which are intended to establish a statistic that can be used to compare each context.

The simplest test is the ratio of count to weight, which can be fit with a regression line. This test is used to identify average sherd size, which is a rough index of different kinds of formation processes. Smaller average sherd size would be associated with secondary refuse; larger sherds would tend to be in locations of primary deposition. If the relative size of sherds remains stable across the site and the r-squared value is near 1 then we would expect that the same “transforms” were affecting the entire site. Rooms that show deviations from the line of best fit highlight cases of higher or lower intactness of the assemblage compared to the rest of the site.

A similar correlation can be made of relative quantities of certain types. For this assemblage the most apt is the ratio of non-decorated to decorated sherds from a context. A decorated sherd was any sherd that included incision, plastic application or surface treatment, especially slipping and burnishing. In this analysis normalizing the data by using count/gram is necessary in order to try to better homogenize the data across the site. The fundamental flaw with this measurement is that instances of plastic application and incision will always yield sherds from the same vessel that are registered as undecorated, meaning that the undecorated variety will inevitably be over represented.

For the sake of trying to understand the relationship between contexts in order to describe the relative distributions of the total assemblage groups of variables were used together in order to approximate the complete assemblage. In order to do this the first thing that needed to be done when approaching the data was to make the categories as uniformly distinct as possible. The aforementioned categories diagnostics, handles, bases, decorated, cooking and general body sherds are not naturally exclusive. As a result, when conducting most of the statistical measurements certain categories were either merged or completely dropped. For the sake of comparing the assemblages from different depositional contexts three categories were used: diagnostics, bases and body sherds. The counts and weights of handles

were completely dropped for the reason that they are appendages to the vessels, and unlike rims, body sherds or bases, not present on every vessel. Decorated and cooking sherds are lumped with the other non-formal body sherds. Because the diagnostics and bases are not differentiated by decoration or cooking, it was necessary for the body sherds to share that uniqueness.

The χ^2 test tells us that there is a difference in the relative material composition of different rooms by comparing the proportions of each room in reference to the total assemblage. Whereas the previously described sets of comparisons were only looking at single variables, the χ^2 test will offer data comparing each of the components (diagnostics, body sherds and bases) in combination with each other across rooms. If a context was not excavated in what could be defined as a room or work area, it was left out of the analysis. Stratigraphy was considered in that any rooms that saw reuse were considered multiple times, once for each strata of occupation. The null hypothesis for this test is that the distribution of pottery would be independent of where it was found - in other words evenly distributed between different rooms. A significant finding would highlight that certain rooms had a unique assemblage that highlights different ratios of the component parts of the vessels.

5.2.2.1. Contingency Tables

For data that is categorical the first step is to understand the frequency of occurrence of different observations. Thus it is important to generate a contingency table, which is also the first step to perform any kind of correspondence analysis (Discussed in Chapter 6.2.2). This process is identical to the χ^2 operation and the creation of a contingency table offers the analyst the ability to compare relative frequencies easily. The basic contingency table tallies the frequency of an instance according to a given row in column. Using the totals within a row and within a column it is possible to calculate an expected frequency by column and by row

for the instance which effectively normalizes the data for the relative frequencies of the different variables considered. That value is then compared against the total value within the column and within the row in order to understand how the actual value compares to what would be expected. The contingency table is the basis for the χ^2 test of association, but when scaled to many variables across multiple contexts it is more difficult to see the general trends in the data and as a result it is important to use other statistical methods that can help understand the underlying trends in the data.

5.2.3. Results of the Basic Statistics

The most important aspect of the analysis of the body sherds was the determination of the average weight of a sherd and how that compared from locus to locus and area to area. Comparisons using regression of the relation between count and weight are used to look more closely at how these counts vary according to space. If the sherds in a context were broken in the same manner as those from neighboring contexts we would expect to see the average sherd weight remain constant, however variations in average sherd size indicates different patterns in breaking (See Table 5.3, Table 5.4 and Figure 5.9). The goodness of fit line offers a baseline for the site's estimated average sherd breakage. The R-Squared value illustrates that there is a reasonably good fit, but room-to-room there is still a fair amount of variation that is not accounted for. There are a number of rooms that highlight very different characteristics. Room 72 in Area L with the high quantity of sherds to weight is indicative of a waste room where there was a high degree of breakage during deposition. By comparison room 53 is an example of a room where the sherds are relatively large. An alternative interpretation for this data is that the original pots are on average smaller or larger. If that is the case the resulting sherds from a context will be smaller or larger according to the original vessel size. Data from the diagnostic analysis in the next chapter will help to reveal which interpretation is correct.

The important factors will be the average breakage of different kinds of vessels and the overall variation of different vessels between different rooms. An even distribution and standard breakage for each vessel type would mean that in most cases the variation in breakage patterns of the non-diagnostics will be the primary indicator of kinds of deposition.

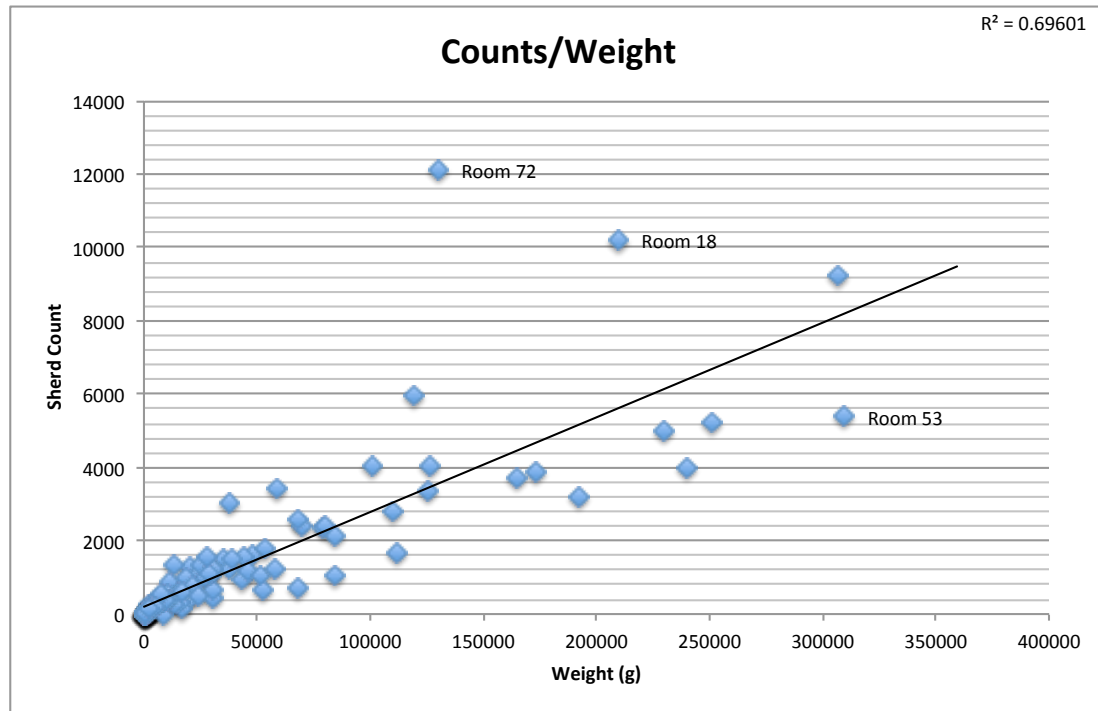


Figure 5.9: Relationship of the pottery count to weight according to room at KHI.

Table 5.3: Pottery counts and weights according to stratum at KHI.

Stratum	Bases Count	Bases Weight (g)	Diagnostic Count	Diagnostic Weight (g)	Body Count	Body Weight (g)
I	515	30045	1080	49796	10629	209145
II	1304	90330	2544	102470	25005	466242
III	7993	722676	14480	922495	113661	3010182
IV	43	6080	134	4115	1413	22345
Grand Total	9855	849131	18238	1078876	150708	3707914

Table 5.4: Pottery counts and weights according to area at KHI in Stratum III.

Area	Count	Weight (g)	Bases Count	Bases Weight (g)	Diagnostic Count	Diagnostic Weight (g)	Body Count	Body Weight (g)
C	12248	357579	525	46325	1276	66940	10314	243109
H	49787	1810404	2847	305626	5424	297235	41403	1203598
L	12143	129920	453	10675	1026	15835	10630	102895
Q	2042	27940	43	1880	136	2660	1850	23000
R	2016	78110	85	9040	238	16210	1687	52750
Y	58313	2260750	4040	349130	6380	523615	47777	1384830
Grand Total	136549	4664703	7993	722676	14480	922495	113661	3010182

The regression analysis is also worth looking at on a locus by locus basis given the intent of understanding how different formation processes affect different areas of the site. Except for Area C, for the line of regression in each of the excavation areas the R-Squared value for each area is higher than the average for the whole site (Figure 5.10). The tightness of the regression lines highlights that within each area we can expect that the general deposition patterns to be uniformly predictable within every area except Area C. Following the expectation of a relationship between the sherd size and the kinds of deposition that is observed, the fact that Areas H and Y have the largest sherds on average highlights that the ceramics from those areas are most likely primary depositions and the best candidates for more detailed analysis.

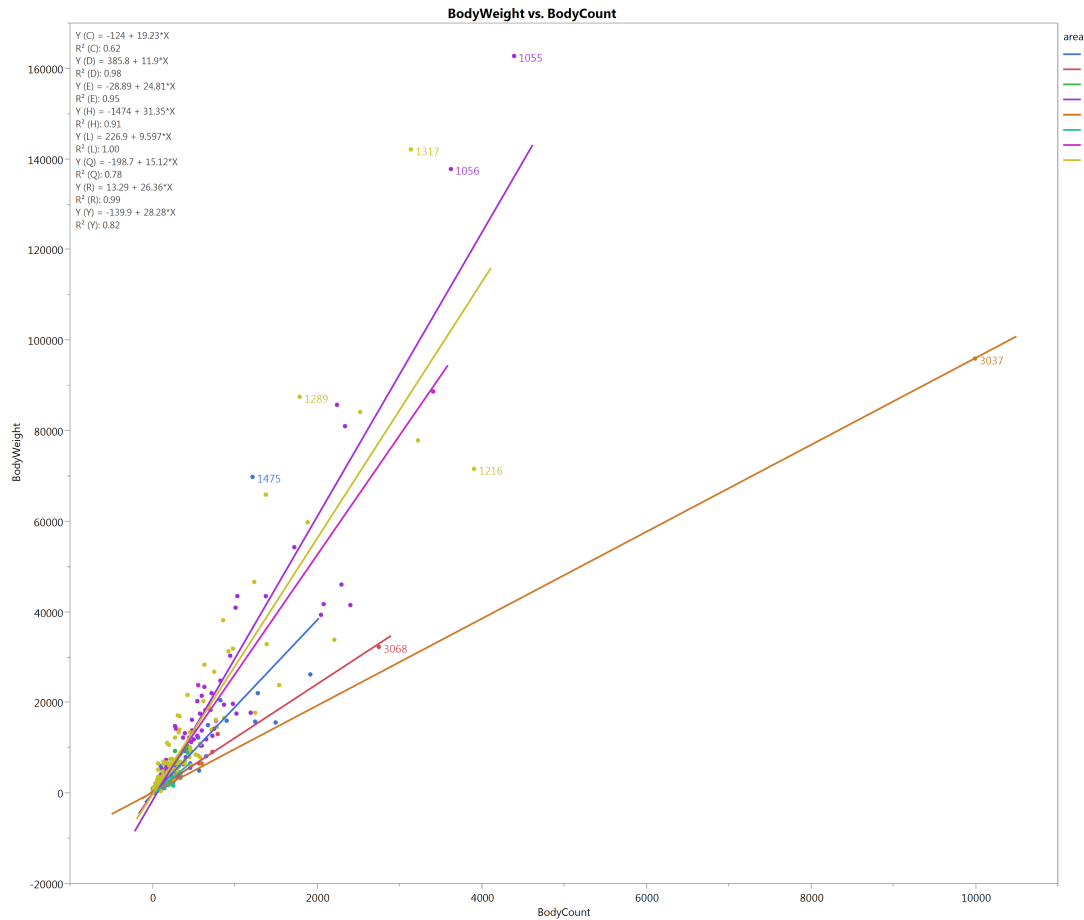


Figure 5.10: Relationship of body sherd count to weight by locus, the analysis is divided by area to highlight different patterns between excavation areas at KHI. The R-squared values indicate that within Areas the regression line is a good predictor of average sherd mass.

In order to determine which area between Areas H and Y would be the best to focus on it is important to check the relative homogeneity of the total amount of ceramics between the areas. We know from the descriptive statistics that outliers certainly exist, but whether those would make a difference in the overall picture of how pottery is distributed within each area is less clear. The χ^2 test (Table 5.5) results highlight that by both measures of count and weight the relative proportions of material varies according to the room in which it was found. Every test returned a significant value indicating a heterogeneous sample. This does not imply that each room contains more pottery than the other, but that the relative distribution of vessel

components (bases, rims and body sherds) varies from room to room. This implies that in different spaces different kinds of accumulations of material occurred. So even though the average sherd size within each area might be consistent, the make up of different parts of each vessel varies from room to room. Rooms where the ratio of one vessel component or another can indicate formation patterns that affect each room differently. When bases are plotted on a ternary plot Rooms 9, 15, 21 and 55 tend to be the greatest outliers with more bases than other sherd parts according to both count and weight (See Figure 5.11 and Figure 5.12). This means that depositional factors that would favor both the preservation and breakage of bases for those rooms in a way that might not have occurred in other spaces. This could have been influenced by the vessels not being stored on the floor or some other unknown factor. That unknown factor may simply be that the rooms that are outliers represent incomplete assemblages. This would lead to the conclusion that it might be best to not examine the material from those rooms more carefully. Three of the four major outlier rooms are in Area Y, which means that Area H will be the primary focus of the analysis.

Table 5.5: The χ^2 test results from room and stratum at KHI.

Stratum	Response	X	Test	Chi-square	Prob>ChiSq
I	Count	Room	Likelihood Ratio	464.84	0.0000
I	Count	Room	Pearson	454.67	0.0000
I	(g)	Room	Likelihood Ratio	22773.05	0.0000
I	(g)	Room	Pearson	22819.22	0.0000
II	Count	Room	Likelihood Ratio	724.82	0.0000
II	Count	Room	Pearson	737.88	0.0000
II	(g)	Room	Likelihood Ratio	16733.48	0.0000
II	(g)	Room	Pearson	16463.60	0.0000
III	Count	Room	Likelihood Ratio	6982.60	0.0000
III	Count	Room	Pearson	7246.92	0.0000
III	(g)	Room	Likelihood Ratio	342631.99	0.0000
III	(g)	Room	Pearson	401585.42	0.0000
IV	Count	Room	Likelihood Ratio	98.44	0.0000
IV	Count	Room	Pearson	125.08	0.0000
IV	(g)	Room	Likelihood Ratio	2785.00	0.0000
IV	(g)	Room	Pearson	2781.53	0.0000

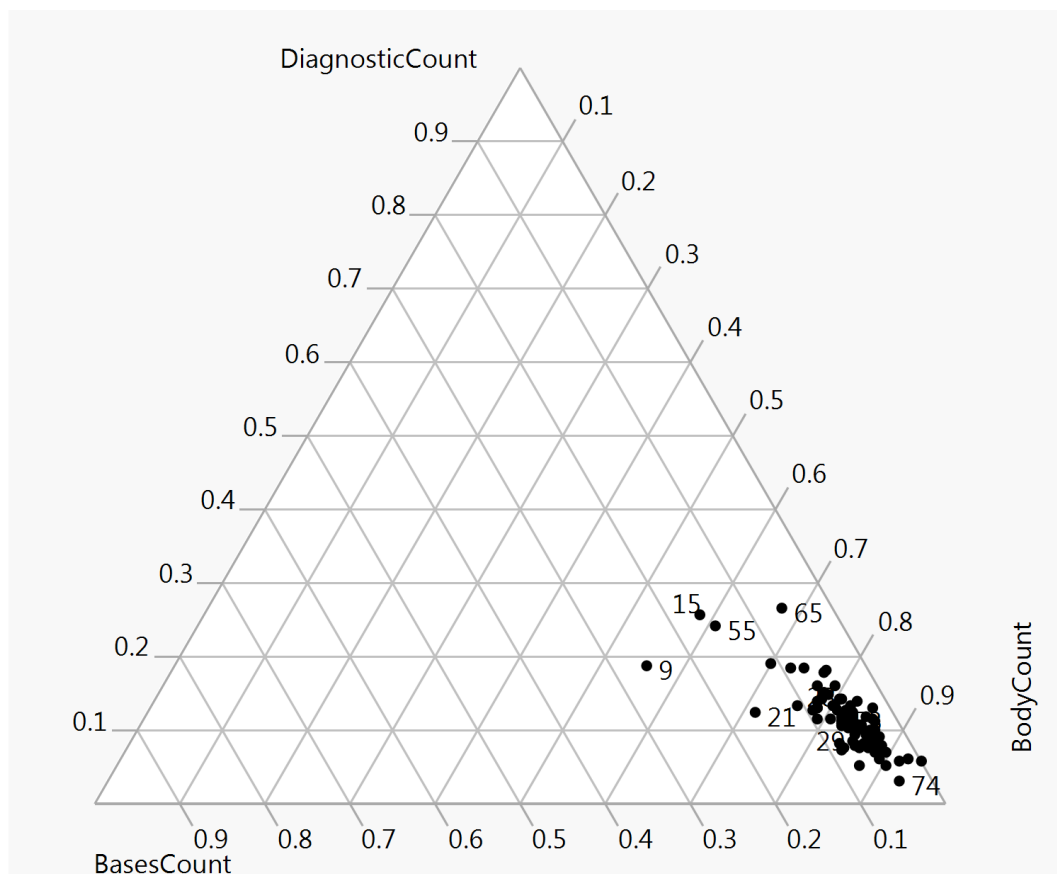


Figure 5.11: Ternary Plot of Counts of Bases, Diagnostics and Body Sherds according to Room at KHI. Each axis is plotted according to the relative quantity.

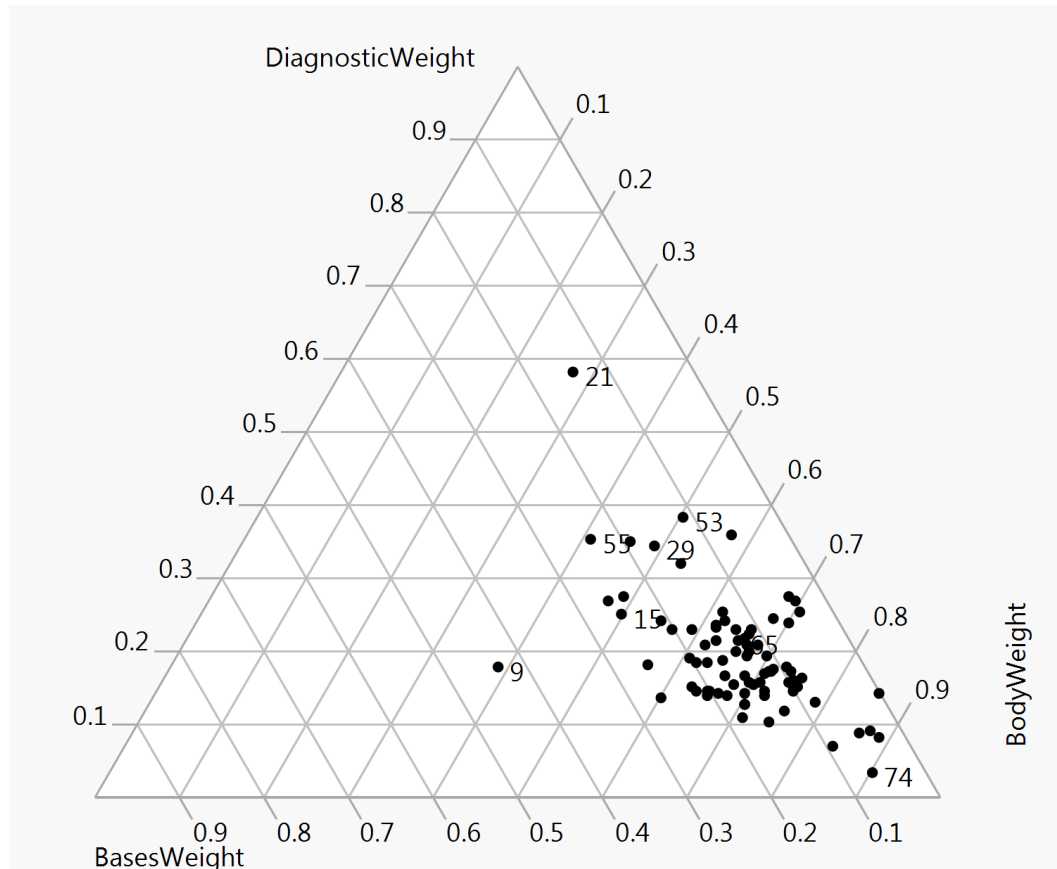


Figure 5.12: Ternary Plot of Weights of Bases, Diagnostics and Body Sherds according to Room at KHI.

5.3. Conclusion

The results from the various statistical analyses of homogeneity across the site present the groundwork in order to being to describe aspects of the social organization of the site and then the site in relation to other sites from the later part of the EBA. ArchaeoSTOR played a significant role enabling this research by providing a means to collate the large quantity of physical material into management digital meta-data. One of the core concerns of this discussion as it relates to ceramic assemblages has to do with the economic basis for the region. In Chapter 4.5.2 the centrality of copper in the *raison d'être* for the settlement in the area around Faynan was established. As primarily a tool for food production, consumption and

storage, ceramics play a role in answering the question of the organization of subsistence. This will be an important part of testing the description of the Negev-Faynan copper production and distribution system as itinerant metal workers working as attached specialist producers (Dever 1992, Haiman 1996, Cohen 1999, Adams 2002, Stein 1999). The Negev Highlands have been described as subsisting primarily using a pastoral nomadic model depending primarily on caprids and otherwise being transient (Muniz 2008, Hakker-Orion 2012, Dunseth 2013). However, the specialist production of copper precludes the pastoral nomadic subsistence strategy as discussed in ethnographic models for pastoralism (See Chapter 2.4). As a result, the detailed comparison of the distribution of ceramic type and forms in relation to aspects of copper production will be very important at KHI to elaborate on the relationship between these modes of production.

The data clearly showed variation in a number of different indices highlighting the lack of homogeneity of the Khirbat Hamra Ifdan ceramic assemblage. That variation included the presence of specific trash deposits and variation in the deposition of artifacts that implies differentiated activity areas within the site. The interpretation of the average size of sherds within different contexts needs to be examined against the diagnostic data reviewed in the next chapter to help clarify the implications of the breakage patterns. The variation in depositional density between the strata also indicates that over time the same intensity of occupation at the site as during Stratum III was not maintained. Preliminarily, it is possible to take all of those factors in combination to indicate the complexity of the social organization within KHI and the reliance on a mixed mode subsistence strategy based on the overall quantity of pottery at the site.

When considering the data gained from the different statistical measures for the sake of this analysis, it was important to consider how developing an understanding for the nature of the assemblage separate from the actual excavation might work. Additionally, the indicators

discussed were also intended to be useful in the case of an excavation. There are number of basic analyses that were not done with the data that could also help with the classification of different areas of production and activity at the site. Examples would be normalizing the data for sherd size to highlight locations of larger or smaller bases, looking at other measures of correlation at the site or drawing out the details of the variation observed more nuanced ways, in addition to many others. Going forward, the data described will help inform more nuanced studies of the diagnostic material to both correlate against the trends observed in the bulk data, but also to provide better detail of exactly what was occurring in different activity areas. In sum, the relatively simple analyses describe in this paper highlight the interpretive power that can be gained from processing the quantitative data collected using a rigorous data collection methodology.

The use of the integrated database that is a part of ArchaeoSTOR as a part of the direct inventory of material has distinct advantages of being able to rapidly qualify different aspects of site deposition. This includes the ability to track different variables both independently and in relation to each other yielding valuable data not just for final analysis, but also as a part of the excavation process. Noticing trends in the overall data either in the presence or absence of expected features, in addition to deviations from those trends provides important data for the researcher. This can inform on stratigraphic variation and validation, in addition to important variation across the site. It is in this sense that the use of a tool like ArchaeoSTOR becomes especially useful when making the transition from lab data entry to field deployment where adding extra data validation can help to ameliorate errors in field recording at the start and help generate a consistent inventory that can be preserved and shared digitally for posterity.

Chapter 5, in part, is a reprint of the material as it appears in Gidding, Aaron, Yuma Matsui, Thomas E Levy, Tom DeFanti, and Falko Kuester. 2013. "ArchaeoSTOR: A data

curation system for research on the archeological frontier." *Future Generation Computer Systems* 29 (8):2117-2127. The dissertation/thesis author was the primary investigator and author of this paper.

Chapter 6: Trends in Material Variability and Their Meaning for Modes of Production using Statistical Methods

In the previous chapter the focus of the pottery studies was to look at how studies of non-diagnostic pottery can be used to generally identify the factors that might influence the deposition of ceramics at KHI. Body sherds are normally not considered with such depth as a part of the overall goals of archaeological analysis, but nevertheless they can tell much about the kinds of depositional factors that would have influenced the assemblage found in each area of the site. That data will be important in understanding not only the function of rooms within the site, but also aspects of the reliability of the data especially in reference to the other parts of the site. This chapter follows up on that innovative approach to highlight what can be gleaned from a more specific analysis of diagnostic ceramics. Based on the analysis of the non-diagnostic sherds in the previous chapter, the focus here is the typological analysis of all of the diagnostic sherds from Area H. Area H is the focus for two reasons: the whole of the area constitutes a single structure from the main, Stratum III occupation of the site and room-by-room it was the densest area in terms of pottery while still being evenly distributed. Borrowing from C. Kramer's (Kramer 1982, Pgs. 80-83) suggestion that entire buildings need to be studied in order to characterize the range of functions that occurred within those spaces, an approach that took into account a total building complex was done in order to be able to characterize the total variation that was seen within that space. Those characteristics made it the best sample for applying an approach to quantify the relative variation in pottery types from room-to-room. The variation in types can be consolidated by function based on the expected use to generate a map of activity areas of KHI.

The quantitative analysis of the distribution of ceramics in Area H is an important dataset for the analysis of the KHI assemblage in reference to other EBA assemblages. For

this approach ethnographic examples of the pastoral nomadic pottery kit are used to set expected dimensions of variation and function expected for pastoral societies (See Chapter 2.4 Cribb 1991, Pg. 76). Specifically, at sites where the number of vessels is limited according to function and the variety is skewed it can be assumed that the assemblage represents a pastoral (nomadic) economy. For the pastoral sites of the EBA Negev Highlands Saidel (2002b) has presented data highlighting a limited range of pottery at EBA pastoral sites compared to urban sites in acceptance of Cribb's (1991, Pg. 76) hypothesis. This offers an important assemblage for comparison to help clarify the nature of KHI within the urban to rural spectrum. The functional analysis of the pottery within KHI offers a complementary way to understand aspects of the local subsistence strategy with the work of Muniz (2008) to contextualize the organization of copper production during the zenith of KHI, in Stratum III. This data can then be extrapolated to describe the economy of the Negev Highlands and southern Jordan. This will utilize the GIS data that was collected during excavation to highlight, when possible, individual activity areas correlated against other collected artifacts, including metallurgical finds.

6.1. Methodology of Diagnostic Pottery Analysis: Typology and Measurement

The general principle for analysis of the pottery from Khirbat Hamra Ifdan was to at least look at every single sherd. As discussed in the previous chapter, this involved a sort of the total assemblage and inventory of the non-diagnostics and diagnostics according to different categories. The results of that sort identified 19,486 individual specimens considered diagnostic at KHI. In order to reduce the analysis of the diagnostics for statistical analysis two different scales of focus were used to analyze the sherds: one being very broad and the other granular. The broad analysis identified all joins from a context and assigned a vessel to every sherd in order to be able to give a general categorization of the total assemblage. The

categorization took into consideration both the broad form, but used expected vessel function to combine some types when appropriate. The granular approach primarily focused on Area H and complemented the rough approach by describing features that could be used to better understand aspects of typological variability and the other key details about each sherd. This included measuring rim diameters, decoration notations, and fabric description.

6.1.1. The Typology Applied to the Analysis at KHI

The typology that was used for the sherds at KHI was based on decades of precedent of EBA typologies from the Negev, southern Jordan and neighboring regions. The first typologies were developed by G.E. Wright (1936, 1937) to identify chronological phasing through the EBA using Megiddo, Beth Sheen, Ai, Jericho and Gezer for reference. That typology was expanded as a part of R. Amiran's (1969) definitive tome of Levantine pottery, where special attention was paid to ledgehandles as an important chronological marker. The most comprehensive description of ceramic typological description in the nearby region of KHI comes from the work at Bab edh-Dhra that was initially excavated by P. Lapp (Schaub and Rast 1989, Rast and Schaub 2003), the excavations at Arad by Amiran (1978) and the excavations of the Negev by Cohen (1999) and Dever (2014). That work provided the framework for Adams' (1999, 2000) ceramic typology for KHI that relied on Dever's (1980) analysis of families TJ and S to help with chronological distinctions and to connect Faynan to the Negev using ceramics (For more on the Families and some of the problems with the applications of the families see Chapter 4.5.1). Ceramic correlations have also been noted for Stratum II and less so Stratum I from Bab edh-Dhra (Rast and Schaub 2003, Pg. 389-397, 445-448). The correlations at Stratum II at Bab edh-Dhra also indicated formal comparisons to Tel Yarmouth (Miroschedji 1988), Jericho (Kenyon and Holland 1983), Ai (Callaway 1972) and Tell Bet Mirsim (Dever and Richard 1977). Bab edh-Dhra's Stratum I indicates a

connection to Khirbet Iskander (Richard 2000). The strong ceramic correlations to the range of sites in the Negev and Southern Jordan, as well as neighboring areas allows for the adoption of the typological framework used in those excavations.

The classification of types used in the analysis was done according to the basic varieties used by a number of different excavations in southern Jordan and the Negev (i.e. Schaub and Rast 1989, Chesson 1997, Richard 2010, Chesson and Goodale 2014, Dever 2014). The types are at their broadest classified as varieties of bowls, holemouth jars and necked-jars. Some of these categories can also be subdivided based on a number of criteria such as decoration, rim treatment, paste types, general dimensions and evidence of use. The subcategories are also especially important when considering the functions that are considered the major grouping categories for each vessel.

In order to compare the assemblage of types to EBA examples of urban and rural the different types are assigned to expected functions. The assignment of type to functional varieties is considered according to the work of Chesson (2014, Fig. 7) and Saidel (2002b, Table 3) in southern Jordan and the Negev, respectively. Their categorizations differ slightly as a result of the different kinds of sites that each worked at (Saidel was at pastoral encampments and Chesson at a sedentary site) and as a result slightly different ceramic repertoires. Saidel's functional categories include cooking, storage and miscellaneous. Chesson's categories are vessels intended for food preparation, storage, and serving. The categories end up being roughly equivalent with Saidel's cooking and Chesson's food preparation categories being roughly the same except that Chesson adds certain kinds of vats, especially those with spouts. The major difference in the storage category is that Chesson includes the smaller jar varieties such as Amphoriskos and jugs as serving vessels. Lastly, Saidel's miscellaneous and Chesson's serving vessel categories are roughly equivalent except for the addition of the aforementioned jar types and other vessels such as lamps that are

naturally outside this categorization. An important difference between these analyses is based on the different subsistence character for each of the functional assignments. For the general break down of functional types I have used Chesson's approach as her material seems to bear that closest resemblance to KHI (See Table 6.1). Already this is an indication that the ceramics at KHI bear closer resemblance to the expected varieties at an urban site as opposed to a pastoralist's site.

Table 6.1: Basic classification of EBA vessels from KHI and their associated functions.

Serving	Preparation	Storage	Other
Platter Bowls	Vats	Jars	Lamp
Bowls	Kraters	Storage Holemouth Jars	
Jugs	Cooking Holemouth Jars		

Table 6.2: Statistics describing each category of vessel with 5% of rim present and vessel was from Stratum III at KHI. Except of Jug and Jar all vessels close to a normal distribution. The details of the statistics are discussed in Chapter 6.3.1.

Form	Mean	Variance	Standard Deviation	Skewness	Kurtosis	Median	CV	N
Bowl	21.73	76.90	8.77	0.81	3.62	20	0.40	679
Cooking	20.44	30.11	5.49	0.50	3.42	20	0.27	403
Holemouth Jar	18.59	36.66	6.05	0.66	3.50	18	0.33	435
Jug	7.14	18.65	4.32	1.39	4.26	5.5	0.60	28
Jar	16.42	29.64	5.44	2.35	27.13	16	0.33	674
Krater	48.11	91.93	9.59	0.46	2.59	48	0.20	96
Lamp	15.47	7.43	2.73	0.47	3.01	15	0.18	81
Platter-Bowl	29.26	57.70	7.60	0.00	2.90	30	0.26	331
Vat	58.22	168.61	12.99	0.03	1.88	58	0.22	51

At KHI, bowls are the most diverse category with variations in function that could be interpreted as a part of food preparation, storage and serving. One exception is the lamp, with the specialized use for illumination. Lamps are shallow bowls with a rounded bottom and

impressed and/or enveloped lips usually on four “corners” of the rim. They were slipped and burnished inside and out and have evidence of burning around the rim. The majority of bowls are simple with a relatively straight rim and a sometimes globular body and typically a flat base (See Figure 6.1). Those bowls were sometimes slipped and burnished, and if they were, typically the slip and burnish covered the entire vessel. These were always classified as plain bowls and are considered to be primarily serving vessels. Another variety included an inverted rim bowl or platter bowl (See Figure 6.2). As the name suggests the rim always had a sharply inverted rim, almost always with slip and burnish on the interior that would cover the entirety of the rim. Fewer of the platter bowls, about half, were slipped and burnished on the exterior. The platter bowls had diameters that were much larger than the typical bowl. Like the typical bowl types, platter bowls are identified as serving vessels. Another bowl type is the krater, which would have been primarily used for storage (See Figure 6.3: 1,4). Kraters are like the typical bowls only much thicker, with a larger rim diameter and a slightly in turned rim. A few examples have a decoration on the rim, but the majority are undecorated. Another large bowl type has been termed a vat, but it unlike the krater is often associated with food preparation, especially related to olive oil (See Figure 6.3: 2, 3 Richard 2010). Vats are sometimes spouted and have an even larger diameter and thicker rim than the krater. The most prominent feature on most vats is a plastic application along the rim and often running vertically down the sides with an impressed pattern that looks like ropes. Often when found in situ these vessels were too large to move.

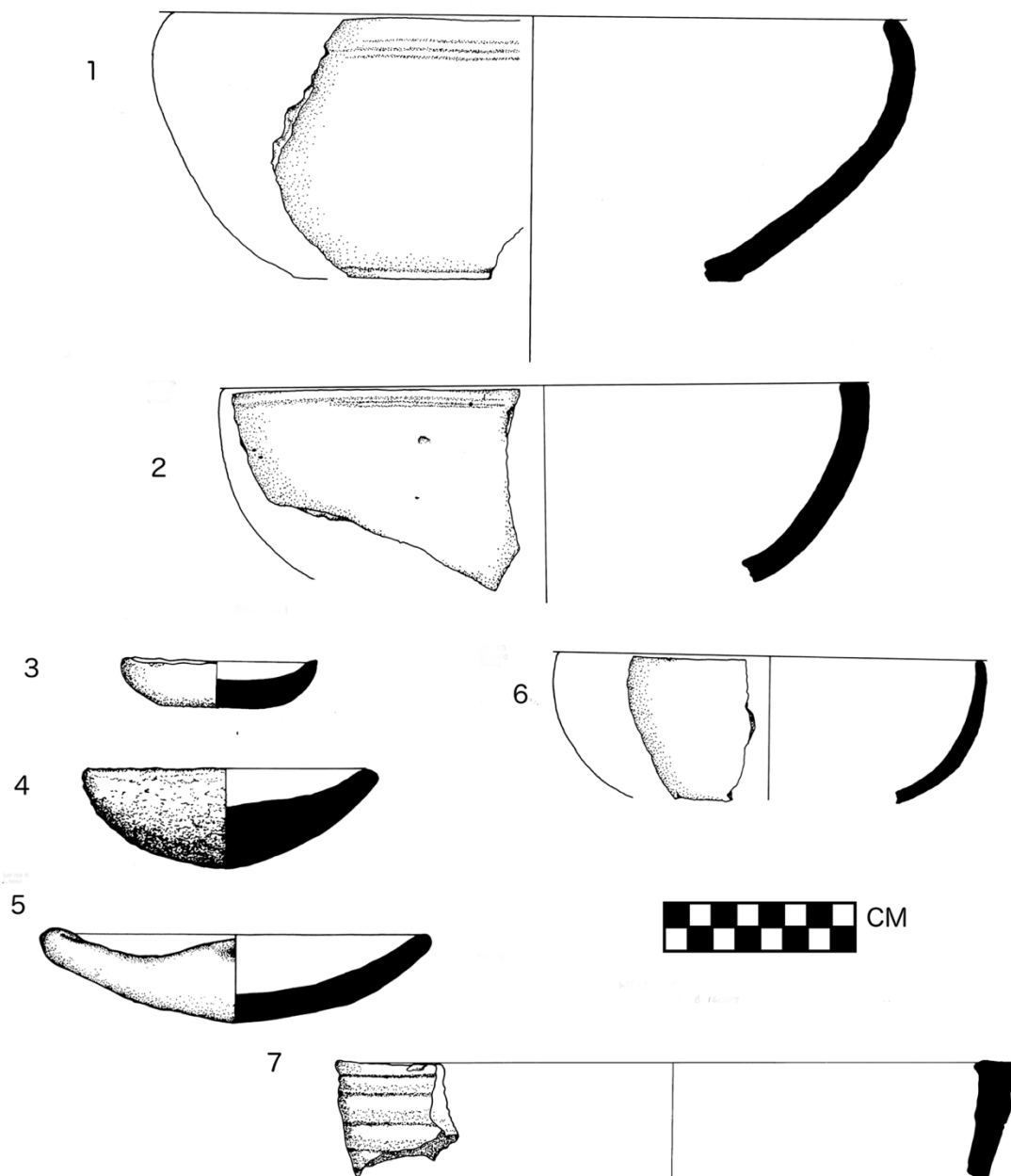


Figure 6.1: Plate of typical bowls excavated from KHI. Drawings by Caroline Hebron, UC San Diego Levantine and Cyber-Archaeology Lab.

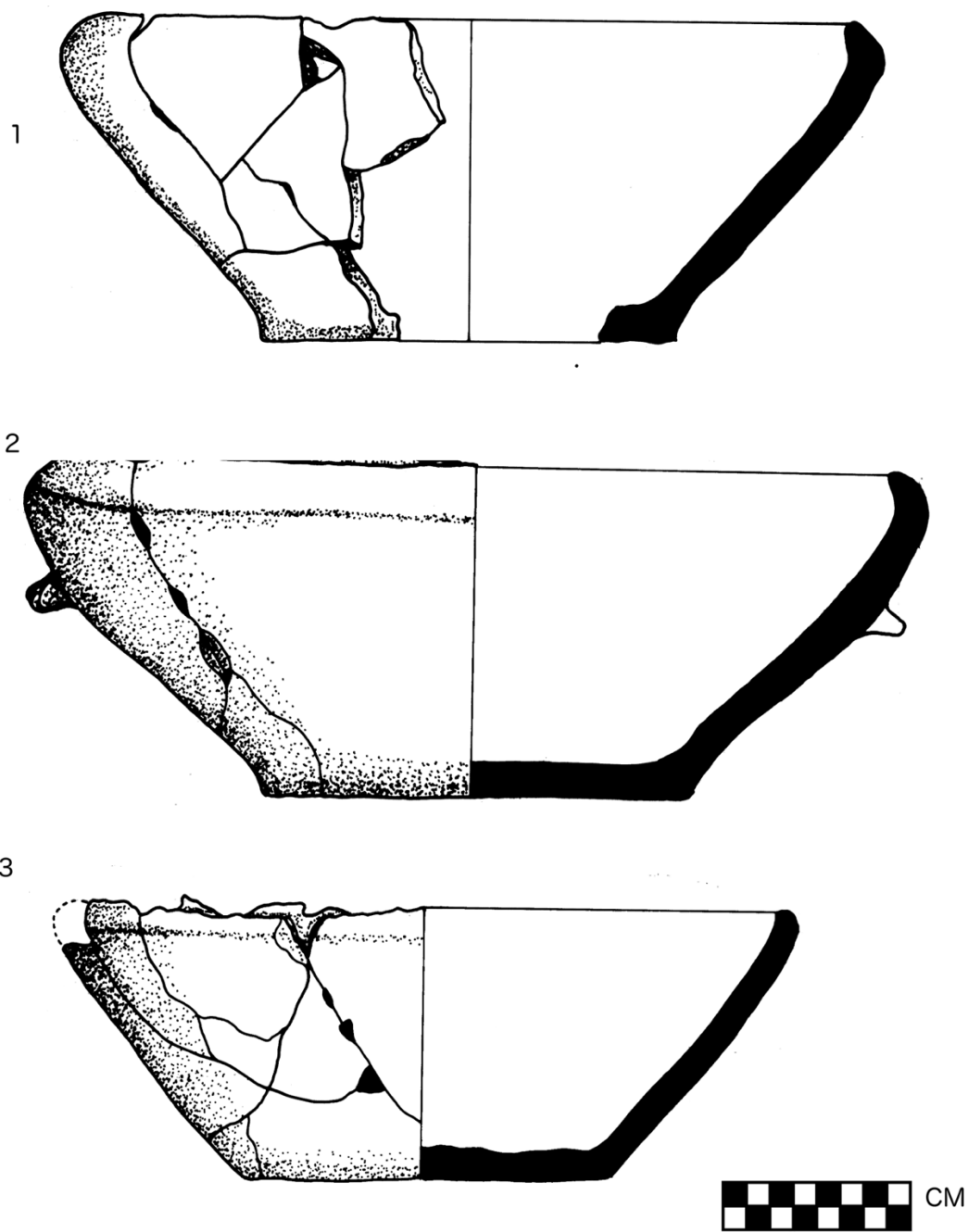


Figure 6.2: Plate of typical platter bowls excavated from KHI. Drawings by Caroline Hebron, UC San Diego Levantine and Cyber-Archaeology Lab.

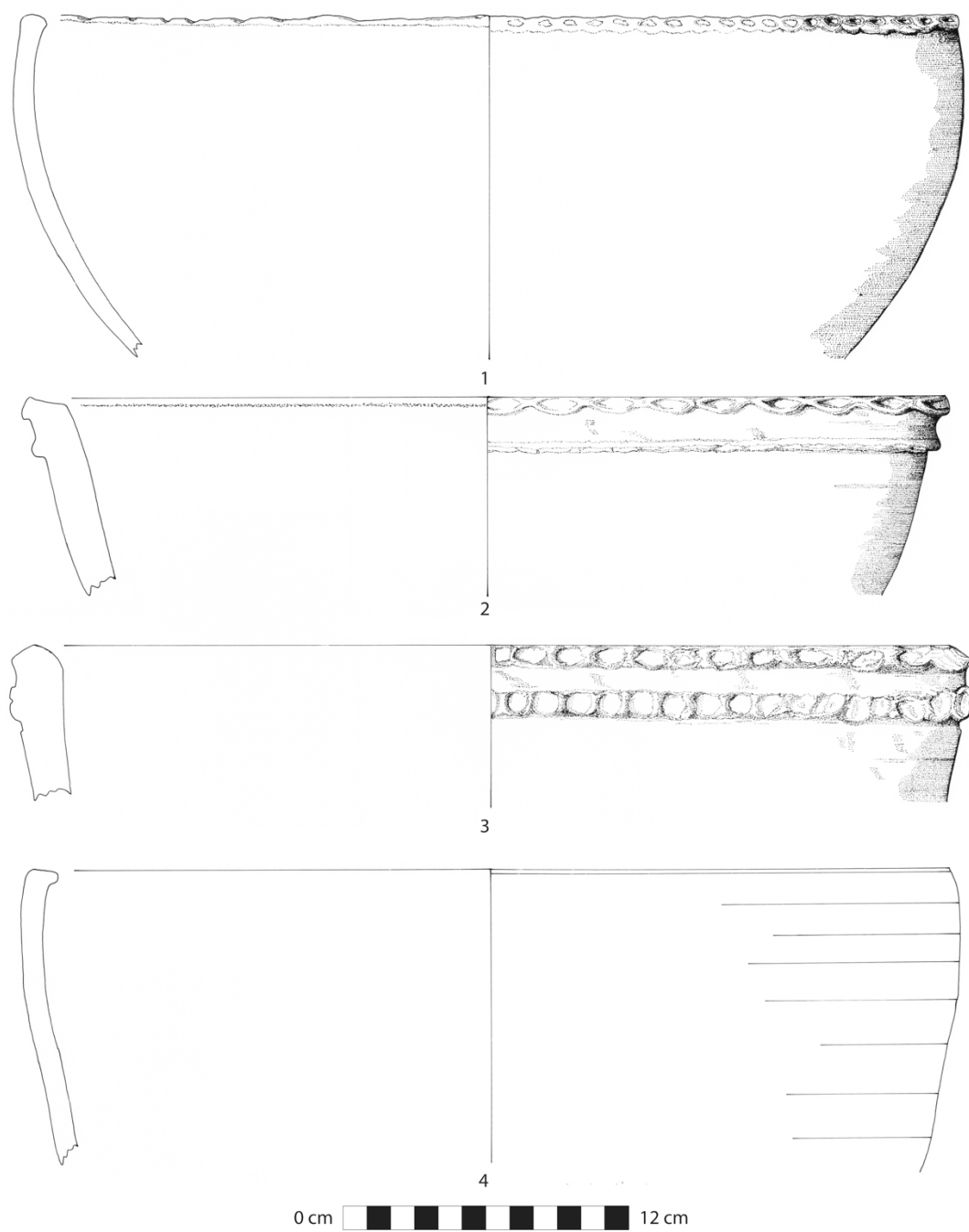


Figure 6.3: Plate of typical vats and kraters excavated from KHI. Drawings by Caroline Hebron, UC San Diego Levantine and Cyber-Archaeology Lab.

There are three varieties of holemouth jar found at Khirbat Hamra Ifdan. Firstly, the most plain of the storage jars was probably intended for the purpose of storage (See Figure 6.4: 3, Figure 6.5: 1,2,4,5). Those vessels are unfinished, typically have a plain rim that was formed by turning over the rim edge to the interior and have a flat base. Other instances of holemouth jar are decorated with an exterior slip and burnish and a plastic appliqué that can be incised or impressed to look like small pieces of rope hanging on the sides of the vessel. Typically, the decorated varieties have a smaller rim diameter compared to the undecorated varieties. This decorated variety also will sometimes have a spout in which case it is clear that they were involved with some aspect of food preparation or serving. Finally, holemouth jars were used as cooking vessels See (Figure 6.4: 1, Figure 6.5: 3) . These are easy to distinguish due to the brittle fabric, often with a lot of calcite inclusions and the external face being heavily burnt. The rim forms are a little more complex with some showing an eversion, a flattened top and other varieties that are most likely associated with various time periods. Additionally, if a complete vessel is present then it is easy to pick out due to the rounded bottom as opposed to the flat bottom seen in the case of the holemouth jars that were used for storage (See Figure 6.4: 1,3).

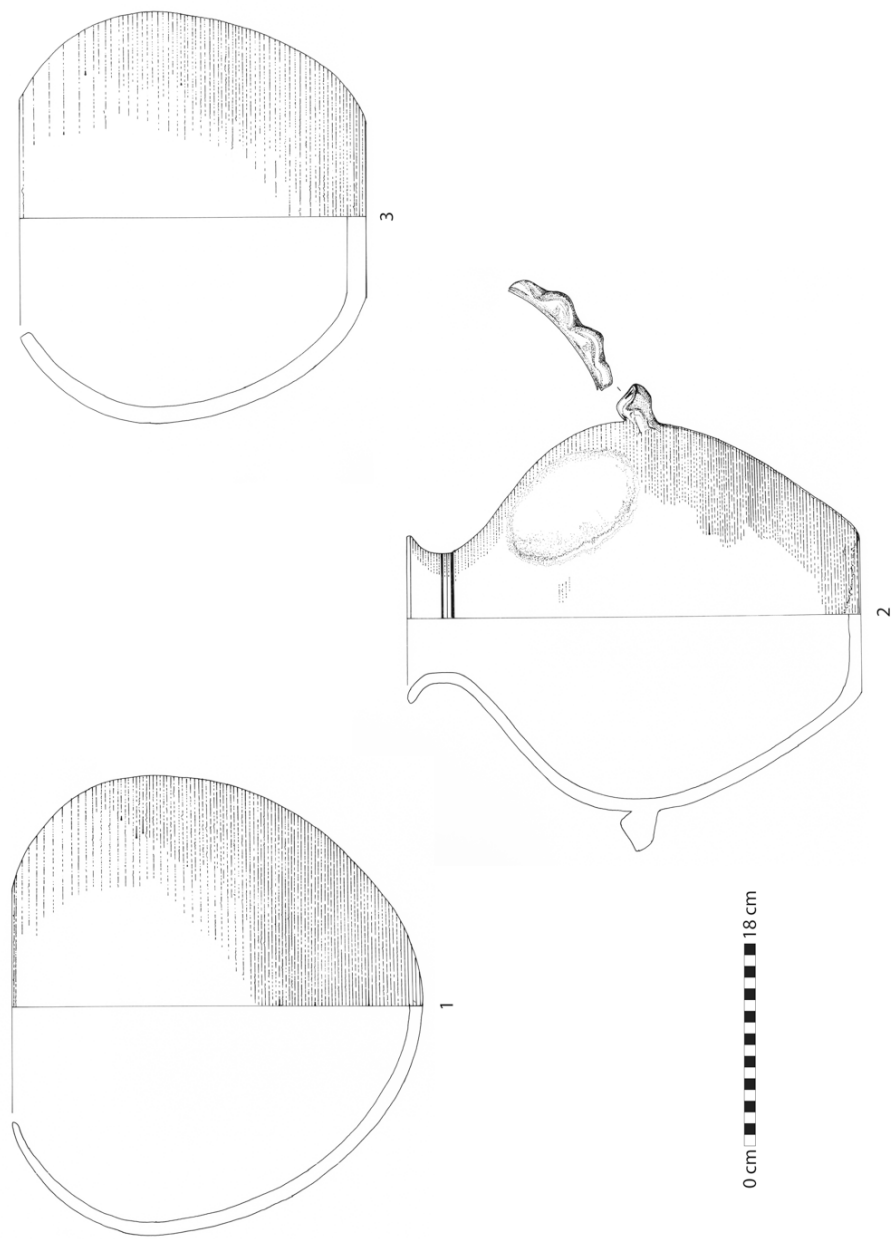


Figure 6.4: Plate of complete vessels found during the 2007 excavation season. Drawings by Caroline Hebron, UC San Diego Levantine and Cyber-Archaeology Lab.

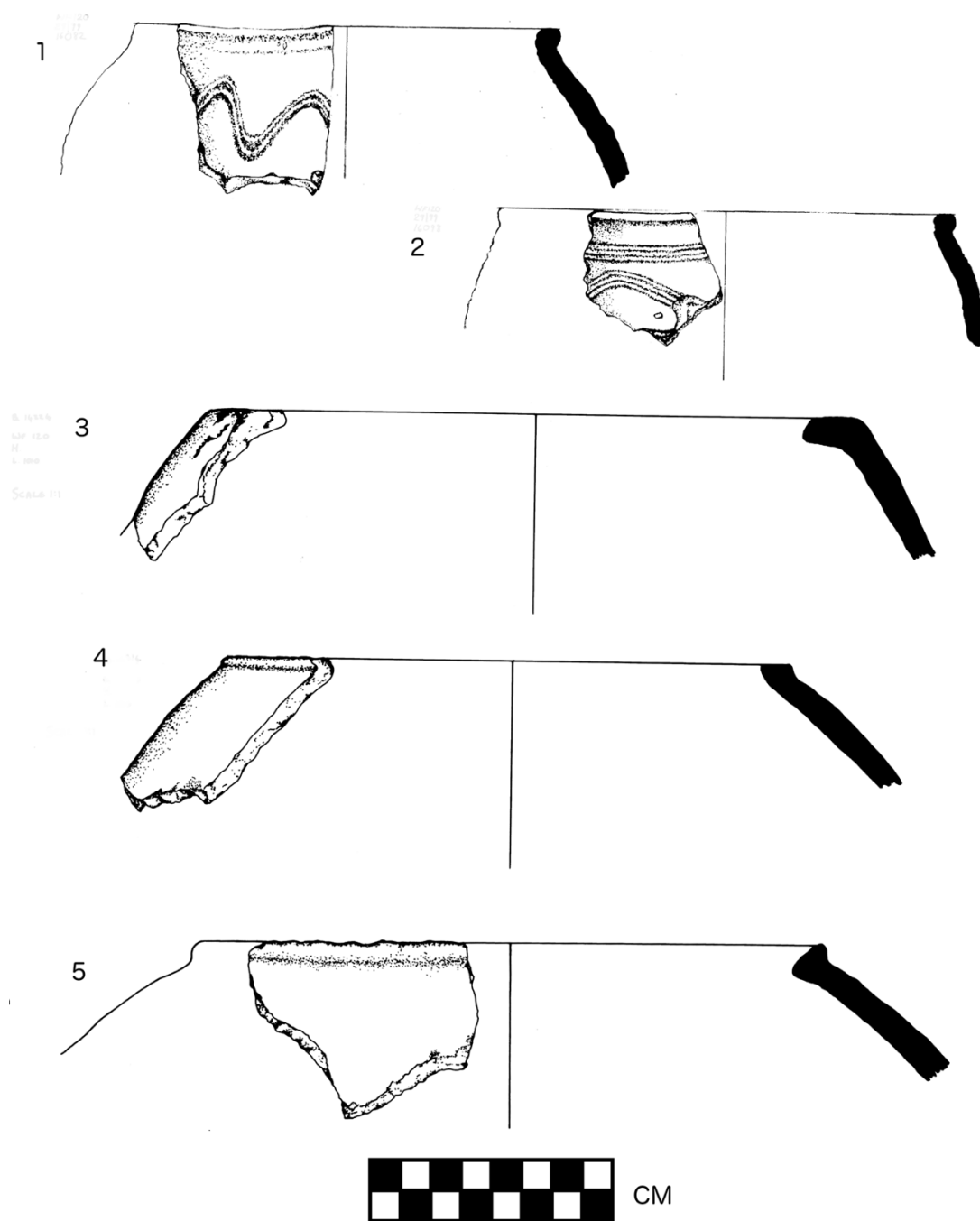


Figure 6.5: Plate of typical holemouth jars excavated from KHI. Drawings by Caroline Hebron, UC San Diego Levantine and Cyber-Archaeology Lab.

The variety of jars is represented by smaller jars, amphoriskoi, jugs and juglets, in addition to large, heavy store jars. The store jars distinguish themselves by the sheer size of the rim diameters and rim thickness (See Figure 6.4:2, Figure 6.6: 2, 4, 6). The rim and collar was sometimes made on a slow wheel and attached. As a part of the process of attaching the collar to the shoulder often an incised pattern was applied to help hide the smoothing between the two vessel pieces (Figure 6.6 : 2, 6). In general, more use of the wheel is seen in the southern Levant over the course of the EBA (Ben-Tor 1992, Pg. 105-106). Store jars as the name implies were primarily used for storage, presumably of foodstuffs and other related goods. The smaller jars also show the same method of production but often do not have the incised shoulder decoration. As a result of the similar production technique and presumed function all jars were grouped together for analysis despite the variation in size. Some jars are also slipped and burnished, with many also having a folded rim to make a juglet or jug depending on the overall size (Figure 6.6 : 1). The jug distinction is important as when identified the function of the vessel is assumed to have been for serving. Other examples serving vessels in this category are the small, slipped and burnished jars called amphoriskoi (Figure 6.6 : 7).

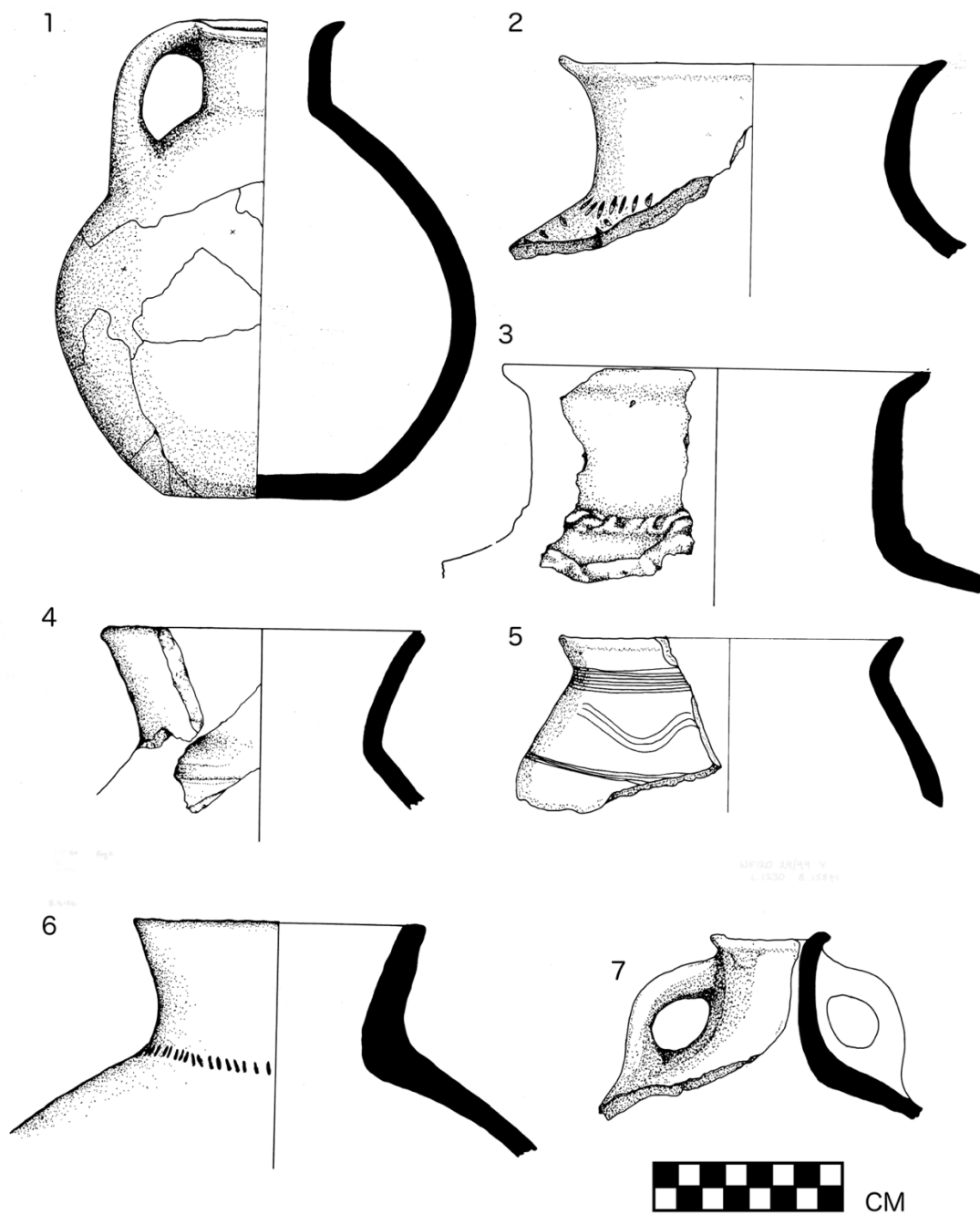


Figure 6.6: Plate of typical jars excavated from KHI. Drawings by Caroline Hebron, UC San Diego Levantine and Cyber-Archaeology Lab.

The wide variety of vessel types found at KHI provides an important data point to characterize the site as permanent and urban when compared to other EBA within the Faynan-Negev region. Only a limited range of pottery types occurs at sites that are identified as pastoral and temporary in the Negev and Sinai (Saidel 2002b). The limited range in variety of types is interpreted to be the result of relying on organic vessels and utilizing single vessel types for multiple functions. By comparison KHI contains the full range of vessel types that has been noted at the larger and more developed urban sites in the region. In lieu of studying the organization of specialized pottery production, functional analysis of the pottery offers another avenue to understand the economy of the Negev Highlands and southern Jordan. The organization of the 19,486 diagnostic sherds from KHI into these categories will provide a structure to help organize the data for intra-site analysis based on function within different rooms. This will utilize the GIS data that was collected during excavation to highlight, when possible, individual activity areas correlated against other collected artifacts, including metallurgical finds.

6.1.2. The Method for Quantifying the Number of Vessels at the Site

In order to apply statistical techniques to the description of the different types identified at KHI it was necessary to reduce the quantity of sherds as a way to take into account depositional factors that would have increased the total number of sherds relative to the actual quantity of ceramics in a given context. The application of a broad and a granular analysis was done in order to make sure that every context from KHI was examined. The broad analysis was performed in a way that would overestimate the total number of vessels found in a context, while the granular approaches would underestimate the total number of vessels. The granular approach required more effort as a part of the data recording process. In order to limit the number of sherds considered the granular approach was only applied to Area H. The broad

approach was done for used for every context at the site. The two approaches can be compared within Area H, along with data produced using the non-diagnostics in the previous chapter, to identify whether the overestimation and the underestimation of counts agree. That data can then be used to extrapolate the expected counts in the other excavations areas.

The broad analysis was used across the site in order to establish a secondary baseline for comparison with the non-diagnostic data that could establish an estimation for the variation of ceramic types across the site. That analysis occurred on a locus by locus basis in order to identify all potential joins within each locus and quantify the **Maximum Number of Vessels** (MxNV). This measure is similar to the **Number of Individual Specimens** (NISP) as might be identified by an archaeozoologist (Van Derwarker 2001, Pg. 10). The overall size of the assemblage was too large to ensure that every single rim sherd could not be rejoined. In this count, entire loci were laid out and organized according to a variety of general types. After the reduction of vessels by MxNV the number of diagnostic vessels found across the site was reduced to 13619. The minimum number of vessels would have required a longer period of examination comparing the total assemblage from each context to ensure that each vessel was only represented a single time.

The fine grained analysis of diagnostic pottery was done entirely using ArchaeoSTOR as a data management tool. This allowed for the easier collation of data for later statistical analysis and provided the ability to quickly review and recall data that was already entered about individual sherds as they were encountered. The idea behind the analysis was guided by the preliminary analysis of ceramic assemblage in its bulk form. As a result, every single sherd excavated in Area H was analyzed very carefully using both quantitative and qualitative measurements. The quantitative metrics for analysis were used to determine the relative dimensions of a number of key features. These were measured to provide as detailed a description of each sherd as possible in case those features could be used for comparison of

vessel types in the future. For rims the diameter, thickness and percent completeness were recorded. When still attached to the rim, bases were also measured for diameter and percent completeness. If present, handle thickness was measured along with details based on the type that would be relevant for chronological analyses. For the purpose of quantification, the percent completeness of the rim was the most important metric. The percent completeness is used according to vessel type when characterizing the total assemblage to create the **Estimated Vessel Equivalent (EVE)**. The EVE offers an “unbiased and invariant” means to characterize an assemblage by counting vessels in a class by only using the actual percentage of the vessel identified for the purpose of total quantification (Orton 1989, Pg. 96). If only a quarter of a vessel is found, then it only counts as .25 in the total count, etc. Thus in contexts such as a potential midden, where many sherds are found but small fractions of a complete vessel, the overall representedness that would be high in MxNV is and significantly reduced for the EVE. As Orton (1993, pg. 177) “argue[s] that our real interest lies in comparing the ‘parent’ assemblages (which represent past activities) rather than our ‘samples’, which have been distorted by their postdepositional history, and that we therefore need to use measures which preserve elements of the comparisons between parent assemblages within the observed comparisons between excavated assemblages.” The amount of breakage is accounted for in each individual case by using the percent of the vessel left as the absolute value of the quantity of the vessels within a context.

The methods MxNV and EVE offer varying levels of confidence in the absolute values for the number of vessels that would have been present within a context. MxNV is an overestimation of the total count that indicated the maximum for vessels from a context. The method guarantees that every sherd from a single context is recorded using a quick and efficient method of analysis. However, this method fails to take into account depositional processes that would create mixed assemblages that would add to the total counts. EVE offers

an alternative estimate that instead is almost certainly too low an estimate for the total count. A number of site formation processes that one must assume are a part of the formation of any excavated assemblage expect that not all of the sherds are representative of the real activities that went on in a given space. Given the quantity of material that was analyzed at KHI it would be useful to be able to reliably compare the breakage of vessels using the data from Area H and applying that to the other excavation areas.

One way to account for the average breakage of vessels within each context is by calculation the **Modulus of Rupture** (MoR). The “MoR” is similar to the EVE, but rather than taking each vessel individually, vessels are grouped to calculate an average breakage. The average is then used to estimate the number of vessels (Mateo Corredor and Molina Vidal 2016). A variation of this idea was also proposed using the term brokenness as an index of the type of pottery and the context as indicative of variation in breaking patterns (Orton 1989, Pg. 97). The groupings can occur on different scale according to features such as fabric type, location, vessel class or any other measurable aspect in order to more narrowly estimate that group’s likelihood of breaking. The MoR is calculated as the average breakage within a given assemblage, but exclude complete rims as unrepresentative of the average breakage pattern. In order to make the comparison between Area H and the total assemblage the distinctions were based on vessel forms. To enhance the distinction from EVE within Area H the vessel thickness was also used. The MoR statistic provides a method to distinguish excavated contexts using a holistic method to measure trends in the data. Both the EVE and the MoR under represent the number of vessels known to be within any given context. The MoR statistic can be used to convert the MxNV data in other contexts into an underrepresented sample similar to what would be expected if the EVE had been calculated in those other contexts.

6.2. Statistical Analyses Used

Statistical methods that are designed to recognize patterns in differences in frequencies were used to describe activity areas within KHI¹⁷. The various excavations that were used as the guides for typology only analyzed the basic quantification of frequencies according to categories such as stratum or excavation area but did not use that data to model activity areas (i.e. Schaub and Rast 1989, Chesson 1997, Richard 2010, Chesson and Goodale 2014, Dever 2014). In order to compare models for the variations of function of different rooms according to the ceramic, faunal and metallurgical data it is necessary to identify trends in the relative distributions of ceramics according to type and function. The goal of such an analysis is to build upon the indices for the variation in ceramic distribution and deposition patterns produced in the previous chapter to model activity from room to room at KHI. Just like with the bulk data, it is impossible to draw explicit a priori hypothesis about causal relationships between the variables. As a result, it is necessary to employ methods that indicate relationships between variables to qualify the difference within different contexts and whether there is difference between assemblages. Unlike the methods used for the bulk analysis, the multivariate exploratory analysis does not examine relationships with a null hypothesis. Instead the interpretation of relationships within the data require contextual interpretation that is not predictive but nevertheless associative.

6.2.1. Standard Measures of Variation

Before conducting exploratory data analysis, it is necessary to verify the typological validity for the different vessel types. The most straightforward way to do this is to identify standardization based on basic features like rim diameter. There are a number of descriptive

¹⁷ The statistical package STATA Version 14 was used to process all of the data (See Appendix 1 for the code used to process the data in Appendices 2 and 3).

statistics that can be used to standardize variance between groups in order to compare the degree of typological consistency. The core statistics used to measure the degree of standardization are the mean, the standard deviation, skew, kurtosis, and the coefficient of variation (CV). The mean is the average value all measurements and the standard deviation measures the amount of variation from the mean. The coefficient of variation standardizes the standard deviation by dividing the standard deviation by the mean to give a percentage of the mean, thus describing the dispersion of the variable independent of unit of measure (VanPool and Leonard 2011, Pg. 54-57). Thus rather than representing the absolute deviation from the mean, as in the standard deviation, we can now understand the relative deviation from the mean between types. When that percentage is high, the higher the dispersion of the variable from the mean. When the percentage is low, dispersion from the mean is relatively low. This metric is especially useful for contexts in which the objects of comparison are materially different and as a result direct comparisons would be difficult. The other important question about the type is whether the dispersion measured by CV applies to a normal curve. This is important because many statistical operations require a normal curve and if the curve is not normal it would not be possible to call a type “standard”. One way to test whether the distribution curve is normal is with the measures of skew and kurtosis (VanPool and Leonard 2011, Pg. 32-34). Skew indicates the evenness of the distribution and kurtosis measures the centrality of the measurements. A skew of 0 and a kurtosis of 3 is considered normal. In combination, if the measures of skew, kurtosis and coefficient of variation are normal then we can accept the typology as it has been described and use that data for other statistical analyses. If there is variation from normal, that variation needs to be accounted for and will hold significance in other statistical analyses.

6.2.2. Correspondence Analysis

Correspondence analysis offers a multivariate method to look at descriptive data using a simplified table using a two-way contingency table just like the χ^2 test. The data that this method yields allows the researcher to explore the patterns in the data. Whereas χ^2 measures whether there is a departure from the expected distribution, using the χ^2 statistic, correspondence analysis attempts to explain that variation. This is done by redistributing the data in Euclidian space along dimensions, which are derived from distance of a data point from the average of the data as a whole. As a result, the data highlights which variables contribute to the departure from the average of the total assemblage. The method has been used in a number of disciplines where trending the relationships between data of abundance needs to be understood with Greenacre (1984, 2007, 2010) being the most cited and doing the most to advance the method across disciplines in the past few decades. The best descriptions of the method for the purpose of archaeology are by Shennan (1997) and Baxter (1994, 2015) who provide a number of excellent examples using archaeological data while explaining the math that underpins the methodology. With the proliferation of computers in the past few decades the method has increasingly become popular for seriation (e.g. Groenen and Poblome 2003, van de Velden, Groenen, and Poblome 2009, Peeples and Schachner 2012). The application of correspondence analysis between areas applies the same principles of seriation analysis, but rather than comparing changes in types to detect chronological variation it is compares variation of types to assume functional differences across the site.

For the analysis of the different activity areas within KHI correspondence analysis was used to compare the frequencies of different vessel types across the site. The three aforementioned methods for quantifying rim frequencies (MxNV, EVE and MoR) were analyzed using correspondence analysis. MxNV was used for an analysis of the distribution of

ceramics across the entire site. EVE and MoR was used for Area H because it was the only area where the more detailed analysis occurred. Within Area H the differences in the results from all three methods will be considered. Additionally, the MoR according to type will be applied to the rest of the site so that the results from MxNV and MoR can also be made for the entire site. Based on the comparison of the over and underestimations of the total assemblage it will be possible to identify trends in the data that can be used to assign function to different rooms.

Although the technical aspects of correspondence analysis are beyond the scope of this dissertation it is important to review the core statistics produced as a part of the analysis to understand interpretation of the results. As already mentioned, the analysis is done based on the generation of a contingency table and is based on the χ^2 statistic. The data for analysis is transformed into relative frequencies according to the row and column profiles. The metric of mass is used to weigh the overall influence that one row or column of the contingency table plays in the analysis. Related to that is inertia, which is a measure of the deviation from the average for a given variable. The mass is used to calculate the inertia or variance so that the rows or columns that have the most mass will also have the most influence on the inertia. What is plotted on the biplot or projection is the amount that a given row or column deviated from the average row or column profile along the dimensions that are created to explain the analysis. This is not a true biplot because it is displayed symmetrically, so the distance between row and column profiles cannot be measured directly, only as an approximation. However, the biplots provide a framework to analyze relationships between measured features according to the amount of deviation from the average on each dimension so that rows and columns are comparable in the same geometric space. If multiple rows deviate positively from the average, they are interpreted as deviating together and are assumed to be similar in relative quantities. If the data from the columns is plotted positively on the same dimension the data in

the rows and columns can be taken together as corresponding. The dimensions along which the data is measured are generated in a method similar to principal components analysis, a best fit line that explains the variation in inertia. The closer values are to the zero on any given dimension, the closer those values are to the average, expected value. Deviation from the average on any dimension suggests association between similar elements within each row and column.

6.3. Results of Quantification and Related Statistical Analyses

The data is grouped into two distinct applications using the different statistical methods outlined above in order to identify trends that indicate different activity areas within the site. The first application seeks to understand the variation in formal types observed in the material record. The second application seeks to understand how the various types distribute within the site in order to describe the variation of distribution according to a number of different metrics. Respectively, analyses of typology and abundance using descriptive statistics and correspondence analysis. When combined these work as an attempt to link the typological features into an analysis of function by room. As already discussed, the functional analysis is important in order to model aspects of the social organization at the site by comparing the ceramic assemblages from room-to-room. This modeling seeks to make connections to both the expected results for different levels of social organization and the different modes of economic production. Given the expectations set by previous research on the copper trading network in the Negev highlands, this approach references ethnographic correlates of pastoral nomad pottery use to set expected dimensions of variety of pottery and relative expectations for the distribution of pots according to function (Saidel 2002b, Table 4). At sites where the number of vessels is limited according to function and variety it can be assumed that the assemblage represents a pastoral (nomadic) economy (Cribb 1991, Pg. 76).

An important derivative of the analysis of vessel distribution will be evidence of a division of labor based on the isolation of different activity areas.

The key non-typological grouping element applied to the ceramic assemblage is based on differences in the assumed function of each vessel type. One of the key distinctions to test the functional variability will be based on the degree of division between activity areas and whether different forms strongly reflect the assigned functions. One would expect highly mobile populations to maintain few heavy ceramic vessels and use vessels for a number of different purposes due to the weight of the vessels. An example of this comes from the ethnoarchaeological study by Grillo (2012, Appendix 1) of pastoralists in Samburu, Kenya where the assemblage of ceramics is standard with no pots with diameters above 20 cm. However, she (Grillo 2012, Pgs. 307-320) notes that despite moving between mobile, temporary homes and permanent squared structures there is no reason to assume that there is an absence of pottery. In support of Cribb (1991, Pg. 76), individual ceramics are used for a larger number of functions. As a point of comparison, the larger jars, vats and kraters found at KHI do not have equivalents in the Samburu ceramic assemblage. In short, the description of the variety of functions in relation to the distribution of pottery at KHI will be an important part of developing a more nuanced approach to understanding the construction of the local economy.

The ceramic variation according to function will be considered in reference to the other datasets available from KHI to describe both the organization of production and the subsistence strategy. Firstly, the work of Muniz that highlighted the fact that the site seems to have certainly relied on pastoralism, but favored meat production over other pastoral products based on the killoff pattern (Muniz 2008). Secondly, the publication on the excavations from 1999 and 2000 highlighted the fact that the primary occupation at the site in Stratum III was significantly involved in the processing of copper (Levy et al. 2002). This presents KHI as

both a pastoral and a site that exhibits “urban” characteristics. The focus of the data analysis as result is on data from Stratum III to examine how the ceramic functional variability compares to other EBA sites in the region.

6.3.1. Identifying Typological Consistency Using Statistics

Typological consistency is an important measure of specialization of production. Basically, the assumption goes that the more regular the vessels in terms of form and dimensions, the more likely the vessel was produced in a specialized environment (See Longacre, Kvamme, and Kobayashi 1988, Blackman, Stein, and Vandiver 1993). A corollary of standardization of form through specialized production is the higher the incidence of specialized or unique vessels for specific functions (Cribb 1991, Pg. 76). The basic premise for both of these points is the expectation that in order to consume large varieties of different pottery types time is invested in a specific place and as a result indicates a less nomadic life. Based on the quantity of pottery at KHI outlined in Chapter 6 it seems that KHI was occupied year round.

The most straightforward way to evaluate typological consistency is to look at how specific sets of measurements vary according to types within the site. The measurements of rim diameter and rim thickness are the best indices to check variability. Anecdotally, many vessels would yield a variety of measurements along the rim for both diameter and thickness. In order to make the measurements comparable between vessel types the coefficient of variation statistic is used to evaluate the vessels on their own and in comparison to the overall assemblage.

When judging aspects of typological consistency, the method of production is important to consider. The majority of vessels from the EBA in the southern Levant were handmade and that holds true for KHI. The exceptions are some jars which had a wheel spun

collar and rim that was attached to a handmade body. However, often the collar was produced on a slow wheel with which it is harder to produce a consistently circular rim compared to a faster wheel. In addition, the vessels that were handmade entirely one would not expect to see a uniformly circular rim and consistent rim thicknesses across the entire vessel. The majority of complete rims from KHI were ovular. The smallest threshold accepted for measurement was 5%, but when the vessel measured was ovular and non-symmetrical the summary of the variation will be greater compared to more circular vessel rims. Nevertheless, the variation in the shapes of rims that makes measurements inaccurate does not preclude that the vessels were made as a part of a specialized workshop. Instead the weaknesses of the measuring technique must be taken into account in the final interpretation with the expectation that if the number of samples is large enough the average will be accurate even if the variance is large. It is expected that the value of the coefficient of variation for the measurement of vessels at KHI will be larger compared to instances where only complete vessels were used.

Other factors will also influence the amount of variation seen within each form category. Firstly, the category for form is broad in case of bowls, hole mouth jars, jugs, and jars where in each case there are multiple more specific types that could be identified. For this survey they were not distinguished for the sake of consistency in analytical terms between the different means of quantifying the assemblage (Discussed in Chapter 6.1.2). For instance, certain types such as jugs show a bimodal distribution between amphoriskoi and larger jug forms, which will lead to a larger CV. Secondly, the material sample is not from a single production center or production episode. It has been shown at Tell Leilan, a site contemporaneous to KHI, that the CV will increase to as much as 27% under the effect of “cumulative blurring” even when measuring complete vessels (Blackman, Stein, and Vandiver 1993, Pgs. 73-76). Compounded with the impact on measuring accuracy introduced by the manufacturing process of the vessels, close to 27% for CV would be considered a good result.

Based on the CV statistic for rim diameter the assemblage shows relative uniformity within each vessel type considering a number of different constraints on the data (See Table 6.2). The range for the majority of forms falls below 35%, with most being below 30%. Of particular note are lamps, kraters, platter-bowls and cooking vessels. Each shows a relatively high degree of regularity in both rim diameter and thickness, nearly all falling around the mean. Of the different types these four highlight a more specific function and each was more closely defined according to a set of expectations: fabric types, rim angles, and general size.

The relatively consistent CV offers an important guide in reference to the skewness and kurtosis statistics for each form. Jug and jar are the only forms to vary from a normal distribution. The tail for those forms is in the same direction as the rest of the forms except for vat. The degree of the tail in each of those cases highlights the fact that there is bimodality for each form indicating a second type defined by a larger average rim diameter within each general type. For jugs and jars this was recognized in the creation of the grouping. As mentioned above, jugs include the small amphoriskoi and jars conflated both the larger store jars and smaller jars. While the characteristics of jars imply a consistent functional explanation, it is a broad term that encapsulates a variety of subtypes that could be explored in an assemblage with more complete vessels.

In order to explain the forms with large CVs it is best to recall which categories encapsulated a number of sub-types to define each grouping. As mentioned above, the categories for bowl, holemouth jar, jug and jar encapsulate the functional expectations for those vessels but fails to capture the typological variety encountered. As a result, the higher CV noted for those types was expected. By comparison, lamps, kraters, platter-bowls and cooking vessels are in all cases more specialized forms of bowl, for the first three, and holemouth jar for the last. While variations in decoration or rim forms existed in each of the forms with a small CV, as a broad category they exhibit a high degree of standardization in for

those details. For example, platter-bowls and lamps were almost universally slipped and burnished. Isolating each of the forms with the large CV according to decoration can be a way to reduce some of the measured variation (See Table 6.3). In the case of the holemouth jar, it is likely that some cases that were slipped and burnished were in fact spouted, even if no evidence was present on the broken sherds. Based on this observation it is likely that some holemouth jars should be assigned to serving vessels instead of basic storage on the assumption that they might have had a spout when slipped and burnished (For Distribution see Figure 6.7). However, without direct evidence it is impossible to make that distinction within the data. The distribution of holemouth jars with slip and burnish is concentrated to only a few areas within Area H, especially rooms 44, 65 and 43. How those rooms compare to others within the correspondence analysis according to function will be an important verification of whether slipped and burnished holemouths should in most cases be considered serving and not storage vessels. Nevertheless, without definite evidence of a spout it is necessary to maintain the generic assignment as a storage vessel.

Table 6.3: Reducing variability of EBA ceramic forms according to slip, burnish and/or plastic application.

Form	Burnished	Plastic Application	Slipped	Rim Diameter (Standard Deviation)	Rim Diameter (Mean)	N	CV
Bowl	TRUE	FALSE	FALSE	7.54	22.14	7	0.34
Bowl	TRUE	FALSE	TRUE	7.74	20.72	309	0.37
Holemouth Jar	FALSE	FALSE	FALSE	6.38	20.09	265	0.32
Holemouth Jar	FALSE	TRUE	FALSE	4.35	20.29	7	0.21
Holemouth Jar	FALSE	FALSE	TRUE	4.97	15.82	33	0.31
Holemouth Jar	FALSE	TRUE	TRUE	4.46	17.29	7	0.26
Holemouth Jar	TRUE	FALSE	TRUE	4.28	15.84	76	0.27
Holemouth Jar	TRUE	TRUE	TRUE	4.69	17.04	25	0.28
Jug	TRUE	FALSE	TRUE	2.37	6.00	6	0.39
Jar	FALSE	FALSE	FALSE	4.48	16.54	501	0.27
Jar	FALSE	TRUE	FALSE	2.66	19.24	63	0.14

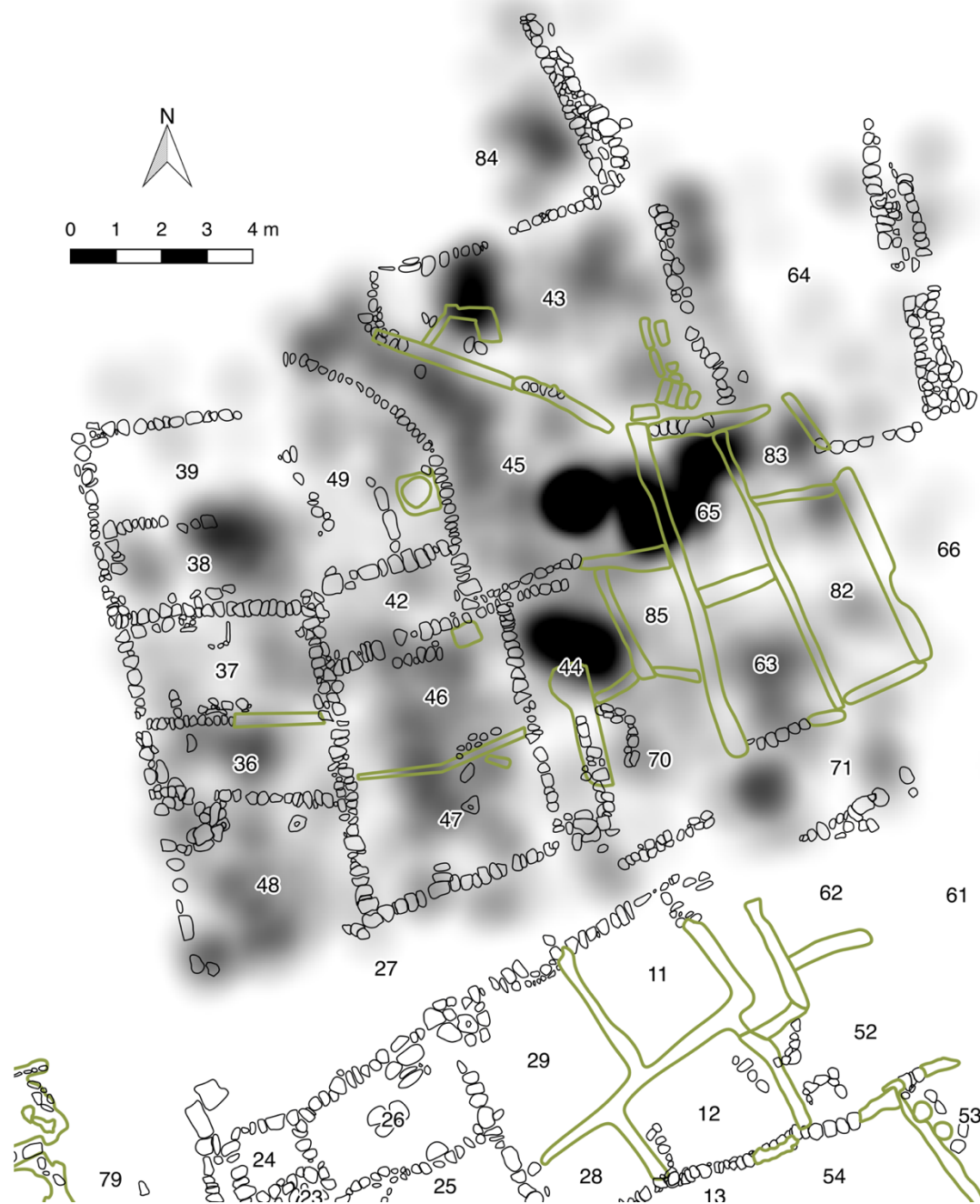


Figure 6.7: Distribution of Holemouth Jars with both Slip and Burnish within Area H at KHI. Solid black is most dense.

One other important factor when considering how we understand the pottery types is its tendency to fracture as measured by the MoR. This data highlights when going on to look at MxNV which vessel types are more likely to be under or over represented relative to each other. Based on this data the most likely forms to be under represented are Jugs and Jars, while the most likely to be over represented are Vats and Platter-Bowls (See Table 6.4). The jug statistic is not entirely surprising given that the identification of a vessel as a Jug instead of a Jar requires that more of the vessel remains indicating the presence of a spout or a handle. The fact that the Jar statistic is so high however also indicates that probably not many jugs were missed in the analysis given their relatively high survivorship rate. Cooking vessels and Holemouth vessels were almost identical, which would be expected since they are typologically almost the same except for fabric and use differences which would make cooking vessels more friable.

Table 6.4: The MoR by type for the total site in Stratum III.

Form	MoR	Function
Jar	0.13	Storage
HolemouthJar	0.08	
Krater	0.06	Food Preparation
Vat	0.06	
Cooking	0.08	
Platter-Bowl	0.06	Serving
Jug	0.18	
Bowl	0.07	
Lamp	0.12	Other

The contraction of forms according to assumed function masks underlying typological variability based on the isolation of descriptive features within each form-type. As was noted in Table 6.3, it is possible to reduce the CV for some of the forms for which a larger CV was present in Table 6.2. In those cases, the lower CV highlights standardization in overall

production forms. Even in cases where the CV is larger, the larger CV is expected for an assemblage made up primarily of handmade vessels, especially in instances where the N is low. For handmade vessels, achieving a high degree of measurable uniformity in vessel shape and dimensions is more difficult than wheelmade due to the likelihood of deformations as a part of the means of production. Deformations on the rim will naturally lead to uneven rim diameters, which were noted during the analysis. That said, within certain groupings there is still a higher degree to dimensional similarity suggesting some specialization for the production of certain vessels or at least a broadly applicable desired type for vessel appearance. This is especially true for lamps, cooking vessels, kraters and platter-bowls. Given that the vessels from KHI do show regularity in form, which implies production for a specific function, it remains to be seen how the distribution of the identified forms maps out across the site as evidence of activity areas.

Finally, the variety of forms that is observed does not match the expectation from a pastoral population. Cribb in his ethnoarchaeological study of semi-pastoralists in Turkey states, “the range of sizes and types of vessel represented is likely to be much narrower than is the case for sedentary sites sharing the same cultural complex” (Cribb 1991, Pg. 76). When compared to other pastoral sites that have been studied according to the variety of ceramic types KHI compares more closely to the accepted “urban” centers such as Arad in the EBII, pastoral sites typically only include two or three different forms (Saidel 2002a). Additionally, the ceramic assemblage offers a wide variety of types of different shapes and sizes, which would not be expected for a pastoral/transhumant group. The measured dimensions of different forms do not fit a Gaussian distribution, containing a number of outliers. This observation reinforces that within the set forms there is more variety than was used for the purpose of this analysis and thus indicative of a more sedentary population that is not searching for multifunction pots.

6.3.2. Tests of Abundance and Relationships between Areas of Deposition

The primary use of ceramic vessels is for different aspects of food storage, production and consumption. Based on morphology and technical characteristics different forms are expected to have different functions (See Table 6.1). Given that a wide variety of vessels types were found at KHI, it is necessary to examine how those vessels are distributed within the site to look for uneven distribution and the potential significance thereof. The distribution of vessels within the site will provide necessary data to characterize two aspects of social organization within the site. First, following from the previous section, it will be important to show that the connection between function and vessel type is replicated within the distribution of vessels in the site. Second, uneven distribution of specific vessel types will indicate some aspect of inequality within the site.

The means of quantifying the frequency of artifacts within the site takes three forms. For the entire site the maximum number of individuals (MxNV) was used in order to give a rough quantification of the total amount of pottery for the entire site. Within Area H the Estimated Vessel Equivalent (EVE) and Modulus of Rupture (MoR) were used to correct for sampling biases (see Chapter 7.1.2). With 19,486 sherds identified as diagnostic for the purposes of typology and dating this was the simplest way to get a relatively quick number for each excavation context. Additionally, as reference faunal and artifact data based on the Number of Individual Specimens (NISP) will be used to provide a reference for the ceramic data. NISP is used primarily because it is the most readily available data for all types. It is similar to MxNV and thus only MxNV will be used for comparison. Only secure contexts from the floors of the primary occupation, Stratum III, are considered in this analysis. Stratum III was the only stratum that contained secure contexts that could be used for a statistical analysis that describes the distribution of material between rooms (see Chapter 4.1).

Table 6.5: MxNV of Each Room By Stratum at KHI according to form.

Room	Stratum	HJ	BL	JG	JR	KR	Cooking	LD	LP	PL	SJ	VT	Total	CalcServing	CalcPrep	CalcStor
1	II	35	48	0	24	2	5	4	4	16	1	5	136	88	10	38
1	III	23	24	0	10	10	2	6	0	9	4	0	82	43	2	37
2	III	11	23	1	13	1	2	2	1	2	17	1	71	39	3	29
3	I	0	4	0	3	0	2	0	1	2	0	0	11	9	2	0
3	III	11	31	0	10	3	13	1	2	15	0	1	84	56	14	14
3	IV	0	1	0	1	0	0	0	0	2	0	0	4	4	0	0
4	III	21	37	0	9	4	26	1	0	23	0	0	120	69	26	25
5	II	7	14	2	5	0	0	0	1	7	0	0	35	28	0	7
5	III	17	52	0	16	1	6	0	3	19	0	1	112	87	7	18
6	III	16	33	1	15	1	9	2	1	11	0	0	86	60	9	17
7	I	2	2	0	1	1	1	0	0	1	0	0	8	4	1	3
7	II	10	28	0	18	4	19	1	4	9	0	2	90	55	21	14
7	III	4	12	0	5	1	5	0	1	5	0	0	32	22	5	5
7	IV	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1
8	II	32	2	0	0	0	3	0	0	2	0	0	39	4	3	32
8	III	11	6	0	9	0	6	0	5	6	1	0	39	21	6	12
9	III	1	3	0	2	0	1	0	0	0	0	0	7	5	1	1
11	III	9	14	3	92	3	5	0	1	9	29	5	169	118	10	41
12	III	9	6	1	15	5	2	0	0	6	3	0	47	28	2	17
14	III	246	220	7	114	64	130	5	17	248	28	9	1066	589	139	338
15	III	7	9	0	3	3	8	0	0	16	1	0	47	28	8	11
16	II	0	2	0	1	0	1	0	0	0	0	0	4	3	1	0
16	III	17	56	1	9	7	32	0	6	39	1	0	162	105	32	25

Table 6.5 Continued: MxNV of Each Room By Stratum at KHI according to form.

Room	Stratum	HJ	BL	JG	JR	KR	Cooking	LD	LP	PL	SJ	VT	Total	CalcServing	CalcPrep	CalcStor
16	IV	2	2	0	1	0	4	0	0	0	0	0	9	3	4	2
17	II	3	1	0	0	0	0	0	0	0	0	0	4	1	0	3
17	III	32	30	1	24	1	27	3	1	19	15	0	149	74	27	48
17	IV	2	1	0	1	0	1	0	0	0	0	0	5	2	1	2
18	II	1	0	0	0	0	1	0	0	2	0	0	4	2	1	1
18	III	36	86	3	26	9	27	7	6	54	45	0	286	169	27	90
19	II	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0
19	III	19	26	3	33	13	16	9	3	15	19	1	145	77	17	51
20	III	19	4	0	6	27	1	0	3	7	2	0	66	17	1	48
21	III	0	1	0	1	3	1	0	0	3	3	0	12	5	1	6
22	III	11	41	1	15	6	27	0	1	21	13	2	137	78	29	30
23	III	2	4	0	3	0	1	0	2	3	0	0	13	10	1	2
24	III	12	24	2	8	3	1	8	1	23	0	1	74	57	2	15
25	III	5	12	0	10	1	15	2	2	2	0	0	45	24	15	6
26	III	3	15	2	11	2	4	1	1	18	0	2	57	46	6	5
27	I	6	13	0	28	0	3	0	0	9	1	1	61	50	4	7
27	II	14	29	2	18	0	10	0	1	10	2	0	85	59	10	16
27	II	3	10	0	10	1	0	0	1	5	6	0	35	25	0	10
27	III	68	93	3	47	8	36	7	11	70	6	1	332	213	37	82
27	IV	0	0	0	0	0	3	0	0	0	0	0	3	0	3	0
28	III	9	1	0	5	2	10	2	0	2	4	1	34	8	11	15
29	III	6	17	0	18	14	6	2	4	7	8	7	83	42	13	28
36	III	25	65	1	29	6	12	2	7	24	1	11	174	119	23	32
37	III	24	77	1	26	8	17	0	6	27	2	0	182	131	17	34
38	III	38	29	0	72	2	19	8	4	20	30	8	218	121	27	70

Table 6.5 Continued: MxNV of Each Room By Stratum at KHI according to form.

Room	Stratum	HJ	BL	JG	JR	KR	Cooking	LD	LP	PL	SJ	VT	Total	CalcServing	CalcPrep	CalcStor
39	III	11	35	0	17	10	9	1	4	18	2	5	107	70	14	23
42	III	9	31	0	28	2	11	0	4	11	0	0	92	70	11	11
43	II	3	11	0	18	2	12	0	1	10	0	1	57	39	13	5
43	III	46	107	2	27	12	43	1	8	57	2	8	304	193	51	60
44	III	13	20	0	17	0	21	0	1	21	1	0	93	58	21	14
44	III	10	5	0	2	0	9	2	1	3	1	1	31	10	10	11
45	III	40	44	0	39	17	45	0	8	28	6	6	225	111	51	63
46	III	26	42	0	40	13	34	0	8	43	8	5	211	125	39	47
47	I	10	15	0	12	0	3	0	0	14	1	1	56	41	4	11
47	III	44	50	0	117	15	30	6	10	17	30	8	311	184	38	89
48	II	2	20	0	13	1	4	0	0	11	0	0	51	44	4	3
48	III	29	72	0	30	12	36	0	7	44	1	2	226	146	38	42
49	III	17	61	0	10	5	8	0	8	38	0	2	141	109	10	22
50	III	36	27	2	53	20	46	2	1	20	4	20	228	102	66	60
51	I	0	1	0	0	0	0	0	0	1	0	0	2	2	0	0
52	III	42	68	2	21	7	18	1	6	43	3	6	210	134	24	52
53	III	61	104	0	67	19	64	8	12	88	29	2	434	259	66	109
54	II	4	7	0	1	0	0	0	0	3	0	0	15	11	0	4
54	III	140	131	2	95	17	61	3	14	74	0	5	525	302	66	157
55	III	5	18	0	2	4	8	0	2	7	4	0	48	27	8	13
56	III	4	1	0	1	1	0	0	0	3	0	0	10	5	0	5
57	III	1	1	0	1	0	0	0	0	1	0	0	4	3	0	1
58	III	5	4	0	9	0	3	0	0	12	2	0	35	25	3	7
59	III	15	10	0	8	1	4	1	1	8	0	0	46	26	4	16
61	II	2	0	0	2	0	0	0	0	2	1	0	7	4	0	3

Table 6.5 Continued: MxNV of Each Room By Stratum at KHI according to form.

Room	Stratum	HJ	BL	JG	JR	KR	Cooking	LD	LP	PL	SJ	VT	Total	CalcServing	CalcPrep	CalcStor
62	II	2	11	1	4	3	2	1	0	4	1	0	28	20	2	6
62	III	11	20	0	7	1	1	0	2	14	1	1	56	41	2	13
63	III	8	35	0	13	2	23	1	0	33	1	3	118	81	26	11
64	I	2	4	0	3	1	1	0	2	4	0	0	15	11	1	3
64	III	2	10	0	0	0	14	0	1	3	1	0	30	13	14	3
65	III	13	52	0	27	3	26	5	4	17	2	1	141	96	27	18
66	I	3	5	0	4	0	1	0	1	2	0	0	15	11	1	3
66	IB	1	15	0	2	0	1	0	0	3	1	1	24	20	2	2
66	III	2	5	0	2	0	0	0	1	1	0	0	10	8	0	2
67	I	5	13	0	6	0	0	0	2	3	3	0	30	22	0	8
67	IB	4	6	1	1	1	1	0	1	2	4	1	21	10	2	9
68	I	1	1	0	0	0	1	0	0	4	1	0	8	5	1	2
68	IB	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0
70	I	8	23	0	15	3	7	1	1	24	2	0	82	62	7	13
70	IB	0	3	0	1	1	0	0	1	3	0	0	8	7	0	1
70	III	3	12	0	3	1	3	0	0	13	1	1	37	28	4	5
71	I	9	26	0	7	2	7	1	0	13	0	0	64	46	7	11
71	III	3	7	0	5	1	7	0	1	4	0	0	27	16	7	4
72	I	0	2	0	1	1	0	0	0	0	0	0	4	3	0	1
72	II	22	33	3	12	2	7	1	1	5	2	0	86	53	7	26
72	III	207	363	2	123	27	19	12	25	151	3	3	898	639	22	237
73	I	2	9	1	4	0	2	0	0	0	0	0	18	14	2	2
74	I	1	4	0	6	0	0	0	0	1	0	0	12	11	0	1
75	I	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0
75	I	0	3	0	3	0	0	0	0	1	0	0	7	7	0	0

Table 6.5 Continued: MxNV of Each Room By Stratum at KHI according to form.

Room	Stratum	HJ	BL	JG	JR	KR	Cooking	LD	LP	PL	SJ	VT	Total	CalcServing	CalcPrep	CalcStor
76	III	3	1	0	2	0	0	0	0	0	0	0	6	3	0	3
77	III	0	2	0	0	0	3	0	0	2	0	0	7	4	3	0
78	III	4	28	0	6	2	3	1	1	7	0	1	51	41	4	6
79	I	3	9	1	6	19	6	3	0	10	2	0	56	26	6	24
79	III	10	29	0	11	7	20	0	3	13	0	3	93	53	23	17
80	III	17	47	0	26	1	34	0	3	17	3	0	145	90	34	21
80	IV	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0
81	III	16	16	0	19	0	15	0	6	22	4	0	92	57	15	20
82	III	9	40	0	19	5	20	1	3	28	5	5	131	87	25	19
83	I	6	19	0	6	1	11	0	1	17	0	1	61	42	12	7
84	I	5	11	0	6	1	7	0	1	8	0	0	38	25	7	6
84	III	11	31	0	16	5	11	1	1	15	6	2	97	62	13	22
85	I	1	6	0	1	0	2	1	0	1	0	0	11	8	2	1
85	III	9	8	0	7	2	5	0	1	13	0	4	48	28	9	11
100	II	10	15	0	10	0	4	0	1	4	4	4	51	29	8	14
101	I	3	6	0	4	0	8	2	1	9	0	0	30	19	8	3
101	II	4	14	0	4	1	10	0	2	5	0	5	43	23	15	5
101	III	25	12	1	5	3	1	2	0	6	0	0	53	24	1	28
102	II	15	7	0	5	0	16	0	1	4	0	7	54	16	23	15
102	III	3	5	0	5	0	2	0	0	2	0	3	20	12	5	3
105	I	2	0	0	1	0	0	0	0	1	0	0	4	2	0	2
105	II	13	31	0	14	3	6	2	4	8	0	0	75	53	6	16
72R	I	12	1	0	4	0	1	0	2	0	0	0	18	5	1	12
72R	II	45	30	2	59	9	21	2	5	26	8	1	201	117	22	62
72R	III	8	6	0	8	1	3	0	0	2	0	0	28	16	3	9

Table 6.5 Continued: MxNV of Each Room By Stratum at KHI according to form.

Room	Stratum	HJ	BL	JG	JR	KR	Cooking	LD	LP	PL	SJ	VT	Total	CalcServing	CalcPrep	CalcStor
B17	IV	1	4	0	1	0	8	0	1	0	0	0	14	5	8	1
Burial	I	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0
CC	III	18	32	0	23	3	23	0	5	19	3	0	121	74	23	24
CC	IV	3	1	0	0	0	0	0	0	0	0	0	4	1	0	3
D1	I	0	1	0	1	1	0	0	0	0	0	0	3	2	0	1
None	I	41	77	5	55	7	22	1	6	45	5	2	259	182	24	53
None	II	122	244	1	98	33	47	6	10	60	22	6	633	403	53	177
None	III	151	202	10	117	37	90	7	36	142	66	9	824	471	99	254
T17	II	14	25	0	6	0	10	1	0	16	1	0	72	47	10	15
T3	II	9	14	1	3	2	0	1	2	5	0	0	34	23	0	11
X1	II	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1
X11	II	8	18	0	12	1	22	2	4	18	2	0	81	48	22	11
X15	III	3	9	0	7	1	0	0	1	3	0	0	23	19	0	4
X16	II	1	4	0	0	0	2	1	0	1	0	1	9	5	3	1
X4	II	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0
X5	II	8	17	0	6	0	3	0	0	2	0	0	36	25	3	8
X6	II	3	2	0	0	0	0	1	0	1	0	0	6	3	0	3
X7	II	3	4	0	1	0	2	0	1	2	0	0	12	7	2	3
X8	III	3	0	0	2	0	0	0	1	2	0	0	7	4	0	3
X8	IV	2	1	0	4	1	4	0	0	0	0	0	12	5	4	3
X9	II	0	2	0	0	0	0	0	0	4	0	0	6	6	0	0
Total		2339	3788	72	2228	569	1555	155	343	2211	491	196	13449	8299	1751	3399

Table 6.6: EVE and MoR within Area H according to stratum.

Room	Stratum	Form	EVE	N	MoR Count
27	I	Bowl	0.55	13	0.55
27	II	Bowl	2.14	30	2.22
27	III	Bowl	1.41	18	1.41
27	I	Cooking	0.24	3	0.24
27	II	Cooking	0.62	10	0.62
27	III	Cooking	0.18	4	0.18
27	I	HolemouthJar	0.36	6	0.36
27	II	HolemouthJar	1.13	14	1.13
27	III	HolemouthJar	0.6	8	0.67
27	III	Jug	0.12	2	0.12
27	I	Jar	2.91	29	2.91
27	II	Jar	3.62	26	2.73
27	III	Jar	0.45	7	0.51
27	II	Lamp	0.06	1	0.06
27	III	Lamp	0.56	3	0.56
27	I	Platter-Bowl	0.49	9	0.49
27	II	Platter-Bowl	0.88	14	0.84
27	III	Platter-Bowl	0.71	11	0.71
27	I	Vat	0.08	1	0.08
27	III	Vat	0.05	1	0.05
36	III	Bowl	3.84	66	3.94
36	III	Cooking	0.82	12	0.82
36	III	HolemouthJar	1.96	25	1.96
36	III	Jug	1.15	2	0.30
36	III	Jar	4.06	29	3.65
36	III	Krater	0.32	6	0.32
36	III	Lamp	0.91	7	0.91
36	III	Platter-Bowl	1.3	23	1.30
36	III	Vat	0.53	11	0.53
37	III	Bowl	5.35	74	5.48
37	III	Cooking	1.34	17	1.34
37	III	HolemouthJar	1.75	24	1.75
37	III	Jug	1.28	2	0.56
37	III	Jar	3.66	26	3.66

Table 6.6 Continued: EVE and MoR within Area H according to stratum.

Room	Stratum	Form	EVE	N	MoR Count
37	III	Krater	0.43	8	0.43
37	III	Lamp	0.53	6	0.53
37	III	Platter-Bowl	1.4	27	1.40
38	III	Bowl	2.1	28	2.10
38	III	Cooking	1.28	19	1.28
38	III	HolemouthJar	3.78	38	3.87
38	III	Jar	16.48	99	16.64
38	III	Krater	0.1	2	0.10
38	III	Lamp	0.79	4	0.79
38	III	Platter-Bowl	1.58	20	1.58
38	III	Vat	0.48	7	0.48
39	III	Bowl	2.55	36	2.55
39	III	Cooking	0.76	8	0.76
39	III	HolemouthJar	0.94	11	0.94
39	III	Jar	2.04	18	2.04
39	III	Krater	0.51	10	0.51
39	III	Lamp	0.32	4	0.32
39	III	Platter-Bowl	0.8	15	0.80
39	III	Spout	0.25	1	0.25
39	III	Vat	0.13	4	0.13
42	III	Bowl	1.33	21	1.33
42	III	Cooking	0.62	9	0.62
42	III	HolemouthJar	0.68	7	0.68
42	III	Jar	1.06	14	1.06
42	III	Platter-Bowl	0.09	1	0.09
43	II	Bowl	1.48	11	1.62
43	III	Bowl	6.75	106	6.97
43	II	Cooking	1.06	12	1.06
43	III	Cooking	3.53	42	3.61
43	II	HolemouthJar	0.32	3	0.32
43	III	HolemouthJar	2.46	46	2.55
43	III	Jug	0.35	3	0.35
43	II	Jar	1.39	16	1.39
43	III	Jar	2.73	27	3.16

Table 6.6 Continued: EVE and MoR within Area H according to stratum.

Room	Stratum	Form	EVE	N	MoR Count
43	II	Krater	0.15	2	0.15
43	III	Krater	0.55	12	0.55
43	II	Lamp	0.68	1	0.68
43	III	Lamp	0.62	7	0.62
43	II	Platter-Bowl	0.79	10	0.79
43	III	Platter-Bowl	2.83	54	2.92
43	II	Vat	0.08	1	0.08
43	III	Vat	0.65	8	0.65
44	III	Bowl	2.63	26	1.70
44	III	Cooking	2.15	30	2.15
44	III	HolemouthJar	2.09	23	2.09
44	III	Jar	3.7	21	1.97
44	III	Lamp	0.22	2	0.22
44	III	Platter-Bowl	1.08	21	1.12
44	III	Vat	0.08	1	0.08
45	III	Bowl	3.24	44	3.32
45	III	Cooking	3.21	45	3.21
45	III	HolemouthJar	3.81	41	3.81
45	III	Jar	5.19	43	5.30
45	III	Krater	1.79	16	1.79
45	III	Lamp	0.6	7	0.60
45	III	Platter-Bowl	1.71	27	1.77
45	III	Vat	0.44	6	0.44
46	III	Bowl	2.11	40	2.20
46	III	Cooking	2.57	33	2.64
46	III	HolemouthJar	2.69	26	2.69
46	III	Jug	0.25	1	0.25
46	III	Jar	6.03	47	5.24
46	III	Krater	1.18	13	1.18
46	III	Lamp	0.81	8	0.81
46	III	Platter-Bowl	2.09	41	2.18
46	III	Vat	0.4	4	0.40
47	I	Bowl	0.61	14	0.65
47	III	Bowl	4.91	47	4.91

Table 6.6 Continued: EVE and MoR within Area H according to stratum.

Room	Stratum	Form	EVE	N	MoR Count
47	I	Cooking	0.11	2	0.11
47	III	Cooking	2.61	30	2.61
47	I	HolemouthJar	0.47	10	0.47
47	III	HolemouthJar	3.39	44	3.39
47	I	Jar	0.77	12	0.83
47	III	Jar	22.84	143	22.30
47	III	Krater	0.95	15	0.95
47	III	Lamp	0.94	10	0.94
47	I	Platter-Bowl	0.46	12	0.49
47	III	Platter-Bowl	1.15	17	1.15
47	III	Vat	0.53	5	0.53
48	II	Bowl	0.94	20	0.94
48	III	Bowl	4.33	73	4.43
48	II	Cooking	0.32	3	0.32
48	III	Cooking	3.31	36	3.39
48	II	HolemouthJar	0.05	2	0.05
48	III	HolemouthJar	2.05	29	2.05
48	II	Jug	0.3	1	0.30
48	III	Jug	1.13	2	0.26
48	II	Jar	1.74	13	1.74
48	III	Jar	3	30	3.09
48	II	Krater	0.05	1	0.05
48	III	Krater	0.59	12	0.68
48	III	Lamp	0.74	7	0.74
48	II	Platter-Bowl	0.84	11	0.84
48	III	Platter-Bowl	2.52	43	2.57
48	III	Spout	1.2	2	0.40
48	III	Vat	0.07	2	0.07
49	III	Bowl	4.18	61	4.30
49	III	Cooking	0.42	6	0.42
49	III	HolemouthJar	1.29	17	1.29
49	III	Jug	0.42	1	0.42
49	III	Jar	1.47	10	1.47
49	III	Krater	0.19	5	0.19

Table 6.6 Continued: EVE and MoR within Area H according to stratum.

Room	Stratum	Form	EVE	N	MoR Count
49	III	Lamp	1.32	7	1.32
49	III	Platter-Bowl	2.22	38	2.22
49	III	Vat	0.15	2	0.15
50	III	Bowl	1.49	25	1.54
50	III	Cooking	2.97	38	3.04
50	III	HolemouthJar	2.12	26	2.12
50	III	Jug	0.45	2	0.45
50	III	Jar	7.39	54	6.74
50	III	Krater	1.19	19	1.25
50	III	Lamp	0.2	1	0.20
50	III	Platter-Bowl	1.56	19	1.64
50	III	Vat	0.9	18	0.99
51	I	Bowl	0.1	1	0.10
51	I	Platter-Bowl	0.05	1	0.05
63	III	Bowl	3.36	50	3.48
63	III	Cooking	2.56	28	2.56
63	III	HolemouthJar	0.59	10	0.59
63	III	Jug	0.13	1	0.13
63	III	Jar	3.25	22	2.46
63	III	Krater	0.18	5	0.18
63	III	Platter-Bowl	1.8	40	1.80
63	III	Vat	0.05	1	0.05
64	I	Bowl	0.12	4	0.15
64	III	Bowl	0.87	10	0.96
64	I	Cooking	0.05	1	0.05
64	III	Cooking	1.25	14	1.25
64	I	HolemouthJar	0.17	2	0.17
64	III	HolemouthJar	0.25	2	0.25
64	I	Jar	0.16	3	0.16
64	III	Jar	0.55	1	0.55
64	I	Krater	0.15	1	0.15
64	I	Lamp	0.55	2	0.55
64	III	Lamp	0.3	1	0.30
64	I	Platter-Bowl	0.28	4	0.28

Table 6.6 Continued: EVE and MoR within Area H according to stratum.

Room	Stratum	Form	EVE	N	MoR Count
64	III	Platter-Bowl	0.09	3	0.09
65	III	Bowl	4.04	52	4.12
65	III	Cooking	1.98	26	1.98
65	III	HolemouthJar	0.97	13	1.04
65	III	Jug	3.5	4	2.00
65	III	Jar	4.38	24	3.68
65	III	Krater	0.25	3	0.25
65	III	Lamp	0.4	4	0.40
65	III	Platter-Bowl	0.96	16	0.96
65	III	Spout	0.15	1	0.15
65	III	Vat	0.02	1	0.02
66	I	Bowl	0.33	5	0.33
66	IB	Bowl	0.89	16	0.94
66	III	Bowl	0.26	5	0.26
66	I	Cooking	0.05	1	0.05
66	IB	Cooking	0.05	1	0.05
66	I	HolemouthJar	0.34	3	0.34
66	IB	HolemouthJar	0.12	1	0.12
66	III	HolemouthJar	0.12	2	0.12
66	I	Jar	0.24	4	0.24
66	IB	Jar	0.28	3	0.28
66	III	Jar	0.26	2	0.26
66	I	Lamp	0.09	1	0.09
66	III	Lamp	0.05	1	0.05
66	I	Platter-Bowl	0.1	2	0.10
66	IB	Platter-Bowl	0.34	2	0.34
66	IB	Vat	0.05	1	0.05
67	I	Bowl	0.72	13	0.77
67	IB	Bowl	0.31	6	0.31
67	IB	Cooking	0.15	1	0.15
67	I	HolemouthJar	0.31	5	0.31
67	IB	HolemouthJar	0.39	4	0.39
67	IB	Jug	0.53	2	0.53
67	I	Jar	1.78	9	1.78

Table 6.6 Continued: EVE and MoR within Area H according to stratum.

Room	Stratum	Form	EVE	N	MoR Count
67	IB	Jar	0.47	3	0.47
67	IB	Krater	0.04	1	0.04
67	I	Lamp	0.24	2	0.24
67	IB	Lamp	0.17	1	0.17
67	I	Platter-Bowl	0.09	3	0.09
67	IB	Platter-Bowl	0.06	2	0.06
67	IB	Vat	0.06	1	0.06
68	I	Bowl	0.08	1	0.08
68	I	Cooking	0.08	1	0.08
68	I	HolemouthJar	0.06	1	0.06
68	I	Jar	0.12	1	0.12
68	I	Platter-Bowl	0.15	4	0.15
68	IB	Platter-Bowl	0.03	1	0.03
70	I	Bowl	1.17	23	1.21
70	IB	Bowl	0.1	3	0.10
70	III	Bowl	0.55	12	0.55
70	I	Cooking	0.37	7	0.37
70	III	Cooking	0.14	3	0.14
70	I	HolemouthJar	0.5	8	0.50
70	III	HolemouthJar	0.27	3	0.27
70	I	Jug	0.24	2	0.24
70	I	Jar	1.25	14	1.25
70	IB	Jar	0.09	1	0.09
70	III	Jar	0.32	4	0.32
70	I	Krater	0.36	3	0.52
70	IB	Krater	0.03	1	0.03
70	III	Krater	0.03	1	0.03
70	I	Lamp	0.04	1	0.04
70	IB	Lamp	0.08	1	0.08
70	I	Platter-Bowl	0.98	23	1.01
70	IB	Platter-Bowl	0.12	4	0.12
70	III	Platter-Bowl	0.57	13	0.70
70	III	Vat	0.05	1	0.05
71	I	Bowl	1.28	26	1.28

Table 6.6 Continued: EVE and MoR within Area H according to stratum.

Room	Stratum	Form	EVE	N	MoR Count
71	III	Bowl	0.53	7	0.53
71	I	Cooking	0.56	6	0.66
71	III	Cooking	0.59	7	0.68
71	I	HolemouthJar	0.52	9	0.52
71	III	HolemouthJar	0.15	3	0.15
71	I	Jar	0.37	6	0.37
71	III	Jar	0.42	5	0.51
71	I	Krater	0.1	2	0.10
71	III	Krater	0.08	1	0.08
71	III	Lamp	0.21	1	0.21
71	I	Platter-Bowl	0.56	13	0.56
71	III	Platter-Bowl	0.23	4	0.23
82	III	Bowl	3.23	38	3.31
82	III	Cooking	1.56	19	1.56
82	III	HolemouthJar	0.59	9	0.59
82	III	Jar	3.75	24	2.99
82	III	Krater	0.25	5	0.25
82	III	Lamp	0.21	3	0.21
82	III	Platter-Bowl	2	27	2.07
82	III	Vat	0.31	5	0.38
83	I	Bowl	1.08	18	1.13
83	I	Cooking	1.3	11	1.30
83	I	HolemouthJar	0.61	6	0.61
83	I	Jar	0.65	5	0.65
83	I	Krater	0.05	1	0.05
83	I	Lamp	0.04	1	0.04
83	I	Platter-Bowl	0.68	16	0.68
83	I	Vat	0.05	1	0.05
84	I	Bowl	0.72	11	0.72
84	III	Bowl	2.2	31	2.20
84	I	Cooking	0.74	6	0.74
84	III	Cooking	1.01	11	1.01
84	I	HolemouthJar	0.22	5	0.22
84	III	HolemouthJar	0.74	11	0.74

Table 6.6 Continued: EVE and MoR within Area H according to stratum.

Room	Stratum	Form	EVE	N	MoR Count
84	I	Jar	0.59	6	0.59
84	III	Jar	3.8	22	2.93
84	I	Krater	0.05	1	0.05
84	III	Krater	0.32	5	0.32
84	I	Lamp	0.23	1	0.23
84	III	Lamp	0.13	1	0.13
84	I	Platter-Bowl	0.37	8	0.37
84	III	Platter-Bowl	0.72	15	0.81
84	III	Vat	0.03	1	0.03
85	I	Bowl	0.47	6	0.47
85	III	Bowl	0.58	9	0.58
85	I	Cooking	0.14	2	0.14
85	III	Cooking	0.26	5	0.26
85	I	HolemouthJar	0.08	1	0.08
85	III	HolemouthJar	1.24	9	1.24
85	III	Jug	0.15	1	0.15
85	I	Jar	0.08	1	0.08
85	III	Jar	0.68	6	0.80
85	III	Krater	0.1	2	0.10
85	III	Lamp	0.3	1	0.30
85	I	Platter-Bowl	0.06	1	0.06
85	III	Platter-Bowl	0.55	12	0.55
85	III	Vat	0.41	4	0.41
100	II	Bowl	1.54	15	1.54
100	II	Cooking	0.25	4	0.25
100	II	HolemouthJar	0.64	10	0.64
100	II	Jar	2.17	14	2.17
100	II	Lamp	0.12	1	0.12
100	II	Platter-Bowl	0.15	4	0.19
100	II	Vat	0.22	4	0.22
101	I	Bowl	0.44	8	0.44
101	II	Bowl	0.9	14	0.90
101	III	Bowl	0.17	3	0.17
101	I	Cooking	0.3	8	0.30

Table 6.6 Continued: EVE and MoR within Area H according to stratum.

Room	Stratum	Form	EVE	N	MoR Count
101	II	Cooking	0.78	10	0.78
101	I	HolemouthJar	0.25	3	0.25
101	II	HolemouthJar	0.26	4	0.26
101	I	Jar	0.39	4	0.51
101	II	Jar	0.31	4	0.40
101	II	Krater	0.04	1	0.04
101	I	Lamp	0.06	1	0.06
101	II	Lamp	0.09	2	0.16
101	I	Platter-Bowl	0.43	7	0.43
101	II	Platter-Bowl	0.31	5	0.31
101	II	Vat	0.36	5	0.36
102	II	Bowl	0.58	8	0.58
102	III	Bowl	0.26	5	0.26
102	II	Cooking	1.37	16	1.37
102	III	Cooking	0.32	2	0.32
102	II	HolemouthJar	1.2	15	1.20
102	III	HolemouthJar	0.34	3	0.34
102	II	Jar	0.34	5	0.34
102	III	Jar	0.58	5	0.71
102	II	Platter-Bowl	0.15	3	0.15
102	III	Platter-Bowl	0.12	2	0.12
102	II	Vat	0.3	7	0.30
102	III	Vat	0.13	3	0.13
Total			360.78	4145	352.28

In order to draw distinctions between contexts the room was used as the container to compare the ceramic counts within Stratum III. During the excavation of KHI a room was loosely defined as any space that could be isolated by a series of walls (See discussion of the excavations in Chapter 4.1, Figure 4.3). The majority of the rooms were excavated as a single locus, without any subdivision according to different activity areas, even in the largest rooms. Individual artifacts or clusters of artifacts were collected with a basket and EDM (electronic

distance measure number). A locus was defined as a cluster of points that defined a collection area and represented as a measurable polygon in geo-spatial terms. This is despite the fact that the excavation reports typically noted the observing multiple phases within Stratum III. The most significant instance where multiple phases were identified within a room, Room 14 in Area Y, will be compared to the data from rooms that were excavated as a single phase in order to highlight one complicating factor for interpreting the range of activities within each room. Unfortunately, the microstratigraphy inside most of the rooms was impossible to identify during the excavation process.

The ceramic data will be considered according to both vessel type and a combined metric of expected function (Discussed in Chapter 6.1). The lamp is the one form that does not fit within function that is associated with foodways. As a result, it will be left out of the analysis when combined according to function. An important part of distinguishing pastoralists from other groups is based on the functional independence of each vessel type (See Chapter 2.4, Cribb 1991, Pg. 76). It will be important to highlight that the distribution of the correspondence analysis based on both ceramic type and simplified by functional category are similar. This would verify that the functional categories for each vessel type are consistent from room to room. If the distribution on the biplots is consistent we can assume that the functional categories have meaning and each type of vessel has a specific function unlike in pastoral settings where single vessel types are multifunctional. The important forms that will be isolated for this distinction are cooking holemouth jars and storage holemouth jars. The rim section of these vessels is similar, distinguished only by fabric, burning, base curvature (if present), and slight variations in the rim morphology (See Figure 6.4). The similar morphology but different function will be important to highlight as occupying different spaces within the site. It is the assumption of a division of space with the site that is a key indicator of a more permanent occupation by a non-pastoral group.

For all of the statistical tests and general comparisons it will be important to consider how the different methods of quantification have inherent weaknesses. For this reason, a correspondence analysis of Area H using MxNV will be compared to the analysis using EVE and MoR and then compared to how the rooms in Area H are represented when shifted to the entire site. This will also result in determining the cases where we would consider MxNV to be representative of the relative distribution of vessels within each room. These different considerations require the use of a holistic perspective that also considers aspects of site formation processes discussed in the previous chapter and the importance of the MoR in determining differential breaking patterns. Area H was selected as the ideal candidate for the spatial analysis presented here because it consisted of a single structure excavated nearly completely and the "bulk" ceramic evidence indicated that the assemblage was representative. Finally, the EBA KHI ceramic data will also be compared to the distributions of associated faunal and metallurgical data from the site. The faunal and metallurgical data will provide more evidence of use in the site for different processes related to metal production, food preparation and consumption. Isolating different activity areas within the site will be an important step in identifying a division of labor within the site.

6.3.2.1. Implications of Pottery Quantities

An important part of identifying different activity areas within the site is based on the relative quantities of material. Establishing an average expected value for each room based on both quantity and density will help to identify spaces that require special attention. The overall quantity of pottery excavated at KHI has already been discussed for its relative abundance, especially with reference to its from other periods in the Faynan region. Given that over the course of four seasons excavation about one fifteenth of the total estimated site area was excavated, if that density continued across the rest of the site we would expect to see well over

two hundred thousand diagnostic sherds. Without excavation this is purely speculative, nevertheless this is an incredible density of sherds for a prehistoric site in a peripheral area such as Faynan. In order to derive meaning from the anomalous density at KHI it is necessary to explore how differences in the distribution of sherds is within the excavated areas to determine aspects of organization within the site.

Superficially, the high density of material found at KHI is indicative of a more permanent occupation. To have so much pottery indicates a significant investment in a place. 14 rooms of the 67 had more than 200 sherds and a further 16 had more than 100 (See Table 6.5). The average number of sherds per room was 139. Of these vessels associated with serving food dominate the assemblage, with over 2600 Bowl fragments found across the site. Platter-Bowl, Jar and Holemouth Jar fragments all numbered around 1600.

Large quantities of pottery within a room will not hold the same significance. Two rooms from the 1999 and 2000 excavations stand out for the total amount of pottery using MxNV found within, Room 14 in Area Y and Room 72 in Area L. Each room has over 800 diagnostic vessel fragments and only two rooms come close to that quantity of material, Rooms 54 and 53 with 525 and 434 sherds counted respectively. All of the sherds in Room 72 were excavated in a single locus, Locus 3037 (See Figure 6.9). It may be recalled from the discussion of bulk pottery that Room 72 was singled out as a midden/trash deposit given the overall breakage apparent in that context, the average size of a sherd was easily the smallest of any other excavated context from Stratum III (See Chapter 5.2.3). Room 14 however can be divided up into 4 different loci (1216/1222, 1261, 1283, 1301) according to phase, the only room excavated across the site that offered such resolution between phases within Stratum III (See Chapter 6.3.2.2. for discussion of phase variation; See Figure 6.8). Each room represents different extremes of alternative interpretations for the significance between total quantity of material. The important data point to help verify the representativeness of each of these

contexts is the average sherd size, which helps to determine the site formation processes that influence each material assemblage.



Figure 6.8: Photograph of Room 14 after excavation by Thomas E. Levy, Levantine Archaeology Lab UC San Diego.



Figure 6.9: Photograph of Room 72. Note the pavement that was interpreted as the lining for a cistern. Photograph by Thomas E. Levy, Levantine Archaeology Lab UC San Diego.

Density of sherds within a room is especially important for determining the kinds of activities that occurred within a space. For instance, smaller rooms might be used for a specific kind of storage and density will be an important factor in the detection of rooms where that usage is particularly important. The average density within each room was approximately 17 sherds per square meter (See Table 6.7). Using this index rooms 72 and 14 remain the densest, but rooms 55, 53, 24, and 5 all are near or exceed 80 sherds per square meter. Of those only 53 had a large number of vessels associated with storage. Although it is important to also note that most of the rooms noted as particularly dense are also very small, 24 and 55 are less than a square meter, five is only 1.26 square meters. Even with that in mind each of the rooms tend to be dominated by serving vessels, with rooms 5 and 24 being nearly 80% serving vessels. Each of the rooms was relatively average in terms of the relative quantity of storage vessels. It is interesting to note that the rooms that were densest with pottery were not primarily filled with vessels for storage, but instead vessels for serving food.

Table 6.7: Table of the MxNV per area, EVE per area, MoR per area and average sherd weight according to room in Stratum III of KHI. Data collated from Appendix 3.

Room	MxNV	EVE	MoR	Area	MxNV/ Area (m ²)	EVE/ Area (m ²)	MoR/ Area(m ²)	Average Sherd Size
1	82			15.83	5.18			28.31
2	71			2.95	24.07			66.09
3	84			10.7	7.85			20.12
4	120			4.7	25.53			18.17
5	112			1.26	88.89			9.75
6	86			9.03	9.52			18.81
7	32			5.22	6.13			28.11
8	39			1.98	19.7			39.95
9	7			0.93	7.53			29.53
11	169			4.56	37.06			60.61
12	47			3.89	12.08			57.94
14	1066			8.25	129.21			33.44
15	47			2.83	16.61			48.94

Table 6.7 Continued: Table of the MxNV per area, EVE per area, MoR per area and average sherd weight according to room in Stratum III of KHI. Data collated from Appendix 3.

Room	MxNV	EVE	MoR	Area	MxNV/ Area (m ²)	EVE/ Area (m ²)	MoR/ Area(m ²)	Average Sherd Size
16	162			3.48	46.55			30.02
17	149			10.7	13.93			33.32
18	286			6.92	41.33			61.62
19	145			7.4	19.59			59.87
20	66			3.59	18.38			77.42
21	12			2.16	5.56			116.28
22	137			11.07	12.38			34.75
23	13			1.6	8.13			17.60
24	74			0.95	77.89			25.40
25	45			3.84	11.72			27.30
26	57			3.66	15.57			24.12
27	332			20.34	16.32			25.26
28	34			1.86	18.28			51.12
29	83			6.34	13.09			73.29
36	174	14.89	13.44	4.22	41.23	3.53	3.19	28.93
37	182	15.74	15.12	5.24	34.73	3	2.89	26.48
38	218	26.59	27.23	4.18	52.15	6.36	6.51	48.02
39	107	8.3	8.38	4.35	24.6	1.91	1.93	26.48
42	92	3.78	3.78	2.2	41.82	1.72	1.72	28.88
43	304	20.47	21.80	10.52	28.9	1.95	2.07	26.29
44	93	11.95	9.35	4.74	19.62	2.52	1.97	39.93
44	31	11.95	9.35	4.74	6.54	2.52	1.97	39.93
45	225	19.99	20.32	13.25	16.98	1.51	1.53	44.93
46	211	18.13	17.67	6.44	32.76	2.82	2.74	37.15
47	311	37.32	36.89	7.87	39.52	4.74	4.69	46.74
48	226	18.94	18.34	7.8	28.97	2.43	2.35	24.63
49	141	11.66	11.87	12.47	11.31	0.94	0.95	31.09
50	228							44.80
52	210			7.93	26.48			28.69
53	434			5.37	80.82			57.58
54	525			29.9	17.56			19.95
55	48			0.56	85.71			45.87
56	10			2.28	4.39			37.87
57	4			1.72	2.33			21.20

Table 6.7 Continued: Table of the MxNV per area, EVE per area, MoR per area and average sherd weight according to room in Stratum III of KHI. Data collated from Appendix 3.

Room	MxNV	EVE	MoR	Area	MxNV/ Area (m ²)	EVE/ Area (m ²)	MoR/ Area(m ²)	Average Sherd Size
58	35			8.06	4.34			16.69
59	46			8	5.75			23.50
62	56			3.52	15.91			29.21
63	118	11.92	11.53	3.94	29.95	3.03	2.93	24.60
64	30	3.31	3.49	19.31	1.55	0.17	0.18	30.97
65	141	16.65	13.28	3.31	42.6	5.03	4.01	30.42
66	10			17.79	0.56			25.81
70	37	1.93	2.08	6.82	5.43	0.28	0.31	16.44
71	27			8.99	3			27.28
72	898			21.61	41.55			10.69
72R	28			33.27	0.84			29.06
76	6			0.64	9.38			16.47
77	7			0.35	20			33.56
78	51			3.46	14.74			25.60
79	93			12.72	7.31			45.36
80	145			5.31	27.31			25.75
81	92			13.27	6.93			38.53
82	131	11.9	11.29	5.18	25.29	2.3	2.18	47.18
84	97			9.1	10.66			46.57
85	48	4.27	4.60	1.88	25.53	2.27	2.45	53.08

The comparison of MxNV to EVE and MoR within Area H is important to help identify if there are inherent errors using MxNV for the entire site as the only means of analysis. We may recall from the previous chapter that loci determined to be midden pits tended to also have smaller sherd sizes and as a result we would also expect smaller sherd size to be an indicator of fewer vessels using EVE or MoR compared to MxNV. Effectively EVE and MoR is a ranking of sherd size, but specific to rims and more accurate by measuring a controlled part of the vessel. The major confounding factor to this expectation would be a room consisting predominantly of smaller vessels that might have fewer breaks. Anecdotally

no locus that was examined was dominated by only smaller sherds. In the case of Area H, MxNV tends to be a good predictor of relative EVE or MoR counts (See Table 6.7). Relative to other rooms within Area H, four rooms would have their total number of vessels ranked higher if using MoR or EVE instead MxNV: Rooms 38, 45, 65 and 85. Each of those rooms were in the top half according to average sherd size and rooms 85 and 38 were the top two by average sherd size. In these cases, average sherd size clearly was a good indicator of instances where MxNV underrepresented the number of complete vessels using one of the alternate indices. A good example of how this works is a comparison of Rooms 47 and 43 with MxNV counts of 311 and 304 respectively. The average sherd size in Room 47 was 46 grams and the average sherd size in Room 43 was 26 grams. That disparity in average sherd size resulted in a difference in count based on EVE of 17 vessels between the two rooms, Room 47 having a total of 37 according to EVE (MoR was similar). Clearly, the average sherd size also works as a good proxy for the EVE within any given contexts. The results reinforce the expectation for the relationship between count and average mass of sherds to predict higher incidences of completeness based on the bulk data. This allows for the use of the average sherd size to help interpret the accuracy of MxNV counts as a proxy for the MoR. Additionally, when the data points are plotted on a line of regression comparing MxNV and EVE the R-squared value is .76 indicating a close relationship, but not perfect (See Figure 6.10). While MxNV is representative of the expected total number of sherds in a context, it needs to be used in conjunction with the bulk data to indicate spaces where formation processes would have artificially inflated the total rim count.

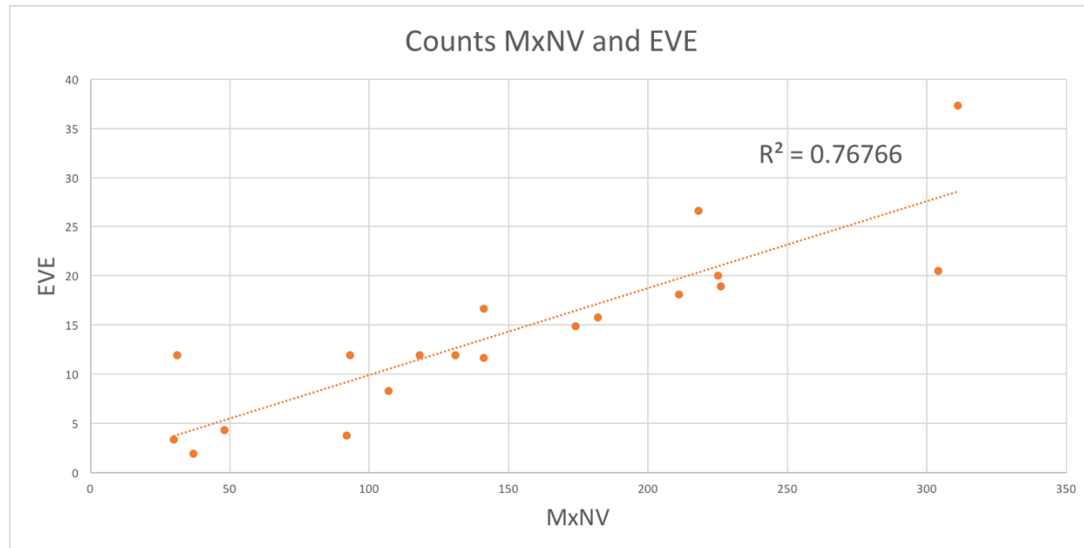


Figure 6.10: MxNV vs EVE in a regression based on data from Stratum III in Area H. Highlights the fact that within contexts like Area H MxNV is a reasonably good predictor of EVE. The most notable exceptions are on the ends of the model.

MxNV is a good indicator that generally agrees with the more specific counts of EVE and MoR. The associated bulk data that can be used to predict the general representativeness of the MxNV. The bulk data can be used to determine whether MxNV is an over estimate or an under estimate of the actual number of sherds in a context without using EVE or MoR. Generally speaking, we can expect a room that has smaller average sherd size to be over represented by MxNV and a room with higher average sherd size to be underrepresented, compared to the average. This is necessary to demonstrate that analysis will also help to identify variation in function of the rooms. Correspondence analysis can thus be used with MxNV data as well as long as the limitations of the data are recognized.

Finally, the relative composition of ceramic types is an important consideration given the fact that KHI is located in such a marginal zone. Using MoR to adjust the relative counts of ceramics across the whole site more than 40% of the ceramics found at KHI in Stratum III were for storage (See Table 6.8). Compared to Stratum II or III at the contemporary site of

Bab edh-Dhra, this is significantly more. It can be expected that in order to occupy a site like KHI for long stretches of time a lot of water and grain would have been stored to provide for the copper workers. The fact that the assemblage contained such a significant percentage of storage vessels suggests that the site could have been occupied for most of the year if not the whole year, supported by the large amount of vessel storage.

Table 6.8: Difference in quantities of ceramics between the Jordanian sites of Bab edh-Dhra and KHI.

Stratum	Serving	Storage	Food Prep.	Special Use	Site
III	165—40%	84—21%	150—36%	12—3%	Bab edh Dhra (Rast et al. 2003, Table 11.7)
II	555—45%	267—22%	301—25%	103—8%	
III - Area H - MoR	34%	47%	14%	3%	KHI
III - Total Site - MoR Adjusted	40%	41%	15%	3%	

6.3.2.2. Using Correspondence Analysis to Explore Material Record within Khirbat Hamra Ifdan

Correspondence analysis will help to identify the different trends in the composition of each room's relative quantity of pottery. The focus of this analysis will continue to be Stratum III, the main phase of Early Bronze Age copper production at KHI, with special attention to the building complex that makes up Area H. The building that constitutes Area H was the most interesting due to the relative evenness of quantities of pottery across the area.

Additionally, unlike the other building complexes, the Area was a single structure excavated by a single supervisor, so the method of identifying phases within the site should be more consistent. In the previous section it was shown that within the areas there was a range of densities of pottery within Area H so the natural next step would be to see how densities also relate to the distribution of vessel types from room to room. The major weakness of Area H as the focus of the study is that the excavations did not yield data on phases within Stratum III. In fact, the only room that was excavated with clear phasing evident was Room 14 in Area Y (See Chapter 4.1.5). The phasing evident in the excavation methods of Room 14, identified in the field as a courtyard, make it an important point of comparison for the Area H data.

In order to make a connection between Area H and Room 14 of Area Y it is necessary to demonstrate that the site formation processes are similar. In the previous section it was shown that MxNV tends to over-represent the number of sherds calculated using PIE or MoR when the average size is small and *vice versa* when the average size is large. This is probably related to some of the depositional variations noted in the bulk analysis, the smaller sherd size representing a trash heap and a larger sherd size is a more pristine deposition. The average sherd size in Area H was 37.2 grams per sherd and the average size from Room 14 is 28.6 grams per sherd, meaning that there is an over representation of the total number of sherds. However, the trend of the average sherd size from the bulk ceramics from each phase shows the average size increasing as the stratigraphy progresses down (See Table 6.9). This suggests that only Locus 1222 has more sherds than expected and that might be related to the earthquake that is suspected of ending Stratum III. As a result, the data will be analyzed using correspondence analysis as is, without correction.

Table 6.9: Table of Pottery from Room 14, KHI.

Locus	Bases Count	Bases Weight	Diagnostic Count	Diagnostic Weight	Handles Count	Handles Weight	Body Count	Body Weight	Body Average (g/sherd)	Base Average (g/sherd)	Diagnostic Average (g/sherd)	Total Average (g/sherd)
1216	369	10295	408	18240	6	180	3912	71485	18.27	27.90	44.71	21.34
1261	62	5825	120	6945	3	65	690	18870	27.35	93.95	57.88	36.23
1283	227	17140	340	20035	8	200	1889	59715	31.61	75.51	58.93	39.40
1301	5	265	14	1515	0	0	67	1620	24.18	53.00	108.21	39.53

The most notable factor that distinguishes Room 14 from every other context at KHI is the total quantity of pottery, which far exceeds any other room in Stratum III. It is noted in the excavation report that the start of each locus was identified with a new floor, indicating a cleaning and resurfacing from phase to phase (Arbel 1999-2000). Between each phase there is no obvious reconfiguration of the room through the building of installations or other new features. The room was considered a “courtyard” where there is evidence that the room was only partially roofed. The resurfacing of the floor highlights Room 14 as a different kind of space compared to other rooms at site where resurfacing was not evident. The room is especially unique because of the massive quantity of pottery found in each layer, comparable to the total amount of pottery in other rooms (See Table 6.5). In Room 14 two loci provide more than eighty percent of the total number of diagnostics from this room, phases 1 and 3 (Locus 1222 and 1283), a total of 619 sherds (See Table 6.9). Phase 4 only had 12 sherds, mostly serving vessels. Phase 2 had 101 sherds with Bowls, Holemouth Jars and cooking vessels making up most of the assemblage, hinting at a connection to food preparation and serving. When compared to the rooms in Area H the overall quantity of sherd in each phase, except for Locus 1301, is similar. The total number in the upper most phase, Locus 1222, in fact exceeds any Area H room, but this is influenced in part by the formation processes that affected that locus.

The correspondence analysis highlight variations from phase to phase according to function within Room 14. When looking at the distribution of loci in relation to form on the biplot the results indicated variations between each of the different phases with the bottom two being very similar (see Figure 6.11). The similarity between 1283 and 1301, given the small size of the assemblage in 1301, could indicate that these are in fact the same phase. Loci 1222, 1261 and 1283 noticeably form different vertices on a triangle highlighting the differences in the relative makeup of each subsequent phase. Notable is the absence of cooking pots in 1283

and the large number of Vats and Lamps in 1222. Cooking pots are relatively abundant in 1261, but is generally missing the larger vessels: Store Jars, Vats and Kraters. These results are significant despite the fact that this analysis doesn't make an attempt to correct for the assumed variation in quantity using PIE/MoR. Nevertheless, the results still highlight important variation in the use of the room from phase to phase (See Figure 6.12). If the average vessel MoR according to vessel in Area H is applied to Room 14 there is not a significant difference in the resulting model (See Figure 6.11 and Figure 6.13). The changing assemblage of material in Room 14 highlights fluidity in function for the space between storage, cooking and other uses. This is reinforced by the associated data of counts of ingot molds with many more coming from the earlier phases compared to the later phases (See Table 6.10). The variation in function, based on the ceramic assemblage, from phase to phase indicates that rooms within the site did not have fixed functions over time.

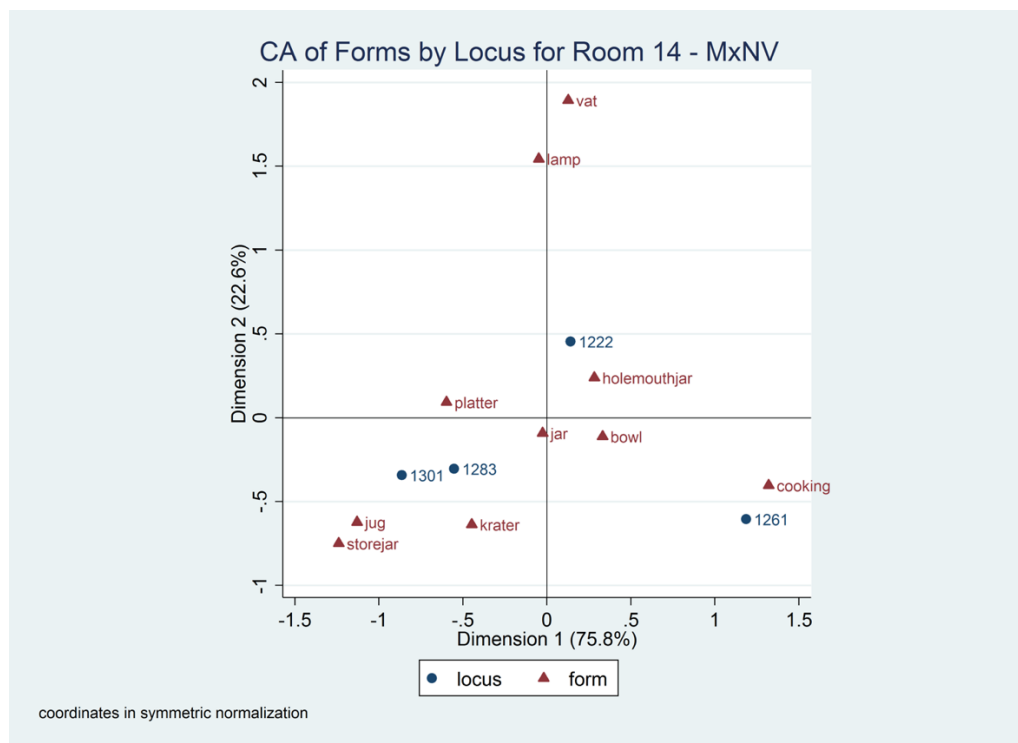


Figure 6.11: Correspondence analysis biplot from Room 14 at using all forms. There is a clear spread of the vessel forms between each phase/locus. Data from Table 6.9.

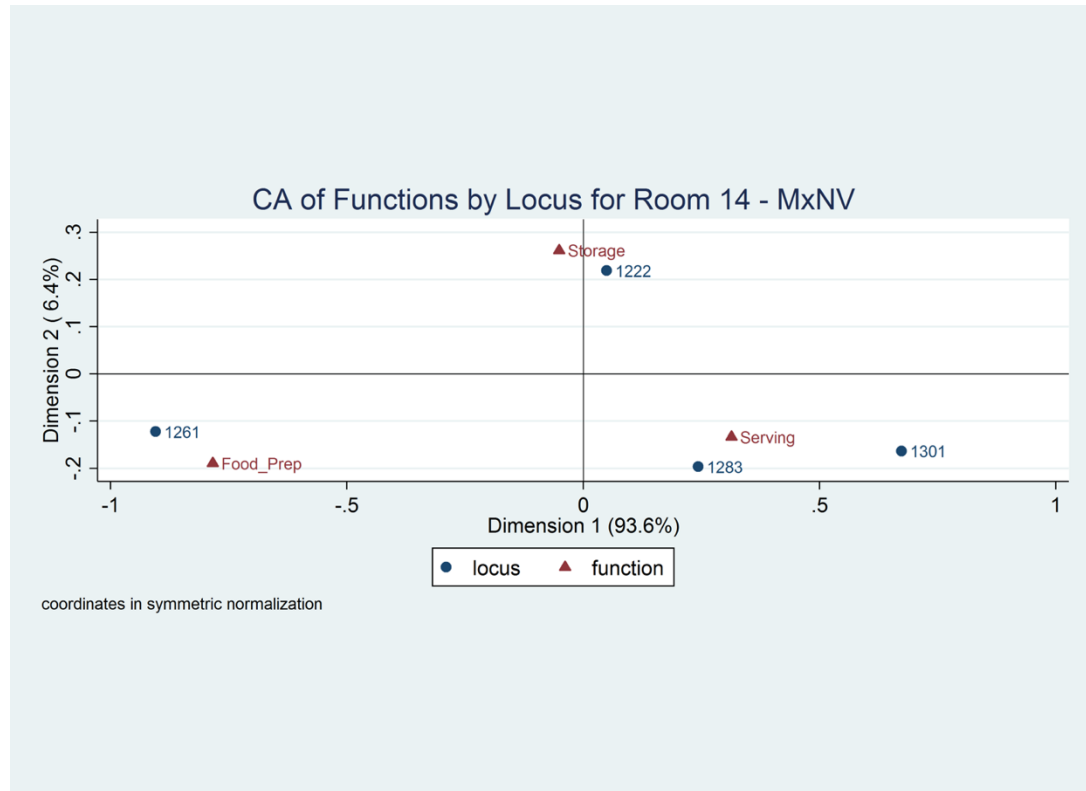


Figure 6.12: Correspondence analysis biplot from Room 14 at KHI grouped according to expected function. The first dimension is most important and highlights a clear change from Serving at the lowest phases to storage in the last phase. Data from Table 6.9.

Table 6.10: Relationship of diagnostic pottery quantity to quantity of ingot molds in Room 14 at KHI.

Locus	Pottery Count	Percent of Total	Ingot Mold Count	Percent of Total
1222	333	45.49	96	37.5
1261	101	13.8	30	11.72
1283	286	39.07	121	47.27
1301	12	1.64	9	3.52
Total	732		256	

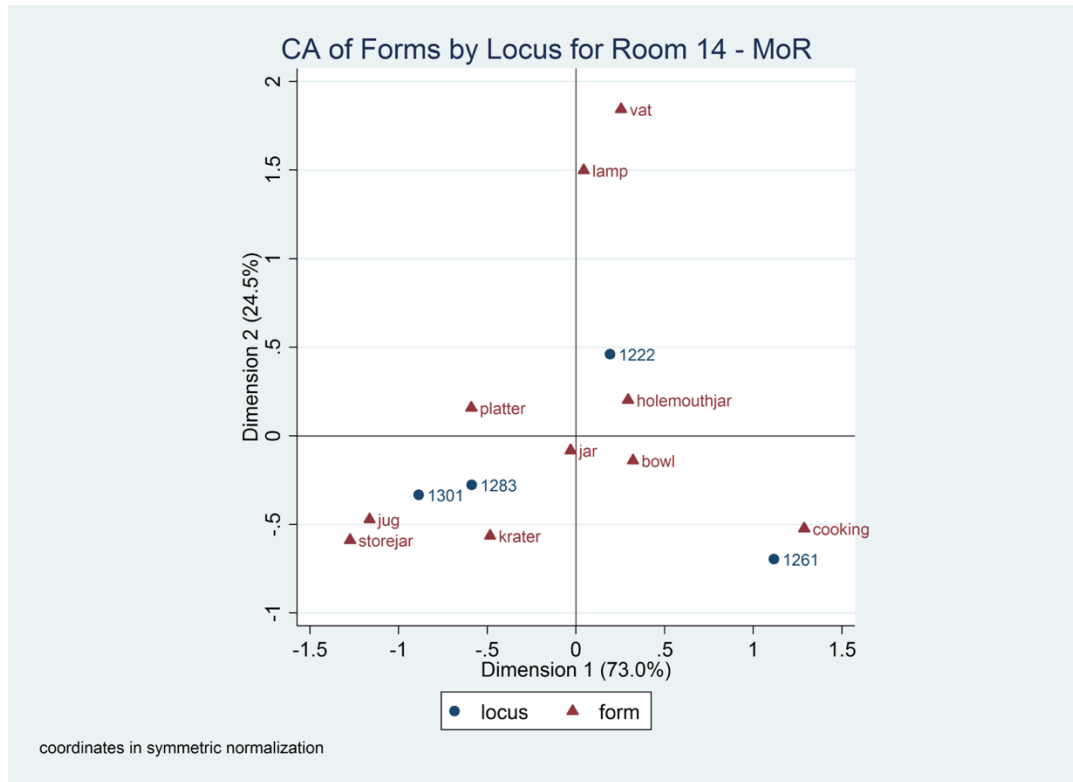


Figure 6.13: The biplot for the correspondence analysis of Room 14 using MoR derived from the site averages.

The observation that rooms within a building would be resurfaced and used for different functions over the period of Stratum III is an important observation to incorporate into the analysis of Area H. In Area H two phases were identified in some rooms, but all rooms were recorded as a single phase during the excavation. Two explanations can be taken for the lack of phases within Area H: the collected assemblages only represent the last phase of occupation or the collected assemblages only represent the total of every phase. It is assumed that each room in Area H represents the total of every phase because in some places multiple phases were noted, even if they were not recorded.

The correspondence CA analysis of Area H looked at both the variation in forms and forms grouped according to expected function (See Table 6.1). The comparison of the results from the two tests is an important validation of the assumed functions by types. As long as the

arrangement of rooms is similar in both the biplot for vessel type and the biplot for expected function it can be said that the functional grouping holds significance. This is an important validation of the assumed function of different vessel types and implicates that each vessel type had a specific function. One of the first things to note is that the categories between the MxNV study and the EVE/MoR studies is slightly different; the Store Jar category was dropped for the EVE/MoR analyses (See Figures Table 6.5 and Table 6.6). While in the initial study an attempt was made to distinguish between the two, in the final analysis it was determined that it was too difficult to make a meaningful distinction. For the purpose of this analysis the conflation of smaller and larger jars is justified by other studies that did not identify functional difference between the two categories (Chesson and Goodale 2014, Fig. 7). Additionally in the typological analysis of the general form there was no definite bimodal distribution indicating a significant distinction between larger and smaller forms of jars based on decorative or other features (see Chapter 6.3.1.). Finally, when the MxNV analysis was done using both Store Jar and Jar as separate categories, the distribution for the two types was nearly identical indicating that the two forms shared nearly the exact same relative distribution pattern (See Figure 6.14). This shows that combining the two categories was acceptable based on the distribution of both types. When the different forms are combined according to function, the constellation of rooms does not change significantly in reference to the different functions (See Figure 6.17 and Figure 6.18 and Figure 6.19). The grouping of forms into functional categories follows what was outlined above in the methodology of analysis. Jars, Holemouth Jars, and Kraters are considered storage vessels. Bowls, Platter-Bowls and Jugs are serving vessels. Vats and cooking pots were used for food preparation. As a result, the distribution of vessels according to room can also be used to highlight different kinds of activity concentrations within KHI.

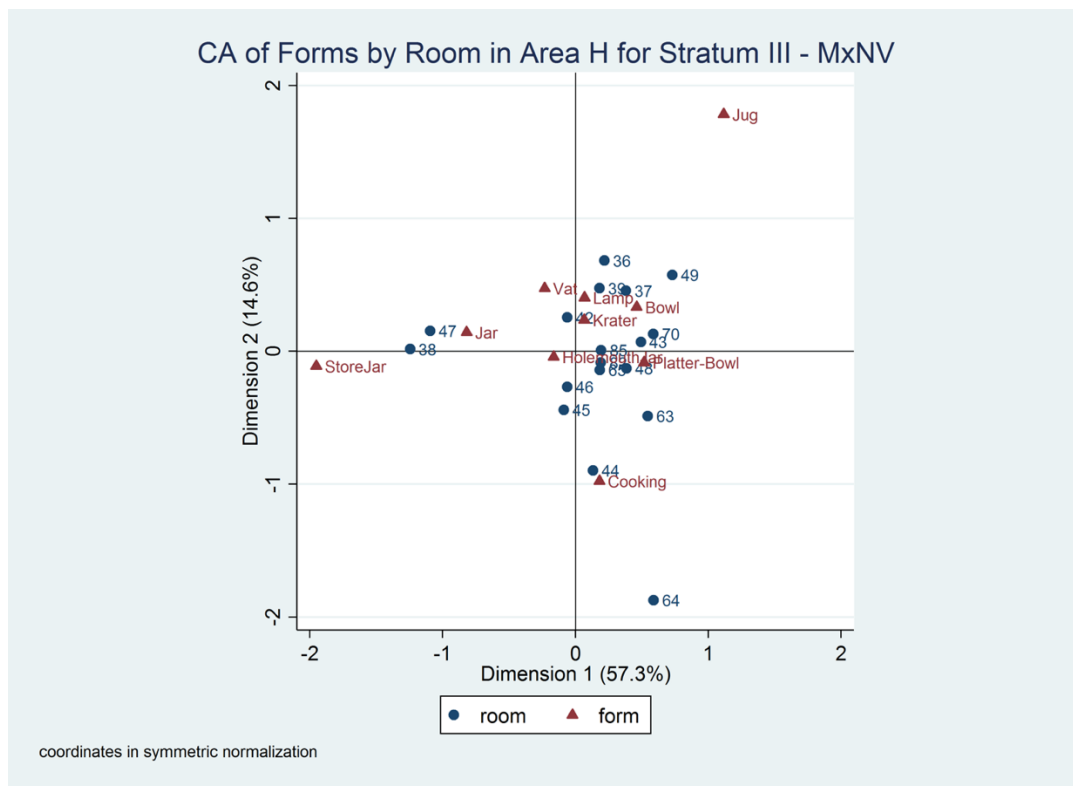


Figure 6.14: Correspondence analysis biplot of MxNV for Stratum III Area H at KHI based on data from Table 6.5. The most important distinction is between storage vessels on the left and serving vessels on the right. Cooking holemouths separate from the group on the second dimension.

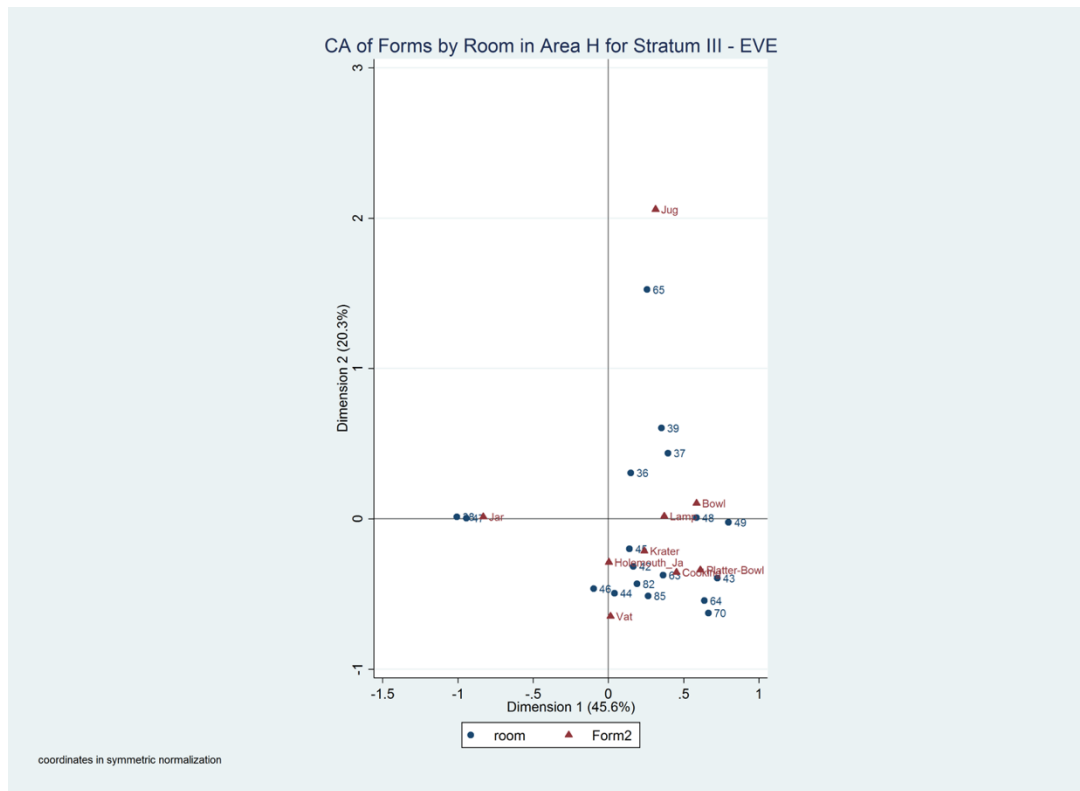


Figure 6.15: Correspondence analysis biplot of EVE for Stratum III Area H at KHI based on data from Table 6.6. Data for the model in Tables 6.13 and 6.14. The general principle of the MxNV plot holds, but cooking vessels are now associated with other forms.

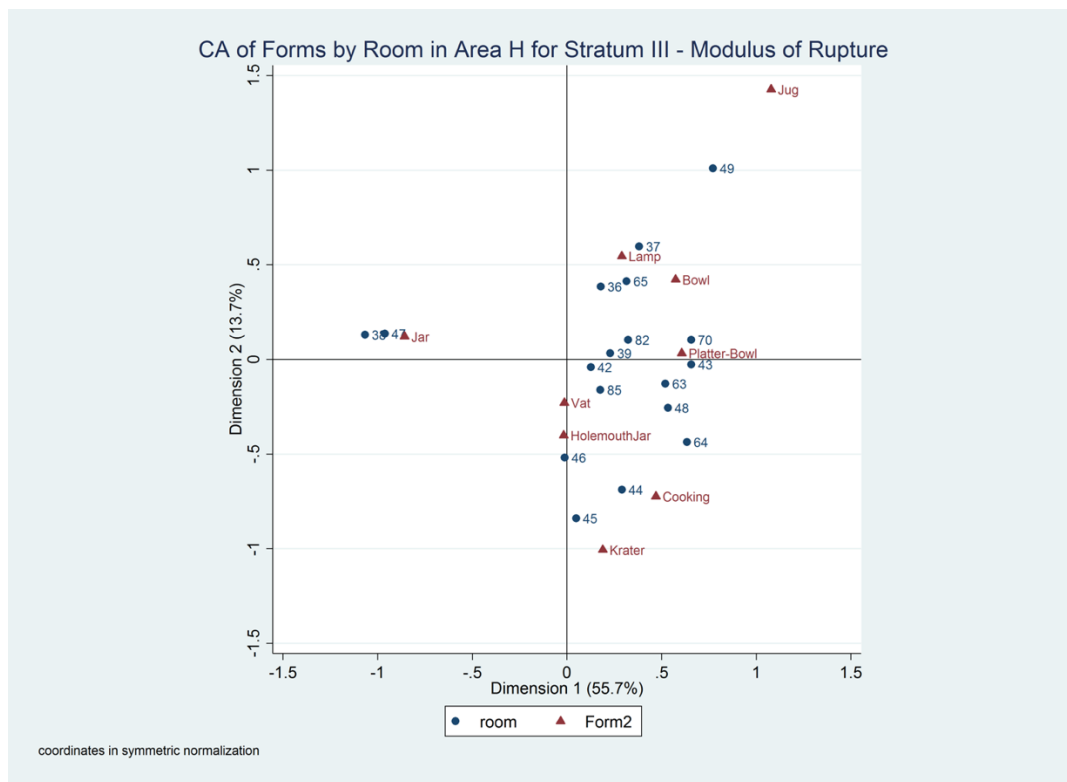


Figure 6.16: Correspondence analysis biplot of MoR for Stratum III Area H at KHI based on data from Table 6.6. Data for the model in Tables 6.11 and 6.12. Similar to the EVE, but better separation on each dimension. As in Figure 6.14 cooking vessels are closest to Rooms 44, 45, and 64.

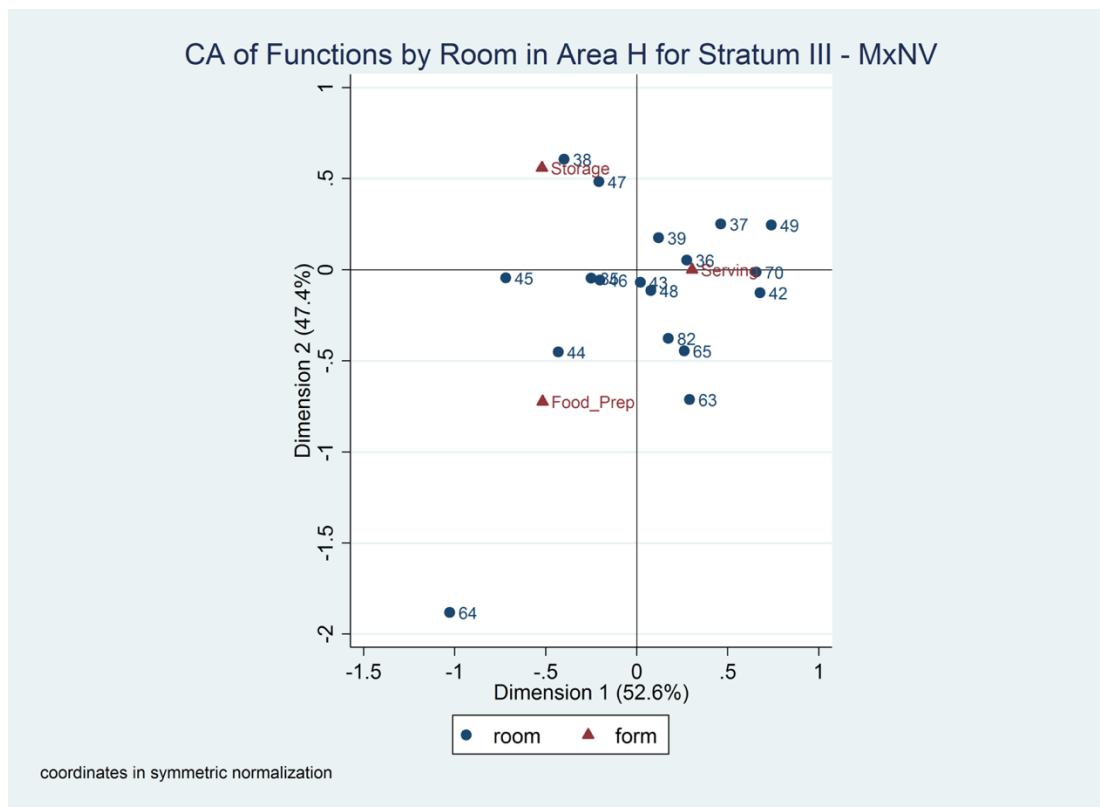


Figure 6.17: Correspondence analysis biplot using simplified forms according to function of MxNV for Stratum III Area H at KHI based on data from Table 6.5. Plot mimics Figure 6.14, but the axis is turned. Data in Table 6.17.

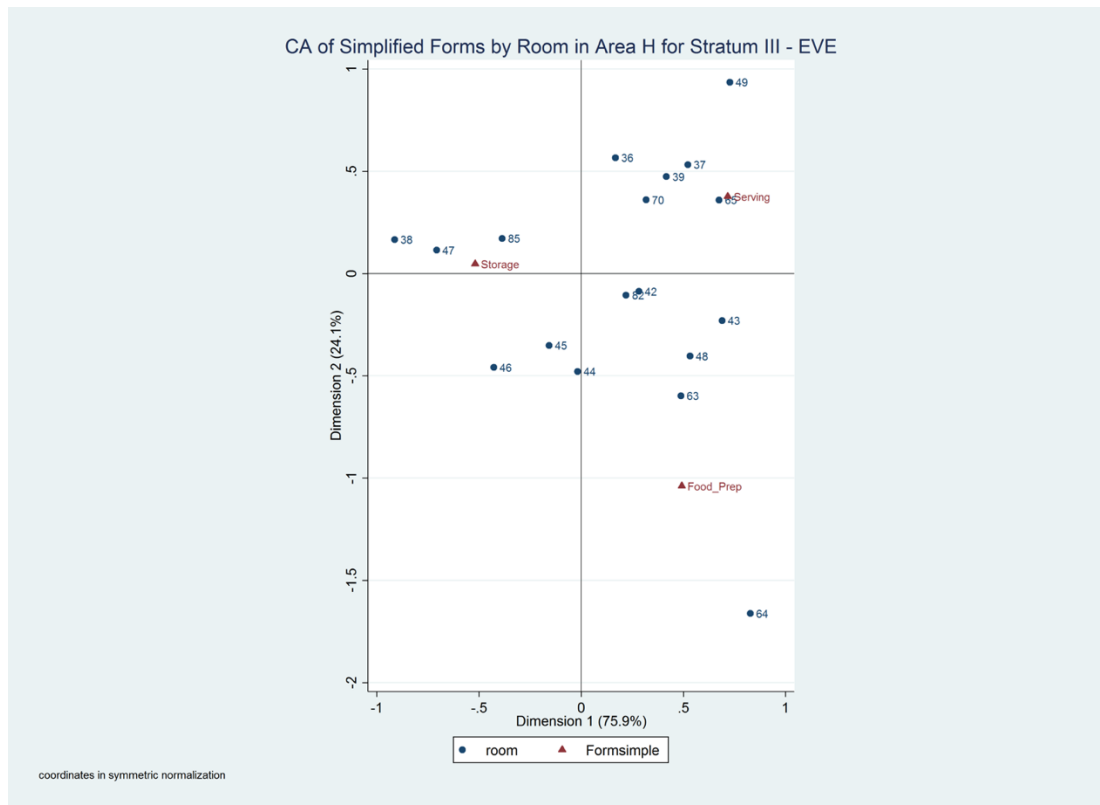


Figure 6.18: Correspondence analysis biplot of EVE using simplified forms according to function for Stratum III Area H at KHI based on data from Table 6.6. Rooms from Figure 6.15 are still generally associated with each other, but the simplification of forms to functional equivalent reinforces the difference between storage rooms and other types. Data in Table 6.16.

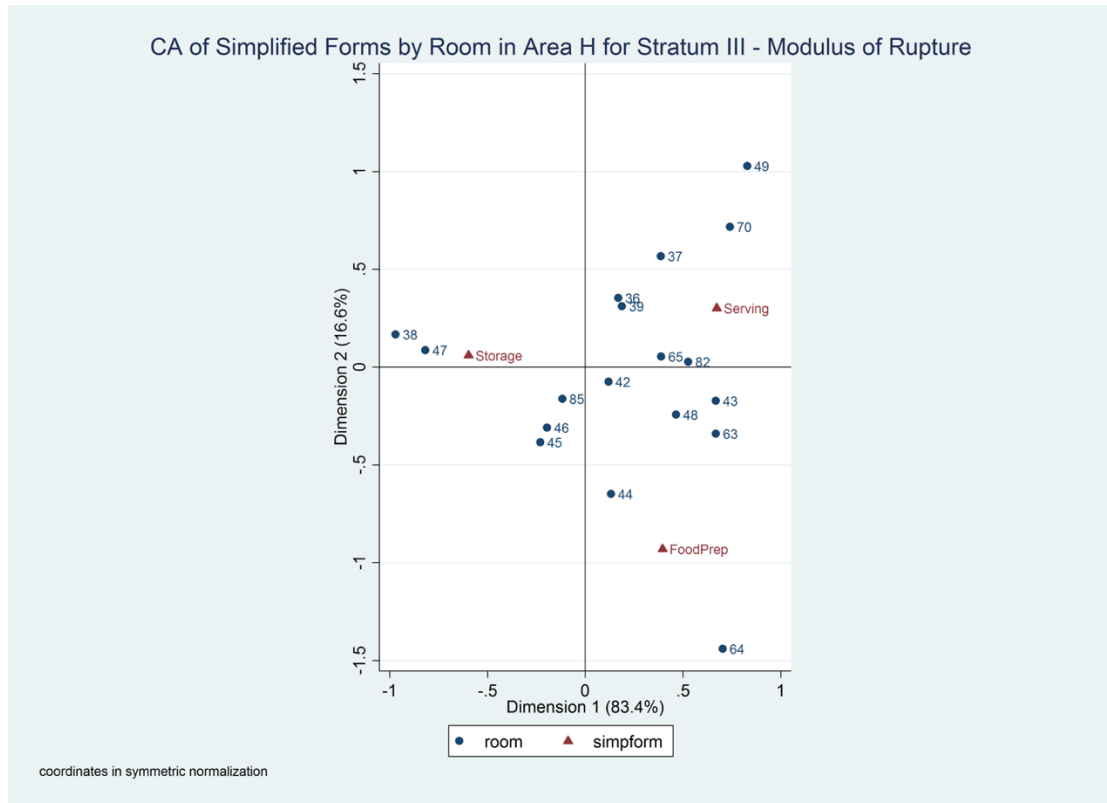


Figure 6.19: Correspondence analysis biplot of MoR using simplified forms according to function for Stratum III Area H at KHI based on data from Table 6.6. Similar to difference between EVE and MoR when using forms. Data in Table 6.15.

The different means of measuring the quantities of ceramics in KHI yielded very broadly the same results for Area H for the correspondence analysis across different forms. The Jar form is clearly dominant in two rooms, 38 and 47, and is isolated from the other forms especially on the much more significant first dimension (See Tables 6.12 and 6.14). The quality of the representation is high, and the dimension on which Jar shows strong distinction from the other forms is also the most important for the representation of that form (See Tables 6.11 and 6.13). Platter-Bowls and Bowls are roughly equidistant from Jars on the first dimension highlighting a strong distinction between those serving forms and storage forms like Jars. The other forms are all on the right side of the biplot with Vats and Holemouth Jars on the lower half of the the line that makes the second dimension. Bowls and Lamps are

generally above the other forms. However, the forms that arrange into an opposition to Jars move around based on nuances in the data.

Table 6.11: MoR Correspondence Analysis data table for forms in Stratum III Area H.

	overall			dim1			dim2			dim3		
	mass	quality	%inert	coord	sqcorr	contrib	coord	sqcorr	contrib	coord	sqcorr	contrib
Bowl	0.23	0.94	0.15	0.57	0.70	0.19	0.42	0.19	0.21	-0.24	0.05	0.07
Cooking	0.12	0.95	0.12	0.47	0.31	0.07	-0.72	0.37	0.33	-0.63	0.26	0.26
HolemouthJar	0.13	0.67	0.06	-0.02	0.00	0.00	-0.40	0.24	0.10	0.56	0.43	0.21
Jug	0.01	0.60	0.06	1.08	0.31	0.03	1.43	0.27	0.12	0.40	0.02	0.01
Jar	0.32	1.00	0.34	-0.86	0.98	0.60	0.12	0.01	0.02	-0.13	0.01	0.03
Krater	0.03	0.44	0.07	0.19	0.02	0.00	-1.01	0.31	0.16	0.62	0.11	0.06
Lamp	0.04	0.56	0.05	0.29	0.08	0.01	0.55	0.15	0.06	0.85	0.33	0.14
Platter-Bowl	0.10	0.59	0.10	0.61	0.55	0.09	0.03	0.00	0.00	0.25	0.04	0.03
Vat	0.02	0.50	0.05	-0.01	0.00	0.00	-0.23	0.01	0.00	1.38	0.49	0.18

Table 6.12: MoR Correspondence Analysis data table for rooms in Stratum III Area H.

	overall			dim1			dim2			dim3		
	mass	quality	%inert	coord	sqcorr	contrib	coord	sqcorr	contrib	coord	sqcorr	contrib
36	0.05	0.73	0.02	0.18	0.10	0.00	0.38	0.23	0.04	0.52	0.40	0.08
37	0.06	0.70	0.04	0.38	0.31	0.02	0.60	0.38	0.11	-0.12	0.01	0.00
38	0.11	0.96	0.18	-1.07	0.95	0.31	0.13	0.01	0.01	0.09	0.00	0.01
39	0.03	0.22	0.01	0.23	0.20	0.00	0.03	0.00	0.00	0.10	0.02	0.00
42	0.02	0.30	0.01	0.13	0.02	0.00	-0.04	0.00	0.00	-0.63	0.27	0.03
43	0.09	0.90	0.06	0.66	0.89	0.09	-0.03	0.00	0.00	-0.08	0.01	0.00
44	0.04	0.49	0.04	0.29	0.13	0.01	-0.69	0.35	0.09	-0.16	0.02	0.01
45	0.08	0.82	0.06	0.05	0.00	0.00	-0.84	0.70	0.29	0.34	0.11	0.05
46	0.07	0.73	0.03	-0.01	0.00	0.00	-0.52	0.47	0.10	0.39	0.25	0.06
47	0.15	0.99	0.20	-0.96	0.96	0.35	0.14	0.01	0.01	-0.21	0.02	0.03
48	0.07	0.88	0.04	0.53	0.76	0.05	-0.26	0.09	0.02	-0.16	0.03	0.01
49	0.05	0.92	0.09	0.77	0.42	0.07	1.01	0.36	0.25	0.65	0.14	0.11
63	0.05	0.87	0.04	0.52	0.39	0.03	-0.13	0.01	0.00	-0.83	0.47	0.17
64	0.01	0.55	0.04	0.63	0.21	0.01	-0.44	0.05	0.01	-1.07	0.28	0.09
65	0.05	0.69	0.03	0.32	0.23	0.01	0.41	0.20	0.04	-0.49	0.26	0.07
70	0.01	0.27	0.02	0.66	0.23	0.01	0.10	0.00	0.00	0.40	0.04	0.01
82	0.05	0.31	0.03	0.32	0.24	0.01	0.10	0.01	0.00	-0.23	0.06	0.01
85	0.02	0.73	0.05	0.18	0.02	0.00	-0.16	0.01	0.00	1.65	0.71	0.26

Table 6.13: EVE Correspondence Analysis data table for forms in Stratum III Area H.

	overall			dim1			dim2			dim3		
	mass	quality	%inert	coord	sqcorr	contrib	coord	sqcorr	contrib	coord	sqcorr	contrib
Bowl	0.22	0.76	0.13	0.58	0.71	0.20	0.10	0.02	0.01	-0.18	0.03	0.04
Cooking	0.12	0.74	0.11	0.45	0.27	0.06	-0.36	0.11	0.06	-0.73	0.36	0.33
HolemouthJar	0.12	0.53	0.05	0.00	0.00	0.00	-0.29	0.15	0.04	0.53	0.38	0.18
Jug	0.05	0.96	0.18	0.31	0.03	0.01	2.06	0.92	0.81	0.15	0.00	0.01
Jar	0.33	0.99	0.28	-0.83	0.98	0.61	0.01	0.00	0.00	-0.11	0.01	0.02
Krater	0.03	0.15	0.06	0.24	0.03	0.00	-0.21	0.02	0.01	0.61	0.10	0.06
Lamp	0.04	0.49	0.06	0.37	0.10	0.01	0.02	0.00	0.00	1.01	0.38	0.19
Platter-Bowl	0.10	0.66	0.08	0.61	0.53	0.10	-0.34	0.11	0.04	0.16	0.02	0.01
Vat	0.02	0.57	0.04	0.01	0.00	0.00	-0.65	0.13	0.03	1.36	0.44	0.16

Table 6.14: EVE Correspondence Analysis data table for rooms in Stratum III Area H

	overall			dim1			dim2			dim3		
	mass	quality	%inert	coord	sqcorr	contrib	coord	sqcorr	contrib	coord	sqcorr	contrib
36	0.06	0.76	0.02	0.15	0.07	0.00	0.31	0.20	0.02	0.54	0.49	0.09
37	0.06	0.68	0.03	0.40	0.37	0.03	0.44	0.30	0.05	-0.07	0.01	0.00
38	0.11	0.95	0.14	-1.01	0.94	0.29	0.01	0.00	0.00	0.14	0.01	0.01
39	0.03	0.82	0.02	0.35	0.26	0.01	0.60	0.51	0.05	0.21	0.05	0.01
42	0.01	0.32	0.02	0.17	0.03	0.00	-0.32	0.08	0.01	-0.61	0.21	0.03
43	0.08	0.92	0.07	0.72	0.76	0.11	-0.40	0.15	0.05	-0.11	0.01	0.01
44	0.05	0.57	0.02	0.04	0.00	0.00	-0.50	0.40	0.05	-0.38	0.17	0.03
45	0.08	0.18	0.05	0.14	0.04	0.00	-0.20	0.05	0.01	0.31	0.09	0.04
46	0.07	0.52	0.03	-0.10	0.03	0.00	-0.46	0.39	0.06	0.28	0.10	0.03
47	0.15	0.97	0.17	-0.94	0.96	0.35	0.00	0.00	0.00	-0.14	0.01	0.02
48	0.07	0.83	0.04	0.58	0.78	0.06	0.01	0.00	0.00	-0.20	0.05	0.01
49	0.05	0.58	0.09	0.80	0.40	0.08	-0.02	0.00	0.00	0.77	0.18	0.14
63	0.05	0.91	0.04	0.36	0.19	0.02	-0.38	0.13	0.03	-0.91	0.59	0.20
64	0.01	0.49	0.04	0.64	0.16	0.01	-0.54	0.08	0.02	-1.10	0.25	0.08
65	0.06	0.96	0.14	0.26	0.04	0.01	1.52	0.90	0.60	-0.27	0.02	0.03
70	0.01	0.43	0.02	0.66	0.26	0.01	-0.63	0.15	0.01	0.24	0.02	0.00
82	0.05	0.45	0.03	0.19	0.08	0.00	-0.43	0.26	0.03	-0.32	0.11	0.03
85	0.02	0.73	0.04	0.26	0.03	0.00	-0.51	0.08	0.02	1.65	0.62	0.24

Despite the similarities in the models, the details of the statistics that describe the correspondence between the variables indicates important differences in the representations. One of the advantages of grouping the data according to function is the simplification of variables making the calculation of fitting each dimension according to expected values more straightforward. The way to measure how well the model represents a variable is with the quality statistic. The more variables that are used to produce a model using correspondence analysis, the higher the likelihood that the quality of the model will decrease for certain variables. The low quality in this case simply means that it is not easy to fit the variable to a general model, which means that a variable with low quality does not follow a predictable distribution pattern in relation to the other variables in its row or column. The form that varies the most between the three measurements of quantity is the Krater, which can be explained by the low quality rating for each method indicating that the representations for that form are poor to begin with (See Tables 6.11 and 6.13). This means that Kraters do not show any regular variance from the mean in respect to the other forms within the site. The issue of low quality of representation is especially problematic more broadly for the correspondence analysis based on MxNV. For MxNV half of the forms and more than a third of the rooms score below 0.5. This is important for the interpretation of the biplot. One of the challenges of accepting either MxNV or EVE/MoR as a means to quantify the ceramic assemblage within a room is the expectation that both methods introduce bias. The fact that the resulting models are similar, independent of the method used to quantify the ceramic assemblage, suggests that the general models are accurate despite the low quality for the MxNV. The quality of representation is much higher for both EVE and MoR suggesting that the variability of counts for MxNV based on how the breakage seen in a context can affect the clarity of the results by reducing evidence of correspondences.

A detailed look of the indicator statistics for the the EVE and MoR models in Area H highlight important trends in the relative distribution of different forms (See Figure 6.15 and Figure 6.16). When representing all of the vessel types using the first two dimensions the majority of forms clump towards the bottom right quadrant, but there are clear nuances in the interpretation of that data based on how well each dimension represents the variation of different forms. The squared correlation indicates how much of the inertia in the row or column is accounted for by the dimension modeled (See Tables 6.11-6.14). On the first dimension, for forms have high squared correlations for both EVE and MoR; in the biplot Jars are placed opposite Bowls, Platter-Bowls and Cooking Vessels. This is significant in that the functions of Jars are unequivocally different from the other three forms as purely designed for storage and not a potentially multifunction ceramic form. The two rooms, 38 and 47, that correlate with Jars on the first dimension must be store rooms. The nuance between the EVE and MoR models is that in the MoR model the squared correlation is high also for Jugs. As discussed in Chapter 6.1.2. , using MoR to quantify an assemblage removes complete vessels from the calculation averages. As a category, Jugs rely on more of the vessels being present to indicate a spout or handle to be associated as a serving vessel (See Chapter 6.1.1.). As a result, Jugs are more likely to be nearly complete or complete when identifying and the application of the MoR statistic will discount the complete vessels from the revised counts, reducing their frequency and becoming a less significant outlier. The other vessels that have not been discussed thus far are best represented on the third dimension with Cooking vessels being opposed to Lamps, Holemouth Jars and Vats (See Figure 6.20 and Figure 6.21). The third dimension explains about 12% of the inertia in both the MoR and EVE models and makes important distinctions between Cooking Holemouth Jars, Holemouth Jars, Lamps and Vats. Both Vats and Holemouth Jars are not explained by the first dimension. However, on the third dimension Cooking Holemouth Jars are opposed to Holemouth Jars, Lamps and Vats and

draws two important distinctions between the four forms. First, the model accentuates a difference in the distribution between the two holemouth forms, highlighting specific functions isolated by working spaces. Second, Vats are associated with heatless food production, as in olive oil, so further distinctions can be brought between different aspects of food production and storage (Richard, pers. comm.). The results of the MoR and EVE correspondence analyses highlight different activity areas according to function within KHI. There is a distinct difference in the distribution of storage vessels, specifically Jars, from the rest of the vessel forms. The variation in distribution of other forms between rooms is nuanced, but highlights important divisions by vessel function within the site.

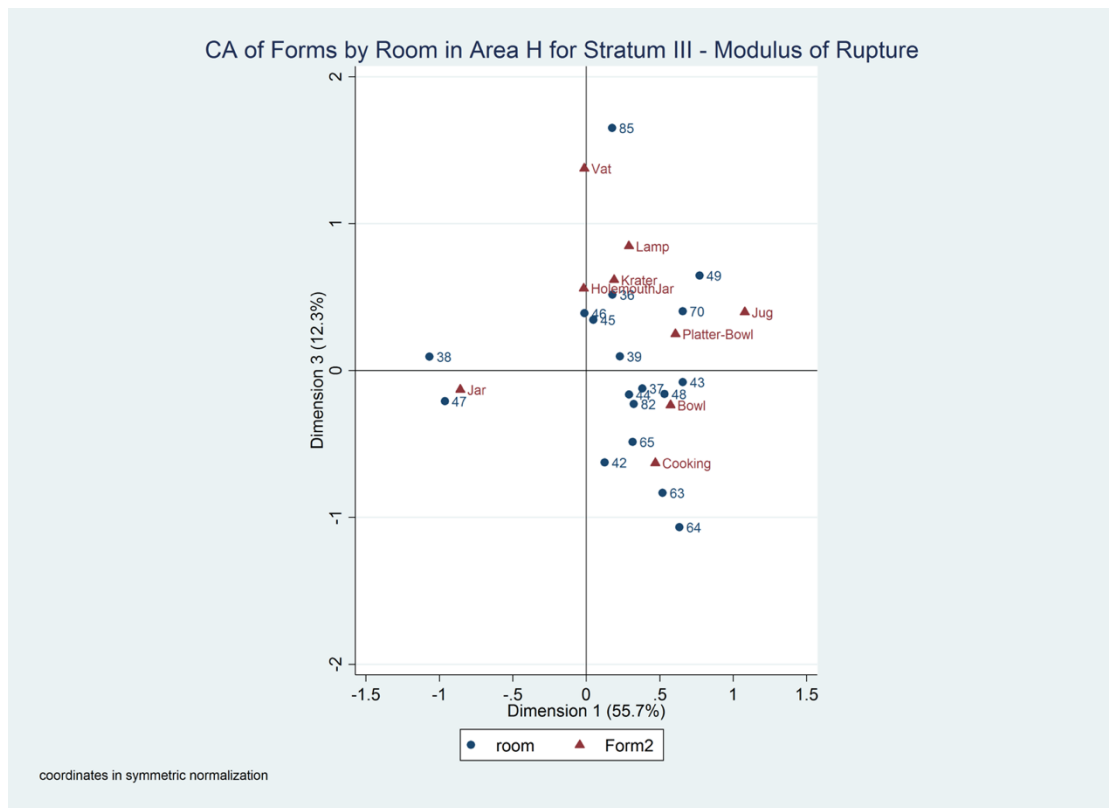


Figure 6.20: Biplot of the first and third dimensions based on the correspondence analysis of Stratum III KHI Area H using Modulus of Rupture to quantify the ceramic counts. Reinforces cluster of 63 and 64 around cooking vessels. Based on data from Table 6.6. Data for the model in Tables 6.11 and 6.12.

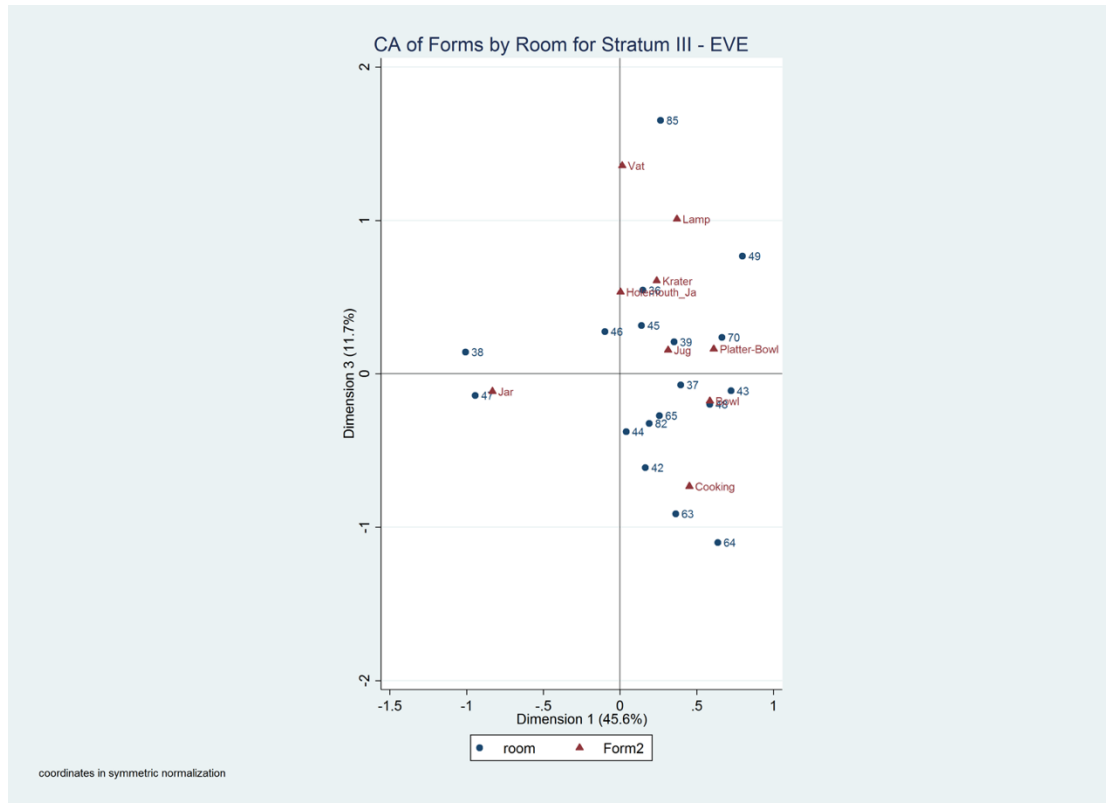


Figure 6.21: Biplot of the first and third dimensions based on the correspondence analysis of Stratum III KHI Area H using Estimated Vessel Equivalent to quantify the ceramic counts. Similar distribution to MoR. Based on data from Table 6.6. Data for the model in Tables 6.13 and 6.14.

The results of the correspondence analysis, where vessel types are combined according to function, mirrors the results seen when analyzed according to vessel type. This is highlighted by rooms 38 and 47 being very closely related to storage (See Figure 6.18 and Figure 6.19). The addition of holemouth jars moved Rooms 45, 46 and 85 closer to the other storerooms in the model, but those three rooms remain closer to the origin than Rooms 38 and 47. In the simplified model the first dimension is the most important and that dimension is defined most strongly by the difference in quantities of storage and serving vessels (See Tables 6.15 and 6.16). Comparing the different means of quantifying the relative frequencies of pottery MxNV offers an even more significantly different reconstruction of the spatial representation of the axes generated by the correspondence analysis (See Figure 6.17). For

MxNV the second dimension accounts for significantly more of the inertia compared to EVE and MoR. Nevertheless, in the MxNV model the inertia remains similar in terms of the relative distribution of rooms and forms in relation to each other. The change in measured inertia and the orientation of the model can be explained by the difference in mass of each functional type, clearly serving vessels are more likely to break than the other forms (See Tables 6.15-6.17). Finally, the models using ceramics according to function vary less from the origin compared to the model based on form, with the exception of Room 64 in the MxNV model. In other words, none of the functional groups show a lot of inertia from the mean. As a result, while there are clear differences of the relative frequency of ceramics according to function from room to room, those differences are not highly pronounced. Compounding the quantities of each function type within each room did not amplify functional variation from room to room. The general model for individual types generally matches the model combined by function and as a result reaffirms the functional groupings.

Table 6.15: Statistics from the analysis of forms according to function using correspondence analysis of Stratum III KHI Area H based on the Estimated Vessel Equivalent.

	overall			dim1			dim2		
	mass	quality	%inert	coord	sqcorr	contrib	coord	sqcorr	contrib
Storage	0.56	1.00	0.33	-0.52	1.00	0.44	0.05	0.00	0.01
Food Prep	0.14	1.00	0.26	0.49	0.28	0.10	-1.04	0.72	0.77
Serving	0.31	1.00	0.41	0.72	0.87	0.46	0.38	0.13	0.23

Table 6.16: Statistics from the analysis of forms according to function using correspondence analysis of Stratum III KHI Area H based on the Modulus of Rupture.

	overall			dim1			dim2		
	mass	quality	%inert	coord	sqcorr	contrib	coord	sqcorr	contrib
Food Prep	0.15	1.00	0.18	0.40	0.29	0.06	-0.93	0.71	0.79
Serving	0.36	1.00	0.40	0.67	0.92	0.45	0.30	0.08	0.20
Storage	0.50	1.00	0.41	-0.60	1.00	0.49	0.06	0.00	0.01

Table 6.17: Statistics from the analysis of forms according to function using correspondence analysis of Stratum III KHI Area H based on the Maximum Number of Vessels.

	overall			dim1			dim2		
	mass	quality	%inert	coord	sqcorr	contrib	coord	sqcorr	contrib
Food Prep	0.16	1.00	0.41	-0.52	0.35	0.27	-0.72	0.65	0.56
Serving	0.63	1.00	0.19	0.30	1.00	0.37	0.00	0.00	0.00
Storage	0.21	1.00	0.39	-0.52	0.48	0.36	0.56	0.52	0.44

Finally, it is important consider the relative frequencies of other material types in relation to the data from rooms at KHI. The faunal data revealed that Rooms 36, 43, and 48 contain the most bones and that the majority of bones identified were meat bearing bones, from the limbs (Muniz 2008, Pg 174-251). A correspondence analysis of the distribution of body parts highlights that Rooms 44 and 63 are most closely associated with the crania; Room 65 is associated with axial bones (See Figure 6.22 and Table 6.18). The limb bones are otherwise spread between rooms. Based on the functional analysis of the ceramics Rooms 44 and 63 were also food preparation rooms. This supports that animals were butchered in those room as a part of food preparation and the limb or axial bones were served. This matches the food preparation process seen at the Iron Age copper production site of Timna; a process that has been used to indicate that the copper workers were of high socioeconomic status (Sapir-Hen and Ben-Yosef 2014). The association of specific bone types with function of ceramics within the site reinforces an interpretation of the ceramic assemblage that there is a clear division of activity within rooms within KHI. The fact that the faunal assemblage is concentrated within Area H further suggests that the division of labor was organized.

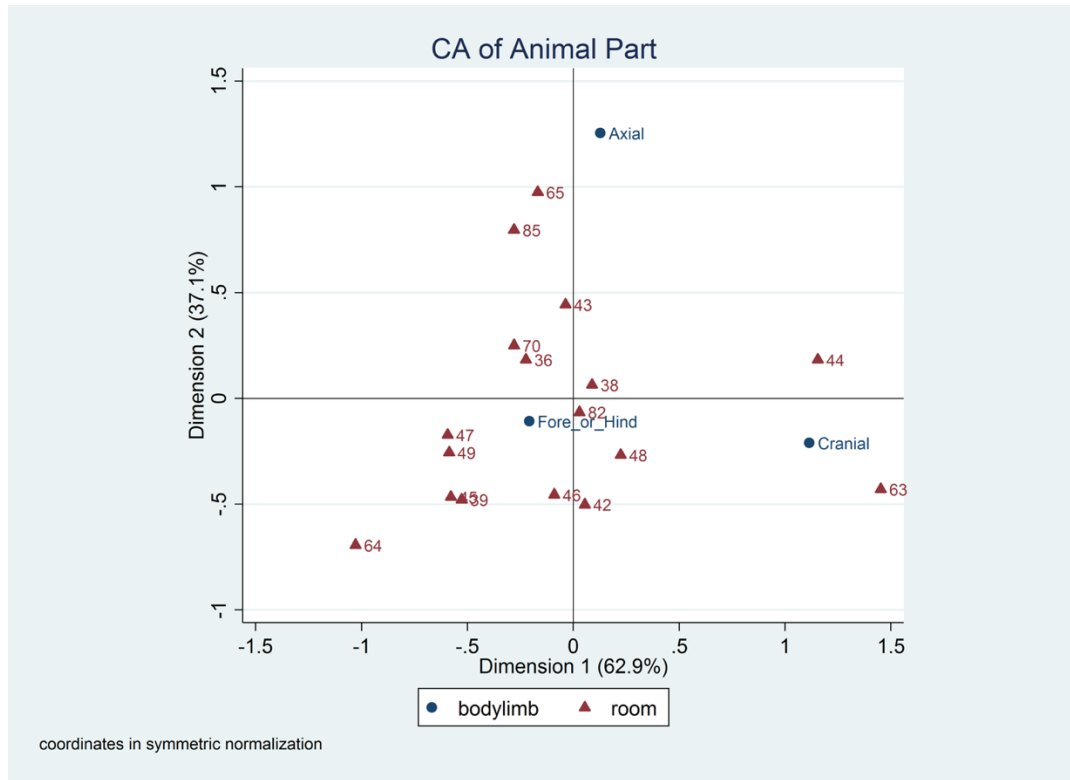


Figure 6.22: Correspondence analysis of different animal body parts within Area H. Limbs are generally distributed, but cranial and axial features isolate to two different sets of rooms. (Data from Muniz 2008).

Table 6.18: Table of data from Correspondence analysis of different animal body parts within Area H (Data from Muniz 2008).

	overall			dim1			dim2		
	mass	quality	%inert	coord	sqcorr	contrib	coord	sqcorr	contrib
Axial	0.09	1	0.34	0.13	0.01	0.01	1.25	0.99	0.90
Cranial	0.13	1	0.53	1.11	0.97	0.83	-0.21	0.03	0.04
Limb	0.78	1	0.13	-0.21	0.83	0.17	-0.11	0.17	0.06

The distribution of copper production between the two excavated structures that consist of Areas H and Y reinforces the conclusion that division of labor existed within KHI (See Figure 6.23). This is supported by the wide distribution of metallurgical production as well across the site. Hammer-stones are widely distributed, but a higher concentration exists in Area H. The molds are distributed between the different buildings with a concentration in different rooms, but the two buildings of Area Y having more overall. With the caveat that a

greater concentration actually existing in the densest room of Area H. That general distribution, roughly taken, again highlights a division of labor. The casting took place in and around the courtyards of Area Y. The final hammering taking place with hammer-stones in Area H. There is no single complex that seems to have exclusive control the total process of casting copper objects.

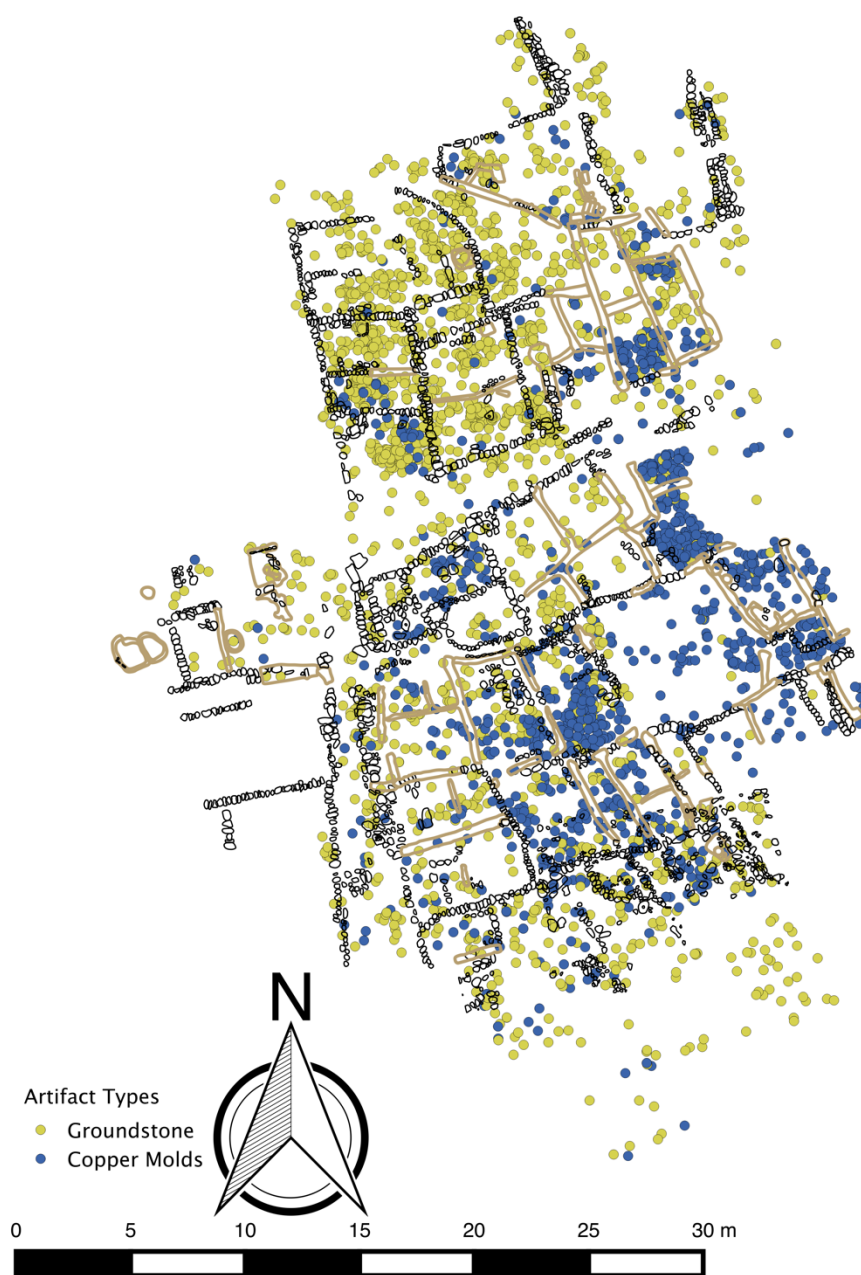


Figure 6.23: Map highlighting the distribution of molds and ceramics as identified in the field. The data in this map is incomplete because more material has been found at a later date and certainly some material was misidentified, but nevertheless the figure provides a good, general picture of the estimated distribution of different artifact types.

Taken together, the ceramic, faunal and metallurgical data suggests divisions within the site according to tasks whether it be food preparation or metal production. Those divisions within the site highlights functional specificity within each context that is not associated with the design of contemporaneous pastoral settlements (Saidel 2002a, Saidel 2002b). The interesting aspect of that division of labor is that there is no obvious distinction in socioeconomic status within the excavated area. The small size of KHI and the fact that copper was a high-value product makes it difficult to make a socioeconomic status distinction within the site. It may be that copper workers were universally high-status and the distinction in status existed beyond the site or related to a different part of the copper production process. The secondary smelting to make the final product was the center of power.

6.4. Conclusion

At KHI the pottery indicates that the site is most similar to EBA permanent settlements and reveals important distinctions in the use of space based on aspects of food consumption and production. Typologically the material shows certain forms that were very regular in construction, especially when isolating according to a set number of key features even though the vessels were handmade. Additionally, within different vessel function groups there was a wide variety of forms being employed, including specialized forms such as the slipped and burnished holemouth jars and cooking jars. A ceramic assemblage that includes wider variety of specialized forms does not suggest a pastoral mode of production and compared to pastoral sites in the Negev a more varied assemblage is present at KHI (Cribb 1991, Grillo 2012, Saidel 2002b). It is known that copper was the most valuable product within KHI, but despite producing such a high value product, the faunal record does not allow for internal distinctions in socioeconomic status based on access to food stuffs (Muniz 2008). In fact, storerooms exist across the excavated area of the site and no area of the site controlled

the total copper production operation from raw metal to finished product. The relative quantity of storage vessels within the site also suggests that the site could have been settled for very long periods of time, especially compared to other sites where there is evidence of irrigated horticulture and contained relatively fewer storage vessels (Rast and Schaub 2003). The variety of forms and the overall quantity of ceramics at the site lends more support to the assertion that the site was occupied as a permanent settlement during Stratum III rather than a temporary location for pastoralists. The lack of comparable data from Stratum II and IV suggest that the occupation of KHI during those periods did not have the permanence seen during Stratum III. This will be important to consider in relation to other contemporaneous sites that were involved in the copper production.

Chapter 7: Pottery in Chronological Context: Revising Models of Copper Exchange in the Early Bronze Age Using Chronological Data

The ceramic data from KHI has elaborated the local subsistence strategy at KHI. The size and variety of forms seen in the ceramic assemblage represents a permanent occupation that exhibited urban characteristics of a large fortified EBA settlement. Additionally, the intensity and scale of metal production at the site, one indication for the division of labor, further highlights the urban characteristics of KHI. However, other aspects of the site highlight pastoralist elements that are associated with smaller ephemeral sites. The kill-off patterns of the animals and the small percentage of the blades with gloss in the lithic assemblage underlines the reliance on pastoral production at the site. Additionally, the site is in an arid area beyond the “zone of uncertainty” where pastoral production would normally occur (See Figure 4.15, Wilkinson et al. 2014, Pg. 53-54). Finally, the site is associated with the Negev copper trade which is associated with the EBIV, when the urban centers of Canaan are abandoned (Haiman 1996). Within the traditional models for the EBA of the southern Levant these two elements, urban and pastoral, are not normally present at a single site (See Chapter 3). As a result, it is necessary to understand interaction between KHI and the regional social sphere of the Early Bronze Age in order to explain how urban and pastoral features might coexist at a single site.

In order to apply the interaction between the pastoral and urban elements at KHI it is necessary to clarify the place of the site within the Levantine EBA chronology. KHI is most commonly associated with EBIV sites in the Negev Highlands based on ceramic correlates (Adams 2000). Ceramic correlates are useful to establish evidence of interaction between areas but are unreliable for chronologies in areas where single occupation sites predominate like the Negev and Faynan. The EBA chronology has been significantly revised recently using

radiocarbon data, the most significant revision occurring in the later part of the EBA, the same period that KHI was predominantly occupied (See Table 3.1, Regev et al. 2012). The revelations based on the reevaluation of the radiocarbon data requires a complete reconsideration of how Negev EBA sites fit in the revised chronology for the EBA. Radiocarbon and other techniques that provide absolute chronological markers are especially important to contextualize KHI with sites that might be associated by providing an independent means to identify contemporaneity.

Measuring the ancient geomagnetic intensity values of objects associated with copper production from KHI and other nearby production sites provides a necessary method to compare the relative age of sites involved in EBA copper production. Any material that is fired to a high temperature will record the properties (inclination, declination and intensity) of the ancient magnetic field once cooled past the blocking temperature of the ferromagnetic components of the material (See Tauxe 2010). This process has been outlined for applicability in archaeological contexts by Sternberg (1997). Given the fact that the process of copper production involved heating ore to produce copper and slag, copper production sites make an excellent location to measure archaeointensity values. This method has been illustrated to be successful at identifying archaeological events through the work of E. Ben-Yosef (2009, 2010) at Iron Age sites in the region; the interpretation of the results was aided by the identification of a narrow spike in the ancient magnetic field. Additionally, Ben-Yosef (2008) already sampled some of the important sites where initial smelting occurred near or adjacent to the mines in Faynan and Timna, which can be used as a reference for new data. Beyond KHI new samples were taken at the sites of 'Ein Yahav and Giv'at Hazeva. Like the sites already sampled by Ben-Yosef the three sites are primary smelting sites, but they are between 25 and 50 kilometers from any ore sources. Each site provides a necessary anchor to model how

copper moved across the landscape and whether the location of copper production relative to the mines changes over time.

It is necessary to consider radiocarbon data from KHI and neighboring sites both in conjunction with and in addition to the dating based on archaeointensity. Archaeomagnetic dating is a new technique for dating archaeological sites of the last few millennia and requires archaeological correlates, including radiocarbon and ceramics, to provide absolute dates for observed fluctuations in the ancient magnetic curve (For examples see Shaar et al. 2015, Shaar et al. 2016). It is only by comparing the measured data with the ancient magnetic curve that an absolute date can be provided. As a result, it is necessary to use both sites with both archaeointensity and radiocarbon data to contextualize sites with only radiocarbon. In addition to contextualizing the archaeomagnetic data, a reevaluation of already published radiocarbon dates also can yield new results. The development of radiocarbon calibration (Buck, Litton, and Smith 1992) and the application of Bayesian analysis (Bronk Ramsey 2009) allows for the refinement of dates in a way that was not possible during previous radiocarbon analysis in the Levant (e.g. Callaway and Weinstein 1977). Additionally, radiocarbon data was often ignored in development of past models for the EBA, in part because the data did not fit the traditional chronology (See Chapter 4.3). By using radiocarbon data to help anchor the results from the archaeointensity data and to reanalyze the chronologies of different sites it will be possible to indicate contemporaneity between KHI and other sites of the Negev.

Ceramic correlations will be necessary to substantiate interaction between sites identified as contemporaneous with KHI using the data from radiocarbon and archaeointensity. The presence of unique vessel types and forms, which also existed within a limited chronological scope, will help to record the interaction sphere of the copper producers of KHI. Certain type-fossil forms have been identified at KHI and can be related to other sites in the region and are indicative of the interaction that the site must have had with other

regional centers seeking to acquire copper (Adams 2000, Rast and Schaub 2003, Pgs. 389-397, 445-448, Dever 2014, Pgs. 233-235). The data substantiating interaction between KHI and a variety of neighboring sites in combination with the archaeointensity and radiocarbon dating will allow for the substantiation of a revised model for the copper trade between KHI and neighboring area.

The fact that KHI exhibits both pastoral and urban characteristics requires the description of the regional context for the copper trade that passed through the site. It is known that the patterns of trade changed through time, especially in relation to the development of the Egyptian state during the Old Kingdom (See Chapter 4.5.2). The development of a model that describes the socio-political organization of KHI needs to incorporate the shifts in the regional occupation of the Negev and other nearby areas in order to understand how the pastoral and urban features of the site coexisted. This is where the idea of an Industrial Landscape is especially useful as a means to guide the interpretation of data associated with the production of copper, including the temporal data (See Chapter 2.5). Further, the incorporation of archaeological studies of the intensity of specialized production are useful to help understand not just aspects of production but the structure of demand for different products (e.g. Brumfiel and Earle 1987, Costin 1991, Costin 2007). The interaction between shifts in demand and the industrial landscape will help explain how KHI could be both pastoral and urban simultaneously. The key aspect of KHI is copper production and as a result everything that has been said so far in regards organization of ceramic finds and their implications for how different spaces at the site functioned needs to be put into place.

7.1. Archaeointensity: Dating production sites to describe the Industrial Landscape of the EBA

The use of archaeomagnetic techniques to date archaeological contexts offers the significant advantage of dating events in the history of archaeological objects rather than dating archaeological material by proxy or associated material. This is especially important in contexts where archaeological objects that are datable, such as ceramics, are not present or do not offer the desired chronological resolution. It is the rapid cooling of material that has been exposed to very high temperatures that allows for the blocking of the thermal remanent magnetization linearly to the geomagnetic field during cooling (Tauxe 2010). Afterwards, it is possible to obtain the data for the ancient magnetic field from the moment of capture using a Thellier and Thellier type experiment, in this case the “IZZI” protocol (Thellier and Thellier 1959, Tauxe and Staudigel 2004, Yu and Tauxe 2005). There are important limitations when analyzing artifacts using archaeomagnetic techniques. In addition to varying through time, the magnetic field varies geographically, so it is important to know exactly where the heating event occurred in order to make the data comparable. As a result, when used to date ceramics great care must be taken to identify the location where the ceramic was manufactured. That limitation is what makes the use of archaeomagnetic data for the analysis of metal production sites particularly useful. It is rare in ancient smelting contexts that slag would have been moved a significant distance from the furnace where it was produced. At many of the EBA slag heaps, including the ones tested and discussed in this study, windblown furnaces associated with EBA copper smelting technology were identified in situ with the slags (Rothenberg and Shaw 1990, Hauptmann 2007, Ben-Yosef, Ron, et al. 2008, Ben-Yosef, Tauxe, et al. 2008). As a result, we can assume that the slag tested for archaeomagnetic dating will provide data about the archaeomagnetic field during smelting events associated within the

furnaces. The slag, however, will not be in the same position at which it was cooled; limiting the archaeomagnetic technique to the detection of the intensity of the ancient magnetic field.

Only being able to use intensity data limits the potential resolution of archaeomagnetic dating and requires additional caution to ensure that the data is interpreted correctly. If it was possible to measure all three aspects of the archaeomagnetic field (inclination, declination, and intensity) it might be possible to achieve dating accuracy of as little as 50 years (Sternberg 1997, Pg. 323). This is done by comparing the variation in each aspect, which in combination offer more precise measurements. Unlike the radiometric dating that relies on a relatively linear decay rate, each aspect of the geomagnetic field fluctuates in such a way that overtime the values for each will overlap (See Figure 7.1 for an example of the variation in the ancient intensity). As a result, when only considering the variation in the ancient intensity there will be overlap in the readings so that the intensity of the magnetic field has been the same at different points in history. Nevertheless, the fact that the intensity of the field fluctuates means that the detection of variation in the intensity indicates a significant time-gap between detected heating episodes (Shaar et al. 2011, Livermore, Fournier, and Gallet 2014). However, when using the reference curve to assign an absolute date caution must be used. The reference curve has been built using proxy data, radiocarbon and ceramics, which have accuracy ranges that limit the precision of correlating new data to the curve (See Figure 7.1 for how the horizontal error bars indicate the potential range for any given intensity reading). Despite the inherent weakness of only being able to use archaeointensity data, any other material record correlate can be used to help constrain which part of the intensity curve to compare to assume a connection between sites.

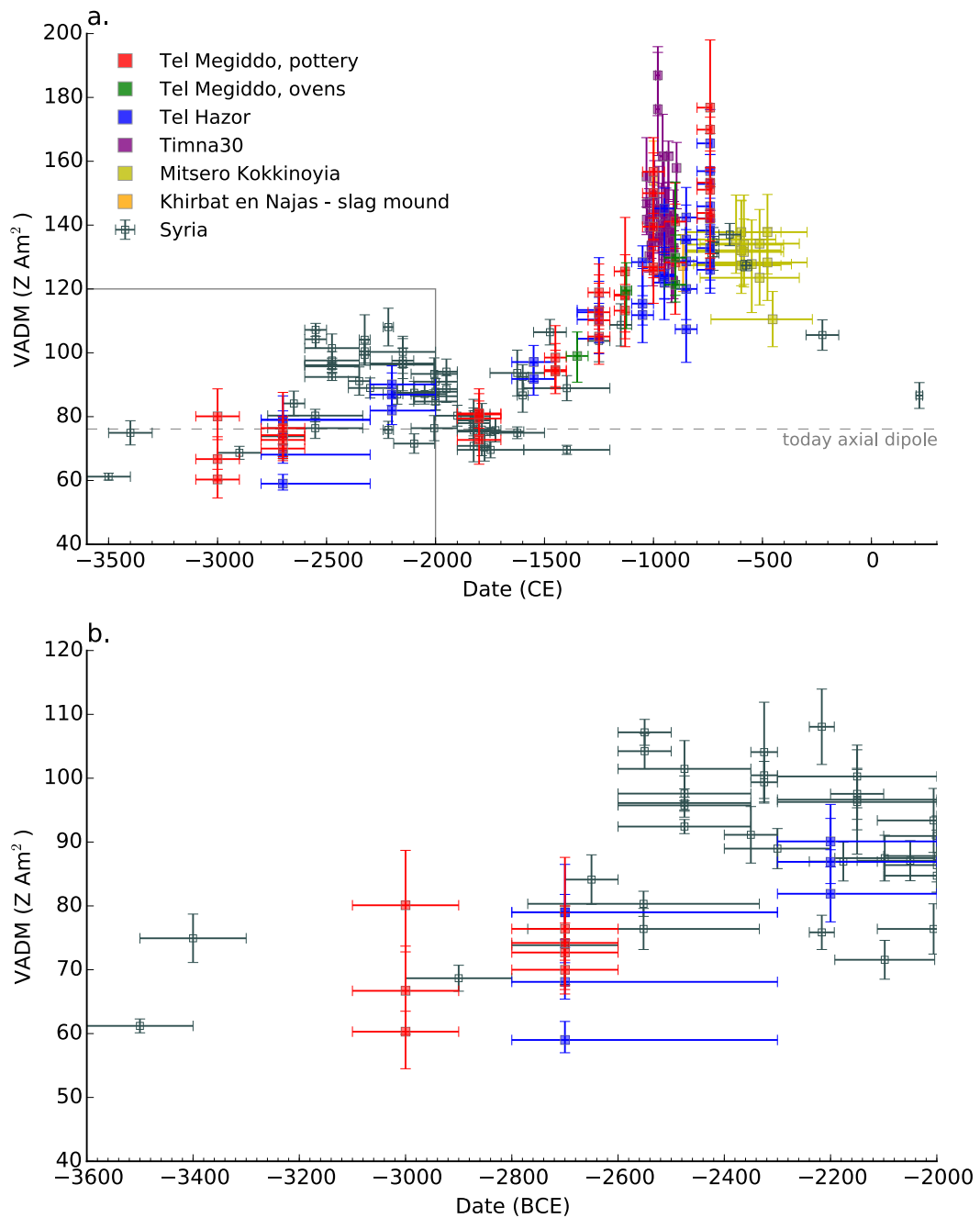


Figure 7.1: Archaeomagnetic intensity curve based on the Levantine Archaeomagnetic Compilation. Figure produced by Ron Shaar (2016).

A total of four sites EBA smelting sites have already been studied using archaeomagnetic dating. The focus of previous research in the Faynan region using the

archaeomagnetic technique has been long term trends in metal production or unique phenomena related to the intensity curve during the Iron Age (Ben-Yosef, Ron, et al. 2008, Ben-Yosef, Tauxe, et al. 2008, Ben-Yosef et al. 2009, Ben-Yosef et al. 2010, Ben-Yosef, Tauxe, and Levy 2010, Shaar et al. 2010). From the EBA the study of trends in metal production included samples taken from the sites: KHI, Fenan 15 and Timna 149 (Ben-Yosef, Tauxe, et al. 2008). Fenan 15 was identified by Hauptmann (2007) as a part of his survey of the mining region around Faynan and was associated with neighboring smelting sites Fenan 9 and 16 based on similar smelting installations (The dates of Fenan 9 and 16 are discussed in the following section). The three Fenan sites are very close to mines. Timna 149 as the name suggests is in the Timna Valley of southern Israel, also very close to ore sources, and was excavated by Rothenberg in 1984 and 1990, who dated the site to the EBIV (Rothenberg and Shaw 1990). During the sampling of the slag from Timna 149 by Ben-Yosef (2008) noted evidence of smelting over multiple periods based on different kinds of slags and as a result sampled each slag type. The Ashalim samples were collected by E. Ben-Yosef from one of the surface slag mounds as a part of a new archaeomagnetic project (See Figure 3.1, Ben-Yosef et al. In Prep). The site was identified initially by Uzi Avner and is noted for the large number of *masseboth* at the site (Avner 2002, Pg. 55-56). The major benefit of the existing research is that the sites sampled are regional diverse.

The sites were chosen for new samples in this study based on their position relative to KHI and the mines of Faynan. In order to understand the regional *chaîne opératoire* or Industrial Landscape it was necessary to sample sites that were intermediate to the Faynan and Negev regions complementing the range of sites that have already been sampled (See Chapter 2.5 for more on Industrial Landscape). 'Ein Yahav and Giv'at Hazeva are both in the Arava valley between Faynan and the Negev Highlands. The sites are slag mounds without any associated material culture. 'Ein Yahav was excavated by Yuval Yekutieli and included a

radiocarbon date (See following section) (Yekutieli, Shilstein, and Shalev 2005). Yekutieli is also the first to mention Giv'at Hazeva in a publication (to my knowledge), describing it at contemporaneous to 'Ein Yahav, but never excavated or dated. Finally, additional samples from KHI were taken during the 2007 excavation season supervised by Adolfo Muniz under the direction of Prof. Thomas E. Levy. Every sample measured came from an insecure context. Unlike the other sites, the samples from KHI were not located near furnaces. As a copper processing site smelting could have been going on at the site in order to further refine the copper (Najjar et al. 1995). It is safe to assume that in the cases of the sites tested the slag was not redeposited from a far distance away. Smelting furnaces were apparent at all of the slag heaps, of the sites included in this study the only exception to this were the slags that were selected for testing at KHI.

All of the archaeointensity samples were processed in the UCSD Paleomagnetic Laboratory. The samples from 'Ein Yahav and Giv'at Hazeva were processed by the author under the supervision of Lisa Tauxe. The methods used follow the IZZI protocol outlined in Tauxe and Staudigel (2004). Standards for identifying specimens of "good quality" are not uniform and applied differently between research groups, but for the purpose of this study the standard set by Ben-Yosef (2009, Pg. 531-534) is used. The important measurement for comparing archaeointensity data is the virtual axial dipole moment (VADM). The VADM is a calculation used to normalize a measured intensity according to the co-latitude of where the specimen was found to match the magnetic moment of a dipole aligned with with the rotational axis of the earth. Variation in the intensity of the ancient magnetic field is presented using VADM in order to compare intensity across a region.

The data from the archaeointensity study shows two groups of values interpreted to be associated with the Early Bronze II-III and the Early Bronze III-IV using the revised chronology (See Table 7.1). The EBII-III VADM values group around 68 ZAm^2 and the later

dates range between 84 ZAm² and 100 ZAm². The EBIII-IV grouping is determined in accordance with the plateau of the intensity curve over the EBIII-IV and the margin of error of the readings. However, the variation between the low and high ends of the EBIII-IV spectrum might be indicative of a distinction between the sites. It is noted in the intensity curve that the earlier part of the EBIV, about 2400 BCE, is higher than the later part of the EBIV. Based on the aforementioned assumption that gaps in intensity are indicative of different heating episodes, there may be reason to make further distinctions within the EBIII-IV grouping (Livermore, Fournier, and Gallet 2014). This is a situation where radiocarbon will be useful to guide the separation of the data (Discussed in the following section). Of special note is that readings from KHI exist within both of the groupings of measurements, highlighting the role of KHI over a long period of time as a copper production hub.

Table 7.1: Table of Archaeointensity Measurements

Site/ Context	Sample	N_B	B (uT)	s_b	s_b\%	VADM	s_vadm	Context average (VADM)	Source
KHI: EBII Culture									
3068	b62579a	2	34.63	1.23	3.6	67.12	2.38	68±1	(This Study - Collected by Adolfo Muniz for UC San Diego)
3031	b62341a	2	34.85	1.25	3.6	67.54	2.42		
	JS08a **	5	36	5.328	14.8	68.6	10.2		
KHI: EBIII-IV Culture									
3069	b62596a	2	41.57	5.53	13.3	80.57	10.72	93±9	(This Study - Collected by Adolfo Muniz for UC San Diego)
3032	b62306a	3	45.48	9.32	20.5	88.15	18.06		
3079	b62425a	3	48.44	1.18	2.4	93.88	2.28		
3104	b62704a	2	49	2.99	6.1	94.97	5.8		
3024	b62214a	2	49.42	1.8	3.6	95.78	3.49		
3020	b62100a	2	54.87	0.21	0.4	106.3	0.4		
Ashalim:									
ash01a	ash01a	3	30.83	2.48	8.1	59.45	4.79	67±11	(This Study - Collected by Erez Ben- Yosef)
ash01b	ash01b	4	38.85	2.71	7	74.91	5.22		
Giv'at Hazeva:									
h	h	4	42.67	8.18	19.2	82.61	15.84	87±6.5	(This Study - Collected by Aaron Gidding)
r	r	7	47.4	6.76	14.3	91.76	13.09		
p	p	2	187.7	10.95	5.8	363.4	21.2	363±21	
‘Ein Yahav:									
t	t	9	45.21	2.99	6.6	87.65	5.79	88±6	(This Study - Collected by Aaron Gidding)
Timna 149:									
Hillside	IS03b	4	43	3.6	8.3	84.1	7	84.1±7	(Ben- Yosef 2008)
Fenan 15:									
JS04a	JS04a	3	51.6	11.2	21.8	99.9	21.7	99.6±15	(Ben- Yosef 2008)
JS04a	JS04a	3	51.3	0.7	1.4	99.3	1.4		

Differences in the kinds of sites that are grouped by the high and low archaeointensity readings provides the basis for interpreting changes in the means by which copper was produced through the EBA. The fact that there are only two sites in the low grouping is important given the association with the EBII-III, the start of broad population agglomeration in the EBA Levant. This may relate to a more geographically disperse copper production network that also included southern Sinai (Beit-Arieh 1983, 2003). The example of Ashalim as an EBII-III site offers a view into the complexity of the people that were involved in the copper trade that is otherwise not understandable looking simply at the sites of KHI and the surrounding area. It offers an example of what is best understood as a ritual site where people that were involved with the copper trade went as a part of their trading activities. The ritual aspect is due to the presence of the ~200 *masseboth* (standing stones). Other examples have been found throughout the southern part of Israel at ephemeral sites and are interpreted as ritual centers in part due to the offering tables set in front of many examples (Avner 2002). The evidence of other kinds of activity at Ashalim is so sparse that it is impossible to fully understand what was going on at the site, but one must interpret the *masseboth* installations as having some importance to the overall organization of the people involved (See Figure 7.2). The different sizes, and complexities of the *masseboth* might have some significance that is difficult to ascertain, the locations of different kinds were irregular except for some that might be considered similar kin groups or the like, especially with similar construction styles or materials use to make the groupings. Either way, the presence of slag at the site in conjunction is unique onto itself.



Figure 7.2: Example of one of the many *maseboth* with offering table in front. Photograph by Aaron Gidding.

By comparison the high grouping of sites, associated with the EBIII-IV, consists of primary smelting sites with the exception of KHI. Each of the primary smelting sites has few associated material remains beyond the slag and associated furnaces. Within the high group there is more measured variation compared to the low group. The sample that does not match is from Fenan 15 (JS04a), where the VADM is about 10 ZAm^2 greater than the other slag production sites. However, one of Ben-Yosef's (2008) published measurements from Fenan 15 has a very large standard deviation that introduces the chance that the precise measurement matches the lower VADMs in the high grouping. At the same time, the other sample from Fenan 15 (JS04b) has a very low standard deviation that is higher than the others in the EBIII-IV group. The other primary copper production sites in this group are far away from the mines at Faynan, all to the west of KHI. If the measurement of JS04b is accepted as representative of

Fenan 15, the more than 10 ZAm² VADM gap between it and the other EBIII-IV sites indicates that it is likely that there is a gap of more than century between the operations at those locations (Livermore, Fournier, and Gallet 2014). The difference that can be seen between the VADM measurements of Fenan 15 and the other sites in the high VADM group introduces the potential for variation in the regional *chaîne opératoire* of EBA copper smelting within the EBIII-IV.

The intensity data provides evidence for at least two distinct groups of production sites that correspond to the EBII-III and the EBIII-IV. KHI belongs to each group, indicating that the site was involved for copper production through a long period of time as the industrial landscape shifted. Within the EBIII-IV group of samples, Fenan 15 indicates that it might date to a different period than the rest of the samples. The data collected through archaeointensity does not provide any definitive answers, but offers a guide for future questions. For the earlier group, how does KHI articulate chronologically with other early sites? For the later group, is it possible to distinguish Fenan 15 from the other sites chronologically? Radiocarbon and ceramic associations are the necessary tools with which to help clarify the data where definitive distinctions in the data from archaeomagnetic measurements are not possible.

7.2. Radiocarbon: Increasing the resolution of archaeointensity data and highlighting linkages

The use of radiocarbon to help understand the relationships between different sites in the Early Bronze Age has become essential due to the various issues with the chronological sequence as outlined above (see Chapter 3.3). Techniques that utilize Bayesian analysis of radiocarbon to increase precisions has been used to try to solve many issues in the dating of the Iron Age in the Levant with some success and only recently has come to the forefront for reevaluation of the Early Bronze Age (Levy and Higham 2005, Levy et al. 2008, Regev, de

Miroschedji, and Boaretto 2012, Regev et al. 2012, Regev et al. 2014). The major innovations in the dating of the EBA as a part of the Associated Regional Chronologies for the Ancient Near East and the Eastern Mediterranean (ARCANE) project has significantly altered the interpretive framework that has been used to model regional interaction through the period (Höflmayer 2014, Lebeau 2015). Important work using radiocarbon to check the Egyptian chronology has been carried out simultaneously (Bronk Ramsey et al. 2010, Dee et al. 2013, Wengrow et al. 2014, Manning et al. 2014, Dee et al. 2014). The results of the revised Early Bronze Age chronology have altered the time-frame for transitions between phases in the southern Levant. This is important because some parts of the Levantine Archaeomagnetic Curve are based on ceramic correlations to phases for which the dates have changed. In this case study the radiocarbon data will help to further detangle the archaeomagnetic data and offer chronological anchors to the sites tested. Additionally, Bayesian analysis will be applied to the site of Arad, which plays an important role in the interpretation of Ashalim and the argument for distinct EBII and EBIV occupations of the Negev Highlands (See Chapter 3.2 - 3.5). The integration of data from archaeointensity and radiocarbon will help to produce a parsimonious model of changes in the EBA industrial landscape over time.

For the comparison of radiocarbon and archaeomagnetism data there is only a limited number of sites that can be used to help disentangle the uncertainty in the archaeomagnetic data. The association with radiocarbon data from the same or similar sites is the only way to contextualize the archaeomagnetic data and assign a time period. However, this is qualified with the understanding that the data from the sites is only associative limiting the confidence in the direct correlation. If a radiocarbon sample was captured in slag it would be possible to make a direct correlation, but no samples used for archaeointensity had organic material embedded. The sites that have both radiocarbon and archaeointensity data are KHI and 'Ein Yahav (See Figure 7.3 for radiocarbon dates from the sites). In addition, the mining site

Fenan 15 will also be discussed as a site with published archaeointensity data (Ben-Yosef, Tauxe, et al. 2008). The radiocarbon determination for this site is done in association with Fenan 9 and Fenan 16, both of which also have published radiocarbon data and based on the morphology of the furnaces at the site is assumed to have been contemporaneous with Fenan 15 (See Figure 3.1, Hauptmann 2007). The radiocarbon data from the four sites ranges from the start of the EBIII through the end of the EBIV and cover the period of the plateau within the archaeomagnetic uncertainty (See previous section). The key for this analysis is the fact that both archaeomagnetic and radiocarbon data from KHI cover a wide spread of time. How the other sites relate to the data from KHI¹⁸ will be very important to interpreting how copper production sites shifted through time and to place each within a historical context.

¹⁸ It cannot be stressed enough that the major difficulty with the attempts to correlate the archaeomagnetic data with radiocarbon is the lack of consistently reliable contextual correlation between samples. All of the data is required to be pieced together with a set of assumptions that takes into account the fact that none of the relevant samples from KHI come from secure contexts. This means that we have to use the general story of KHI based on the combination of radiocarbon data and stratigraphy to make the necessary assumptions of how the site could be related to the other sites.

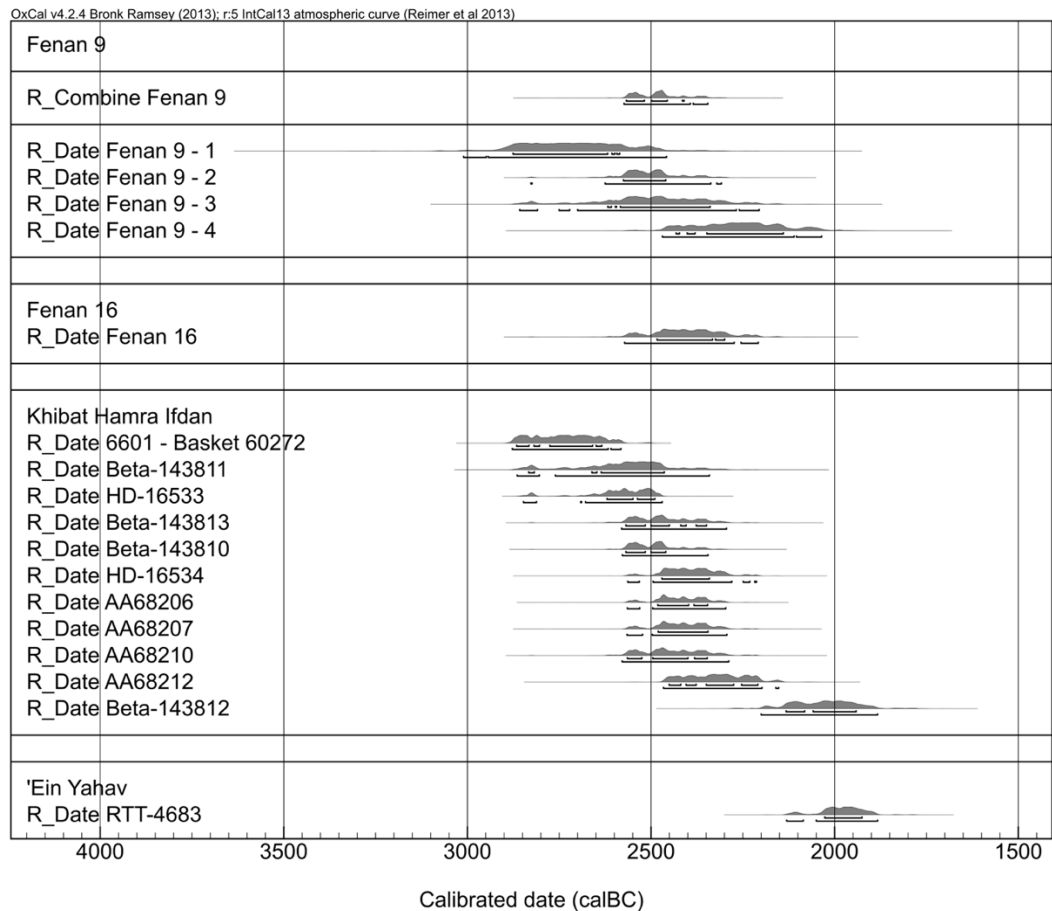


Figure 7.3: Radiocarbon dates from KHI, Faynan smelting sites and 'Ein Yahav. Dates were taken from (Levy et al. 2002, Yekutieli, Shilstein, and Shalev 2005, Hauptmann 2007).

'Ein Yahav is the best site to correlate radiocarbon with archaeointensity data. The site contained a single archaeomagnetic determination and a single radiocarbon determination making the correlation straighter forward. The radiocarbon date was taken from the site during excavation and the few artifacts corroborate a late EBIV date 1981 ± 61 cal BCE (Yekutieli, Shilstein, and Shalev 2005). The associated single slag sample taken from the surface slag scatter from the site confidently fits in the the higher VADM grouping. As a result, it is easy to assume that the nearby and similar slag mound at Giv'at Hazeva is of a similar date (See Figure 3.1). Giv'at Hazeva has a slag scatter on the side of a hill like 'Ein Yahav and is

located 13 kilometers up the Wadi Arava. The VADM readings are slightly below the combined reading from KHI, but fit with the assertion that slag would have been produced contemporaneously across the site. Finally, the presence of a single late date at KHI is indicative of activity at the site in the later part of the EBA. The sample (Beta-143812) from the upper part of a locus, Locus 1010 in Area H, assigned to Stratum III is assumed to have been part of a later deposit given that another sample (Beta-143810) from the same locus that was associated with the floor deposit dates to an earlier phase in the EBIV. Thus the youngest radiocarbon sample at KHI highlights the late EB occupation was most likely a part of late EBA smelting operations that occurred over a wide geographical space across the Arava Valley. That landscape included the smelting installations in the Wadi Arava, both 10 kilometers west of KHI. For building a model of the Industrial Landscape at the end of the EBA it is important that primary smelting operations occur west of KHI, away from the mines. This is further supplemented by the data from Timna 149, that share the features of a small hilltop smelting with 'Ein Yahav and Giv'at Hazeva. The fact that a smelting site appears in the Timna Valley at the end the EBA, similar in form to those ~100 kilometers to the north, indicates a dispersed industrial landscape as the EBA came to a close. Opportunistic primary smelting was occurring beyond KHI, where copper had been funneled from smelting sites earlier in the EBA.

The major cluster of radiocarbon dates at KHI coincides with the radiocarbon dates collected by Andreas Hauptmann (2007) at Fenan 9 and Fenan 16 (See Figure 7.3). The time span covered by those radiocarbon dates centers roughly around 2600 BCE through 2200 BCE. The same period of time assumed to have been the primary occupation and copper production period of KHI. The average VADM for the two slag samples from the sister site, Fenan 15, registers at 99 ZAm^2 with a pooled single sigma standard deviation of 15.3 ZAm^2 , but one of the samples (JS04b) was as small as 1.4 ZAm^2 (See Table 7.1). Even when taking

into account statistical error, the measured VADM for JS04b is a little higher than the VADMs that was observed at the Arava sites of 'Ein Yahav, Giv' at Hazeva and Timna 149. Other evidence from the site of Tell Mozan in Syria in the northern Levant highlights that there is a small increase and plateau in the VADM in the middle of the 3rd Millennium and a progressive decrease towards the end of the period (Stillinger, Feinberg, and Frahm 2015). That middle period correlates well with the dates collected from Fenan 9 and Fenan 16. Like the slag sample from Fenan 15, at KHI most of the slags that form the upper group are above 90 ZAm² (See Table 7.1). This indicates that the slags with a high VADM should be grouped with Fenan 15 and not the Arava sites of 'Ein Yahav, Giv' at Hazeva and Timna 149. However, the data from KHI can not be taken without qualification. All of the EBA slag samples came from insecure contexts that in some cases originated in the layers near the boundary between EBA and Iron Age layers at the site. As a result, it is impossible to associate any of the strata with the high or low grouping seen at KHI. Nevertheless, the intensity of the magnetic fields during Iron Age and the EBA do not overlap, so it is safe to assume the slags are in fact EBA. As a result, the two phases observed in the slag from KHI simply indicate that the site was active at the same time as the sites with slags of a similar VADM. Accepting a slight peak in the intensity curve between 2500 and 2200 BCE there is reason to believe that the smelting activities observed at Fenan 15 and KHI are separate from those in the Arava valley. The combination of the radiocarbon data and archaeomagnetic data from the Fenan sites is indicative of the intense primary smelting of copper near the mines east of KHI, representing yet another, slightly earlier formation of the EBA industrial landscape. The last smelting site that needs to be contextualized is Ashalim, a site with slag scatters and many *masseboth*. The location of the site is between the city of Arad and Bab edh-Dhra in an area that has been described as being a part of a road network between the Dead Sea Basin and

the settled areas of Israel (Yekutieli 2006a, 2006b). The site is not near any springs or other land marks, but would have been between 2 and 3 kilometers from the estimated level of the Dead Sea during the Third Millennium BCE (Migowski et al. 2006, Pg. 423). The low VADM for the slag from site has led to the assumption that it dates to the EBII/EBIII transition based on correlation with the Levantine Archaeomagnetic Compilation. The EBII/III data for the low grouping is important because while the excavators of KHI mention evidence of an early occupation in Stratum IV there is no significant data from that stratum except for in Area Q (See Chapter 4.1). As a result, the archaeointensity data indicates that Ashalim dates to before the main occupation phase, Stratum III, at KHI based on the variation in the archaeointensity curve.¹⁹ During the 2011 season one radiocarbon sample was taken from the Stratum IV which was identified by the appearance of ceramics that appeared to be earlier than those found in the Stratum III fill deposits. The date from that layer 2736 ± 83 cal BCE (AA99137 - Sample 6601, see Figure 7.3) is the earliest that has been identified at the site. With that date it is possible to push back the date of the earliest occupation of KHI to the early part of the EBIII, using the revised chronology.

The early date from KHI and the chronological association with Ashalim indicates contemporaneity of copper production at KHI with the large urban center of Arad. The calibrated date from Stratum IV of KHI matches the modeled occupation of Stratum II at Arad (See Figure 4.14). This would place the foundation of EBA KHI at the same time of the florescence of the EBII town of Arad with Ashalim being an important stopping off point in the regional copper trade. Additionally, the EBII Negev settlements and production in southern Sinai are dated to this same period using ceramic correlates (Amiran, Beit-Arieh, and

¹⁹ The date for Ashalim cannot come after the EBA due to what is generally known about the time period of the used of the *masseboth* found at the site and the fact that copper is not produced in the Arava region again until the Iron Age (Avner 2002).

Glass 1973, Saidel and Haiman 2014). For the first time this places early KHI in the same industrial landscape of copper production of the EBII regional copper trading that included Arad and southern Sinai. Additionally, this copper trading network did not date to the EBII as it is normally determined, but instead the early EBIII using the revised chronology (See Chapter 4.3). That change in the relative chronology is enabled by revised “high” chronology for the EBA (Regev et al. 2012). That timeframe also just precedes the foundation of the Old Kingdom of Egypt and the collapse of Arad as a settlement. The revision of Stratum II at Arad to the early EBIII is a contentious conclusion in part because Arad has a large influence on establishing the chronologies of many sites in the neighboring areas.

As the chronological anchor for the EBII in the northern Negev and neighboring regions, shifting the collapse of the site to the early EBIII requires a reevaluation of the socio-economic role that Arad played in the EBII-III industrial landscape. In all likelihood the location of Ashalim and the ritual activities that took place there were likely tied to the continued settlement at Arad and the maintenance of a polity in the Dead Sea Region that controlled the important east to west trade route into Canaan (Yekutieli 2006a). Perhaps it is as a result of control of trade routes along the Dead Sea that Arad was able to play a central role in copper exchange. The importance of Arad as a hub, facilitating the transport of copper into Canaan is further reaffirmed by the relationship with southern Sinai as indicated by ceramic correlations (Discused in the next section, Amiran, Beit-Arieh, and Glass 1973, Beit-Arieh 1986). As long as Arad was occupied the copper trade would not have been only directed to Egypt; indicating the important role that Canaan played as a market for copper into the EBIII. After all the EBIII, “represents the zenith of the Early Bronze civilization in the southern Levant, when sites reached their maximum extension and monumental architecture developed” (de Miroschedji 2014, Pg. 313). The importance of northern Israel and Jordan as

markets for copper from Faynan and Sinai must have played a role in the development of Arad as a city and help to define the organization of another industrial landscape.

There is a progression of copper production systems through the EBA based on the three different phases outlined using the correlation between radiocarbon and archaeomagnetic data. The earliest evidence (Phase 1, See table below), signified by the data from Ashalim, highlights a widely distributed system where primary copper was smelted at a number of sites over a dispersed landscape with the assumption that Arad was an important conduit that helped to regulate trade routes. For that phase the primary evidence for production centers has historically been focused on southern Sinai, in part because that was where the best evidence for EBII copper production had been found along with a petrographic connection (Amiran, Beit-Arieh, and Glass 1973, Beit-Arieh 1983, Porat 1989, Beit-Arieh 2003). That same petrographic connection also indicates that Faynan was involved in the copper trade (Adams 1999, Pg. 251) with the addition lead isotope analysis of Arad copper (Hauptmann, Begemann, and Schmitt-Strecker 1999). Two sites in the Faynan region, Barqa el-Hetiye and Khirbat Faynan, may have also played an important role in first phase of the EBA industrial landscape (Discussed in detail based on ceramic correlations in the next section, Fritz 1994, Adams 2003, Levy et al. 2012). That phase contracts, approximately at the same time as the foundation of the Old Kingdom in Egypt into a much more constrained system (Phase 2) where there is a linearly clear organization of labor that shows first smelting near the mines followed by secondary production of finished good for trade down the line. At that point, Arad has been abandoned and in this period KHI is the primary locus of production. Based on the ceramic evidence already presented production was certainly organized, but without a strong redistributive hierarchical element controlling production. The last phase (Phase 3) returns to a more loosely defined organization system that exists after the collapse of the Old Kingdom and during the First Intermediate period. In this system production is spread to other sites in

Timna and throughout the Arava Valley. Final processing of copper presumably occurs at other sites along the way.

In order to validate the three phase model presented above ceramic correlates are necessary to verify the assumed connection between sites within each phase. KHI is the one site that appears in each phase and as a result it will be necessary to connect the stratigraphy of KHI with the overall model. In the previous chapter only Stratum III was considered for statistical analysis due to the absence of similar contexts in the other strata. Stratum IV, which would correlate to the first phase identified in association with Arad is relatively short and barely noticed in excavation. The later phase in Stratum II is unevenly noted across the site, and later EBIV pottery is not noted as densely as forms from earlier periods (See Chapter 4.1). An important key to understand this stratigraphic relationship comes from the ceramic finds; in particular, there are a few key vessel types that can provide useful intra-site correlates. The mixed modes of subsistence production at KHI, where both pastoral and urban characteristics are evident, highlights the need to consider how the site interacted with a contemporaneous central trading partner to support the settlement. Over the course of the EBA the largest state that could trade for large quantities of copper was the Old Kingdom, which matches the period of Phase 2.

The developing model that is presented here highlights autochthonous production of copper in a similar cultural tradition to the “Timnian” model that emphasized the distinction of the Negev and surrounding areas from the settled areas to highlight local agency and cultural practices (See Chapter 3.5). Evidence for continuity is most prevalent in the lithic assemblage where technological traditions continued from the EBI-II and distinguish the desert areas from areas to the north (Vardi, Rosen, and Hermon 2007, Rosen and Vardi 2014). Haiman in his model for settlement in the EBII assumed that the pastoralists of the Negev were not involved in copper production and trade because they lacked the necessary hierarchical structure to

require copper surplus to finance their political economy (Saidel and Haiman 2014, Pg. 173). This model was supported by his perceived gap in copper production as noted by the absence of settlement in the Negev Highlands (Contra Avner and Carmi 2001). The model proposed here of an industrial landscape that shifts according to demand through time instead relies on a continuity of copper production in the Faynan region from the EBII through the EBIV. A secondary test of continuity between each phase of the copper production system will depend on the persistence of ceramic forms between phases and sites. As the site that persists from the EBII through the EBIV, KHI will provide the necessary data in the form of ceramics to link the sites from each phase.

Table 7.2: Proposed phasing with key sites listed as cultural and chronological markers for the changing industrial landscape of the EBII through EBIV using the revised chronology.

Phase Number	Key Sites	Timeframe (BCE)	Organization of Copper Production	Egypt
1	Khirbat Hamra Ifdan - Stratum IV	3100-2700	Dispersed	First through Second Dynasty
	Arad			
	Ashalim			
	Barqa el-Hetiye			
	Khirbat Faynan			
	Southern Sinai			
2	Khirbat Hamra Ifdan - Stratum III	2700-2200	Centralized	Third Through Sixth Dynasty (Old Kingdom)
	Beer Resisim			
	Ein Ziq			
	Fenan 9			
	Fenan 15			
	Fenan 16			
3	Khirbat Hamra Ifdan - Stratum II	2200-2000	Dispersed	Sixth Through Eleventh Dynasty (First Intermediate Period)
	Beer Resisim			
	Ein Ziq			
	'Ein Yahav			
	Giv'at Hazeva			
	Timna 149			

7.3. Variation in Forms and Features of Pottery

Radiocarbon data is useful in order to establish an independent means to correlate similar temporal frameworks for the analysis of different sites, but ultimately the best way to indicate cultural association is through the material record and pottery correlates still make up some of the most convincing associations. It is only through the material culture that

continuity of cultural traditions can be established both within a site and between sites. In his seminal study of EBIV pottery, Dever (1973) highlighted that his concept of ceramic families was derived from cultural continuity that in some cases went back to the EBI. That model was established under the assumption of a region-wide collapse at the end of the EBIII that is no longer accepted as the prevalent model in part due to the reconfiguration of the EBA chronology that precludes interconnectivity with cultural shifts in neighboring regions. As a result, the family model assumed *a priori* that the ceramics identified the development of distinct regional traditions that have since been challenged (See Chapter 4.5.1). Nevertheless, the importance of continuity, which in part is still tied to the development of ceramic traditions that are constrained to specific regions, remains fundamental to how the southern Levantine EBA ceramic assemblage is interpreted.

Identifying continuity in the published record of EBA ceramics is challenging after the reconfiguration of the regional relative chronology. Based on the new EBA chronology of Regev (2012), the EBIV period is enlarged and expands into what was previously identified as the EBIII, which has enveloped part of the EBII (See Table 3.1 and c.f. Stager 1992). This has important implications for combining studies of EBA ceramics that primarily used of ceramic chronologies for dating with studies of EBA ceramics that primarily used radiocarbon to place the ceramics in the relative chronology. Further, using purely ceramic data for the basis of establishing chronological association can lead to *a priori* assumptions based on the expected social and political shifts from the EBIII to the EBIV. Already it has been noted that the interpretation of the occupational sequence of the Negev has relied on this tautological reasoning to assume the absence of the EBIII (See Chapter 3.2-3.4).

The most striking aspect of the ceramic assemblage at KHI is how similar it is to many of the other EBA sites in the region in general. For instance, when we consider the assemblages of many of the significant settlements in the regions adjoining Faynan and the

Negev from the EBIII, the assemblage from KHI compares favorably in terms of the general form varieties and types represented from sites in the southern part of the settled areas in the EBA (Esse 1982, Miroschedji 1988, Maeir 2012). The results from the previous chapter highlight the range of variation in ceramic forms from KHI that resembles an assemblage from the settled areas, where dry farming was possible. A preliminary study of the pottery from KHI was published by Adams (2000) and provides the preliminary framework to examine ceramic correlations between KHI and other sites. This analysis highlights the fact that much of the material from KHI clearly fits within a sphere of interaction that includes the Negev Highlands. The publication of Bab edh-Dhra has also suggested close correlates to the assemblage at KHI in their Stratum II (Rast and Schaub 2003, Figs. 11.7:3, 8; 11.8:1, 5; 11.9:6, 9; 11.10:10; 11.11:14; 11.1, 2, 3, 4, 11; 11.12:6, 8, 10, 14). Those correlates are broadly seen in the style of large storage jars, bowls, and platter-bowls, especially the red-slipped and burnished ware that is emblematic of the period (See Figures 6.2 and 6.6). The evidence for connections between Bab edh-Dhra and KHI is part of growing evidence for a local ceramic tradition in southern part of Israel in the later part of the EBA (de Miroschedji 2000, pg. 339). Further evidence for continuity comes from D'Andrea (2012) who has reevaluated the ceramic assemblages from sites primarily around the Dead Sea and draws many parallels from KHI and the Negev Highlands. She used the combination of radiocarbon dates and the traditional, low chronology to place the Negev Highlands sites within an earlier chronological framework that includes the late EBIII phases from Khirbat al-Batrawy (D'Andrea 2012, Pg. 36-41). This analysis reaffirms the work of Adams (2000) utilizing formal comparisons and Goren (1996) using petrographic analysis to note connections between ceramics from the Negev Highlands, Faynan and the Dead Sea region. In order to extend the continuity of interaction between those three regions back to the EBII it is

necessary to integrate the archaeointensity data presented above from Ashalim and to use ceramics to highlight the Arad connection to KHI and other sites in the Faynan region.

In order to argue for a connection between Ashalim and Arad as part of a connected EBII industrial landscape it is necessary to validate a connection between KHI and Arad. The synthesis of the archaeointensity and radiocarbon data has only presented a hypothetical connection between Arad and KHI based on the expectation that Ashalim was an outpost related to Arad's involvement in the copper trade (See Chapter 7.1 and 7.2). The radiocarbon data indicates that KHI was first occupied during the main occupation of Arad (See Figure 7.6). The contemporaneity of metal production activity at Ashalim and KHI is based on matching archaeointensities measured in slags at each site (Chapter 7.1). However, the slag from KHI does not come from secure contexts that are from Stratum IV of the site. The fact that the slag is from EBA fill allows for the assumption that based on the intensity values the slag was produced at the same time as other EBA slags, those from Ashalim, with a matching intensity value. To make the connection between Ashalim, KHI and Arad however requires direct evidence of interaction via ceramic correlates. Besides the vessels that make up the typical wares associated with the EBIII and IV there are a few very *fossil directeurs* in the EBA in general and even fewer in the southern part of the southern Levant (c.f. Philip and Baird 2000, Pgs. 14 - 22). In order to validate the ceramic associations between Arad and KHI, and the Faynan region in general it is necessary to use a variety highly unique ceramic types from both the Faynan area and Arad to show cultural interaction.

Ledgehandles are one of the key ceramic types that has long been used to identify chronological shifts in the EBA. One of the first accessible and modern seriations of ledgehandle varieties was presented by Amiran (1969, Pg. 39). Typically, the forms are a bill of clay that is attached to the side of a vessel with the edges upturned or impressed. It is the treatment of the edges of the handle, the shape and the overall size of the bill that are

determining factors for the chronology. At the site of KHI two highly unique ledgehandle types were excavated for which limited parallels exist at other sites. What makes the two types distinct is unlike the typical ledgehandle there is a hole along the body of the vessel (see Figures 7.4 and 7.5: 2, 3, 4). The two ways that these holes were created was by punching a hole through an otherwise whole ledgehandle or forming the handle as in a strap handle, attaching on both ends, but maintaining the ledge form and the typical impressions along the outside edge of the handle. The punched whole variety tends to be closer to the body of the vessel and was found below the floor of the Stratum III deposit in Area Y in Room 80 (See Figure 7.5: 2). The wrapped version sticks out further from the vessel and was found in locus designated to Stratum III in Area H in Room 27 (See Figure 7.4). That Locus (1075) was designated fill, but with no excavation below and a total of ~30 cm excavated there is a strong possibility that some of the material in this locus is in fact from Stratum IV. The stratigraphic details that tie these ledgehandles to the earliest occupations found within KHI indicate their importance for confirming connections to other sites that date to the EBII.



Figure 7.4: Photograph of ledgehandle formed to make a hole along the body. Photograph Aaron Gidding, UC San Diego Levantine and Cyber-Archaeology Lab.

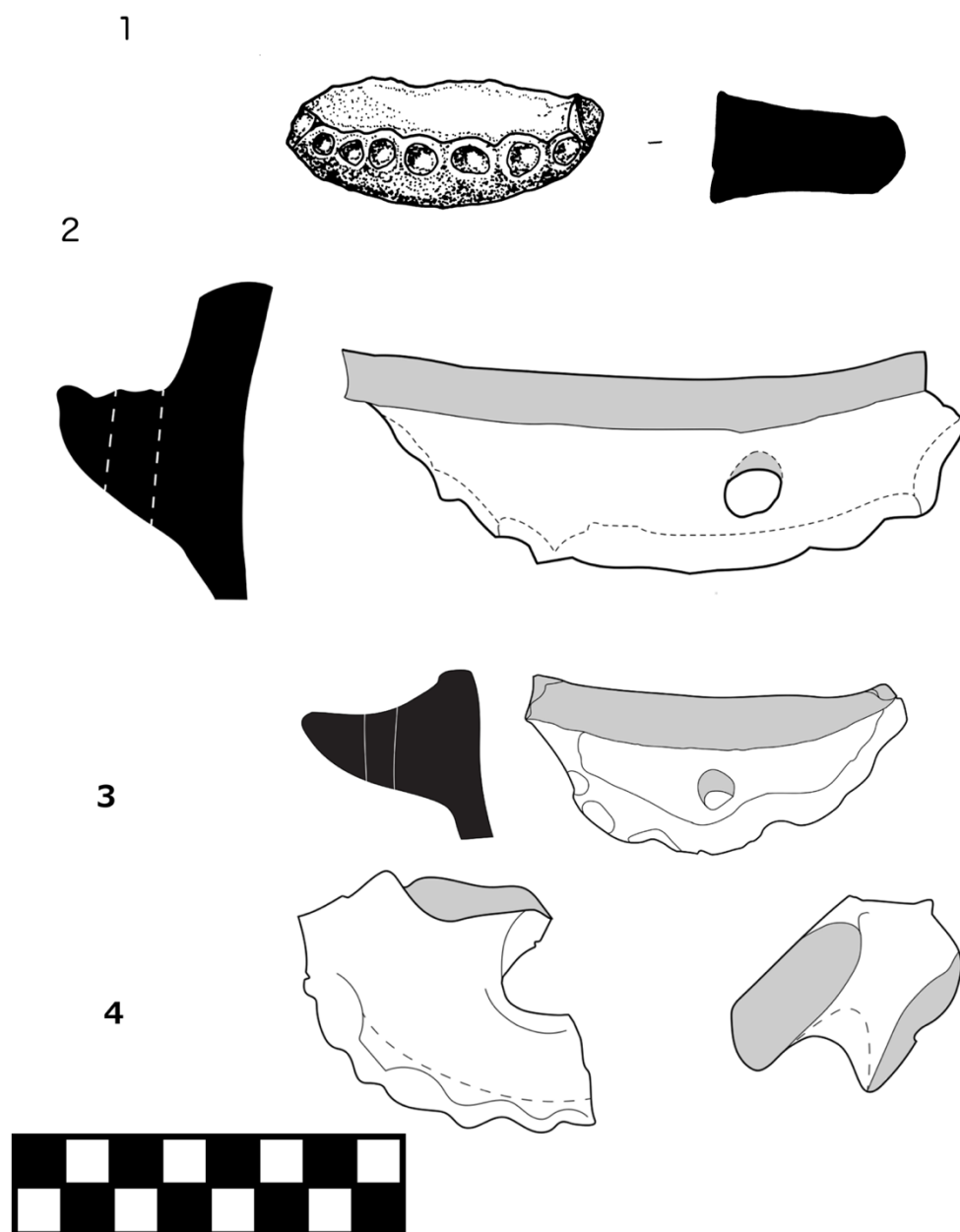


Figure 7.5: Plate of Ledgehandles drawn by Caroline Hebron and Kathleen Huggins, UC San Diego Levantine and Cyber-Archaeology Lab.

To date, within the Faynan region there are only two sites that have been excavated and yielded EBII remains: Barqa el-Hetiye (Fritz 1994, Adams 2003) and Khirbet Faynan (Levy et al. 2012). Barqa el-Hetiye is well known through publications of excavations that took place in the 1990s that highlighted the sites connection to Arad and yielded radiocarbon samples that clearly indicated an EBII date (Fritz 1994, Hauptmann 2007, Adams 2003). Among the published pottery from that site a ledgehandle of what looks to be the wrapped type was found (Fritz 1994, Fig. 4:7). Khirbet Faynan was excavated by Thomas E. Levy and Mohammed Najjar and supervised by the author. Within Khirbet Faynan Area 16 Square 57 yielded 5 EBA rooms and a radiocarbon date of 3055 ± 114 cal BCE (AA99133 - Sample 8661, See Figure 7.6), the date places the excavated context within the EBII using the revised chronology of Regev (2012). During that excavation both types of ledgehandles with holes were identified (Figure 7.5: 3,4). Based on this evidence it seems highly likely that the three sites of KHI, Barqa el-Hetiye and Khirbet Faynan were occupied simultaneously.

The only other site in the region with the ledgehandles with holes that has been published is the site of Arad. The ledgehandles there are of the punched whole variety and were found within Arad Stratum III (Amiran 1978, Pl. 16: 23-24). The radiocarbon dates from Arad that have been revised based on the phasing discussed in Chapter 4.3.3 highlights dating in line with KHI, Khirbet Faynan and Barqa el-Hetiye, in the last century of the fourth millennium and into the third millennium BCE (See Figure 7.6). Arad was used as a primary reference for the ceramic assemblage and architecture in the initial publications of Barqa el-Hetiye (Fritz 1994, Adams 2003). The ledgehandle example presents growing evidence that Arad interacted and shared at pottery styles with sites more sites in Faynan to form an interaction zone that was limited to the desert areas in the Negev, Faynan and Sinai. The addition of KHI and Khirbet Faynan to this interaction zone is an important addition to the existing model for the industrial landscape of the EBII.

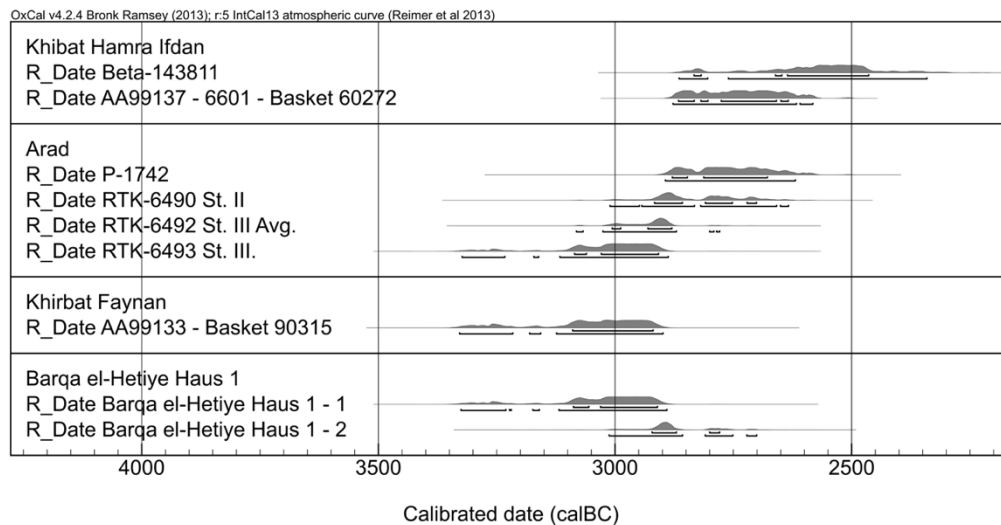


Figure 7.6: Comparison of EBII and Early EBIII dates from Arad (Regev 2013, Pg. 208), Barqa El-Hetiye (Fritz 1994, Pg 132), KHI and Khirbet Faynan.

Further evidence of the connection between Arad and KHI comes from painted pottery at both sites. Painted pottery is rare in EBA contexts, and the most typical designs include a series of lines and sometimes other features, the most common “wares” identified as Abydos and trickle-painted (e.g. Amiran 1978, Pgs. 51-52, D'Andrea 2008). Abydos ware has traditionally been an important chronological indicator and substantiates interaction between Egypt and the southern Levant as it has been found in Egyptian contexts that include other Levantine forms (Knoblauch 2010). However, those wares do not match the style of the painted sherds found at KHI. At KHI the sherds were burnished and then the design was applied with red slip into a number of different linear patterns that do not resemble Abydos ware (See Figure 7.7). The thickness and style of the lines is similar across all of the painted sherds at KHI, on larger sherds a more complex design appears that looks something more like a palm. Moreover, the largest cache of painted sherds at the site were described in the site report for Area H as being found below the foundations of the Stratum III walls in Locus 1052 in Room 48, again indicating that they date to a period at the start of the site. Other sherds

were in Area C Locus 1519 and Area Q Locus 338, both basal layers, in addition to the surface fill of Area H Locus 1003. To the knowledge of the author, the only site that has similar sherds in both design and method of painting is Arad (Amiran 1978, Pl. 9:9, 10, Pl. 10:7).

Unfortunately, the sherds that connect the two sites are fragmentary and do not clearly indicate the form of the vessels. Nevertheless, the highly unique production process of burnishing below the red slip paint seems indicate a correlation between these examples of painted sherds from KHI and Arad.

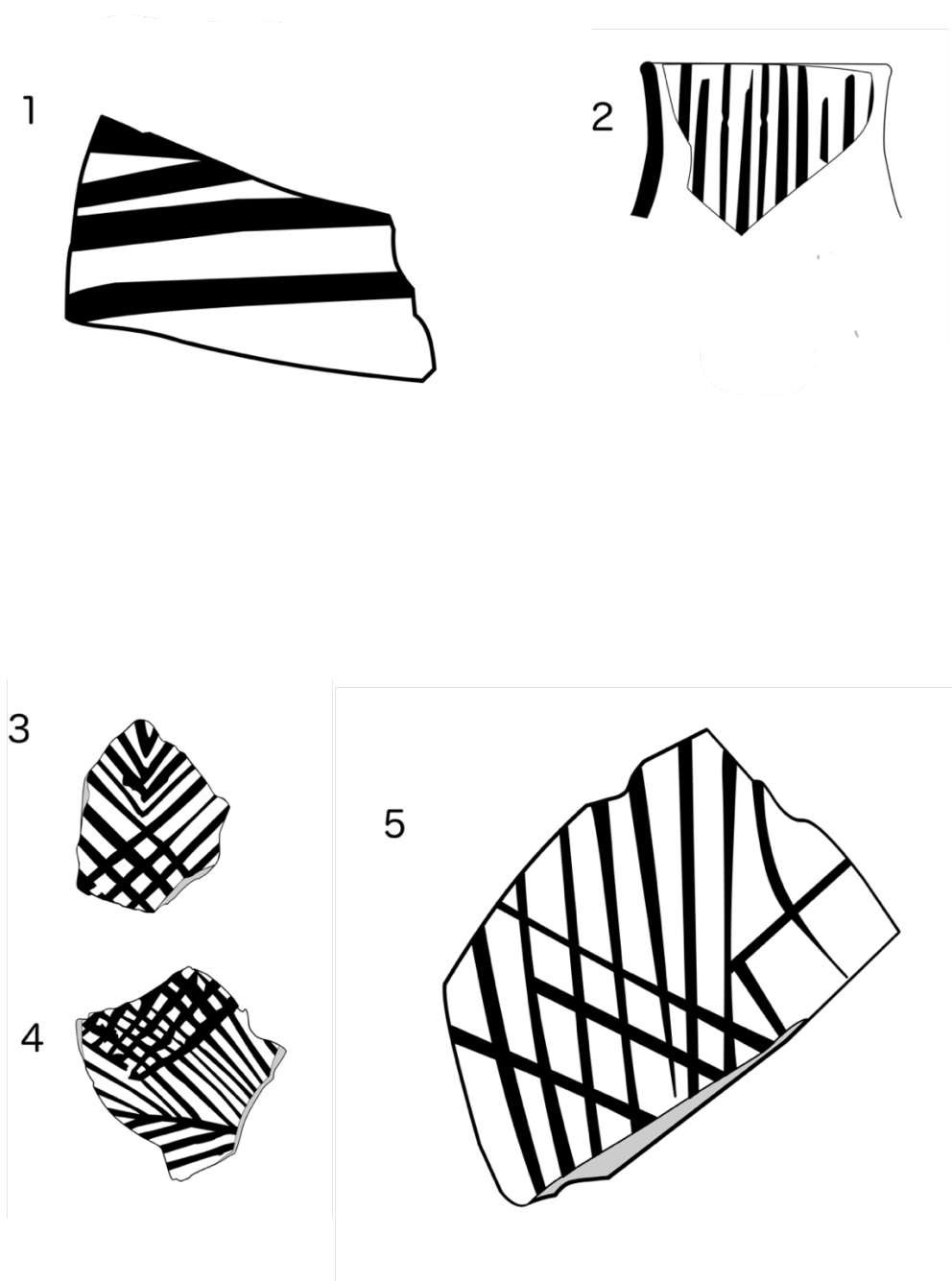


Figure 7.7: Examples of Painted Sherds from KHI. Not to Scale. Drawn by Kathleen Huggins.

Finally, the lamp is one of the most important forms for the identification of both continuity and connection between KHI and Arad. Lamps are unusually common at KHI,

which might indicate that a lot of activity at the site took place. The predominant form of lamp from KHI are shallow bowls with slip and burnish on the interior and the exterior. Some examples have envelopes or impressions on the rim (See Figure 6.1: 3-5, Figure 7.8, Adams 2000, Fig. 21.6:5,6). In his initial outline for the development of EBIV ceramic forms Dever (1973, Pgs. 48-50) used this four enveloped shallow-bowl lamp, also seen in the EBIII at Bab edh-Dhra Stratum II (Rast and Schaub 2003, Pl. 64: 4-6, 67:3) and 'Ein Ziq (Cohen 1999, Pl. 155:5), to fully formed four-spouted lamps at Jebel Qa'Aqir (Dever 1973, Fig.4:8).²⁰

Unslipped versions have been noted at the EBII-III site Tell el-Handaquq in the Jordan valley (Chesson 1997, Pl. A12:3.41, 3.413). EBII antecedents of this form have also been at Bab edh-Dhra Stratum III (Rast and Schaub 2003, Pg. 240 Fig. 9.3: 19, 20 Pls. 31:26, 36 and 33:16). At the site of Arad one of the predominant lamp forms was a shallow bowl with a rounded base that in early strata was plain and by the end of occupation included envelopes on four sides (Amiran 1978, Str. III Pl 13:1-19, 24, Str. II Pl 22:1-49, Str. I Pl 52:1-9). In sum, for the southern part of the southern Levant the shallow bowl lamp has long been assumed to be a part of a long tradition and evolution of the form can be used as an important chronological marker (D'Andrea 2012). The continuity of the slipped and burnished shallow lamp bowl at Arad and the important correlates from KHI and Bab edh-Dhra underline the sphere of interaction that included Faynan, the Negev and the Dead Sea Basin starting in the EBII and continued through the EBIV.

²⁰ Lamps from tombs assigned to the EBIV in instances include both the four cornered spouts that were associated with the later EBIV and one example of the simpler shallow bowl with slight pinching or envelopes along the rim. This is just one example where the different forms mix in contexts that otherwise would normally be assigned to a single event (Wightman 1988).



Figure 7.8: Photograph of Lamp with clearly burned rim and a very slight impressions along the rim. Photograph Aaron Gidding, UC San Diego Levantine and Cyber-Archaeology Lab.

The ceramic data from KHI reveals some important evidence of interaction that helps to substantiate the model presented in the previous section of different phases for the industrial landscape. That model of interaction was detected in the work of Goren (1996) that used petrography to highlight the interconnectedness of the Negev Highlands “mega-sites” to neighboring regions (Discussed in Chapter 4.5.1). However, the associations that were detected and their applicability to a model that incorporated wider socio-political factors was hindered by an incorrect chronological framework. Using archaeointensity and radiocarbon data a framework was presented in the previous two sections that revised periods of contemporaneity between sites in the Negev and Faynan. One of the most important contributions of this analysis was to show that the fall of Arad was during the EBIII. It can now be shown that during the main occupation of Arad, in Stratum II, there is also a

contemporary settlement cluster in Faynan at the sites: Barqa el-Hetiye, Khirbet Faynan and KHI. This forms the first phase of the EBA industrial landscape in relation to KHI (See Table 7.2). The scant evidence from KHI indicates occupation but the scale of production does not compare to the main occupation in Stratum III. In the following phase, during the occupation of KHI Stratum III, both Arad and Barqa el-Hetiye are not occupied as evident from the radiocarbon data, but the “mega-sites” of the Negev Highlands begin to develop with the ceramic evidence reinforcing the radiocarbon data for contemporaneous settlement. Finally, in Stratum II KHI is still operating, but at lesser capacity while the Negev Highlands “mega-sites” continue to be occupied and used. The intensity of copper production at KHI and the changing industrial landscapes from phase to phase can be best understood in the context of changes regional political organization throughout the Third Millennium BCE.

7.4. Discussion: Copper Production Through the Third Millennium

The shifts in the industrial landscape over the course of the Third Millennium BCE was a response to changes in demand. One of the most important sites to understand those changes in demand is KHI, which at its height was an important specialized workshop for the production of raw copper to be consumed in the southern Levant and neighboring areas (Levy et al. 2002). The greatest challenge to understand the operations at KHI within the context of the EBA been the uniqueness of the site as a highly specialized copper production facility isolated in a hyper-arid area. If we recall the model of Philip (1988, Pg. 191), there is no evidence for a hierarchical, complex polity in the southern Levant, that is a precondition of intense copper production as an attached specialization, therefore KHI should not exist. However, the copper production system of Faynan in the EBA is the first time in the southern Levant that copper production exceeds 300 tons (Hauptmann 2007, Table 5.3). The chronological implications of the archaeointensity, radiocarbon and ceramic data from sites

involved in the Third Millennium industrial landscape help to outline different phases of how copper production responded to exogenous influence (See Figure 7.9).

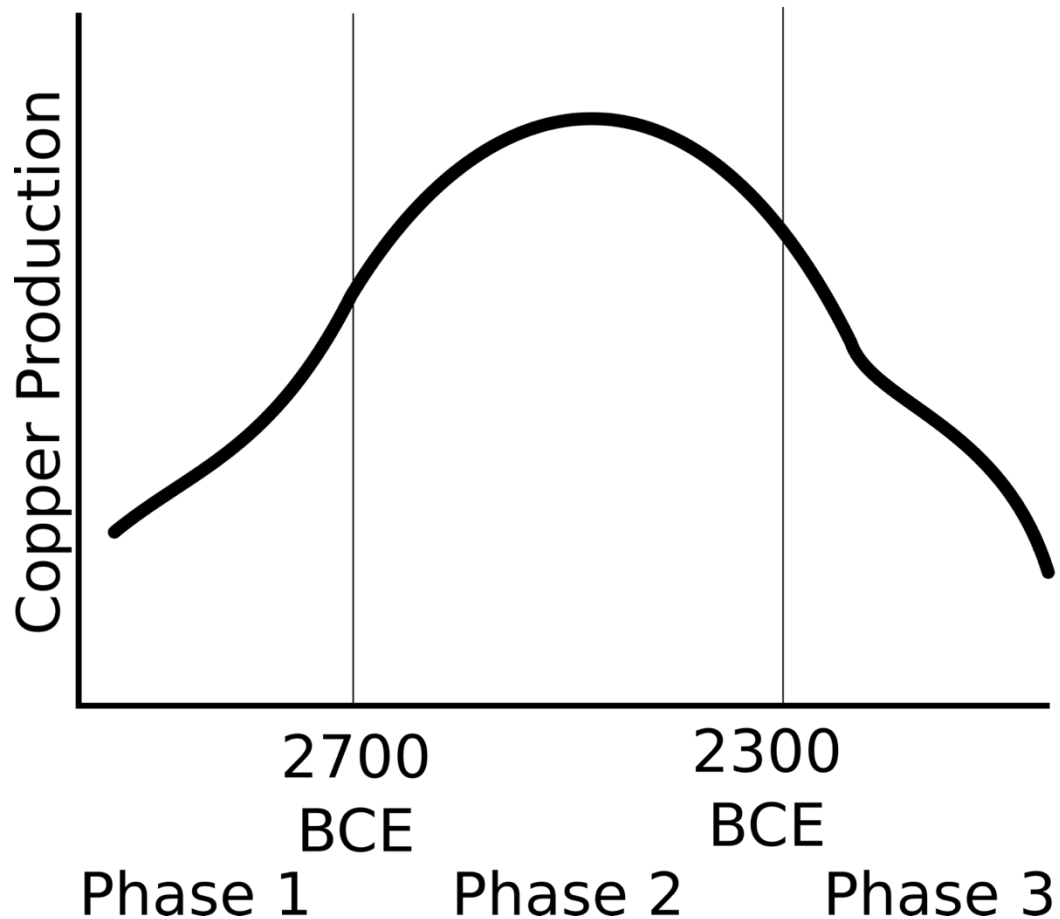


Figure 7.9: Phases of production according to expected total copper output from Faynan region.

The EBA industrial landscape of copper was based in the arid zone of the southern Levant, which necessitated external demand for copper as the underlying cause for any intensification of production. It is the changes in the political economy of the primary consumers of Faynan copper that will help understand the phases of the industrial landscape in the area around Faynan. That context can help explain the important paradox that still needs to

be explained for the site of KHI, materially it resembles both a pastoralist's site and a horticulturalist's site (Discussed in Chapter 6). Within the traditional models for the EBA these two elements are distinct, the assumption coming from the expectation that pastoralism already represents a form of specialized production that would preclude intense metallurgy, which should be supported directly by a central authority (See discussion in Chapter 2.1-2.6). Ultimately, it is the characterization of the demand for copper in the region around the southern Levant that provides the reference point to contextualize the changes in the Faynan industrial landscape.

How copper was consumed by the large states of the Third Millennium plays an important role in validating the means of exchange through the industrial landscape. The records from the large states of the end of the Third Millennium are informative regarding the methods of copper procurement. The written records not just of Egypt but also Mesopotamia support the necessity of importing copper from specialist producers outside of the direct control of local elites. In Sargonic/Ur III Mesopotamia Foster (1977, Pg. 38) identifies based on textual sources that while the state was responsible for the acquisition of copper for the city it used outside agents to manage the acquisition from entities beyond state control. During the same time period the Egyptian state was involved in copper procurement using similar mechanisms as seen in the Mesopotamian example. Once copper entered the Egyptian elites were responsible for verifying weights and measures of the material before further distribution for use by lesser elites (Eyre 1987, Pg. 13). Once in Egypt the copper tools would have been an important part of a patron-client relationship as the tools enabled public works that were an important part of the Egyptian cosmography (Odler and Dulíková 2015). No where is this better illustrated than in the tomb reliefs that illustrate the use of the same kinds of copper tools found in the tombs to act out important parts of daily life that would be important for an elite in the afterlife (See Figure 7.10). In the case of these tomb reliefs, it is assumed that the

depictions are of the expected function of laborers for the elite in death as in life using the same tools that were interred with the elite. Based on formal comparisons those tools have been correlated to axe/adze heads excavated at KHI (See Figure 7.11, Bárta 2006, Pg 62). These adzes are known from Egyptian contexts starting in the EBA, but proliferate in tomb contexts significantly in the Fourth, Fifth and Sixth Dynasties (Odler 2015, Table 3). Circumstantial evidence from Egyptian texts referring to “Asiatic Copper” as important for funerary cult activities and evidence of Egyptian goods indicates that copper for this purpose was imported, Faynan being a potential source of especially valued copper (Sowada 2009, Pgs. 138 - 9). The copper that was used to produce the ingots at KHI was of exceptionally high quality due to its purity after the refining process of secondary smelting (Hauptmann 2007, Pg. 242). Unfortunately, the only compositional analysis of Old Kingdom copper was done with X-ray fluorescence and cannot verify the source, however the data from Old Kingdom material used in funerary contexts was noted for being purer copper relative to other objects tested (Cowell 1986, Pg. 467). This compares well with the copper produced in Faynan, which was very pure (Hauptmann et al. 2015, Pg. 20). Anecdotally, the data from Egypt supports the assertion that independent producers were responsible for supplying copper. The height of demand in Egypt for imported copper was in the Fourth through Sixth Dynasties (See Table 3.1). Based on the circumstantial references Faynan is a viable candidate for the copper source. The written sources refer to “Asiatic” copper as a higher value commodity and it is noted that the copper that was produced at KHI may have fit the needs of the developing bureaucratic elite in Egypt (Bárta 2006, 2010). The demand for copper from Egypt can be taken in conjunction with local demand for copper within the southern Levant to explain the shifts in the industrial landscape over the course of the Third Millennium.



Figure 7.10: Relief carving from the Tomb of Ty with figures using hafted adzes for ship building, the adzes are similar to those found at KHI (Wild 1953, Pl. LXV).



Figure 7.11: Photograph of axe/adze head from KHI. Photograph Aaron Gidding, UC San Diego Levantine and Cyber-Archaeology Lab.

The first phase of production noted in the data is noted by a dispersed copper production network that correlates to Stratum IV at KHI. In this phase three sites were occupied in the area of Faynan: KHI (Stratum IV), Barqa el-Hetiye and Khirbet Faynan. Based on ceramic correlations those three sites interacted with Arad, which is thought to have been a trade emporium connecting the settled north with the rural south (Kempinski 1989). Copper has long been considered the most important good that moved through Arad and the source of the copper was the Faynan area (Hauptmann, Begemann, and Schmitt-Strecker 1999). Of the three sites in Faynan identified to be contemporaries of Arad only Barqa el-Hetiye has evidence of copper smelting in the immediate vicinity (Fritz 1994, Adams 2003). Ceramic evidence also connects these sites to the copper producing region of southern Sinai, but the evidence of copper production there is limited compared to the data from Faynan (Amiran, Beit-Arieh, and Glass 1973, Beit-Arieh 1983, 2003, Pgs. 196-207). As the largest settlement involved in this trade network, Arad seems to be an important hub that used its influence to protect trade routes from the copper bearing regions to the settled areas in the

north (Yekutieli 2006a, 2006b). Using the archaeointensity data it is assumed that Ashalim was one part of the trade network that Arad regulated. The archaeointensity data also implicates KHI as one site that was involved in production, but in this first phase KHI is relatively small and there is no evidence for intense smelting activity. The evidence for this phase points to a dispersed industrial landscape with a number of production centers that are roughly contemporary, none close to the mines (See Figure 7.12). During this phase Egyptian goods are still entering Arad as a part of sympathetic trade, of which copper was one part. The location of Arad in the Negev, between the desert and the settled areas, suggests that during the first phase of the EBA industrial landscape trade moved primarily in the direction of the north.

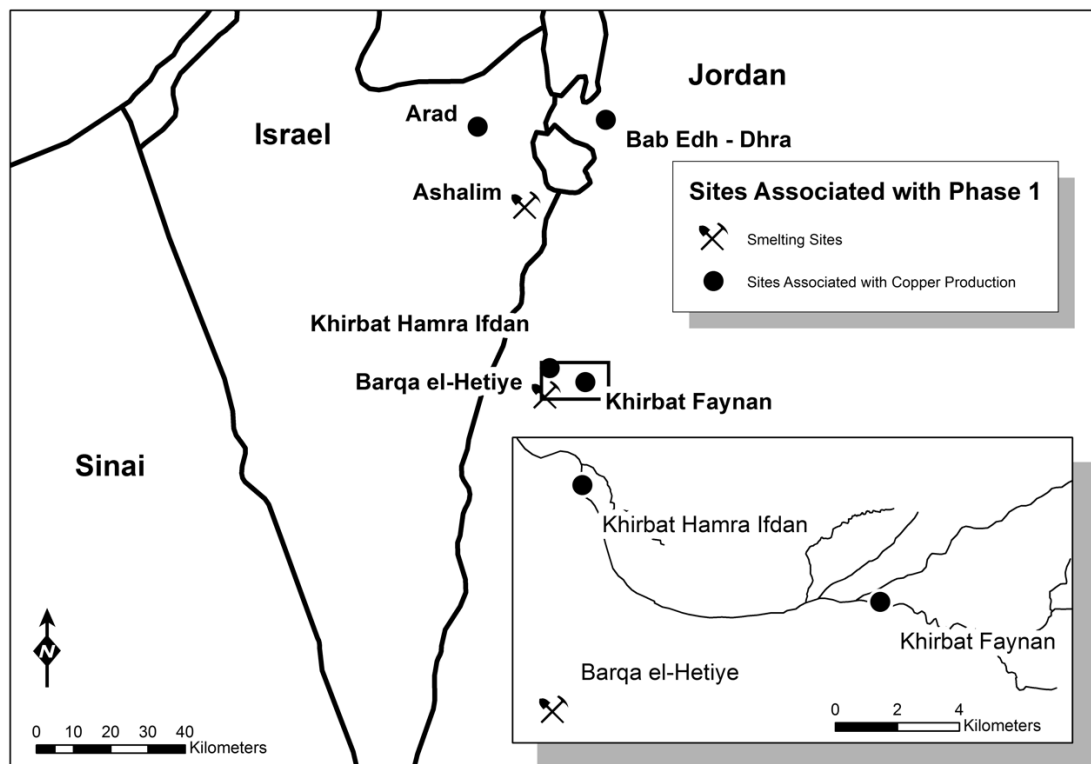


Figure 7.12: Map of sites in Phase I

The second phase is noted by the consolidation of settlement in the Faynan region. Of the three Faynan sites occupied in Phase One only KHI remains and at this time KHI enters its florescence, Stratum III. The florescence of KHI marks an important change in the industrial landscape by becoming the first intense copper casting facility in the southern Levant. This is one piece of a new, clear division of labor; split between different sites with a linear order of operations similar to what was proposed by Yekutieli and colleagues (2005). Near the mines the smelting sites Fenan 9, Fenan 15 and Fenan 16 appear producing only copper and no other material culture. The raw copper was transported to KHI for casting into the form of ingots, axe/adze heads, and pins for long distance trade. The production of standardized forms of ingot is especially symbolic of the intent for long distance trade, absent in earlier periods. The unique form would have been an important tool to communicate the origin of the copper and is indicative of relationships with foreign elites, even if it is indirect (See Chapter 4.5.2). The conduit for the trade during this phase would have been the Negev Highlands, and it is in this period that the occupation of the “mega-sites” begins. Based on radiocarbon, this occupation matches the start of the Old Kingdom in Egypt (See Chapter 4.3.2). As highlighted above, it is during the Old Kingdom that more copper is imported into Egypt to meet the demands of the growing elite class. The fact that Arad disappears and the development of sites like Beer Resisim and ‘Ein Ziq in the Negev Highlands highlights a reorientation of the course of trade, now primarily directed towards Egypt (see Figure 7.13). The absence of significant Egyptian finds at KHI suggests that the trade in copper was indirect. I would suggest that the occupants of the Negev highlands sites were the primary merchants for the copper while the occupants of KHI remained in the Faynan area. This is in part supported by the differences in the petrography of ceramics from Negev sites, which show high levels of interaction and sources, compared to KHI, where the majority of ceramics were from sources nearby (See Chapter 4.5.1). The occupants of KHI specialized in copper production due to the high demand for the

material that in turn allowed for the full-time occupation of an otherwise impossible site for year-round occupation.

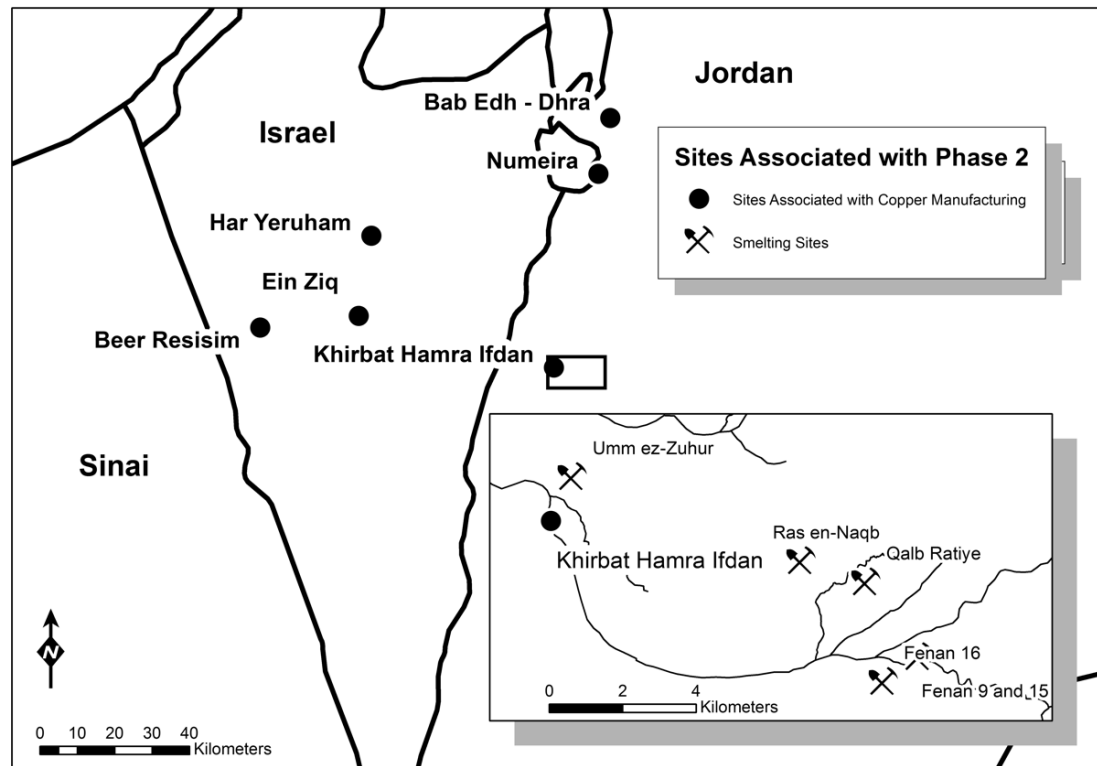


Figure 7.13: Map of sites in Phase II

The dissolution of the demand for copper in the southern Levant and neighboring areas is reflected in the industrial landscape of the third phase, associated with Stratum II at KHI. The start of this phase is associated with three events that independently or in combination might have introduced instability that altered the industrial landscape. First, the 4.2 kBP desiccation event, while perhaps not as extreme as once assumed, was a significant environmental shift that would have made Faynan a much harder place to live (See Chapter 4.4). Second, the Old Kingdom in Egypt dissolves into the First Intermediate Period which led to a restructuring of the previous social order (García 2014, Pg. 24). Finally, at KHI the excavations revealed what appeared to be an earthquake that sealed the Stratum III occupation in a “Pompeii effect” (See Chapter 4.1). Each of these factors working independently or

together would have affected demand or supply of copper in relation to KHI. D'Andrea (2012, Pg. 44) has used changes in ceramic production techniques to indicate there is evidence for a break in occupation in the Negev and Faynan around 2300 BCE that matches the transition between Phase 2 and Phase 3. Nevertheless, copper production continues in the Third Phase and copper consumption is most commonly found as funerary goods at a number of sites across the southern Levant (Dever and Tadmor 1976, Philip 1988, Dever 2014). Primary smelting at sites like 'Ein Yahav and Giv'at Hazeva, east of KHI, continues away from the mines (See Figure 7.14). Other areas for copper smelting appear such as Timna 149. No longer was KHI a funneling point for copper material moving east to west. The combination of the significant decrease in activity at KHI, archaeointensity data that matches the Arava sites and the presence of the same wares as in the Negev Highlands indicates that the last occupation at KHI was a part of a disintegrated system of production that still served to supply copper to the surrounding region at a lower level of intensity. No longer is there a site like KHI or Arad through which the copper trade is directed. The sudden appearance of copper hordes associated with burials and copper bronzes found in such contexts is often indicative of other social changes occurring across the region (Phillip, Clogg, and Dungworth 2003, Kaufman 2013). The addition of bronze metals is reflective of new sources of metals that become more important in the subsequent Middle Bronze Age.

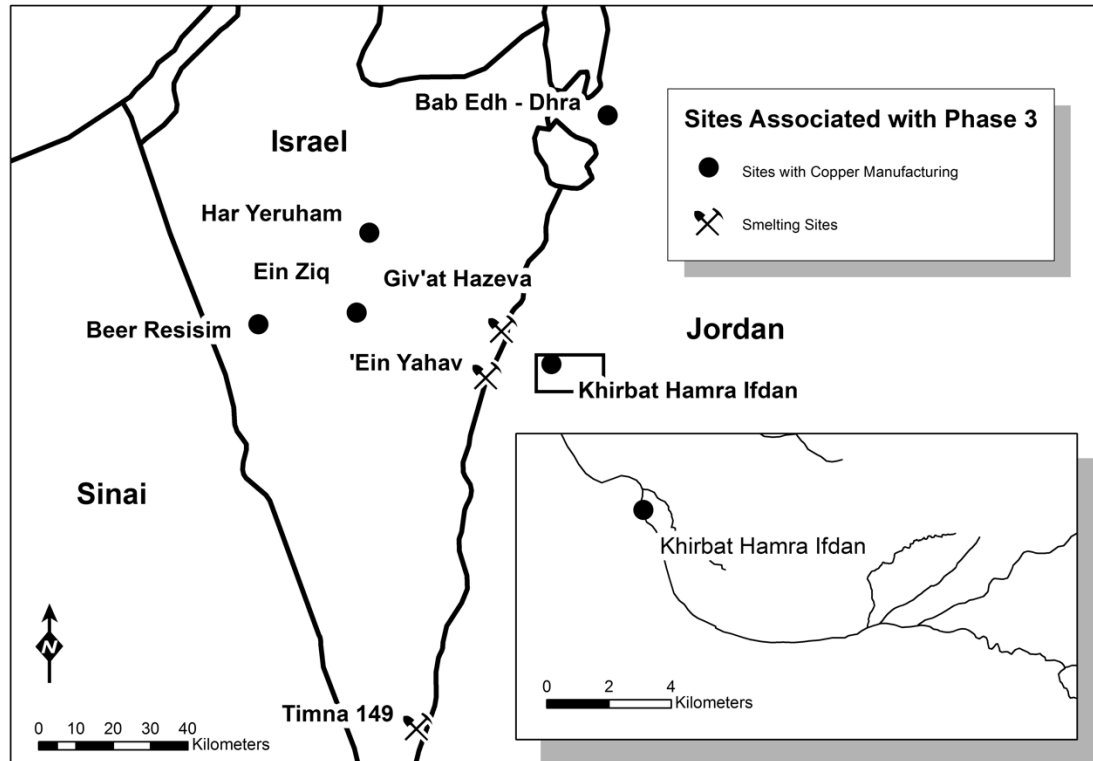


Figure 7.14: Map of sites in Phase III

Three phases of the EBA industrial landscape as it relates to KHI highlights changes in the integration of production of copper through the Third Millennium. While the focus of this dissertation is data that coincides with the occupation of KHI, there is evidence for a phase of production previous to Phase 1, which similarly had a relatively low level of integration and was tied to the direct involvement of Egypt as a colonizer in the areas of southwestern Canaan (Chapter 4.5.2). The key development of Phase 1 is the role of Arad as a center for trade that also helped to maintain the connections for exchange. Shifts in the nature of demand led to a reconsolidating of copper production in the Faynan area in such a way as to dramatically increase the intensity of production, as seen at Stratum III KHI. Finally, during the final phase the effects of events that are correlated to around the same time as the 4.2 kBP event leads to the dissolution of the industrial landscape. Copper is still produced, but there are no clear centers where either the trade is managed through an urban center or a production

center for the secondary smelting of copper to produce final products. In fact, the Faynan area is not an active copper production zone again until the start of the Iron Age, nearly 1000 years later (Ben-Yosef et al. 2010). The changes in the industrial landscape of the EBA directly mirror the larger shifts in the political integration of Egypt, which reflects the changing demand for the high-value commodity copper and the identity of the primary consumer.

Chapter 8: Conclusion

One of the major debates in the current literature for the EBA of the southern Levant is whether there is convincing evidence of hierarchically organized societies both within and between settlements. The advocates for hierarchically organized society typically advocate for the appearance urban structure of individual settlements (Walls, planned settlement, public buildings) as indicative of hierarchically organized societies (Nigro 2010, de Miroschedji 2014). The opposition focuses on the fact that inter-settlement variability is small and as a result no single entity maintained central control over the region (Falconer and Savage 1995, Harrison and Savage 2003, Chesson and Philip 2003). This alternative trajectory maintains that local social complexity existed, but only within local corporate groups that could periodically cooperate on larger scale projects (Chesson 2003). This dissertation contributes to the debate by providing a chronological study of archaeointensity, radiocarbon and ceramic material that established a set of expected contemporary sites for each of the three EBA strata at KHI. The location and characterization of sites associated with each stratum help to contextualize the structure of the political economy of KHI from phase to phase. Data from the primary EBA occupation of KHI, Stratum III, offers important details of the organizations of the intense, specialized production of copper. Metal production is especially important for the story of the development of complex hierarchical systems due to associated requirements to facilitate the trade of such a high value good that requires significant investment in knowledge, labor and resources to produce in large quantities (Kassianidou and Knapp 2005, Pg. 239). The data presented in this dissertation highlights a division of labor through differential organization of the processes for copper production and foodways at KHI. The data from the primary stratum can be associated with changes in the industrial landscape of the region of Faynan and the Negev to highlight changes in intensity related to expected demand.

The implications for the changes of intensity of production at the site during the Old Kingdom significantly alters the general perception of the political economy of the EBII though EBIV.

The three phases outlined for Stratum IV through Stratum II at KHI reveal the importance of the Egyptian chronology for rendering a model for activity at KHI. Each of the major phases of settlement change within the southern part of the southern Levant to match the transitions from Early Dynastic to Old Kingdom to First Intermediate Period in Egypt (See Table 7.2). With the revision of the EBA chronology for the northern part of the southern Levant, the necessity for a related but distinct desert chronological system becomes more apparent for the south (Rosen 2011, Regev et al. 2012). The phases in the chronology of copper production in Faynan, seen through the lens of KHI, highlights the need to incorporate structural economic demands local to the copper producing region. The degree to which KHI illustrates a highly specialized production center during Stratum III also indicates a large or “thick” market to absorb the copper (Grantham 1999, Pg. 217). Otherwise the occupants of KHI would have required a broader, less specialized subsistence strategy. The reconfiguration of the Levantine chronology ignores shifts in social power in Egypt that could be used to model the expected changes in demand. As a result, based on the revision the cultural associations of the EBA do not match the dynamics of KHI and the surrounding region.

The continuity of settlement provides an important justification for the use of the Timnian designation as a part of a broader local chronological sequence for sites related to copper production during the Third Millennium. The ceramic evidence in Chapter 7.3 highlights continuity in relation to the settlement of Arad, and also with local elements unique to the southern deserts. That includes close relationships with sites in southern Sinai and the Negev Highlands, such as 'Ein Ziq and Be'er Resisim, as seen in the petrographic evidence (See Chapter 4.5.1). The continuity observed in the Faynan area and other parts of the Negev based on radiocarbon evidence suggests that there were no significant breaks in occupation, as

had been previously suggested (See Chapter 2.1-2.5, Avner and Carmi 2001). The terminal part of the Timnian occupation, incorporating the sub-phases as defined here, would match oscillations in structure of the Egyptian state that influenced the development of an autochthonous copper production system for which the structure is dependent on its primary consumer base (Rothenberg and Glass 1992, Rosen 2008). EBA specialized copper production was a phenomena developed by local inhabitants. The shifts in the structure of the industrial landscape was a local reaction to external stimuli, supported by the lack of evidence for significant changes in the material culture or outside control of production.

The location of KHI in the arid periphery necessitated the exploitation of pastoral products as an important part of subsistence. Settlements outside of the “zone of uncertainty” are expected to have not been permanent. Instead pastoralists moved in search of better pasture through the year. In the northern Levant occupation within the “zone of uncertainty” is said to expand with the expansion of settlements in zones where horticulture is possible as it becomes more profitable to produce and sell secondary pastoral products (Wilkinson et al. 2014). A large market for pastoral products makes the creation of surplus by pastoralists more straightforward as a way to mediate dry years when horticulture is impossible in marginal zone without large scale irrigation works (e.g. Castel and Peltenburg 2007). KHI is similar to the example of the northern Levant, but the absence of large southern Levantine urban centers necessitated a different approach to life outside of the “Zone of Uncertainty”. At KHI surpluses must have been created through the production of copper, the value of which enabled permanent occupation. The faunal evidence and the absence of sickle blades reinforces a characterization part of the local subsistence strategy as being pastoral (See Chapter 4.2). At the same time the intensity of production, the organization of the settlement and variety of ceramic forms with distinctions according to function highlight a more permanent occupation at KHI that was reliant on other forms of subsistence. This was

reinforced by the overall quantity of storage vessels relative to other forms at the site, which allow for long term occupation (See Table 6.8). The evidence for independent village specialization at KHI matches the prediction for a unitary state where power is concentrated allowing for indirect acquisition of important commodities by the state (Mann 1986, Mann 2008). During the height of the Egyptian state, the second phase, the high demand for copper allowed for KHI to self-organize year-round specialized production of copper as a means to subsist. The existence of that system was predicated on a number of local factors that led to the initial exploitation of ores in the southern desert areas of the Levant and the means of transporting the finished product to consumers.

One of the key elements that still requires more investigation is the nature of the copper exchange system. Even though circumstantial data is necessary to indicate the consumption of Faynan copper in Egypt, the entrance of Faynan copper into the southern Levantine market in the early EBA is undeniable. The copper from Arad in the earlier part of the EBA, predates the Old Kingdom also originated in Faynan (Hauptmann, Begemann, and Schmitt-Strecker 1999). At EBIII sites in northern Jordan, Beth-Shean, Pella and Khirbet al-Batrawy, copper objects have also been chemically sourced to Faynan (Phillip, Clogg, and Dungworth 2003, Segal and Yahalom-Mack 2012, Corbett et al. 2014). Khirbet al-Batrawy is especially important as the major copper finds included finished adze heads, similar in form to the adze heads from Egypt, in addition to other small finds that highlight evidence for long distance contacts in Egypt and Arabia (Nigro 2010). The evidence from these sites points to the fact that the Negev region was a transit zone for copper from Faynan to other locales throughout the EBA. However, the absence of significant quantities of imports to KHI highlights both that exchange might not have been direct and that exchange might have been predominantly in non-durable goods, invisible to the archaeological record.

The shifts in patterns of the industrial landscape from phase to phase indicates important shifts in the local control of copper production that reflect not just changes in demand, but also the means of controlling the copper trade. The locations of known smelting installations in Phases 1 and 3 was disperse, generally further away from the Faynan mines and there is no known major secondary smelting site. The production of copper in these phases was less intense compared to the more compact copper production system observed in the Second Phase. The key difference between Phases 1 and 3 is that in Phase 1 there is more diverse evidence of settlement in the area of Faynan. All three sites in the Faynan region show relationships with Arad through the ceramic record, but there is no single entity through which production was managed.

The industrial landscape of Faynan and the surrounding areas was a complex adaptive system where regional scale patterns emerge based on trends on the local and interregional level. In Phase 1, Arad, as the predominant site, appears to exert control through the maintenance of important trade routes that link the Negev areas to the settled areas (Yekutieli 2006a, 2006b, 2009). The role of desert people in this trade is underpinned by the site of Ashalim, which offers evidence of ritual practice associated with copper production and trade (Avner 2002). Ritual being an important factor in how cooperative economies can be established for the purpose of long distance exchange (Stanish 2013). However, during the Old Kingdom in Egypt the demand for copper increases, but on routes that bypass Arad along with the trade in other goods (Sowada 2009, Pgs. 245-248). KHI becomes a new center for the copper trade, but there the focus is not on trade regulation, but control of production. KHI began as a site involved in the copper trade while Arad had been in control, but increased demand also meant that the process of production intensified. KHI, the production of copper appears to have been controlled so that a division of labor existed in order to produce a finished pure copper object before the copper leaves the Faynan area. The ceramic

assemblages of Negev Highland sites that were involved in the copper trade highlight a broad interaction sphere with a variety of trading partners. The evidence does not support that the occupations of KHI were involved in the regulation of trade routes. Instead instead they produced goods with a newly devised, standard ingot shape that indicated the origin of the commodity. The ingot was highly significant as a signaling devise; it allowed for a guarantee of purity without direct contact. The guarantee and its small size facilitated intermediaries that could trade the ingots and potentially take advantage of the insulation between producer and consumer to increase prices (Stager 2001). The ingot in this model is indicative of the inhabitants of KHI working as would be expected under the Law of Competitive Advantage and mediating the Fundamental Problem of Exchange over long distances with the ingot as a communication device (See Chapter 2.7). If this is the case, it would suggest that the occupants of sites in the Negev Highlands and northern Negev facilitated the trade and the occupants of KHI were not directly involved. After Stratum III at KHI, the division of operations collapsed to an opportunistic production sequence that couldn't support the permanence of occupation at KHI. After the end of Phase 2 the mechanisms of demand for copper changed in such a way that it was impossible to maintain a surplus to mediate dry years. Only limited copper production continued in an industrial landscape that lacks evidence for any locus of control for intensive production or exchange.

A few important factors make this model distinct from many of the previous models for the EBA copper production system (See Chapter 3). Many of the previous models were challenged by chronological frameworks that constrained interpretation making it difficult to match the the material record with the socio-economic organization of the period. The general revision of the southern Levantine chronology highlights the fact that many of the previous assumptions of interconnectivity were incorrect. Recognizing the problems in the existing data, shifts in the industrial landscape were used to match changes in the inter-regional

demand for commodities. This required a total revision of many of the conventionally accepted relationships between sites. Through a combination of the ceramic and radiocarbon record it is possible to apply a reconfiguration that will require more research to validate in the future (Chapters 7.2 and 7.3). Local to the area of production, the fact that radiocarbon dates from the most important elements of the copper trading network match the Old Kingdom in Egypt supports the revised phasing according to expected demand (See Chapter 7.2). However, without future analysis of the Egyptian copper assemblage it is impossible to verify that association. Without Egypt, the florescence of the Faynan industrial landscape matches the start of the nadir of settlement in the rest of the southern Levant (Regev et al. 2012, Regev, de Miroschedji, and Boaretto 2012). While there is evidence of copper consumption in the EBIV, many sites with hordes lack other datable material (Philip 1988, Kaufman 2013). Some traditionally dated to the late EBIV include ingots that match KHI Stratum III and lack other datable material (Dever and Tadmor 1976). These inconsistencies stress the necessity for continued research to continue to refine our understanding of the Third Millennium copper trade.

The nature of the copper trade is very important to developing an understanding of the southern Levant during the Third Millennium. As a scarce resource that required considerable labor to control and produce, the mechanisms that were involved in copper production can illuminate more aspects of the socio-political system that existed during the EBA. In order to verify that Egypt was a primary consumer of Faynan copper it is necessary to examine more aspects of the underlying mechanics of the exchange network. Local to KHI, three artifact assemblages require more detailed consideration in the future. Firstly, I would suggest that stable isotopes are necessary to elucidate the range traveled by animals found at KHI, especially donkeys and cows. Cows are an expensive animal to feed, so it would be expected that they were not raised locally for their whole lives. Donkeys were the beasts of burden for

long distance trading and could inform greatly on the range of distance that the occupants of KHI went or from where they received their animals (e.g. Greenfield, Shai, and Maeir 2012). A second concern is the contents of the storage vessels at KHI. A lipid study of the ceramics would provide better evidence of the variety of functions especially as it varies from room to room (e.g. Charters et al. 1993, Dudd, Evershed, and Gibson 1999). Third, within KHI the lithic assemblage requires detailed study, including sourcing of the flint. This is very important to compare with the assemblages from the Negev, specially in regards to whether the source of the flint at Negev sites matches KHI (e.g. Vardi, Rosen, and Hermon 2007, Vardi et al. 2008, Vardi 2014). Certain forms of lithic in the EBA like the tabular scraper were imported from places the Eastern Desert during the EBA, so it would be useful to know the extent of the relationship between peoples that inhabited other arid areas of the southern Levant (Quintero 2002). The study of the transportation and distribution of lithic production would be complimentary to this one to highlight another specialized production system within an even more marginal environment. Finally, the site of Khirbet Faynan has only just begun to be understood. During the small excavation season there, important finds highlight settlement in the Faynan region at the start of the Third Millennium. Continued excavation at the site would illuminate more aspects of the copper production associated with Phase 1.

It is clear that for the Early Bronze Age there is still a lot to be understood regarding the overall organization of social, political and economic forces. This dissertation has highlighted how much the reevaluation of the absolute dating chronology can affect interpretation of the overarching narrative for the period. The earlier work of researchers that pushed for a vision of the EBA using a corporate village model highlighted the impermanence of settlements in the EBA southern Levant (Chesson 2003). That impermanence has only been further reinforced by the renewed radiocarbon project that has provided the new chronology for the southern Levant that highlights asynchronous ends to many of the sites that had once

been assumed to be coterminous (Lebeau 2015). In light of the new chronology, other parts of the southern Levant will require an ongoing, significant revision of the prevailing narrative for the period. It will be interesting to see what the new evidence indicates especially as it relates to the Egyptian chronology, which has otherwise been marginalized by the new data.

Furthermore, that new absolute chronology creates a massive 500-year timespan for the EBIV, the cultural period that ends the EBA, in which there is sparse evidence of long term occupation. Continued investigation are needed to continue to develop a better model for other aspects of the settlement beyond the Negev and Faynan. That investigation will, over time, refine the phases described here and introduce new contemporary strata at other sites based on long distance exchange.

The industrial landscape of the EBA highlights the importance of long distance trade for the development of different forms of socio-political organization related to copper production. The increase in the production of copper allowed for the intensification of settlement at KHI, which exhibited features of a structured production system alongside pastoral subsistence strategies. The scale precludes a purely household production level during Stratum III (Phase 2), but it is also clear that the industrial landscape is dispersed before and after Stratum III reflecting less centralized production. For residents of the semi-arid zones of the southern Levantine EBA, the evidence points to a developing network of regional producers that concentrate on a narrower productive focus with a limited set of commodities that were exchanged within the Levant and further abroad. At some point towards the end of the Early Bronze Age this system collapses, only to be replaced by the more centrally organized Middle Bronze Age urban system with city-states operating more independently.

Appendix 1: Coding for Statistical Analysis

Detailed Analysis Coding

```
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedDiag.dta", replace
egen Type = concat( general_type type)
encode Type, gen (Typeconcat)
recode Typeconcat ( 8 9 10 13 15 17 22 3 = 2) (26 7 27 = 26 ) ( 4 16 21 11 35 55 59 74 = 58) ( 5 6 23 24
25 33 34 73 = 30) (32 36 37 38 = 31) ( 41 40 43 64 65= 42) ( 45 46 54 = 44) ( 48 49 50 51 52 53 56 81
82 83 85 = 47) ( 61/63 87 88 98 = 60 ) ( 67 12 = 66 ) (72 75= 71) ( 95 57 14 39 76 = 94) (26 27 28
40/43 64 65 68 69 76 78 79 80 86 89 91/3 97 19 20 18= . )
decode Typeconcat, gen(typef)
encode typef, gen(Form)
drop Type Typeconcat typef
encode Room, gen(room)
encode RevStrat, gen (Strat)
encode name, gen(Site)
encode area, gen(Area)
recode Form (22=.)
replace rim_diameter = round(rim_diameter)
egen diamcode = cut(rim_diameter), at(1(5)100) label
egen thickcode = cut(rim_thickness), at(.01(.5)6) label
encode is_burnished , gen(burn)
encode is_burnished_inside , gen(burnint)
encode is_burnished_outside , gen(burnext)
encode is_plastic_application, gen(plasapp)
encode is_painted, gen(paint)
encode is_slipped, gen(slip)
encode is_slipped_inside, gen(slipint)
encode is_slipped_outside, gen(slipext)
gen EVE = ( rim_complete * 100)
encode typegen, gen(typesimple)
encode typevar, gen(typefeature)
encode is_incised, gen (incise)
encode rim_treatment, gen(rimtreat)
encode rim_angle, gen(rimangle)
label define Form 2 "Bowl", modify
label define Form 3 "Crucible", modify
label define Form 5 "Cooking", modify
label define Form 6 "Holemouth Jar", modify
label define Form 8 "Jug", modify
label define Form 9 "Jar", modify
label define Form 10 "Krater", modify
label define Form 21 "Vat", modify
label define Form 14 "Platter-Bowl", modify
label define Form 12 "Lamp", modify
label define Form 11 "Lid", modify
label define typefeature 1 "Basin", modify
label define typefeature 2 "Crucible", modify
label define typefeature 4 "Jug", modify
label define typefeature 5 "Krater", modify
```

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label define typefeature 6 "Lamp", modify
label define typefeature 8 "Store Jar", modify
label define typefeature 9 "Vat", modify
label define typesimple 2 "Bowl", modify
label define typesimple 3 "Holemouth Jar", modify
label define typesimple 4 "Jar", modify
label define typesimple 5 "Platter-Bowl", modify
label define thickcode 0 ".01-.50", modify
label define thickcode 1 ".51-1", modify
label define thickcode 2 "1.01-1.50", modify
label define thickcode 3 "1.51-2", modify
label define thickcode 4 "2.01-2.50", modify
label define thickcode 5 "2.51-3", modify
label define thickcode 6 "3.01-3.5", modify
label define thickcode 7 "3.51-4", modify
label define thickcode 8 "4.01-4.5", modify
label define thickcode 9 "4.51-5", modify
label define thickcode 10 "5.01-5.5", modify
label define rimtreat 6 "Grooved", modify
label define diamcode 0 "1-5", modify
label define diamcode 1 "6-10", modify
label define diamcode 3 "16-20", modify
label define diamcode 4 "21-25", modify
label define diamcode 2 "11-15", modify
label define diamcode 5 "26-30", modify
label define diamcode 6 "31-35", modify
label define diamcode 7 "36-40", modify
label define diamcode 8 "41-45", modify
label define diamcode 9 "46-50", modify
label define diamcode 10 "51-55", modify
label define diamcode 11 "56-60", modify
label define diamcode 12 "61-65", modify
label define diamcode 13 "66-70", modify
label define diamcode 14 "71-75", modify
label define diamcode 15 "76-80", modify
label define diamcode 16 "81-85", modify
label define diamcode 17 "86-90", modify
label define diamcode 18 "91-95", modify
label define diamcode 19 "96-100", modify
recode thickcode (10 11 = 9)
encode handle_type, gen(Handle)
recode Handle (2/5 = 5)
recode Form (20 1 3 4 7 11 13 15/9 22 = .), gen(Form2)
recode Form2 (9 = 8) if Handle == 5
label values Form2 Form
label define Formsimple 1 "Storage" 2 "Food Prep" 3 "Serving" 4 "Lamp"
recode Form2 ( 2 8 15 = 3) ( 5 23 = 2) ( 12 = 4) ( 10 9 6 = 1) (else = .), gen(Formsimple)
label values Formsimple Formsimple
*recode for types
recode incise (.=1) if rim_diameter >= 1 & incise != 2
recode burn (.=1) if rim_diameter >= 1 & burn != 2
recode burnint (.=1) if rim_diameter >= 1 & burnint != 2
recode burnext (.=1) if rim_diameter >= 1 & burnext != 2
recode plasapp (.=1) if rim_diameter >= 1 & plasapp != 2

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recode slip (.=1) if rim_diameter >= 1 & slip != 2
recode slipint (.=1) if rim_diameter >= 1 & slipint != 2
recode slipext (.=1) if rim_diameter >= 1 & slipext != 2
replace EVE = round(EVE)
replace rim_diameter = . if id == 41860 | id == 38936 | id == 38988 | id == 42807 | id == 42727 | id ==
27454
compress
ca room Form2 [fw = EVE] if Site == 2 & Strat == 6 & room != 66 & room != 62 & room != 3 & room
!= 4 & room != 20 & room != 35 & room != 46 & room != 50 & Form2 != 11 & Form2 != 18 & Form2
!= 1 & Form2 != 2 & Form2 != 3 & Form2 != 4 & Form2 != 7 & Form2 != 8 & Form2 != 9 & Form2
!= 10 & Form2 != 11 & Form2 != 12 & Form2 != 13 & Form2 != 14 & Form2 != 15 & Form2 != 21 &
Area == 5,
screepplot, title("CA of Holemouth Jars and Cooking Vessels by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\HJIIIscreep.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\HJIIIscreep.png", replace wid(4000)
caprojection, title("CA of Holemouth Jars and Cooking Vessels by Room in Area H for Stratum III -
EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\HJIIproject.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\HJIIproject.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\HJIII.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\HJIII.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\HJIII.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room Form2 [fw = EVE] if Site == 2 & Strat == 6 & room != 66 & room != 62 & room != 3 & room
!= 4 & room != 20 & room != 35 & room != 46 & room != 50 & Form2 != 11 & Form2 != 18 & Form2
!= 1 & Form2 != 2 & Form2 != 3 & Form2 != 4 & Form2 != 7 & Form2 != 8 & Form2 != 10 & Form2
!= 11 & Form2 != 12 & Form2 != 13 & Form2 != 14 & Form2 != 15 & Form2 != 21 & Area == 5,
screepplot, title("CA of Holemouth Jars and Cooking Vessels by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\HJJRIIscreep.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\HJJRIIscreep.png", replace wid(4000)
caprojection, title("CA of Holemouth Jars, Jars and Cooking Vessels by Room in Area H for Stratum III
- EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\HJJRIIproject.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\HJJRIIproject.png", replace wid(4000)
cabiplot, origin scale(.5) title("CA of Holemouth Jars, Jars and Cooking Vessels by Room in Area H for
Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\HJJRIII.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\HJJRIII.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\HJJRIII.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\HJJRIII.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\HJJRIII.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
* site is KHI Form is not BS, LD, or Spoon Strat is III and no none room
ca room Form2 [fw = EVE] if Site == 2 & Strat == 6 & room != 66 & room != 62 & room != 3 & /*
*/ room != 4 & room != 20 & room != 35 & room != 46 & room != 50 & Form != 11 & Form != 18 &
Area == 5, dim (3)

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cabiplot, origin scale(.5) title("CA of Forms by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomformIIIbiplot.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomformIIIbiplot.png", replace wid(4000)
cabiplot, origin scale(.5) dim(3 1) title("CA of Forms by Room for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomformIIIbiplotdim3.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomformIIIbiplotdim3.png", replace wid(4000)
screepplot, title("CA of Forms by Room for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomformIIIscree.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomformIIIscree.png", replace wid(4000)
caprojection, title("CA of Forms by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomformIIIproject.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomformIIIproject.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomformIII.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomformIII.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomformIII.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*repeat above but with the simple types
ca room typesimple [fw = EVE] if Site == 2 & Strat == 6 & room != 66 & room != 62 & room != 3 & /*
*/ room != 4 & room != 20 & room != 35 & room != 46 & room != 50 & Form != 11 & Form != 18 &
Area == 5, dim (3)
cabiplot, origin scale(.5) title("CA of Simplified Forms by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomtypesimIIIbiplot.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomtypesimIIIbiplot.png", replace wid(4000)
caprojection, title("CA of Simplified Forms by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomtypesimIIIproject.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomtypesimIIIproject.png", replace wid(4000)
screepplot, title("CA of Simplified Forms by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomtypesimIIIscree.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomtypesimIIIscree.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomtypesimIII.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomtypesimIII.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomtypesimIII.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*repeat above but with the formsimple types
ca room Formsimple [fw = EVE] if Site == 2 & Strat == 6 & room != 66 & room != 62 & room != 3
& /*
*/ room != 4 & room != 20 & room != 35 & room != 46 & room != 50 & Form != 11 & Form != 18 &
Area == 5, dim (3)
cabiplot, origin scale(.5) title("CA of Simplified Forms by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIbiplot.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIbiplot.png", replace wid(4000)
caprojection, title("CA of Simplified Forms by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIproject.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIproject.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomFormsimIII.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names

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putexcel set "Z:\FinalPottery\AnalyzedDiags\roomFormsimIII.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomFormsimIII.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room Formsimple [fw = EVE] if Formsimple != 4 & Site == 2 & Strat == 6 & room != 66 & room !=
62 & room != 3 & /*
*/room != 4 & room != 20 & room != 35 & room != 46 & room != 50 & Area == 5
cabiplot, origin scale(.5) title("CA of Simplified Forms by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIbiplotnolamp.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIbiplotnolamp.png", replace wid(4000)
caprojection, title("CA of Simplified Forms by Room in Area H for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIprojectnolamp.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIprojectnolamp.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIinolamp.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIinolamp.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomFormsimIIIinolamp.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
* CV representations
putexcel set "Z:\FinalPottery\AnalyzedDiags\SumstatsCV.xls", replace
putexcel A1=("Form") B1=("Mean") C1=("Variance") D1=("Standard Deviation") /*
*/ E1=("Skewness") F1=("Kurtosis") G1=("Median") H1=("CV")
summarize rim_diameter if rim_diameter <= 100 & Form == 2, detail
putexcel A2=("Bowl") B2= (r(mean)) C2= (r(Var)) D2= (r(sd)) /*
*/ E2= (r(skewness)) F2= (r(kurtosis)) G2= (r(p50)) H2= (r(sd)/r(mean))
summarize rim_diameter if rim_diameter <= 100 & Form == 5, detail
putexcel A3=("Cooking") B3= (r(mean)) C3= (r(Var)) D3= (r(sd)) /*
*/ E3= (r(skewness)) F3= (r(kurtosis)) G3= (r(p50)) H3= (r(sd)/r(mean))
summarize rim_diameter if rim_diameter <= 100 & Form == 6, detail
putexcel A4=("Holemouth Jar") B4= (r(mean)) C4= (r(Var)) D4= (r(sd)) /*
*/ E4= (r(skewness)) F4= (r(kurtosis)) G4= (r(p50)) H4= (r(sd)/r(mean))
summarize rim_diameter if rim_diameter <= 100 & Form == 8, detail
putexcel A5=("Jug") B5= (r(mean)) C5= (r(Var)) D5= (r(sd)) /*
*/ E5= (r(skewness)) F5= (r(kurtosis)) G5= (r(p50)) H5= (r(sd)/r(mean))
summarize rim_diameter if rim_diameter <= 100 & Form == 9, detail
putexcel A6=("Jar") B6= (r(mean)) C6= (r(Var)) D6= (r(sd)) /*
*/ E6= (r(skewness)) F6= (r(kurtosis)) G6= (r(p50)) H6= (r(sd)/r(mean))
summarize rim_diameter if rim_diameter <= 100 & Form == 10, detail
putexcel A7=("Krater") B7= (r(mean)) C7= (r(Var)) D7= (r(sd)) /*
*/ E7= (r(skewness)) F7= (r(kurtosis)) G7= (r(p50)) H7= (r(sd)/r(mean))
summarize rim_diameter if rim_diameter <= 100 & Form == 12, detail
putexcel A8=("Lamp") B8= (r(mean)) C8= (r(Var)) D8= (r(sd)) /*
*/ E8= (r(skewness)) F8= (r(kurtosis)) G8= (r(p50)) H8= (r(sd)/r(mean))
summarize rim_diameter if rim_diameter <= 100 & Form == 14, detail
putexcel A9=("Platter-Bowl") B9= (r(mean)) C9= (r(Var)) D9= (r(sd)) /*
*/ E9= (r(skewness)) F9= (r(kurtosis)) G9= (r(p50)) H9= (r(sd)/r(mean))
summarize rim_diameter if rim_diameter <= 100 & Form == 21, detail
putexcel A11=("Vat") B11= (r(mean)) C11= (r(Var)) D11= (r(sd)) /*
*/ E11= (r(skewness)) F11= (r(kurtosis)) G11= (r(p50)) H11= (r(sd)/r(mean))

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*CV for Form2
putexcel set "Z:\FinalPottery\AnalyzedDiags\SumstatsCV2.xls", replace
putexcel A1=("Form") B1=("Mean") C1=("Variance") D1=("Standard Deviation") /*
*/ E1=("Skewness") F1=("Kurtosis") G1=("Median") H1=("CV") I1=("N")
hist rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 2 & Site == 2,
title("Bowl") frequency kdensity
graph save "Z:\FinalPottery\AnalyzedDiags\histbowl.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\histbowl.png", replace wid(4000)
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 2 & Site == 2,
detail
putexcel A2=("Bowl") B2= (r(mean)) C2= (r(Var)) D2= (r(sd)) /*
*/ E2= (r(skewness)) F2= (r(kurtosis)) G2= (r(p50)) H2= (r(sd)/r(mean)) I2=(r(N))
hist rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 5 & Site == 2,
title("Cooking Holemouth") frequency kdensity
graph save "Z:\FinalPottery\AnalyzedDiags\histcooking.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\histcooking.png", replace wid(4000)
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 5 & Site == 2,
detail
putexcel A3=("Cooking") B3= (r(mean)) C3= (r(Var)) D3= (r(sd)) /*
*/ E3= (r(skewness)) F3= (r(kurtosis)) G3= (r(p50)) H3= (r(sd)/r(mean)) I3=(r(N))
hist rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 6 & Site == 2,
title("Holemouth Jar") frequency kdensity
graph save "Z:\FinalPottery\AnalyzedDiags\histHJ.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\histHJ.png", replace wid(4000)
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 6 & Site == 2,
detail
putexcel A4=("Holemouth Jar") B4= (r(mean)) C4= (r(Var)) D4= (r(sd)) /*
*/ E4= (r(skewness)) F4= (r(kurtosis)) G4= (r(p50)) H4= (r(sd)/r(mean)) I4=(r(N))
hist rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 8 & Site == 2,
title("Krater") frequency kdensity
graph save "Z:\FinalPottery\AnalyzedDiags\histJG.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\histJG.png", replace wid(4000)
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 8 & Site == 2,
detail
putexcel A5=("Jug") B5= (r(mean)) C5= (r(Var)) D5= (r(sd)) /*
*/ E5= (r(skewness)) F5= (r(kurtosis)) G5= (r(p50)) H5= (r(sd)/r(mean)) I5=(r(N))
hist rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 9 & Site == 2,
title("Jar") frequency kdensity
graph save "Z:\FinalPottery\AnalyzedDiags\histJR.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\histJR.png", replace wid(4000)
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 9 & Site == 2,
detail
putexcel A6=("Jar") B6= (r(mean)) C6= (r(Var)) D6= (r(sd)) /*
*/ E6= (r(skewness)) F6= (r(kurtosis)) G6= (r(p50)) H6= (r(sd)/r(mean)) I6=(r(N))
hist rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 10 & Site == 2,
title("Krater") frequency kdensity
graph save "Z:\FinalPottery\AnalyzedDiags\histKR.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\histKR.png", replace wid(4000)
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 10 & Site == 2,
detail
putexcel A7=("Krater") B7= (r(mean)) C7= (r(Var)) D7= (r(sd)) /*
*/ E7= (r(skewness)) F7= (r(kurtosis)) G7= (r(p50)) H7= (r(sd)/r(mean)) I7=(r(N))
hist rim_diameter if rim_diameter <= 28 & rim_complete >= .03 & Form2 == 12 & Site == 2,
title("Lamp") frequency kdensity

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graph save "Z:\FinalPottery\AnalyzedDiags\histLP.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\histLP.png", replace wid(4000)
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 12 & Site == 2,
detail
putexcel A8=("Lamp") B8= (r(mean)) C8= (r(Var)) D8= (r(sd)) /*
*/ E8= (r(skewness)) F8= (r(kurtosis)) G8= (r(p50)) H8= (r(sd)/r(mean)) I8=(r(N))
hist rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 14 & Site == 2,
title("Platter Bowl") frequency kdensity
graph save "Z:\FinalPottery\AnalyzedDiags\histPL.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\histPL.png", replace wid(4000)
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 14 & Site == 2,
detail
putexcel A9=("Platter-Bowl") B9= (r(mean)) C9= (r(Var)) D9= (r(sd)) /*
*/ E9= (r(skewness)) F9= (r(kurtosis)) G9= (r(p50)) H9= (r(sd)/r(mean)) I9=(r(N))
hist rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 21 & Site == 2,
title("Vat") frequency kdensity
graph save "Z:\FinalPottery\AnalyzedDiags\histVT.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\histVT.png", replace wid(4000)
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .03 & Form2 == 21 & Site == 2,
detail
putexcel A11=("Vat") B11= (r(mean)) C11= (r(Var)) D11= (r(sd)) /*
*/ E11= (r(skewness)) F11= (r(kurtosis)) G11= (r(p50)) H11= (r(sd)/r(mean)) I11=(r(N))
graph box rim_diameter if Form2 != 1 & Form2 != 3 & Form2 != 4 & Form2 != 7 & Form2 != 11 &
Form2 != 13 & Form2 != 15 & Form2 != 16 & Form2 != 17 & Form2 != 18 & Form2 != 19 & Form2
!= 20 & rim_diameter <= 100 & rim_complete >= .03 & Site == 2, over(Form2) scale (.6) title("Rim
Diameter Boxplot")
graph save "Z:\FinalPottery\AnalyzedDiags\SumstatsCV2.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\SumstatsCV2.png", replace wid(4000)
*rim thickness
putexcel set "Z:\FinalPottery\AnalyzedDiags\SumstatsCV3.xls", replace
putexcel A1=("Form") B1=("Mean") C1=("Variance") D1=("Standard Deviation") /*
*/ E1=("Skewness") F1=("Kurtosis") G1=("Median") H1=("CV")
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .03 & Site == 2 & Form2 == 2,
detail
putexcel A2=("Bowl") B2= (r(mean)) C2= (r(Var)) D2= (r(sd)) /*
*/ E2= (r(skewness)) F2= (r(kurtosis)) G2= (r(p50)) H2= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .03 & Form2 == 5 & Site == 2,
detail
putexcel A3=("Cooking") B3= (r(mean)) C3= (r(Var)) D3= (r(sd)) /*
*/ E3= (r(skewness)) F3= (r(kurtosis)) G3= (r(p50)) H3= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .03 & Form2 == 6 & Site == 2,
detail
putexcel A4=("Holemouth Jar") B4= (r(mean)) C4= (r(Var)) D4= (r(sd)) /*
*/ E4= (r(skewness)) F4= (r(kurtosis)) G4= (r(p50)) H4= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .03 & Form2 == 8 & Site == 2,
detail
putexcel A5=("Jug") B5= (r(mean)) C5= (r(Var)) D5= (r(sd)) /*
*/ E5= (r(skewness)) F5= (r(kurtosis)) G5= (r(p50)) H5= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .03 & Site == 2 & Form2 == 9,
detail
putexcel A6=("Jar") B6= (r(mean)) C6= (r(Var)) D6= (r(sd)) /*
*/ E6= (r(skewness)) F6= (r(kurtosis)) G6= (r(p50)) H6= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .03 & Site == 2 & Form2 == 10,
detail

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putexcel A7=("Krater") B7= (r(mean)) C7= (r(Var)) D7= (r(sd)) /*
*/ E7= (r(skewness)) F7= (r(kurtosis)) G7= (r(p50)) H7= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .03 & Site == 2 & Form2 == 12,
detail
putexcel A8=("Lamp") B8= (r(mean)) C8= (r(Var)) D8= (r(sd)) /*
*/ E8= (r(skewness)) F8= (r(kurtosis)) G8= (r(p50)) H8= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .03 & Site == 2 & Form2 == 14,
detail
putexcel A9=("Platter-Bowl") B9= (r(mean)) C9= (r(Var)) D9= (r(sd)) /*
*/ E9= (r(skewness)) F9= (r(kurtosis)) G9= (r(p50)) H9= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .03 & Site == 2 & Form2 == 21,
detail
putexcel A11=("Vat") B11= (r(mean)) C11= (r(Var)) D11= (r(sd)) /*
*/ E11= (r(skewness)) F11= (r(kurtosis)) G11= (r(p50)) H11= (r(sd)/r(mean))
graph box rim_thickness if rim_thickness <= 5 & rim_complete >= .03 & Site == 2 & Form2 != 1 &
Form2 != 3 & Form2 != 4 & Form2 != 7 & Form2 != 11 & Form2 != 13 & Form2 != 15 & Form2 !=
16 & Form2 != 17 & Form2 != 18 & Form2 != 19 & Form2 != 20 , over(Form2) scale (.6) title("Rim
Thickness Boxplot")
graph save "Z:\FinalPottery\AnalyzedDiags\SumstatsCV3.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\SumstatsCV3.png", replace wid(4000)
*CV for Form2 - Strat III
putexcel set "Z:\FinalPottery\AnalyzedDiags\SumstatsCV4.xls", replace
putexcel A1=("Form") B1=("Mean") C1=("Variance") D1=("Standard Deviation") /*
*/ E1=("Skewness") F1=("Kurtosis") G1=("Median") H1=("CV") I1=("N")
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .05 & Form2 == 2 & Site == 2 &
Strat == 6, detail
putexcel A2=("Bowl") B2= (r(mean)) C2= (r(Var)) D2= (r(sd)) /*
*/ E2= (r(skewness)) F2= (r(kurtosis)) G2= (r(p50)) H2= (r(sd)/r(mean)) I2=(r(N))
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .05 & Form2 == 5 & Site == 2 &
Strat == 6, detail
putexcel A3=("Cooking") B3= (r(mean)) C3= (r(Var)) D3= (r(sd)) /*
*/ E3= (r(skewness)) F3= (r(kurtosis)) G3= (r(p50)) H3= (r(sd)/r(mean)) I3=(r(N))
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .05 & Form2 == 6 & Site == 2 &
Strat == 6, detail
putexcel A4=("Holemouth Jar") B4= (r(mean)) C4= (r(Var)) D4= (r(sd)) /*
*/ E4= (r(skewness)) F4= (r(kurtosis)) G4= (r(p50)) H4= (r(sd)/r(mean)) I4=(r(N))
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .05 & Form2 == 8 & Site == 2 &
Strat == 6, detail
putexcel A5=("Jug") B5= (r(mean)) C5= (r(Var)) D5= (r(sd)) /*
*/ E5= (r(skewness)) F5= (r(kurtosis)) G5= (r(p50)) H5= (r(sd)/r(mean)) I5=(r(N))
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .05 & Form2 == 9 & Site == 2 &
Strat == 6, detail
putexcel A6=("Jar") B6= (r(mean)) C6= (r(Var)) D6= (r(sd)) /*
*/ E6= (r(skewness)) F6= (r(kurtosis)) G6= (r(p50)) H6= (r(sd)/r(mean)) I6=(r(N))
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .05 & Form2 == 10 & Site == 2
& Strat == 6, detail
putexcel A7=("Krater") B7= (r(mean)) C7= (r(Var)) D7= (r(sd)) /*
*/ E7= (r(skewness)) F7= (r(kurtosis)) G7= (r(p50)) H7= (r(sd)/r(mean)) I7=(r(N))
summarize rim_diameter if rim_diameter <= 28 & rim_complete >= .05 & Form2 == 12 & Site == 2 &
Strat == 6, detail
putexcel A8=("Lamp") B8= (r(mean)) C8= (r(Var)) D8= (r(sd)) /*
*/ E8= (r(skewness)) F8= (r(kurtosis)) G8= (r(p50)) H8= (r(sd)/r(mean)) I8=(r(N))
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .05 & Form2 == 14 & Site == 2
& Strat == 6, detail

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putexcel A9=("Platter-Bowl") B9= (r(mean)) C9= (r(Var)) D9= (r(sd)) /*
*/ E9= (r(skewness)) F9= (r(kurtosis)) G9= (r(p50)) H9= (r(sd)/r(mean)) I9=(r(N))
summarize rim_diameter if rim_diameter <= 100 & rim_complete >= .05 & Form2 == 21 & Site == 2
& Strat == 6, detail
putexcel A11=("Vat") B11= (r(mean)) C11= (r(Var)) D11= (r(sd)) /*
*/ E11= (r(skewness)) F11= (r(kurtosis)) G11= (r(p50)) H11= (r(sd)/r(mean)) I11=(r(N))
graph box rim_diameter if rim_diameter <= 100 & rim_complete >= .05 & Form2 != 1 & Form2 != 3
& Form2 != 4 & Form2 != 7 & Form2 != 11 & Form2 != 13 & Form2 != 16 & Form2
!= 17 & Form2 != 18 & Form2 != 19 & Form2 != 20 & Site == 2 & Strat == 6, over(Form2) scale (.6)
title("Stratum III Rim Diameter Boxplot")
graph save "Z:\FinalPottery\AnalyzedDiags\SumstatsCV4.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\SumstatsCV4.png", replace wid(4000)
*rim thickness - Strat III
putexcel set "Z:\FinalPottery\AnalyzedDiags\SumstatsCV5.xls", replace
putexcel A1=("Form") B1=("Mean") C1=("Variance") D1=("Standard Deviation") /*
*/ E1=("Skewness") F1=("Kurtosis") G1=("Median") H1=("CV")
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .05 & Site == 2 & Form2 == 2 &
Strat == 6, detail
putexcel A2=("Bowl") B2= (r(mean)) C2= (r(Var)) D2= (r(sd)) /*
*/ E2= (r(skewness)) F2= (r(kurtosis)) G2= (r(p50)) H2= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .05 & Form2 == 5 & Site == 2 &
Strat == 6, detail
putexcel A3=("Cooking") B3= (r(mean)) C3= (r(Var)) D3= (r(sd)) /*
*/ E3= (r(skewness)) F3= (r(kurtosis)) G3= (r(p50)) H3= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .05 & Form2 == 6 & Site == 2 &
Strat == 6, detail
putexcel A4=("Holemouth Jar") B4= (r(mean)) C4= (r(Var)) D4= (r(sd)) /*
*/ E4= (r(skewness)) F4= (r(kurtosis)) G4= (r(p50)) H4= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .05 & Form2 == 8 & Site == 2 &
Strat == 6, detail
putexcel A5=("Jug") B5= (r(mean)) C5= (r(Var)) D5= (r(sd)) /*
*/ E5= (r(skewness)) F5= (r(kurtosis)) G5= (r(p50)) H5= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .05 & Site == 2 & Form2 == 9 &
Strat == 6, detail
putexcel A6=("Jar") B6= (r(mean)) C6= (r(Var)) D6= (r(sd)) /*
*/ E6= (r(skewness)) F6= (r(kurtosis)) G6= (r(p50)) H6= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .05 & Site == 2 & Form2 == 10 &
Strat == 6, detail
putexcel A7=("Krater") B7= (r(mean)) C7= (r(Var)) D7= (r(sd)) /*
*/ E7= (r(skewness)) F7= (r(kurtosis)) G7= (r(p50)) H7= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .05 & Site == 2 & Form2 == 12 &
Strat == 6, detail
putexcel A8=("Lamp") B8= (r(mean)) C8= (r(Var)) D8= (r(sd)) /*
*/ E8= (r(skewness)) F8= (r(kurtosis)) G8= (r(p50)) H8= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .05 & Site == 2 & Form2 == 14
& Strat == 6, detail
putexcel A9=("Platter-Bowl") B9= (r(mean)) C9= (r(Var)) D9= (r(sd)) /*
*/ E9= (r(skewness)) F9= (r(kurtosis)) G9= (r(p50)) H9= (r(sd)/r(mean))
summarize rim_thickness if rim_thickness <= 5 & rim_complete >= .05 & Site == 2 & Form2 == 21 &
Strat == 6, detail
putexcel A11=("Vat") B11= (r(mean)) C11= (r(Var)) D11= (r(sd)) /*
*/ E11= (r(skewness)) F11= (r(kurtosis)) G11= (r(p50)) H11= (r(sd)/r(mean))
graph box rim_thickness if rim_thickness <= 5 & rim_complete >= .05 & Strat == 6 & Site == 2 &
Form2 != 1 & Form2 != 3 & Form2 != 4 & Form2 != 7 & Form2 != 11 & Form2 != 13 & Form2 != 15

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& Form2 != 16 & Form2 != 17 & Form2 != 18 & Form2 != 19 & Form2 != 20 , over(Form2) scale (.6)
title("Stratum III Rim Thickness Boxplot")
graph save "Z:\FinalPottery\AnalyzedDiags\SumstatsCV5.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\SumstatsCV5.png", replace wid(4000)
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedDiag.dta", replace
egen Type = concat( general_type type)
encode Type, gen (Typeconcat)
recode Typeconcat ( 8 9 10 13 15 17 22 3 = 2) (26 7 27 = 26) ( 4 16 21 11 35 55 59 74 = 58) ( 5 6 23 24
25 33 34 73 = 30) (32 36 37 38 = 31) ( 41 40 43 64 65= 42) ( 45 46 54 = 44) ( 48 49 50 51 52 53 56 81
82 83 85 = 47) ( 61/63 87 88 98 = 60) ( 67 12 = 66 ) (72 75= 71) ( 95 57 14 39 76 = 94) (26 27 28
40/43 64 65 68 69 76 78 79 80 86 89 91/3 97 19 20 18= . )
decode Typeconcat, gen(typef)
encode typef, gen(Form)
drop Type Typeconcat typef
encode Room, gen(room)
encode RevStrat, gen (Strat)
encode name, gen(Site)
encode area, gen(Area)
recode Form (22=.)
replace rim_diameter = round(rim_diameter)
egen diamcode = cut(rim_diameter), at(1(5)100) label
egen thickcode = cut(rim_thickness), at(.01(.2)6) label
encode is_burnished , gen(burn)
encode is_burnished_inside , gen(burnint)
encode is_burnished_outside , gen(burnext)
encode is_plastic_application, gen(plasapp)
encode is_painted, gen(paint)
encode is_slipped, gen(slip)
encode is_slipped_inside, gen(slipint)
encode is_slipped_outside, gen(slipext)
gen EVE = ( rim_complete * 100)
encode typegen, gen(typesimple)
encode typevar, gen(typefeature)
encode is_incised, gen (incise)
encode rim_treatment, gen(rimtrat)
encode rim_angle, gen(rimangle)
label define Form 2 "Bowl", modify
label define Form 3 "Crucible", modify
label define Form 5 "Cooking", modify
label define Form 6 "HolemouthJar", modify
label define Form 8 "Jug", modify
label define Form 9 "Jar", modify
label define Form 10 "Krater", modify
label define Form 21 "Vat", modify
label define Form 14 "Platter-Bowl", modify
label define Form 12 "Lamp", modify
label define Form 11 "Lid", modify
label define typefeature 1 "Basin", modify
label define typefeature 2 "Crucible", modify
label define typefeature 4 "Jug", modify
label define typefeature 5 "Krater", modify
label define typefeature 6 "Lamp", modify
label define typefeature 8 "Store Jar", modify
label define typefeature 9 "Vat", modify

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label define typesimple 2 "Bowl", modify
label define typesimple 3 "Holemouth Jar", modify
label define typesimple 4 "Jar", modify
label define typesimple 5 "Platter-Bowl", modify
* label define thickcode 0 ".01-.50", modify
* label define thickcode 1 ".51-1", modify
* label define thickcode 2 "1.01-1.50", modify
* label define thickcode 3 "1.51-2", modify
* label define thickcode 4 "2.01-2.50", modify
* label define thickcode 5 "2.51-3", modify
* label define thickcode 6 "3.01-3.5", modify
* label define thickcode 7 "3.51-4", modify
* label define thickcode 8 "4.01-4.5", modify
* label define thickcode 9 "4.51-5", modify
* label define thickcode 10 "5.01-5.5", modify
label define rimtreat 6 "Grooved", modify
label define diamcode 0 "1-5", modify
label define diamcode 1 "6-10", modify
label define diamcode 3 "16-20", modify
label define diamcode 4 "21-25", modify
label define diamcode 2 "11-15", modify
label define diamcode 5 "26-30", modify
label define diamcode 6 "31-35", modify
label define diamcode 7 "36-40", modify
label define diamcode 8 "41-45", modify
label define diamcode 9 "46-50", modify
label define diamcode 10 "51-55", modify
label define diamcode 11 "56-60", modify
label define diamcode 12 "61-65", modify
label define diamcode 13 "66-70", modify
label define diamcode 14 "71-75", modify
label define diamcode 15 "76-80", modify
label define diamcode 16 "81-85", modify
label define diamcode 17 "86-90", modify
label define diamcode 18 "91-95", modify
label define diamcode 19 "96-100", modify
recode thickcode (10 11 = 9)
encode handle_type, gen(Handle)
recode Handle (2/5 = 5)
recode Form (20 1 3 4 7 11 13 15/9 22 = .), gen(Form2)
recode Form2 (9 = 8) if Handle == 5
label values Form2 Form
label define Formsimple 1 "Storage" 2 "Food Prep" 3 "Serving" 4 "Lamp"
recode Form2 ( 2 8 15 = 3) ( 5 23 = 2) ( 12 = 4) ( 10 9 6 = 1) (else = .) , gen(Formsimple)
label values Formsimple Formsimple
*recode for types
recode incise (.=1) if rim_diameter >= 1 & incise != 2
recode burn (.=1) if rim_diameter >= 1 & burn != 2
recode burnint (.=1) if rim_diameter >= 1 & burnint != 2
recode burnnext (.=1) if rim_diameter >= 1 & burnnext != 2
recode plasapp (.=1) if rim_diameter >= 1 & plasapp != 2
recode slip (.=1) if rim_diameter >= 1 & slip != 2
recode slipint (.=1) if rim_diameter >= 1 & slipint != 2
recode slipext (.=1) if rim_diameter >= 1 & slipext != 2

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replace EVE = round(EVE)
replace rim_diameter = . if id == 41860 | id == 38936 | id == 38988 | id == 42807 | id == 42727 | id ==
27454
compress
save "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", replace
drop if thickcode == 0
drop if thickcode == 1
drop if thickcode == .
collapse (sd) SD = rim_diameter (mean) Mean = rim_diameter (count) N = rim_diameter if
rim_diameter <= 100 & rim_complete >= .05, by (Form2 thickcode Strat)
gen cv = SD/Mean
drop if N <= 5
export excel using "Z:\FinalPottery\AnalyzedDiags\CVbythickcode.xls", firstrow(varlabels) replace

use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
drop if thickcode == 0
drop if thickcode == 1
drop if thickcode == .
collapse (sd) SD = rim_diameter (mean) Mean = rim_diameter (count) N = rim_diameter if
rim_diameter <= 100 & rim_complete >= .05, by (Form2 thickcode Strat burnext)
gen cv = SD/Mean
drop if N <= 5
export excel using "Z:\FinalPottery\AnalyzedDiags\CVbythickcodeburnext.xls", firstrow(varlabels)
replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
drop if thickcode == 0
drop if thickcode == 1
drop if thickcode == .
collapse (sd) SD = rim_diameter (mean) Mean = rim_diameter (count) N = rim_diameter if
rim_diameter <= 100 & rim_complete >= .05, by (Form2 thickcode Strat rimtreat)
gen cv = SD/Mean
drop if N <= 5
export excel using "Z:\FinalPottery\AnalyzedDiags\CVbythickcoderimtreat.xls", firstrow(varlabels)
replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
drop if thickcode == 0
drop if thickcode == 1
drop if thickcode == .
collapse (sd) SD = rim_diameter (mean) Mean = rim_diameter (count) N = rim_diameter if
rim_diameter <= 100 & rim_complete >= .05, by (Form2 thickcode Strat incise)
gen cv = SD/Mean
drop if N <= 5
export excel using "Z:\FinalPottery\AnalyzedDiags\CVbythickcodeincise.xls", firstrow(varlabels)
replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
drop if thickcode == 0
drop if thickcode == 1
drop if thickcode == .
collapse (sd) SD = rim_diameter (mean) Mean = rim_diameter (count) N = rim_diameter if
rim_diameter <= 100 & rim_complete >= .05, by (Form2 Strat incise)
gen cv = SD/Mean
drop if N <= 5
export excel using "Z:\FinalPottery\AnalyzedDiags\CVbyincise.xls", firstrow(varlabels) replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear

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drop if thickcode == 0
drop if thickcode == 1
drop if thickcode == .
collapse (sd) SD = rim_diameter (mean) Mean = rim_diameter (count) N = rim_diameter if
rim_diameter <= 100 & rim_complete >= .05, by (Form2 Strat burn)
gen cv = SD/Mean
drop if N <= 5
export excel using "Z:\FinalPottery\AnalyzedDiags\CVbyburn.xls", firstrow(varlabels) replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
drop if thickcode == 0
drop if thickcode == 1
drop if thickcode == .
collapse (sd) SD = rim_diameter (mean) Mean = rim_diameter (count) N = rim_diameter if
rim_diameter <= 100 & rim_complete >= .05, by (Form2 Strat burn slip)
gen cv = SD/Mean
drop if N <= 5
export excel using "Z:\FinalPottery\AnalyzedDiags\CVbyburnslip.xls", firstrow(varlabels) replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
drop if thickcode == 0
drop if thickcode == 1
drop if thickcode == .
collapse (sd) SD = rim_diameter (mean) Mean = rim_diameter (count) N = rim_diameter if
rim_diameter <= 100 & rim_complete >= .05, by (Form2 Strat burn slip plasapp)
gen cv = SD/Mean
drop if N <= 5
export excel using "Z:\FinalPottery\AnalyzedDiags\CVbyburnslipplas.xls", firstrow(varlabels) replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
drop if thickcode == 0
drop if thickcode == 1
drop if thickcode == .
collapse (sd) SD = rim_diameter (mean) Mean = rim_diameter (count) N = rim_diameter if
rim_diameter <= 100 & rim_complete >= .05, by (Form2 Strat plasapp)
gen cv = SD/Mean
drop if N <= 5
export excel using "Z:\FinalPottery\AnalyzedDiags\CVbyplas.xls", firstrow(varlabels) replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (sum) Sum = rim_complete (count) N = rim_diameter if rim_diameter <= 100, by (Form2
Room Strat)
export excel using "Z:\FinalPottery\AnalyzedDiags\countanalysis.xls", firstrow(varlabels) replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (sum) Sum = rim_complete (count) N = rim_diameter if rim_diameter <= 100 & Area == 5, by
(Form2 Room Strat thickcode)
export excel using "Z:\FinalPottery\AnalyzedDiags\countanalysismodruptcompare.xls",
firstrow(varlabels) replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
egen burnplas = concat( is_burnished is_plastic_application)
encode burnplas, gen(Burnplas)
label define Burnplas 1 "None", modify
label define Burnplas 2 "Plas App", modify
label define Burnplas 3 "Burnish", modify
label define Burnplas 4 "BurnandPlas", modify
ca Burnplas room [fw = EVE] if Area == 5 & Form2 == 9 & Strat == 6 & Site == 2 & room != 66 &
room != 62 & room != 3 & room != 4 & room != 20 & room != 35 & room != 46 & room != 50, dim (3)

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cabiplot, origin scale(.75) title("CA of Jars by Room for Stratum III - Burinshed and Plastic App
Features - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplotadjust.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplotadjust.png", replace wid(4000)
cabiplot, origin scale(.75) dim(3 1) title("CA of Forms by Room for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplotdim3adjust.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplotdim3adjust.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplotadjust.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplotadjust.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplotadjust.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca Burnplas room [fw = EVE] if Area == 5 & Form2 == 6 & Strat == 6 & room != 66 & room != 62 &
room != 3 & room != 4 & room != 20 & room != 35 & room != 49 & room != 46 & room != 50, dim (3)
cabiplot, origin scale(.75) title("CA of Holemouth Jars by Room for Stratum III - Burinshed and Plastic
App Features - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomHolejarIIIbiplotadjust.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomHolejarIIIbiplotadjust.png", replace wid(4000)
cabiplot, origin scale(.75) dim(3 1) title("CA of Holemouth Jars by Room for Stratum III - EVE")
graph save "Z:\FinalPottery\AnalyzedDiags\roomHolejarIIIbiplotadjust.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomHolejarIIIbiplotadjust.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomHolejarIIIbiplotadjust.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomHolejarIIIbiplotadjust.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\roomHolejarIIIbiplotadjust.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*To generate a MoR for Forms
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (mean) ModulusRupture = rim_complete (count) N = rim_diameter (sd) StandardDev =
rim_complete (sem) standarderrormean = rim_complete if rim_diameter <= 100 & rim_complete < 1 &
rim_complete > .01, by (Form2 Strat)
save "Z:\FinalPottery\AnalyzedDiags\modrupttojoin.dta", replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (mean) ModulusRupture1 = rim_complete (count) N1 = rim_diameter if rim_diameter <= 100,
by (Form2 Strat)
joinby Form2 Strat using "Z:\FinalPottery\AnalyzedDiags\modrupttojoin.dta"
save "Z:\FinalPottery\AnalyzedDiags\modruptdata.dta", replace
gen correctedcount = ( ModulusRupture * N1)
export excel using "Z:\FinalPottery\AnalyzedDiags\modulusofruptureForm.xls", firstrow(varlabels)
replace
export delim using "Z:\FinalPottery\AnalyzedDiags\modulusofruptureForm.csv", replace
*To generate a MoR for rooms
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (mean) ModulusRupture = rim_complete (count) N = rim_diameter (sd) StandardDev =
rim_complete (sem) standarderrormean = rim_complete if rim_diameter <= 100 & rim_complete < 1 &
rim_complete > .01, by (Strat Room)
save "Z:\FinalPottery\AnalyzedDiags\modrupttojoinroom.dta", replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear

```

```

collapse (mean) ModulusRupture1 = rim_complete (count) N1 = rim_diameter if rim_diameter <= 100,
by (Room Strat)
joinby Room Strat using "Z:\FinalPottery\AnalyzedDiags\modrupttojoinroom.dta"
save "Z:\FinalPottery\AnalyzedDiags\modruptdataroom.dta", replace
gen correctedcount = ( ModulusRupture * N1)
export excel using "Z:\FinalPottery\AnalyzedDiags\modulusofruptureFormroom.xls",
firstrow(varlabels) replace
export delim using "Z:\FinalPottery\AnalyzedDiags\modulusofruptureFormroom.csv", replace
*To generate a MoR for Rooms
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (mean) ModulusRupture = rim_complete (count) N = rim_diameter (sd) StandardDev =
rim_complete (sem) standarderrormean = rim_complete if rim_diameter <= 100 & rim_complete < 1 &
rim_complete > .01, by (Room Area Strat)
save "Z:\FinalPottery\AnalyzedDiags\modrupttojoin.dta", replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (mean) ModulusRupture1 = rim_complete (count) N1 = rim_diameter if rim_diameter <= 100,
by (Room Area Strat)
joinby Room Strat using "Z:\FinalPottery\AnalyzedDiags\modrupttojoin.dta"
save "Z:\FinalPottery\AnalyzedDiags\modruptdata.dta", replace
gen correctedcount = ( ModulusRupture * N1)
export excel using "Z:\FinalPottery\AnalyzedDiags\modulusofruptureRoom.xls", firstrow(varlabels)
replace
export delim using "Z:\FinalPottery\AnalyzedDiags\modulusofruptureRoom.csv", replace
*For counts tor report
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (mean) ModulusRupture = rim_complete (count) N = rim_diameter (sd) StandardDev =
rim_complete (sem) standarderrormean = rim_complete if Area == 5 & rim_diameter <= 100 &
rim_complete < 1 & rim_complete > .01, by (Form2 Room Strat)
save "Z:\FinalPottery\AnalyzedDiags\modrupttojoin.dta", replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (sum) EVE = rim_complete (mean) ModulusRupturewo1 = rim_complete (count) NMoR =
rim_diameter if rim_diameter <= 100, by (Form2 Room Strat)
joinby Form2 Room Strat using "Z:\FinalPottery\AnalyzedDiags\modrupttojoin.dta"
save "Z:\FinalPottery\AnalyzedDiags\modruptdata.dta", replace
gen correctedcount = ( ModulusRupture * NMoR)
export excel using "Z:\FinalPottery\AnalyzedDiags\modulusofrupturereport.xls", firstrow(varlabels)
replace
export delim using "Z:\FinalPottery\AnalyzedDiags\modulusofrupturereport.csv", replace
*For Analysis
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (mean) ModulusRupture = rim_complete (count) N = rim_diameter (sd) StandardDev =
rim_complete (sem) standarderrormean = rim_complete if rim_diameter <= 100 & rim_complete < 1 &
rim_complete > .01, by (Form2 Room Strat thickcode)
save "Z:\FinalPottery\AnalyzedDiags\modrupttojoin.dta", replace
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
collapse (mean) ModulusRupture1 = rim_complete (count) N1 = rim_diameter if rim_diameter <= 100,
by (Form2 Room Strat thickcode)
joinby Form2 Room Strat thickcode using "Z:\FinalPottery\AnalyzedDiags\modrupttojoin.dta"
save "Z:\FinalPottery\AnalyzedDiags\modruptdata.dta", replace
gen correctedcount = ( ModulusRupture * N1)
export excel using "Z:\FinalPottery\AnalyzedDiags\modulusofrupture.xls", firstrow(varlabels) replace
export delim using "Z:\FinalPottery\AnalyzedDiags\modulusofrupture.csv", replace
*What to do? Need to check on the rooms here....
use "Z:\FinalPottery\AnalyzedDiags\modruptdata.dta", clear

```

```

gen correctedcount = ( ModulusRupture * N1)
gen count = round( 100*correctedcount)
encode Room, gen(room)
recode room (1/19 21 34/40 44 46 48 50/57 60 64/71 = .)
recode Form2 (5 21 = 1) (2 8 14 = 2) (9 10 6 = 3) (12 = 4) (else = .), gen (simpform)
label define simpform 2 "Serving", modify
label define simpform 1 "FoodPrep", modify
label define simpform 3 "Storage", modify
label define simpform 4 "Lamp", modify
label values simpform simpform
ca room Form2 [fw=count] if Strat == 6 & room != 66 & room != 62 & room != 3 & room != 4 & room
!= 20 & room != 35 & room != 49 & Form2 != 18, dim(3)
cabiplot, origin scale (.6) title("CA of Forms by Room in Area H for Stratum III - Modulus of Rupture")
graph save "Z:\FinalPottery\AnalyzedDiags\ModruptIIIbiplot.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\modruptIIIbiplot.png", replace wid(4000)
cabiplot, origin scale(.6) dim(3 1) title("CA of Forms by Room in Area H for Stratum III - Modulus of
Rupture")
graph save "Z:\FinalPottery\AnalyzedDiags\ModruptIIIbiplotdim3.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\ModruptIIIbiplotdim3.png", replace wid(4000)
cabiplot, origin scale(.6) dim(3 2) title("CA of Forms by Room in Area H for Stratum III - Modulus of
Rupture")
graph save "Z:\FinalPottery\AnalyzedDiags\ModruptIIIbiplotdim23.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\ModruptIIIbiplotdim23.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\ModruptIII.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\ModruptIII.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\ModruptIII.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room simpform [fw=count] if Strat == 6 & room != 66 & room != 62 & room != 3 & room != 4 &
room != 20 & room != 35 & room != 49 & Form2 != 18, dim(3)
cabiplot, origin scale (.6) title("CA of Simplified Forms by Room in Area H for Stratum III - Modulus
of Rupture")
graph save "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIIIbiplot.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\modruptsimpIIIbiplot.png", replace wid(4000)
cabiplot, origin scale(.6) dim(3 1) title("CA of Simplified Forms by Room in Area H for Stratum III -
Modulus of Rupture")
graph save "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIIIbiplotdim3.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIIIbiplotdim3.png", replace wid(4000)
cabiplot, origin scale(.6) dim(3 2) title("CA of Simplified Forms by Room in Area H for Stratum III -
Modulus of Rupture")
graph save "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIIIbiplotdim23.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIIIbiplotdim23.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIII.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIII.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIII.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))

```

```

ca room simpform [fw=count] if simpform != 4 & Strat == 6 & room != 66 & room != 62 & room != 3
& room != 4 & room != 20 & room != 35 & room != 49 & Form2 != 18
cabiplot, origin scale (.6) title("CA of Simplified Forms by Room in Area H for Stratum III - Modulus
of Rupture")
graph save "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIIIbiplotnolamp.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\modruptsimpIIIbiplotnolamp.png", replace wid(4000)
putexcel set "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIIIInolamp.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIIIInolamp.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\AnalyzedDiags\ModruptsimpIIIInolamp.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
use "Z:\FinalPottery\AnalyzedDiags\AnalyzedForm2DO.dta", clear
egen burnplas = concat( is_burnished is_plastic_application)
encode burnplas, gen(Burnplas)
label define Burnplas 1 "None", modify
label define Burnplas 2 "Plastic App", modify
label define Burnplas 3 "Burnished", modify
label define Burnplas 4 "Burnished and Plastic App", modify
ca Burnplas room if Form2 == 9 & Strat == 6 & Site == 2 & room != 66 & room != 62 & room != 3 &
room != 4 & room != 20 & room != 35, dim (3)
cabiplot, origin scale(.75) title("CA of Jars by Room for Stratum III - Burinshed and Plastic App
Features")
graph save "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplot.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplot.png", replace wid(4000)
cabiplot, origin scale(.75) dim(3 1) title("CA of Forms by Room for Stratum III")
graph save "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplotdim3.gph", replace
graph export "Z:\FinalPottery\AnalyzedDiags\roomjarIIIbiplotdim3.png", replace wid(4000)
collapse (sd) SD = rim_diameter (mean) Mean = rim_diameter (count) NRaw = rim_diameter (sum)
NAdjust = EVE if Form2 == 9 & Strat == 6 & Site == 2 & room != 66 & room != 62 & room != 3 &
room != 4 & room != 20 & room != 35 & rim_diameter <= 100 & rim_complete >= .03, by (room
Burnplas)
export excel using "Z:\FinalPottery\AnalyzedDiags\burnplasbyroom.xls", firstrow(varlabels) replace

```

Broad Analysis Coding

```

import excel "Z:\FinalPottery\BasicDiags\Stackcount.xlsx", sheet("Stackcount") firstrow clear
rename Form2 Count
label variable Count "Count"
encode RevStrat, gen(Strat)
encode Form, gen(form)
recode Strat (3 = 4) (9 10 = 8) (12 = 6)
encode Room, g(room)
recode room (76 22 40 46 52 56 51 39 9 61/70 72 73 79/95 2/5 = 200) (else = .), gen (badroom)
recode room (26/29 31/38 53/55 60 74 75 77 = 200) (else = .), gen (areah)
recode Strat ( 1 6 8 11 = 1) (else = .), gen(stratgood)
label define form 1 "Bowl", modify
label define form 2 "Food Prep", modify
label define form 3 "Serving", modify
label define form 4 "Storage", modify
label define form 6 "HolemouthJar", modify

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label define form 7 "Jug", modify
label define form 8 "Jar", modify
label define form 9 "Krater", modify
label define form 10 "Lid", modify
label define form 11 "Lamp", modify
label define form 5 "Cooking", modify
label define form 12 "Platter-Bowl", modify
label define form 13 "StoreJar", modify
label define form 14 "Vat", modify
compress
save "Z:\FinalPottery\BasicDiags\Stackcount.dta", replace
*need to take out bad rooms make new variable
recode form ( 2/4 11 = 1) (else = .), gen(formgrouped)
compress
ca room form if badroom == . & formgrouped == 1 & Strat == 8 [fwe=Count], dim(3)
cabiplot, scale (.75) origin title("CA of Functions by Room for Stratum III - MxNV")
graph save "Z:\FinalPottery\BasicDiags\simpleabundanceIII.gph", replace
graph export "Z:\FinalPottery\BasicDiags\simpleabundanceIII.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIII.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIII.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIII.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room form if badroom == . & formgrouped == 1 & Strat == 8 & form != 11 [fwe=Count]
cabiplot, scale (.75) origin title("CA of Functions by Room for Stratum III - MxNV")
graph save "Z:\FinalPottery\BasicDiags\simpleabundanceIIIinlamp.gph", replace
graph export "Z:\FinalPottery\BasicDiags\simpleabundanceIIIinlamp.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIinlamp.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIinlamp.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIinlamp.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room form if formgrouped == 1 & Strat == 1 [fwe=Count], dim(3)
cabiplot, scale (.75) origin title("CA of Functions by Room for Stratum I - MxNV")
graph save "Z:\FinalPottery\BasicDiags\simpleabundanceI.gph", replace
graph export "Z:\FinalPottery\BasicDiags\simpleabundanceI.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceI.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceI.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceI.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room form if formgrouped == 1 & Strat == 6 [fwe=Count], dim(3)
cabiplot, scale (.75) origin title("CA of Functions by Room for Stratum II - MxNV")
graph save "Z:\FinalPottery\BasicDiags\simpleabundanceII.gph", replace
graph export "Z:\FinalPottery\BasicDiags\simpleabundanceII.png", wid(4000) replace

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putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceII.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceII.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceII.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room form if areah == 200 & formgrouped == 1 & Strat == 8 & form != 11 [fwe=Count]
cabipLOT, scale (.75) origin title("CA of Functions by Room in Area H for Stratum III - MxNV")
graph save "Z:\FinalPottery\BasicDiags\simpleabundanceIIIareahnoLamp.gph", replace
graph export "Z:\FinalPottery\BasicDiags\simpleabundanceIIIareahnoLamp.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIareahnoLamp.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIareahnoLamp.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIareahnoLamp.xls", sheet(tablestats,
replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")/*
*/ B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room form if areah == 200 & formgrouped == 1 & Strat == 8 [fwe=Count], dim(3)
cabipLOT, scale (.75) origin title("CA of Functions by Room in Area H for Stratum III - MxNV")
graph save "Z:\FinalPottery\BasicDiags\simpleabundanceIIIareah.gph", replace
graph export "Z:\FinalPottery\BasicDiags\simpleabundanceIIIareah.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIareah.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIareah.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIareah.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")/*
*/ B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca Strat form if stratgood == 1 & formgrouped == 1 [fwe=Count], dim(3)
cabipLOT, scale (.75) origin
graph save "Z:\FinalPottery\BasicDiags\simpleabundanceStrat.gph", replace
graph export "Z:\FinalPottery\BasicDiags\simpleabundanceStrat.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceStrat.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceStrat.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceStrat.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
use "Z:\FinalPottery\BasicDiags\Stackcount.dta", clear
recode form ( 2/4 10 = 1) (else = .), gen(formgrouped)
compress
ca room form if badroom == . & areah == . & formgrouped == . & Strat == 8 [fwe=Count], dim(3)
cabipLOT, scale (.75) origin title("CA of Forms by Room for Stratum III - MxNV")
graph save "Z:\FinalPottery\BasicDiags\complexabundanceIIIwoH.gph", replace
graph export "Z:\FinalPottery\BasicDiags\complexabundanceIIIwoH.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIwoH.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIwoH.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names

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putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIwoH.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room form if badroom == . & formgrouped == . & Strat == 8 [fwe=Count], dim(3)
cabiplot, scale (.75) origin title("CA of Forms by Room for Stratum III - MxNV")
graph save "Z:\FinalPottery\BasicDiags\complexabundanceIII.gph", replace
graph export "Z:\FinalPottery\BasicDiags\complexabundanceIII.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIII.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIII.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIII.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room form if areah == 200 & formgrouped == . & Strat == 8 [fwe=Count], dim(3)
cabiplot, scale (.75) origin title("CA of Forms by Room in Area H for Stratum III - MxNV")
graph save "Z:\FinalPottery\BasicDiags\complexabundanceIIIareah.gph", replace
graph export "Z:\FinalPottery\BasicDiags\complexabundanceIIIareah.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIareah.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIareah.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIareah.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca Strat form if stratgood == 1 & formgrouped == . [fwe=Count], dim(3)
cabiplot, scale (.75) origin
graph save "Z:\FinalPottery\BasicDiags\complexabundanceStrat.gph", replace
graph export "Z:\FinalPottery\BasicDiags\complexabundanceStrat.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceStrat.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceStrat.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceStrat.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
use "Z:\FinalPottery\AnalyzedDiags\modrupttojoinnoroom.dta", clear
export excel using "Z:\FinalPottery\BasicDiags\modrupttojoinnoroom.xls", firstrow(variables) replace
recode Form2 (2=1) (5=5) (6=6) (8=7) (9=8) (10=9) (11=10) (12=11) (14=12) (21=14), gen(form)
recode Strat (1=1) (2=4) (3=5) (4=6) (5=7) (6=8) (7=11), gen(strat)
drop Strat
rename strat Strat
save "Z:\FinalPottery\BasicDiags\modruptdatanoroom.dta", replace
use "Z:\FinalPottery\BasicDiags\Stackcount.dta", clear
joinby form Strat using "Z:\FinalPottery\BasicDiags\modruptdatanoroom.dta"
save "Z:\FinalPottery\BasicDiags\modruptjoined.dta", replace
export excel using "Z:\FinalPottery\BasicDiags\modruptjoined.xls", firstrow(variables) replace
gen correctedcount = (round(ModulusRupture * Count),.01)* 100
ca room form if badroom == . & areah == . & Strat == 8 [fwe=correctedcount], dim(3)
cabiplot, scale (.75) origin title("CA of Forms by Room for Stratum III - MxNV MoR Adjusted")
graph save "Z:\FinalPottery\BasicDiags\complexabundanceIIIMoR.gph", replace
graph export "Z:\FinalPottery\BasicDiags\complexabundanceIIIMoR.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIMoR.xls", sheet(GSC, replace)

```



```

putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIMoR.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIMoR.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room form if badroom == . & areah == 200 & Strat == 8 [fwe=correctedcount], dim(3)
cabiplot, scale (.75) origin title("CA of Forms by Room for Area H Stratum III - MxNV MoR
Adjusted")
graph save "Z:\FinalPottery\BasicDiags\complexabundanceIIIMoRareaH.gph", replace
graph export "Z:\FinalPottery\BasicDiags\complexabundanceIIIMoRareaH.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIMoRareaH.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIMoRareaH.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\complexabundanceIIIMoRareaH.xls", sheet(tablestats,
replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
recode form (1 7 12 = 3) (5 9 14 = 2) (6 8 13 = 4)
ca room form if badroom == . & areah == . & Strat == 8 [fwe=correctedcount], dim(3)
cabiplot, scale (.75) origin title("CA of Function by Room for Stratum III - MxNV MoR Adjusted")
graph save "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoR.gph", replace
graph export "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoR.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoR.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoR.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoR.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room form if badroom == . & areah == 200 & Strat == 8 [fwe=correctedcount], dim(3)
cabiplot, scale (.75) origin title("CA of Function by Room for Area H Stratum III - MxNV MoR
Adjusted")
graph save "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoRareaH.gph", replace
graph export "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoRareaH.png", wid(4000) replace
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoRareaH.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoRareaH.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoRareaH.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room form if badroom == . & areah == 200 & Strat == 8 & form != 11 [fwe=correctedcount]
cabiplot, scale (.75) origin title("CA of Function by Room for Area H Stratum III - MxNV MoR
Adjusted")
graph save "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoRareaHnolamp.gph", replace
graph export "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoRareaHnolamp.png", wid(4000)
replace
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoRareaHnolamp.xls", sheet(GSC,
replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoRareaHnolamp.xls", sheet(GSR,
replace)

```

```

putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\BasicDiags\simpleabundanceIIIMoRareaHnolamp.xls", sheet(tablestats,
replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))

```

Petrography

```

import excel "Z:\FinalPottery\Petrography\Petrography.xlsx", sheet("Named Locations") firstrow clear
reshape long Reg, i(Site) j(site, string)
encode site, gen(source)
drop site
encode Site, gen(site)
compress
ca site source [fwe=Reg], dim(3)
cabiplot, scale (.75) origin title("CA of Negev Petrography")
graph save "Z:\FinalPottery\Petrography\Petrography.gph", replace
graph export "Z:\FinalPottery\Petrography\Petrography.png", wid(3500) replace
cabiplot, scale (.75) dim (3 1) origin title("CA of Negev Petrography")
graph save "Z:\FinalPottery\Petrography\Petrographydim3.gph", replace
graph export "Z:\FinalPottery\Petrography\Petrographydim3.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Petrography\PetrographyCA.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Petrography\PetrographyCA.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Petrography\PetrographyCA.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))

```

Room 14

```

import delimited Z:\FinalPottery\Room14\Rm14.csv, clear
reshape long count, i(locus) j(type, string)
encode type, gen(form)
drop if form == 8
recode form (2 6 11 = 12) (1 5 9 = 13) (3 4 10 = 14), gen(function)
label define form 12 "Food Prep", modify
label define form 13 "Serving", modify
label define form 14 "Storage", modify
label values function form
save "Z:\FinalPottery\Room14\Room14.dta", replace
ca locus form [fwe = count], dim(3)
cabiplot, scale (.75) origin title("CA of Forms by Locus for Room 14 - MxNV")
graph save "Z:\FinalPottery\Room14\complexabundance.gph", replace
graph export "Z:\FinalPottery\Room14\complexabundance.png", wid(4000) replace
putexcel set "Z:\FinalPottery\Room14\complexabundance.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Room14\complexabundance.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Room14\complexabundance.xls", sheet(tablestats, replace)

```

```

putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca locus function [fwe = count]
cabiplot, scale (.75) origin title("CA of Functions by Locus for Room 14 - MxNV")
graph save "Z:\FinalPottery\Room14\simpleabundance.gph", replace
graph export "Z:\FinalPottery\Room14\simpleabundance.png", wid(4000) replace
putexcel set "Z:\FinalPottery\Room14\simpleabundance.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Room14\simpleabundance.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Room14\simpleabundance.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*drop lamp
ca locus function [fwe = count] if form != 7
cabiplot, scale (.75) origin title("CA of Functions by Locus for Room 14 - MxNV")
graph save "Z:\FinalPottery\Room14\simpleabundancenolamp.gph", replace
graph export "Z:\FinalPottery\Room14\simpleabundancenolamp.png", wid(4000) replace
putexcel set "Z:\FinalPottery\Room14\simpleabundancenolamp.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Room14\simpleabundancenolamp.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Room14\simpleabundancenolamp.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*used JR to sub for SJ
use "Z:\FinalPottery\Room14\Room14.dta", clear
joinby form using "Z:\FinalPottery\Room14\modruptdatanoroom.dta"
save "Z:\FinalPottery\Room14\modruptjoined.dta", replace
export excel using "Z:\FinalPottery\Room14\modruptjoined.xls", firstrow(variables) replace
gen correctedcount = ( round(ModulusRupture * count),.01)* 100
ca locus function [fwe = correctedcount] if form != 7
cabiplot, scale (.75) origin title("CA of Functions by Locus for Room 14 - MoR")
graph save "Z:\FinalPottery\Room14\simpleabundancenolampMoR.gph", replace
graph export "Z:\FinalPottery\Room14\simpleabundancenolampMoR.png", wid(4000) replace
putexcel set "Z:\FinalPottery\Room14\simpleabundancenolampMoR.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Room14\simpleabundancenolampMoR.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Room14\simpleabundancenolampMoR.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca locus function [fwe = correctedcount]
cabiplot, scale (.75) origin title("CA of Functions by Locus for Room 14 - MoR")
graph save "Z:\FinalPottery\Room14\simpleabundanceMoR.gph", replace
graph export "Z:\FinalPottery\Room14\simpleabundanceMoR.png", wid(4000) replace
putexcel set "Z:\FinalPottery\Room14\simpleabundanceMoR.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Room14\simpleabundanceMoR.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names

```

```

putexcel set "Z:\FinalPottery\Room14\simpleabundanceMoR.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca locus form [fwe = correctedcount], dim(3)
cabiplot, scale (.75) origin title("CA of Forms by Locus for Room 14 - MoR")
graph save "Z:\FinalPottery\Room14\complexabundanceMoR.gph", replace
graph export "Z:\FinalPottery\Room14\complexabundanceMoR.png", wid(4000) replace
putexcel set "Z:\FinalPottery\Room14\complexabundanceMoR.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Room14\complexabundanceMoR.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Room14\complexabundanceMoR.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
/*
*/B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))

```

Faunal and Metallurgical Data

```

import excel "Z:\FinalPottery\Metalceramicandfaunal\Faunal120room.xlsx", sheet("Faunal120room")
firstrow clear
rename ABMedanimalcount CountMedanimal
rename ABLargeanimalcount CountLargeanimal
rename ABSmallAnimalCount CountSmallAnimal
rename ABWeight CountBoneWeight
rename ABBONEcount CountBone
reshape long Count, i(Room) j(type, string)
save "Z:\FinalPottery\Metalceramicandfaunal\Faunal120room.dta", replace
import excel "Z:\FinalPottery\Metalceramicandfaunal\BoxlistRoom.xlsx", sheet("DESC") firstrow clear
rename ABBead CountBead
rename ABCopperMetal CountCoppermetal
rename ABCopperObject CountCopperobj
rename ABCrucible CountCrucible
rename ABFinalProductMold CountFinalprodmold
rename ABFurnaceFragment CountFurnfrag
rename ABIngot Countingot
rename ABIngotMold Countingotmold
rename ABMold Countmold
rename ABOre Countore
rename ABPin Countpin
rename ABPlaster Countplaster
rename ABPrill Countprill
rename ABSlag Countslag
reshape long Count, i(Room) j(type, string)
gen desc = 1
save "Z:\FinalPottery\Metalceramicandfaunal\artifactdesc.dta", replace
import delimited Z:\FinalPottery\Metalceramicandfaunal\Calcbyroom.csv, clear
rename abhj Counthj
rename abbl Countbl
rename abjg Countjg
rename abjr Countjr
rename abkr Countkr
rename abcook Countcook

```

```

rename abld Countld
rename ablp Countlp
rename abpl Countpl
rename absj Countsj
rename abvt Countvt
rename abcalcserving Countservring
rename abcalcprep Countprep
rename abcalcstor Countstorage
reshape long Count, i(room) j(type, string)
rename room Room
save "Z:\FinalPottery\Metalceramicandfaunal\pottery.dta", replace
import delimited Z:\FinalPottery\Metalceramicandfaunal\BoxlistRoomchaine.csv, clear
rename abproduct Countproduct
rename abproduction CountProduction
reshape long Count, i(room) j(type, string)
rename room Room
gen metalchaine = 1
save "Z:\FinalPottery\Metalceramicandfaunal\metalchaine.dta", replace
import delimited Z:\FinalPottery\Metalceramicandfaunal\BoxlistRoomkind.csv, clear
rename abceramic Countceramic
rename abmetal Countmetal
rename abore Countore
rename abslag Countslag
reshape long Count, i(room) j(type, string)
rename room Room
gen metalmaterialtype = 1
save "Z:\FinalPottery\Metalceramicandfaunal\metalkind.dta", replace
append using "Z:\FinalPottery\Metalceramicandfaunal\metalchaine.dta"
append using "Z:\FinalPottery\Metalceramicandfaunal\pottery.dta"
append using "Z:\FinalPottery\Metalceramicandfaunal\Faunal120room.dta"
append using "Z:\FinalPottery\Metalceramicandfaunal\artifactdesc.dta"
drop RevStrat
drop revstrat
compress
save "Z:\FinalPottery\Metalceramicandfaunal\beforecode.dta", replace
encode type, gen(Type)
recode Type (36 33 30 = 1), gen (ceramicfunction)
recode Type (13 15 16 19 20 21 22 23 28 34 37 = 1), gen (ceramickind)
recode Type (10 9 12 = 1) (else = 0), gen (animalsize)
recode Type (3 = 1) (else = 0), gen (boneweight)
recode Type (2 = 1) (else = 0), gen (bonecount)
gen integer = round(Count)
encode Room, gen(room)
drop if room == 70 | room == 71 | room == 72 | room == 73 | room == 67 | room == 48 | room == 43 |
room == 38 | room == 37 | room == 20 | room == 2 | room == 3
recode room (24 25 26 27 29 30 31 32 33 34 35 36 49 50 51 54 66 68 = 1), gen (areah)
label define Type 32 "FinalProduct", modify
export excel using "Z:\FinalPottery\Metalceramicandfaunal\finaldata.xls", replace
*master
*ca room Type [fwe=integer] if desc != 1 & metalmaterialtype != 1 & ceramickind != 1 & boneweight
!= 1 & bonecount !=1 & metalchaine != 1 & animalsize != 1 & ceramicfunction != 1
*Ceramics by simp function and production or product
ca room Type [fwe=integer] if desc != 1 & metalmaterialtype != 1 & ceramickind != 1 & boneweight
!= 1 & bonecount !=1 & animalsize != 1

```

```

cabipplot, scale (.75) origin title("CA of Ceramic Function MxNV and Chaine Stage")
graph save "Z:\FinalPottery\Metalceramicandfaunal\functionchain.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\functionchain.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionchain.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionchain.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionchain.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*Ceramics Simp function and animal size
ca room Type [fwe=integer] if desc != 1 & metalmaterialtype != 1 & ceramickind != 1 & boneweight
!= 1 & bonecount !=1 & metalchaine != 1
cabipplot, scale (.75) origin title("CA of Ceramic Function MxNV and Animal Count by size")
graph save "Z:\FinalPottery\Metalceramicandfaunal\functionanimalsize.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\functionanimalsize.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionanimalsize.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionanimalsize.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionanimalsize.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*Ceramics simple metal material type
ca room Type [fwe=integer] if desc != 1 & ceramickind != 1 & boneweight != 1 & bonecount !=1 &
metalchaine != 1 & animalsize != 1, dim (3)
cabipplot, scale (.75) origin title("CA of Ceramic Function MxNV and Metal Production Materials
Type")
graph save "Z:\FinalPottery\Metalceramicandfaunal\functionmetaltype.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\functionmetaltype.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionmetaltype.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionmetaltype.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionmetaltype.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*Ceramics simple artifact desc
ca room Type [fwe=integer] if metalmaterialtype != 1 & ceramickind != 1 & boneweight != 1 &
bonecount !=1 & metalchaine != 1 & animalsize != 1, dim (5)
cabipplot, scale (.75) origin title("CA of Ceramic Function MxNV and Artifacts")
graph save "Z:\FinalPottery\Metalceramicandfaunal\functionArtifacts.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\functionArtifacts.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionArtifacts.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionArtifacts.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionArtifacts.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*Production chaine and bone count
ca room Type [fwe=integer] if desc != 1 & metalmaterialtype != 1 & ceramickind != 1 & boneweight
!= 1 & animalsize !=1 & ceramicfunction != 1
cabipplot, scale (.75) origin title("CA of Animal Bone Count and Chaine Stage")

```

```

graph save "Z:\FinalPottery\Metalceramicandfaunal\bonecountchain.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\bonecountchain.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bonecountchain.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bonecountchain.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bonecountchain.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*bone count and description
ca room Type [fwe=integer] if metalchaine != 1 & metalmaterialtype != 1 & ceramickind != 1 &
boneweight != 1 & animalsize !=1 & ceramicfunction != 1
cabipLOT, scale (.75) origin title("CA of Animal Bone Count and Artifacts")
graph save "Z:\FinalPottery\Metalceramicandfaunal\bonecountArtifacts.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\bonecountArtifacts.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bonecountArtifacts.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bonecountArtifacts.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bonecountArtifacts.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room Type [fwe=integer] if metalmaterialtype != 1 & boneweight != 1 & metalchaine != 1 &
animalsize != 1 & ceramicfunction != 1
cabipLOT, scale (.75) origin title("CA of Animal Bone Count, MxNV of Ceramics and Artifacts")
graph save "Z:\FinalPottery\Metalceramicandfaunal\complexall.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\complexall.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\complexall.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\complexall.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\complexall.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room Type [fwe=integer] if desc != 1 & ceramickind != 1 & boneweight != 1 & bonecount !=1 &
metalmaterialtype != 1
cabipLOT, scale (.75) origin title("CA of Animal Count by Size, MxNV of Ceramics by Function and
Artifacts by Production Stage")
graph save "Z:\FinalPottery\Metalceramicandfaunal\simpleall.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\simpleall.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\simpleall.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\simpleall.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\simpleall.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room Type [fwe=integer] if metalmaterialtype != 1 & ceramickind != 1 & boneweight != 1 &
metalchaine != 1 & animalsize != 1 & Type != 1 & Type != 29, dim (5)
cabipLOT, scale (.75) origin title("CA of Animal Count, MxNV of Ceramics by Function and Artifacts
Aassociated with Metal Production")
graph save "Z:\FinalPottery\Metalceramicandfaunal\bonecountfunctionmetalprod.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\bonecountfunctionmetalprod.png", wid(3500)
replace

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cabipplot, dim(3 1) scale (.75) origin title("CA of Animal Count, MxNV of Ceramics by Function and
Artifacts Aassociated with Metal Production - Dimension 3")
graph save "Z:\FinalPottery\Metalceramicandfaunal\bonecountfunctionmetalproddim3.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\bonecountfunctionmetalproddim3.png",
wid(3500) replace
cabipplot, dim(4 1) scale (.75) origin title("CA of Animal Count, MxNV of Ceramics by Function and
Artifacts Aassociated with Metal Production - Dimension 4")
graph save "Z:\FinalPottery\Metalceramicandfaunal\bonecountfunctionmetalproddim4.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\bonecountfunctionmetalproddim4.png",
wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bonecountfunctionmetalprod.xls", sheet(GSC,
replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bonecountfunctionmetalprod.xls", sheet(GSR,
replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bonecountfunctionmetalprod.xls", sheet(tablestats,
replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room Type [fwe=integer] if metalmaterialtype != 1 & ceramickind != 1 & boneweight != 1 &
bonecount !=1 & metalchaine != 1 & animalsize != 1 & ceramicfunction != 1 & Type != 1 & Type !=
29, dim (5)
cabipplot, dim(4 1) scale (.75) origin title("CA of Metal Production")
graph save "Z:\FinalPottery\Metalceramicandfaunal\metalprod.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\metalprod.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\metalprod.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\metalprod.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\metalprod.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
*Area H Stuff
drop if room == 1
ca room Type [fwe=integer] if areah == 1 & metalmaterialtype != 1 & ceramickind != 1 & boneweight
!= 1 & bonecount !=1 & metalchaine != 1 & animalsize != 1 & ceramicfunction != 1 & Type != 1 &
Type != 29, dim (5)
cabipplot, dim(3 1) scale (.75) origin title("CA of Metal Production - Area H - Dim 3")
graph save "Z:\FinalPottery\Metalceramicandfaunal\metalprodareahdim3.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\metalprodareahdim3.png", wid(3500) replace
cabipplot, scale (.75) origin title("CA of Metal Production - Area H")
graph save "Z:\FinalPottery\Metalceramicandfaunal\metalprodareah.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\metalprodareah.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\metalprodareah.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\metalprodareah.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\metalprodareah.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca room Type [fwe=integer] if areah == 1 & metalmaterialtype != 1 & ceramickind != 1 & boneweight
!= 1 & bonecount !=1 & metalchaine != 1 & animalsize != 1 & Type != 1 & Type != 29, dim (5)

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cabiplot, dim(3 1) scale (.75) origin title("CA of Metal Production and Ceramic Function - Area H -
Dim 3")
graph save "Z:\FinalPottery\Metalceramicandfaunal\functionmetalprodareahdim3.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\functionmetalprodareahdim3.png", wid(3500)
replace
cabiplot, scale (.75) origin title("CA of Metal Production and Ceramic Function - Area H")
graph save "Z:\FinalPottery\Metalceramicandfaunal\functionmetalprodareah.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\functionmetalprodareah.png", wid(3500) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionmetalprodareah.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionmetalprodareah.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\functionmetalprodareah.xls", sheet(tablestats,
replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
import excel "Z:\FinalPottery\Metalceramicandfaunal\Faunal120roomtotal.xlsx",
sheet("Faunal120room") firstrow clear
encode Room, gen(room)
encode Area, gen(area)
encode H, gen(bone)
encode TAXON , gen(taxon)
encode SkeletalGroup , gen(bodypart)
recode bodypart (3 5 = 4), gen(bodylimb)
label values bodylimb bodypart
ca taxon room if area == 2 & room != 15 & room != 31 & room != 62 & room != 63 & room != 43 &
room != 44 & room != 45 & room != 2 & room != 3 & room != 48 & room != 4 & room != 67 & taxon
!= 4 & taxon != 6 & taxon != 7 & taxon != 9 & taxon != 10 & taxon != 11 & taxon != 12 & taxon != 13
& taxon != 14 & taxon != 16
cabiplot, scale (.75) origin title("CA of Animal Type")
graph save "Z:\FinalPottery\Metalceramicandfaunal\animaltype.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\animaltype.png", wid(4000) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\animaltype.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\animaltype.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\animaltype.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca bodypart room if area == 2 & room != 15 & room != 31 & room != 62 & room != 63 & room != 2 &
room != 3 & room != 48 & room != 4 & room != 67 & room != 43 & room != 44 & room != 45 & taxon
!= 4 & taxon != 6 & taxon != 7 & taxon != 9 & taxon != 10 & taxon != 11 & taxon != 12 & taxon != 13
& taxon != 14 & taxon != 16
cabiplot, scale (.75) origin title("CA of Animal Part")
graph save "Z:\FinalPottery\Metalceramicandfaunal\bodypart.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\bodypart.png", wid(4000) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bodypart.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bodypart.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bodypart.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))

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ca bodylimb room if area == 2 & room != 15 & room != 31 & room != 62 & room != 63 & room != 2 &
room != 3 & room != 48 & room != 4 & room != 43 & room != 44 & room != 45 & room != 67 & taxon
!= 4 & taxon != 6 & taxon != 7 & taxon != 9 & taxon != 10 & taxon != 11 & taxon != 12 & taxon != 13
& taxon != 14 & taxon != 16
cabiplot, scale (.75) origin title("CA of Animal Part")
graph save "Z:\FinalPottery\Metalceramicandfaunal\bodylimbpart.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\bodylimbpart.png", wid(4000) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bodylimbpart.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bodylimbpart.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bodylimbpart.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))
ca bone room if area == 2 & room != 15 & room != 31 & room != 62 & room != 63 & room != 2 &
room != 3 & room != 48 & room != 4 & room != 43 & room != 44 & room != 45 & room != 67 & taxon
!= 4 & taxon != 6 & taxon != 7 & taxon != 9 & taxon != 10 & taxon != 11 & taxon != 12 & taxon != 13
& taxon != 14 & taxon != 16
cabiplot, scale (.75) origin title("CA of Animal Bone")
graph save "Z:\FinalPottery\Metalceramicandfaunal\bone.gph", replace
graph export "Z:\FinalPottery\Metalceramicandfaunal\bone.png", wid(4000) replace
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bone.xls", sheet(GSC, replace)
putexcel A1=matrix(e(GSC)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bone.xls", sheet(GSR, replace)
putexcel A1=matrix(e(GSR)), names
putexcel set "Z:\FinalPottery\Metalceramicandfaunal\bone.xls", sheet(tablestats, replace)
putexcel A1=("Observations") B1=(e(N)) A2=("Dimensions") B2=(e(inertia)) A3=("Percent Intertia")
B3=(e(pinertia)) C1=("Chi-Sq Stat") D1=(e(X2)) C2=("p-value") D2=(e(X2_p))

```

Appendix 2: Analyzed Diagnostic Data

Supplementary file: [Gidding_AnalyzedDiag_Appendix2.csv](#)

Appendix 3: Ceramic Bulk Data from KHI

Gidding_FinalBulk_Appendix3.csv

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