

On the Chopping Block: Animal Butchery Technologies in Old Kingdom Egypt

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Abstract

The development of an egalitarian to a complex society has often been studied from the perspective of social development (i.e. social stratification, specialisation, resource intensification) and the impact of aspects of daily life are left marginally explored. This study aims to explain how the development of metallurgy, particularly the adoption of metal-based tools, played an important role in early complex societies by acting as a driver for social stratification. Specifically, the study examines whether stone or metal based blades were utilized in animal butchery during the Old Kingdom in Egypt.

To test the hypothesis that stone or metal tools were employed during the Old Kingdom in Egypt, slice marks on animal bone are examined for diagnostic characteristics that allow for the determination of stone or metal blades used in animal butchery practices. The faunal assemblage from the Kromer Dump at Giza is chosen as a sample for this study. The assemblage derives from the Quarry Settlement at Giza where some of the pyramid workers resided during the construction of the pyramids of Kings Khafra and Menkaure of the 4th Dynasty. It was within this faunal assemblage that an abundant quantity of butchered bones with slice marks were found. The slice marks were identified according to diagnostic criteria established by previous authors, mainly that of Haskel Greenfield who examined the development of metallurgy over broad swaths of the Old World, including neighbouring southern Levant. The results demonstrate that stone-based blades were used for animal butchery at the Quarry Settlement at Giza during the Old Kingdom and that metal-based blades were not adopted for quotidian activities.

These results suggest that metal objects were reserved for individuals of higher status and in fact acted as mechanisms to maintain the social stratification as a symbol of status and wealth. The individuals of lower strata (i.e. butchers) likely did not have access to such rare commodities during this time as a result of their social status. This thesis demonstrates that the development of metallurgy played an important role in social complexity in Egypt, but that the adoption of metal for various purposes occurred for quotidian purposes occurred much more slowly.

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Dedication

To my partner Sean, for encouraging me to take the first step and giving me unconditional support. Thank you.

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Chapter 1: Introduction

1.1 Introduction

This thesis examines animal butchery marks from the Old Kingdom site of the quarry settlement at Giza to determine if they were made by stone or metal tools. This is significant because current knowledge of the spread and adoption of metallurgy for daily life (quotidian) activities has been long dependent on the survival of odd pieces of bronze or copper metal objects in the archaeological record. The replacement of stone, development of metallurgy, and the impact either had on ancient Egyptian society cannot be completely understood simply by examining the material culture alone (specifically flint and metal tools). The metal (copper-based) record is biased through the limited depositional contexts, and the likely reuse and melting down of metal objects. Hence, a new means needs to be developed to document and understand the shift from stone to metal technologies. Since ancient Egyptians domesticated, raised, and butchered animals for food, it is useful to examine the fauna that were slaughtered and butchered. The tools used to slaughter animals produced marks on the bones that can be studied to identify whether the animals were butchered with flint or metal-based blades. In this thesis, the development of utilitarian metallurgy and its replacement of chipped stone tools for butchering in Old Kingdom Egypt is explored from a zooarchaeological perspective.

Egyptian archaeology has been traditionally focused on understanding the meaning behind ancient religion, hieroglyphics, architecture and material culture (e.g. ceramics and stone tools), while the impact of aspects of daily life such as food preparation is left marginally explored. Food can be a key to understanding social status, economy, and social stratification in ancient Egyptian society (Frood 2010: 484; Ikram 1995: 215-216; Janssen 1975; Redding 2010; Wengrow 2005: 46-49). The quantity of evidence related to food in offering-lists, tomb decorations, three-dimensional models, and hieroglyphic inscriptions is extensive, all of which provide information on food production, distribution, and consumption in ancient Egypt. While some research has been done on meat processing in ancient Egypt (e.g. Ikram 1995), there is little consideration for the types of technologies used in the butchering process and their chronology of adoption. It is still not clear when utilitarian metallurgy appears and is widely adopted in Egypt for such quotidian activities.

One way to achieve a new understanding of the process of replacement of chipped stone by metal tools in ancient Egypt is through zooarchaeological methods. Zooarchaeology has long

been used to increase our understanding of the relationships of not only economy (Binford, Mills, and Stone 1988), but also society and politics, such as differences in diet among individuals of different status (Redding 2010). Zooarchaeology can also help our understanding of the evolution of productive specialisation as part of the development of complex society (Campana et al. 2010). The study of technological change from a zooarchaeological perspective allows for a more comprehensive understanding of how the development and/or adoption of certain technologies is shaped by cultural choices in early complex societies. Elsewhere, the application of butchery mark analysis on animal bones has enhanced our knowledge of the use of various tool types in early complex societies (Greenfield 2006, 2008, 2013, 2017).

Metallurgy in Egypt followed a similar line of development as other societies in the Near East. Egypt was a complex society by the time of the Old Kingdom and with it all of the aspects of social development including a stratified society, inequality, and technological advancements. These elements shaped the Old Kingdom and metal became an influencer in maintaining the social structure. Despite this shift, the traditional methods of tool use such as flint continued to be adopted because of the limited accessibility of innovative technologies to the elite class. It is unclear if metal use during the Old Kingdom is limited to the elite or also used by the lower strata of society for daily domestic activities. The zooarchaeological approach for determining the nature and frequency of metal or stone tools through the analysis of butchery marks can be applied to fill in this gap.

An important site where social complexity is evident among flint and metal use is at Giza, Egypt. Giza was an important site during the time of the Old Kingdom (Early Bronze Age) for the construction of the pyramids and funerary complexes of the kings where areas were divided according to status. However, this thesis aims at taking a different approach from the narrative of kings or monumental building and instead, focuses on the social impact the state had upon the population of Egypt through tool development and how the use (or lack thereof) of metal acted as a driver to maintain the status quo in society.

In light of this approach, slice marks on animal bone from Giza are examined to understand which tool types were used in animal butchery. The collection of flint, metal, and animal butchery at Giza makes it an ideal site for the study of metallurgy.

1.2 Theoretical background: Characteristics of complex societies

“The task of archaeology is to find the mechanisms that produce change from one form of

social integration to the next” (Paynter 1989: 373). The article by Paynter on “the archaeology of equality and inequality” discusses how social complexity was a natural shift for populations who live in egalitarian societies. While other scholars have theorised about the evolution of society (Johnson 2020), it was the neoevolutionist approach (Adams and Kasakoff 1975; Adams 1974; Blau 1977; Flannery 1972) that provoked questions about social equality and inequality and other archaeological theories (Dunnell 1982; Hodder 1982; Patterson and Gailey 1987; Paynter 1989; Schiffer 1988; Spriggs 1984; Wright 1986). The neoevolutionary theory considers the presence of equality in simple societies and that individuals “achieved social integration with little social differentiation” (Flannery 1972: 89), while inequality is found in societies where integration is based on a hierarchical system (complex society) (Adams and Kasakoff 1975; Blau 1977; Flannery 1972).

Let us consider the above quote by Paynter in relation to the research conducted in this thesis. Our task as archaeologists is to “find the mechanisms that produce change from one form of social integration to the next” (Paynter 1989: 373). The change from an egalitarian society to a complex society in Egypt affected socioeconomic dynamics. Socioeconomic differentiation is a characteristic of complex societies (Adams 1966; Baines and Yoffe 1998; Johnson and Earle 1987; Paynter 1989) and defined as,

Differential access to and/or control of economic, productive, or symbolic resources and the mechanisms of enhancing socioeconomic status and the methods of displaying it, and the existence of economic and social mobility within a given social system, through the operation of agency, entrepreneurship, and the manipulation of other factors (Richards 2005: 13).

At the heart of this quote lies an important ideology that the use of metal in ancient Egypt directly reflects - the idea of a “mechanism” acting as a driver in social change. The concept of metal as a mechanism for social change is exemplified in the development and use of metal in ancient Egypt, chiefly as an agent in differential access to resources and enhancing individual status. Two concepts derive from this socioeconomic differentiation. First is the presence of differential access to or control of economic, productive, or symbolic resources and second, the mechanisms of enhancing socioeconomic status and the methods of displaying it. The development of metallurgy and the adoption of metal-based tools is in fact, a mechanism that influenced social change in Egypt, where individuals obtain the ability to integrate within the higher parts of society. In fact, funerary goods are directly linked to social integration within the

hierarchical system. For example, the display of metal tools among funerary goods, including knives that resemble ritualistic animal butchering, symbolised socioeconomic status. The state was heavily involved in the production of metal and this enabled an exclusiveness to metal resources and in turn, resulted in metal objects acting as symbols of identity and status (see Chapter 5).

1.3 Old Kingdom Egypt – Chronology and Society

The shift from one social integration (simple) to the next (complex) occurred during the Early Dynastic and Old Kingdom periods in Egypt (Wenke 1989). Egypt was a complex society in the Old Kingdom when social stratification was the core of the social structure. The king was at the top of the hierarchical pyramid and viewed as a direct successor of the gods (Horus and Re) which provided him with a number of ways to exercise his dominance and power over the population which included acting as a symbol between good and evil (Egyptian *ma'at*) (Wilkinson 2010: 54; Malek 2010: 92-94; Baud 2010: 63-65). Old Kingdom nobles, court members, and individuals of high profession (priests, nomarchs, administrators, scribes, etc.) mediated between the king and the majority of the population with political agendas as their objective (Strudwick 1986; Malek 2010: 95; Roth 1991). The lower strata of society were made up of farmers, labourers, craftsmen, butchers, weavers, potters, and the like. Despite extensive archaeological evidence for the upper strata of society, little is known about the 'daily folk' and how they lived their day to day lives in the Old Kingdom.

Memphis was the royal capital during the Old Kingdom and key settlements in the Delta and Nile Valley contributed to the greater economy and society of Egypt through farming and cattle rearing (Kom el-Hisn: Wenke et. al. 2016), as religious centres (Heliopolis: Nuzzolo and Krejci 2017, and Bubastis: Lange 2013), frontier borders and trade (Elephantine: Kopp 2006; Buhen: O'Connor 2014; Tell el-Farkha: Chlodnicki 2012). Contributions to the state were received in the form of temple benefits, taxation, and labour - all of which supported the bureaucracy of Egypt (Muhs 1999; Wilkinson 2010: 54).

The various social ranks in Egypt's complex society was not exclusive to an upper (elite) class and lower class. In fact, the shift into a complex society typically increases social stratification and inevitably, a middle class or group develops that lies between the small elite and the lower general population in the social structure (Richards 2005: 15). The presence of a middle elite class is certainly present in ancient Egyptian society. One instance is a subclass of

wealthy peasants who were connected to subsistence activities (Richards 2005; see Johnson and Earle 1987). It is within this class that another ideology of complex societies arises – a gradual freeing of the peasantry (lower society) where individuals and groups who rely on the feudal state level and are essentially controlled by the upper level of society, now gain autonomy within society and independent access to resources (Richards 2005: 15; see Johnson and Earle 1987). At the dawn of the Old Kingdom, a group of “sub-elite” individuals began to obtain prominence including those who were among military personnel, priests, and dignitaries (nobles). These individuals were wealthy, connected to court members, and had a sense of power.

The presence of “wealthy peasants” for instance is attested in ancient Egyptian texts and demonstrate that opportunities existed for individuals in lower strata to be “freed” from peasantry by taking advantage of agricultural resources (Wilbour Papyrus, Brooklyn Museum 34.5596.4; cf. Gardiner 1948; Hayes 1955; Moreno Garcia 2019). These sub-elite individuals were cultivators who supervised the cultivation of temple and crown agricultural land of about 30-50 hectares and had a variety of resources available (Moreno Garcia 2019: 97). Through the management of agricultural land, these “entrepreneurs” had the ability to rise up the social ranks in ancient Egypt (Moreno Garcia 2019: 97). The Wilbour Papyrus exemplifies this by mentioning cultivators as land holders of temple land. Some of these individuals were able to afford prestigious items typically reserved for elite individuals and become involved within temple activities to secure their social position (Moreno García 2016: 229). Wealthy peasants are just one example of the many advantageous position’s individuals acquired in hopes of obtaining prominence in ancient Egyptian society. As Richards (2005) mentioned, a factor in the gain of autonomy and access to resources are “the existence of ideological flexibility regarding social categories and of economic mobility within the system – and the methods by which both are operationalised” (Richards 2005: 15). By the Old Kingdom, the beginning of “independent access to resources” resulted from an increase in social mobility among the lower and middle class.

1.4 Social mobility in ancient Egypt

Social mobility was thus the consequence of internal dynamics that led to continuous rearrangements of economic, cultural, political, and social resources that preserved inequality and culminated in instability in the long term (Moreno García 2018: 1).

This statement by Garcia summarises well the political landscape of the Old Kingdom,

particularly the administrative changes that occurred to maintain a stratified society and that preserved the inequality among the social classes (see chapter two). However, as the statement highlights, social mobility was likely the main factor for the instability that ended the Old Kingdom.

Social mobility in ancient Egyptian society was limited. The hierarchical system present in the Old Kingdom consisted of social ranks or positions that were complex higher strata based on wealth and connection to the state which were at times ‘informal hierarchies based on patronage rather than on official functions’ (Garcia 2018: 1). Elite individuals can be categorised by those who were wealthy, literate, provided service to the king, received benefits from the king or were associated with the temple (i.e. priests) (Garcia 2018). Positions at this level included the treasurer, nomarch, and overseer who were highly valued by the crown.

Beneath the ruling elite were individuals whose duties were versed and involved a kind of duality in their positions. Producers and cultivators for instance were both farmers and land holders, or agricultural managers, while priests who mainly conducted religious activities also were involved in secular duties (Garcia 2018). Such flexibility within the social structure demonstrates how social mobility in ancient Egypt was conceivable under particular circumstances such as connection to the court and literacy. The *onomastica* is a pharaonic document that exemplifies this as it catalogues positions of Egyptian society including deities, royals and nobles, state administration, and who were wealthy and considered children/descendants of the king who also had their own administrators of wealth on behalf of the state (For information on elite individuals in the Old Kingdom see Gardiner 1947; Garcia 2018: 1; for Old Kingdom administrators see Kanawati 1980).

Literacy in particular, provided “access to the managerial realms of society (with their associated enhanced access to resources” (Richards 2005: 15). Scribes were among the literate sub-elite class who for some were wealthy enough to afford private statuary (e.g. The Seated Scribe, Louvre E3023). A 19th Dynasty text called *The Instruction of Dua-Kheti* exemplifies ancient Egyptian mentality on the need for literacy *and* good service to the court (in this case one of a scribe) to obtain a prestigious social position (Litchtheim 1973: 184). The text demonstrates that social mobility in ancient Egyptian society was consequently based on internal relations with elite individuals and a particular behaviour towards the court.

It is only within this sub-elite class where social mobility is visible. The wealthy peasants

example discussed above demonstrates how opportunities increased for individuals who were wealthy by participating in a national or localised market system (Johnson and Earle 1987: 279). The mobility within the social latter, occurs when “empowered groups manipulate the built environment to construct and maintain relations of social inequality, and therefore, patterning in the built environment reflects patterning in the society” (Richards 2005: 16; also see Paynter 1989). In this belief, consumption patterns reflect the differential access to resources upon which stratification rests and hence the structure that generated them (Costin and Earle 1989; Richards 2005: 16).

Social mobility consequently affected accessibility to expensive resources such as copper. The cost of the product was not strictly monetary, but perhaps directly related to the value of the individual according to their social status. Although there were limited means to achieve higher ranking, the majority of ancient Egyptian society likely did not have access to resources or tools (such as copper or bronze knives) afforded to those of valued professions. Despite a possible rise of a middle class later in the Middle Kingdom (Richards 2005), the population of the Egyptian Old Kingdom resided in a relatively immobile society where the combination of status and wealth provided the means to have access (i.e. purchase) special grave goods and perhaps particular tools for animal butchery.

1.5 Social differentiation and inequality in ancient Egyptian society

Inequality exists when socially distinct entities have differential access to strategic resources, and this differentiation gives those with access the ability to control the actions of others (Paynter 1989: 369-70).

Social stratification and inequality are present in ancient Egyptian society. These concepts are reflected through individuals of the court or valued social professions who were in advantageous positions that offered direct lines to power and wealth (Hoffman 1979; Moreno García 2018: 1-2; Trigger 1993: 55-69; 2003). As a result, an individual’s social rank in Egyptian society afforded them access to economic wealth and expensive products (Richards 2005). This is evident in the funerary landscape of ancient Egypt where higher ranking individuals demonstrated their wealth and status in the grave goods placed with them (Richards 2005).

How resources are accessed and distributed can be used as a measure of social and economic differentiation (Childe 1936; Cohen 1978; Fried 1967; Johnson and Earle 1987; Richards 2005: 13-18; Service 1975). This implies that an imbalance exists in access to resources between

members of a complex society (Richards 2005; Paynter 1989: 369-70; Trigger 1993). The differential access to strategic resources fosters social hierarchy through the provision of economic power and the legitimisation of positions (Costin and Earle 1989: 691; Richards 2005: 14). The result of this division in economic power and social positions is social stratification (Adams 1966; Johnson and Earle 1987: 157), which is associated with the “cross-cutting of society into political/economic classes” (Richards 2005: 14).

The court and higher status members of society were at the core of ancient Egyptian technological developments and had access to rare and expensive resources such as metal (Moorey 2001). In fact, “differential access to certain goods confers real economic power and legitimises existing social hierarchies” (Costin and Earle 1989: 691). In Egypt, most copper objects from the Old Kingdom are either used for state projects (such as the pyramid construction) or placed in burials of individuals in the higher spectrum of the hierarchical society. Moreover, archaeological evidence implies that the production of early metal (copper) was heavily guarded by the state and its production limited to specialised craftsmen (Odler 2016: 30, 135-149; Roth 1991; Strudwick 1985: 284; Wilson 1938: pl. 32-33). The supervision of copper by the state is suggestive that metal was a resource restricted to those with the means of obtaining it (i.e. wealth or by a connection to the state). The display (or use) of metal therefore Metallurgy therefore, served to justify one’s position in the higher ranks of society.

1.6 Technology and innovation – a social process

Technological change...is not always a progressive sequence of innovations but can also be characterised by continued use of traditional methods or artefacts, and even the surprisingly frequent re-introduction of techniques that might be assumed to become outmodeled (Shaw 2012:1).

This statement by Ian Shaw brings the work of Edgerton (2008) into context of ancient Egyptian technology and innovation. Shaw (2012) stresses how technological advancements are heavily influenced by traditional and progressive viewpoints. The idea that technology “has been responsible for keeping things the same as much as changing them” (Edgerton 2008: 212), is present in the Early Bronze Age with the shift from stone to metal-based tool technologies, particularly in the realm of animal butchery.

The Old Kingdom marks a period of major advancement for Egypt. Massive monumental architecture that required plentiful resources and a large labour force were commissioned by the

kings and foreign missions expanded the borders of Egypt and provided means of trade for luxury items and resources (Baud 2010; Wenke et al. 2016). These projects sparked technological advancement (Shaw 2012: 19-23, 68-76; Trigger et al. 1983: 85-92) and innovative technologies such as the development of alloyed copper begin to appear during this time (Cowell 1986; Garland 1927; Lucas 1927; Odler 2016; Ogden 2000; Scheel 1989).

The Early Bronze Age is defined by the appearance of metal objects, more specifically the adoption of copper and early bronze materials in craft production. However, the transition from Chalcolithic to the Early Bronze Age in the development of societies is a slow process that differs between cultures. One of the reasons for this slow process is that the evolution of technologies often involves traditional and innovative approaches that can be both adopted until the innovative form becomes widespread (Shaw 2012). Early metallurgy in the Levant for instance, has proven to be a slow transition that took millennia to fully replace stone tools (Baumgartel 1960: 10-16; Greenfield 2008: 1644; Greenfield 2013; Greenfield 2017; Needler 1984: 280-2; Payne 1993: 146, cat. 1215-20; Rosen 1996; Wengrow 2006: 38-39, cat. 180-3). Traditional methods of tool use (i.e. flint) continue across the Near East well into the later Bronze Age, but the ratio between stone and metal changes over time with a decrease of stone use (Greenfield 2017). In Egypt this is exemplified in the production of a number of crafts such as pottery, glass, and metal (Shaw 2012). Much like neighbouring cultures, the adoption of metal-based tools in Egypt was a slow transition that was adopted alongside flint tool use with copper dominating the archaeological record (over flint) beginning in the Middle Kingdom with an almost absolute adoption in the New Kingdom (Graves-Brown 2010: 97).

The study of copper in the Chalcolithic and Early Bronze Age has proven to be useful in understanding how social factors were involved in the process (Greenfield 2017, 2000). Technology in Egypt developed as a product of social production and really became integral within ancient Egyptian society (Bourriau and Phillips 2004; Lemonnier 1993: 26; Mathieu et al. 2006; Shaw 2012; Shortland 2001; Wengrow 2005). In fact, the first uses of copper in Egypt were cosmetic (Lucas 1959: 245-249). The production of copper in Egypt was multi-layered with individuals at various levels of society including miners, metalsmiths, overseers, administrators and transporters. It is important to note however, that despite the fact that metal production involved a number of individuals from social ranks, its production was heavily guarded by the state and such precious objects were only accessible to those of higher status and wealth. The

development of metallurgy therefore, mirrored the hierarchical structure prevalent in pharaonic Egypt and dominant in the Old Kingdom. In this view, the process of metallurgy is very much integrated, even a reflection, of Old Kingdom society – “keeping things the same as much as changing them” as Edgerton stated to describe technological advancements in complex societies (Edgerton 2008: 212).

1.7 Early copper and bronze production in the Near East

The introduction of copper is characteristic of the Early Bronze Age and its presence is often used to measure significant changes within a society. Early metallurgy in Egypt had its roots in the Levant (Greenfield 2008b: 1639-1647; Muhly 1980, 1988; North 1955; Tylecote 1987; Tylecote 1992) where early production of copper began during the Pre-pottery Neolithic and quickly spread throughout the Near East. During the Chalcolithic period, copper metallurgy is rapidly adopted throughout the Near East. The alloying of copper with other metals (arsenic and tin) later became an innovation that strengthened the material and made it more widely usable than its predecessor (Greenfield 2008: 1640). Consequently, it is during the Early Bronze Age in the Levant that the presence of metal begins to increase (Rosen 1984), but it is not until the Middle Bronze Age that metallurgy begins to become truly quotidian across the Near East and beyond (Greenfield 2008: 1643, 2013, 2018). In Egypt, this is associated with the Middle and New Kingdoms.

1.8 Early copper production in Egypt in the Early Bronze Age

The development of metallurgy influenced changes within Egyptian Old Kingdom society. As discussed above, Egypt was a complex society during this time, which had a differential social structure based on integration within hierarchical levels. In this idea, the use of metal is a powerful symbol of identity and status for an individual. This begs the question, how is the adoption of metal objects an example of identity and status? What does the development of metallurgy inform us about complex societies?

The earliest recorded mining expedition occurred in the 1st Dynasty (likely by Semerkhet) in the Sinai region (Lucas 1927: 167). Inscriptions from mining or production sites suggest that extensive mining operations occurred from Dynasty 1 to Dynasty 6 of the Old Kingdom (Lucas 1927; Emery 1963; Klemm 2008:1685). Copper became a highly desired commodity by the 3rd dynasty and as a result, the Egyptian court secured “control over the copper mines of south-western Sinai” (Wengrow 2005: 147; also see Stager 1992: 35). An extensive number of sites in

the Sinai and Eastern Desert have given archaeological evidence of early copper working including the areas of Gebel Safariat (at Senned and Nebk-Sherm), Wadi Araba, Mt. Gebel Dara, Mt. Gebel Atawi, Hamish, Hamamid, Abu Seyal, and Buhen in the south where a copper smelting production area contained three furnaces (Muhly 1999: 630; Lucas 1927: 163-165). The royal agenda to control copper mining and production in the Old Kingdom shows a direct interest in reserving resources for the use of Egypt, which was likely for the royal court and elite (Baud 2010: 72; Mumford 2010: 347; Tillman 1999: 314). The expansion of copper production during the Old Kingdom was still not at a level that allowed for widespread use and therefore was likely scarce and expensive and restricted to particular activities such as in funerary practices (i.e. model replicas of symbolic objects) which consequently aided in the limited use of copper during this time (Lucas 1927: 167).

The exclusiveness of copper mining undertaken by the state exemplifies a desire to reserve copper (metal) resources to the state, that in turn nourished an ideology of elitism among the product. This corroborates with Paynter's statement of how socially distinct entities have differential access to strategic resources that in turn provide them with the ability to control the actions of others (Paynter 1989: 369-70). It is difficult to measure how control of individuals (or populations) is related to metallurgy in the Old Kingdom but as described above, metal objects were mechanisms of identity and status. It is within this ideology where control can be seen as agency, that is – metal is used to symbolise status, power, and control. As the Old Kingdom administration worked to solidify its position within Egypt and abroad (Chapter 2), metal use provided a means of exclusiveness to those in elite (or sub-elite) positions.

1.9 Copper consumption in Old Kingdom Egypt

The consumption of copper during the Old Kingdom is evident in two contexts: household and funerary. The evidence for household consumption of copper objects is scarce for the time period but a few exceptions have been found that are mostly isolated finds (Odler 2016). The limited evidence of copper use at the lower levels of society for domestic household activities cannot be attributed to any assumptions of the use of copper on a mass scale. Although can be argued that the absence of copper objects in settlement contexts may be due to the melting, reuse, or degrading over time (Greenfield 2008), its absence in household contexts is likely evident of inaccessibility among the lower class.

The near exclusiveness of copper objects to the higher strata of society is most evident among

funerary contexts. Most copper objects from the onset of metallurgical advancement derive from funerary contexts in the Old Kingdom (Petrie 1912, 1913; Muhly 1999; Odler 2016: 66-69). The earliest metal objects appear among grave goods during the Neolithic Badarian period (c.4500-3500 BCE) (i.e. at el-Mustagidda in Grave 596 as copper beads - Scheel 1989: 8; Muhly 1999: 629), and in the Chalcolithic Naqada I-II cultures (c. 4,000-3,200 BCE) (i.e. axes, adzes, chisels, razors, knives) (Needler 1984: 280-2, cat. 180-3; Muhly 1999: 629) and continue into the Early Dynastic, Old Kingdom, and later periods (Odler 2016; Kobusiewicz 2015: 1-2). Copper knives resembling those used in animal butchery have been found in tombs dating from the Early Dynastic and Old Kingdom periods (Maddin et al. 1984; Muhly 1999; Petrie 1913; Odler 2016: 66-69). Although the quantity of copper objects increases during the Old Kingdom, this cannot be confirmed to transcend into quotidian activities. In this regard, copper is viewed as having a symbolic importance during the Old Kingdom Egypt. Whether early copper knives were used in utilitarian activities or strictly for ceremonial purposes is difficult to determine but their exclusiveness to religious contexts and state-run production suggests an agenda to their production which was to feed the elite individuals with status symbols including the crown's use to achieve what may have been perceived as impossible monuments with expensive resources to construct them.

1.10 Keeping things the same – flint use in the Old Kingdom

The limited frequency of copper is coupled with an extensive use of flint tools during the Old Kingdom. The use of flint in Egypt predates the Old Kingdom where in the Predynastic period in particular, exquisite flint objects can be found such as those found in the tomb of King Khasekhemwy of the 2nd Dynasty (Late Naqada period) that included bifacial knives (Angevin 2015). These early objects served as mechanisms for identity and status much like copper when copper was not yet available (Angevin 2015). A shift in the ideology of flint use occurred in the Old Kingdom when flint was no longer viewed as an elite product and the quality of flint knives decreased (Ikram 1995; Graves-Brown 2010), but its use continued to be widespread (Chapter 4). Flint is easily found in Egypt and during its early history, and was acquired through mining or by simply picking up pieces in localised areas (Chapter 4). In contrast to copper use, the use of flint was extensive during the Old Kingdom and various types of blades were produced that could have been used in animal butchery.

While flint was commonly available throughout Egypt, flint blades that were made of mined

flint (as opposed to tabular and other forms) were typically manufactured outside of settlements in specialised workshops during the Old Kingdom. It is unclear if these specialised workshops were state-run, but it is likely that the state was involved at some level. Despite this specialisation, mined flint was available to most of the population, especially those with economic activities related to the state. Unlike copper, the use of flint was adopted among the lower strata of society for a number of activities including animal butchery. In fact, when the archaeological contexts are studied among the zooarchaeological data, a correlation emerges (Chapter 6). Particular types of flint seem to be attributed to particular animals for slaughter.

1.11 Zooarchaeology to solve the metal vs. stone conundrum

The two and three-dimensional butchery scenes are useful for hypothesising animal butchery techniques and the types of tools adopted. There are two issues with relying only on these types of resources for understanding the use of stone or metal in the Old Kingdom. Firstly, they are found depicted (or placed) in tombs whose owners were wealthy enough to afford its commission and secondly, they lack the evidence required to have a good overview of how widespread metal or stone tools were for animal butchery among the entire population.

Zooarchaeological methods are effective in understanding sustenance and diet of past populations (e.g. Redding 2010, 2016), but they can also be used to investigate butchering technologies and activities (Greenfield 1999). The study of a slice marks created as a by-product of butchering activities is based on the morphology of the groove produced in the bone using microscopic analysis. This approach has proven useful in distinguishing between stone and metal material in animal butchering implement. These also allow for the investigation of broader questions related to social and economic development, such as the transition between stone and metal technologies (Binford 1981; Fisher 1995; Greenfield 2006, 2013; Rosen 1984). This technique has proven to be informative in understanding developments within complex societies (Rosen 1984). Results from this type of approach can lead to interesting discussions on the interplay between tool use and social status in ancient Egypt. Therefore, this study aims at applying the study of slice mark morphology on zooarchaeological remains from Giza, Egypt. These analytical methods have been shown to be successful in identifying the development of metallurgy on a local and regional scale (Greenfield 2017). The understanding of the use of metallurgy on a local and regional scale is a good way to fill in the gap in the current knowledge on metal use in ancient Egypt. Chiefly, its influence in ancient Egyptian society in regard to

social status and identity.

1.12 Animal butchery at the pyramid workers village, Old Kingdom Giza

The most prominent necropolis during the Old Kingdom was Giza (Fig. 1.2) (Lehner 2017; Malek 2010: 85). The construction of the largest state projects brought a large workforce from all social strata and occupations (Redding 2013; Lehner: 2017). Years of archaeological research at Giza have recovered a plethora of artefacts, including more than 500,000 pottery fragments, over 1,000 name bearing seal impressions (Nolan 2010), large architectural elements with areas of production, administration, sleeping quarters, and dining areas that supported a large workforce (Lehner 2017).

Zooarchaeological studies of the fauna at Giza have provided useful information on the diet of individuals, but has also been used to identify status and differences in diet according to status (Redding 2010). A large quantity of faunal remains have been excavated from the settlements at Giza (Redding 2013, 1991). These are the remains of food that were consumed by the large workforce required to construct the pyramids at Giza (Redding 2010). Study of animal consumption produced from zooarchaeological data has proven useful for distinguishing differences in diet among individuals of different social strata in Egypt (Redding 2010, 2013). Fish (ex. Nile Perch) and common domesticates (sheep, goat, pig, cattle,), as well as wild game and bird taxa were consumed by the population at Giza (Redding 2010).

Additionally, evidence of chisel marks, slag, and smelting from production areas confirm intensive use of copper at the site (Lehner et. al. 2011; Lehner 2017). Consequently, the study of metallurgical developments during the Old Kingdom is ideal at Giza where butchered fauna, flint blades, and copper production is found.

1.13 The butchered bones from Kromer, Giza

The data selected for the study of this thesis comes from the ancient garbage pit known as the “Kromer Dump” at Giza recently excavated by the AERA team at Giza. The assemblage is contemporaneous with the construction of the pyramids and the quarry settlement of the pyramid workers. The dataset contains an extensive amount of animal bone that had been chopped and sliced during the butchering process. The fact that these bones were butchered to feed a large workforce in a location that had metal produced and circulated for pyramid construction suggests a high potential of metal use in mundane activities such as animal butchery at the site.

1.14 Questions and hypothesis

This thesis aims at answering a number of questions regarding the influence of metallurgy in complex societies. The main research question explored is: *'what are the roles of metal and stone tools in complex societies? How does their relative availability impact socioeconomic differentiation?* These questions lead to important information regarding the impact of the development and adoption of metallurgy in complex societies. Furthermore, *were metal or stone tools differentially available to individuals of all social strata in a complex society?* Such questions provide an innovative line of enquiry where aspects of complex societies that are more poorly known can be investigated.

The Old Kingdom of Egypt is used as a case study to understand these questions. In particular, given the zooarchaeological data that are utilised in this thesis, the following questions can be investigated: *were metal-based (copper) or stone blades adopted in animal butchery during the Old Kingdom?* and *what impact did the presence or absence of metal and stone butchering objects have in Old Kingdom society?*

Therefore, the following testable hypotheses can be framed in light of the zooarchaeological assemblage to be investigated:

1. General - If there is large-scale metal production in the Old Kingdom, then it is expected that butchering with metal tools will dominate on animal bones. It is assumed that the extensive quantity of copper production during the Old Kingdom would lead to a greater use of copper tools, particularly at Giza where evidence of copper production and tool use have been found.
 - a. Specific - If metal tools (i.e. knife blades) are used in the butchery process, then metal butchering marks should be present in the zooarchaeological assemblage.
2. General – If flint for chipped stone tool blades is easily available to the non-elite and less expensive to produce, then flint will be more widely utilised for quotidian activities
 - a. Specific - If chipped stone tools (i.e. knife blades) are used in the butchery process, then stone butchering marks should be present in the zooarchaeological assemblage.

The presence of metal alongside an extensive use of flint in Old Kingdom Egypt makes this time period ideal for the study of the development of metallurgy and to answer broader questions about the impact quotidian tool use had in complex societies. Whether metal was widely adopted

or not during this crucial period in Egyptian history can provide information about the impact metal had upon society such as its role in identity and status during the Old Kingdom.

Copper objects are almost exclusively found in funerary contexts which indicate that it was available to higher members of society, while individuals of the lower strata may not have had access to such tools. Copper during the Early Bronze Age was an expensive product that required plenty of resources to mine and smelt. The expensiveness of copper likely restricted its use to the upper strata of society and served as a symbol of status in funerary practice and fed into the social stratification that was present in Egypt at the time.

These questions go beyond answering a simple yes or no for the presence of metal in Old Kingdom Egypt. The aim is to understand the relationship between metal, stone, and society, to understand the impact had upon the population, and to provide the lower strata individuals with a voice so that we understand why perhaps, metal tools such as blades, were not accessible for them to accomplish their daily tasks.

1.15 Chapter breakdown

Chapter 2 (*Old Kingdom Egypt*) provides context and historical background on the time period to be examined. In the description of the Old Kingdom sites, stress is placed upon the involvement of the state – particularly within settlements that benefited the state through the provision of products such as grain and livestock. It delves into the socioeconomic impact the Old Kingdom administration had upon the population and how they benefited (or rose through the social hierarchy) from the positions. The chapter focuses on the administrative changes that occurred during the middle of the Old Kingdom that evidently caused the state to collapse.

Chapter 3 (*Animal processing technologies in ancient Egypt*) looks closely at animal butchery and the types of tools employed during the butchering process. Examples of stone and metal tools used in animal butchering will be given and compared with existing ancient sources. Two and three-dimensional butchery scenes are examined for what they can tell us about animal butchery and tool types used in the process.

Chapter 4 (*Flint implements*) examines the importance of flint blades in the Old Kingdom. Much like the theme of this introduction, the chapter exemplifies how mined flint tools were likely produced in specialised workshops that may or may not have been overseen by the state. This chapter utilises examples from Old Kingdom settlements to highlight the various uses of flint blades including religious contexts and animal butchery. An interesting correlation is drawn

between the use of bifacial knives and truncated blades and animal butchery, particularly the use of bifacial knives in the ritualistic slaughter of cattle. It ends with the decline of flint from the end of the Old Kingdom with the advent of copper and an almost complete absence by the New Kingdom when the Bronze Age is well underway.

Chapter 5 (*Development of metallurgy in the Old Kingdom, Egypt*) highlights how the development of metallurgy was a collective effort put forth by the state. The Chaîne Opératoire approach is adopted in this chapter to highlight the various phases of copper production from mining to consumption. The chapter also reviews how copper smelting within settlements were likely controlled by the state and how the consumption of copper objects were restricted to elite members of society.

Chapter 6 (*Methods*) describes how the zooarchaeological approach can provide useful information about past populations and how the study of slice mark morphology allows for a better understanding of the evolution of metal in the Near East. The methods implemented in this study are explained in detail and the technologies adopted for the macroscopic and microscopic study of the slice marks.

Chapter 7 (*Site description: Giza and HeG*) describes the site of Giza during the Old Kingdom and the site of Heit el-Ghurab/**HeG** (Workers Village) that the dataset for the thesis derives. A description of the various settlements and towns are explored along with how they served to maintain social stratification. Areas with copper production is highlighted and current zooarchaeological research is described.

Chapter 8 (*Data: zooarchaeological analysis and slice mark identification*) provides the data and results from zooarchaeological study on the fauna from HeG. The chapter provides the zooarchaeological analysis of the animal bones and the slice mark data. It highlights how the use of tool type was connected to the type of animal butchered.

Chapter 9 (*Discussion of results*) discusses patterns in the data and draws connections between the data and historical context of the Old Kingdom. Differences among tool types are discussed and differences between the technologies used for slice mark morphology are highlighted.

Chapter 10 (*Conclusions*) details the significance of the findings presented here and considers future directions of research.

1.16 Conclusion

In this introductory chapter, the overall goals of the thesis are presented, and the archaeological context is reviewed. It provides an overview on the society of ancient Egypt which is developed more in later chapters.

The site of Giza is presented as an appropriate site for investigation as it contains all of the elements required for the current comprehensive study – metal, flint, animal bones, and social stratification. Zooarchaeological methods are presented as a means to answer questions about Old Kingdom society through the lens of animal butchery. In particular, the fauna from Heit el-Ghurab will not only help us understand the transition from a stone based to a metal-based technology in ancient Egypt, but also provide an understanding of the social, economic, and technological advancements that occurred during this time. In the next chapter, a broad overview of Old Kingdom Egypt will be presented.

Chapter 2: Old Kingdom Egypt

2.1 Introduction

This chapter places the research studied in this thesis in culture historical framework as it pertains to the Old Kingdom period. It provides a geographical, social, economic, and historical description of the relevant time period (middle of the 3rd millennium BCE). It is important to recognise the historical context from which the development of metallurgy in Egypt derives (for a discussion on Old Kingdom metallurgy see (Odler 2016). The adoption of metal is not an isolated development, but one that is influenced by the nature of social complexity and the many layers that exist within it (Chapter 1 and see Shaw 2012 for discussions on society and innovation). As stated by Cagle (2001),

Old Kingdom Egypt is characterized by a strong central government centered on the king and his court, an extensive system of taxation to support state projects, and an administrative class that derived its authority directly from the king but whose loyalties were directed in part at accumulating personal wealth (Cagle 2001).

During the Old Kingdom, Egypt's society, administration, economy, and settlements were organised as part of the state's agenda to solidify the country administratively and create a centralised economic network to achieve complete control of Egypt and support the needs of the elite (Cagle 2001; Ikram 2014: 286; Lehner 2010: 85; Lehner and Tavares 2010; Moeller 2016: 113-187). The centralisation of Egypt is reflected in the maintenance of stratified society, the establishment of state-run settlements, kingship ideology, and the organisation of the administration. These elements worked together to support the sovereigns of the Old Kingdom and gave them complete control of revenues, resources, cult activities, and the other sources necessary for monumental construction until the collapse of the state at the end of the 6th Dynasty.

2.2 Old Kingdom chronology

The relative chronology of Egypt has been traditionally reconstructed using historical methods based on a number of ancient sources, including the Turin Royal Canon (Gardiner 1959; Malek 1982), Palermo Stone (Schaefer 1902: pl.1; Wilkinson 2000), Famine Stelae, (Lichtheim 2006a: 94-103), and ancient historians, such as Manetho from the third century BCE (Manetho and Waddell 1948) and Herodotus (c.484-425 BCE) (Lloyd 1988; Manetho and Waddell 1948). The chronology of Old Kingdom Egypt has been the topic of much debate over

the last century (Ehrich 1992; Hornung, Krauss, and Warburton 2006; Nicholson and Shaw 2000; Vymazalová and Bárta 2008). Discussions surrounding the use of ancient sources to reconstruct historical chronologies, including inscriptional evidence, were at the centre of debates (Vymazalová and Bárta 2008), but also included the use of annual or biannual events such as “cattle counts” that were argued to be either symbolic annual festivals or actual state organised census counts (Nolan 2008). Nonetheless, recent refinements to the absolute chronology of Old Kingdom Egypt has helped fill in the gap on dating and derive from a number of sources including archaeological work at Giza (Hawass and Lehner 2017), unpublished papyri from the archive of Neferefre (Verner 2001), radiocarbon dating (Dee et al. 2013; Dee et al. 2009), and entire volumes dedicated to new ways of reexamining the chronology of Egypt (Hornung, Krauss, and Warburton 2006; Vymazalová and Bárta 2008). These refinements have given a better understanding of the dates that surround the events, rulers, and settlements of the Old Kingdom

While there has been an attempt to fill in the gaps in Old Kingdom chronology, the discussion is far from resolved and work continues (e.g. Ramsey et al. 2010; Shortland and Ramsey 2013). The dating adopted for this thesis is based on the chronology in the volume edited by Hornung et al. (2006) which is a collaborative work by Egyptologists that compiles timelines for each of the major periods (Table. 2.1). According to the volume, the Old Kingdom (2543-2118 BCE) begins with the reign of King Djoser in the 3rd Dynasty 2592-2566 BCE and ends upon the death of King Pepi II (2216-2153 BCE), the last pharaoh of the 6th Dynasty in 2153 BCE. Although the 7th and 8th Dynasties (2150-2118 BCE) have been attributed to the Old Kingdom by Hornung (2006), the limited information on these dynasties and the collapse of the state at the end of Pepi II’s reign is a widely recognised event for the end for the Old Kingdom (e.g. Ikram 2014: 286). After the more than forty-year rule of Pepi II, the Old Kingdom state collapsed and power devolved to the nomarchs (previously governors, and now rulers of small regions). Absence of centralised authority and political instability characterises the following First Intermediate Period (Baud 2010: 63; Posener 1957; Rice 1999: 150).

2.3 Geographical considerations

The geographical region of Egypt is rich with a dynamic landscape that offered resources and protection to its ancient people (Fig. 2.1). The various geographical regions of Egypt had plentiful resources ranging from flint to gold which were exploited throughout Pharaonic history

(Tillmann 1999: 314) (Fig. 2.2). The *Eastern Desert* was one of the most important are for natural resources in Egypt throughout Pharaonic history, particularly the Red Sea Mountains which was extensively quarried for rare and high-quality building stone such as calcite (i.e. alabaster) and granite (Arnold 1991), and also mined for copper, led, tin, and gold (particularly in areas of the Wadi Hammamet and Wadi Allaqa for gold) (Baines and Malek 2000: 21; Ward 1999: 1031). The *Sinai Peninsula* to the east of the Red Sea Mountains was highly exploited for its resources of copper, malachite, and turquoise (Baines and Malek 2000: 21). Throughout the *Nile Valley*, areas rich with limestone, sandstone, calcite, and natron provided sufficient supply for state construction projects (i.e. pyramids and temples) and religious practices (i.e. natron for mummification) (Baines and Malek 2000:12-21).

During the Old Kingdom, Egypt was protected by its landscape (still present today) which consisted of natural borders made up of the Mediterranean Sea to the north, river cataracts in the south (Fig. 2.3), Red Sea mountains to the east, and the large Western Desert covered with sand dunes (Baines and Malek 2000:12-21). Much of the *Western Desert* was uninhabitable due to a lack of water sources (and thus impassable) with the exception of the Siwa, Bahriya, Dakhla, Kharga, Dunqul, and Kurkur oases where settlements have been found dating throughout ancient Egyptian history. The *Eastern Desert* offered protection by its highly elevated and treacherous Red Sea mountains that lie along the Red Sea coast. The main point of entry in and out of Egypt was through the *Sinai Peninsula* which served as passage for routes to neighbouring societies in the Levant from the Predynastic period but mostly during the Egyptian Middle and New Kingdom periods when the trade route was also used for foreign invasions (Sowada 2009). These borders provided Egypt with a type of isolation that allowed its ancient culture to thrive for thousands of years. The landscape also offered protection from foreign societies (i.e. states, cultures, empires) because of the difficulty it posed for invasion. Needless to say, Egypt was still conquered in numerous occasions throughout its history, but its culture remained relatively untouched until the Roman period.

The Nile Valley allowed for sedentary settlements to thrive and thus was the most populated region of Egypt. The area was rich with water and resources that provided populations with the ability to practice farming, fishing, hunting, and husbandry (Baines and Malek 2000:12-21). The inundation of the Nile River was of utmost importance to the population because of the nutrients and water it provided for the growth of crops as reflected in ancient Egyptian ideology, this

meant an annual renewal of life and balance and therefore an annual restoration of harmony in daily life (Bard 2015: 40). The Nile Valley was traditionally divided between Upper Egypt (the Nile River valley to south), Middle Egypt (area of the Nile Valley north of the bend in the river at Qena and Nag Hammadi to the region of the Fayum, see (Bard 1999: 1; Redford 2001: 390), and Lower Egypt (the Delta to the north) (Fig. 2.1).

2.4 State control in Old Kingdom settlements

The current archaeological evidence for Old Kingdom settlements is considerably skewed by the evidence for state foundations that are of non-urban character and belong to the category of specialized towns funded by the central government (Moeller 2016: 186).

This statement by Moeller (2016) clearly reflects the issues regarding what is known about Old Kingdom settlements and how most of what has been recovered demonstrates a presence of state control. However ancient Egyptian settlements can be viewed from two perspectives, a ‘global’ perspective where settlements are understood to serve the larger economic and political networks of the crown, or a local perspective where settlements have a more localised structure with smaller powerful households (families) serving as higher ruling elite for the state and function semi-autonomously (at least during the late Old Kingdom) (for the global and local perspective on settlements see (Kemp 1977: 196; Lehner 2010: 85-86).

Archaeological evidence of Old Kingdom settlements is dominated by those connected with royal mortuary cults commissioned by the state such as tombs and pyramids (Moeller 2016). Moreover, Old Kingdom villages, towns, or urban centres were also part of a network that allowed the administration to monitor individuals, maintain royal cults, and supervise the goods and revenues of the treasury (global settlement type) (Cagle 2001; Ikram, Renfrew, and Bahn 2014; Kemp 1977; Lehner 2010: 85; Lehner and Tavares 2010; Moeller 2016: 113-187). The settlements that reflect this are royal mortuary cult settlements, Nile Valley and Delta settlements, and settlements in more marginal regions of Egypt (Moeller 2016). The study of these settlements can help bring an understanding of how the state was heavily involved in ancient Egyptian society in the Old Kingdom.

2.4.1 Royal mortuary cult settlements

The main settlement type investigated here in the Memphite region are towns connected to royal mortuary cults. The monuments themselves legitimised the position of the king as a symbol of the political strength of the monarchy (Kemp 2007: 109). These settlement types include the

pyramid towns at Giza (Khentkawes Town, Menkaurae Town, Menkaurae Industrial town, and Heit el-Ghurab), Abusir, and Dashur. They served as centres of economic activity, trade, and production for the construction of funerary monuments and the maintenance of funerary cult activities. Urban centres had a number of purposes including functioning as residential and administration towns, workmen's barracks, and valley temple sites (Lesur 2015; Moeller 2016; Seidlmayer 1996; Warden 2014: 242-262; Wenke, Redding, and Cagle 2016).

Residential and administrative towns were associated with the funerary cult of the kings and can be defined as, "a [cluster of] mud-brick buildings used for residential purposes and possibly administration situated at the pyramid temples" (Moeller 2016: 119). These include structures connected with the temple and consist of dwellings for priests with limited storage facilities and strictly related to cult activities. Examples of this type can be found throughout the Old Kingdom at Giza (Hawass and Lehner 2017), at the 4th Dynasty pyramid complex at Abu Rawash (Moeller 2016: 119-123), and the 5th Dynasty royal necropolis at Abusir (Moeller 2016: 123-125; Verner, Barta, and Ústav 2006: 24, 72-77). Residential and administrative towns reflect communities that conducted activities related to religious activities but particularly those connected to the state and the king's cult. In retrospect, these settlement types are not a proper representation of Old Kingdom society as a whole but in fact are agents for the broader objectives of the state to maintain religious dominance within Egyptian society.

Workmen's barracks are "barracks and installations for production and manufacturing activities in close proximity to the royal construction sites" (Moeller 2016: 119). The most thoroughly excavated workmen towns are at Giza and include the best example and most systematically and methodologically excavated 4th Dynasty site of Heit el-Ghurab, (See Chapter 3; (Hawass and Lehner 2017; Moeller 2016) and the Menkaura Pyramid Complex (Moeller 2016: 126-139; Saleh 1974).

Valley Temple towns are "larger settlements located at or near the Valley temples along the border to the floodplain" (Moeller 2016: 119). These settlements contain residential, administrative, and large storage areas that are connected to the maintenance of cult activities of the king. They include the settlements of the 4th Dynasty Valley Temple of the Bent Pyramid at Dashur (Fakhry 1951-1952; Fakhry and Maslahat 1959-1961; Moeller 2016: 141), the mortuary complex of the late 4th Dynasty Queen Khentkawes at Giza (Hawass and Lehner 2017; Moeller 2016: 144-150) and the settlement of the late 4th Dynasty king Menkaura Valley Temple

complex (MVT) (Moeller 2016: 150-153). Valley Temple towns have characteristics of long-term occupation and lack aspects of urbanisation in the sense of larger market areas, central administrative areas, and larger socially stratigraphic dwellings. The long-term occupation in such towns gave the state an opportunity to become embedded within local village and town society through activities undertaken in the temples related to kingship ideology (Moeller 2016: 153-154). This provided the state with a close relationship, perhaps even a monopoly with the local elites - e.g. priesthood who maintained royal cults (Moeller 2016: 153-154). The absence of urbanisation in these settlements parallels an inorganic manner of settlement planning which was perhaps forced upon by the state (Moeller 2016: 187).

All three types of royal mortuary cult settlements demonstrate a high degree of state involvement and control (Lehner 2015; Moeller 2016: 116). The settlements were often situated within an external enclosure wall that divided the space physically perhaps for administrative reasons, but also acted as a symbolic barrier between the temporal and the secular. The presence of administrative structures and objects throughout these types of settlements further denoted state presence. At Giza for example, royal seals were found within administrative areas (Nolan 2010). The presence of elite housing belonging to administrative personnel (governors) are also found at Giza and Heliopolis (Saleh 1996), Elephantine in the south (Kaiser 1999b; Raue 2002; Raue et al. 2005; Steidlmayer 1996), and at Ain Asil in the Dahkhla Oasis (Soukiassian, Wuttmann, and Pantalacci 2002). Areas that reflect state control are evident in areas of mass production and storage (e.g. at Giza, (Hawass and Lehner 2017; Saleh 1974), or areas that were highly guarded by the state such as guard post instalments (e.g. at Giza, (Hawass and Lehner 2017). These physical elements present in royal mortuary cult sites demonstrate the pervasive presence of state-level organisation.

The literary evidence from the Old Kingdom also implies a close relationship between the state and the pyramid towns. The Abusir archive from the pyramid town of Abusir dating from the reign of King Neferefre of the 5th Dynasty yields detailed information of the professional administration of the town and shows that “the king’s pyramid complex was constantly exchanging goods and offerings with state institutions” (Strudwick 2006: 60-61). The connection between state and settlement is further evident in the intermittent nature of the occupations which coincide with the periods of construction or restoration of royal monuments, such as at Abu Rawash (Moeller 2016: 121; Valloggia 2011: 71), the Heit el-Ghurab (Hawass and Lehner 2017)

or the Menkaurae settlement at Giza (Hawass and Lehner 2017: 398-400; Lehner 2015).

2.4.2 Nile Valley and Delta settlements

The Old Kingdom settlements located in the Nile Valley and Delta are characterised by architectural elements that connected them to religion and the state. They were enclosed by a town wall, were about 3ha to 5ha in size, contained a temple dedicated to the local town god, and typically included manufacturing or production areas (Moeller 2016: 186). However, these towns did not have any monumental public buildings, central markets, or main streets (Moeller 2016). On the contrary, the layout of these settlements reflected a labyrinth-type town plan that did not have a particular flow or division of space reflective of state settlement planning. Although the Nile Valley/Upper Egypt and Delta provinces were geographically distant of the Memphite region, the archaeological evidence speaks of a coherent and complex administrative network that allowed the state to maintain control of its interests (Papazian 2005).

Although not much is known about Old Kingdom settlements in the *Delta* (Moeller 2016: 161), recent archaeological work has demonstrated that these settlements reflected a strong sense of state control and management of its revenues and products (Wenke, Redding, and Cagle 2016). The presence of administrative areas in settlements, such as at Buto (Hartung 2008; Hartung 2012), Mendes (Adams 2007; Papazian 1999; Redford and Redford 2020), Tell Ibrahim Awad (Eigner 2000, 2003), and Kom el-Hisn (Wenke, Redding, and Cagle 2016) attest to the organisation of the state beyond towns related to religious structures.

The state benefited from these settlements in a number of sources or revenue. One of these ways was through cattle management. For instance, at Kom el-Hisn, livestock were provided to the state to feed its labourers (Wenke, Redding, and Cagle 2016); Cattle rearing in the delta see Wilkinson (Wenke, Redding, and Cagle 2016; Wilkinson 1999: 105). Other settlements provided temple revenues from cult activities, such as at Mendes where the local temple provided revenues to the crown (for temple economy in the Old Kingdom see Adams 2007: 355; Redford and Redford 2020: 65; Savel'eva 1992).

Archaeological work in the Nile Valley of Middle and Upper Egypt have also demonstrated the control of the state over the local population in the form of revenue in the form of grain storage and production. Production areas were present at the industrial sites of Al-Shaykh Sa'id and Wadi Zabyda in the Nile Valley that were used for the manufacture of stone objects and had evidence of large-scale food production in the form of large quantities of bread moulds (Moeller

2016: 24).

Many sites in Upper Egypt were part of the broader administrative network of the state from the onset of the Old Kingdom. For example, Elephantine, which is located in the First Cataract region, already had fortifications in the 1st Dynasty and served as an administrative centre for the south during that time (Bard 1999: 33). Elephantine had an administrative complex dating to the 3rd Dynasty and the presence of royal seals, large quantities of bread moulds and beer jars, and a governor's palace of the 6th Dynasty further confirm administrative presence (Moeller 2016: 168-169; Steidlmayer 1996). This is further evident in improvements to the landing place that occurred during the Old Kingdom, perhaps to support its growing interests south of the border (Moeller 2016: 169). The evidence from Elephantine suggests that it was an important settlement to the state for much of the Old Kingdom.

2.4.3 *Marginal region settlements*

Old Kingdom settlements found in more marginal regions of Egypt have aspects that reflect the economic interests of the state, such as the presence of an infrastructure aimed at facilitating the exploitation of raw materials and long-distance trade expeditions (Moeller 2016: 174). Such sites include Balat (Jeuthe 2018; Soukiassian, Wuttman, and Pantalacci 1990, 2002), Ain el-Gazzareen (Mills and Kaper 2004), sites in the Dakhla Oasis in the Western Desert, and Ayn Soukhna and Wadi el-Jarf in the Red Sea coast. These sites had administrative structures, mayoral complexes, a governor's palace, and fortified enclosures. At Balat, there was even evidence that the Old Kingdom state took control of the Dakhla Oasis and trade routes extending into the Western Desert (Moeller 2016: 174-182). At Ain el-Gazzareen, industrial bakeries and seal impressions also suggest state influence. On the Red Sea coast, Ayn Soukhna proved to be an important harbour site for copper and turquoise mining expeditions of the state. At Wadi el-Jarf, a harbour, gallery complex, high camp area, and large administrative building denotes the use of the site by the state (Moeller 2016: 174-186). All of these examples provide evidence that such Old Kingdom towns functioned under the administration of the crown to serve its objectives (Moeller 2016: 174).

2.5 *Kingship ideology*

State influence was not limited to settlement planning or the use of settlements to achieve objectives. The position of the king at the pinnacle of the state is enshrined in Egyptian culture. The major construction works that arose in the Old Kingdom were a direct result of an ideology

prevalent in ancient Egyptian kingship and religion. The monarch was believed to be an incarnate of the sun-god Re and his falcon-son Horus (Assmann 2001: 1-52; 2003: 46-77; Baud 2010: 63-70; Kemp 2007: 99-110). Consequently, Old Kingdom kings were deified, venerated, and had pyramids built in their honour (Malek 2010: 85-87). In fact, the earliest corpus of texts that deal with religious and kingship ideology are the Pyramid Texts found in the pyramid of Teti at Saqqara dating to the Old Kingdom (Baud 2010: 65). The duality of the king was reflected in the massive monuments that were constructed during the Old Kingdom, through their royal titular, and phraseology (Malek 2010: 63-92). The duties of the king were believed to be both administrative and religious so that Ma'at (balance between good and evil) would be maintained (Assmann 2001; Baud 2010: 63-65; Malek 2010: 92-94). The Old Kingdom King Djoser, for instance, was viewed by the population (likely those of higher strata of society) as a holy, wise, and sacred ruler throughout ancient Egyptian history that extended into the Ptolemaic period as denoted in the Famine Stelae (Lichtheim 2006b: 94; Malek 2010: 85-87).

Egypt was divided symbolically in two parts, Upper and Lower Egypt. The Kings claimed their rule over the whole of Egypt as “King of Upper and Lower Egypt” which included areas beyond the Egyptian border. This is reflected in titles such as ‘King of the Nine Bows’ that included the conquered lands outside of Egypt (Shaw 2003: 309-310). The adoption of such titles signifies the sovereign’s desire to lay claim to Egyptian and foreign lands and served as a symbolic representation of the power the monarchs exercised among the population.

2.6 State Administration in the Old Kingdom

A developed bureaucratic system reveals and actively promotes a specific human trait: a deep satisfaction in devising routines for measuring, inspecting, checking, and thus as far as possible controlling other people’s activities. This is a passive and orderly exercise of power in contrast to direct coercion (Kemp 2007: 163).

The statement made by Kemp summarises well the dynamic between the administration and the Egyptian populace. The central administration consisted of the king who had absolute power, while other positions such as vizier, controller, overseer, and other administrators were beneath them (Bard 1999: 39-41). The administration was centralised among geographical divisions that compartmentalised Egypt into *nomes* (provinces) (Moeller 2016: 113-117). There were 22 *nomes* in Upper Egypt and 20 *nomes* in Lower Egypt (Fig. 2.2). Each was governed by a *nomarch* (Bard 1999: 41). This pattern of government centralisation was already in existence in the Early

Dynastic Period, but it became more solidified in the 3rd and 4th Dynasties when royal family members were appointed into positions of the court. The early 4th Dynasty in particular was a time when sons of the king served in important roles within the higher court, such as the role of vizier (Bard 1999: 373-379; Strudwick 1986: 300-335). An example of this is in the case of Nefermaat, the son King Snefru, who served as vizier (Harpur 2001); Tomb at Meidum, Mastaba of Nefermaat see Petrie 1892 pl. XVIII right).

Major administrative changes occurred during the end of the 5th and into the 6th Dynasties of Egypt when demands for tax revenue and productivity increased (Kanawati 1980: 128-129; Katary 2007: 190). As a result, various administrative positions in the Egyptian state were implemented for the maintenance of economic activities including the central government's policies of taxation, temple tributes, and security of the treasury revenue that included goods such as grain and cattle (Katary 2007: 187-190). As the power of the state weakened during these dynasties, nomarchs began to take on more and more of the roles of the state including the maintenance of central state policies regarding taxation and religious cults (Kanawati 1980: 128-129; Katary 2007: 190). As the nomarchs grew in power, they were eventually able to marry into the royal house and rise up the administrative structure which inevitably posed a threat to the centralised government and sovereign (Baud 2010: 77; Ikram 2014: 268; Malek 2010: 105). However, such changes brought issues to the state and local elites had to balance the demands for revenue requested by the central government while dealing with local power structures ((Eyre 2004: 167; also see Eyre 2015). Consequently, an imbalance began to arise in social and economic relations between the central authority and the rural countryside (Seidlmayer 1996: 108). An example of this shift in power relations can be seen in situations where provincial administrators adopted high positions of the court, including the administration of nome provinces (Kanawati 1980). These changes shifted control away from the royal family and into local powerful families creating a 'less centralistic and more individually oriented culture' (Bard 1999: 41). This shift to local administration continued in the 6th Dynasty when individuals from humble upbringings were given opportunities to rise within the court. For example, the famous Weni the Elder began his career in the humbler role of custodian of a storehouse and later became a general under Kings Teti, Pepi I, and Merenra (CA 1435 cf. Litchtheim 2006: 18-23; also see Kanawati 1980: 128-129; Katary 2011: 6).

Local governors enjoyed more wealth and autonomy following the 5th Dynasty's

administrative changes (Baud 1999: 40-42). For instance, local rulers of Elephantine became powerful and autonomous during the latter part of the Old Kingdom because of their close trade relationship with Nubia (Raue (Ikram 2014: 286; Raue et al. 2002). This autonomy is represented in the elaborate style of the tombs of local governors that had long causeways and located away from the royal necropolis and near their local supporters (Katary 2007: 190; Baud 2010: 77; Malek 2010: 101; Ikram 2014: 268). By the end of the Old Kingdom, local nomarchs gained enough power and autonomy to cause a decentralisation of the central government (Katary 2007: 190; Baud 2010: 77; Ikram 2014: 268).

Despite the state's decentralisation during the Old Kingdom, the state remained heavily involved in revenues (i.e. taxation) until the end of the Old Kingdom (Garcia 2001: 411-450; Katary 2011: 4; Müller-Wollermann 1986). By the end of the 6th Dynasty, the decentralisation of the government was well underway, and the autonomy of local nomarchs was on the rise (Ikram 2014: 268). This process continued until the collapse of the central government at the end of the Old Kingdom. As a result, local kingships of nomes begin to emerge in the First Intermediate Period, (Katary 2007: 190; Baud 2010: 77; Ikram 2014: 268).

2.7 State control of economy in the Old Kingdom

The state controlled economic activities in all of Egypt, but maintained its strongest presence in the Memphite region because Memphis served as the administrative centre of the government and place of residence of the king and royal court (Bard 1999: 40, 2010: 64; Katary 2007: 187; Ikram 2014: 286). Settlements contributed to the greater economy through the supply of food and other goods (e.g. farming and cattle rearing - Kom el-Hisn: Wenke et. al. 2016), served as religious centres (Heliopolis: (Nuzzolo and Krejčí 2017), and Bubastis: (Lange 2013)), and the maintenance of frontier borders and trade entrepôts (for examples, Elephantine: (Kopp 2006); Buhen: (O'Connor 2014)).

The Royal Treasury consisted of a royal chancellor who was responsible for the supervision of the collection, storage, processing and distribution of state revenues and reported economic activities to the vizier (Katary 2011: 5). Separate treasuries existed for Upper Egypt, Lower Egypt, and the Two White Houses (Katary 2011: 5). The crown collected revenues in the form of taxation by holding an annual royal tour called the “following of Horus” (Helck 1972: 1.1, 4). The tour is when the king and court travelled along the Nile and ‘recorded Egypt’s economic wealth as measured in herds of livestock, arable fields, resources in precious metals, and human

population' (Katary 2011: 4-5; also see Kees and Morrow 1961: 102-103; Wilkinson 1999: 142, 220-221; Wilkinson 2000). In these annual tours, the inundation of the Nile (or livestock and grain) were used to determine the amount of tax (in the form of livestock and grain) that the population had to pay to the crown (for inundation of Egypt see Butzer 1976: 18-19; Katary 2011: 5). The population, therefore, was forced to contribute greatly to ancient Egyptian society and economy through temple benefits, taxation, and labour - all of which supported the bureaucracy of Egypt (Katary 2011: 4; Muhs 2005). Settlements provided comprehensive logistical networks, such as the transportation of raw materials, which can be seen in a document of an inspector called Merer from the reign of Khufu who organized the transportation of limestone from the quarries at Turag to Giza (Moeller 2016: 117; Tallet and Marouard 2014: 8-12).

State economy also derived from temples that maintained religious cults, particularly those connected to the King. During the 5th Dynasty, the cult of the sun-god Re became more prominent and encouraged an increasing interest in temple construction in honour of Re (Baud 2010: 68; Malek 2010: 98-99). In order to maintain these cults and the management of revenue coming from them, the need for religious staff (priests of Re) and local viziers increased. By the 5th Dynasty, such positions were also offered to non-royal literate Egyptians (Bard 1999: 41; Ikram 2014: 286). Those who chose to be employed as maintainers of a cult received land gifts and tax exemption (Ikram 2014: 286; Katary 2011: 5-6; Warden 2015: 484, Table 13.1). Revenue may have been a reason for the royal prerogative of temple building to continue into the 6th Dynasty when temples to Khentiamentiu at Abydos, Satet at Elephantine, Min at Koptos, Hathor at Dendera, and Horus at Hierakonpolis were constructed and individuals were required to maintain these cults and monitor the tax-generated revenue (Katary 2007; Malek 2010: 105).

The decentralisation of the government and beginnings of the Old Kingdom collapse is evident in a number of cases that demonstrate challenges faced by the state to its tax-collecting authorities (Katary 2011: 4). An example comes from the tomb of Khentika of the 6th Dynasty where the vizier lays charges against five nomarchs for corruption or dereliction in the remission of tax revenues (James 1953: 21, pl. IX; Katary 2007: 190). Another example is found in the mastaba of Mereruka where a man is flogged for non-payment of taxes (Wilson and Allan 1938b: 17, pl.36-38). Tax evasion became a part of the behaviour of the late Old Kingdom nomarchs who had to struggle between serving the needs of the central government and local

power structures (Eyre 2004: 167). The effects of increased autonomy eventually had a grave effect on the integration of the centralized state (epitomised by the crown). Eventually, when competition among the increasing members of elite brought a conspiracy to murder Pepy I by his Queen. Weni the Edler describes his testimony as a witness to the queens trial and says, ‘when there was a secret charge in the royal harem against Queen Weretyamtes, his majesty made me go in to hear it alone’ (CA 1435; Lichtheim 2006: 19; Malek 2010: 105). Pepy II increased taxation during his reign and it is likely that his policies created further unrest among the population and drove the collapse of the Old Kingdom state (Malek 2010: 105; Karary 2011: 6; Ikram 2014: 268).

2.8 Conclusion

This chapter discussed the culture history of Egypt during the Old Kingdom. Egypt is situated in north-east Africa and contains a number of natural borders and a good number of resources. The people of Egypt lived in a stratified society where the king, royal house and administration were at the top and most of the population remained at the bottom. The state had a strong presence in the daily lives of people in Old Kingdom Egypt through taxation, control of resources, and religious royal cults – all of which are evident in many of the settlements of the period. While the Old Kingdom marked a period of major advancement for Egypt, the massive monumental architecture that required plentiful resources and a large labour force was essentially built by the kings to ensure that social stratification was maintained and that they were kept at the top. The period was also a time when foreign missions expanded the borders of Egypt and provided means of trade for luxury items and resources – mostly for the upper strata of society (Baud 2010; Wenke et. al. 2016).

Old Kingdom settlements reflect a strong element of state imposition which is reflected through the presence of royal structures such as palaces, administrative areas, and temples related to royal cult activities (Moeller 2016). These structures functioned as nuclei for the state to supervise its interests in revenue, production, and storage of goods (e.g. RAB at Giza). Settlements, therefore, became part of a broader economic network that allowed the state to function and successfully complete its projects such as the pyramids of Giza and maintain control of the population (Bard 1999: 39-41, 373-379).

The crown’s power was solidified through the organisation of its administration which ensured a nomarch honourable to the crown was in place throughout Egypt in the various provinces

(Kemp 2007 163). The centralised government of the Old Kingdom closely monitored its financial interests through fiscal tours and taxation which were overseen by an appointed treasurer (e.g. “following of horus”, Helck 1972: 4; Karary 2011: 4-5).

Near the end of the Old Kingdom (around the 5th Dynasty), a shift began to occur which moved the power of settlements into the hands of local elite families (Bard 1999: 40-42; Ikram 2014: 268; Malek 2010: 101). As they received more autonomy throughout the Old Kingdom, they began to rule their areas (e.g. Elephantine, see Raue, et al. 2002). Local authorities struggled to balance power and the interests of the state and with it came the beginnings of the collapse of the Old Kingdom state (Ikram 2014: 268). The collapse of the Old Kingdom was not strictly due to administrative causes (although that may seem the main issue) but perhaps also due to inadequate inundation and natural disasters. Nevertheless, the rise of local rulers had a great impact on the sustainability of the centralised state and influenced the characteristics of the succeeding First Intermediate Period (Baud 2010: 77; Katary 2007: 190).

The Old Kingdom of Egypt therefore is encompassed of strong elements of state control that benefited its interests. The presence of the state is explicit in the settlements of the Old Kingdom and embedded within Egyptian society. The precedent set out by the Old Kingdom rulers cannot be ignored as an influential agent in the social structure that persisted throughout the period and as the following chapters will demonstrate, transcended into aspects of animal consumption, lithic tool production, and access to metal tools.

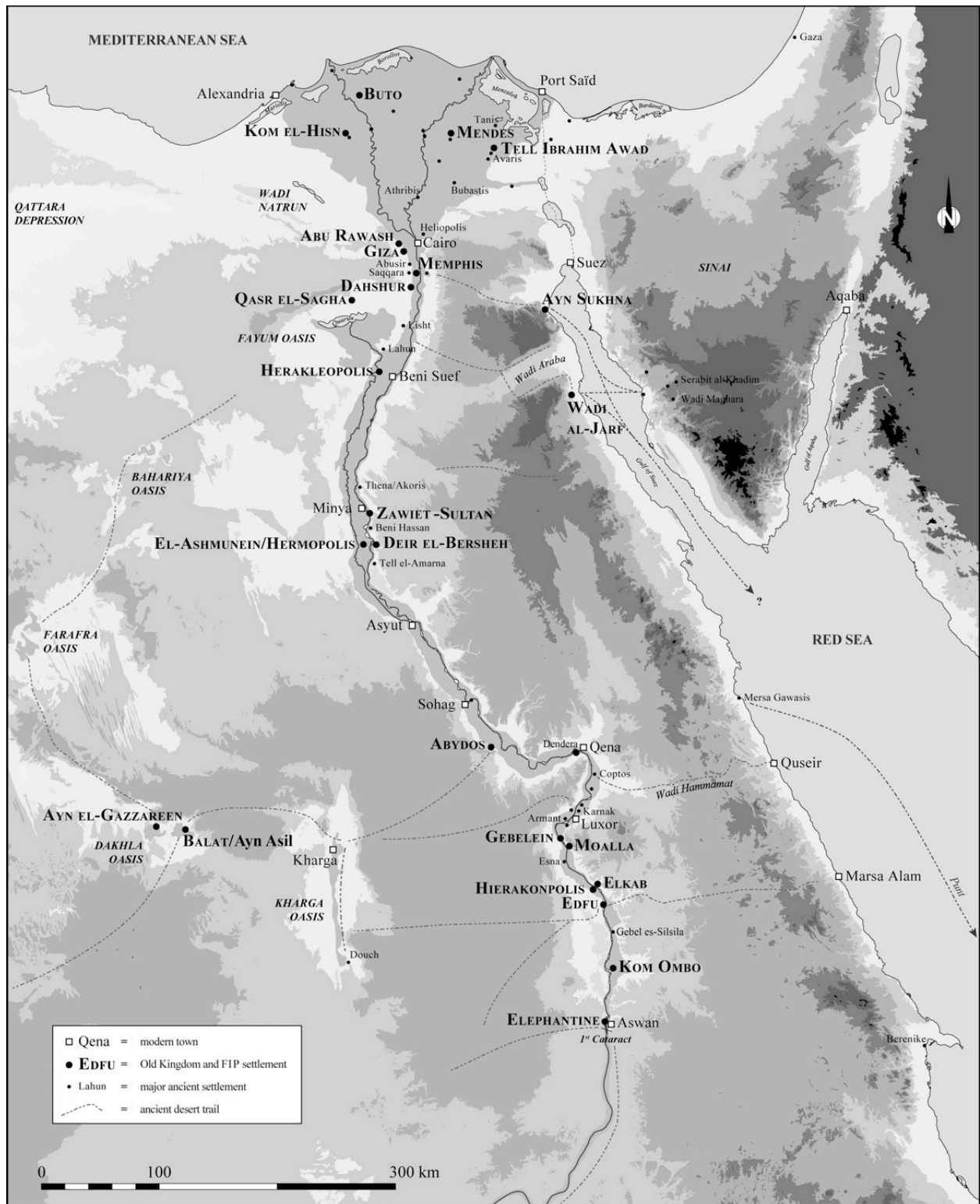


Figure 2.1 Map of Old Kingdom and First Intermediate Sites (Moeller 2016:115)

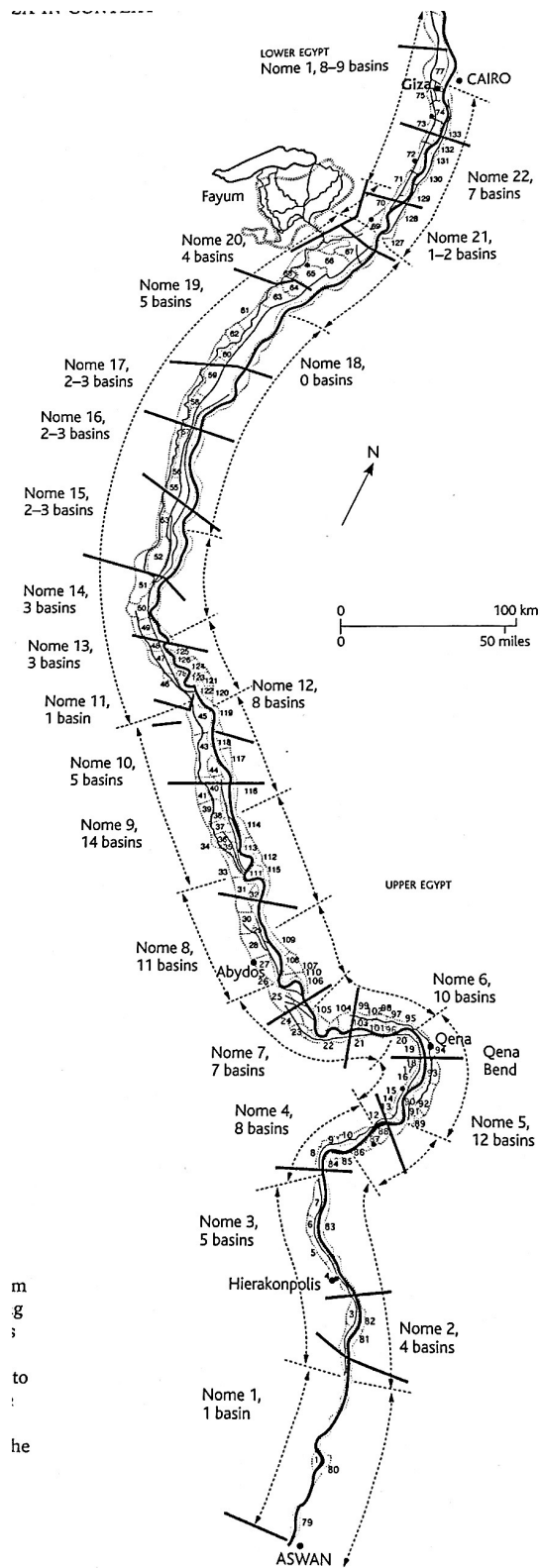


Figure 2.2. Nomes of Egypt in the Old Kingdom. (Lehner and Hawass 2017: 38).

Table 2.1 Chronological Table for Dynastic

Egypt (After Hornung 2006: 490-495 with the exception of placing the

3rd dynasty into the Old Kingdom)

Late Predynastic Period	c. 3000 bc	Middle Kingdom	
Early Dynastic Period		11th dynasty	1980-1940
1st dynasty	2920-2730	12th dynasty	1939-1760
Hor-Aha (Menes); Djer; Djet; Den; Adjib; Semerhket; Qa'a		Second Intermediate Period	
2nd dynasty	2730-2590	13th dynasty	1759-1630
Hetepsekhemwy; Raneb; Ninetjer; Peribsen; Sekhemib; Sened; Khasekhemwv		14th dynasty contemporary with 13th or 15th	
Old Kingdom		15th—17th dynasties	?-1540
3rd dynasty	2592-2544	New Kingdom	
Djoser	2592-2566	18th dynasty	1539-1292
Sekhemkhet	2565-2559	Ahmose	1539-1515
Khaba	2559-?	Amenhotep I	1514-1494
Nebka	?	Thutmose I	1493-1483
Huni	?—2544	Thutmose II	1482-1480
4th dynasty	2543-2436	Thutmose III	1479-1425
Sneferu	2543-2510	Hatshepsut	1479-1458
Khufu (Cheops)	2509-2483	Amenhotep II	1425-1400
Djedefre	2482-2475	Thutmose IV	1400-1390
Khafre (Chephren)	2472-2448	Amenhotep III	1390-1353
Meofcs*re (Mycerious)	2447-2442	Amenhotep IV/Akhenaten	1353-1336
Shepseskaf	2441-2436	Smenkhare/ Nefernefruatn	1336-1334
5th dynasty	2435-2306	Nefernefruatn	1334—?
Userkaf	2435-2429	Tutankhamun	?—1324
Sahure	2428-2416	Ay	1323-1320
Neferirkare	2415-2405	Horemheb	1319-1292
Raneferef	2404	19th dynasty	1292-1191
ShepseSkare	2403	Ramesses I	1292-1291
Niuserre	2402-2374	Seti I	1290-1279
Menkauhor	2373-2366	Ramesses II	1279-1213
Djedkare Isesi	2365-2322	Merenptah	1213-1203
Unas	2321-2306	Seti II	1202-1198
6th dynasty	2305-2118	Amenmesse	1202-1200
Teti	2305-2279	Siptah	1197-1193
Pepi I	2276-2228	Tawosret	1192-1191
Merenre	2227-2217	20th dynasty	1190-1077
Pepi II	2216-2153	Third Intermediate Period	
7th/8th dynasties	2150-2118	21st-25th dynasties	1076-723
First Intermediate Period		Late Period	
9th/10th dynasties	2118-1980	25th dynasty	722-655
11th dynasty (Theban)	2080-1940	26th dynasty	664-525
		27th dynasty	525-404
		28th dynasty	404-399
		29th dynasty	399-380
		30th dynasty	380-343
		2nd Persian Period	343-332
		Greco-Roman Period	332 BCE-AD 395

Chapter 3: Animal butchery in Ancient Egypt

3.1 Introduction

The previous chapter reviewed Egypt in the Old Kingdom and highlighted the impact the state had within aspects of society such as settlement planning, administration, and religious ideology. This chapter delves into the evidence available for understanding animal butchery in ancient Egypt. It focuses on two- and three-dimensional daily life scenes that depict animal butchery from the Old and Middle Kingdoms.

Food is often utilised as a key to understanding social status, economy, and social stratification in ancient Egyptian society (Frood 2010: 484; Ikram 1995: 215-216; Janssen 1975; Redding 2010: 74-75; Wengrow 2005: 46-49). One way to understand the relationship between food and ancient Egyptian society is by examining the quantity of evidence related to food in offering-lists, tomb decorations, three-dimensional models, and hieroglyphic inscriptions which are extensive, and provide information on food production, distribution, and consumption in ancient Egypt. The images available for study from the Old and Middle Kingdoms depict butchery practices and tools used in butchery activities vividly (e.g. Fig. 3.1), while ancient texts are informative on the social aspect of butchers (i.e. perception of the craft and how it fits within Egypt's stratified society).

While some research has been done on meat processing in ancient Egypt (e.g. Ikram 1995), there is little consideration of the types of technologies used in the butchering process and their chronology of adoption. This lack of consideration has relevance for the larger issue of the origins of metallurgy and its influence on aspects of daily life (*i.e.* food processing). It is still not clear when utilitarian metallurgy appeared and was widely adopted in Egypt for quotidian activities. The early use of metal in animal butchering is unclear despite its presence early in ancient Egyptian history and the accessibility of metal knives to all social strata is ambiguous. In other words, when is the shift from a stone- to metal-based (*i.e.* bronze) tool technology for meat processing? Such discussions are vague, rare, and often do not attribute the transition to any particular period and focus on ceremonial artefacts of copper or bronze in relationship to the development of Egypt into a complex society and the need for more copper (Baud 2010: 72; Koehler 2010: 31-46; Tillmann 1999: 314). Some view the transition to have occurred during the Middle Kingdom (c.1975-1640 BC) since bronze tools only begin to appear at this time (Graves-Brown 2010: 188; Ikram 1995: 66-75). However, the presence of copper metal tools from the

Early Dynastic and Old Kingdom (c. 2680-2180 BC) suggests that a metal-based technology for animal butchery may have appeared earlier than has been suggested, at least to a certain level or specific activity within the society.

In this chapter, the evidence for animal butchery processing with flint and metal implements (e.g. knives) and summarise current knowledge on the introduction of bronze utilitarian metallurgy. These will provide insights on how widespread metal use was in daily life and whether it was available to individuals from all social strata of ancient Egyptian society. This study is important for increasing our understanding of the relationship between tool type, the nature of the transition from stone to metal-based technology, and the relationship between status and resources.

3.2 Evidence of animal butchery

The evidence that ancient Egyptians killed, processed and ate meat is extensive from the earliest periods onwards. In the Neolithic and Chalcolithic periods (Badarian and Naqada I-II) the faunal remains recovered from a variety of sites demonstrate the importance of meat to ancient culture (Koehler 2010: 27; Wengrow 2005: 69-70, 46-49; Wetterstrom 1993). There is limited iconography from the Early Dynastic period (Wilkinson 1999: 25-27); it is only in the Old Kingdom onward that texts and iconography with butchery begin to appear. The two-dimensional and three-dimensional butchery scenes from the Old and Middle Kingdoms provide valuable information on animal processing and the types of tools that may have been adopted in the process (e.g. Ikram 1995).

3.2.1 Two-dimensional butchery scenes

Butchery scenes are frequently illustrated in tombs for the elite dating from the Old Kingdom onward. Although cattle are most depicted in these scenes, a few cases of wild game such as gazelle have been recorded (Strandberg 2009: 103). An Old Kingdom limestone relief from the tomb of Niankhenesut, Saqqara (Dynasty 5-6, c. 2300 BC AS5967, Tomb 67, (Porter and Moss 2004)[PM] III.II: 696), depicts men slaughtering cattle (or oxen) (Fig. 3.1).

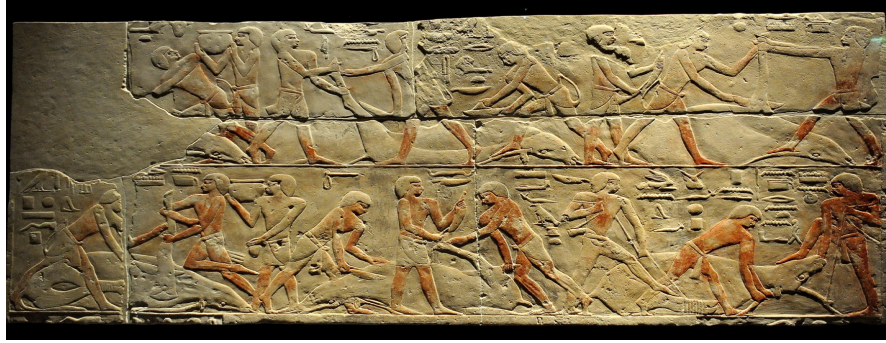


Figure 3.1. Animal butchery scene. Painted limestone relief. Provenance: Tomb of Nianchenesut, Saqqara. Old Kingdom (Dynasty 5-6, c. 2300 BCE). ©State Museum of Egyptian Art, Munich, Germany.

In this scene, what appears to be a large knife is used to skin, chop, slice, and dismember the animal for food. In another Old Kingdom tomb, that of Iput (PM III: 396) (Firth and Gunn 1926: 1-14) at Saqqara (6th Dynasty, c. 2325–2150 BC), there is a depiction of butchers slaughtering what is possibly an ox – the sex is indeterminate because the sexual organs are not clearly depicted (Fig. 3.3). Butchery scenes such as these have successfully been used to understand the nature of animal processing in ancient Egypt and the different tool types used in butchering activities (Ikram 1995). For instance, these scenes inform us that the types of animals consumed ranged from wild game including fish, to domesticates such as sheep, goat, and cattle (for an example with all these types of fauna see Redding 2010). The scenes also demonstrate clearly the butchering activities which typically reflect the animal (usually cattle) lying on its back with several individuals (butchers) dismembering the animal. More importantly however, is the use of knives (large in size) to butcher the animal. A number of publications have deduced knife typologies based on these scenes and the artefacts that are commonly found in settlements and tombs (Ikram 1995; also see Chapter 4 and 5).



Figure 3.2 Animal butchery scene. Painted limestone relief. Provenance: Tomb of Idut, Saqqara. Old Kingdom (Dynasty 5-6, c. 2300 BCE). ©Werner Forman Art Resource.

3.2.2 *Three-dimensional butchery scenes*

Three-dimensional models of animal butchering also exist from the late Old Kingdom through

the early Middle Kingdom and are useful in creating a picture of animal butchery in ancient Egypt. These are different in form but reflect similar scenes to the two-dimensional ones described above. From the Old Kingdom, there is only a single example – a limestone painted figurine found in the tomb of Nykauinpu in Giza dating from the 5th Dynasty (ca. 2477-2466 BC) (PM III.I: 300-301). It depicts a man slaughtering a calf (E10626 Oriental Institute Chicago) (Fig. 3.3). The man holds a knife in preparation of slaughtering the animal. The figurine presents a rare example of three-dimensional depictions of butchery in the Old Kingdom since animal butchery scenes are generally represented only in two-dimensional reliefs in tombs during this period.



Figure 3.3 Figurine of a man slaughtering cow. Painted limestone. Provenance: Tomb of Nykauinpu, Giza. Old Kingdom (3rd Dynasty). Oriental Institute Museum E10626. ©The Chicago Oriental Institute Museum.

During the First Intermediate Period and Middle Kingdom, butchery scenes are more commonly represented by three-dimensional models of animal butchery in addition to two-dimensional ones that are placed with wooden coffins common in the Middle Kingdom (Tooley 1989). These take the form of the well-known painted wooden models recovered from a variety of tombs. The wooden models became a common addition (or replacement) for the representation of two-dimensional tomb scenes (Ikram 2015: 139-150; Ikram and Dodson 1998). The wooden models that portray animals being butchered with a large knife from the tomb of Meketre in Thebes (Tomb 280; PM I.I: 359-364) (c.11-12th Dynasty) are some of the best-preserved (Fig. 3.4).



Figure 3.4 Wooden model of a slaughterhouse. Painted wood. Provenance: Tomb of royal chief Meketre, Thebes. Reign of Amenemhat I, 12th Dynasty, Middle Kingdom. MET 20.3.10. © Haskel Greenfield

Similar models come from a variety of tombs in Middle Egypt (Beni Hassan and Asyut) and near the Faiyum (Sidmant) such as a model found in the tomb of Sebekhetepi at Beni Hasan (Tomb 723) representing a cow whose neck has been painted with a red line to denote its slaughter (BM EA41576) (Tooley 1989: 46) (Fig. 3.5). The knife is not preserved. Another example of a butchery model comes from the 12th Dynasty tomb of Khety (Tomb 366) at Asyut which shows butchers slaughtering cattle (Breasted 1948: 37; Garstang 1907: 105, 224; Strudwick et al. 2016: 142, 145). A unique model of a butcher's workshop was also found in 11th Dynasty at Asyut (Tomb 7) (Breasted 1948: pl. 33; Chassinat and Palanque 1911: 50, pl. XV). In other words, models appear at the end of the Old Kingdom and continue into the Middle Kingdom.



Figure 3.5 Wooden model of a butchery activity. Painted wood. Provenance: Tomb of Sebekhetepi, Tomb 723, Beni Hasan. Middle Kingdom. British Museum EA41576. ©The British Museum.

There seems to be no correlation between the placement of daily life models in tombs and regional stylistic practices. Models that reflect animal butchery scenes are found throughout Egypt. The variation in artistic quality and style between models and wooden coffins suggests that there was a range of artists working on these painted wooden models throughout Egypt and

that production was not localised (Grajetzki 2016). For example, compare the aesthetic quality execution of the model in BM EA41576 (Fig. 3.5) with that of MET 20.3.10 (Fig. 3.4) – one is executed with greater aesthetic qualities than the other.

Written records can also be a line of evidence for understanding animal butchery and its place within Egyptian society. There is clear evidence that butchery was a specialized profession already during the Old Kingdom. Literary evidence on the titles of individuals dating from the Old Kingdom suggests local butchers that had a high position in society were hired for animal slaughter but that a ranking of butchers also existed (Fisher 1960).

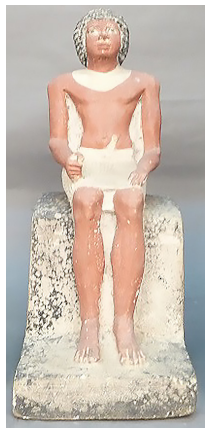


Figure 3.6 Painted limestone statue of Itisen, seated on an inscribed seat, wearing shendyt, short black wig and pectoral. GEM 1079.

Several examples similar to that of Itisen reflect that butchers were within the higher strata of society. Individuals bearing titles related to *Master Butcher* or *Butcher of the Great House* are numerous for the Old Kingdom (Fisher 1960: 174). For instance, a statue from the 5th Dynasty

recovered from the necropolis at Saqqara belonging to a member of the royal household (Ph-r-nfr), holds the title *Butcher of the slaughterhouse* and *Master Butcher* (Louvre A 107; Fisher 1960: 171). The individual holds a number of titles that are related closely with royal temple or ritualistic activities, including offerings of meat to the royal house (Fisher 1960).

Perhaps the most exquisite example of butchery titles from the Old Kingdom however, is found in the tomb of Irukaptah, also known as the *Tomb of the Butchers* (PM III.II: 639) (McFarlane 2000). The tomb is located at Saqqara and dates between the 5th and 6th Dynasties. Irukaptah held the titles, *Butcher of the Main Property of the Palace*, i.e. *Head Butcher*, *The Royal Overseer of the Butchers*, and *The Royal Acquaintance, the Head Butcher* (De Rachewiltz 1960). Itukaptah's tomb is beautifully carved with portraits of himself and his family and a well painted butchery scene illustrating men slaughtering an ox with black and white hide (De Rachewiltz 1960: 17-18). It is clear in the example of Irukaptah that the close relationship with the king provided him with enough wealth to commission an elaborate tomb. More importantly however, is how the tomb of Irukaptah serves as another example for butchers who are connected closely with the state, and in this case the palace.

Instances of officials of the court who have the title *Master Butcher* also exist. One case is the official Seshemnefer who served under the King Unas (6th Dynasty) and has the title Overseer of the Tenants of the Great House and Master Butcher (PM II.II: 614) (Rice 1999: 187; Saad 1947: 56-57, pl. XVIII). A priest of King Khufu of the 5th Dynasty, by the name of Khnemu had the title, *The Master Butcher of the Great House*, inscribed on the lintels of his tomb in the Western Cemetery at Giza (Tomb G 2191) (Fisher 1978: 56-57). In fact, the entire inscription reads:

The Master Butcher of the Slaughterhouse of the Palace, He Who Is Privy to the Secret of the Darkness, Who Opens It (the darkness) in Strangling the Bird of the Desert Regions, Hnmw, [priest of Khufu, royal acquaintance] (Fisher 1978: 57).

Fisher (1978) deduced the meaning of “darkness” and related it to the subjugation of the enemies of Egypt. He states:

While these epithets are apparently without parallel, there can be no question that they allude to the apotropaic symbolism that was attached to the slaughter of cattle and fowl, these victims representing the enemies of Egypt and the forces of chaos (Fisher 1978: 57).

Fisher raises an important point in what is expressed in the “elite” butchery titles. Although the other examples above are not as explicit in the description (i.e. strangling the bird of the

desert regions), there is still a sense of duality among their position. All the examples discussed thus far are individuals who are connected to the court either through their position as priests of royal cults or as court members in temple activities. This is further attested in a writing-board at the University College London from the Middle Kingdom period which places butchers among temple workers (Gardiner 1947: 64-68; Ikram 1995: 110). The titles therefore suggest that a benefit is obtained by holding such titles, a benefit to providing royal cults with the ritualistic sacrifices required to maintain the balance between good and evil (ma'at). Therefore, although the other examples do not explicitly state their role, their role by nature is to do the same in the forces of chaos.

In light of this perspective, three important points need to be mentioned regarding the examples discussed. Firstly, these inscriptions are in tombs that belong to high priests, noticeably individuals who had the means to afford an elaborate tomb and commission expensive artistic works such as private statuary. Therefore, they are not reflective of other lower-class butchers that may have existed. Secondly, these examples suggest that butchers were highly regarded in Old Kingdom society, at least in relation to temple activities. Thirdly, their role as butchers fit within the ancient Egyptian ideology of maintaining Ma'at (the balance between good and evil).

Elite butchers received great benefits from functioning as agents in temple activities (Ikram 1995: 109-110). The examples consisted of wealthy individuals who had the means to commission their own private tombs and funerary goods, including private statuary. As described earlier in Chapter 1, placement in the upper strata of society allowed such benefits to be easily accessed while unavailable to those in the lower classes. In fact, some butchers may have been wealthy enough to own estates (Ikram 1995: 109-110). In the case of butchery for royal cults and temples, the temple and state benefited from the continuation of religious practices while the butchers benefited from their wealth and status.

3.2.4 *Non-elite butchers*

Not all butchers were among the elite class of society. There is evidence for butchers who had titles that did not particularly place them at the top of the social hierarchy (Ikram 1995: 109; Fisher 1960: 177). These titles do not have the hieroglyphic prefix that is associated with wealthy butchers (Fisher 1960: 177). It is unclear the role that non-elite butchers played in the sphere of animal butchery or the extent that lower status individuals were involved because of the lack of archaeological evidence for that strata of society (i.e. they did not have the means to construct

lavish tombs with inscribed biographies). However, the fact remains that various titles for butcher exist which implies that groups of skilled butchers existed in ancient Egypt (Ikram 1995: 109). This group had a sort of hierarchy as differences in titles suggest (Fisher 1960: 171, 177; Ikram 1995: 109-111). This is also made explicit in the model slaughterhouse at the MET (Fig. 3.5 above) which depicts two higher status individuals (denoted by their sceptres) overseeing the slaughterhouse and the workers, one (perhaps the *royal overseer of the butcher*) claims his status by placing the sceptre onto the shoulder of the butcher at work. It is clear from the evidence that the group of animal butchers in ancient Egyptian society was directly linked to social hierarchy whereby higher ranked individuals supervised those from the lower social strata.

3.3 *Deducing technology from iconography and models*

It is very difficult to reconstruct the nature of raw materials used in butchery from the iconographic and three-dimensional models. While many of the models have been well-preserved, which allowed for their original shape and colour to be maintained, the knife held by the butcher is missing on some of them or shaped into their body (e.g. Model of Butchers at Work, E.71c.1903, Fitzwilliam Museum, Cambridge). In these cases, the butcher's hand is left floating where once a model of the knife was placed, which makes tool identification impossible. Where the knife is preserved in the model, it is not possible to do a metallurgical analysis since the model knives are painted wood (e.g. MMA 20.3.10).

In most butchery scenes, a large knife is used to slaughter and dismember the animal. It is difficult to use the shape and colour of the knife as an indication of its raw material (stone or metal) because both flint and metal tools are similar in shape and can also be similar in colour. Hence, these painted models of animal butchery are not particularly useful in identifying if metal or stone were used to slaughter the animal. Some scholars have suggested that knife sharpening scenes (Fig. 3.9) are suggestive of metal sharpening, stating that “sparks are seen falling from sharpened knives, indicating that they are of metal” (Martin 1979: 12). However, what is portrayed in these images is the sharpening of chipped stone knives because of the flakes falling from the knife (Graves-Brown 2008: 4-5; Ikram 1995: 70-73). It is without question that the knives depicted are of stone. It is also assumed that the Old Kingdom butchering tools were made of stone (Ikram 1995) given that hard tin-bronze (10% tin) does not appear until the end of the 3rd millennium BC. Stone tools dominate the butchering assemblages during this period in neighbouring regions (Greenfield 2013), but the situation is quite different in the Middle

Kingdom.

3.4 *Flint Knives*

The literature on the use of flint in animal butchery is exhaustive as it relates to stone chipped knives (Fig. 3.7) similar to those depicted in animal butchery scenes (Graves-Brown 2010; Ikram 1995; Kobusiewicz 2016b). Flint knives are the most exquisite during the Neolithic when they were at the peak of their manufacture. Beautiful flint knives are found in a variety of Neolithic contexts ranging from settlements to private tombs, such as that found in the Tomb of King Khasekhemui (Fig. 3.7). The shape of these knives varies, and their typologies have been studied to better understand the evolution of tool types (Graves-Brown 2010: 173-179; Ikram 1995: 63-73; Kobusiewicz 2016). In fact, the variety of sharp flint tools found implies that they were used for a variety of activities, including animal butchery. Even though the shape of the knife is ambiguous in allowing determination if it is made of metal or stone in the animal butchery scenes, it is clear from Old Kingdom iconographic depictions of slaughtering and carcass processing scenes that they are flint or stone knives. In a few scenes, the knife is being sharpened and one can see the baton used for hitting the tool and causing the sharpening flakes to flow from the flint knife (e.g. Fig. 3.7; Graves-Brown 2010: 176).



Figure 3.7 Flint bifacial knife. Provenance: Tomb of King Khasekhemui. Abydos. Late 2nd Dynasty, Early Dynastic Period. MET 01.4.30. ©Haskel Greenfield.

During the Old Kingdom, the visual evidence on animal butchery suggests that curved knives were the preferred tool for animal butchery. These flint knives are “flaked, with slightly curving backs, rounded or pointed tips and gently curving blades” (Ikram 1995: 63). However, there is a variety of sharp flint tools from Archaic and Old Kingdom sites that are not depicted in these scenes and could have been used in butchering activities such as slicing or filleting. These types are bifacial flint knives, fishtail knives, or bi-truncated blades (Kobusiewicz 2015: 13-5; see figures in chapter 4). Particularly, bi-truncated blade tools or “razor blades” are extensively

found in archaeological contexts and although their use is unclear, it is difficult to imagine that these small, sharp tools would not have been used in filleting and other butchery activities (Skarzynski 2017; Kobusiewicz 2015; Graves-Brown 2010). Examples of these are found in several Old Kingdom sites (see Chapter 4) including Saqqara (Macramallah 1940: 6-8, 10; Kobusiewicz 2015: 78) and Giza (Kobusiewicz 2015: 48). Differences among the quantities of blades (bifacial vs bi-truncated blades) may be due to differences among activities they are used for such as higher status mortuary site where ceremonial knives might have been more frequent due to accessibility, affordability, and ritual (Schmidt 1992: 87).

The lack of evidence where animal bones and flint knives are found together makes it difficult to identify if animal slaughter performed with a flint knife was performed in ancient times. However, an exception dating to the Old Kingdom suggests that animal offerings were part of funerary rituals. The “Shrine of the Knife” in the funerary complex of Raneferet of the 5th Dynasty at Abusir is one example of this (Svoboda 1993, 2006; Vachala and Svoboda 1989).

3.5 The advent of metal knives

Metal knives that resemble those used in animal butchery appear in the Early Dynastic period (e.g. 1st Dynasty necropolis of Tarkhan, where both flint and copper knives were found in a number of tombs) (Petrie 1913) (examples see UC17081; UC28612). Perhaps the most exquisite example is a copper knife with a curved blade found dating to the Early Dynastic Period 1st Dynasty at Abydos (Manchester Museum 6783) (Fig. 3.8). These early examples are made of arsenical copper (Muhly 1999: 630). Excavations at the 6th Dynasty Tomb of Impy at Giza (G2391) recovered a large quantity of copper tools, including copper knives (Maddin et al. 1984) (for example, Museum of Fine Arts, Boston 13.3471). Whether these early copper knives were used in animal butchery for daily life or only for ceremonial purposes is difficult to determine but it is unlikely that they were used for animal butchery given that this early copper is a relatively soft metal and would not hold an edge during the slaughtering or butchering processes. Moreover, a recent study demonstrates that an astounding percentage (95%) of the sharp metal-based implements from the later third millennium BC that may have been used in animal butchery (such as knives) come from elite, ritual and ceremonial contexts, such as tombs, temples, or foundation deposits, while very little (5%) derive from settlement contexts where they may have been used in utilitarian activities (Odler 2016: 66-69).



Figure 3.8 Copper knife. Provenance: Abydos. 1st Dynasty, Early Dynastic Period. Manchester Museum 6793. ©Manchester Museum

Although the near absence of metal tools from settlement contexts may reflect their lack of use in daily life for activities such as animal butchery, the phenomenon is complicated by the likely recycling of rare and expensive materials, such as copper or bronze, which can be melted down, repaired, and reused (Greenfield 1999, 2013; Ikram 1995: 67; Tillmann 1999: 314). An example of a copper production workshop area that reworked and recycled copper was found at the First Intermediate Period site of Balat in the Dakhla Oasis and its presence demonstrates the re-working of copper shortly after the Old Kingdom (Moeller 2016: 242).

The presence of metal in wealthy burial contexts is indicative of a product that seems to have been reserved for the wealthier or higher classes of ancient Egyptian society. It cannot be determined yet whether the reuse of metal was a factor in hiding its distribution in antiquity. Metal may have been more widespread than previously believed, but this could only be investigated through proxy measures, such as microscopic butchering marks on bones (Greenfield 2013).

3.6 Middle Kingdom and later stone and metal use

In Egypt, the development of metallurgy continued during the Middle Kingdom with the widespread production of hard arsenic/tin-bronze tools alongside the continued use of flint in household activities (Graves-Brown 2010; Odler 2016). Flint and copper tools are found together in several contexts, such as at Lahun in the Fayum (see objects 192, 205, 229 Manchester Museum). The site yielded flint, copper, and bronze knives that resemble in shape those used in animal butchery iconography and three-dimensional wooden models from the same time period. It is unclear if the Middle Kingdom bronze and copper knives were used for animal butchering for the population in general, restricted for use by higher status/wealthier individuals, or primarily for symbolic purposes. It is likely given the abundance of stone tools during this period that they were the primary butchering technology for the lower strata of society.

By the time of the New Kingdom, bronze knives are found in abundance, and flint chipped

stone flint tools begin to decline dramatically in frequency and quality (Graves-Brown 2010: 97). It is more than likely that by the New Kingdom, bronze had nearly replaced stone as the primary technology in animal carcass processing. Metalworking also continued to be a specialised craft as seen in the administrative document Papyrus P.BM 10068 which lists copper smiths as 5% of the total occupations that existed (Shaw 2012: 135-138).

3.7 Discussion – transition from stone to metal knives

Although metal knives are present early in ancient Egypt and produced alongside flint knives from at least the Early Dynastic Period onward, the rate of change from stone to metal knives in daily life activities such as animal butchery is still unclear (Ikram 1995: 65-69). Some authors attribute the transition from stone to metal for quotidian activities to the Middle Kingdom based on the decline in frequency of stone tools during this period (Graves-Brown 2010: 97). The larger quantity of bronze objects recovered from New Kingdom sites suggests that the transition had already occurred earlier. But it is unclear how widespread the use of metal knives in the lower strata of society was in each of these periods, and the types of functions they were used for. Whether metal knives were exclusively used in ceremonial contexts or in daily life is unknown as is its accessibility to all social classes of society.

A recent publication on the ideological significance of flint in Dynastic Egypt measured the declining frequency of flint from the Old and Middle Kingdoms by examining changes in quality, typology, technique of production, and most importantly (for our purposes) frequency over time (Graves-Brown 2010: 97). She documents a drastic decline in frequency of flint tools beginning in the Middle Kingdom with a near absence by the New Kingdom. This recent study corroborates earlier studies (Ikram 1995: 65-9). This decline is likely related to changes in metal production that would make it easier to mass produce and less expensive and more affordable to a wider segment of society (Graves-Brown 2010: 43, 83; Rosen 1996: 131, 153). Although metal knives existed in the Old Kingdom, there is no evidence on how widespread its use was during this time and if it was restricted to the wealthier members of society. It is clear from the decline of flint and increase of metal objects from the Old Kingdom into the Middle Kingdom that a socio-evolutionary change occurred resulting in more use of metal objects.

While the third millennium is characterised by copper tools, bronze metal production appears to undergo a dramatic change in the Middle Kingdom based on the increased frequency of bronze metal objects. In combination with the decline in flint knives, it would suggest that the

transition from stone to metal butchery technology occurs at this time. Nevertheless, the presence of copper knives from the third millennium (Odler 2016), begs the question as to whether they could have also been used in butchery activities.

3.8 Examining the origins of metallurgy through animal butchery

Greenfield microscopically examined butchering marks on faunal remains from the southern Levant (Israel, Jordan, and Palestinian Territories) (Greenfield 2002, 2005; Greenfield and Marciniak 2019). This method avoided the pitfalls of relying exclusively on the few metal objects that survive. Based on experiments conducted with modern tools and modern replicas of ancient tools (stone and metal), through the use of light optical and scanning electron microscopes, he was able to demonstrate that there are microscopic diagnostic distinctions between slice marks produced by chipped stone and metal blades (Greenfield 1999, 2000, 2002, 2005, 2006). Application of his results to zooarchaeological materials from the southern Levant allowed for a quantitative assessment of the frequency of butchering marks made by flint and metal tools. These in turn provided an independent line evidence for the rate of adoption of metallurgy for animal butchering during the Bronze Age of the southern Levant. It is now clear that butchering marks made by metal butchering implements did not appear until the Middle Bronze Age (Greenfield 2013). This work has been largely validated as it was extended to other regions. Metal butchering implements only became the dominant technology in the Late Bronze Age across much of the Middle East and Europe (Greenfield 2017; Marciniak and Greenfield 2013). However, in some regions, stone tools continue to be used through the Iron Age and even later periods (Greenfield and Marciniak 2019). In consequence, one should really conceptualise the Early Bronze Age (including 3rd millennium BC Egypt) as part of the long and continuous use of stone tools. Given the diversity of rates and nature of adoption of metal from stone across the Old World, this analytical perspective can and should be applied to test theories about the development of metallurgy in ancient Egypt and to increase our understanding of the impact metal tools had in ancient Egyptian society.

3.9 Conclusion

Animal butchery in ancient Egypt was an important part of daily and ceremonial life for both the living and the dead. Previous research focused on animal butchering techniques, the types of animals butchered, and the types of knives used in the butchering process based on texts, iconographic reliefs, and models of animal butchery scenes (e.g. Ikram 1995). However, when

the shift from stone to metal tools occurred remains ambiguous and poorly understood. It is unclear how common metal knives were for butchery since the archaeological evidence is biased through recycling and toward funerary contexts that further distort any understanding of whether all levels of society had access to metal tools for more than elite funerary activities.

Given the collated published information relevant to the topic summarised here, it may be suggested that the transition to metal knives for butchery was a complex process. It does not appear to be likely that animal butchery was conducted with metal knives with the first appearance of copper knives during the third millennium BC, but likely took place a thousand years later during the Middle Kingdom when bronze knives first appear. Flint knives continued to be used throughout the third millennium BC but begin a long decline afterwards. While the decline of flint in the Middle Kingdom may suggest a higher use of metal tools, the presence of copper metal knives in the Old Kingdom begs the question as to whether they were of a utilitarian nature for butchery activities. The next couple of chapters begin to answer this question, starting with Chapter 4 which discusses the use of flint in the Old Kingdom.

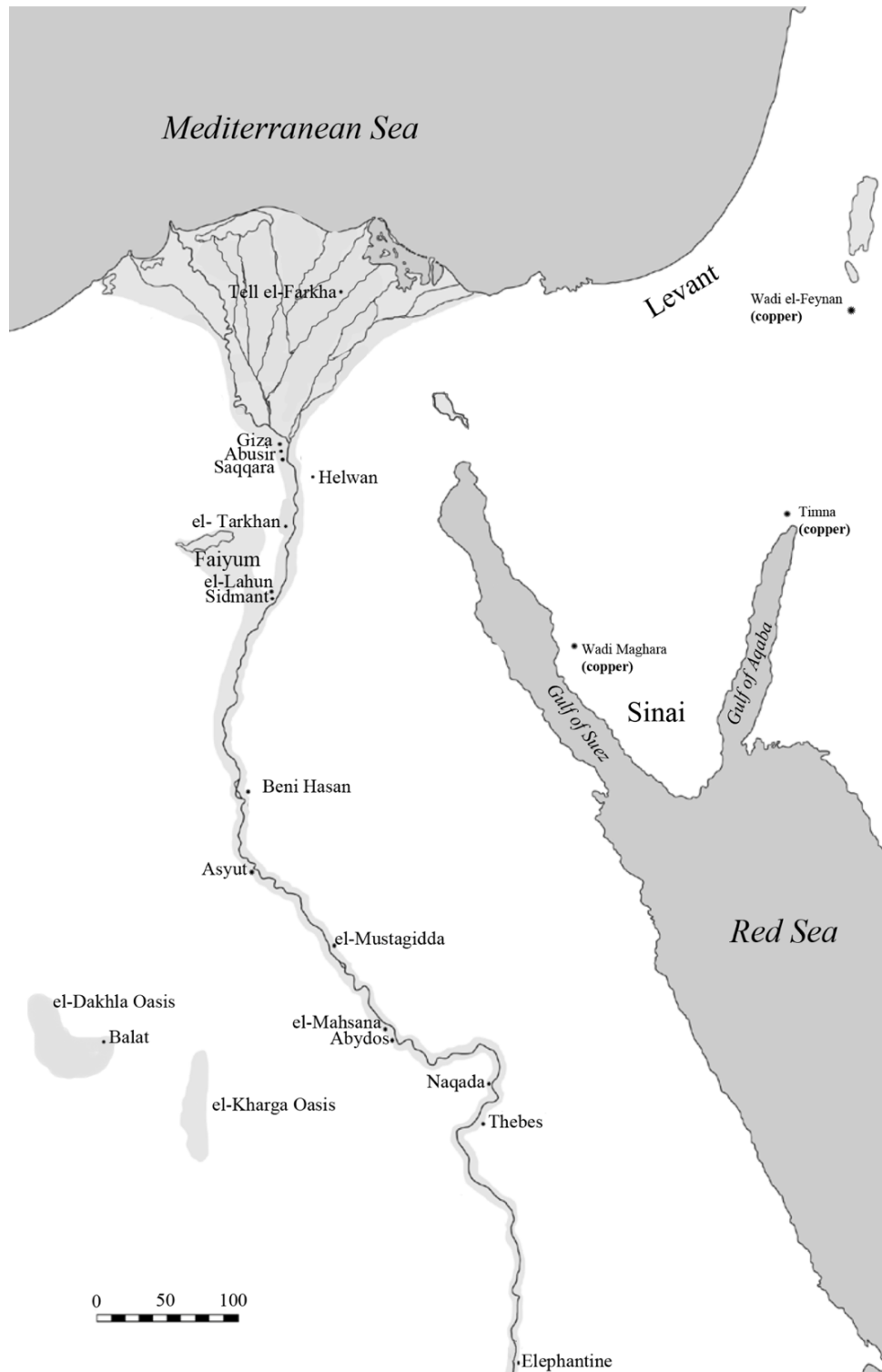


Figure 3.9. Map of Egypt with the names of locations mentioned in text.

Chapter 4: Flint Implements

4.1 Introduction

The previous chapter examined evidence of animal butchery including those represented in two-dimensional scenes and three-dimensional models. Old Kingdom animal butchery scenes depict the slaughter of animals with a knife, but its material type is ambiguous. This chapter delves into the use of flint implements during the Old Kingdom, particularly those likely used in animal butchery. The use of stone technology predates the Old Kingdom when exquisite and best quality objects were produced during the Naqqada (Predynastic) period. Objects such as those seen in the animal butchery scenes have their roots during this early period. However, a consensus exists that the quality of flint objects decreased beginning in the Old Kingdom (Tillman 1999: 312; Graves-Brown 2010) which may or may not be related to the introduction of metal use. Despite this fact, the use of stone blades continued throughout the Old Kingdom in a variety of utilitarian activities including animal butchery and its study is useful in understanding the social impact flint has in Old Kingdom society.

4.2 Definition of flint material

Flint is a hard siliceous rock (slightly harder than quartz) that consists of three raw types: nodular flint, tabular flint, and mined flint (Kobusiewicz 2015: 6; Stocks 2003: 1). *Nodular flint* are nodules collected from the surface and spherical or oval in shape, brown/pale brown or dark grey. *Tabular flint* are typically flat sheets of raw material, caramel, orange, and wine-cherry in colour with a slab surface that is typically whiteish or reddish yellow and flint that is reddish brown. *Mined flint* is usually brownish in colour and is the most expensive to obtain because it is obtained by quarrying and also has a reduced amount of internal cracks due to its physiochemical structure which is ideal for large items. These various types of flint were used during the Old Kingdom for the manufacture of lithic tools including blades for animal butchery. Flint has several uses and its study provides insight to interesting associations present between artefact type and context (i.e. percentages of mined flint versus local flint to determine the import of tools). One of these cases can be found at *Tell Murra* where mined flint was likely the raw material used in the production of tools due to its proximity to mines (Lajs 2019).

4.3 Sources and quarrying of flint in Old Kingdom Egypt

Egypt was rich with sources of flint located throughout the Nile Valley (Hamimi et al. 2020). Flint nodules found in Eocene limestone were located throughout Egypt including from Cairo to

Isna (Hikade 2000b; Kobusiewicz 2015: 7), on a high plateau near the Fayum Oasis (Ginter 1985), on the plateau near Abydos (Hikade 2000a), near west Thebes (Debono 1971; Tillman 1999), around Sin El Kaddab (Kopp 2006), and in Dakhla and Kharga Oases in the Western Desert (Kobusiewicz 2015: 7). The large amount of readily available flint meant that little effort was required to obtain the resource and surface accumulations, or eroded limestone was typically harvested for use (Kobusiewicz 2015: 10).

Two key areas have evidence of quarrying during the Old Kingdom, the *Wadi Sojoor* and *Wadi el-Sheikh*. *Wadi el-Sheikh* in the Eastern Desert is most commonly discussed as having been quarried extensively in Predynastic, Early Dynastic, and Old Kingdom periods (Baumgartel 1960; Harrell 2012: 5; Kobusiewicz 2015; Negro and Cammelli 2010) while the *Wadi Sojoor* was extensively active during the Predynastic and Old Kingdom periods (Kobusiewicz 2015: 12; Tillman 1999: 311). It is highly probable that the quarrying of flint was organised by the state with skilled professionals who were knowledgeable of quarrying methods (Kobusiewicz 2015: 10; for quarrying see Negro and Camelli 2010) and the use of animals were employed for the transportation of heavy loads (most probably cattle or donkeys) (for cattle as transport see Close 1996: 550-552).

Although Egypt was plentiful with flint, other material types used in the Old Kingdom was also present in areas outside of the Nile Valley such as in the Western Desert where *chalcedony* has been found around Darb el-Arbain (Said and Hayah al-Misriyah al-`Ammah 1990: Ch. 25) and Elephantine where *obsidian* was found in areas of production (Kobusiewicz 2015: 7). The latter was most probably an import of Anatolia or Yemen and transported along the Red Sea route (Hendrickx (Hendrickx and Bavay 2002: 60; Kobusiewicz 2015: 7; Sowada and Grave 2009: 26; Wilkinson 1999: 138-139). Nonetheless, most flint recovered from the Old Kingdom derives from Egypt proper and consisted of the nodular, tabular, or mined flint types.

4.4 Modes of production of flint and state involvement

According to Kobusiewicz (2015), the shaping of nodular core flint was done through three types of technologies: *flake technology* involved flint knappers shaping the core into tools that could be utilised, *core technology* was used for processing tabular flint, *lithic technology* involved chipped flint and bifacial retouch was employed in subsequent phases of bifacial knives production, and *Par pression technology* “was used to strike regular slender blades off a single platform core” (Kobusiewicz 2015:8) (also see Kobusiewicz 1988; Kobusiewicz 2007; for Old

Kingdom examples of the latter see Midant-Reynes 1998). The reworking and sharpening of flint tools were depicted in several tomb scenes from the Old Kingdom onward (Fig. 3.9) (Lund 2015). The most common technologies adopted for butchery knives or blades were flake and lithic technologies (Lund 2015).

The processing of flint occurred at the find or mining location where the on-site production provided sufficient requirements for the needs of the local population especially in areas near flint deposits (Kobusiewicz 2015: 10). On-site production is evident by the presence of cores, debitage, and tools (Kobusiewicz 2015: 10) such as at *Ain el-Gazareen* (Kobusiewicz 2007), *Ain Asil* in the Dakhla Oasis (Midant-Reynes 1998), or at *Elephantine* (Hikade 2013). Domestic production of flint tools also occurred in individual households at some settlements including *Ain el-Gazzareen*, *Kom el-Hisn*, and *Elephantine* (Kobusiewicz 2015: 10-11). These examples demonstrate that flint tools were produced in localised (i.e. within the settlement) and rural (i.e. near the mining source) contexts, but the study of flint in Egypt suggests that mined flint was likely produced by the state (Kobusiewicz 2015: 11).

The presence of imported quarried flint produced by highly skilled individuals at some sites is indicative of a state organised flint distribution system (Kobusiewicz 2015:11). Further evidence is in the absence of unworked mined flint nodules at sites where mined flint tools are found, indicative that initial flint processing was not produced locally at some sites and most probably processed at the mining location (Kobusiewicz 2015: 10-11). An example is found at *Kom el-Hisn* from the 6th Dynasty where the agricultural settlement that appears to have used sickle blades heavily, but the lack of flint knapping waste suggests that they did not engage in flintknapping locally (Kobusiewicz 2015:11). Such off-site flint production is believed to occur in workshops organised by the state that likely existed before and into the Old Kingdom (Kobusiewicz 2015: 11) (for discussions on flint workshops see Adams and Cialowicz 1997; Chlodnicki and Cialowicz 2012: 24, 110, 279 ; Florek, Hikade, and Carter 2019; Midant-Reynes 1998; Schmidt 1992a; Svoboda 2006; Tillmann 1992, 1999).

Until recently, no published evidence for excavated flint workshops have come to light and the existence of such workshops was presumed on deduction from archaeological finds and tomb scenes i.e. Beni Hassan Tomb 23 (Hikade 2004). However, Hikade and others (2019) argue for the presence of flint knapping workshops located in the Eastern Desert at *Wadi el-Sheikh* (Florek, Hikade, and Carter 2019). It is unclear if such flint workshops employed state organised

workers who were highly skilled at flint knapping and the manufacturing of flint tools or autonomous localised skilled individuals. Nonetheless, recent research suggests the state was involved in the production of flint tools indicated by the craftsmanship of flint tools and the lack of mined flint waste among these sites (Hikade et al 2019; Kobusiewicz 2015:13).

4.5 Types of flint artefacts for utilitarian purposes from the Old Kingdom

A variety of flint artefact types exist from the Old Kingdom, with some specimens (e.g. scrapers) from the Early Dynastic period possibly in use for a long time (Hikade 2004; Kobusiewicz 2015: 9). Flint artefacts varied in type and use from sickles used for crops to scrapers used for dressing hides. However, particular to this thesis, special attention is only given to those strictly related to animal butchering activities. These include bifacial knives, bi-truncated regular blade tools, and scrapers.

4.5.1 Bifacial knives

Bifacial knives are sharp edged flint knapped tools that often have handles (Fig. 4.2). This flint tool type were typically manufactured from mined flint and have a high degree of standardisation and quality which suggests that they were likely produced off-site and delivered in complete pieces to the settlement or funerary location (Kobusiewicz 2015: 13-14). Bifacial knives can be categorised into six types according to Tillman (1992) and others (Ikram 1995; Kobusiewicz 2015: 13-15) four of which were in use during the Old Kingdom (Fig. 4.1). The following types are based on the description given by Kobusiewicz (2015):

Type 1 (Fishtail type) has a “U or V-shaped working edge set transversely to the tool axis of a tool. Both of its faces are covered with flat, fairly regular retouch, and margins are refined with bilateral fine retouch” (Kobusiewicz 2015: 13).

Type 2 knives are long and slender with a simple handle extended from the blade and made from steep retouch method (Kobusiewicz 2015: 14). These types date from Dynasty 1-6. Examples of these were found in Saqqara in the tomb of Hemaka (Emery 1938: pl. 11), in Helwan (Saad 1951), and Elephantine (Dreyer 1986).

Type 3 are “less curved knives, with a narrower and rounded blade and a short, simple, unnotched handle...with a fine retouch” These were in use from the 2nd to the 4th Dynasty (Kobusiewicz 2015: 14).

Type 4 has a pointed blade and dates to the 5th to the 6th Dynasties (Kobusiewicz 2015:f.106).

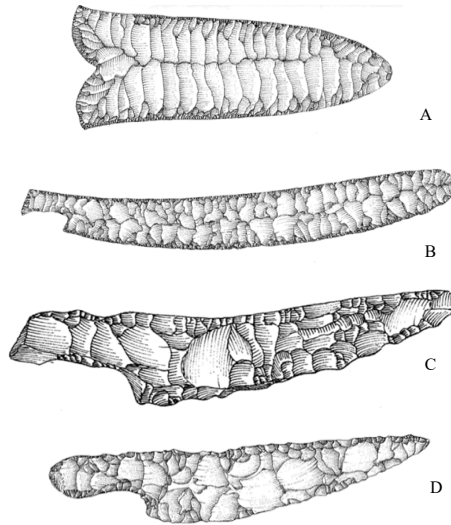


Figure 4.1. Bifacial knife types. Kobusiewicz (2015), A. Type 1 Fishtail (p. 71, fig. 37). B. Type 2 (p. 70, fig. 36), C. Type 3 (p. 72, Fig. 38.2), D. Type 4 (p. 73, fig. 39).

4.5.2 *Bi-truncated regular blade tools*

Bi-truncated regular blade tools (also known as razor blades or square flakes) from the Old Kingdom are rectangular shaped with single-sided worked blades (Fig. 4.2) (Kobusiewicz 2015: 18; for dating and origins see (Hikade 1999; Hikade 2013). They are typically categorised into two types differentiating from their transverse edges; those dating to the Old Kingdom have straight transverse edges and are shaped into long rectangles (Kobusiewicz 2015: 18). Similar to bifacial knives, these blade tools were made of high-quality mined flint and probably manufactured in specialised workshops to be traded or distributed by the state (Kobusiewicz 2015: 18). Bi-truncated regular blades were used in a variety of tasks from beauty treatments (Hikade 1999; Kobusiewicz 2015: 14) such as those found in the tomb of Heteperes at Giza that were placed among other copper cosmetic items (Reisner 1929) to animal butchery.

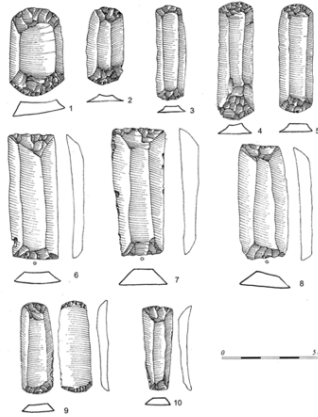


Figure 4.2. Bi-truncated blade types. Kobusiewicz (2015: 78) 1-5,9 bitruncated regular blade tools (“rasor blades”) older phase (Saqqara); 6-8, 10 bitruncated regular blade tools (“rasor blades”) younger phase (Elephantine).

4.5.3 Scrapers

Scrapers are commonly found in Old Kingdom settlements and often make up a large part of the flint inventory for sites. They are sharp implements made of nodular or tabular flint (local flint) and appear in Egypt from the Neolithic periods and throughout the Old Kingdom onwards (Kobusiewicz 2015: 18; Rizkana and Seeher 1985). Scrapers range in size and shape but are characterised by their sharp edges produced by flat steep flaking (Fig. 4.3) (Kobusiewicz 2015: 18). Different types of scraper include end scrapers and ‘nosed’ end scrapers (for a detailed description on scraper typologies see Kobusiewicz 2015: 19-20). The ease of manufacture made these tools extremely popular throughout Egyptian history including the Old Kingdom. As Kobusiewicz states, “scrapers were ad hoc tools, requiring no special skills or practice to make”, dissimilar to knives or blades which were much more difficult to produce (Kobusiewicz 2015: 19).

Their ease-of-use and versatility in a number of activities including dressing slaughtered animals, butchering a carcass, scraping bones, working hides, and manufacturing objects of wood make these tools popular among local populations. As a result, scrapers make up a fair percentage of the flint assemblage from Old Kingdom sites (between 10-20% see Kobusiewicz 2015: 19).

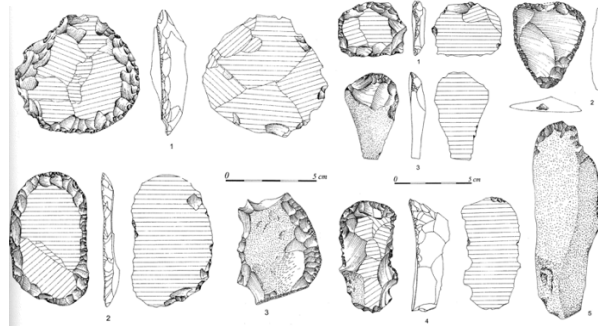


Figure 4.3. Various scraper types. Kobusiewicz 2015: 79-80.

4.6 Consumption of flint artefacts

The number of Old Kingdom sites that contain evidence of flint consumption is exhaustive. Flint knives similar to those represented in animal butchery scenes have been found in religious and settlement contexts of the Old Kingdom. The recent study by Kobusiewicz for instance, Giza had the highest percentage of bifacial knives (22.26%) and Elephantine had the second highest (9.44%), while other sites that had less religious activities also had a lower percentage of bifacial knives (Table 4.1). As the description below exemplifies, flint knives were multi-use and not restricted to religious activities but rather common also in utilitarian purposes. In order to obtain an overall picture of the typologies utilised in Old Kingdom settlements, it is necessary to examine those that have a large reflective sample. Although isolated finds can be indicative of flint tool-use, they provide little context to the relationship between utilitarian activities and tool use. As a result, the sites described below couple context and provenance to better understand the relationship between tool-types and activity uses.

Table 4.1. “Comparison of percentages of different tool types from selected sites. Percentages based on the total number of tools (Helwan, Elephantine, Giza, Ibrahim Awad and Ain Ail according to Hikade 2005)” (Kobusewicz 2015: 19)

Tool type	Helwan	Elephantine	Giza	Ibrahim Awad	Ain Asil	Ain el-Gazzareen	Kom el-Hisn
Bifacial knives	1.24	9.44	22.26	3.01	1.06	3.90	9.45
Scrapers	16.96	15.06	15.63	0.00	51.00	19.53	0.44
End scrapers	3.30	3.61	4.84	1.20	no data	6.01	0.23
Segmented blades	6.12	8.03	11.06	33.13	6.08	15.79	76.69
Bitruncated rect. blades	0.83	25.70	1.60/ 6.44	4.22	0.00	0.00	0.00
Retouched blades and flakes	54.13	25.50	12.90	no data	7.25	31.42	1.10

4.6.1 Flint in contexts during the Old Kingdom

A number of flint artefacts have been recovered from Old Kingdom settlements. Flint implements such as knives, blades, and scrapers are often included among the archaeological

finds and can provide information about their adoption into utilitarian activities. One such activity was in the butchery of animals. The adoption of sharp flint implements into the realm of animal processing is vividly expressed in numerous tomb scenes from the Old Kingdom (Ikram 1995). Most of these scenes depict cattle butchered by a sharp (flint?) knife (Chapter 3).

Old Kingdom settlements provide a lens where such relationships can be studied. Understanding the from whence flint blades derive can help explain the types of activities performed with them. Moreover, parallels among the zooarchaeological evidence and tool types can also be drawn to understand the connection between tool types and types of animals slaughtered. Some Old Kingdom settlements that reflect these connections are located within the *Nile Delta* (Kom el-Hisn, Tell Ibrahim Awad, Tell Murra), *Nile Valley* (Giza, Helwan, Memphite necropolis, Elephantine), and the *Dakhla Oasis* (Ain Asil and Ain el-Gazareen).

4.6.2 Nile Delta

The flint assemblage from *Tell Ibrahim Awad* had an extensive quantity of lithics that were mostly from religious contexts (i.e. temple or funerary) (Schmidt 1992b; van Haarlem and Hikade 2006). A total of 11% of the flint assemblage were ‘blade’ types (bifacial knives and retouched blades) (Haarlem 2006). A large quantity of bifacial knives produced from mined flint in specialised workshops were recovered from the temple area (over 50% of the flint types) (Haarlem 2006: 390-391). The provenance of the bifacial knives implies that they were important in temple activities, most probably in the slaughter of cattle (Haarlem 2006: 390-391; Kobusiewicz 2015).

The well excavated site of *Kom el-Hisn* revealed substantial quantities of material culture, including flint and faunal material dating to the Old Kingdom. The flint recovered was produced from the mined flint type and manufactured off site (Kobusiewicz 2015: 44-48). The most common flint debitage were blade fragments (402=76.73%) while bifacial knives were present in small quantities for flint tool types (43=9.45%) (Kobusiewicz 2015: 44). The blades were noted to have heavy use wear, Kobusiewicz states that “several of the better preserved bifacial knives have distinct traces of heavy wear, especially near the handle, but also along the cutting edge” (Kobusiewicz 2016a: 33) It is unclear whether these blades were used strictly for animal butchery or in a variety of activities. However, a high quantity of faunal remains recovered at the site suggests their use in animal processing is probable (Redding 2016). Kom el-Hisn is considered a cattle rearing site that was provisioned by the crown and the local population

consumed mostly pig and sheep/goat (Redding 2016). The higher quantity of blade types may reflect the tool type adopted for the butchering of pigs and sheep/goat at the site while the low quantity of bifacial knives may be related to the absence of cattle slaughter at the site.

At *Tell Murra*, a large number of flint artefacts was recovered from the settlement (context T5) (Lajs 2019: 11). The type of flint used to produce these knives is considered the mined type because of the settlement's location in proximity to nearby mines (Jucha et al. 2016). The assemblage consisted of 80.1% blade segment inserts (rectangular and triangular), razor blades (about 4.1%), and a small percentage of bifacial knives (3.7%) (Lajs 2019: 12). These bifacial knives are similar to those depicted in animal butchery scenes but likely used in various household activities as suggested by heavy use (i.e. use wear and re-sharpening marks) (Jucha 2015; Lajs 2019: 13-17). The low percentage of bifacial knives present in the flint assemblage may be reflective of the types of animals butchered if the relationship between bifacial knives and cattle slaughter is considered (Lajs 2019: 9). The zooarchaeological record was dominated by *Sus scrofa* (pig) and *Caprines* (sheep/goat) with very little *Bovine* (cattle) (Jucha 2016: 142) which correlates with the use of bifacial knives.

Tell el-Farkha lies just a few kilometres from *Tell Murra* and excavations during the 2015-2016 season on the Eastern part of the site recovered a small flint assemblage that consisted of 1 bifacial knife and 75% of segmented blades from Phase 7 (Old Kingdom) (Skłucki 2018: 131). The difference among the quantity of bifacial knives at Tell el-Farkha (1) and Tell Murra (over 50) may result from differences in uses, such as differences in the types of animals butchered. At Tell el-Farkha for instance, a large quantity of the fauna contained pig and cattle from the earlier Naqqada phase, which may have continued into the Old Kingdom (Abłamowicz 2012). The zooarchaeological reports are vague in the relationship of particular taxon to each phase and do not differentiate which taxa were specific to Phase 7 (Abłamowicz 2012). Additionally, animal remains were present in graves from earlier phases (e.g. Naqqada) but those belonging to the Old Kingdom were absent of fauna (Dębowska-Ludwin 2012). The absence of animal offerings within Old Kingdom burials at the site may help explain the low quantity of bifacial knives which were commonly used in ceremonial activities for animal sacrifices (Ikram 1995; see chapter 3). Whether the flint knives and blades were used in animal butchery remains unclear, but the low quantity of bifacial knives recovered from the Old Kingdom layers indicates that segmented blades were the preferred tool-type and likely adopted in animal butchery for the

slaughter of other mammals at Tell el-Farkha.

Flint blades and bifacial knives were also present in the flint assemblage at the Old Kingdom settlement of *Tell el-Neshed* (Guyot et al. 2018). A total of 31 retouched blades, 19 razor blades, and 12 bifacial knives were recovered from the site. These blades were likely produced outside of the settlement in specialised workshops and imported (Guyot et al. 2018: 165). The settlement was not one that was state established in the Old Kingdom but rather, a more localised settlement with local lineages of power (Guyot et al. 2018: 170). In fact, the settlement reflected more of a community-based agricultural settlement with perhaps little interest in animal butchery activities. The presence of low-quality bifacial knives found at the site (total of 12) and high quality segmented and sickle blades (total of 187 and 157 respectively) demonstrates this (Guyot et al. 2018: 165). If bifacial knives were produced by the state, then the presence of low quantity bifacial knives at Tell el-Neshed may be reflective of the local nature of the settlement.

4.6.3 Nile Valley

Excavations in the Nile Valley have also revealed information on flint implements. The flint assemblage at *Giza* is extensive with artefacts ranging from grinding stones to beautiful complete bifacial flint handle knives for the Old Kingdom (Conard 2000; Kromer 1978). The settlements here were related to the state construction of mortuary complexes and religious activities. These two contexts allow the use of flint tools to be compared throughout the site. Blades produced from mined flint are common in Giza's archaeological reports and complete bifacial knives are part of the typologies recovered in religious and settlement contexts (Conrad 2000: 25; Kromer 1978; Werschckun 2007: 251). Although there has been debate on whether the bifacial flint knives found at Giza were secular or profane; (Kromer 1978: 30; Schmidt 1992b: 87; Werschckun 2007: 251), it is likely that some of these flint knives were used for animal butchery in non-secular contexts to some extent as an exhaustive quantity of fauna have been recovered throughout the sites and layers at Giza (Redding 2010; Redding and Ahmed 2020). These include a variety of wild game, fish, avian, and mammals including sheep, goat, pig, and cattle (Redding 2010). The zooarchaeological studies have given information on sustenance patterns from which status and diet at Giza has been deduced (Redding 2010). The extensive quantity of flint blades and fauna recovered from Giza suggests that flint was adopted in animal butchery to some extent.

To the south, along the Nile Valley, near the border of Nubia, lies the site of *Elephantine*

which also had plenty of lithic tools recovered from settlement and religious contexts (Dreyer 1986; Hikade 2013; Kobusiewicz 2015: 53-55). The flint implements at Elephantine consist of blades and knives in settlement contexts with bifacial knives making up a high percentage of the assemblage (about 25%) (Kobusiewicz 2015: 54). It is unclear if the quantity of bifacial knives were connected to animal butchery for utilitarian purposes or to religious activities. At Elephantine, faunal data from Old Kingdom contained a high percentage of cattle located in the settlement, necropolis, and temple areas (Hollmann 1990: 30-43) while pig counts were 22.5%, sheep/goat 36%, and cattle 41.5% (Hollmann 1990). The relationship between higher quantity of cattle and religious activity at Elephantine may correlate to the high degree of bifacial flint knife use.

4.6.4 Memphite region

Multiple bifacial flint knives have been found in funerary contexts such as tombs or burials within the Memphite region from the Old Kingdom. Some examples include the funerary complex of Nyankhnefertem at *Saqqara* (Myśliwiec and Kuraszkiewicz 2010) where bifacial flint knives were excavated and cemeteries at *Bet Khalaf* of the 3rd Dynasty (Garstang 1903). Perhaps the best Old Kingdom example is the mortuary pyramid complex of Raneferef and Khentkaus II of the 5th Dynasty at *Abusir* where an extensive quantity of bifacial flint knives was found purposefully destroyed and discarded prior to their deposition in the temple storerooms and slaughterhouse (Svoboda 1993, 2006) (for excavation details see (Verner 1986). The act of destroying flint knives prior to their deposition in burials has been suggested to be a symbolic ritual practiced in ancient Egypt (Graves-Brown 2010). Therefore, the use of flint in Raneferef's mortuary complex is a direct example of religious or ceremonial use.

4.6.5 Dakhla Oasis

Two important settlements to the study of flint during the Old Kingdom are in the surrounding area of Balat at *Ain el-Gazzareen* and *Ain Asil*. Faunal datum for these sites are currently unavailable to the researcher to draw parallels between animal butchery and flint typologies. Yet, the flint typologies from the sites reflects different utilitarian uses including food production and animal processing.

At *Ain el-Gazzareen* a variety of flint artefacts were uncovered, including blades and bifacial knives (Kobusiewicz 2015: 26-31; Millis and Kaper 2003). The bifacial knives were manufactured from imported mined flint and made up only 3.9% of the tool types (Kobusiewicz

2015: 30-31). Retouched flakes are high at 30.12% and retouched blades made up 1.30%. The low quantity of blades and knives may be related to the agricultural activities conducted at the site which supplied food to the surrounding towns in the oasis (Mills 1995; Mills and Kaper 2003). Moreover, the high number of retouched flakes may be suggestive of localised re-sharpening of tools from use and perhaps usage in the agricultural activities at the site as evident by the high number of sickle blades (total of 20.51% for various types, Kobusiewicz 2015: 30-31, fig.7). It is likely that knives and blades related to animal butchery were not required at the site.

Ain Asil is the largest Old Kingdom site in the Dakhla Oasis. It is a fortress site that contains a governor palace surrounded by a residential complex where a number of religious activities were undertaken (Kobusiewicz 2015: 39). The site yielded mostly nodular flint with some mined flint tools dating to the 6th Dynasty, including bifacial knives (Midant-Reynes 1998). Much like *Ain el-Gazzareen*, the lithic technology was locally produced by unspecialised individuals (Kobusiewicz 2015: 39). Moreover, a high quantity of bifacial trimming flakes (22.44%) was recovered from the site while an exceptionally low quantity of sickle blades were present the flint assemblage (Kobusiewicz 2015: 39). The high quantity of flakes at the site is suggestive of use and re-sharpening. Kobusiewicz (2015: 40) states that “such high frequency could attest to some intense activities of ritual significance associated with the use of bifacial knives for sacrifice.” The extensive religious activities conducted at the site and the presence of re-sharpening suggests that bifacial knives are likely connected to animal butchery (Kobusiewicz 2015: 42). Some of these religious activities are evident in the number of *ka* (spirit) chapels and related outbuildings within palace complexes which were used to receive benefits to the cult of the individual (Moeller 2016: 175-177).

The examples discussed above demonstrate that use of flint tools in the Dakhla Oasis was primarily for agricultural activities where the use of sickle blades would be most useful and ritual activities where the use of bifacial knives was adopted for ritualistic purposes. The presence of heavy use and re-sharpening of bifacial knives at the sites suggests that they were valuable tools and heavily used for daily activities and likely also for the ritualistic slaughter of animals (Kobusiewicz 2015: 42). It is unclear whether a higher degree of religious activity occurred in the Dakhla Oasis than in the Nile Delta and Nile Valley, but given the difference in bifacial knife use between sites *Ain Asil* and *Ain el-Gazzareen* it is possible that a higher degree of ritualistic

slaughter occurred at Ain Asil.

4.7 Economic importance of flint during the Old Kingdom

The large number of imported tools made from mined flint and produced by highly specialised individuals found at Old Kingdom sites suggests the existence of a central distribution of flint tools organised by the state (Hikade 2013; Kobusiewicz 2015: 61). Workshops are suggested to exist at the onset of the Old Kingdom (with the centralisation of the state) and located at or near quarrying sites (Kobusiewicz 2015: 61). The state likely employed highly skilled individuals at such specialised workshops to manufacture flint tools for state-controlled settlements (Kobusiewicz 2015: 61). It is unclear if the tools produced in these workshops were manufactured in a central location or at multiple sites as part of a broader state-run network, but the striking evidence towards a state ran flint network suggests the state may have been involved in its organisation to some extent.

Kobusiewicz states that the current discourse surrounding sophisticated tools is that they were produced by “highly qualified specialists working somewhere outside settlements” (Kobusiewicz 2015: 62), a centralised production facility for flint tools by the state likely existed and would have benefited both parties (settlement communities and the state) (Hikade 2000a; Kabacinski 2012; Svoboda 2006). Settlements could benefit from well-made tools (produced from mined flint) without requiring the resources to manufacture them while the state ensured the productivity of revenues affected by the quality of tools. Bifacial knives and blades in particular likely had a high production cost, perhaps too expensive in resources for local production but attainable through the state (Graves-Brown 2010: 118). As a result, mined flint tools became highly practical and economical for various utilitarian and religious activities including animal butchery. The expense of these tools (i.e. bifacial knives produced from mined flint) allowed such objects to be used symbols of wealth and status that differentiated individuals in death, i.e. they were often placed as part of funerary material.

4.8 Symbolic Importance of flint during the Old Kingdom

The presence of bifacial flint knives and other sharp flint implements in religious contexts such as those discussed above, implies that a connection existed between flint and religious ideology and activities pertaining to the afterlife throughout ancient Egyptian history (Graves-Brown 2010: 160-162; Morschauer 1991: 12, 31-35, 135-143, 265; Ritner 1993: 163-167; Stevens 2006: 204-205; Zandee 1960: 147-158). Although a variety of material was available for

ritualistic use, such as ceramic, wood, precious stones, pigments, and other sharp flint implements (i.e. daggers) – it was flint knives that gained prominence among the religious sphere, particularly in animal slaughter. Settlement sites with religious activity (such as Giza, Elephantine, Tell el-Abrahm Awad) have a higher percentage of bifacial flint knives over other settlements (such as Ain Asil, see Midant-Reynes 1998: 44-48). It is also clear from the archaeological evidence deriving from burials in the Memphite region, that individuals from the court (including royalty) viewed flint knives as highly symbolic. The flint artefacts placed into tombs of the Old Kingdom were of very high quality and exceptionally crafted often with no traces of use wear (Hikade 1997). Similar tools excavated from settlements were often made from used specimens and much more inferior in quality (Graves-Brown 2010: 201; Kobusiewicz 2015: 14). This begs the question, what is the symbolism behind flint knives?

The message transmitted by artefacts is not only constrained and allowed by social context (as well as physical properties) but metaphorical messages may emerge as a result of particular contextual situations (Graves-Brown 2010: 170).

The work of Graves-Brown places flint into the perspective of religious and symbolic ideology where objects of flint are reflective of greater ideological beliefs in ancient Egypt (Graves-Brown 2010). Most of these symbolic representations were rooted in the daily life or tomb scenes where a variety of funerary scenes depict the use of tools used in ceremonial activities. One of these ritualistic activities is the *opening of the mouth ceremony* which was an elaborate ritual where the deceased and their statues were touched with a flint object to revive their senses and be reanimated in the afterlife (Roth 1992), “mummies and statues that underwent this ritual were effectively transformed into vessels for the Ka [spirit] of the deceased” (Fig. 4.4) (also see Bard 2015: 166; Ikram 1995: 30; Shaw and Nicholson 1995: 211-212). Examples of these scenes exist throughout ancient Egypt, and demonstrate a variety of instruments used in the opening of the mouth ritual, many of which symbolise the rebirth of the deceased (Fig. 4.4). As Roth (1992) stated,

The 'opening of the mouth' ceremony seems to have derived from a ritual sequence of actions and spells ensuring the ability of a newborn and developing child to partake of nourishment. By analogy, the same ritual would have allowed the newly reborn deceased person to eat the real and symbolic food that Egyptian mortuary customs went to great lengths to provide (Roth 1992: 146).



Figure 4.4. Fragment of a section of the opening of the mouth scene with fishtail knife used in the ritual. Painted limestone. Late Dynasty 18. UCL 14479. Photo: © Dr. Osama Shukir Muhammed Amin.

Roth provides archaeological evidence for the interpretation and placement of the flint knife used in ceremonial ritual of the burial or entombment of the individual. A variety of instruments and vessels were used in the opening of the mouth ceremony (e.g. Fig. 4.5). One of the main instruments used in the ceremony is the fishtail flint knife (*psS kf*) which was an important tool used to reanimate the individual for the afterlife (Roth 1992; Shaw and Nicholson 1995: 211). Many of these still exist and are found in several museums, such that recovered from the Mastaba of Rawer II of the 6th Dynasty at Giza (Fig. 4.6) or the beautifully crafted inscribed fishtail knife belonging to King Khafre found at Giza (MFA 11.765).



Figure 4.5. Model of equipment for Opening of Mouth Ceremony: five vessels (calcite and limestone) and two implements (schist and limestone) set into depressions of limestone tablet. Note the model tool shaped as the fishtail flint knife in the centre. 6th Dynasty, Egypt. EA58404 © The Trustees of the British Museum.

These objects demonstrate the importance of flint knives to a funerary ritual. The use of a flint knife was particularly important in the cutting of the umbilical cord of a newborn infant to symbolise rebirth and in the case of the opening of the mouth ceremony it served to reanimate the individual to life (Roth 1992). Although these scenes can be viewed as allegorical (Ikram 1995: 41), the evidence of such objects within tombs suggests that ritual activities such as the

opening of the mouth ceremony was in fact performed upon the deceased.

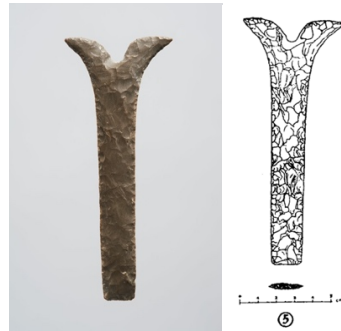


Figure 4.6. Fishtail knife used in Opening of the mouth ceremony. Mastaba of Rawer II. Old Kingdom. 6th Dynasty, Giza. Kunsthistorisches Museum Wien, Ägyptisch - Orientalische Sammlung INV 7902 Photo: ©KHM-Museumsverband. Right: Junker 1938: 226.

Perhaps one of the most obvious symbolic uses of bifacial flint knives in religious ideology is found in animal slaughter scenes which are also part of daily life scenes depicted in tombs (e.g. Fig. 3.2; Chapter 3). In these scenes, mammals (most commonly cattle or oxen) are slaughtered and dismembered (typically the right hindlimb) to provide the deceased with plentiful food in the afterlife (Graves-Brown 2010: 173-179; Tillman 1992: 197). The preferred tool choice in these scenes were the bifacial knife described above.

Animal butchery scenes had a variety of meanings including slaughtering an animal for a fruitful afterlife and representing the balance of order and chaos where slaughter “symbolised the destruction of the enemies of the god, and the king” (Fairman 1958: 80; also see Ikram 1995: 42; Junker 1910: 72; Otto 1950). Although it is difficult to understand if one or more of the meanings were intended in the display of these scenes, their depiction reflected symbolic meat offerings slaughtered with a knife for the deceased. In such scenes, what appears to be bifacial knives of various types are shown slaughtering, dismembering, and skinning the animal (Chapter 3). In almost all animal butchery scenes, the use of these larger knives gives the impression that they were the primary tool used in slaughtering and carcass processing activities. However, their large size would make it difficult to conduct some activities (skin, and fillet), even on large animals (such as cattle), and to dismember, disarticulate, skin and fillet the common smaller domesticates (*i.e.* sheep, goat, or pig). If these larger knives were difficult to use in animal butchery, why depict them? Perhaps the reason for the consistent depiction of large flint knives in the slaughtering or butchering of larger mammals (cattle, antelope) is that they held a special place in the ideological relationship of ritualistic activities (such as butchering), and that they

reflected status and wealth (Graves-Brown 2010: 173-5).

The possibility that these knives are depicted strictly for illustrative purposes is difficult to substantiate but the presence of flint knives with animal residue in tombs confirms that such knives (particularly the fishtail type) were used for animal slaughter prior to its placement in the tomb at least during the Predynastic period (Christensen and Walter 1991; Christensen, Walter, and Menu 1992). Moreover, the mortuary complex of Raneferef (5th Dynasty) from Abusir which may be one of the best examples of bifacial flint knife use in religious contexts, contained several bifacial knives similar to those depicted in the animal butchery scenes (Svoboda 1993: 216). These examples corroborate the idea that flint knives held a symbolic importance in ancient Egyptian religious ideology and were embedded into the ceremonial ensemble of animal slaughter to the deceased.

Further evidence for the symbolic use of flint derives from the several flint flakes and objects related to ceremonial animal butchery that were found within religious contexts (Fig. 4.7). Some animal butchery scenes depict an individual sharpening flint, one of the many steps depicted in these scenes. Some of the large flint knives depicted in these scenes may not have been used in daily butchering activities but used as mediums of their symbolic importance for the elite in their mortuary activities (Kobusiewicz 2015: 59-60).

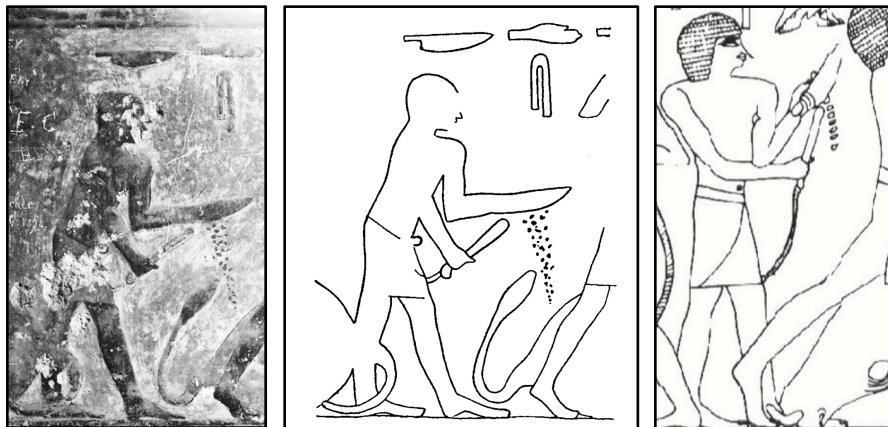


Figure 4.7. Sharpening of flint knife. Houliham 1996, fig 14). Resharpening illustration from the tomb of Iymery, Giza, G 6020. Left: Photograph M. Ibrahim © 2014 Museum of Fine Arts, Boston. Center: Line-drawing after Smith 1949: 271, Fig. 99. Right: Resharpening Resharpening scene from the tomb of Hetepka, Saqqara. (After Martin 1979: pl. 14). © The Egypt Exploration Society.

Two-dimensional butchery scenes are explicit in demonstrating the use of knives (likely bifacial flint types) in ceremonial activities (see Chapter 3; for further discussions see Graves-Brown 2010: 177-178; Ikram 1995; Kobusiewicz 2015; Lund 2015). However, the presence of

various blade implements, including bifacial flint knives in Old Kingdom settlements suggests that their use was not restricted to ceremonial animal butchery. In fact, archaeological finds of flint from the Old Kingdom corroborates with the idea that blades and bifacial knives were multipurpose and adopted in a number of utilitarian activities including animal butchery for non-religious purposes (local or state consumption). Moreover, it is likely that bifacial knives were not the only tool type used in animal butchery, but adopted alongside other sharp flint implements such as bi-truncated blades (Graves-Brown 2010; Kobusiewicz 2015).

The relationship between prime cuts of meat (cattle, oxen) and large flint knives is strengthened because there are examples where they were found together (Tillman 1992: 197). Large flint knives were uncovered at 1st Dynasty Helwan among oxen bones (Graves-Brown 2010: 174; Saad 1951: 10-11), and at Early Dynastic Tell el-Farka where cattle ribs and a flint knife were found together (Cialowicz 2009: 86-87; Graves-Brown 2010: 174). Bifacial knives similar to those in animal butchery scenes have been found in domestic contexts, such as Block 3 at El-Mahâsna where a wealthy individual was found with a large quantity of wild fauna and cattle remains that perhaps were slaughtered using the flint knife found beside them (Skarzynski 2017: 71-73). Although large curved bifacial flint knives have been found in domestic contexts, they are few in number (Graves-Brown 2010: 174-175). The limited presence of bifacial blades outside of ceremonial contexts may suggest that they may have been limited to ceremonial use (Graves-Brown 2010: 174-175; Schmidt 1992: 87).

4.9 Decline of flint and the rise of the Bronze Age

A drastic decline in frequency of flint tools began in the Middle Kingdom with a near absence by the New Kingdom (Table 1) (Graves-Brown 2010; Kobusiewicz 2015: 13; Ikram 1995: 65-9). This decline may be related to changes in metal production that made it easier to mass produce, more affordable, and therefore more common to a wider segment of society (Graves-Brown 2010: 83; Rosen 1996: 131, 153). It is clear from the decline of flint and increase of metal objects from the end of the Old Kingdom into the Middle Kingdom that a socio-evolutionary change occurred and resulted in an increase of metal object use. Yet, flint tools continued to be preferred for much of the period.

The development of metallurgy continued through the Middle Kingdom with the widespread use of hard arsenic/tin-bronze tools alongside the continued use of flint in household activities (Graves-Brown 2010; Ikram 1995; Odler 2016). Flint and copper tools are found together in a

number of contexts (such as at Lahun/Kahun in the Fayum, see David 1996: 168-170), which suggests that both types were adopted during the Old Kingdom (Fig. 4.7). Lahun had flint, copper, and bronze knives that resemble in shape those used in animal butchery iconography and three-dimensional wooden models from the same time period. It is unclear if the Middle Kingdom bronze and copper knives were used for animal butchering for the population in general, restricted for use by higher status/wealthier individuals, or primarily used for symbolic purposes. It is possible that given the abundance of stone tools during this period that they were the primary butchering technology for the lower strata of society until the decline of flint in the later part of the Old Kingdom.

By the time of the New Kingdom, bronze knives are found in abundance, and flint chipped stone tools began to decline dramatically in frequency and quality (Graves-Brown 2010: 97). It is more than likely that by the New Kingdom, bronze had nearly replaced stone as the primary technology in animal carcass processing. Bronze tools increased in the Middle Kingdom with the exploitation of mines by Amenemhat III (Leprohon 1999: 54). By the New Kingdom metal technology evolved including pot bellows in its manufacture which became a more efficient means of production (Muhly 1999: 631).

4.10 Conclusion

The production and consumption of flint blades, particularly blade types was extensive during the Old Kingdom (Kobusiewicz 2015: 11). Flint tools were produced locally and in specialised workshops. The availability of flint throughout areas in Egypt allowed it to be a widely used resource for tool production during the Old Kingdom (Baines and Malek 2000: 21; Kobusiewicz 2015). Specialised workshops are evident in the large quantity of mined flint objects recovered from archaeological sites in Egypt and the absence of mined flint flakes or cores suggests that specialised workshops manufactured flint tools for settlement use (Adams and Cialowicz 1997; Chlodnicki and Cialowicz 2012:24, 110, 279 ; Florek, et al. 2019; Midant-Reynes 1998; Schmidt 1992a; Svoboda 2006; Tillmann 1992; Tillmann 1999). Although state involvement in flint production is unclear, it is possible that the king would have had the means to employ the individuals necessary to mine and produce the tools.

These tools vary in typology but those related to animal butchery (bifacial knives, bi-truncated blades, and scrapers) are found throughout Old Kingdom settlements in Egypt (Ikram 1995; Kobusiewicz 2015; Tillman 1992). The study of the frequency of these tools brings an

interesting find to light. A relationship between the quantity of bifacial knives and cattle remains exists. Moreover, the types of flint knives found in settlements are related to the quotidian activities conducted at the site (e.g. at Giza, Kobusiewicz 2015). Religious, agricultural, and animal butchery were all uses adopted by individuals who used flint knives during the Old Kingdom.

Perhaps most importantly is the importance of flint in Old Kingdom society. Flint had an economic, symbolic, and practical use (for economy see Kobusiewicz 2015: 61; for symbolic see Graves-Brown 2010; for uses in daily life/butchery see Ikram 1995). State and settlements benefited economically from the centralised manufacturing of mined flint (Hikade 2000a; Kabacinski 2012; Svoboda 2006). The symbolism behind the use of flint allowed it to be versatile and adopted in a variety of ritualistic activities including animal slaughter.

The decline of flint began in the Middle Kingdom upon the advent of bronze in Egyptian society (Graves-Brown 2010; Kobusiewicz 2015: 13; Ikram 1995: 65-9; Odler 2016). The Old Kingdom saw the beginnings of this shift from flint to copper-based tools with the increase of copper mining and production in various sites throughout Egypt. However, much like the production of flint, copper was heavily influenced by the state. The development of metallurgy in Old Kingdom Egypt is discussed in the following chapter.

Chapter 5: Development of metallurgy in Old Kingdom Egypt

5.1 Introduction

The previous chapter examined the use of flint in ancient Egypt and demonstrated that its versatility allowed it to be widely adopted and used throughout the Old Kingdom in various aspects of daily life including ceremonial activities and animal butchery. The decline of flint was brought upon by the development of metallurgy which started to gain popularity in the Old Kingdom. This chapter examines the development of metallurgy during the Old Kingdom of Egypt. It compiles the information on the different steps of the metallurgical process and the exploitation of the various geographical areas by the Old Kingdom state for the production of copper objects. The chapter demonstrates that copper was an expensive product to produce that required an extensive amount of resources which resulted in its limited availability to majority of the population during the Old Kingdom. Consideration therefore, is given to the technological and social aspect of the development of metallurgy. As will be shown in this chapter, the evolution of copper and eventually bronze production was a slow process involving multiple institutions and individuals from all levels of society. Copper as an innovative technology was not new in the Old Kingdom, but the extent of its production was unprecedented. The consumption of copper was limited to state institutions, individuals of wealth, or those individuals connected to the state. The state acted as its largest consumer.

5.2 Technology and innovation: the adoption of metallurgy

The adoption of copper-based metallurgy was a slow evolution that developed alongside the continued use of stone-based tool use throughout the Near East. Research on the development of copper metallurgy in the Near East has shown that the earliest metallurgy had its roots in Anatolia and neighbouring parts of the Near East (e.g. Mesopotamia, the Levant) (Boydell, Rothenberg, and Tylecote 1978; Greenfield 2008a: 1639-1647; Milevski 2012; North 1955; Tylecote 1987; Tylecote 1992) 1986, 1987, 1992). Early copper production in this region begins during the Pre-pottery Neolithic period with low heating cold hammering (Bienkowski and Millard 2000: 79) and quickly spread throughout the Near East during the Chalcolithic period (Bienkowski and Millard 2000: 79; Hauptmann 2003, 2007; Hauptmann, Begemann, and Schmitt-Strecker 1999). The complexity and slow evolution of metallurgical development is reflected in the division of the Early Bronze Age in the Near East, particularly in the Levant (Canaan) where it is divided into four phases: EB1, EBII, EBIII, and EBIV (Regev 2012;

Sowada and Grave 2009: 4) (Table 5.1).

Table 5.1. Early Bronze Age Timeline for Egypt and Canaan (Levant) (Sowada 2009: 4).

<i>Egypt</i>	<i>Canaan</i>	<i>Absolute Dates</i>
Naqada IIIC1-early 1st Dynasty (Narmer, Horus Aha)	Late EB IB	c. 3050-3000 BC
Early Dynastic Period (Naqada IIIC1/IIID - 1st and 2nd Dynasty) from reign of Djer to reign of Khasekhemwy (end of 2nd Dynasty)	EB II	c. 3000-2686 BC
3rd Dynasty to end of the 4th Dynasty	EB IIIA	c. 2686-2498 BC
5th and 6th Dynasty to the reign of Pepy I	EB IIIB	c. 2494-2287 BC
Late 6th Dynasty (Merenre to Pepy II) to end of the First Intermediate Period	EB IV/MB I	c. 2287-2055 BC

Reasons for the slow and complex evolution of technologies lie in the involvement of traditional and innovative approaches (Shaw 2012). This is certainly true in Egypt where traditional stone tools continued to be used alongside metal tools until the New Kingdom (see chapter 4). Lemonnier states that “every technical system is continually evolving and is subject to a mixture of conversation and change” (Lemonnier 1993: 22) also see (Bourriau and Phillips 2004) (Shaw 2012: 2). If consideration is given to the development of metallurgy in Egypt, then it makes sense that technological methods would be adapted with the increase of intercultural contact and foreign missions that shaped the Old Kingdom. This is evident in the complexity of copper objects which begin as simple objects in the Predynastic period and develop into utilitarian tools that become embedded in Egyptian society by the end of the Old Kingdom (Baumgartel 1960: 10-16; MacIver, Mace, and Griffith 1902: 23, pl.6: 1-2; Needler 1984: 280-282, cat. 180-3; Payne 1993: 146, cat. 1215-20; Wengrow 2005: 38-39). Therefore, the idea of metallurgical development being a product of social interaction should not be ignored. Metallurgy was very much embedded within ancient Egyptian society from its early beginnings through to the New Kingdom and later (Lemonnier 1993: 26; Mathieu, Meeks, and Wissa 2006; Shaw 2012: 90-91, 122-126, 145-146; Shortland 2001; Wengrow 2005: 38-39).

5.3 *The chaîne opératoire of metallurgy*

[The chaîne opératoire] provides an analytical framework through which the observer tries to bring together, within the technical time frame (from the procurement of a raw material to the abandonment of an object-tool), materials, tools and actors and their actions (Delage 2017: 158).

The chaîne opératoire of metallurgy breaks down the modes of production into mining, smelting, fabrication, trade, and consumption (Fig. 5.1). This functional approach helps

understand working systems and in the case of metallurgical development, the impact of economic activity on a regional scale and the individuals involved in the process (as examples in the Levant have shown) (Hauptmann 2007). When the approach is applied to metallurgical development, an in-depth understanding occurs of the different steps, its economic impact, and the individuals involved (Hauptmann 2007:7). Such approaches have been useful to understand the complexity of society in other areas of the Near East (Hauptmann 2007; Stollner 2003).

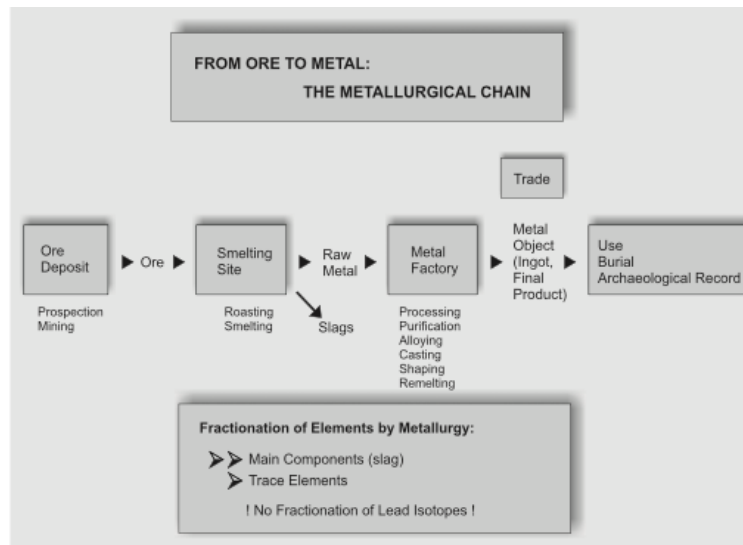


Figure 5.1. The chaîne opératoire of metallurgy (Delage 2017).

The chaîne opératoire is applied here to the development of metallurgy in Egypt to further understand the relationship between technological innovation, the state, and society. It is within the interplay of aspects of cultural change that a better understanding can be given to the impact metal development had in Egypt.

5.3.1 Mining and sourcing copper ore

The first step in the *chaîne opératoire* of metallurgy is the mining and sourcing of copper ore. The sourcing and mining of copper ores during the Old Kingdom were concentrated in the Sinai Peninsula desert region and the Eastern Desert (Avner 2014; Ball 1916: 191; Petrie 1906; Rothenberg 1987: 3). Rich copper deposits were found in the areas of Wadi Kharig, Wadi Nasib, Serabit el Khadim, and Maghara which became key areas of mining activities during the Old Kingdom. The main copper ores mined in these areas were malachite, azurite, and chrysocolla (Lucas 1927; Ogden 2000: 151). Malachite was the most commonly mined ore during the Early Dynastic and early part of the Old Kingdom (Lucas 1927, 1959; Odler 2016), while the more

advanced arsenic copper alloys (arsenical bronze) appear in the later part of the Old Kingdom (Odler 2016).

Archaeological evidence of Egyptian copper mining has been found in the Sinai region and in the Levant (mainly Wadi Faynan and Timna) dating to the Chalcolithic period (Hauptmann 2007; Sowada 2009: 46-52), but the earliest textual record of copper ore mining in Egypt dates to the 1st Dynasty by King Semerkhet at Maghara which continued to be an extensive mining area during the Old Kingdom (Gardiner and Cerny 1955: 52-53; Gardiner, Peet, and Cern 1952: pl.1; Giveon 1974; Ogden 2000: 149; Petrie 1906: 51-52; Selin 2008). Copper mining, therefore, occurred early in the development of metallurgy in the Near East, but Egypt developed later in comparison to other cultures.

The 3rd Dynasty marked an important change for Egyptian copper mining when the state took control of the copper mines in the south-western Sinai (Gardiner and Cerny 1955; Gardiner, Peet, and Cern 1952; Stager 1992; Wengrow 2005: 147). Inscriptions in the area provide evidence for constant control of the copper mines from the beginning of the Old Kingdom into the late 6th Dynasty (Gardiner and Cerny 1955). By the end of the Old Kingdom, Egyptian mining in the Sinai peninsula stretched from Wadi Kharig to the west, Wadi Nasb in the centre, Serabit el Khadim to the east, and Maghara to the south (southwest of the Sinai peninsula, modern day Abu Zenima and Abu Rodeis region) (Bard 1999: 1-2, 33; Feucht 1999: 465; Lucas 1959: 228-249; Selin 2008; Ward 1999: 1031). Egyptian sherds and a rock engraving along the *Wadi Kharig* and a monumental hieroglyphic inscription near *Wadi Ba'ba* that bears the name of King Sahure of the 5th Dynasty are both evidence of Old Kingdom mining activity in the area (for mining in the Wadi Kharig see Ball 1916: 190-191; Rothenberg 1987: 4); for mining in the Wadi Kharig see . Other areas that were extensively mined and can be confirmed to the Old Kingdom include the *Wadi Ba'ba* (located at its junction with *Wadi Kharig*) and *Bir Nasib* (located at *Wadi Nasb*) (Rothenburg 1987). *Wadi Malha* (Wadi Halliq) and *Gebel Um Rinna* (both located northernmost area of the region) also had ancient mining evidence, that support mining during the Old Kingdom but lack chronological evidence (Ball 1916: 188; Barron 1907: 167, 206; Rothenberg 1987: 2; Tallet, Castel, and Fluzin 2011: 80). All of these sites located in the south-western Sinai provide evidence for extensive copper mining during the Old Kingdom from the 3rd Dynasty into the late 6th Dynasty (the end of the period).

Areas in the south-eastern Sinai and Eastern Desert also have evidence for ancient copper

mining. In south-eastern Sinai, evidence for mining was found near the plain of *Senned* (Hume 1906:118-119), in *Wadi Samara/Nebk-Sherm plain* (Hume 1906), and at *Wadi Ramthi* (Lucas 1959:234), all of which had “ancient workings for copper ore and ancient slag heaps” (Lucas 1959:234). Due to a lack of archaeological evidence, it is unclear if these were in use during the Old Kingdom, but the presence of ancient mining suggests that the exploitation of copper resources went beyond the highly mined south-western Sinai. In the Eastern Desert, a few copper mines are known to have existed during ancient times, but archaeological evidence for direct Old Kingdom activity is limited. In particular, *Umm Soleimat* (located in the central Eastern Desert of Egypt) (Klemm and Klemm 2008: 1685; Klemm and Klemm 1994), *Gebel Atawi* (Hume 1912: 37), *Gebel Dara* (Barron and Hume 1902: 33, 259; Hume 1912), *Abu Seyal* (Absciel) (Lucas 1959: 206-8), and *Um Semiuki* (at the foot of Gebel Abu Hamamid) (Hume 1934: 837-842), all have specific evidence to Old Kingdom mining operations.

Analysis of Old Kingdom Egyptian copper-based metal compositions confirms that copper objects largely originated from the Sinai and Eastern Desert regions of Egypt (Cowell 1986; Farag 1981; Garland and Bannister 1927; Kallfass and Hoerz 1989; Lucas 1959; McKerrell 1971, 1993; Pelleg, Baram, and Oren 1979; Philip 2006; Rademakers et al. 2018: 187). The most recent study suggests that Old Kingdom copper objects were produced from ores from the Eastern Desert and Sinai regions (Rademakers et al. 2018). Even though there are mentions of Eastern Desert copper sources, these studies on metallurgical compositions accompanied by the archaeological evidence described above corroborate that the Sinai region (particularly southern Sinai) was the most important source for copper mining in the Old Kingdom.

5.3.2 Smelting of copper ore in Egypt

The study of smelting sites can be very valuable to the understanding of early metal production in Egypt since it provides insight into the extent of copper production during the Old Kingdom. The extraction of copper from its ore involves the smelting of copper ores at high temperatures. As a result of its production, smelting is “always connected with the production of large amounts of slag and problems of fuel supply” (Hauptmann 2007: 13). There are a variety of types of evidence for copper smelting, such as slag (glass-like material that is left over from the smelting process), furnaces, and crucibles.

The basic technique generally employed in copper smelting involved crushing ores and placing them into a heated furnace (crucible) that had blowpipes used for sufficient airflow to

maintain high temperatures. This process resulted in small prills or a bun ingot (De Young 2008: 1635). The earliest smelting methods likely relied upon small shaft furnaces with an open top and base (Craddock 2000; Craddock and Meeks 1987: 187-204). Most copper was smelted in crucibles throughout the Near East and the smelting technique was also adopted in Egypt (Muhly 1999: 630-631). Ancient smelting methods likely achieved a 90% copper purity (Craddock 1995: 126-127; Doonan 1994: 84-97; Ogden 2000: 151). In fact, a recent metallurgical study on Predynastic, Protodynastic and Old Kingdom copper objects from various sites in Egypt confirmed that “all artefacts in the presented sample consist of strikingly pure copper: apart from arsenic and iron” (Rademakers et al. 2018: 185). Such studies demonstrate that by the Old Kingdom, highly technologically effective techniques were adopted in the manufacturing of copper.

More advanced techniques, such as ‘fluxing’, which involved “the presence or addition of materials [e.g. iron] to aid the melting and separation of the copper” (Ogden 2000: 151) were also adopted. Fluxing was present at Timna in the Levant since the 4th millennium BCE, but only employed in Egypt from the 2nd Dynasty onward (Cowell 1986; Craddock 1995: 130-140; Craddock and Meeks 1987: 187-204; el-Gayar and Rothenberg 1998). A number of metals can be found in the object post-production because native copper is not 100% copper and contains a “variety of other metallic impurities” such as iron, arsenic, tin, and lead (Ogden 2000: 151; for recent archaeometallurgical analysis see Rademakers et al. 2018).

Iron is common in many early Egyptian alloy objects ranging from low amounts of 1-2% to higher amounts of about 7% (i.e. a 5th Dynasty amulet, see Brunton (Brunton, Gardiner, and Petrie 1927: 69). At Buhen for instance, a 0.5% iron content was found in the copper produced and demonstrates that true fluxing techniques were employed at the site (El Gayar and Jones 1989)). The content of iron in copper objects increased during the Old Kingdom (Rademakers et al. 2018: 185) but copper-arsenic alloys were more common.

Arsenic was naturally present in several ore types and used to increase hardness of the copper which became particularly useful during the Old Kingdom when adzes, axes, and chisels were required for the construction of monuments and weapons. Recent metallurgical studies have found the presence of arsenic in several Old Kingdom copper-based objects including pigments dating to the 5th Dynasty (El Gorsey, Schiegl, and Weiner 1998; Ogden 2000: 152-153).

Tin has also been found in a number of copper objects dating from the Old Kingdom such as

in an ewer and basin from the tomb of king Khasekhemwy of the 2nd Dynasty (Cowell 1986; Kaczmarczyk and Hedges 1983: 78; Odler 2016: 238; overview see Ogden 2000: 153-154). Copper-tin alloys are less toxic and have an increased hardness, lower melting temperature and increased fluidity of molten metal which is better for casting (Ogden 2000: 153). However, it is likely that the addition of tin during this period was purely accidental and that copper-tin alloy or pure tin-bronze was not widely adopted until the New Kingdom (Ogden 2000: 154).

Lead alloyed with copper is rare for the Old Kingdom but found in a number of objects in small quantities such as in the ewer and basin described above (Cowell 1987; Ogden 2000: 154). It is likely that the lead-alloyed copper during the Old Kingdom was less deliberate for functionality and more accidental for properties of durability.

“Wherever slag heaps were located, copper mineralisation and mine workings could be found nearby” (Rothenburg 1987: 2). This quote by Rothenburg exemplifies the process of smelting at or near mining sites. Smelting was done at the mining location itself for much of the Near East and this practice can be found in Egypt as well (ex. in the area around Wadi Nasb) (De Young 2008: 1635; Hauptmann 2007: 13-14; Levy and Shalev 1989; Shalev 1994). The largest quantity of slag heaps was found around the mines of *Wadi Nasb* where Petrie found an “enormous mass of slag from copper smelting about 6 to 8 ft along the valley and 300 ft wide” (Petrie 1906: 27). Nearby *Seih Baba* (near the lower part of Wadi Nasb) also had a small heap of slag likely from smelting ores brought from the nearby Wadi Nasb via the Wadi Baba (Petrie 1906: 19; Lucas 1959: 235). Large quantities of copper slag and other heating mechanisms, such as furnace fragments and crucibles were found in the mines of *Wadi Maghara* dating to the Old Kingdom. (Petrie 1906: 39, 51-2; Rothenburg 1987: 3; Sowada 2009: 91). Other areas of smelting in the Sinai included *Serabit el Khadim*, where a crucible for copper smelting was found in the local temple with copper objects (Petrie 1906: 161-162, Fig. 161) and *Mt. Gebel Safariat* (south of Gebel Hebran) where slag was found (Barron 1907: 208; Lucas 1959: 235).

In the Eastern Desert, several sites have evidence of copper smelting where slag and/or crucibles were found. At *Mt. Gebel Atawi* ancient workings of ore were found (Hume 1912: 37; Lucas 1959: 235). *Mt. Gebel Hamamid* contained ore crushers, broken crucibles, and slag which provide evidence of post-mining smelting slag evident of smelting (Lucas 1959: 236).

The most important Old Kingdom smelting site south of the Egyptian border was *Buhen*, located in Nubia. Extensive evidence of copper smelting operations, particularly from the 4th and

5th Dynasties, was uncovered and demonstrates that smelting during the Old Kingdom went beyond the Egyptian borders (Emery 1963; Klemm and Klemm 2008: 1685; Lucas 1927: 163-165; Muhly 1999: 630).

5.3.3 *Fabrication of metal copper objects*

Once the desired amount of metal was retrieved, the object was shaped either through hammering the soft copper or by the ‘lost-wax technique’ (De Young 2008: 1635; Ogden 2000:151-152). An example for the hammering technique is the life-sized copper statue of Pepi I of the 6th Dynasty (Garland and Bannister 1927: 7-9). The lost-wax technique is a method that adopts the use of moulds created in wax or other medium with a low melting temperature that is coated with material (such as clay and organic matter) and contains a hole to drain the wax. Then, it is fired to be used as a reservoir for the molten metal (De Young 2008: 1635). Once the molten metal has cooled and solidified, the mould is broken to obtain the object (Ogden 2000: 157). Other improvements to this technique were also achieved such as adding air escape holes and links between parts (Garland and Bannister 1927: 45). Casting methods such as these date back to the Predynastic period (Carpenter 1932: 625-626; Emery 1939; Lucas 1959: 213; Ogden 2000: 156-157), but were most common during the Old Kingdom (i.e., as in objects of the 4th Dynasty) (Garland and Bannister 1927: 35; Lucas 1959: 215; Schorsch 1992).

Two-dimensional painted and bas-relief scenes provide valuable information on copper-based metal production in the Old Kingdom (Davey 2012) (Fig. 5.2). Six preserved late Old Kingdom (5th and 6th Dynasty) metalworking scenes serve as examples found in the tombs of *Unas* at Saqqara (Edwards 1993: 173), *Mereruka* at Saqqara (Wilson and Allan 1938a: pl. 29-30), *Ti* at Saqqara (Wild 1966: fig. 173), *Nebemakhet* at Giza (Hassan 1943: 140, fig. 81; Lepsius 1904: pl. 13), *Wepemnefert* at Giza (Hassan 1936: 219; Weinstein 1974), and *Pepyankh: Heny-kem* at Meir (Blackman and Apted 1953: pl. 16). The best-preserved metalworking scene is that in the tomb of *Mereruka* which depicts workers weighing and smelting ore, pouring molten copper, beating copper-based metal foil, and making jewellery (Davey 2012: 88-90; Wilson and Allan 1938a: pl. 29-30). The remaining four scenes depict the smelting of metal in the crucibles and the pounding of metal into sheets (manufacturing). The *Wepemnefert* scenes are unique as they depict annealing and make reference to it with the caption, “*There is no cracking (?) if it is heated excellently*” (Ogden 2000: 155). It is likely that this 5th Dynasty reference to annealing is the earliest example in Egypt (Weinstein 1974). Annealing is applied in the heating process and

used to soften and make metal more workable once it has become hard and brittle, essentially reworking the metal (Ogden 2000: 155).

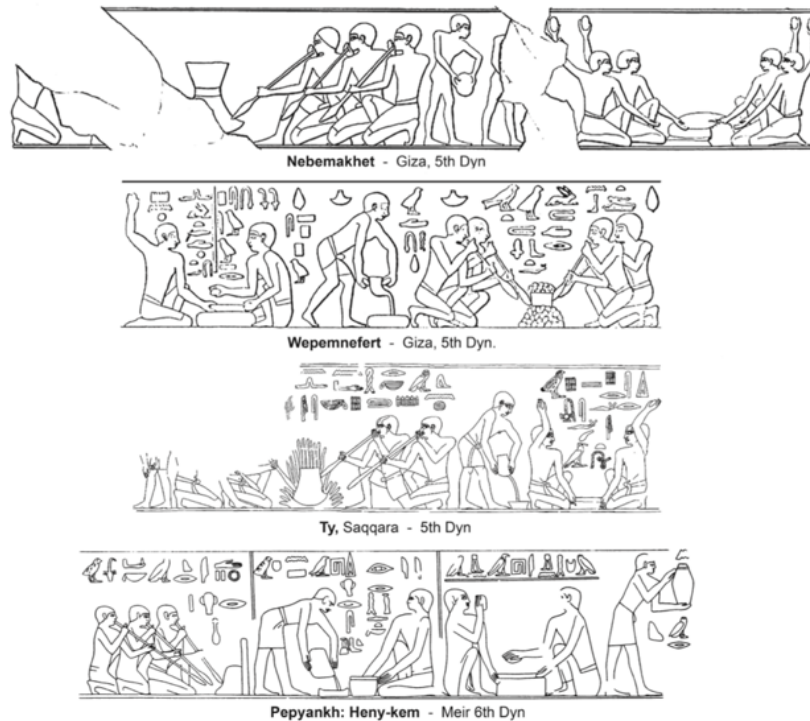


Figure 5.2. Metalworking scenes (smelting and casting) from various tombs. ©Davey 2012: 93, who reproduced from the following publications: C.R. Lepsius, *Denkmäler aus Aegypten und Aethiopien* Text 2 (Leipzig, 1904), pl. 13 (Nebemakhet); S. Hassan, *Excavations at Giza 1930-1931* 2 (Cairo, 1936), fig. 219 (Wepemnefert); H. Wild, *Le Tombeau de Ti 3: La chapelle* (MIFAO 65; Cairo, 1966), fig. 173 (Ty); A.M. Blackman & M.R. Apted, *The Rock Tombs of Meir* 5 (ASE 28; London, 1953), pl. 16 (Pepyankh: Heny-kem).

The scenes described above clearly reflect aspects of the *chaîne opératoire of metallurgy* particularly the step of production which includes the working of ingots, use of crucibles with blowpipes, and casting of objects into their form through the use of moulds. Whether the Old Kingdom metalworking scenes can be taken as factual or as artistic representations of metalworking activities has been the centre of some conjecture (Davey 2012: 85; Malek 1999: 128; Muhly 1999: 630; Robins 1986: 57), but the fact that archaeological finds corroborate with much of these scenes suggest they are evidence of metalworking in the Old Kingdom.

It is important to note that these scenes are also reflective of the social involvement in metal production during the Old Kingdom - multiple individuals likely from different social ranks (denoted by their differences in dress and hieroglyphic titles) are clearly depicted doing different tasks, including record keeping. It is unclear if these individuals were employed by the state, but

given the lack of titles, it may be suggested that this type of labour was available to the general population.

5.3.4 Metalworking and Old Kingdom society

The study of metalworkers provides insight about their position in Old Kingdom society. Limited written evidence exists on mining personnel and administration, but a few instances point towards an organised specialised workforce that consisted of high and low ranked individuals (Eyre 1987: 12-13). Ancient Egyptian texts imply that metalworking was a specialised craft and the organisation of metal production was overseen by the crown and its administrators who likely supervised the main storage areas of raw materials (Odler 2016: 30; Roth 1991: 284; Strudwick 1986; Wilson and Allan 1938a: pl. 32-33). An earlier reference recognised the state control over copper and states that “in those early days, metals must have been entirely monopolies of the Court” (Garland and Bannister 1927: 7). This opinion was supported by the evidence related to expeditions to mines and quarries on behalf of the king and is still supported by current evidence. One example is in the metalworking scene of Mereruka, where an individual (scribe?) who holds a different position is seen recording the weighing of metal in the first part of the register. Such examples are not consistent in metalworking scenes, but titles relating to metalworking such as “metals scribe”, “overseers”, “overseer of scribes of crews” are evidence for a well organised administrative system closely related to the state (Eyre 1987: 12-13). As Eyre states,

It is worth noting that weighing and the direct supervision of a scribe are standard elements only of metal-working scenes in private tombs, implying a more direct control than was usual for other raw materials (Eyre 1987: 13).

Although positions involving the supervision of copper extraction and production were likely highly regarded due to their position in society, labourers producing metal products were viewed differently, at least during the Middle Kingdom. A text known as the “*Satire of the Trades*” (Instruction of Dua-Khety) describes the hardships that metalworkers faced daily. The text reads:

I never saw a sculptor as envoy, nor is a goldsmith ever sent; but I have seen the smith at work; at the opening of his furnace; with fingers like claws of a crocodile. He stinks more than fish roe. (Satire of the Trades/Instruction of Dua-Khety in Lichtheim 2006: 186).

This text provides a vivid image of the difficulties metal production brought to individuals and it also places metalworkers into a lower class of society - individuals who would never be called

upon to represent the court.

5.3.5 *Trade of metal objects*

Little is known about the post-production of copper metal-based objects in the Old Kingdom. Intercultural trade with neighbouring societies provided a means to obtain resources unavailable in Egypt including Nubia, Levant, Ebla, and much of the Near East (Sowada 2009). This type of trade existed prior to the Old Kingdom but the exploitation of natural resources intensified from the 3rd Dynasty onward by kings Djoser, Sekhemkhet, Sanakht, Sahura, Nyuserra, and Menkauhor (Baud 2010: 72-74) and continued through the Old Kingdom and kings Djedkara, Pepy I, and Pepy II of the 6th Dynasty (Baud 2010: 72; Ikram 2014: 286; Ikram and Rossi 2004; Kuper 2001; Kuper and Förster 2003; Malek 1999: 101; Redford 1992: 37-48). In fact, an alabaster vase found in the destruction layer of the palace at Ebla (modern Syria) attests to the extent Pepi I reached in his expeditions (Archi 2015: 27, 487; Baud 2010: 79; Scandone Matthiae 1979: 37-38).

There is substantial evidence to suggest that the state obtained areas of resources through force and control. Rock-cut reliefs and graffiti at the *Wadi Maghara* mark events of conquest with images of pharaohs smiting foreign enemies with maces (Baud 2002: 260-269; Redford 1986: 136-139; Sowada and Grave 2009: 91-92). The use of skilled individuals brought from Egypt to produce the graffiti is indicative of the state's attempt to enforce dominance and Egyptian nationalism over subjugated people, lands, and resources (Goedicke 1964: 39-41). Most of the rulers of the Old Kingdom are depicted in these scenes beginning with the 3rd Dynasty's Sanakht, Djoser, and Sekhemkhet (Gardiner, Peet, and Cern 1952: pl. 1; Givon 1974; Gonenim 1957: pl. 78), 4th Dynasty kings Sneferu (Urkunden des ägyptischen Altertums [Urk.] I: 8; Gardiner et al. 1952: pl. 2.5, 4.6) and Khufu (Urk. I: 8; Gardiner et al. 1952: pl. 2.7, 3), 5th Dynasty kings Sahure (Urk. I: 32; Gardiner et al. 1952: pl. 5.8, 7.9), Niuserre (Urk. I: 53; Gardiner et al. 1952: pl. 4.11, 6.10), Menkauhor (Urk. I: 54; Gardiner et al. 1952: pl. 7.12) and Djedkare-Isesi (Urk. I: 56; Gardiner et al. 1952: pl. 4.15, 7.13, 8.14), and 6th Dynasty kings Pepy I and Pepy II (Urk. I: 91- 2; Gardiner et al. 1952: pl. 8.16, 9.17). Moreover, titles given such as "controller of copper, Shepses" further reflected a claim to copper resources in the area (Gardiner et al. 1952: 61, pl. 7.13). These claimed areas belonged to a broader network of Canaan copper mining from the Early Dynastic period when intercultural connections with Egypt were extensive (Sowada 2009: 45-48). However, the increased demand for copper in the Old

Kingdom forced Egypt to obtain full control of its closest mines (i.e. southwestern Sinai) and lay claim to its territories by the 3rd Dynasty (Sowada 2009: 247).

Further examples of subjugation come from texts dating to the Old Kingdom. The *Autobiography of Harkhuf* (6th Dynasty) describes expeditions to foreign lands on behalf of the king with an army who brought gifts as booty from the “mine-land” (mines in the Sinai) (Lichtheim 2006a: 23-27; Obsomer 2007: 39; Strudwick 2005: 328-333). The inscription on the tomb of Pepynakht also discusses missions to Nubia and the Eastern Desert vividly:

I did what pleases my lord and killed a great number there, including the ruler's children and the commander of the excellent Nubian force. I brought a great number of them to the Residence as prisoners... (Strudwick 2005: 327–40).

However, the most compelling inscriptions indicating control over the Sinai copper region comes from the Wadi Maghara where phrases such as “*subduing the foreign lands*” are written above smiting scenes (Strudwick 2005: 134). An inscription of Izezi in Wadi Maghara makes particular reference to expeditions relating to control of resources (turquoise and copper):

A royal mission was sent under the command of the boat captain Nyankhkhentykhety to the hills of turquoise; he carried it out, together with...The scribe of copper Khunes (Strudwick 2005: 137).

These Old Kingdom inscriptions clearly suggest that the Egyptian state was willing to take extreme measures to ensure that its supply of resources was secured through the subjugation of neighbouring states (Eyre 2010: 304). In essence, the state of the Old Kingdom established a system that provided Egypt with the resources it required through subjugation and implementation of military personnel as security measures (Andrassy 1991: 128; Fischer 1959: 265; Mumford 2006: 54-55).

Old Kingdom local trade of copper-based objects likely occurred at local markets where metalsmiths sold their products (Odler 2016: 33-34). Examples of the copper market trade are found in market scenes dating to the Old Kingdom, such as in the tomb of Kagemni at Saqqara where a metal mirror is traded, and in the tomb of Fetekty in Abusir where fishhooks are traded (Odler 2016: 33). A market scene in the tomb of Nyankhnum and Khnumhotep at Saqqara (Odler 2016: 33-34) is particularly exceptional (Fig 5.5). It depicts a transaction between a buyer “*craftsman of deben*” who purchases an adze blade and a bundle of three copper fishhooks from a *bd* ‘metalworker’ (Odler 2016: 33). This scene also provides particular information on the use

of copper as currency, called a *dbn* in ancient times, depicting the metal weighed in the scene in exchange for a vessel (for copper as currency see Eyre 1987: 24-25; Moussa and Altenmuller 1977: 83, ab. 10; Wilkinson 2013: 181-182). Further evidence from Old Kingdom inscriptions indicate copper being used as payment in the wages of tomb builders (Eyre 1987: 24-25, 2010: 299).

5.3.6 Copper consumption pre-Old Kingdom

The earliest metal objects appear during the Neolithic Badarian period (c.4500-3500 BC) in Egypt, for example the copper beads found at el-Mustagidda in Grave 596 (Muhly 1999: 629; Scheel 1989: 8). Copper objects including axes, adzes, chisels, razors begin to appear in the Chalcolithic Naqada I-II cultures (c.4,000-3,200 BC) (Needler 1984: 280-2, cat. 180-3; Muhly 1999: 629) and continue into the Early Dynastic, Old Kingdom, and later periods (Kobusiewicz 2015: 1-2; for Old Kingdom see Odler 2016).

Metal knives that resemble those used in animal butchery appear in the Early Dynastic period – e.g. 1st Dynasty necropolis of Tarkhan where both flint and copper knives were found in a number of tombs (Petrie 1912, 1913; examples see UC17081; UC28612). Perhaps the most exquisite example is a copper knife with a curved blade found dating to the Early Dynastic Period 1st Dynasty at Abydos (Manchester Museum 6783) (Fig. 5.3). These early examples were made of arsenical copper (Muhly 1999: 630).



Figure 5.3. Copper knife with a curved blade. 1st Dynasty. Abydos. Manchester Museum 6783.

5.3.7 Household copper consumption in the Old Kingdom

The evidence for household consumption of copper objects is scarce for the Old Kingdom. A few exceptions have been found, but these are mostly isolated finds and cannot be used to substantiate any assumptions of the use of copper on a mass scale at the local level (for a corpus of Old Kingdom copper objects see Odler 2016). Some evidence for ‘household’ consumption comes from the excavations of the pyramid builder’s settlement at Giza, where copper objects such as a fishhook and needle were found among slag, charcoal, and ash within a residential

gallery (Lehner and Hawass 2017: 370). However, such examples should still be considered related to the state and not reflective of the general population since this is a settlement designed to service the pyramid builders.

5.3.8 *Funerary commodities for consumption during the Old Kingdom*

Most copper-based metal objects derive from funerary contexts (Muhley 1999; Petrie 1912, 1913; for an extensive corpus on Old Kingdom metal objects see Odler 2016). These include chisels, knives, axe heads, and adzes (Fig. 5.4). Many of these objects reflect the “model” type which are produced to represent real-life tools but likely only produced for funerary equipment and not used. The 6th Dynasty Tomb of Impy at Giza (G2391) for instance contained a large number of copper tools (these types were unalloyed copper, see Muhly 1999: 630), including copper knives (Maddin et al. 1984).



Figure 5.4. Abusir South, Tomb AS 27, complete model tool kit with model blades of chisels, adzes, axes and saws. Photo by Kamil Voděra, © Faculty of Arts, Charles University in Prague, Czech Institute of Egyptology. (Archaeopress 2017).

Copper knives resembling those used in animal butchery have been found in a number of tombs dating from the Early Dynastic and Old Kingdom periods (Maddin et al. 1984; Muhly 1999; Odler 2016; Petrie 1912, 1913). However, whether these early copper knives were used in utilitarian activities or strictly for ceremonial purposes is difficult to determine, especially since they are found only in funerary contexts. Large numbers of copper based tools appear in a number of property lists in private tombs and the objects themselves are most often found in tomb contexts which is indicative of the relationship between the workmen (producers of the metal objects) and the tomb owner (individual who provisioned the objects to be made) (Eyre

1987: 13; Junker 1940: 72-73). Such examples demonstrate a clear sense of exclusiveness for those who could afford their own tomb also were often able to afford to provision copper objects for their afterlife.

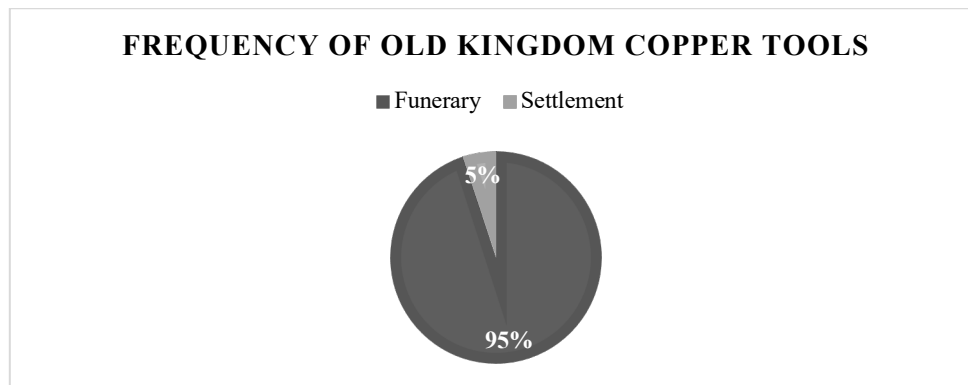
5.3.9 *State consumption*

Unlike funerary and settlement contexts, evidence for state consumption of copper-based metal objects is extensive. Much of the evidence comes from the construction of state projects which required the use of metal objects for the stone masonry, such as at Giza where both copper tools and mason's marks were found along with areas with bits of copper, copper objects, malachite ore, and areas of copper smelting (Lehner and Hawass 2017, particularly 406-407). Utilitarian copper objects excavated from Giza include blades, blocking stone pins, chisels, hooks, drills, hinges, needles, and saws (Hawass and Lehner 2017). Funerary complexes such as the complex of Sahure in Abusir also had an elaborate drainage system consisting of copper basins and pipes (Edwards 1993: 167-168). These examples demonstrate the use of copper by the state to achieve its state projects.

5.4 *Frequency of copper*

A complicating factor that prevents an association between these early copper knives and animal butchery practices is that the depositional context for knives only includes high status burials. There are no examples of copper knives from excavations that reflect non-ceremonial daily life contexts to date (at least from the extensive sources examined in this thesis). Most of the metal objects from the third millennium BC that may have been used in animal butchery (including knives) come from elite, ritual, and ceremonial contexts, such as tombs, temples, or foundation deposits. Most (95%) metal tools (including knives) from this period were found in funerary contexts with the remainder (5%) from settlement contexts (Table 5.2) (Odler 2016: 66-69). The objects examined by Odler are excavated from funerary contexts and very little of the corpus came from settlement contexts. Therefore, it is unclear whether other sites would yield different results with copper objects in settlement contexts.

Table 5.2. Pie graph demonstrating the percentages of Old Kingdom copper tools found in funerary and settlement contexts. After Odler 2016: 66-69.



Although the near absence of metal tools from settlement contexts may reflect their lack of use in daily life for activities such as animal butchery, this phenomenon is complicated by the likely recycling of rare and expensive materials, such as copper or bronze, which can be melted down, repaired, and reused (Greenfield 1999, 2013; Ikram 1995: 67; Tillman 1999: 314). An example of a copper production workshop area that reworked and recycled copper was found at the First Intermediate Period site of Balat in the Dakhla Oasis (Moeller 2016: 242).

The presence of metal in wealthy burial contexts is indicative of a product that seems to have been reserved for the wealthier or higher classes of ancient Egyptian society. Despite arguments that copper was not only for elite members of society (Sowada 2009: 45-48; 185-188), the absence of copper-based objects in household contexts and the presence of copper in funerary contexts suggests that it was not widely available to the general population, but only to those who had the means to acquire them.

5.5 Conclusion

The development of metallurgy in Egypt began with the invention of copper in the Predynastic period (Baumgartel 1960:10-16; Needler 1984:280-282, cat. 180-3; Payne 1993:146, cat. 1215-20; Wengrow 2005:38-39) and later developed into more complex objects such as knives that resemble those used in animal butchery (e.g. MM6783, see Petrie 1912, 1913). The development of metallurgy was a slow process that occurred alongside the continued use of flint tools (Chapter 4) but became more common from the advent of the Old Kingdom.

The *chaîne opératoire* of metallurgy in Egypt followed similar patterns as elsewhere in the Near East from mining, smelting, manufacturing, trade, and consumption (metallurgy in the Near East see Greenfield 2008a:1639-1647). The influx of copper objects was driven by the control of

copper mines which began at the onset of the Old Kingdom (Ogden 2000). The extensive archaeological evidence for smelting and copper production from the Old Kingdom corroborates with a large project designed to fulfil the need for copper resources. A social aspect can be seen in the production of metallurgy through the metalworking scenes of the Old Kingdom which vividly depict individuals from various ranks involved in copper production (Davey 2012).

However, the consumption of copper objects mirrors the stratified society from which they came. Although early copper objects that resemble knives used in animal butchery are found dating to the Early Dynastic Period (e.g. Tarkhan, 1st Dynasty), the use of copper objects is restricted to funerary and state contexts – particularly for those who were among the higher ranks of society (for a corpus of Old Kingdom copper objects see Odler 2016). Household consumption of copper objects is rare and copper production is not found in smaller villages or localised settlements.

An important social aspect needs to be considered regarding metallurgy during the Early Bronze Age in Egypt. The textual and archaeological evidence presented in this chapter suggests that copper production was heavily influenced by the state and its consumption was limited to the higher classes of society. The presence of mining operations east of the Nile Valley and royal involvement in interregional trade demonstrate that metal was clearly produced for the royal household and its retainers (Baud 2010: 72; Tillman 1999: 314). This begs the question, *why was copper limited to those of higher status?* Local individuals such as farmers, peasants, tradesmen, or potters likely did not have access to copper objects due to the limited “financial” resources. Another possibility is that these objects served as mechanisms for identity and status (see Introduction) and restricted to individuals of higher status to maintain the status quo. It is through such mechanisms where social complexity thrived, and social stratification was maintained.

Chapter 6 looks closely at Giza and the pyramid workers settlement which is used as a case study to examine the implications metal had on ancient Egyptian society at the state level. It describes the context studied in this thesis and how valuable the faunal assemblages at Giza are to the current study.

Chapter 6: Giza and the Kromer Dump: a case study

6.1 Introduction

This chapter begins with a general summary of the results of the excavations at Giza and a focused description of the results of the excavation(s) at the Kromer Dump. In order to ultimately understand these results within their broader chronological, social, and economic contexts, the chapter then summarises the larger zooarchaeological assemblage from which the butchered material was selected. Giza is particularly desirable for the study of the early use of metallurgy in animal butchery during the Old Kingdom (Early Bronze Age) because of a strong relationship that existed between the state and settlements. This relationship was driven by pyramid construction, which reflected a high degree of state control. It is within this paradigm that a complex network of state, status, pyramid construction, and settlement activities can be found. The paradigm lies in the effect that status had on the accessibility to products (i.e. cuts of meat or copper tools), and the ability of the state to control the products. This begs the question: Were copper-based tools also connected to status? At Giza, the presence of copper-based metal objects and metalworking throughout the settlements at Giza suggests that expensive resources were readily available to use. However, archaeological understanding of the line between the state's 'elite' products (i.e. copper consumption) and its use by the 'lower class' for activities such as animal butchery is blurred. This chapter aims to shed light on the issue of copper and cattle consumption in Old Kingdom society by assessing archaeological data from Giza.

6.2 Old Kingdom Giza

The archaeological site of Giza is located in the desert on a terrace above the western bank of the Nile River overlooking the modern city of Cairo. This site is separate from, but in close proximity to, the ancient capital of Memphis. Giza was the most important necropolis of the Old Kingdom for the kings and nobles from the 4-6th Dynasties. The monuments at Giza served as an important symbol of strength and power for the kings, a reflection of the intense organisation involved to produce the objectives of the state. As the funerary centre for the Old Kingdom (i.e. Dynasty 4), this was an ideal location for the supervision of the construction of the pyramids and associated funerary monuments (Hawass and Lehner 2017: 40-45) (Fig. 6.1).

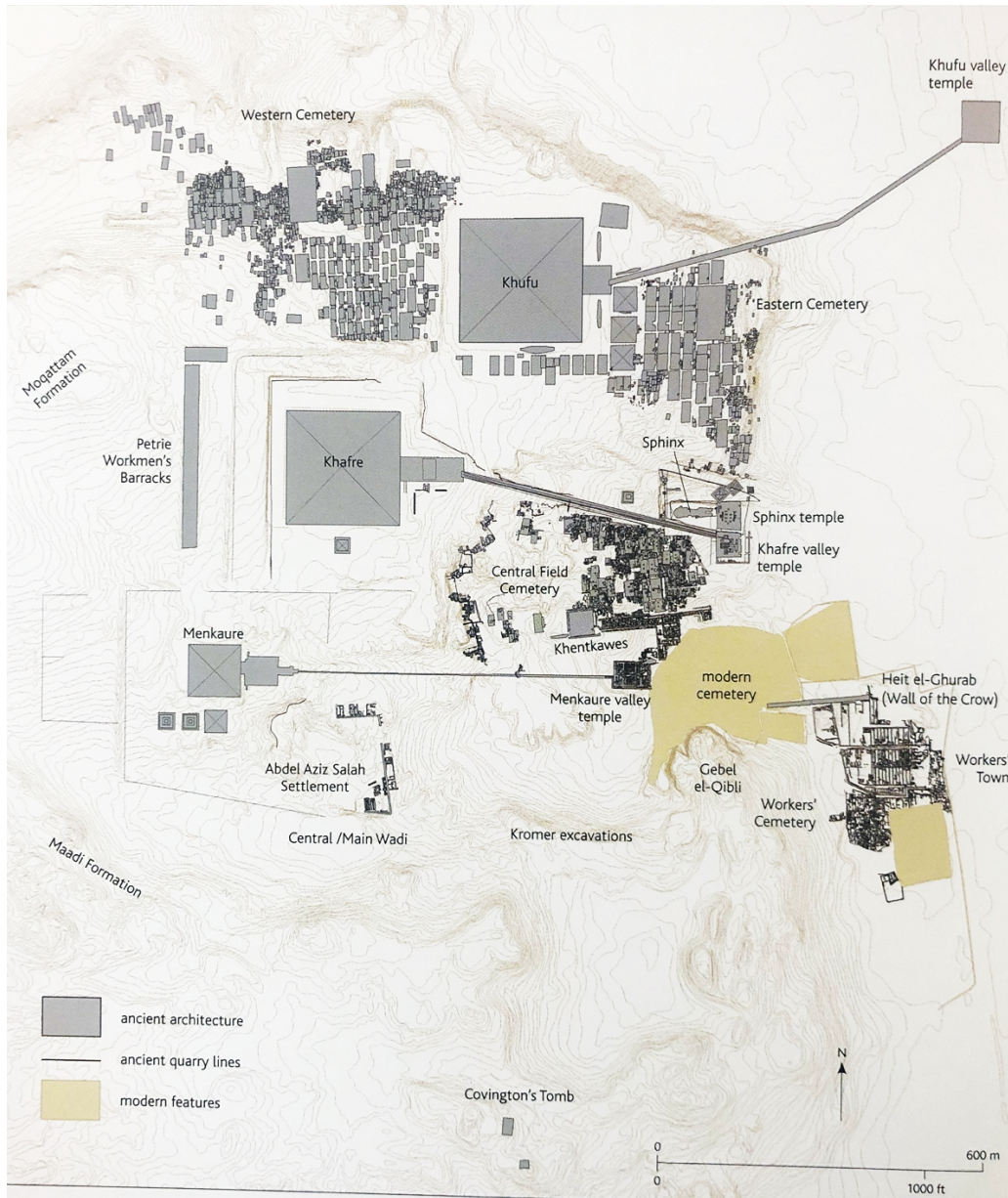


Figure 6.1. Aerial map of Giza Plateau. (Lehner and Hawass 2017: 10) ©AERA.

There are three main elements to understanding the importance of Giza to the state. First, it must be understood that the construction of the pyramids and related structures (i.e. burial structures/pyramids, associated valley temples, support systems, housing, etc.), was a massive undertaking (David 1996; Malek 2010: 85-87). Constructing and maintaining such colossal monuments and their supporting infrastructure required a large and complex workforce (including all levels of society – scribes, priests, acolytes, foremen, masons, painters, bakers, cooks, etc.), meticulous organisation, and continuous access to supplies (both for construction

and resources for its workforce) (Hawass and Lehner 2017; Ikram 2014: 286; Lehner 2007). Next, it must be recognised that there were settlements associated with the pyramids. These were established to support the construction of the monuments and maintenance of the royal religious cults (Malek 2010: 92-93). These settlements were directly connected to and dependent upon the state, and their existence and location clearly reflects characteristics of state control and organisation. Finally, to understand the importance of Giza to the state, the role of Giza in the supply chain must be recognised. Goods and resources needed to be produced to ensure that state projects such as the pyramids were completed in a timely manner (i.e. before the death of the Pharaoh) (Hawass and Lehner 2017). This included the manufacture and production of equipment and supplies. Settlements, quarries, fields, workshops, and other areas of production were necessary to support the system of construction and maintenance. Archaeological research has revealed evidence for the organisation, production and distribution of ceramics, lithics, metals, and food (Lehner and Hawass 2017). The areas of metal tool production are of greatest interest in this thesis because they contain indirect evidence for the nature of butchering technology.

Access to the best products and skilled individuals was provided by the state in order to manufacture the tools necessary for completing the pyramids (for example, copper see Chapter 5). The presence of administrative areas, tool manufacturing, food storage, and animal butchery in a variety of sites at Giza demonstrates the range of products produced and consumed during the Old Kingdom in a state environment. It is not surprising that we find evidence of such activities in the settlements including large areas for grain storage (ex. Storehouse in RAB, see Lehner and Hawass 2017: 380), metalworking (ex. Gallery III.8, see Lehner and Hawass 2017: 370), and animal butchery (Redding 2010).

6.3 Monumental architecture: the pyramids of Khufu, Khafra, Menkare.

Although there are many monuments at Giza, the Old Kingdom pyramids and their related religious structures are the best-known and most popular. The great pyramids of Khufu, Khafra, and Menkare at Giza still stand today, some 3500 years after they were built. They are a testament to Old Kingdom Egypt's breadth of knowledge, the depth of state control over the economy and society, and the strength of its political power (Fig 6.2). The largest pyramid was built as a funerary monument for the Pharaoh Khufu. It was originally 146.59 meters high and covered a total area of 5.3 hectares (Lehner and Hawass 2017: 140-155). The second largest pyramid was built for his son and heir Khafra. It was slightly smaller, at 143.5 meters in height,

and covered a total area of 4.6 hectares (Lehner and Hawass 2017:188-201). The third smallest pyramid was built for the Pharaoh Menkaure. It was 61.87 meters in height with a total area of 11,025 square meters (Lehner and Hawass 2017: 244). The creation of these monuments required an established administration, plentiful resources, and a large and predictably available workforce (Lehner and Hawass 2017; Shaw 2012: 67-68).



Figure 6.2. Pyramids of Giza. Photo: Eleuterio Sousa.

The pyramids were constructed using a large workforce that consisted of labourers, craftsmen, butchers, potters, and administrators (Lehner 2017: 419). The collective effort initiated a number of advancements to ancient Egyptian society (Shaw 2012: 19-23, 68-76; Ogden 2000). In particular, the completion of the pyramids introduced innovative methods of engineering attempted by previous rulers (i.e. Djoser and his Step Pyramid at Saqqara) but the kings of the Old Kingdom were able to achieve the construction of a complete pyramid.

A number of settlements were established under the state during the Old Kingdom, many of which provided the materials, goods, and food required for constructing pyramids (see Chapter 2; Shaw 2012: 4-8; Eyre 1987). It has been suggested that the transportation of goods from remote settlements to Giza occurred during the Old Kingdom (Lehner and Hawass 2017: 410-11), and settlements such as Elephantine supplied granite to Giza as part of a greater network of resources (Arnold and Pischikova 1999: 129, no. 23; Kaiser 1999a: 71-81; Shaw 2012: 67-68). The state projects brought a sort of collective unification of a workforce that fostered development of technologies and labour (Eyre 1987; Shaw 2012: 68).

6.4 Settlement and industrial areas

There was a close relationship between the pyramid construction and the settlements that housed its labourers, craftsmen, administration, and related religious cult personnel. These pyramid settlements of the Old Kingdom are examples of the society at the time which can be seen at Giza. The pyramid towns currently known at Giza are the Heit el-Ghurab Settlement (HeG), Menkaurae industrial area, Menkaurae pyramid settlement, and the Kentkawes Town (Fig. 6.3).

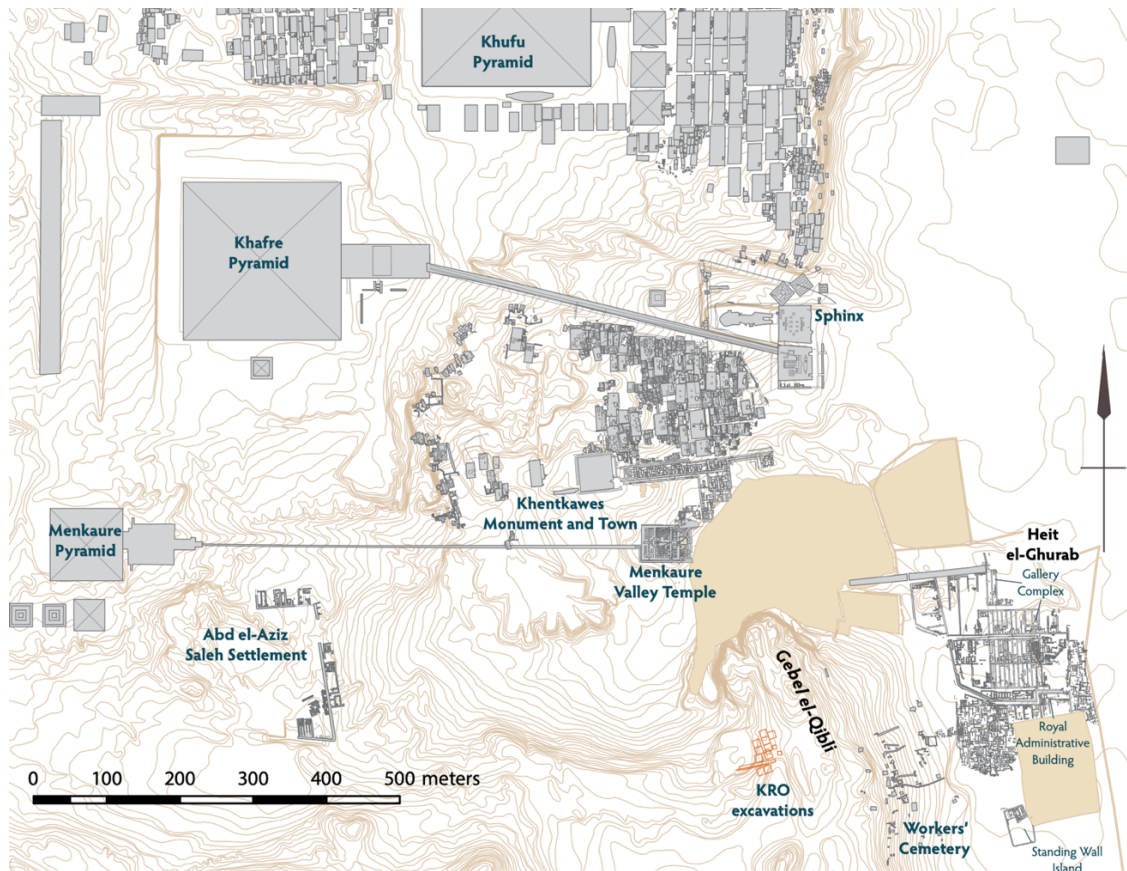


Figure 6.3. Topographic map of the settlements at Giza, including the KRO excavations (Lehner 2018: 2) ©AERA AERAGRAM 2018.

6.4.1 Heit el-Ghurob (HeG) workers village of the Great Pyramids

The first settlement established at Giza in the Old Kingdom was the Heit el-Ghurob (HeG) built to house the workers of the pyramids of Khufu and Khafra (Fig. 6.4) (Lehner and Hawass 2017: 355-401). The town was located in the low desert area of the Giza plateau between the Moqattam and Maadi geological formations. The general layout of the HeG provided efficient movement and management of a large workforce. For instance, the entrance and exit from the

town to the construction site were heavily guarded (Lehner and Hawass 2017: 385) and the streets and alleyways acted as a maze that guided workers through to residential quarters (Gallery Complex), dining areas (Hypostyle hall), and to production areas (silos, copper smelting, kitchens). The ‘Wall of the Crow’ or Arabic *Heit el-Ghurab*, (a large stone enclosure wall that is still visible today), for instance, denoted the entrance to the workers village which is currently 250 meters east-west by 400 meters north-south (Lehner and Hawass 2017: 385). The HeG had a harbour that allowed imported materials to be brought to the site and transported to the upper construction areas (Lehner and Hawass 2017: 362). The town had roads, residential quarters, and public spaces which had been divided into areas named according to their distinct purposes - Gallery Complex, Hypostyle Hall, Royal Administration Building (RAB), Eastern Town, Western Town, Gatehouses, and Bakeries (Lehner 2007).



Figure 6.4. Map of the Heit el-Ghurab (HEG) site (Lehner and Hawass 2017: 365).

The *Gallery Complex* consisted of 4 key areas/structures where individuals lived and conducted daily activities (Lehner and Hawass 2017: 369). Guard posts were found in the complex and suggests that individuals were monitored closely, and gatekeepers maintained the flow of human traffic in and out of the camp (Lehner and Hawass 2017: 371-75). It is believed that the complex was the main barracks and that it slept approximately 10,000 workers (Lehner and Hawass 2017: 371-75). The dwellings had two levels and the first floor had vaulted ceilings (Lehner and Hawass 2017: 369). Evidence of production, such as cooking, grain storage, pigment grinding, and copper-smelting, have been found within the structures of the complex (e.g. Gallery III.8) (Hawass and Lehner 2017: 24-25; Lehner 1992, 2002). The presence of “abundant slag, charcoal and ash, and bread moulds used as crucibles” is indicative of copper-smelting and has confirmed copper production at Giza (Lehner and Hawass 2017: 370).

The *Hypostyle Hall* resembles a common dining area fitted to accommodate many individuals (Lehner and Hawass 2017: 372). Attached to the Hypostyle Hall was a residence (called *The Manor*) which had a series of bakeries for large-scale baking that belonged to an overseer who managed the operations in the Hypostyle Hall (Lehner and Hawass 2017: 375). The presence of such a residence denotes the presence of the state, perhaps to monitor its interests and rations for its workers.

The *Royal Administration Building (RAB)* received its name from the large number of seal impressions found within the building. The administrative centre was located on the southeast side of the site. It contained storage areas for goods and was likely where the import, export, management of goods were handled (Lehner and Hawass 2017: 378-80). A recent study that examined the inscribed impressions found that a large percentage were replicated impressions and reused (Lehner and Hawass 2017: 383; Nolan 2010). The large silos, mud tokens for weights, and evidence of copper and alabaster working in the RAB all support the idea of a state management system of valuable products (Lehner and Hawass 2017: 379, 2019). The presence of copper working in the RAB demonstrates that the state managed metal production closely and considered it to be a valuable product, perhaps exclusive to the state.

Two areas (possible neighbourhoods, see (Lehner 2019: 25-26) called the Eastern and Western Towns demonstrate some differences between status and material culture. The *Eastern Town* was a more informal, self-organised area with small chambers and courts that were more organic and autonomous in nature and reflective of smaller Old Kingdom villages (Lehner 2015, 2017: 380-81, 2019; Lehner and Tavares 2010). The dwellings here contained evidence of small-scale cooking (bread making) and objects that reflect a community that was somewhat self-sufficient (Lehner and Tavares 2010). There is no evidence of copper in this area.

On the contrary, the *Western Town* nearby is an example of an elite neighbourhood (Lehner 2007: 45-46) with dwellings in close proximity to one another reflective of a crowded neighbourhood. A number of large houses (perhaps belonging to overseers or administrators) had painted mud-brick benches, plaster walls, moulding, and contained surrounding galleries for utilitarian activities and storage of goods (Lehner and Hawass 2017: 381-85). The architecture and material culture here are reflective of individuals who were wealthier than in the Eastern Town. Specifically, a large quantity of seal impressions was found in the Pottery Mound (a cache excavated by AERA) that connects this neighborhood to wealthy 'elite' individuals of the court

(Nolan 2010; Lehner and Hawass 2017). The Pottery Mound also contained heaps of animal bones, pottery, seal impressions, bread moulds, and ash with botanical remains which have contributed to understanding how pyramid workers lived and provided absolute dating for HeG (Lehner 2007, 2010, 2015, 2017: 383, 2019).

Another area located west of the Khafre pyramid was the Workman's Barracks (Area C) which consisted of a large number of galleries (some roofed) used by the state for the storage of raw materials and food supply for pyramid construction (Lehner and Hawass 2017: 361-363). The area had evidence of habitation and specialised craft manufacturing such as pottery sherds, fauna, grains, and charcoal indicative of cooking activities and copper working (Conrad and Lehner 2001; Lehner and Hawass 2017: 362). Certain areas had a large quantity of copper pieces that were excavated, including 10 pieces found in unit C8 (Conard and Lehner 2001: 38).

6.4.2 *Kentkhawes Town KKT*

The Khentkawes Town (KKT) was a unique settlement that was occupied for about 300 years (Fig. 6.5) (Lehner 2011, 2015, 2017: 306-311; Hassan 1943). The town was built to house the workers of the funerary complex of Queen Khentkhawes I from the 4th Dynasty and her funerary activities (Lehner 2011, 2015, 2017: 306-311; Hassan 1943). The Queen's tomb was placed on bedrock shaped during the construction of the pyramids. The five hectares of land that it dominated sat within embankment walls with a thick outer enclosure wall and contained houses, ceremonial structures, and roads (Lehner and Hawass 2017: 395).

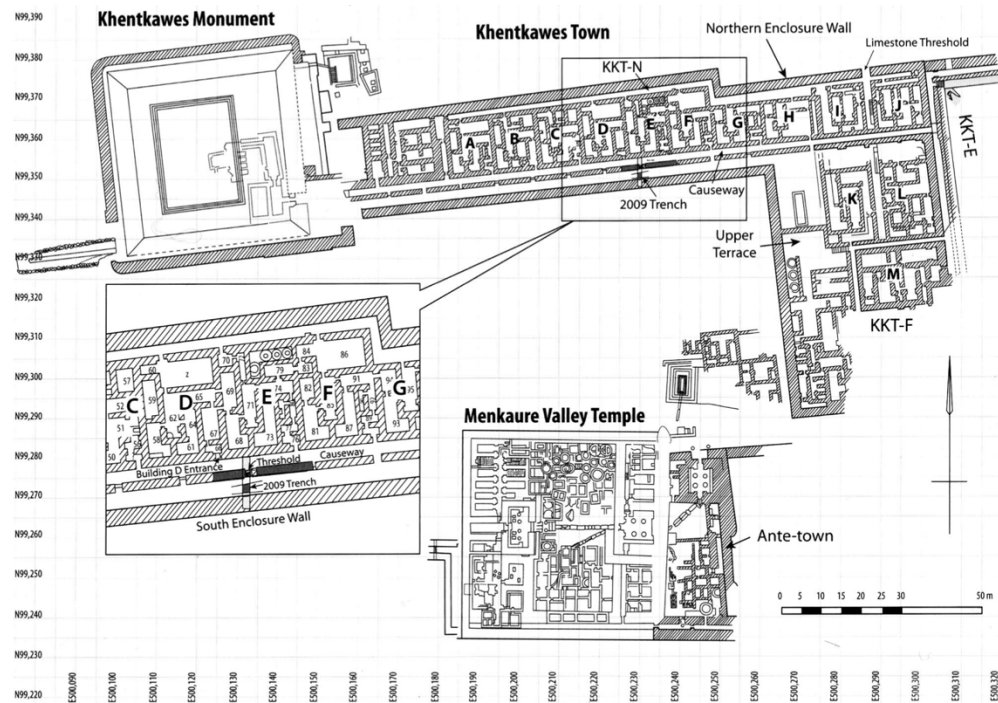


Figure 6.5. Map of Khentkawes Town (KKT) (Lehner et al. 2011: 148).

The site has been claimed as “the earliest state-planned settlement” for the region of Giza, and as an example of a typical pyramid town of the Old Kingdom (Moeller 2016: 34; Lehner 2011: 144-145; Lehner and Hawass 2017: 394). Although the majority of the architectural elements of the site date to the 4th Dynasty, there are parts that connect the town to the later reign of Nisurre of the 5th Dynasty and also to the 6th dynasty (Lehner and Hawass 2017: 308). A period of abandonment occurred at the settlement between the late 5th and early 6th dynasties (likely due to a flash flood that tore through Giza during that time) before it was reoccupied and rebuilt (Lehner 2011: 157-157; 2017: 395-396; Reisner 1931:30; Lehner and Hawass 2017: 393). Evidence of copper was found among some of the material culture from the site (Lehner et al. 2011: 172). The copper recovered from the KKT further confirms the use of copper-based technologies at Giza during the Old Kingdom.

A number of architectural elements made the KKT unique compared to the other pyramid settlements. The KKT was accessed via a set of ramps located near an ancient basin (Lehner 2011: 164; Lehner and Hawass 2017: 308). The basin was intended to be a functioning harbour that connected the town to the Nile and during the inundation of the river would be useful in providing access to the funerary cult for visitors and to receive imported goods (Lehner and

Hawass 2017: 393).

Another notable feature was the layout of the houses, which were lined along the causeway of the temple (Lehner 2011; Lehner and Hawass 2017: 305). A total of ten houses were excavated along the causeway, some of which were occupied by funerary cult officials or priests (Lehner and Hawass 2017: 395). Many of these were large houses containing kitchens, ovens, and granaries (Hassan 1943).

6.4.3 Industrial complex of Menkaure Pyramid

An industrial complex located southeast to the pyramid of Menkaure has also provided information on Old Kingdom pyramid settlements (Fig. 6.6) (Saleh 1974). The site was dated by radiocarbon to the reign of King Menkaure (Saleh 1974: 139). The complex consisted of two embankments (A and B) that were constructed from “broken rocks and rubble joined with *tafl-clay* [local Egyptian style] mortar” which surrounded fifteen large rectangular structures (Saleh 1974: 131). Despite initial assumptions that the area was an ‘Industrial Settlement’ (Saleh 1974) the absence of daily life activities, dwellings or sleeping quarters reflected an area more of an industrial nature (Bard 1999: 423). Moreover, the purpose of the structures excavated (large furnaces and silos) seemed to further support the idea of an industrial area (Bard 1999: 423; Saleh 1974). The evidence related to craft specialisation and large-scale food production has also connected this area to industrial production: copper production was present in the complex in the hearths of open courtyards (Bard 1999: 423). The presence of copper production here suggests two things: That the area was aimed for industrial activity, and, perhaps more importantly, that metalworking continued during the reign of Menkaure at Giza in a specialised fashion.

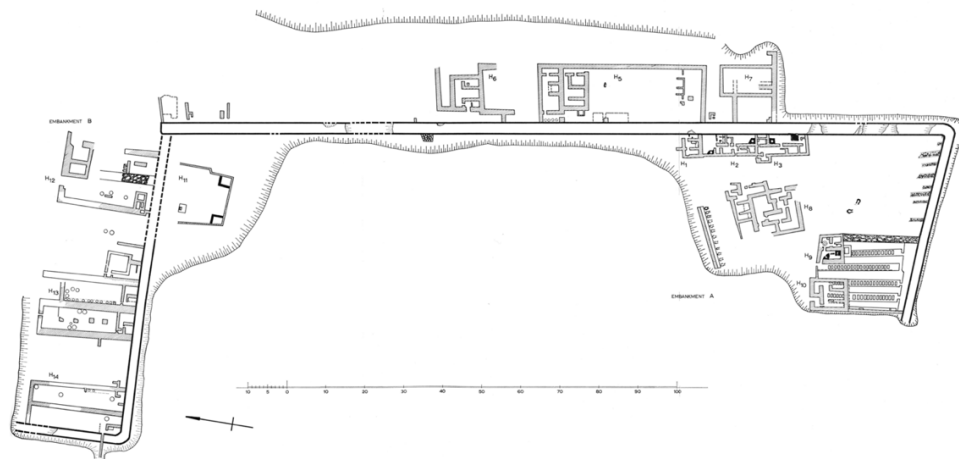


Figure 6.6. Map of Menkaurae industrial settlement (Saleh 1974: fig. 2).

6.4.4 *Menkaure valley temple settlement MVT*

The Menkaurae Valley Temple (MVT) had a residential area located on the northeast side of the temple that housed the caretakers of the king's cult (Hawass and Lehner 2017: 398-400; Lacovara 2014; Reisner 1931; 1942: 49). The settlement has been described as a “sort of semi-official, squatter-occupation” (Lacovara 2014: 447), ‘crowded warren’ (Lehner and Hawass 2017: 398), and with a ‘slumminess’ impression (Reisner 1931: 49-50; Lehner and Hawass 2017: 400). These descriptions reflect the settlement’s overcrowded area with small dwellings that overlap sacred areas of the temple (Lacovara 2014; Reisner 1931). It was located high above the ancient floodplain and was accessed by the ancient population through a series of ramps and corridors that flanked a deep basin (perhaps a ceremonial pool) or via a causeway corridor on the south (Fig. 6.7) (Lehner 2015: 231; Lehner and Hawass 2017: 398-400).

Three major building phases of occupation were recognised at MVT by earlier archaeologists (Reisner 1931: 51-54) and these are still under investigation (Lehner and Hawass 2017: 398; AERA Spring 2019 Newsletter; Lehner and Hawass 2017, 2015, 2012, 2011). The different building phases were comprised of small mud-brick houses and round silo granaries similar to those in other areas at Giza (Lehner and Hawass 2017: 398). The first phase has been dated to the 4th dynasty when the construction of the pyramid complex of Menkaure began (Lehner and Hawass 2017: 398; 2015: 231-232). The second phase or ‘middle period’ have been dated to the mid-5th dynasty, during the reign of King Nisurre (2402-2374 BC). The site was reoccupied during the middle period and state areas were renovated and developed through, for example, the

addition of five apartments in the southern court, restoration of bins and granaries in the northern court, and the construction of a vestibule (Lehner 2015: 237-242; Lehner and Hawass 2017: 398-399). Another period of abandonment followed. This may have occurred because of a halt on tax exemptions to temple staff and / or as the result of a massive flash flood that tore through Giza during the end of the 5th or early 6th Dynasty (Lehner and Hawass 2017: 399). The settlement was again reoccupied in the late 6th Dynasty for its third phase. It was during this final phase that the site received more revitalisation and became more popular as a place of residence. This is indicated by the crowded mud-brick houses placed around the eastern temple wall and interior spaces of the temple developed during this time (Lehner and Hawass 2017: 399-400).

A number of decrees were found within the temple complex which confirmed the Valley Temple settlement as the pyramid town of Menkaurae (ex. Pepi II see Reisner 1931: 280). The decrees also provided valuable information for the chronology at Giza (Lehner and Hawass 2017; Lehner 2015, 2012, 2011). Recent excavations by the AERA of the various phases have found a connection between the KKT and MVT and suggested that “people abandoned and, after a hiatus, reoccupied both of the conjoined settlements” (Lehner and Hawass 2017: 398; also see Lehner 2015). In fact, the current theory is that when the population abandoned the HeG settlement, they resettled at the KKT and MVT sites, evolving from settlements with an agenda for state construction to one of maintenance of royal cult activities (AERA 2019).

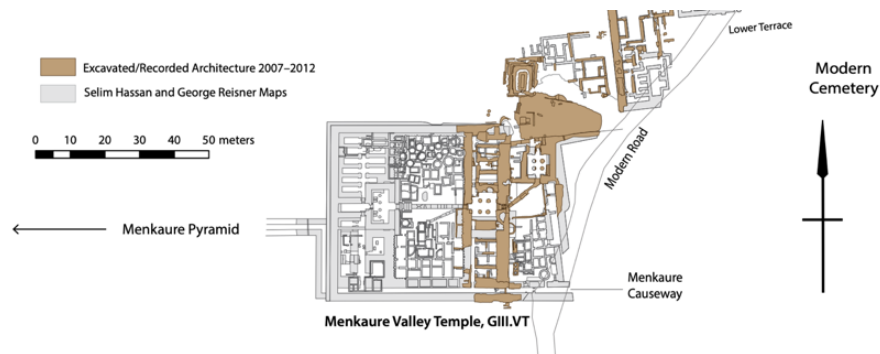


Figure 6.7. Map of Menkaure Valley Temple ©AERA (AERA 2018: 14)

6.5 Copper evidence at Giza

The evidence of metallurgy at Giza has been found in two forms. First, evidence of copper-based metal use has been attributed to pyramid construction in stone masonry methods (Edwards 1985: 254; Hawass and Lehner 2017: 160-163, 406-607). In particular, mention has been made of fuel brought to Giza for the production of copper tools for pyramid construction (Lehner and

Hawass 2017: 410).

The second context where copper has been found is throughout Old Kingdom layers in various settlements at Giza. A number of the pyramid towns described above have contained evidence of copper-working or physical copper objects (Lehner and Hawass 2017; Edwards 1985; Salah 1974; Odler 2016). These have included the industrial settlement of Menkaure's pyramid (Salah 1974), the Khentkawes Town where a cut in the Northern Lateral Ramp revealed a hearth and fragments of copper (KKT-E 6b) (Lehner 2011: 172), Gallery III.8 where there was "clear evidence of copper working using bread moulds as crucibles or small furnaces" (Lehner and Hawass 2017: 370), and the Royal Administration Building (RAB) where deposits "yielded evidence of working copper" (Lehner and Hawass 2017: 279). In addition to these production areas, a variety of copper-based objects have been recovered at Giza over the years that include blades, chisels, hooks, drills, hinges, needles and saws (Lehner and Hawass 2017; Odler 2016: fig. 27).

6.6 Faunal studies at Giza

6.6.1 Meat consumption at HeG

At the HeG, Redding analysed approximately 310,000 bone fragments which consisted of mammal, fish, aves, and reptilia. *Ovis/Capra* (sheep/goat) make up about 25,000 fragments which were the highest quantity of mammal in the assemblage with a ratio of 3:1 (sheep to goats) (Redding 2010: 68). *Bos taurus* (cattle) were the second most common mammal represented with over 8000 fragments (Redding 2010: 68). Ratio of cattle to sheep-goats was 0.35:1. *Sus scrofa* (pig) made up over 1000 fragments and make up a ratio of 8.1:1 (cattle to pig) and 23.1:1 (sheep-goat to pig). The distribution between sheep/goat and cattle does not necessarily suggest that more sheep/goat were eaten because cattle had more meat (3.5 times more than sheep and goat) and could feed more individuals (Redding 2010: 68). Despite this caveat, the quantity of individual *Ovis/Capra* still surpass that of *Bos Taurus*. Through the distribution of taxa it is clear that cattle were consumed more than sheep and goat at HeG, particularly that cattle could feed more individuals.

6.6.2 Status and diet at HeG

The fauna from the HeG site at Giza have given enough zooarchaeological data to deduce information on the relationship between diet and status (Redding 2010). It has been recognised that wealthier individuals consumed better cuts of meat in ancient Egypt (Ikram 1995) and the

faunal evidence at the HeG is indicative of this.

The PM in the Western Town of the HeG had massive quantities of fauna and ceramics in its layers (over 50,000 faunal). Redding (2010) examined 50% of the sample (27,122 bone fragments) which contained 936 cattle, 69 sheep/goat, 6 pig, 6 gazelle, 1 leopard. The ratios showed that much more cattle were consumed over other taxa (for instance, 13.6:1 ratio for cattle to sheep goat). Other material culture studied from the PM suggests that individuals of the Western Town were of higher status and had greater access to cattle than other areas of the HeG (Eastern Town for instance) (Redding 2010: 73). Redding stated that “the highest status individuals at the site consumed cattle, almost exclusively, and consumed very young animals, less than one-year of age” (Redding 2020b: 6; also Redding: 2010). The North Street Gate House (NSGH) also located in HeG also had a better-quality diet than the workmen in the barracks with a high consumption of cattle provisioned by the state and high-quality fish (Redding 2010: 70-73).

On the contrary, individuals in the Eastern Town and workmen’s barracks had a lower quality diet. Individuals who resided in the Eastern Town (ET) of the HeG had a diet that was dominated by pig remains and sheep, not cattle (Redding 2010: 73). The high quantity of sheep and pig is suggestive of a pastoral system different than other areas of the HeG, where individuals likely “engaged in subsistence procurement activities” (Redding 2010: 73; 2020b). Fauna from Gallery III.3 and III.4 (barracks, working class) also demonstrate consumption of ‘least desirable’ meat choices with sheep and goat representing a higher quantity than cattle (Pellett and Shadarevian 2013; Redding 1981). Material culture from these areas consist of simple objects reflective of a working class and corroborate with lower status individuals not having access to high quality meat choices.

6.6.3 MVT and elite animal consumption

The individuals who resided at the MVT were directly connected to the funerary temple of Menkaurae and the religious activities related to the royal cults. Some of these activities included dismembering cattle limbs for offerings of meat (Redding 2020b: 1-3; Ikram 1995: 41; Papazian 2005: 260-262; Chapter 3). As a result of its context, the faunal assemblage from the MVT is vastly different in comparison with that of the HeG. In 2019, Redding and the team at the AERA examined the faunal remains excavated from the MVT and found that cattle dominate the faunal record with an astonishing ratio of 36:1 (cattle to sheep/goat) and that particularly hindlimbs are

overrepresented (Redding 2020b).

Such conclusions correlate with offering scenes dating to the Old Kingdom where cattle were depicted being slaughtered for the deceased and hindlimbs given as offerings (Ikram 1995). The high quantity of cattle remains corroborates with the historical narrative connecting religious ideologies with the daily activities conducted by the residents of MVT.

The faunal record throughout Giza demonstrates clearly that cattle were likely slaughtered for temple offerings and then divided among the population according to status. Highly ‘elite’ individuals and priests consumed cattle (steak) (HeG Pottery Mound and the MVT) while the workers ate stew (HeG Gallery III.3 and Gallery III.4). The zooarchaeological studies conducted on the various faunal assemblages at Giza give a well detailed picture of the relationship between people, status, and diet during the Old Kingdom. The faunal remains demonstrate that status affected the accessibility to particular cuts of meat.

6.7 *Kromer Dump (KRO) Archaeological History*

6.7.1 *20th century Karl Kromer*

Austrian prehistorian Karl Kromer excavated between 1971-1975 and cleared 1550 cubic meters, 6.5 meters deep of a settlement that contained 4,500-year-old trash that pyramid builders dumped on the high western slope of the Gebel el-Qibli (Southern Mound), south of the HeG (Fig. 6.9 & 6.10) (Kromer 1978). Kromer describes the area as a rubbish heap rich of building and cultural material (Kromer 1978). The mound was made up of the trash from pyramid builders of the 4th Dynasty, some of which includes pottery, flint blades, mud bricks, fauna, bone implements, mud sealings, and copper implements (Fig. 6.8) (Kromer 1978).



Figure 6.8. Section from Karl Kromer’s excavation catalogue, Innsbruck University, 1971. Note the find of copper objects (adze, fish hook, slag) among the various tools and equipment. EMC_SR_2/17465, p. 10, Egyptian Museum, Cairo. © Egyptian Museum, Cairo.

6.7.2 21st century Mark Lehner and Ancient Egypt Research Associates (AERA)

The trash included everything from hair balls to fishhooks and demolition and quarry debris, including pieces of walls, hard-trodden floors, roofs, painted plaster, hearths, and clay sealings impressed with hieroglyphic titles of high-ranking officials (Lehner 2018: 2).

In 2018 the AERA re-excavated the Kromer Dump (Sondage 185=Kromer Dump=KRO) (Fig. 7.10 and 7.11) and found the rich material culture described above (Lehner 2018). The mound is 6.5 meters thick with an eight-degree slope to the west-northwest and spread over an area of 12.5 acres (Lehner 2018). The Kromer Dump contained the rubbish from the pyramid workers who built those of King Khafra and possibly Menkaurae of the 4th Dynasty (Lehner 2018). Ancient garbage can be one of the most useful sources of information for archaeologists and the Kromer Dump provided extensive information about the ancient pyramid builders of the 4th Dynasty and included faunal remains that provided information on animal consumption and butchery practices.

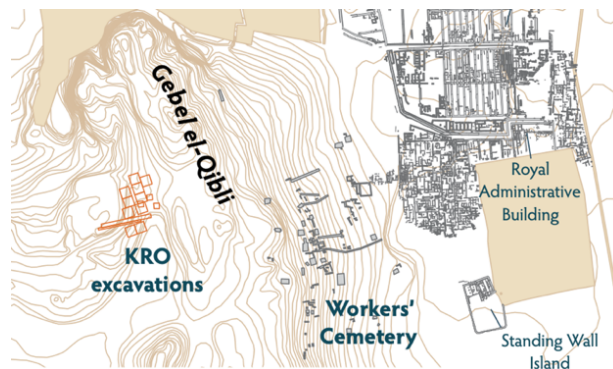


Figure 6.9. Map with the Kromer excavations (KRO). Section taken from Fig. 7.3. (AERA 2018).

The team excavated a sondage (185) that contained material from Kromer's earlier excavation and in-situ ancient material to the east and west (Fig. 7.10). Two discoveries were made from this archaeological survey. Firstly, the areas that were previously unexcavated (185 to the east and west of Kromer's excavations) contained tiplines of ancient material (rubbish) that were deposited at an angle to the east which suggests that the material derives from an area west of the HeG (Lehner 2018: 4). Second, the stratigraphy contained tiplines that included layers of what Mark Lehner calls "quarry crush" which was broken down, powdered limestone that was removed from the quarry area to move the large limestone blocks for the pyramids (Lehner 2018). The abundant quantity of quarry debris is indicative that quarrying was done nearby at the Gebel el-Qibli which was abundant with limestone (Lehner 2018: 5). The area here is rounded

from the pyramid builders quarrying tafla, gypsum, and limestone for the construction of the HeG workers village. The archaeological evidence given by the angle of the tiplines (Figs. 6.11 and 7.12) suggests that workers trekked from the west and dumped their trash in an eastern direction (Lehner 2018: 4). This indicates that the Kromer material derived from a settlement or area where limestone blocks were quarried for pyramid construction (Lehner 2018: 4; for a discussion on quarrying see pp.6).

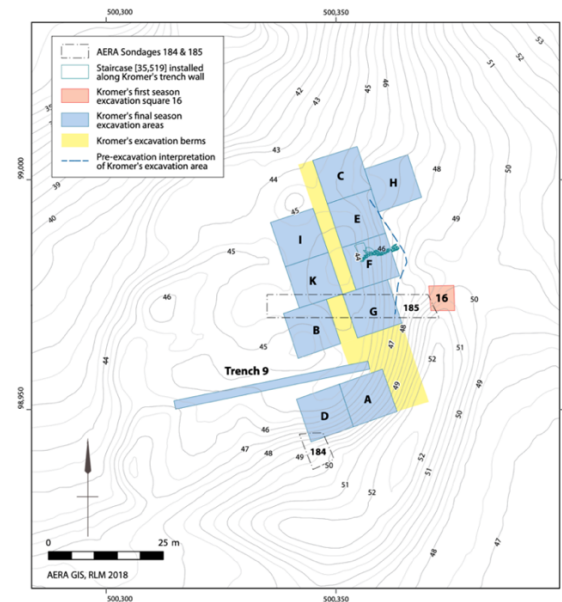


Figure 6.10. Kromer and AERA Excavations at KRO. Note Sondage 185 and its extension beyond the initial Kromer 1970's excavations. ©AERA

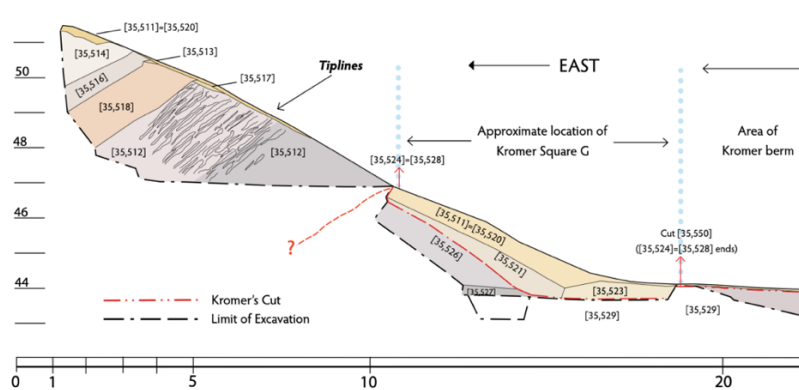


Figure 6.11. Composite section of Sondage 185 from 2018 Kromer Excavations. Note the tiplines that slope down to the East. ©AERA.



Figure 6.12. Photo of the tiplines from the East with ghosted workers superimposed for illustration. ©Mark Lehner.

Another important discovery that the team made was that below the Kromer excavation, tiplines were also angled the opposite direction – brought from the east and have a western slope (Lehner 2018:4). This was evident in Quadrant A and D which Kromer had previously made note of earlier but did not recognize the significance of it (Kromer 1978: 17-21, 115) (Fig. 6.13). It was clear to Lehner that the dump from the East comes from the HeG settlement (Fig. 6.14). Therefore, the eastern layers from the West are likely of a later date than the material from the western layers from the East.



Figure 6.13. Quadrant A and D showing the tiplines from the West and East. Ghosted workers added for illustration. ©Mark Lehner.

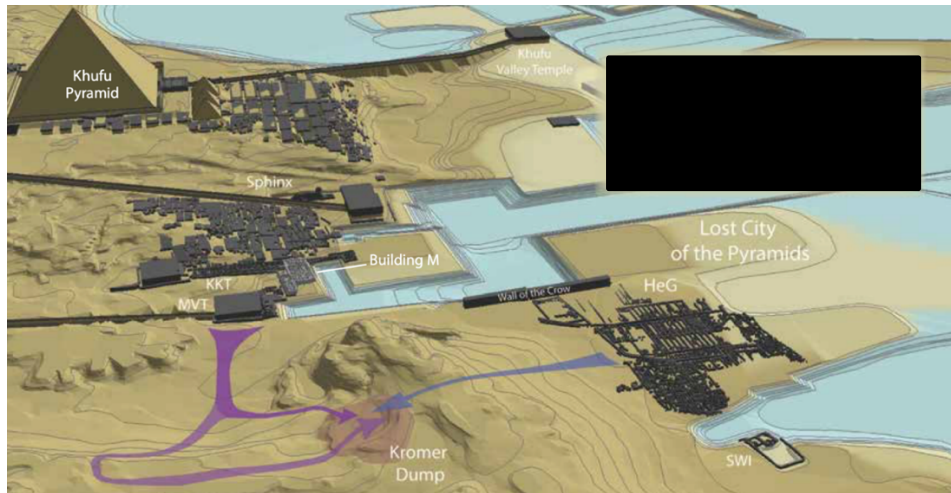


Figure 6.14. Map showing the directions of the rubbish brought from the HeG and MVT settlements. (AERA 2018: 12) ©AERA.

It is currently believed that a settlement or seasonal camp existed in what is now a depression filled with sand called the “Tafla Bowl” (Fig. 6.15) (Lehner 2018: 6-8). The variety of material culture found within the Kromer Dump (i.e. fishhooks, walls, plaster) was deposited within a 60 year span (approximately the time span for most of Giza, see Lehner 2017) and is indicative of a settlement, particularly the faunal remains and mudbrick, Lehner states:

Based on the quantities of bone that we found, and the many fragments of dark gray, Nile alluvial mudbricks, I think we must see these deposits as coming from a settlement on or near the floodplain, to the east-northeast (Lehner 2018: 6).

Hence, it is likely that the Kromer material derives from a settlement camp related to the quarrying likely located within the Tafla Bowl where seasonal pyramid builders resided (Fig. 6.16) (Lehner 2018: 6-8), perhaps farmers who came up during the inundation of the Nile (pers. comm Richard Redding).

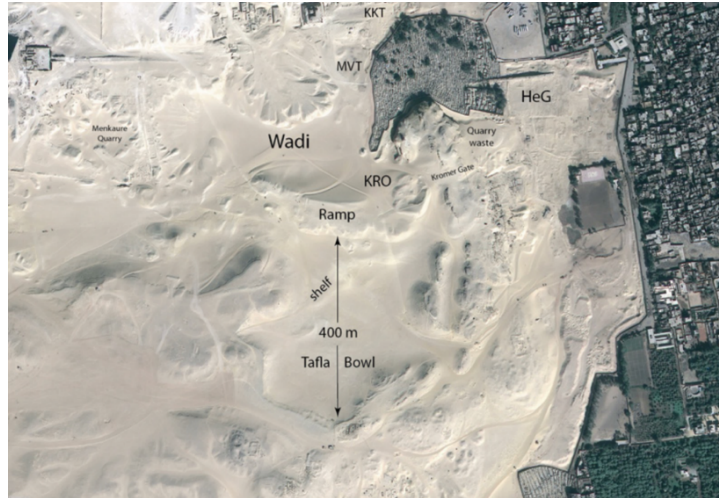


Figure 6.15. The “Tafla Bowl” in the Maadi formation. ©Mark Lehner.

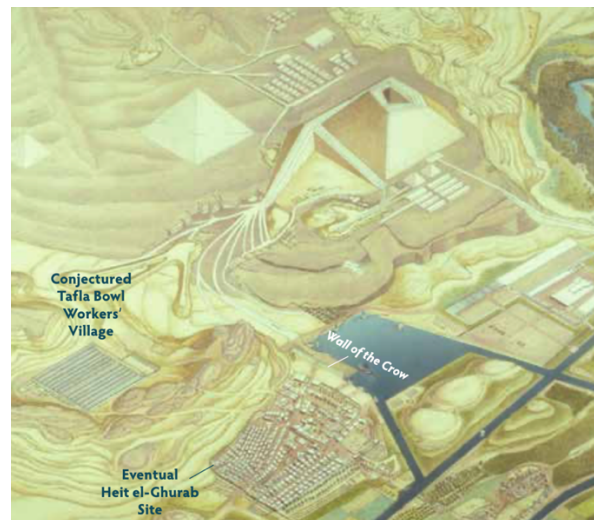


Figure 6.16. Earlier isometric drawing (Lehner 1985) that depicts the possible Tafla bowl Workers Village presumed by Mark Lehner in 1985, 30 years prior. ©Mark Lehner.

Each stratigraphic layer was given a feature number (Fig. 6.11) that helped attribute each layer to a particular event in time or context. Feature number 35512 was particularly rich with material culture including some copper, flint blades and knives, and an abundant quantity of faunal remains (unpublished report AERA 2019). This feature is particularly useful to the study of metallurgy and tool use in animal butchery because it contains blades and knives similar to those used in animal butchery and faunal remains that contain excessive butchery marks including slices that can be analysed for characteristics of stone or metal.

6.8 Zooarchaeological data from KRO

The zooarchaeological data from the Kromer Dump (KRO) has not yet been published.

However, zooarchaeologist Richard Redding and the team at the AERA have analysed the faunal assemblage and written up primary results which will be summarised here (Redding 2020: 51-54).

A large quantity of mammal bone was excavated from the Kromer Dump (KRO) Feature 35512. A total of 177 cow, 1232 sheep-goat, and 13 pig bones were recovered (Redding 2020: 51). A large portion of these included shaft fragments (femur, humerus, tibia, radius, metapodia) which made up 248 NISP's (Number of Identified Specimens). The lowest represented elements were the humeri (NISP=26) and femura (NISP=26) while the most represented were the metapodia (NISP=83). All the faunal displayed some sort of butchery, such as slices, chops, and/or skinning. The few bone tools found in the excavation are not included in this study. Most of them resembled cooking implements (i.e. spatula) (Richard Redding, pers. comm.). This extent of butchery makes the Kromer Dump a valuable assemblage for the study of slice marks to determine the nature of tool types utilised in the animal butchery process at Giza.

The fauna from KRO are unique in comparison to all other faunal assemblages excavated from the workers village (HeG) at Giza because they are largely made up of medium mammals (sheep/goat), have shafts with no proximal or distal ends (epiphyses), and contain extensive amounts of butchery marks (i.e. slices, chops) (personal comm. Richard Redding). The fauna examined from the HeG such as that from Gallery III or the Pottery Mound, contained a higher quantity of cattle which indicates a higher yield of meat per animal, and in this context they had little or no butchery marks. The faunal studies suggest that the HeG was the more permanent settlement for the pyramid workers while the KRO or Tafla Bowl settlement represents a more seasonal camp (pers. comm. Richard Redding).

The study of the animal bones from KRO provides a narrative on the consumption of low-quality cuts of meat at Giza. It has been suggested that the workmen from the quarries consumed the proximal and distal parts of the animal in a highly nutritious stew (Redding 2011; Redding and Ahmed 2020). Individuals smashed the long bones and the ends of long bones, boiled them in water, and skimmed off the grease (Redding 2011; Yeomans 2011). Moreover, recent experimental work by Redding on bone crushing demonstrates how these bones were boiled for stew, he states, 'at Giza the bones of sheep, goats, and cattle were broken to expose the marrow cavity and then boiled in a stew' (Redding 2017: 18).

The study of the large quantity of butchered animal bones from KRO has provided valuable

information on animal consumption at Giza during the 4th Dynasty, particularly on those individuals who worked in the quarry and may have resided in a settlement within the Tafla Bowl. The slice marks on the KRO bones can continue to be studied to shed light upon other aspects of ancient Egyptian society such as the types of tools used in animal butchery.

6.9 KRO: a case study of tool-types adopted in animal butchery in the Old Kingdom

There are three reasons that make the KRO fauna an ideal assemblage for the study of tool-types adopted in animal butchery during the Old Kingdom. Firstly, the presence of copper and metalworking found to be adopted in the construction of the pyramids and in the various settlements (chronological periods) at Giza suggests a high potential for copper-based metal tool use in animal butchery. Secondly, the intensive presence of the state throughout the settlements at Giza and in the organisation of the production of goods (including copper) suggests that accessibility to expensive products may have been available through the state for its use. Thirdly, the unusually high quantity of butchered animal bones that have high numbers of slice marks and are well preserved means that a good enough sample can be obtained for such a study to render conclusive results that can fill the gap on tool use in animal butchery and the adoption of metal.

6.10 Conclusion

It has been demonstrated in previous chapters that the Egyptian Old Kingdom state was heavily involved in the production of particular flint tools (Chapter 4), copper production (Chapter 5), and settlement planning (Chapter 2). This chapter reviewed the various sites at Giza through the lens of status, copper production, and animal consumption. The archaeological work conducted at Giza has allowed for a narrative to emerge on life during the Old Kingdom at a state-run site, one which mirrors state involvement at other Old Kingdom settlements. The social ranks that existed during the Old Kingdom (Chapter 2) are prevalent at Giza where the presence of administrative areas, production facilities, guarded residences, elite houses, lower class neighbourhoods, and differences among animal consumption are examples.

As Redding put it, ‘a picture emerges of a well-organised subsistence economy controlled by the central authority and dedicated to feeding a large number of workers and elite. Status was reflected in the diet’ (Redding 2010: 75). This statement summarises well the interplay between the state, elite individuals, and workmen who all had various access to particular cuts of meat at Giza. The presence of copper-based objects and metalworking at various settlements throughout Giza from the Old Kingdom implies that ‘status’ likely also affected accessibility to expensive

materials such as copper for utilitarian uses. The uniqueness of Giza therefore, lies in the availability of the various parts of the puzzle - flint, copper, settlement, fauna - to be collectively studied to understand the use of metallurgy in Old Kingdom Giza.

Particularly related to this thesis are the areas of copper finds or production and animal consumption at Giza. Zooarchaeological studies have demonstrated that higher-status individuals ate better meat provisioned from the state while the working class ate stew or fended for themselves (Redding 2010, 2020). Moreover, the presence of butchered animal bones provides another area to study this ancient population. Copper items and production facilities are also present at Giza which means that the use of copper blades in animal butchery is possible. Copper is found within close proximity of state-run structures (i.e. administrative centres, production areas with silos) which allowed the state to closely monitor its production while better meat choices were also consumed in these areas. This begs the question, was copper blade use reserved for higher status individuals?

The animal remains from Kromer Dump (KRO) provides a remarkable opportunity to answer questions on the adoption of copper blades at Giza during the Old Kingdom. The high quantity of butchered bones available for study from a site where copper was widely produced and consumed is ideal for research pertaining to the development of metallurgy, particularly the use of metal knives in animal butchery. The application of zooarchaeological methods to such a culturally rich assemblage has proven to be useful in understanding diet patterns. The following chapter describes the methods adopted in this thesis to answer such questions. Now, the adoption of slice mark morphological approaches and scientific technologies to an assemblage rich with butchered bones will help fill the gap on what tools were used to slaughter animals for food. The ability to compare the results of this study with the historical narrative supplied by decades of archaeological work is extraordinary.

Chapter 7: Methods

7.1 Introduction

The evolution of stone and metal-based tools cannot be completely understood simply by examining the material culture alone (specifically the quantity of flint and metal tools). Although animal butchery scenes depict bifacial knives used in animal butchering activities, the evidence present for the use of flint suggests that a variety of tool types may have been used for the slaughter and butchery of animals. Even though evidence for the use of metal is limited in Old Kingdom settlement sites, its presence raises questions about its use and purpose in quotidian activities, particularly its adoption in animal butchering activities. Moreover, it is unclear whether the use of metal was limited or restricted to higher-ranked individuals or those within close quarters of state administration. In consequence, there is the potential that both stone and metal tools may have been used for butchering during the Old Kingdom in Egypt. Such sites, therefore, may exhibit part of the transition from stone to metal-based tools for use in utilitarian activities.

However, one cannot simply examine the tools, which may or may not be preserved, as a proper measure of material type adopted in tool use during the Old Kingdom. It has been successfully shown elsewhere that this shift is best moved from a focus on the tool artefacts themselves and onto the result of their use - the butchered animal bones (e.g. Greenfield 1999). Except for dismemberment, the primary butchering activity leaves a slice mark on the bone and experimental research has shown that slice marks can be identified as produced by a stone or metal knife (e.g. Greenfield 1999). As a result, the study of such slice marks is particularly useful in identifying the transition from stone to metal tools.

This chapter provides a literature review on the previous studies of butchering marks on faunal remains and outlines the methods adopted in this thesis. This includes on-site analysis on the faunal assemblage, preliminary identification of slice marks, moulding, and rendering specimens under a Scanning Electron Microscope (SEM) for confirmed identification. These steps collectively provide a thorough comprehensive examination of the slice marks to identify stone or metal tool use at Giza during the Old Kingdom.

7.2 Previous zooarchaeological studies on slice-mark morphology

Zooarchaeological research has two related goals: (1) to understand, through time and space, the biology and ecology of animals, and (2) to understand the structure and function of human behaviour (Reitz and Wing 2008: 11).

The statement made by Reitz and Wing (2008) reflects on objectives that zooarchaeologists should aim for when undertaking studies that deal with animal remains. The second goal mentioned in the quote is a particularly useful framework to conceptualise the broader implications of zooarchaeological studies. Ancient Egyptians butchered animals for food, and it is within the study of this human behaviour that questions about the interaction between animals and humans can be answered, particularly questions regarding the types of tools used in animal processing.

The study of zooarchaeology began as an anthropological, anatomically focused discipline (e.g. Sisson 1914) but took a shift in the 20th century with the advent of scientific instruments that were adopted in archaeological methods to answer questions about human and animal behaviour (e.g. Binford 1981). One of these major developments was the understanding of the various impressions (morphologies) left on animal bone as a result of natural/environmental effects (i.e. weathering, animal gnawing) and human activities (i.e. animal butchery, trampling, chopping). The use of basic optical microscopes and later developed high-end SEM allowed for microscopic viewing of morphological characteristics present in bone modifications. The new developments were useful in identifying patterns associated with particular animal processing activities, such as slice marks on animal bone caused by sharp tools (Walker and Long 1977) and are still widely adopted today, including in this study.

7.2.1 By eye and light optical approaches

Phillip Walker and Jeffrey Long's (1977) work was one of the earliest publications to systematically examine the impact of the use of different technologies on animal bone. They applied experimental archaeology to the study of morphological characteristics of tool marks left on animal bone. The authors were also the first to use silicone moulding on the microscopic butchering marks to obtain a profile view and then draw the transverse sections for identification (Walker & Long 1977: 607). The experiments provided criteria to differentiate tools types and their raw material on slice marked bone. The methods and materials used in this early publication continue to be used and referenced in more recent studies (Greenfield 1999; Olsen and Shipman

1988; Pollio 2009).

Another pioneer in bone modification studies was Lewis Binford (1981) who is known for his work on the ethnoarchaeological studies of modes of bone modification. His processual approach was based on observations of Native American hunter-gatherers and the analysis of faunal remains from their hunting and butchering activities. He provided a comprehensive description of different modifications and their causes that can appear on animal bone. He also differentiated human and non-human activities such as gnawing, tooth marks, trampling, filleting, and disarticulation. Binford's discussion on butchering marks not only delves further into Walker and Long's (1977) work, but also identified additional characteristics of stone and metal tool types. For example, he found that metal slice marks were hairline in size, and that they were typically long in length even though the angle of metal slice marks make them difficult to view. He also investigated the meaning of the distribution of butchering marks located on animal bone (Binford 1981: 96-147).

7.2.2 Scanning Electron Microscope approaches

The invention of the first SEM by Charles Oatley occurred in 1948 at the University of Cambridge. This invention ultimately revolutionised how zooarchaeologists identified butchering marks by providing researchers with the capability of high resolution, high magnification images for study (McMullan 1995). By 1965, the SEM was commercially available and adopted in a number of disciplines including archaeology and it reached its peak in the 1980's with the establishment of the SEM in Archaeology conference held in 1986 at the University of London (Frahm 2017: 6489-6490; McMullan 1995). Since its invention, the SEM has been widely adopted in the analysis of slice mark morphology on ancient faunal remains (Fisher 1995).

The SEM produces a beam of electrons through an electron gun which is aimed at the specimen to produce a micrograph (Malainey 2011: 487; Shipman 1981: 362-366). The micrograph is obtained by focusing the electron beam through the adjustment of apertures and electromagnetic lenses at the specimen which is contained in a vacuum sealed chamber. The vacuum sealed chamber keeps the electrons together and disruptive air molecules out for a clear high definition image of the specimen. Once the adjustments are made and the beam is focused on the specimen, signals are sent to the computer to produce an image for microscopy (a micrograph) (Shipman 1981: 362-366). The usefulness of the SEM lies in its ability to produce

high resolution photos at high magnifications. According to Shipman, the SEM is useful for its 'superior resolution of three-dimensional structures, greater depth of field, and the capability for higher magnification of specimens' (Shipman 1981: 360).

Shipman (1981) was the first to apply SEM to butchered faunal remains to increase understanding of the effects that activities of daily life have on animal bone. She created a series of criteria that were applied to ancient animal bone to determine if the marks are humanly or naturally created. She recognised the benefits of the application of silicone moulding of marks developed by Walker & Long (1977) as a way to study marks on bone that were beyond the dimensions of the chamber and used moulds for SEM microscopy (Shipman 1981: 362). The ability of obtaining high-resolution images at higher magnification allowed the SEM to be an effective technology in determining the origin and nature of mark morphology. Shipman demonstrated that it was essential to collect variable information of the slice mark (striations, angle, profile) that was only visible with an SEM before making any determination about the nature of a mark.

In the same year, Potts and Shipman (1981) examined slice marks on faunal remains from early hominid sites at Olduvai Gorge, Tanzania with a SEM. Like Shipman's earlier publication, the SEM was used to identify how differences in hominin activities left different types of markings on animal bone. They identified that hominids at the site were using stone tools during the Lower Pleistocene in Africa by eliminating the possible markings that were created from other human activities causing butchery marks such as slicing, scraping, chopping, tooth marks/gnawing, and excavation (Potts and Shipman 1981: 579). The identification was made possible through SEM microscopy where micrographs were examined for characteristics of stone tools such as striations (Potts and Shipman 1981: 578). The authors provided a detailed criterion for distinguishing different slice marks made from different hominin activities, a result that was revolutionary in its time.

Although the variable information was recorded and differences in stone and metal morphologies were recognized, Sandra Olsen (1988) was the first to adopt the SEM to identify morphological differences between stone and metal tool slice marks left on animal bone. Olsen analysed 73 Early Bronze Age artefacts (mostly antler) from Britain to understand the production of tools and the effect that metallurgy had in the manufacturing stages. Although her findings corroborated those of Shipman (1981) in the recording of variable marks on animal bone, the use

of the SEM allowed her to identify differences between slice-mark tool types and to create a general criteria for identification. She concluded that the SEM allowed her to view the detail required for identification, stating that ‘the SEM provided a means of seeing the manufacturing traces at low magnifications with high resolution and great depth of field’ (Olsen 1988: 358). The work of Shipman (Shipman 1981), Potts and Shipman (Potts and Shipman 1981), and Olsen (Olsen 1988) demonstrates that the SEM can be an invaluable tool for the analysis of microscopic features on zooarchaeological remains.

The idea of identifying stone and metal slice marks with the assistance of SEM technology over a regional area was proposed by Haskel Greenfield (1999). Greenfield built testable hypotheses to distinguish metal from stone based upon the earlier research by Binford (1981) and Walker and Long (1977). Greenfield conducted experiments with metal and chipped stone knife blades on animal bone to identify their key diagnostic characteristics at the microscopic level. He suggested that initial observations can be made with a light optical microscope but need to be verified at a higher power in a SEM because the variables of the slice mark that identify them as metal or stone require high magnification to be viewed. It is clear that without the use of microscopy, identifying tool type in slice marks is mostly guesswork. This is particularly true when fine-grained chipped stone tools (e.g. those made from obsidian) are used. Only with SEM microscopy can the diagnostic criteria be systematically observed and reliably applied to identify the type of raw material and the nature of the production process. Greenfield’s (1999) results not only refined earlier research, but also demonstrated that this method of analysis can be applied to answer broad questions, such as the transition from stone to metal tools in butchering across sites and regions (e.g. Greenfield 2013), and between continents (e.g. Greenfield 2018). Thus, the development of metallurgy can be applied on a regional scale. Based on his results, we now understand that the transition from stone to metal tools for butchering only began to occur during the Middle Bronze Age in the Levant and central Balkans, and in the Late Bronze Age in central Poland (Greenfield 2018; Marciniak and Greenfield 2013). It is clear from his research that one cannot assume that the transition occurred broadly in the Early Bronze Age – each region must be separately investigated.

Since the work conducted by Greenfield (1999, 2013), a number of authors have arrived at similar results including Pollio (2009) who analysed slice marks on protohistoric bison remains from Fish Creek Park in Calgary, Alberta using SEM technology and found that stone and metal

were used at the site at different periods of time that corresponded with the shift from stone to metal tools on the Canadian Prairies, and Kooi and Fairgrieve (2013) who compared the results of SEM and stereomicroscope analyses of slice marks in fresh and burnt bone. The usefulness of the SEM to determine tool type was acknowledged by both authors. In fact, the authors of the later study stated, “the use of an SEM not only enhances the appearance of slice mark characteristics observed in the stereomicroscope, it also acts as an excellent tool for confirming the presence of the noted features” (Kooi and Fairgrieve 2013: 457). Again, the SEM proved to be a valuable instrument for viewing microscopic features that define tool type.

7.2.3 Micro-imaging digital technologies

Since the advent of the 21st century, various new microscopic approaches have been used as analytical techniques for understanding the various types of marks on animal bone that reflect butchery activities. Two digital technologies have appeared during this time: The Dino-Lite and the Confocal Microscope.

The development of nanotechnology allowed for the invention of optical digital microscopes that are easy to travel with, very cost effective, and efficient for collecting the equivalent of light optical microscopic images in a computer-generated image. The most popular technology to appear is the Dino-Lite (developed year 2000). It has become a very useful technology and is often applied to zooarchaeological questions such as slice mark morphology (Buccheri et al. 2016; Hanon, Péan, and Prat 2018). The Dino-Lite provides the ability to obtain images at up to 220x magnification anywhere in the field and this has made it an ideal microscope to travel with among archaeologists. The limitations of the Dino-Lite lie in its limited depth of field and inability to obtain very low magnification which consequently produce images that are essentially flat and lack the detail required for studies of slice mark morphology.

Buccheri et. al. (2016) has coupled the use of the Dino-Lite and SEM to analyse slice marks on cave bear and wolf faunal remains likely produced by a Neanderthal. The experimental work employed a variety of microscopes to examine the slice marks at different magnifications (macroscopic and microscopic). The authors identified small differences between slice-marks made by different stone types of raw material and suggested that two individuals may have used different types of stone tools in the butchering process (Buccheri, et. al. 2016: 48). While the Dino-Lite provided surface information, the SEM gave detailed micrographs that were used to differentiate between raw material type.

The Dino-Lite for macroscopic and the SEM for microscopic analyses of linear marks was used on an early Pleistocene hominid cranium from South Africa and mammal butchery marks to understand the origin of the marks on the hominid that was previously believed to be slice marks (Hanon, et. al. 2018: 51-52). The authors created morphological criteria to base their taphonomic identification of the marks that could be used during microscopic analysis (Hanon, et. al. 2018: 50-53). The Dino-Lite and SEM provided the team with a statistical data set that was used to confirm that the impact marks on the cranium were made from natural activity (trampling marks) and not human activity (slice marks) (Hanon et. al. 2018: 53).

7.2.4 *Confocal light-based microscopy*

One highly touted approach that is less expensive than SEM technology is confocal light-based microscopy. It is essentially an elaborate form of photogrammetry to capture high-resolution three-dimensional images of surfaces (Aramendi (Courtenay et al. 2019; Domínguez-Rodrigo et al. 2009; Mate-Gonzalez et al. 2017; Maté-González et al. 2018; Yravedra et al. 2017). Theoretically, it can distinguish nano-sized features on bone surfaces, known as Bone Surface Modifications (BSMs) such as butchery, carnivore tooth marks, or trampling marks on aquatic and terrestrial taxa (Archer and Braun 2013; Bello 2011; Bello, Parfitt, and Stringer 2009; Bello and Soligo 2008; Bello et al. 2016; Domínguez-Rodrigo and Yravedra 2009), modern deer (Pante et al. 2017), lamb (Otárola-Castillo et al. 2018), and modern cattle and deer (Gümrükçü and Pante 2018). The new technology yields detailed high-resolution images that can be manipulated digitally to examine the various characteristics on the bone caused by human activity. The microscopic approaches adopted into the suite of analytical techniques in the new millennium provide different (not necessarily better) and complementary ways to study microscopic features on bone surfaces from archaeological contexts.

7.3 *Methods of analysis*

In this thesis, zooarchaeological methods coupled with scientific imaging techniques are used to identify the raw material used to produce the various tool types adopted in animal butchery during the Old Kingdom of Egypt. The study of butchering slice (sometimes known as cut) mark morphology (microscopic groove analysis) has proven to be useful in the analysis of animal butchering activities (e.g. Rosen 1984; Binford 1981; Fisher 1995; Greenfield 1999, 2002, 2005, 2006, 2008, 2013).

7.3.1 *Materials*

Selection of the slice mark samples occurred on site at the Ancient Egypt Research Associates (AERA) laboratories at the Giza Plateau in Cairo, Egypt where the faunal remains from the Kromer Dump are curated. Windows in the lab provided daylight that was not sufficient for analysis so a small directional table lamp was used to provide directional lighting when needed. The entire assemblage were excavated from feature 35512 of KRO. The faunal remains were analysed during a two-week field study in February 2019 where the assemblage was triaged, analysed, and moulded. A high quantity of fauna was excavated from KRO and stored in eight Dasani water bottle boxes. Due to time constraints, 50% of the assemblage were randomly selected for analysis and slice mark sampling. Also, although the fauna contained extensive chop marks that are useful in identifying tool materials, they were not included in this limited case study. Each specimen (animal bone) was closely examined by eye and microscope (see below) for the presence of slice marks. Animal bones that had other taphonomic features that resembled slice marks (i.e. gnawing, trampling marks) were placed back into the assemblage for storage. Each selected specimen was numbered in sequence of taxa and element. An excel database was created for recording zooarchaeological identification (i.e. age, size of the element, taxa, sex, taphonomic variables) and specifics of slice marks (location on the bone, angle, slice counts). Digital images were also given numbers corresponding to the element photographed. Silicone moulds were bagged separately and given a number that corresponded to the element.

The fauna were very well preserved (Figs. 7.1 and 7.2). The dry and sandy composition of the soil at the Giza plateau are generally fantastic conditions for preservation. The elements contained no contamination from other soils or degradation from any natural taphonomic variables (acidic soil, heavy rain or moisture). The storage facility (lab) is also free from moisture and the ziplocked bags conserve the fauna in the boxes well. These variables have provided excellent conditions for the study of slice marks on the fauna because the characteristics of the slice remain preserved and free from debris that can cause degradation (i.e. damp soils, mould).



Figure 7.1. A.& C. KRO faunal assemblage. Notice the abundant butchery marks visible on the shafts. Photo courtesy of Richard Redding. B. Various elements from KRO with chopped distal and proximal ends and slice marks. Photo courtesy of Richard Redding. C. Humerus shaft, note the multiple slice marks



Figure 7.2. A. *Capra hircus*. Right Femur, caudal view, notice the chop mark to obtain the marrow. B. *Capra hircus*. Right Femur, medial view. Notice the slice mark mid-shaft. C. & D. Medium mammal rib. Posterior and anterior face. Notice the multiple slice marks.

7.3.2 Zooarchaeological identification

In the studied assemblage, medium mammal shaft fragments identify as ovis, capra, or ovis/capra according to their size, bone weight, and association with previous studies on the KRO fauna. Moreover, large mammal shaft fragments unidentifiable to element are present in the studied assemblage and are identified as cattle, again according to their size, bone weight, and association with previous studies on the KRO fauna that did not contain any other large mammal types (Redding 2020).

Specimens were fully identified and recorded including information on taxon, element, age, sex, orientation (such as right, left, distal, proximal), location of butchery mark, condition (burning, bleaching), and preliminary identification of slice marks. The identification and measurement of mammal remains followed the criteria set out in a variety of animal bone manuals including Sisson (Sisson 1914), Schmid (Schmid 1972), Boessneck (Boessneck, Mueller, and Teichert 1964), and Von den Driesch (von den Driesch 1976), as well as the modern comparative skeletal assemblage available in the AERA Giza laboratory. A measurement of the bone was taken according to anatomical position (i.e. vertically for limb

elements, horizontally for axial elements) to help confirm taxa and age. Age estimation are based on the criteria set out by Wilson (Wilson, Grigson, and Payne 1982), Silver (Silver 1969), and Schmid (Schmid 1972) and rely on the fusion of bone (i.e. distal and proximal epiphyses) to determine age-at-death for the specimens, particularly those without easily identifiable age characteristics. Age categories were done according to fusion. *Adults* are those that have fully identifiable elements that are fully fused, high porosity, and some muscle markings.

Adults/subadults are those that have been likely identified as adults but lack the diagnostic parts of the bone and therefore can be either adult or subadult (e.g. shaft with no ends). *Juveniles* are those that have begun to fuse and depending on the element, will not be fully fused and show low porosity and density in the bone (Wilson 1982; Silver 1969; Schmid 1972).

Cultural and natural taphonomic characteristics were also recorded as per Greenfield et al. (2016) to assist in the identification of impressions unrelated to animal butchery yet affecting the overall characteristics of the bone. *Cultural taphonomic* characteristics are major forms of bone modification that are caused from human activities such as cooking, which leaves a discolouration on the bone or polished appearance (Shipman, Foster, and Schoeninger 1984). *Natural taphonomic* characteristics are the conditions of preservation or weathering of the bone caused by the natural environment such as poor soil conditions. Weathering is recorded as none, light, medium, and heavy. The identification of cultural and natural characteristics allows for the differentiation between marks that are caused by butchery and those that are not.

The taxonomic quantification of data is done according to Butchered Number of Identified Specimens (**bNISP**) (Greenfield et al. 2016: 106) which is the number of individual bones that contain slice marks. The bNISP differs from the Number of Identified Specimens (NISP) which accounts for all of the individuals regardless of butchery (Grayson 1979, 1984; Greenfield 1986) that considers the total quantity of individuals. In the case of this study, only butchered elements were examined from the total faunal assemblage, therefore the use of bNISP is an accurate representation of the individuals studied. The Minimum Number of Individuals (MNI) is not used in this study (Bökönyi 1970) as it is not relevant to the current study of slice marks.

Butchering Incidences (**BI**) (Greenfield et al. 2016: 90) are the locations of the bone that contain slice marks. Some areas have “multiple slice clusters” which contain multiple slice marks in one area. Lyman (1994) stated,

If butchery marks are epiphenomena, that is, if they are in some sense an unintended, accidental, fortuitous, or incidental result of butchery activities, ... [and] If the frequencies of butchery-marked bones are not positively correlated with the frequencies of butchered bones then frequencies of butchery-marked bones, either absolute or proportional, are potentially ambiguous indicators of the quantitative aspects of human butchering behaviors (Lyman 1994a: 301-303).

A difference among butchered bones and those that contain butchery marks must be distinguished. The frequency of the BI on the bones provide information on the butchery practices and where the animal was most commonly sliced. McHenry and O'Brien (1986) in their study stated, "the frequency and location of cut marks are the result of differential access to skeletal elements" (McHenry and O'Brien 1986: 447). The use of bNISP and BI in the quantification of butchering activities on bone therefore, 'is useful to the understanding that the distribution of cut marks at different anatomical portions of the skeleton are certainly indicative of different butchery processes and differential access to carcasses' (Nilssen 2000: 263). It has proven to be useful in deepening our understanding of the relationship between slice cut marks and animal butchery practices in sustenance behaviours (Greenfield 1999, 2006, 2013, 2016).

7.4 Imaging analysis

Although butchering slice marks are often visible to the naked eye and with light optical microscopes, these are often not powerful enough for viewing the diagnostic identifiers required to distinguish between stone and metal tool-based slice marks (Fisher 1995: 34; Olsen 1988: 7-8). It is necessary therefore, to use traditional methods of zooarchaeological analysis for faunal identification and slice mark characteristics and scientific instruments such as the SEM to obtain the required magnification to view the characteristics for identification. The microscopic analysis undertaken for this method included several stages that included various instruments and procedures.

Initial sorting of material was undertaken on site in the AERA Laboratory on the Giza Plateau, Egypt. Given the expense of submitting all specimens to SEM level microscopy, the bulk of the assemblage was checked with the Nikon SMZ8000, a low power optical light microscope with a 1-8x zoom range and a total magnification range 5-480x (10-80X) and a working distance of 78mm, to make an initial selection of butchered material. Light optical non-digital microscopy was used to view preliminary details of slice marks to verify that they were not natural or cultural taphonomic and a subsample was selected for verification in high-powered

SEM microscopy. A lamp light was used with the Nikon microscope to view the specimens and provide appropriate directional lighting where shadows were required for better viewing of bone impressions. Initial impressions about the nature of the grooves were recorded (e.g. types of striations, shape of groove) and inferences about whether it made by metal or stone.

Next, low-powered digital microscopy was used. Each slice mark was digitally photographed at the AERA lab with a Dino-Lite AM4115ZT USB microscope camera with polarizer, a 10-220x magnification range, a working distance ranging from 4.1-50.2 mm, and a 1.3-megapixel camera that can produce a 1280x1024-pixel resolution photograph (Fig. 7.3). The digital microscope was secured on a stand that allowed the microscope to be placed at a height of 14.5 cm directly above the specimen. The slice was laid horizontally to enhance precision focus and depth of field in the image. The image was captured using the DinoCapture 2.0 software in Windows 10. Multiple angles of the slice were recorded including birds-eye view at two magnifications (high and low), and profile-view to determine the shape of the slice.



Figure 7.3. Dino-Lite AM4115ZT USB microscope camera with polarizer. Photo: Eleuterio Sousa

Due to limits on the depth of field capability of Dino-Lite, it was difficult and at times not possible to photograph the slice mark at the higher magnification or to capture an image of the groove's profile. The length of the bone and location of the slice marks often posed a complicating issue for proper focus. During these situations, any criteria that was visible was used to identify the slice mark. Nevertheless, each slice mark was examined under the DinoLite digital microscope and photographed to the best ability for a total of 1,217 photos. An attempt was made to obtain photos at 20x magnification to provide a general wide view, and 220x which provided a detailed above microscopic view where slice mark characteristics such as striations and apex could be viewed. Standardising the magnifications was not possible because of the various depths and sizes of each sample (animal bone) but in most samples a 20x and 220x

magnification was achieved and mostly arial photos were taken. When possible the profile of the slice mark was also photographed at 220x, but the working distance restricted this at times. These photos were later used during SEM analysis to compare images for identification of the slice marks.

As a result of the limitations posed by the Dino-Lite, the use of high-powered microscopes was required as expressed by authors as a requirement for good analysis that aids at viewing key identifiers of stone and metal tool slice marks (Fisher 1995). The need for high-powered microscopy is imperative to identifying key characteristics that differentiate tool-types because they cannot be seen with the naked eye (Fisher 1995: 5; Greenfield 2018: 24; Olsen 1988: 7). Slice marks with the highest potential of clear identification were prepared for SEM analysis and moulded on site using EXAFLEX hydrophilic vinyl polysiloxane impression material (silicone moulding material) (Fig. 7.4) (Fisher 1995: 51-52; Olsen 1988: 341; Shipman 1981: 362). Slice marks that had multiple slices in one groove or interference from another slice were not moulded because they cannot be correctly identified.



Figure 7.4. Exaflex moulding applied to faunal to obtain slice marks. Photo: Eleuterio Sousa.

The method of moulding slice marks was adopted for three reasons. Firstly, the size of the specimen is restricted to the dimensions of the instrument's stage and chamber. A solution to this issue is to mould the specimen and obtain an impression of the slice mark which is small enough to fit into the SEM. Second, moulding is very practical for specimens that cannot be exported due to restrictions from local antiquities authorities (particularly in Egypt) and provides a solution for out-of-country analysis. Lastly, the process of SEM is minorly destructive because it requires samples to be coated in gold or carbon in order to react to the electron beams and this process can damage ancient specimens for other types of analysis making moulding a better

option.

As described above, the electrons of the SEM require conductivity, which necessitate the moulds to be plated prior to analysis. The moulds were plated and examined further at the Near Eastern Biblical Archaeology Lab (NEBAL) at the University of Manitoba where a Denton Vacuum Desk II was used to gold plate the samples selected for SEM (Fig. 7.5).



Figure 7.5. Denton Vacuum Desk II. Photo: Eleuterio Sousa.

Each plated mould (Fig. 7.6) was then placed into the Cambridge Stereoscan 90 SEM for detailed microscopy (Fig. 6.7). The Stereoscan 90 SEM has a stage that is 4.45 cm with a chamber that is 30 cm deep, 16.5 cm height, 26.6 cm wide, and uses 30Kv of energy and requires a separate power source. Each sample varied in size and depth which restricted consistency across samples. However, most samples were examined and photographed between 200 μ and 500 μ , and magnifications between 30-170x (most done around 150-170 μ) with an aerial view, some at a 40-degree angle, and when possible, samples were sliced to obtain the profile. The various angles helped achieve images that provided details of the criteria required for identification (i.e. striations, angle, wall).

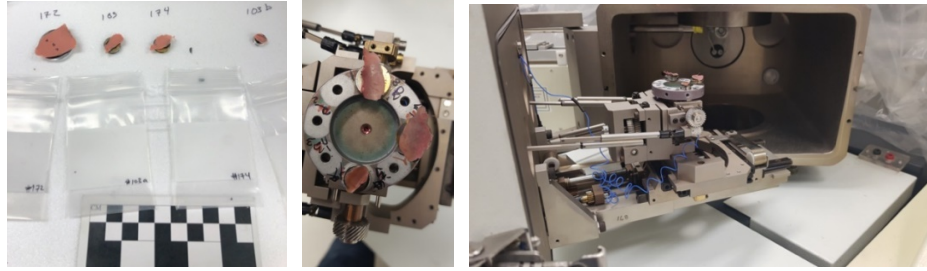


Figure 7.6. Mould samples. Left: prior to coating. Center: placed onto platform. Right: moulds entering chamber. Photo: Eleuterio Sousa



Figure 7.7. Cambridge Stereoscan 90 SEM. Photo: Eleuterio Sousa..

7.5 Image analysis - slice mark morphological study

A slice mark on animal bone can be identified as a butchering-related slicing activity made with a sharp tool and its criteria is long set out and tested by various analysts (e.g. Potts and Shipman 1981; Walker and Long 1977; Olsen 1988; Greenfield 1999). The criteria for identifying tool type on cut marks outlined by previous authors are applied to this study in order to identify tool type (Greenfield 1999; Olsen 1988; Potts and Shipman 1981; Walker and Long 1977). There are morphological differences between slice marks caused by stone or metal tools. The impression that is left on the bone is identified by differences in several characteristics - apex, wall, and striations (Fig. 7.8).

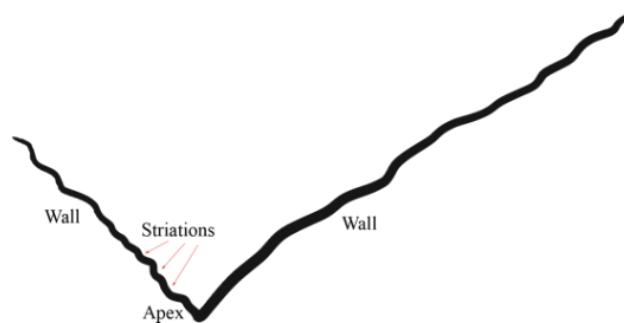


Fig. 7.8. Example of a slice mark profile with the walls, apex, and striations.

Metal based tool implements leave a clear, straight, deep, V-shaped or |_| shaped impression on the bone. Stone based tools are more complex and can have a variety of characteristics depending on the type of tool used to butcher the animal (Greenfield et al. 2016). The following characteristics were used to identify the tool type of slice marks. Generally, stone tools have shallow, rough, wavy, and irregular grooves. However, the variety of flint implements that can be used for animal butchery (Chapter 4) can leave different impressions on the bone (Table 7.1) (Greenfield 1999; Greenfield et al. 2016). The way that stone tools are produced (i.e. unifacial, bifacial, unretouched, and retouched) will result in different morphological characteristics as they cut into bones.

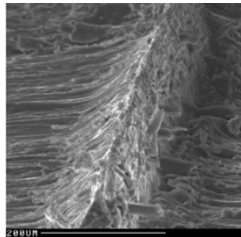
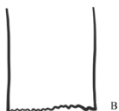
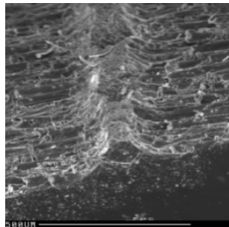
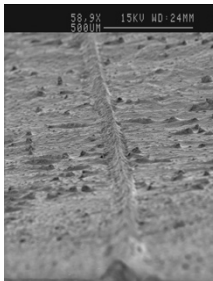
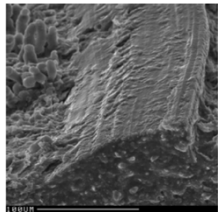
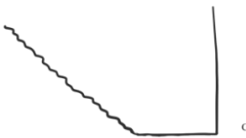
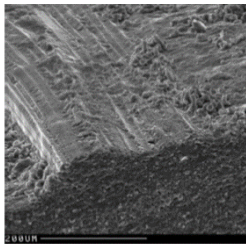
Identification of tools based on slice marks	Description	Profile drawing	SEM example
Metal-based slice marks	A. Presence of a deep, straight slice from overhead 90 degree (aerial view); B. Light or little evidence of bone crushing (clean slice); C. Profile is an even V or $\sqcap$ shape; and D. Absence of striations or steps on the slice walls		
Metal-based slice marks (dull)	A. Presence of a deep, straight slice from overhead 90 degree (aerial view); B. Light or little evidence of bone crushing (clean slice); C. Profile is an even V or $\sqcap$ shape; and D. Absence of striations or steps on the slice walls		
Bifacial retouched chipped stone tool	A. V identifies as a bifacial blade; B. Series of lateral striations on both sides (caused by uneven chipping of the tool edge when the tool is re-sharpened); and C. Increase in striations on both sides (retouched).		
Unifacial retouched chipped stone tools	A. Series of lateral striations on one or both sides (caused by uneven chipping of the tool edge when the tool is re-sharpened); and B. Increase in striations on one or both sides (retouched).		
Unifacial and unretouched chipped stone flakes or blade	A. Unbalanced V-shape with one slope angled and the other steeper, such as $\backslash \sqcap$ B. short straight incisions identifying a unifacial and unretouched chipped stone tool flake and/or blade. C. Lateral striations parallel to the apex of the angled slope ($\backslash$) which correspond to the dorsal face of the tool (smoother, steeper face ($\sqcap$) corresponds to the ventral face).		

Table 7.1. Greenfield (2013: 166) A. SEM micrograph of an inverse mold of an experimental slicing mark made by a flat sided sharp metal (steel) knife (Greenfield 2013: 166). B. SEM micrograph of an inverse mold of an experimental slicing mark made from a dulled metal (steel) knife (Greenfield 2013: 166). STONE SEM - Drawing of stone slice mark profiles. A. Bifacial retouched blade. B. Unifacial retouched blade. C. Unifacial retouched blade. A. SEM micrograph of an inverse mold of a bifacially retouched stone blade, sample number 144. B. SEM micrograph of an inverse mold of an experimental slicing mark made by unifacially unretouched chipped stone blade (obsidian). C. SEM micrograph of an inverse mold of an experimental slicing mark made by unifacially unretouched chipped stone blade, quartzite (A,B,C: Greenfield 2013: 167).

7.6 Verification

Specimens initially identified as metal at the AERA laboratory under light microscopy and the DinoLite were examined under the SEM and their identifiable characteristics in relation to tool type were recorded. The SEM data was scrutinised for the characteristics of tool type slice mark impressions in order to conclusively identify tool use (Fig. 7.9). The SEM diagnosis was done alongside the reference of the initial identification of stone or metal done prior to analysis on SEM. The characteristics visible in the SEM micrograph were paired with the criteria for stone or metal blade tool types and identified according to presence or absence of characteristics (i.e. striations, angle of the profile – V or \).



Figure 7.8. SEM micrograph of slice mark of sample 16. Photo: Eleuterio Sousa

7.7 Conclusions

As this chapter outlined, the identification of faunal remains and slice mark morphology through zooarchaeological methods coupled with scientific instruments such as the SEM are an effective method for examining morphological characteristics that identify slice marks produced by a stone or metal tool. This study aims to apply these methods to answer several questions that fill in the gap about the development of metallurgy in Egypt during the Old Kingdom. In order to answer such questions, the butchered animal remains from the Kromer Dump at Giza are examined to determine tool use in the animal butchery process during the Old Kingdom. However, the study also attempts to test the scientific instruments discussed (Dino-Lite and SEM) to determine their suitability for studies of slice mark morphology. This thesis builds upon previous authors who have adopted the DinoLite and SEM in slice mark analysis and tests each technology to determine the best option for slice mark identification. As a result, the two-folded approach explored in these methods goes beyond answering questions about metallurgy in the Old Kingdom and contributes to the zooarchaeological discipline, particularly to discussions surrounding the suitability of modern scientific instruments to the study of zooarchaeology.

Chapter 8: Zooarchaeological analysis and slice mark data

8.1 Introduction

This chapter presents the zooarchaeological data from the ‘Kromer Dump’ assemblage and butchered slice mark analysis conducted in the AERA laboratory at Giza, Egypt. It also discusses the results of the analysis of the slice mark data conducted with the SEM at the University of Manitoba’s Near Eastern and Biblical Archaeology Lab in Winnipeg, MB. Data related to the use of chipped stone and metal tools are presented in this chapter for animal butchery at the quarry settlement at Giza during the Old Kingdom.

8.2 Taphonomy

8.2.1 Natural taphonomic variables

The environmental conditions at Giza provide great preservation of the faunal material. This is reflected in the frequency of the bone weathering, which is very minimal (light) on the bone surfaces. Most of the assemblage is not weathered (bNISP = 72, 32%) or lightly weathered (bNISP = 99, 44%) (Table 8.1). Other natural variables such as gnawing, bleaching, and staining are absent.

Table 8.1. Demonstrating the quantity and percentages of levels of weathering for all taxa and bNISP.

Weathering	bNISP	%
None	71	31.70%
Light	99	44.20%
Medium	31	13.84%
Heavy	23	10.27%
TOTAL	224	100.00%

8.2.2 Cultural taphonomic variables

Cultural activities (such as cooking or tool use) can reduce the preservation in bone assemblages. Evidence of cooking processes (such as boiling, frying, roasting, steaming, smoking, etc.) is generally left on the bone through the form of polish, lighter colouration, boiling or burning (Koon, O'Connor, and Collins 2010; Munro, Longstaffe, and White 2007; Roberts et al. 2002; Shipman, Foster, and Schoeninger 1984; Subias 2002; von Endt and Ortner 1984). The entire assemblage has light polish and a lighter colouration. There is no evidence of burning on any of the specimens examined. The high quantity of bones that are reflective of cooking possibly resulted from boiling. The presence of slice marks and boiling is suggestive that the meat was filleted off the bone and then boiled, perhaps to use any leftover nutrients. The

process of meat stripping and then boiling of animal bone to obtain the marrow and nutritious fats is common in ancient cooking and previously discussed elsewhere (e.g. Speth 2000; Stokes 2000; Vehik 1977) .

8.3 Taxonomic distribution

In the current study, all the butchered remains consist of medium and large mammals. Slice cut marks on birds, fish, and other small mammals are excluded in the study because they are not easily visible, particularly by the eye on the cut marks. A total of 224 bNISP were examined (Table 8.2).

Domestic caprines are the mammalian taxon with the highest frequency (total bNISP= 73.66%). These are divided between *Capra hircus* (goat) bNISP=10 (4.46%), *Ovis aries* (sheep) bNISP=11 (4.91%) and Ovis/Capra (sheep/goat) (specimens that are identifiable only to a more general taxonomic unit) bNISP=144 (64.29%). The term caprine will be used when referring specifically to all Capra, Ovis and Ovis/Capra that are grouped as a single taxonomic unit. Ovis and Capra are distinguished when identifiable elements were present, such as the ends of long bones or innominate. Specific breed types are not identified in the study. The higher quantity of caprine over other taxa suggests that sheep and goat may be a primary part of the workmen's diet from the quarry settlement.

Domestic large bovine remains (cattle - *Bos taurus*) consist of a total bNISP=59 (26.34%). Although the quantity of cattle (bNISP=59) is lower than that of ovis/capra (bNISP=165), the amount of meat that cattle can contribute is far greater and can feed a higher number of individuals as a result (Redding 2020). Even though *Sus scrofa* (pig) accounted for in the initial overall assemblage study (Redding 2020), no remains were documented with butchering marks and as a result they are not included in this study.

Table 8.2. Quantity of taxa and bNISP. Only Caprines and Bovines were present in the study.

Taxa	bNISP	%
<i>Ovis aries</i>	11	4.91%
<i>Capra hircus</i>	10	4.46%
<i>Ovis/capra</i>	144	64.29%
<i>Bos taurus</i>	59	26.34%
Total Taxa	224	100.00%

8.4 Age (Table 8.3)

Many of the fragments in the study are absent of identifiable characteristics for age

determination (i.e. fusion lines, distal or proximal ends). In these cases, the size, porosity, and density of the bone (Wilson 1982; Silver 1969; Schmid 1972) are used to estimate the age-at-death for the specimens without easily identifiable age characteristics (Table 8.3).

Caprines: 97 adults are identified according to their fusion, muscle attachments, and size which makes up the largest age group at 58.79%. 50 adult/subadult are present at 30.30% that could not be identified specifically to either age group but reflected characteristics of subadult/adult. Juvenile is also present with a count of 11 and 6.67% (9 identified as young and 2 as old juveniles according to fusion). Subadults are least common at 4.24%.

Bovines: Bovines taurus are represented in lower frequencies than are sheep and goat. Adult is the largest age group with 47.46% with the adult/subadult (not identifiable to either age group, but likely adult) slightly under with 27 at 45.66%. Juvenile is the third most common age group (5.08%). A very low quantity of subadults are present in the bNISP study with a single bone (1.69%).

Table 8.3. Age distribution of Caprines and Bovines.

Age	Bovines	Bovines %	Caprines	Caprines %
Adult	28	47.46%	97	58.79%
Adult/subadult	27	45.66%	50	30.30%
Subadult	1	1.69%	7	4.24%
Juvenile	3	5.08%	11	6.67%
Total	59	100%	165	100%

8.5 Element distribution (Table 8.3)

There are several different elements represented in the assemblage (Table 8.3). Generally, there are few scapulae (Caprines=8, Bovines=6), innominate (Caprines =9, Bovines=1) and vertebral elements (Caprines =11, Bovines=6) respective to other elements in this study. Although the scapulae, innominates, and vertebrae are fewer than other elements, they may represent a higher accuracy of individuals. For instance, the quantity of vertebrae (bNISP=11, thoracic=bNISP=9, lumbar=bNISP=2) is equal to that of metatarsals (bNISP=11). Yet, while the former is higher in quantity, it is difficult to estimate the NISP which can lie somewhere between 2 to 11, but the latter (i.e. metatarsals) reflects a greater accuracy of individuals with 5-6 to 11 individuals (either one or a pair of metatarsals per individual) which can represent 5 to 6 individuals or 11.

Caprines: The most highly represented element for caprines are ribs (bNISP=44). The second

most represented element are radii (bNISP=23), followed by tibiae (bNISP=18), metapodium (bNISP=17), and humeri (bNISP=14). There are much smaller quantities of innominates (bNISP=9), scapulae (bNISP=8), femura (bNISP=3), ulnas (bNISP=4), and phalanges (bNISP=1). The higher quantity of meat-bearing elements, particularly from the anterior part of the body, may suggest that meat was an important part of the diet of the workers who resided near the quarries at Giza.

Bovines: Long bones are too highly fragmented for identification. However, long bone fragments and ribs are the most common element type (bNISP=19, respectively). Scapulae (bNISP=6), vertebrae (bNISP=6), mandibles (bNISP=4), and crania (bNISP=2) are found in smaller numbers. The limited quantity of bovine bones present in this study suggests that *Bos taurus* were not a primary food source for the individuals connected to the Kromer Dump, but were still part of the diet.

Table 8.4. Element Counts showing the distribution of elements for each species (table organised according to anatomical position).

Element:	Bovines	Bovines %	Caprines	Caprines %
Cranial	2	3.39%	0	0.00%
Mandible	4	6.78%	11	6.67%
Vertebrae	6	10.17%	11	6.67%
Ribs	19	32.20%	44	26.67%
Scapula	6	10.17%	8	4.85%
Humerus	0	0.00%	14	8.48%
Radius	0	0.00%	23	13.94%
Ulna	0	0.00%	4	2.42%
Innominate	1	1.69%	9	5.45%
Femur	0	0.00%	3	1.82%
Tibia	0	0.00%	18	10.91%
Fibula	0	0.00%	0	0.00%
Metacarpal	2	3.39%	6	3.64%
Metatarsal	0	0.00%	11	6.67%
Phalanx	0	0.00%	1	0.61%
Calcaneus	0	0.00%	1	0.61%
Long bone fragments	19	32.20%	1	0.61%
Total limbs (bNISP)	59	100.00%	165	100.00%

8.6 Butchering characteristics

The faunal assemblage is unique compared to other fauna throughout Giza (Chapter 9). A large percentage (total of 42.34%) of the long bones for the caprines had their distal and/or proximal ends dismembered. Long bones include humerus, femur, radius, tibia, ulna, fibula (total bNISP=62). A smaller number (n=50; 81%) of them are only shafts. Chop marks are not

included in this study of knife tool types and their effects on the butchering process.

The most common location of the slice marks is in three areas - the lateral and medial sides of the bone (i.e. long bone shaft, vertebra, and innominate) and mid-shaft of long bones. Butchering marks on the medial sides make up 33.95%, while those on the lateral sides make up 26.20%. Only 14.76% occur mid-shaft. The slice marks for the most part are identified as for filleting and /or the stripping of meat based on their location and frequency.

Table 8.5. Quantities of shafts with proximal or distal ends.

Element	Bovines	Bovines %	Caprines	Caprines %
Shaft only	0	0%	50	36.5%
Fragments	38	53.52%	0	0%
Long bone without distal or proximal end	0	0%	4	2.92%
Complete long bones	12	16.90%	79	57.66%
Unidentifiable shafts	9	12.68%	0	0%
Complete non-shaft elements	12	16.90%	0	0%
Total bNISP	71	100%	137	100%

8.7 Butchering Incidences (BI)

Butchering Incidences (BI) occurred on nearly every element present with the exception of Fibula. Two types of BI occurred – single slice marks and multiple slice marks (slice clusters that contain more than one slice mark in a particular area). The quantity of single slice marks (26% total) are substantially lower than multiple slice marks (76% total) in both caprine and bovine specimens (Table 8.6). In the current study, single and multiple slice marks on metapodia are located mostly on the medial (25%) and lateral (22.22%) faces, most of which are located on the mid-shaft of the bone (30.56%). In contrast, the relative frequency of slice marks on the proximal end was only 8.33% and on the distal even smaller at 2.78%. The slice mark data clearly reflect that multiple slice mark clusters are favourable to limb elements (with the exception of ribs), particularly on the medial and lateral sides. Humerus, radius, tibia, and long bone fragments had the highest quantity of slice clusters – all of which are meat bearing elements.

Table 8.6. Butchering Incidences (BI) for all the elements of caprines and bovines.

Element	Caprines		Bovines		Total	
	Single	Multiple	Single	Multiple	Single	Multiple
Humerus	3	11	0	0	3	11
Femur	2	1	0	0	2	1
Ribs	2	42	3	16	5	58
Radius	7	16	0	0	7	16
Tibia	2	16	0	0	2	16
Ulna	2	2	0	0	2	2
Fibula	0	0	0	0	0	0
Innominate	5	4	1	0	6	4
Metacarpal	1	5	1	1	2	6
Metatarsal	4	7	0	0	4	7
Scapula	2	6	3	3	5	9
Vertebrae	3	8	3	3	6	11
Phalanx	1	0	0	0	1	0
Calcaneus	1	0	0	0	1	0
Cranium	0	1	2	0	2	1
Long Bone Fr	0	0	4	15	4	15
Mandible	7	4	1	3	1	7
Total bNISP	42	123	18	41	59	164
Total taxa	165		59		223	
Total %	25%	75%	31%	69%	26%	74%

There are differences, however, between the size of taxa (Fig. 8.1 and 8.2). In Caprines, the largest ratio gap is in ribs with a 21:1 ratio, tibia 8:1 ratio, and humerus at 3.67:1 ratio (multiple to single ratio). While bovine elements also have a high rib ratio of 5.33:1 it is not nearly as high as that of caprines. Most bovine elements have a 1:1 ratio (metacarpals, scapulae, and vertebrae), while others remained low (below 1). The comparison of multiple to single slices on long bones have a slight difference among the taxa at 3.75:1 for bovines and 2.88:1 for caprines. Other elements that have multiple slices are on low meat bearing elements - ribs (21:1) and vertebrae (2.67:1) In essence, a higher ratio of multiple slice clusters is present in long bone elements among bovines. The difference in BI may be largely due to differences in the size of the animal and the amount of meat available for consumption. Redding (2020) explains that the yield of meat for bovines is much higher (3.5 times the meat) than caprines (Redding 2010: 83-84). Therefore, more effort would be required to slaughter the larger mammals than medium mammals. The humerus for instance is a large meat bearing element and contains the highest ratio between single and multiple slice marks. Another observation is the high frequency of BI on ribs and vertebrae which are low meat bearing elements. The multiple slice marks on these elements may suggest that the butchers were hastily slaughtering animals to feed the large population of workers and/or being resourceful with the meat.

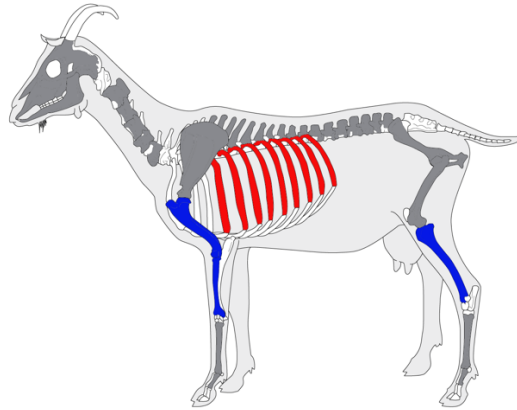


Figure 8.1. Caprine anatomic drawing demonstrating the frequency of multiple slice marks. White=0 multiple slice clusters, Blue=10-19 multiple slice clusters, Red=20-60 multiple slice clusters.

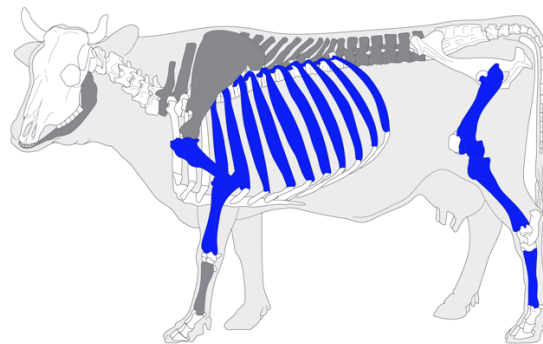


Figure 8.2. Bovine anatomic drawing demonstrating the frequency of multiple slice marks. White=0 multiple slice clusters, Blue=10-19 multiple slice clusters, Red=20-60 multiple slice clusters. Butchery tool technology

A total of 256 slice marks were studied on-site at the AERA in Egypt. Some of the animal bones contain multiple slice marks (bNISP=176) from butchering activities, while others have single slices (bNISP=80). The analysis of these slice marks varies under analogue and digital microscopy and under SEM. This variance expresses limitations in the types of technologies adopted in the analysis of morphological characteristics of slice marks.

8.8 *Slice cut mark analysis under analogue and digital microscopy*

Initial results from the field study based on the use of a hand-held lens suggested a total of 192 stone, 43 metal, 14 questionable metal, and 7 unidentifiable slice marks (Table 8.7). The supposed metal slice marks were identified as such since they seem to have appeared to present the characteristics typical of metal knife blade marks, such as a deep V-shape or broad U (U shape) profile and a clean slice with no lateral striations. Some of these supposed metal marks were checked under the light optical low power microscope and Dino-Lite digital microscope.

However, it was not possible to view the profile clearly in many of these due to the limitations of the instruments. Examples of supposed metal identification based on such analytical tools can be seen in sample 220. It displayed the typical characteristics of slice marks produced from metal-based tools (ex. V-shaped profile). In all cases, these represent a very small minority of Caprine (about 10%) and slightly larger Bovine specimens (30% - Table 8.6 and 8.7). These results are very suspect and display the limitations of the analytical instrumentation employed in the field lab. When the data are broken down by taxon, the following misleading patterns emerge:

Caprines: Initial field lab analysis utilizing light optical microscopy and the Dino-Lite from the bNISP=166 of caprine butchered specimens suggested a very high percentage of stone-based tool use 80.61% and small percentage (9.70%) of metal, 5.45% as possibly metal, and 4.24% as unidentifiable. These early results suggest that stone was the primary tool used for animal butchery of sheep and goat within the quarry settlement at Giza.

Bovines: Initial analysis of slice marks under light optical microscopy and Dino-Lite of the cattle fragments (bNISP=57) suggested a different pattern. A much smaller quantity of remains (64.84%) were identified as having been made by stone-tool marks. However, the metal and possibly metal marks, collectively, make up an astonishingly high quantity of 35.16%. At the conclusion of the field lab stage of analysis, it was believed that metal use for cattle butchery was common. In ancient Egypt, cattle were revered for the dead and seen as better-quality meat for the living (Ikram 1995). Therefore, the results begged the question, was there a relationship between rare (metal) tool-use and the butchery of cattle, and if so, was this connected to prestige or simply practical for slaughtering larger animals? SEM analysis was needed to answer such questions.

Table 8.7. Identification of tool type for caprines based on light optical microscopy and Dino-Lite. Note the high quantity of stone.

Identification	Caprine	Caprine %	Bovine	Bovine %
Stone	133	80.61%	59	64.84%
Metal	16	9.70%	27	29.67%
Metal?	9	5.45%	5	5.49%
Unclear	7	4.24%	0	0.00%
Total slice marks	165	100%	91	100%

8.9 *Slice cut mark analysis under Scanning Electron Microscope (SEM)*

When the data are viewed within a SEM, the results dramatically change. Upon returning to the University of Manitoba NEBAL facility, all of the moulds initially identified as suggesting

metal blades were examined in the SEM. Due to time restraints created by the Corona-19 virus pandemic and shut down of university facilities, only bNISP=13 moulds could be examined in the SEM and considered in this thesis. Most of these contained multiple slice marks which brought the BMF to a total of 23 slice marks examined (Table 8.8).

A total of 4 Caprines and 9 Bovines samples are examined in the SEM. Priority in examining the cattle was greater since a higher percentage initially identified as metal blades (29.67% of cattle versus 9.70% of caprines were examined). The SEM analysis accounts for 30.32% of the total that had been initially identified as metal. Appendix A contains detailed images of each sample.

Table 8.8. Slice marks examined in the SEM. Note the difference between the initial identification under Dino-Lite and the confirmed SEM identification. A higher quantity of bifacial knives is used on Bos taurus (cattle).

Sample #	Taxa	Element	Initial identification	SEM Identification	Stone Tool Production Type	bNISP	Type of butchering mark (slice, chopped, sawn)	Type of butchering instrument	Butcher location	Direction of butchering, tool modification, etc.
16a	Ovis/Capra	Femur	Metal?	Stone	Unifacial = /	1	Slice	Knife	Lateral side	Horizontal to long axis
16b	Ovis/Capra	Femur	Metal?	Stone	Unifacial = /		Slice	Knife	Medial side Mid-shaft	Caudal to Distal
144	Ovis/Capra	Vertebrae	Metal	Stone	Bifacial - \	1	Slice	Knife	Right side	Horizontal to long axis
145	Ovis/Capra	Vertebrae	Metal	Stone	Unifacial = /	1	Slice	Knife	Right side	Axial to Distal
148	Ovis/Capra	Vertebrae	Metal	Stone	Unifacial = /	1	Slice	Knife	Right side	Horizontal to long axis
172a	Bos taurus	Vertebrae	Metal	Stone	Bifacial = \ /	1	Slice	Knife	Left side	Horizontal to long axis
172b	Bos taurus	Vertebrae	Metal	Stone	Bifacial = \ /		Slice	Knife	Left side	Horizontal to long axis
172c	Bos taurus	Vertebrae	Metal	Stone	Unifacial = /		Slice	Knife	Left side	Horizontal to long axis
174	Bos taurus	Vertebrae	Metal	Stone	Unifacial = /	1	Slice	Knife	Right side	Horizontal to long axis
192	Bos taurus	Rib	Metal	Stone	Unidentifiable	1	Slice	Knife	Cranial border	Horizontal to long axis
193	Bos taurus	Rib	Metal	Stone	Unifacial = /	1	Slice	Knife	Medial	Horizontal to long axis
199	Bos taurus	Rib	Metal	Stone	Unifacial = /	1	Slice	Knife	Medial	Axial to Distal
204a	Bos taurus	Rib	Metal	Stone	Bifacial - \	1	Slice	Knife	Medial	Horizontal to long axis
204b	Bos taurus	Rib	Metal	Stone	Bifacial - \		Slice	Knife	Medial	Horizontal to long axis
204c	Bos taurus	Rib	Metal	Stone	Bifacial - \		Slice	Knife	Medial	Horizontal to long axis
205	Bos taurus	Long bone	Metal	Stone	Bifacial - \	1	Slice	Knife	Medial	Horizontal to long axis
208	Bos taurus	Long bone	Metal	Stone	Bifacial - \	1	Slice	Knife		Mid shaft
220a	Bos taurus	Long bone	Metal	Stone	Bifacial - \	1	Slice	Knife		Mid shaft
220b	Bos taurus	Long bone	Metal	Stone	Bifacial - \		Slice	Knife		Mid shaft
220c	Bos taurus	Long bone	Metal	Stone	Bifacial - \		Slice	Knife		Mid shaft
220d	Bos taurus	Long bone	Metal	Stone	Bifacial - \		Slice	Knife		Mid shaft
220e	Bos taurus	Long bone	Metal	Stone	Bifacial - \		Slice	Knife		Mid shaft

8.9.1 Caprines:

Sample 16 (Appendix A.1): Adult/subadult, femur, shaft, left side, fragment. The slice-mark is located on the lateral side. The morphology reflects a sharp, deep, / (asymmetrical) groove shape. On-site light optical microscopy and Dino-Lite analyses tentatively identified this specimen as made by “metal?” based on its depth and sharpness of the slice (Figs. A-D). However, under SEM examination, the appearance of characteristics of stone become visible, such as the asymmetry of the groove and lateral striations along one (left) side leading to the

apex (Fig. E). The morphology of the shape and lateral striations are identified as being made by an unifacially produced unretouched flakes/blades.

Sample 144 (Appendix A.2): Young subadult. Thoracic vertebrae, spinous process fragment. The slice-mark is located on the right side and the morphology reflects a sharp, deep, V shape. When examined on-site under microscope and Dino-Lite, the deep V shape was understood as a metal slice mark (Figs. A-D). However, analysis under SEM provide images (Figs. E-H) of an uneven V shape (most clearly seen in Fig. H) with uneven lateral striations on the left side (Figs. E-H). These characteristics identify this specimen as produced by a retouched bifacial blade.

Sample 145 (Appendix A.3): Young adult. Thoracic vertebrae, spinous process fragment. The slice is located on the right side and the morphology shows a sharp, deep, |_ shape. On-site microscopic and Dino-Lite study showed characteristics of a dull knife produced by metal with the shape |_(Figs. A-B). Under SEM analysis however, lateral striations are present on both sides of the slice and the walls are slightly angular (Figs. C-D). The shape and lateral striations therefore, identify this specimen as produced by a chipped stone tool blade.

Sample 148 (no image): Adult. Thoracic vertebrae, spinous process fragment. The slice-mark is on the right side and the morphology shows a shallow / shape. On-site analysis under microscope and Dino-Lite identified the sample as metal based on the depth and V shape appearance (Figs. A-D). Under SEM analysis, the apex is offset and lateral striations are present on one side. These confirm that the groove was produced by a unifacial retouched blade.

8.9.2 *Bos taurus:*

Sample 172 (Appendix A.4): Adult. Lumbar vertebra, body and spinous process fragment. Three slice marks are present that were deep, straight, and V-shaped. On-site microscope and Dino-Lite study identified the deep V shape as metal (Figs. A-D). Under SEM analysis, a clear _ / shape profile (Fig. D) and lateral striations are present on the left side of the slice. Some of the images show more of a / lop-sided groove shape with a clear steep slope on one side and angled slope on the other that is characteristic of a stone-tool based technology (e.g. Fig. L). The slice mark morphology, therefore, can be identified as produced by an unifacially produced and unretouched chipped stone blade.

Sample 174 (Appendix A.5): Adult. Thoracic vertebra, spinous process fragment. The slice mark morphology demonstrated a dull, shallow, slice which initially identified as metal on-site under microscope and Dino-Lite (Figs. A-B). Lateral striations on the right side and a / sloped

shape clearly appear under SEM (Figs. C-E), which identifies the specimen as being made by a unifacially produced retouched chipped stone blade.

Sample 192 (Appendix A.6): Subadult/adult. Left rib body fragment. There are multiple slices indicative of mass production. The slice marks appeared deep and slightly V-shaped under on-site microscope and Dino-Lite (Figs. A-B) and were identified as produced by a metal blade. However, SEM images show lateral striations present on both sides caused by multiple slices which is a pattern characteristic of chipped stone tool blades (Fig. C). Unfortunately, the distortion caused by multiple slices on the cranial border area makes it impossible to identify the stone tool production type.

Sample 193 (Appendix A.7): Subadult/adult. Right rib body fragment. Multiple single slices are located on the medial side. Morphology is deep, dull, and |_/ shaped. On-site microscope and Dino-Lite study showed deep slices with a V shape perhaps produced by a metal blade (Figs. A-D). However, SEM images show multiple lateral striations present on one side that is a pattern characteristic of chipped stone tool blades (Fig. E). The sample is identified as a unifacially produced retouched chipped stone blade.

Sample 199 (Appendix A.8): Subadult/adult. Right rib body fragment. The slice mark is located on the medial side. The slice appeared very sharp, deep, and V shaped under microscope and Dino-Lite were identified as metal (Figs. A-D). However, under SEM, the clear off-set |/ shape characteristic of stone is reflected and lateral striations are present on one side (Figs. E-F). These characteristics are of a unifacially produced, retouched and chipped stone blade.

Sample 204 (Appendix A.9): Subadult/adult. Left rib body fragment. Multiple slice marks are located on the medial side of the bone. On-site microscope and Dino-Lite analysis reflected deep, somewhat sharp V shape slice marks characteristic of metal blades (Fig. A). Under SEM examination, the specimen proved to have a V-shaped, but also had multiple lateral striations on both sides (Fig. B). This is identified as produced by a bifacially retouched chipped stone blade.

Sample 205 (Appendix A.10): Subadult/adult. Left rib body fragment. Multiple slices are located on the medial side of the bone. The slice mark morphology appeared to be sharp, deep, and V-shaped which is characteristic of metal blades under on-site microscope and Dino-Lite (Figs. A-B). However, SEM images reveal a more expansive “_/” groove shape with lateral striations on both sides. This is likely reflective of a dull bifacially produced and retouched chipped stone blade (Fig. C).

Sample 208 (no image): Subadult/adult. Long bone shaft fragment. Multiple slices are located mid shaft characteristic of filleting. On-site analysis under microscope and Dino-Lite revealed a V shape characteristic of metal blades. Under SEM, a slightly offset V shape with lateral striations on both sides is visible, characteristic of a bifacially produced and retouched chipped stone blade.

Sample 220 (Appendix A.11): Subadult/adult. Long bone shaft fragment. Multiple slices are located on the mid-shaft of the bone which is characteristic of filleting. The slight V shape and possible lateral striations on both sides seen under microscope and Dino-Lite on-site was believed to have been produced by a metal blade (Figs. A-C). However, SEM analysis reveals the presence of multiple unevenly spaced lateral striations on both sides (Fig. D). This suggests that the slice was produced by a bifacially produced and retouched chipped stone blade.

Each of the slice marks described above display two common traits. The first is the presence of lateral striations on one or both sides of the groove. These are caused by the uneven surface of a chipped stone knife/flake. An example of this is seen in sample 220 where multiple steps (representing the lateral striations) appear on the left side of the slice in the image (Appendix A). The second trait is the presence of slice marks which have one straight steep side and a second off-angle side which is characteristic of unifacially produced blades. An example of this trait is seen in samples 136, 205, 220.

Overall, the SEM analysis removes any of the analytical ambiguities as a result of lower power technologies and demonstrates that the presence of chipped stone tools is ubiquitous (at least in this sample). It demonstrates that certain technologies cannot consistently identify the type of tool that creates microscopic grooves - what was previously believed to be metal under Dino-Lite microscopy is in fact sharp stone-based slice marks.

8.10 Conclusions

This chapter presented the analysis of the butchered assemblage under study from Kromer Dump. A large sample (n=224 individual specimens) was identified as having butchering marks that qualified for this technological study. The absence of proximal and distal ends along with the presence of multiple slice marks is clearly reflective of animal butchering practices such as dismemberment (to be discussed further in Chapter 9). Although the initial field-lab study of the slice marks suggested the presence of (n=43) metal slice marks, examination in the higher-powered SEM instrumentation definitively demonstrates that butchering took place with a

chipped stone-based tool technology. The slice marks studied under SEM all reflect characteristics of chipped stone slice marks since they include lateral striations, uneven V-profile, and uneven slice walls. There is no evidence for the use of metal instruments for butchery during the occupation of Kromer Dump in the 4th Dynasty of the Old Kingdom.

Chapter 9: Discussion

9.1 Introduction

This chapter places the zooarchaeological and slice mark data from the Kromer Dump (KRO) into context. It compares the previously examined zooarchaeological data with the current study and provides further evidence from the fauna for the consumption of a local version of stewing meat (Kawara). The chapter also examines the butchering practices at Giza and draws upon data from the thesis to reconstruct the manner in which animals were butchered for food. In particular, the frequency and nature of slice marks present is utilised in this study to explore the issue of mass production of meat. The tool types reflected in the slice mark data are also reconstructed and whether they corroborate with our current knowledge of Old Kingdom Egypt butchering technologies is tested. The final point raised is the difference in quality and consistency of butchering tool type identification through the use of two different imaging technologies: microscopic imaging (Dino-Lite) and SEM.

9.2 Patterns and inferences from zooarchaeological analysis

9.2.1 Zooarchaeological data from the Kromer Dump

Zooarchaeological data from the Kromer Dump originally examined by Richard Redding and the team at the AERA provide useful information for understanding the nature of animal consumption at Giza during the Old Kingdom. First, it is noted that Ovis/Capra were the most consumed mammal by the pyramid workers who resided in the quarry settlement (Redding 2020: 51-54). Second, Redding (2020) has demonstrated that the pyramid workers who resided in this area of Giza processed and consumed meat in a way similar to modern-day Egyptian Kawara stew. The high emphasis on shafts with no ends and metapodia in the zooarchaeological data set of domestic livestock animals suggests that they were used in a similar stew to Kawara (Redding 2020).

The current study examined 248 bNISP from the original assemblage. Parallels can be drawn between the two datasets for caprines (Ovis/Capra) and bovines (cattle). The percentages of humerus and femur were the lowest in both studies, while the second most frequent elements were the radius and tibia. Similarities are expected because these data from the current study derive from the larger dataset. However, an interesting difference appears in the current study; the frequency of metapodia is only 17 bNISP=22.67, while in Redding's study (2020), they are higher in the counts of the total assemblage at 83 NISP=33.47% and are in fact the largest

represented shaft element. The reason for this difference is because only shafts with slice marks (and not those that just presented evidence for chops) are included in the current analysis.

Additional differences can also be identified between the two studies. The BMF (butchering mark frequency) in the current study among the tibiae is 18 bNISP=24%, and humeri is 14 bNISP=18.67% which places metapodia in the middle of the bNISP counts (bNISP=17=22.67%). Therefore, the BMF (butchering mark frequency) element distribution remains relatively even in the current study except for the radius which has the highest count of all (23 bNISP=30.67%) and femur which has the lowest count (4 bNISP=4%). Even though the overall assemblage contains a higher frequency of metapodia over other elements, the distribution of bNISP metapodia is almost equal to other elements. This stands in contrast to Redding's analysis where metapodia were the highest represented element in the overall assemblage. These data suggest, therefore, that radii contained the highest quantity of slice marks which means that they are likely the most butchered element in the assemblage. This discrepancy may suggest that particular practices were involved in the meat production that allowed for an even distribution of butchering marks (slice marks) on the faunal. In his approach of the distribution of cut marks at different anatomical portions of the skeleton of the animal, Binford used the frequencies of the slice marked elements to measure the amount of effort required in butchery (Binford, Bunn, and Kroll 1988: 132-134). Binford's study found that the highest butchered elements were the humerus and radius in large and small animals and the humerus and tibia on the small mammals but other elements had a close distribution of slice marks (Binford 1988: 32). In fact, the high frequency of slice marks on the femur from the Bugas-Holdin site in bison and sheep almost mirrored the results of this study (Binford 1988: Table 4). Another more recent study also came to similar results with the radii and humerus having the highest counts in one area but an overall even distribution of frequencies (Nilssen 2000: 273). In short, the element distribution for slice marked bone presented here is similar to other studies and likely suggests a uniform way of butchering.

9.2.2 *No ends for Kawara*

One of these unique cooking practices is revealed through the study of butchered remains from KRO. The seemingly high quantity of shafts for Caprine (bNISP=57), the absence of Bovine shafts (bNISP=0), and the high percentage of absent proximal and distal ends (epiphyses)

from the shafts, suggests that a unique animal butchery practice was present at the quarry settlement at Giza. Previous zooarchaeological analysis of the KRO fauna observed that the proximal and distal ends of the shafts were chopped off and likely placed into a highly nutritious dish, similar to one served in modern day Egypt, called *Kawara* (Redding and Ahmed 2020). Redding describes the *Kawara* stew as a protein rich, high calorie dense dish that is prepared using the shank and feet of cattle, sheep, and goats (Redding and Ahmed 2020: 9). His recent study delves into the importance of considering the nutritional contribution of different bones (e.g. metapodia) and parts of the bone (tissue, cartilage, marrow) and explains that the distal ends of most long bones are very high in nutrients and calories. He reconstructs that the animals used in the quarry settlement (KRO) were prepared in a *Kawara*-like stew to feed the various individuals who were engaged in heavy labour at Giza. Such a diet would help the labourers maintain healthy muscle and cartilage and provide them with sufficient calories to satisfy the labour-intensive activities that was undertaken (Redding 2020: 44). The zygopodia and autopodia of the butchered animal skeletons (podials and phalanges) carry the highest per capital content of oleic acid in the marrow and bone which is an important nutrient for bone and muscle repair (Redding 2020: 44). The extraction of bone grease and marrow from these bones “reflects a significant form of resource intensification” (Blasco et al. 2019: 1; also see Church and Lyman 2003). Consequently, the marrow and bone grease extracted from the distal ends of the skeleton would have been an inexpensive way to feed the large number of workers residing at the quarry settlement at Giza with a highly nutritional diet (Morin 2007; Redding 2020: 53).

In his study of *Kawara* preparation in Egyptian culture today, Redding (2020) found that the limb element units most commonly used were “the ends of limb bones, usually the feet, after the removal of any large muscles, leaving all the marrow, cartilage and connective tissue” (Redding and Ahmed 2020: 9). These include the distal ends of the radius and ulna, the carpals, proximal and distal metacarpal, the distal tibia, tarsals, proximal and distal metatarsal, and phalanges. He claims that “it would be an efficacious use of the most desirable marrow in the distal limb elements” (Redding 2020: 44). Although carpals and tarsals were not present in the current study of bNISP, the high frequency of metapodia, tibiae, and radii (average of 30% BMF) without ends corroborates with the *Kawara* stew theory proposed by Redding. Just as he found, the current study demonstrates a preponderance of long bone shafts without ends (radius, tibia, and

metapodia), all of which are used in Kawara stews. Perhaps future archaeological studies of other areas at Giza will discover where the ends were disposed, but for now, the consumption of a dish such as Kawara at Giza helps explain the features seen in the zooarchaeological data (Redding 2020: 53).

9.3 Butchering activities through the study of slice marks

The location of slice marks on the KRO animal bone assemblage makes it possible to deduce some information about animal butchering activities at the quarry settlement at Giza. Slice marks are concentrated on the all faces of the bone. The comparison of the location of the slice marks (below) suggests that animals were butchered on their backs and that mass production of meat occurred at the quarry settlement of Giza during the construction of the pyramids.

9.3.1 The butchery of animals on their back

The slice marks on the shaft of the major meat-bearing long bones (humerus, femur, radius, ulna, and tibia) are mostly present on the medial (30.68%) and lateral (26.14%) faces of the element for a total of 56.82% of the slice marks. Less commonly found locations are those located on the caudal (12.5%) and cranial (11.36%) faces for a total of 23.86%. The remaining 19.32% slice marks are divided almost evenly on the proximal (10.23%) and distal (9.09%) ends of the long bones. The high frequency of slice marks on the medial face of shafts may suggest that once the limb was disarticulated from the animal, it was placed onto a surface to be skinned and stripped of meat (medial and lateral). The difference between the high concentration of slice marks on the medial and lateral faces in comparison to the lower frequencies on the cranial and caudal faces are consistent with such butchery activities, slicing of limbs (filleting) on a flat surface (Binford 1981: 114; Domínguez-Rodrigo 1997; Lyman 1994a; Lyman 1994b). The butchery of animals on their back is attested by Nilssen (2000) who suggests that once the animal has been gutted and skinned, the limbs are dismembered and then filleted – all on a flat surface (Nilssen 2000). The authors results were comparable to those of this thesis where the slice marks on shafts were located on the medial and lateral faces and mostly mid-shaft (Nilssen 2000: also see 529-649). Further to the point of animals butchered while lying on its back was noted by zooarchaeology pioneer, Lewis Binford who states:

Marks Inflicted during primary butchering are generally concentrated just anterior or posterior of the acetabulum socket on the ventral face of the pelvis. These marks are produced during the removal of the rear leg from the axial skeleton. The animal is commonly resting on its back or slightly turned to one side (Binford 1981: 114).

More recent experimental work on animal butchery have adopted and tested butchery methods to answer questions about butchery marks and taphonomy and also butchered animals on their backs (Lloveras, Moreno García, and Nadal 2009; Nilssen 2000). The study of Lloveras (2009) for instance, had similar frequency of butchery marks located on the vertebrae, innominate, ribs, febur, and tibia (Lloveras 2009: 185-186, fig. 4).

Ancient sources of information on animal butchery corroborate with the results seen in this study. A great deal is known about butchering practices from two-dimensional scenes dating to the Old Kingdom and three-dimensional models of the Middle Kingdom (see Chapter 3). In these types of scenes, the legs of oxen or cattle are tied at the joints while the animal is laying on their back during the disarticulation of the limbs (Ikram 1995). Slice marks examined in this study reflect similar characteristics. The slice marks on scapula (caprines: 8=bNISP, bovines: 6=bNISP) are located along the caudal side of the bone (the position of the bone near or toward the tail) near the articulating parts of the element and are sliced in various directions including axial to distal (position at the top of the bone toward the vertebrae to the position of the bottom of the bone, toward the toes), caudal to cranial (the position of the bone toward tail to the position of the bone toward the head), cranial to caudal (the position of the bone toward the head to the position of the bone toward the tail), and some caudal to distal (the position of the bone toward the tail to the position of the bottom of the bone, toward the toes). Slice marks such as those found on the scapulae suggest the butcher was slicing away from the torso vertically either toward the feet, rear, or horizontally perpendicular to the axis of the animal (Nilssen 2000). Similar directions of slices are found on the medial side near the articulating part of the innominate (the auricular surface). If the animal was suspended, slice marks are more likely to occur on the cranial face of the bone more so than the caudal region simply because the use of gravity is adopted to assist in slicing the animal. The study by Nilssen (2000) on animal butchery in South Africa dating to the Upper Pleistocene and Plio-Pleistocene noted that larger mammals such as Bovines contained more slice marks that resulted from the effort required to butcher larger animals (Nilssen 2000; also see Binford 1988). Therefore, the slice marks visible on the

limbs of the elements studied are congruent with disarticulating the animal while on its back.

9.3.2 *Animal production at the Quarry Settlement*

There are indications in the data that suggest the presence of mass production at the site. There is a very high frequency of multiple slicing marks at the same location on the bone (aka slice clusters) (Table 8.6). The vast majority (n=176; 68.75%) of the total number of slice marks are found in slice clusters, while only 80 (31.25%) were identified as single or isolated slices. Single slice marks appear much less than multiple slices (slice clusters). Only 26% of the slice marks are single occurrences while 74% are multiple slices. BI occurrences among the taxa are similar (caprines - 25% single, 75% multiple, bovines – 31% single, 69% multiple) with multiple slice marks occurrences at a high percentage. This pattern suggests two alternative explanations about the nature of animal production at the Quarry Settlement. Firstly, the very high frequency and extent of anatomical coverage of butchery marks may be interpreted that butchers were hastily butchering large numbers of animals and attempting to remove as much meat off the bone as quickly as possible. Secondly, the extensive butchery marks may be interpreted as having been made by unskilled individuals who were perhaps butchering animals only for their local household. It is difficult to choose between these alternatives since both can be used to explain the patterns in the data. More data are necessary to solve this question.

A recent study done on Middle Pleistocene animal bone from the Qesem Cave, Israel (Blasco et al. 2019) demonstrated similar looking slice marks that were likely produced from skinning the metapodia and then breaking the bone in order to obtain marrow inside, while another study further corroborates that such slice marks located on the mid-shaft are evident of meat stripping or filleting (Binford 1981: 96). The slice marks in these studies are strikingly similar to the slice mark activity observed with the KRO fauna from the quarry settlement and reflect a desire to obtain as much meat off the bone as possible (“resource intensification”) as fast as possible. The bones were then boiled to make a stew reminiscent of *Kawara* that also extracts the remaining marrow. The experimental work of Blasco et al. 2019 demonstrates this clearly and found that a high quantity of nutrients is obtained in the process.

Although the fauna is evident of resource intensification, it is difficult to say whether it is a result of mass production or local consumption. In the current study, single and multiple slice marks on metapodia are located mostly on the medial (25%) and lateral (22.22%) faces, most of

which are located on the mid-shaft of the bone (30.56%). In contrast, the relative frequency of slice marks on the proximal end was only 8.33% and on the distal even smaller at 2.78%. The slice mark data clearly reflect that multiple slice mark clusters are favourable to the medial and lateral faces of the bone. A butchery study on South African faunal dating to the Plio-Pleistocene also found most slice marks on meat bearing limb elements with most of the slice marks from larger animals appearing on the mid-shaft (Dominguez-Rodrigo 1997: 681-682).

These data suggests that a uniform manner exists in animal butchery across cultures and that the pattern seen in the KRO fauna are not unique. It is likely that the slice marks evident on the KRO fauna are a result of universal methods of mammal butchery created by the structure of the skeleton and enclosing flesh, that is, the disarticulation of limbs, (the slicing along where ligaments and muscle attachments are most frequent), dismemberment of limbs (chopping through the bones), skinning of the carcass, and filleting of the flesh (Binford 1981). The extensive slicing on the areas of the bone that contain the most meat and limited slicing near the ends of the bone, which would likely have been chopped for the stew, is a common practice seen in other studies, such as that of Dominguez-Rodrigo et al. (1997). Moreover, the desire to obtain high nutritional content through a stew as discussed by Blasco et al. 2019 and also suggested by Redding and Ahmed (2020), who mentioned that although metapodia are low meat bearing elements, their high nutrient content (within the marrow) likely made them desirable in a stew (Redding and Ahmed 2020). Similar butchery patterns have been found elsewhere and have been suggested to be resulted from soup consumption to obtain the highly nutritious fats of the bone (Stokes 2000: 67-68; Vehik 1977). Other studies on marrow fracturing from animal bones also had similar bone breakage as in this study (Noe-Nygaard 1977). The high quantity of slice marks on the mid-shaft may suggest they were stripped of meat and then placed into the stew. Yet, the uniformity of the butchered bone assemblage in the KRO fauna therefore suggests that there was large-scale preparation for stews. This would support an argument that butchery was conducted on a mass level by a central facility that provided sustenance for the pyramid workers and their families.

There are several separate lines of evidence that suggest the presence of mass production at KRO. Firstly, the multiple slice marks likely further suggest that mass production of meat occurred at Giza. On its own, the high frequency of slicing marks in clusters does not in and of itself demonstrate mass production. But, the slice marks on large and medium mammals were

similar in frequency which suggests standardisation of butchery which in itself is indicative of a centralised butchery shop at Giza. Regardless of taxa, the percentages are almost equal (single to multiple slice marks) and the elements that contain the highest BI are the ribs and long bones for both taxa. Second, the large numbers of workers who worked at Giza and had to be fed daily. According to Redding, an estimate of 6000-8000 workers for the Barracks area at Giza is realistic. Third, corrals for the storing of livestock have been found at Giza (Lehner and Hawass 2017). Fourth, faunal studies from the Heit el-Ghurab suggest that large numbers of cattle, sheep, and goat were being delivered for rations from outside of the site (Redding 2010, 2014; for yield and annual quantities of cattle slaughter for the Old Kingdom see Redding 2020 cattle: 32-33). These separate lines of evidence in combination reinforce each other. Therefore, it is unlikely whether the slice marks studied from KRO reflect mass production of animals or butchery at the household level.

While it is possible and currently believed that individuals (or individual households) received a daily ration of livestock (sheep, or goat, or cattle) to be slaughtered for their days pay (Richard Redding, Pers. Comm.), the uniformity of the butchering practices suggests otherwise.

9.4 Tool types reflected in slice marks

Two interesting conclusions can be drawn from the current study of slice marks. First, the absence of metal-based slice marks on the faunal remains suggests an exclusive use of a stone-based tool technology in animal butchery by the pyramid workers at the quarry settlement at Giza during the Old Kingdom. Second, a variety of stone-based tool types were adopted in animal butchery. These two observations shed light onto the tool types and their raw material adopted in the animal butchering process during the Old Kingdom.

9.4.1 Identifying stone-based slice marks

The samples studied under SEM demonstrate clear characteristics of chipped stone tool-based slice marks. These include the presence of lateral striations (either on one or both sides), uneven apex, and asymmetrical profiles characteristic of unifacially or bifacially produced chipped stone blades (Shipman 1981: 365; Greenfield et al. 2016, 2006). Lateral striations are present on one or both sides of the slice marks in all the samples examined under SEM. Examples can be seen in each of the SEM photographs of samples (e.g. Appendix A 103, 130, 134, 136, 204, 205, 220). The uneven nature of the apex (profile) is characteristic of stone-based butchery (Greenfield et al. 2016: 89), while characteristics of slice marks produced by metal knives (deep straight apex,

see Greenfield 1999) remain absent. The slices demonstrate clear irregular apexes and lines typical of stone knives (e.g. Appendix A 103, 130, 134, 136, 204, and 205).

9.4.2 *Stone-based butchering typologies*

The shape of the apex (uneven $\vee$, or a $\searrow$) in the studied samples reflect a variety of stone blade types (see Chapter 6: Methods; Greenfield 1999, 2006; Greenfield et al. 2016). Unifacially produced truncated blades are worked on the dorsal side while the ventral side remains untouched. This results in a $\searrow$ impression on the stone tool which is impressed on the bone upon slicing. Samples 103 and 204 are examples that have a $\searrow$ shape resembling a unifacially produced retouched chipped stone blade. Retouched bifacial blades are worked on both sides and leave lateral striations on both sides of the slice mark and produce an uneven $\vee$ shape (see Chapter 6; Greenfield et al 2016: 89). Samples 205 and 134 are reflective of what has been produced by a bifacially retouched chipped stone blade. In the samples studied in the SEM, the total number of specimens with butchering marks indicative of unifacially produced retouched chipped stone blades is 7 (33.33%), while 14 (66.67%) are bifacially produced retouched chipped stone blades. The quantity of blade types in caprines is almost equal with 3 unifacially produced unretouched stone blades and 2 bifacially produced chipped stone blades. However, bovines have a higher frequency of bifacial blades in use with a total of 14 (73.68%) and unifacial knives representing only 5 (26.32%). These counts result in the following two conclusions. First, blade type is affected by the size of the animals – unifacial for caprines (60%) and bifacial for bovines (74%). Second, bifacially produced retouched stone blades seem to be exclusively used for cattle butchery.

Although the tool blade type depicted in the two-dimensional animal butchery scenes has been suggested to be flint (Ikram 1995), there has been nothing conclusive from the zooarchaeological record that can corroborate with the ancient evidence until now. These Old Kingdom scenes show the slaughter of cattle with what is likely a bifacially produced chipped stone knife (Chapter 3; e.g. Fig. 3.2 - Tomb of Nianchenesut, Saqqara. Old Kingdom, AS5967, Tomb 67, PM III.II: 696). The presence of flint knives with animal residue in tombs further confirms that such bifacial knives (particularly the fishtail type) were used for animal slaughter prior to its placement in the tomb at least during the Predynastic period (Christensen and Walter 1991; Christensen, Walter, and Menu 1992). However, the evidence from this microscopic study of slice marks corroborates with the ancient evidence and overwhelmingly demonstrates that

butchering was also conducted with chipped stone tool blades in non-religious contexts, at least at the quarry settlement at Giza but perhaps regionally throughout Egypt during the Old Kingdom.

In addition, the choice of blade type is affected by the size of the animal. This may be largely due to differences in the size of the animal and the amount of meat available for consumption. Redding (2020) for instance, explains that the yield of meat for bovines is much higher (3.5 times the meat) than caprines (Redding 2010: 83-84). It likely took more physical effort to fillet or “chop up” a cow than a sheep or goat therefore requiring different tool types. The BI data further confirms this. The frequency of single and multiple slice marks are nearly equal regardless of the size of the animal (medium vs. large) (Table 8.6). Although different tool types were used to butcher the animals (unifacial blade vs bifacial blade) the results in BI are almost the same. These data suggests that the difference in tool type “resolved” the issue of animal size. If smaller blades such as a smaller unifacial razor blade was used on a large Bovine, a higher quantity of multiple slices would be expected because of the higher quantity of slices it would take to butcher the larger animal.

This study demonstrates that bifacially produced retouched chipped stone blades were the tool of choice for butchering bovines while unifacially produced unretouched and retouched stone blades were adopted for butchering caprines. However, as Greenfield states, “it is impossible to determine if the flakes used in butchering were the by-products of tool production, or if they were struck from a core with the intent of using them (unmodified) for butchering” (Greenfield 2006: 160). Therefore, it cannot be said for certain that these unifacial or bifacial tools were necessarily knives, such as the ones depicted in the Old Kingdom butchery scenes, but rather blades in a variety of forms including unifacially produced retouched chipped stone blades (i.e. razor blades) and bifacially produced retouched chipped stone blades (e.g. fishtail knives) which also may have been used in a variety of tasks which butchery was also a part of.

9.5 Errors in initial identification and benefits of SEM

The initial conclusions concerning the type of tool used in the butchering process that was made during the initial on-site study of slice marks with a Dino-Lite yielded ambiguous results at best. The Dino-Lite images did not cope well with the depth of field necessary for definition of tool type. As a result, any conclusions made with the Dino-Lite are only a best guess based on

the characteristics that were visible. Initially, several marks were identified as metal tool marks under Dino-Lite. However, when these were re-examined within the SEM, each proved to be produced by various types of chipped stone tool blades. The initial identification of such samples demonstrates an important consideration. Initial identification under low magnification without consideration of depth of field cannot be considered accurate. The use of a more powerful microscope with a high depth of field range is required to view the characteristics in the slice mark from multiple angles to yield accurate determinations. It is unclear if instruments with z-stacking capacity (also known as extended depth of field, EDOF) would achieve similar results because they were not used in this study due to time constraints, but accurate results are unlikely because many of the essential diagnostic characteristic differences between stone and metal tool marks are simply not viewable under low magnification and particularly under the limited range of depth of field, lighting, and filters currently available on the lightweight and portable instruments often used on site (such as the Dino-Lite which cannot produce the definition required for identification).

A major difference between the Dino-Lite and the SEM requires attention. The slice mark analysis on the Dino-Lite consisted of analysing the slice mark on the actual specimen (animal bone), while an inverse silicone mould impression of the slice mark was studied in the SEM. The limitation of using the actual animal bone to study the slice mark is that the characteristics necessary for identification are not completely visible with the Dino-Lite – such as the striations, or angle of the profile, when trying to view into a groove. However, when the slice mark is inverted with a silicone mould, all of the characteristics become visible and are clear to the viewer for study. In essence, the combination of better technology (SEM) and the adoption of the inverse slice mark impression moulds allow for accurate results of identification of tool type.

The results show a major disparity in capabilities between the use of the Dino-Lite AM4115ZT USB microscope camera with polarizer and the SEM. Although similar models of the Dino-Lite has been suggested as a useful technology for analysis of butchering mark morphology (e.g. Buccheri 2016; Hanon et. al. 2018), it has a limited capacity to identify characteristics of stone or metal blades on slice marks. The main issue lies in the ability to view the characteristics of the slice mark clearly for tool type identification. Image quality and angles are often barriers in obtaining the required information. The Dino-Lite still requires pairing with SEM methods to confirm any identifications (for examples of such studies that used similar

Dino-Lite models with limited capacities see Buccheri 2016; Hanon et al. 2018). The study conducted by Hanon et al 2018 concluded that the linear marks present on the maxillary zygomatic process of the hominin fossil was not produced by stone tools as previously believed but were in fact produced by natural taphonomic causes, trampling marks. The study did not examine the cutmarks in detail for characteristics of stone but rather was able to identify trampling marks clearly with the use of the Dino-Lite and SEM. The study conducted by Buccheri (2016) used the Dino-Lite in experimental work to determine the morphological differences in stone tool types but still used the SEM for the analysis of the ancient specimens. In both studies, the Dino-Lite was used in addition to the SEM where morphological characteristics could be viewed.

The use of moulding coupled with the SEM provides a higher detailed image that can be used for identifying characteristics of metal or stone based tool use. This current study further affirms that the Dino-Lite is ideal for providing a better image than the naked eye and can capture the image through digital macrography, but lacks the sophistication and magnification of the SEM for micrographic analysis of butchering technology.

Chapter 10: Conclusion

The faunal remains examined in this study are the very animal bones that were chopped, sliced, boiled, and prepared for consumption by the workmen who resided in the quarry settlement at Giza perhaps during the reign of King Khufu and Khafre in the 4th Dynasty. The workforce was large, and food cooking methods were designed to provide the requisite nutrients required by the workforce to maintain production (Redding 2020). The study of these animal remains sheds light on the animal butchery practices at the quarry settlement, animal consumption, and how tool types are reflective of the complexity that existed in Old Kingdom society.

Several conclusions are drawn from the data in this slice mark study. The location and frequency of slice marks suggest that animal processing at Giza was conducted on a mass scale (rather than by localised households) since they followed similar butchery methods to what is seen in two-and-three dimensional models of slaughterhouses recovered from the Old and Middle Kingdom tombs. There is not enough variability to support the hypothesis that individual households conducted their own butchery. The location of slice marks suggests that animals were placed on their backs, limbs removed, and had the limbs placed onto a table for skinning or fileting. The lack of difference among taxa and butchering incidences demonstrates that regardless of tool use, the frequency of multiple slice marks was the same for caprines and bovines.

The high frequency of multiple slice marks can be best explained as a result of using chipped stone tools rather than reflecting unskilled individuals butchering animals (Haskel Greenfield, pers. comm.). It can also reflect a sense of hastiness that demonstrates food production occurred on a mass scale. The high number of about 30 cattle or 80 sheep/goat that was required to fulfil the nutritional needs of the high number of workmen daily (Redding 2020) is indicative of mass production under these conditions. Two potential scenarios emerge – an individual receives his daily ration of animals to be slaughtered freshly in the home, or secondly, that the animals were mass slaughtered quickly to provide a large workforce with sufficient nutrients for the day. Based on the current evidence (mass butchery, large dining areas in the HeG, large number of animals slaughtered daily), the likelihood of mass production is the more appropriate explanation

for the data since it encapsulates the wealth of faunal, historical, and archaeological data from the site. One can imagine that workers/households would have received their rations of meat from a local butcher shop that was supplied from a slaughterhouse with a production similar to a modern-day production line, where butchers of varying levels were quickly butchering animals to feed the hungry and tired workers of the state.

The zooarchaeological data presented in this thesis corroborates with previous zooarchaeological analyses from Giza (Redding 2018; 2020). The anomaly of the KRO assemblage to contain nearly no distal or proximal ends suggests that most of the meat was prepared in a highly nutritious stew similar to modern day Kawara where the ends of shafts and metapodia were preferentially used for their high nutritional value (Redding and Ahmed 2020). The presence of shafts with no distal or proximal ends are attributes of ancient cooking at Giza and the taphonomic characteristics of boiling further confirm this.

The butchers required tools to slaughter, dismember, skin, and filet the animals. The types of tools reflected in slice marks from the fauna at Giza indicates that stone chipped blades were strictly used for animal butchery. Although the types of stone blades vary, bifacial blades (likely knives) are most frequent for cattle butchery while unifacial blades are the chosen tool type for sheep and goat. The difference in tool type is likely connected to the size of the animal but there may be a symbolic connection between bifacial knives and cattle butchery as denoted in many Old Kingdom scenes that depict animal butchery. Nevertheless, it should not be assumed that the knives depicted in butchery scenes were the only tool type adopted in animal butchery during the Old Kingdom.

10.1 Significance:

In the introduction of this thesis, a quote by Paynter was used to describe what archaeologists should do, it stated: *‘The task of archaeology is to find the mechanisms that produce change from one form of social integration to the next’* (Paynter 1989: 373). In this thesis, zooarchaeological methods of slice mark analysis were applied to study the shift from a stone to metal based technology and its widespread effect on ancient Egyptian society during the Old Kingdom. Egyptian society in the Old Kingdom had greater organisation, greater differentiation of structure, and increased specialisation – all of which are characteristics of complex societies (White 1949: 367; Service 1962). The level of social integration was limited during this time and based on hierarchical and horizontal differentiation (i.e. an individual’s status in society)

(Paynter 1989: 373). Integration was enabled through various mechanisms (agents) that maintained social stratification, one of them was metallurgy that served as symbols of wealth and status and provided individuals with access to resources, including particular tool types such as copper knives or mined flint blades. The frequency of metal objects found at the site or throughout Egypt during the Old Kingdom is not a reflection of their use or how widespread metallurgy was during this time. In fact, the results of this thesis demonstrate that metal tools (copper) were not used in animal butchery. Instead, stone-chipped blades (unifacial and bifacial) were the primary tool used in animal butchery.

These new data provide a great deal of new information that enhances our understanding of not only the nature of food production in Old Kingdom Egypt, but the differential role that metal- and stone-based objects played in enhancing social complexity, social stratification, and social differentiation during the Old Kingdom. Old Kingdom society was highly stratified and individuals had limited social mobility (Moreno-Garcia 2018). It thrived on the presence of kings as heads of state and administrative individuals (e.g. nomarchs, treasurers, military men) working to achieve the state's objectives including military expeditions, tax collecting, and the maintenance of royal cults (Chapter 2). In return, these administrative individuals were maintained in the higher social strata where they received tax benefits, royal estates, better cuts of meat, and access to expensive objects including copper knives (Ikram 2014: 286; Katary 2011: 5-6). Although a rise of a middle class occurred during the Old Kingdom, as evident by the presence of wealthy peasants, an individual's rank within society determined accessibility to resources. The division between higher and lower status individuals prevalent in society is reflected in Old Kingdom settlements where administrative areas and neighbourhoods acted as dividers between the different levels of society (elite and non-elite) (Chapter 2). Such examples are found throughout Egypt for the Old Kingdom but particularly present at Giza where material objects, faunal, and architecture has allowed for a narrative of neighbourhoods to be drawn (Lehner and Hawass 2017).

Differential access to resources are evident in the diet of individuals at Giza. Faunal studies for areas throughout Giza have amply demonstrated that higher status individuals (e.g. administrators) consumed a higher-quality diet with more cattle while lower status individuals (e.g. workmen) received lower-quality food with high nutrient content (Redding 2010). The faunal assemblage from KRO reflects a low-quality diet dissimilar to other areas of Giza with

much more sheep and goat, no pig, and limited fish. The faunal data from KRO contains limited quantities of meat bearing elements and demonstrates a high degree of butchery (slices and chops) which are both reflective of a low-status diet, but that the individuals received high-nutrient meals in the form of a stew. Hence, these individuals were labourers from the lower strata of society and likely had limited access to expensive resources reserved for the elite, particularly copper blades for animal butchery.

The complexity of Egyptian society and limited accessibility to resources increased with the rise of metallurgy. The increased complexity during the Old Kingdom caused differential access among individuals to economic, productive or symbolic resources (Richards 2005: 13). The development of metallurgy was a social process that included individuals from all levels of society to complete the *chaine de operatre* (mining, smelting, producing, consuming) (Chapter 5). Although all levels of society were involved in metallurgical activities, evident in metalworking scenes and archaeological evidence of slag and crucibles, the consumption of copper objects was done by individuals of higher status. The various copper objects that are found in Old Kingdom tombs (i.e. model copper knives, blades, axes) and the limited quantity of quotidian copper objects in settlement contexts (i.e. fishhooks, chisels, mirrors) are examples of the interplay between status and metal. Nevertheless, whether the use of copper objects was widespread should not be based on the survival of odd pieces of bronze or copper metal objects in the archaeological record alone. The zooarchaeological methods of slice mark analysis used in this thesis offers a different perspective for the discussion on the use of copper-based blades in animal butchery. The results of this study suggests that copper-based blades were reserved for the state and higher status individuals, while flint-based blades were readily available to all social classes. In this view, copper objects acted as mechanisms in the maintenance of social stratification that acted as symbols for the elite (i.e. burial goods). In turn, the social constraints placed upon copper objects restricted its accessibility to individuals from lower social strata for quotidian activities and therefore can be understood as a development rooted from social complexity.

Social complexity and specialisation also impacted more traditional uses of tool types that were widespread and continued throughout the Old Kingdom. Flint-based blades were plentiful for the Old Kingdom and were adopted into areas of daily life, particularly animal butchery (Chapter 4). Yet, mined flint blade types such as some bifacial knives, were manufactured by

centralised workshops likely overseen by the state and its administration (Chapter 4; also see Hikade 2004; Hikade, et al. 2019). Increased specialisation, therefore, may have limited accessibility to better choice tools such as mined flint types, that were produced at or near mining locations by specialised groups (Hikade, et al. 2019). Although some flint blades were likely acquired through the state, archaeological evidence from Old Kingdom sites and the results from the slice mark data suggests that flint blades were accessible to individuals of all social strata.

One of the other conclusions that can be drawn from this analysis is that the use of bifacially produced chipped stone knives were predominantly used for the slaughter of cattle while unifacial and smaller chipped stone blades were used to slaughter sheep and goat. Two- and three-dimensional scenes from the Old and Middle Kingdoms depicted cattle being slaughtered with what appears to be a large knife (Ikram 1995). The belief that the blades depicted in these butchery scenes were metal is problematic (Martin 1979: 12). The research and data from this study strongly suggests that the knives depicted in the scenes are flint-based blades. This conclusion is based on what appears to be flakes falling in a knife sharpening tableau (e.g. Tomb of Iymery, G 6020) and the absence of metal blade in the slice mark data for use in animal butchery at Giza (Chapter 8).

Consequently, a relationship may be drawn between cattle slaughter and better-quality blades (mined, bifacially produced stone chipped knives). Two possibilities arise from this idea - that larger blades were simply adopted because they were easier to slaughter larger animals with, and/or that they were adopted because of their symbolic importance in ancient Egyptian society. In either possibility, bifacially chipped flint knives are seen as important – as a tool to butcher a valued animal and as a tool related to religious activities.

Furthermore, this study clearly demonstrates that one cannot assume that everyone has access to or even equal access to metal with the introduction of metallurgy. Clearly, even though the elites in Egypt had access to Bronze metallurgy for display, its availability did not extend to the lower strata for quotidian uses. This is a pattern that can be now seen extending across the Near East and Europe (Greenfield 2017) and probably beyond.

10.2 Considerations and future suggestions:

The methodology adopted in this thesis was successful in determining stone or metal tool use in animal butchery. The coupling of zooarchaeological methods of slice mark morphology and

scientific instruments to view characteristics of slice marks provided a comprehensive way to answer questions about tool types. However, differences among the Dino-Lite and SEM resulted in varying identifications of tool types. Although the Dino-Lite had a decent magnification, working range, and provided very good photos of the slice marks, it lacked the capability to view details of the characteristics of slice marks such as striations and profiles. This was largely due to the nature of the slice mark and the size of the animal bone. Sample moulding and the SEM were required to view the particular characteristics that identify slice marks as produced by stone or metal blades. The silicone moulding allowed the slice mark to be viewed invertedly and therefore allow the characteristics to be clearly studied without any room for error. Furthermore, the high magnification, depth of field, and working distance of the SEM allowed an incredibly close view to examine the slice mark characteristics unattainable with the Dino-Lite. The misidentification of slice marks that occurred on-site with the Dino-Lite is an example of the errors that can occur with such technologies. However, the Dino-Lite provided a great addition to the analysis and offered original micrographies of the slice mark. Nevertheless, it is highly suggested that the Dino-Lite not be used solely for the identification of slice marks and that other methods and technologies are adopted.

Appendix A

Appendix A.1

Sample: #16

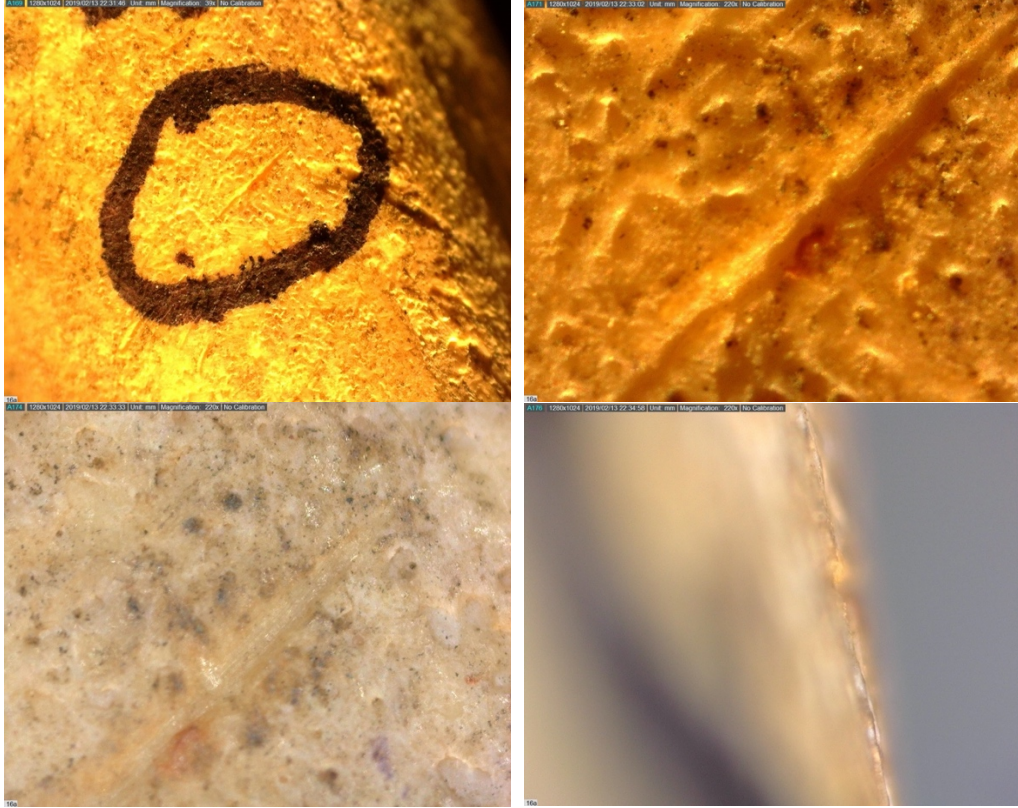
Taxa: Ovis/Capra

Age: Adult/Subadult.

Element: Femoral shaft

Part: Left shaft fragment.

Slice mark morphology: Slice located on the lateral face. Sharp, deep, slightly off angled V-shaped (|/).



Figs. A-D. Dino-Lite microscopy of slice mark #16. A. 39x magnification aerial angle. B. 220x magnification aerial angle with apex and striations visible similar to metal. C. 220x magnification of slice mark which appears to have a steep right side, apex on the right side, and more gradual descent with lateral striations on the left side. D. 220x magnification profile view. The sample was initially identified as “metal?”. It is now recognized based on SEM as a groove made by a unifacial production, unretouched, chipped stone tool. In the Dino-lite, the groove appeared more like |/, but in the SEM it became |/.



Fig. E. SEM micrograph of slice mark #16 with 200μm, 90-degree overhead angle. The |/ shape and striations typical of unifacial production, unretouched chipped stone tool flake/blade are visible.

Appendix A.2

Sample: 144

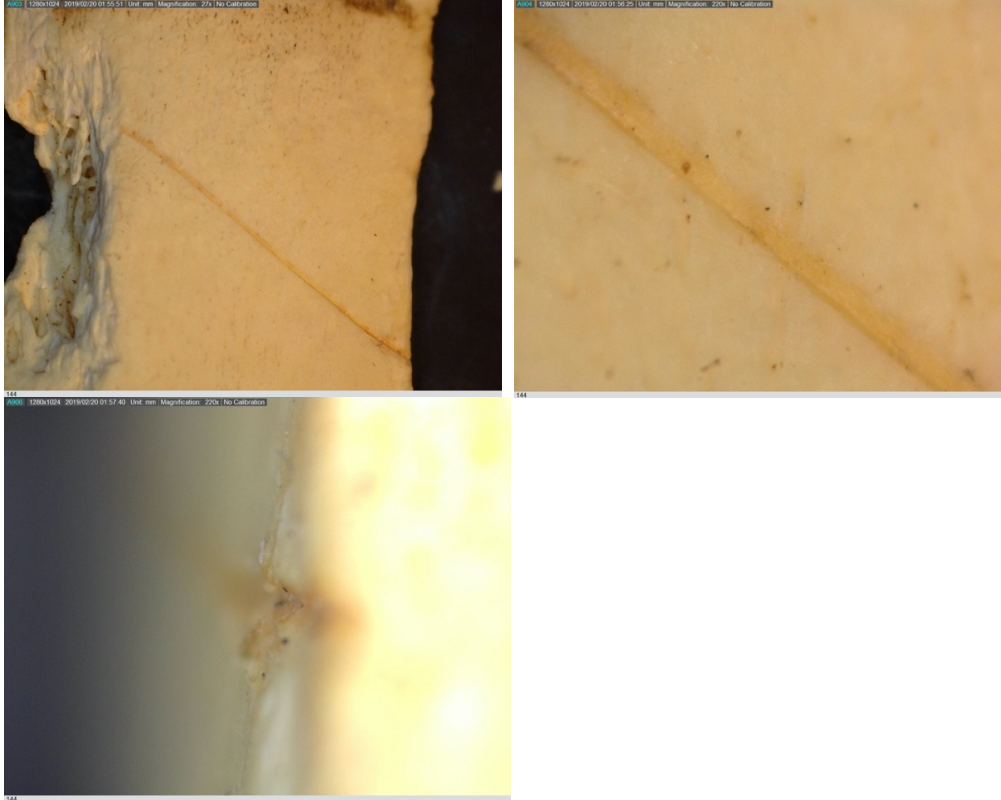
Taxa: Ovis/Capra

Age: Young subadult.

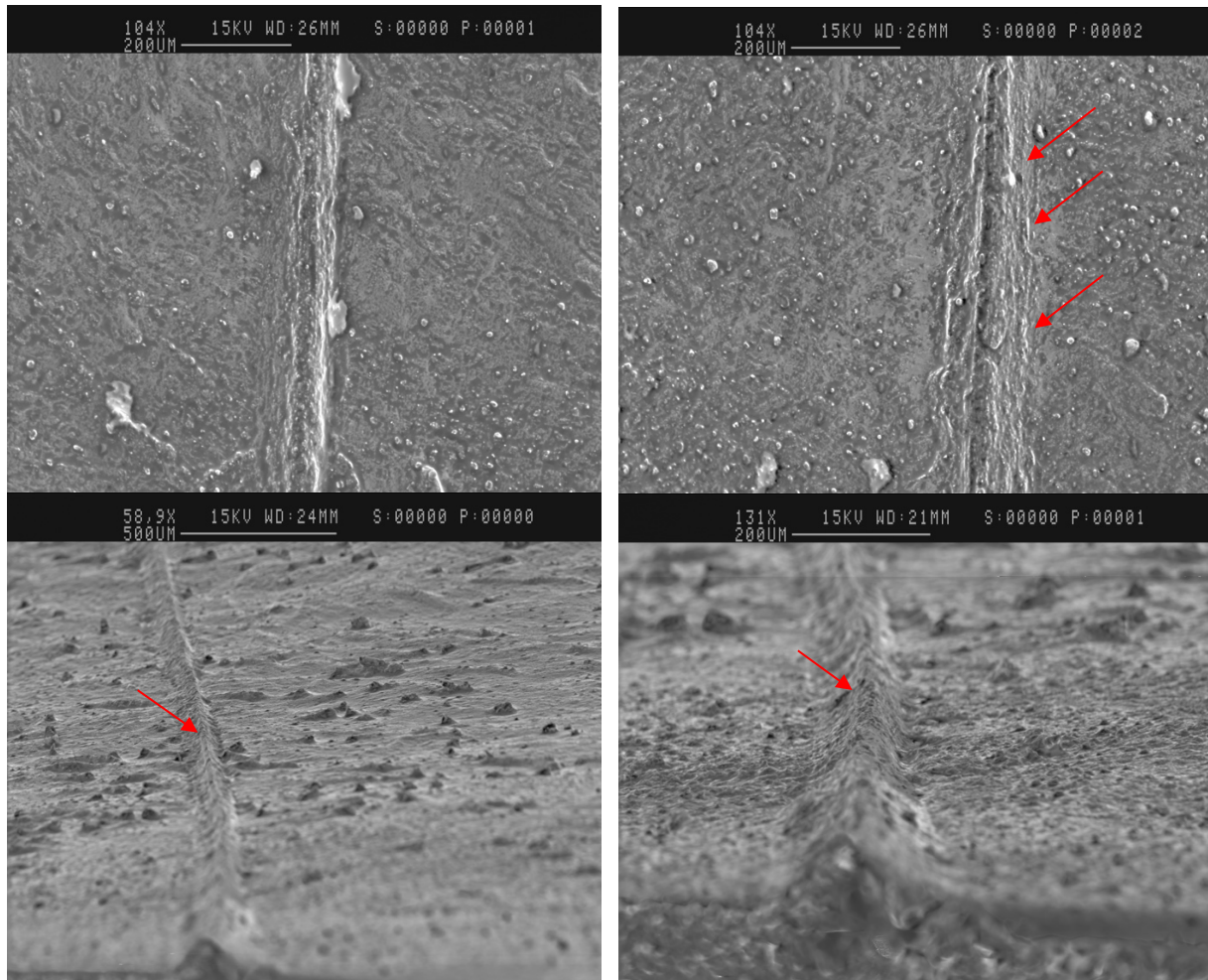
Element: Thoracic vertebra

Part: Spinous process fragment.

Slice mark morphology: Slice located on the right lateral face. Sharp, deep, slightly off angled V-shaped (|/).



Figs. A-D. Dino-Lite microscopy of slice mark #144. A. 27x magnification aerial angle. B. 220x magnification aerial angle. C. 220x magnification profile view. At this magnification, these images appeared to reflect characteristics of grooves created by a metal blade. However, when examined in the UofM lab, it is clearly a result of a chipped stone tool.



Figs. E-H, SEM micrography of slice mark. E. 200um magnification aerial angle. F. 200 μ at an aerial angle. G. 500 μ profile view. H. 200 μ profile view. The striations (denoted by the arrows) are present in these images, the long lines that run along the wall of the slice mark and are reflective of stone despite the presence of a somewhat straight V. B is more reflective of the angle of stone with a steep step and a more angular side.

Appendix A.3

Sample: #145

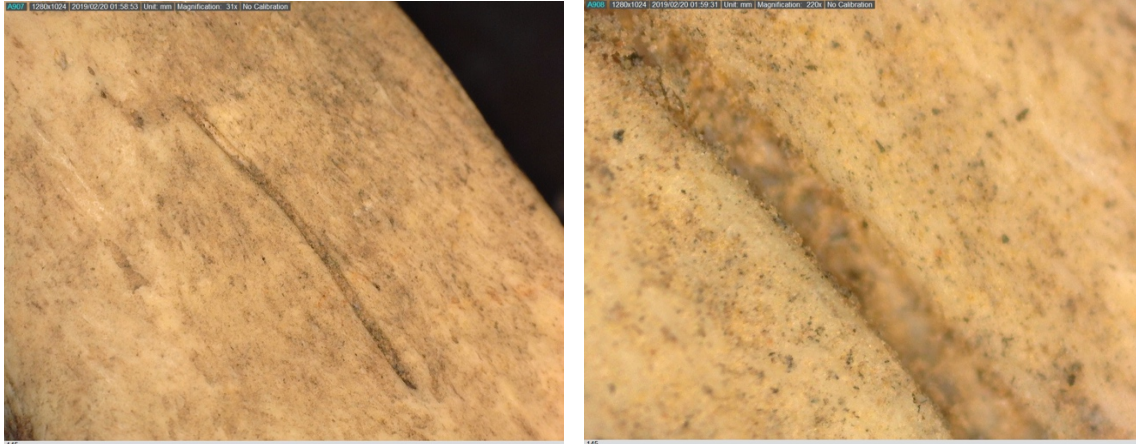
Taxa: Ovis/Capra

Age: Young adult/subadult.

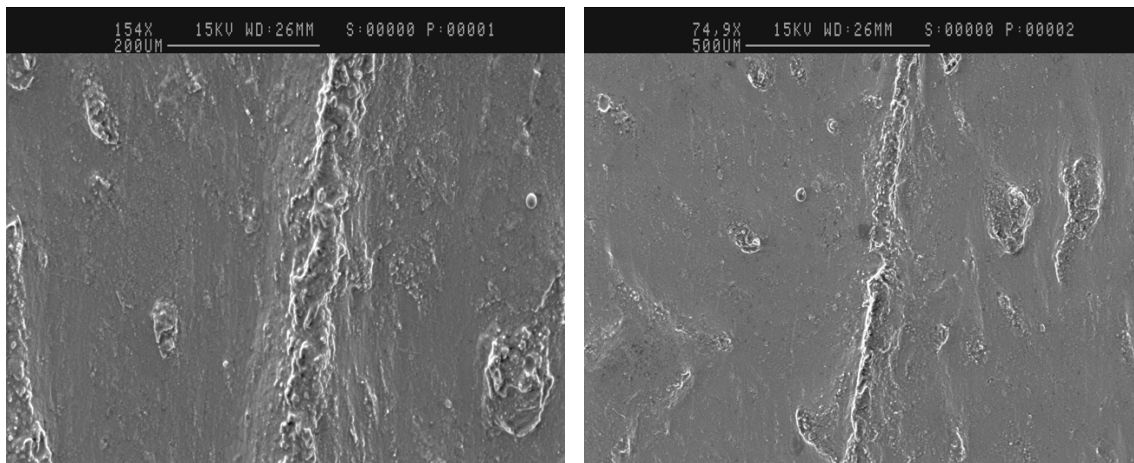
Element: Thoracic vertebra

Part: Spinous process fragment.

Slice mark morphology: Slice located on the right face. Sharp, deep, slightly \ / shaped.



Figs. A-B. Dino-Lite microscopy of slice mark. A. 31x magnification aerial angle. B. 220x magnification aerial angle.



Figs. C-D. SEM micrography of slice mark. C. 200µ aerial angle. D. 500µ aerial angle. The slice mark reflects an uneven, 'dirty' line. The striations present in these images are reflective of stone with a steep step and \ / shape.

Appendix A.4

Sample: #172

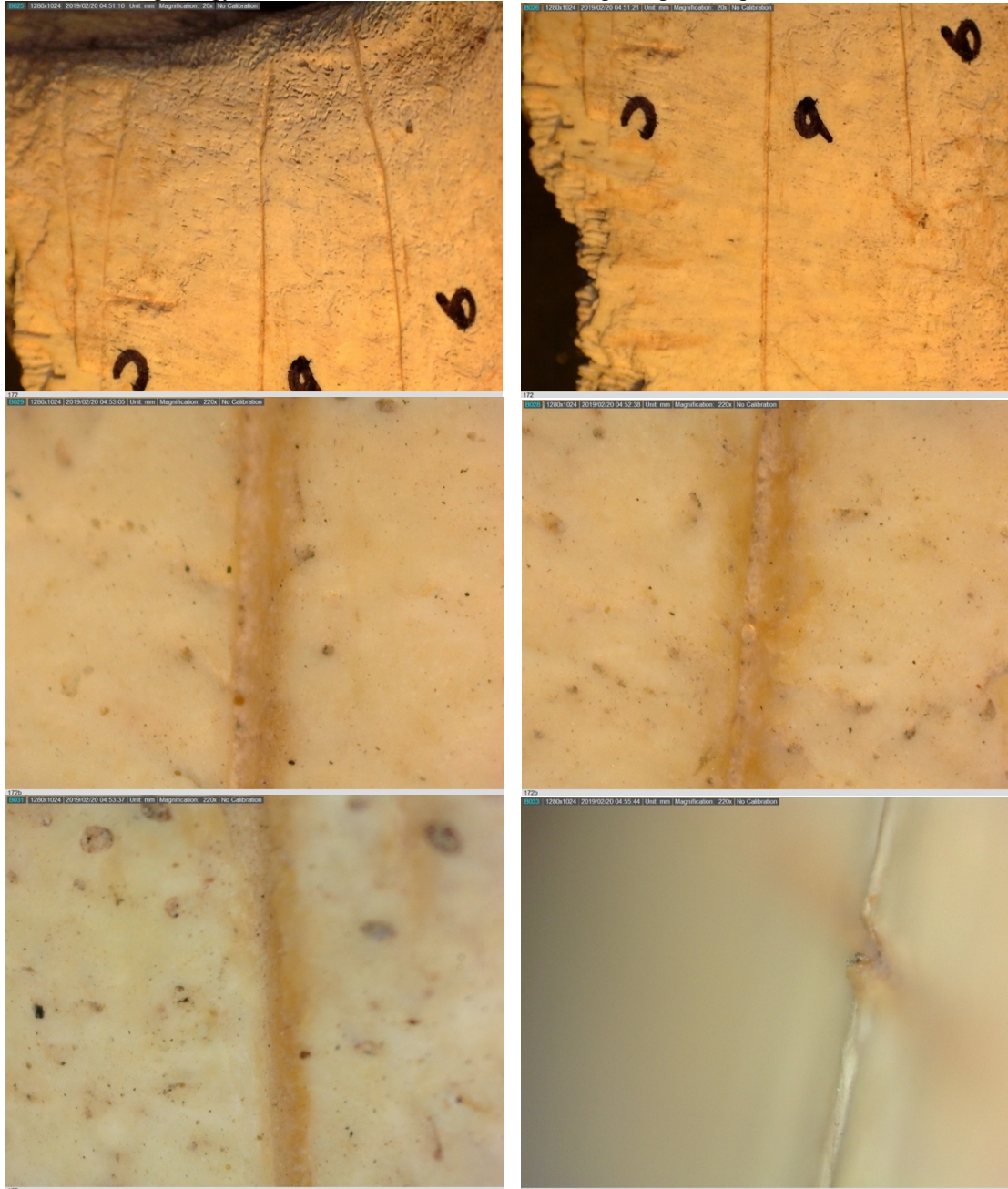
Taxa: Bos Taurus

Age: Adult/subadult.

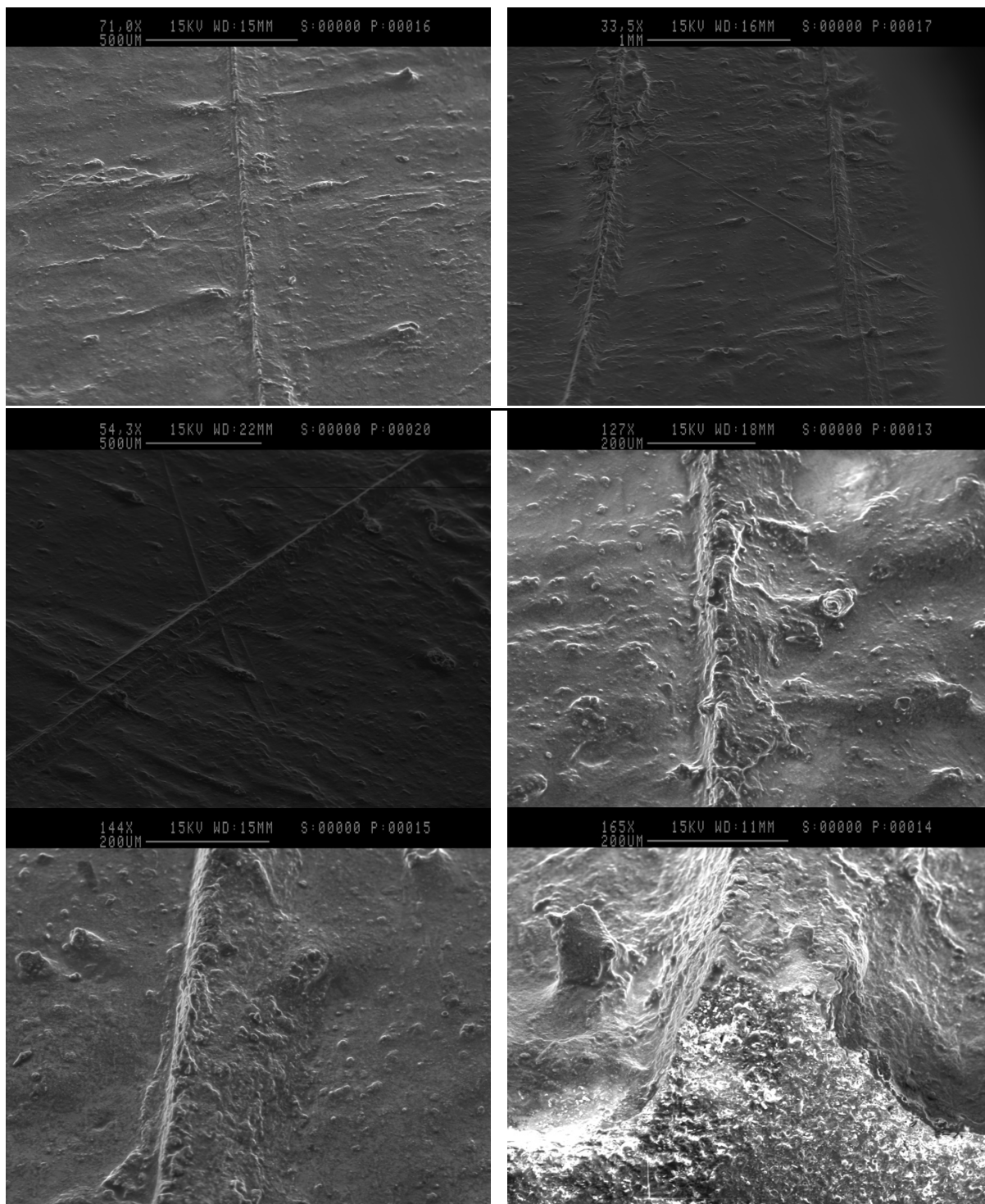
Element: Lumbar vertebra

Part: Body and spinous process fragment.

Slice mark morphology: 3 slices located on the left side. Sharp, deep, V shaped.



Figs. A-F, Dino-Lite microscopy of slice mark. A and B 20x magnification aerial angle. C and D 220x magnification aerial angle. E. 220x magnification showing // slice reflective of stone but F. is more V shaped reflective of metal yet the apex is not deep.



Figs G-L. SEM micrography of slice marks. G. 500 μ aerial angle. H. 1mm magnification aerial angle. I. 500 μ side angle. J. and K. 200 μ 45-degree view angle. Note the clear steep slope on one side and angled slope on the other. L. Slice through the mould, you can see clearly the profile shaped _ / with striations on the sides.

Appendix A.5

Sample: #174

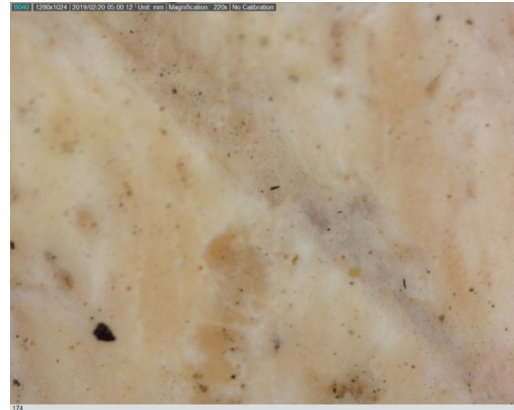
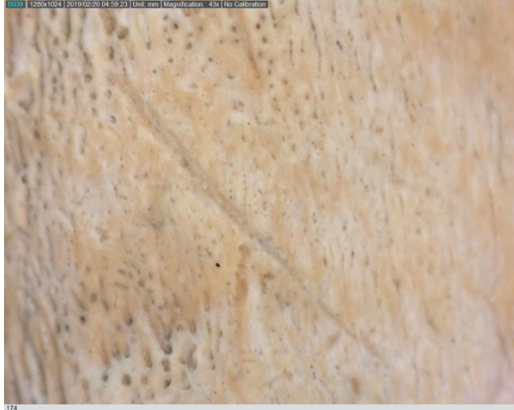
Taxa: Bos taurus

Age: Adult/subadult.

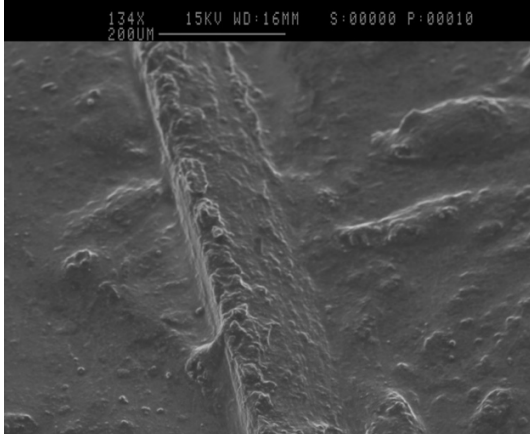
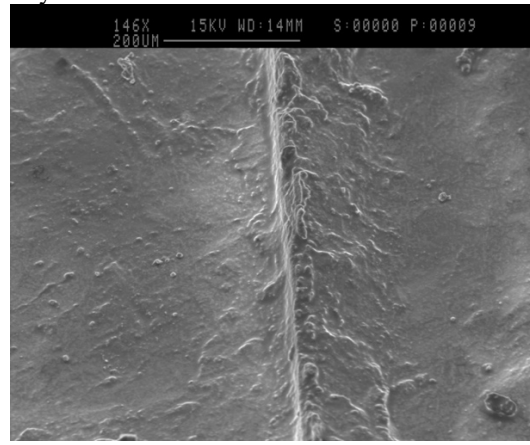
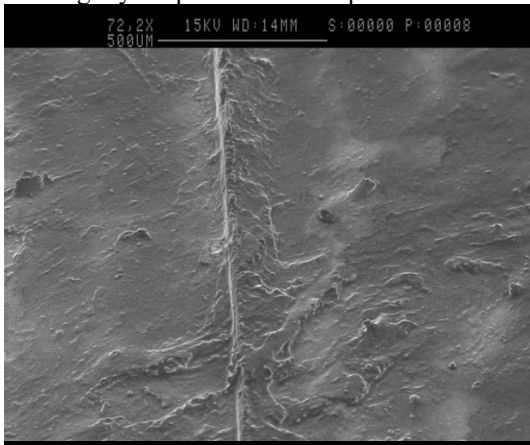
Element: Thoracic vertebra

Part: Spinous process fragment.

Slice mark morphology: Dull, deep, V shaped.



Figs. A-B. Dino-Lite microscopy of slice mark. A. 34x magnification top angle. B. 220x magnification aerial angle. The slightly deep slice was interpreted as metal initially.



Figs C-E. SEM micrography of slice marks. C. 500μ aerial angle. D. 200μ aerial angle. E. 200μ side angle. Note the clear steep slope on one side and angled slope on the other on D and E, |/.

Appendix A.6

Sample: #192

Taxa: Bos taurus

Age: Adult/subadult.

Element: Left rib

Part: Rib fragment.

Slice mark morphology: Multiple slices on cranial border. Dull, deep, V shaped.



Figs. A-B. Dino-Lite microscopy of slice marks. A. 27x magnification top angle. B. 220x magnification aerial angle. The deep slices reflect filleting and were initially identified as metal.

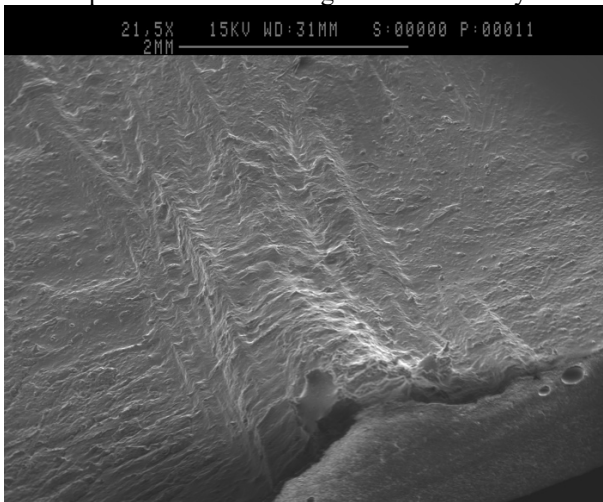


Fig. C. SEM micrography of slice marks. 2mm aerial angle. Unidentifiable tool-type but the image demonstrates clearly the distortion caused by multiple slices in one area. Only one image was required because the multiple slice marks make this sample unidentifiable.

Appendix A.7

Sample: #193

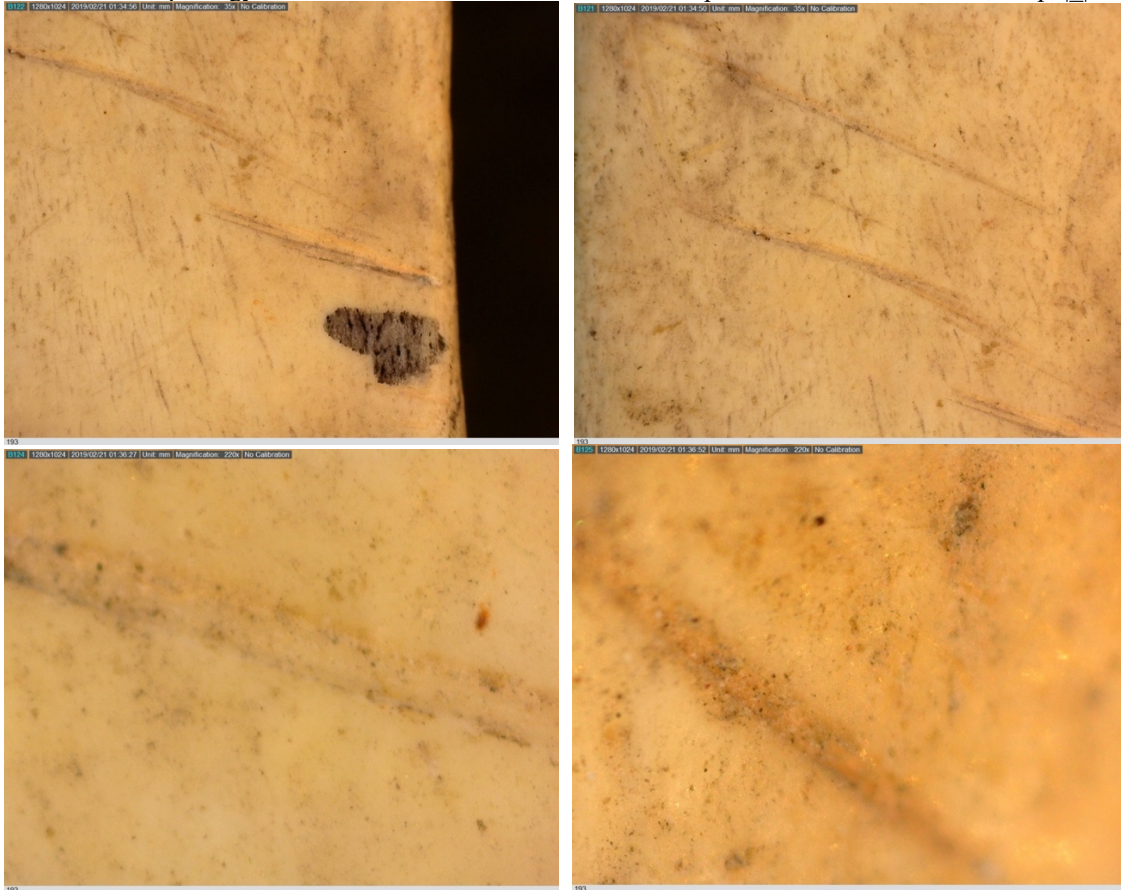
Taxa: Bos taurus

Age: Adult/subadult.

Element: Right rib

Part: Rib fragment.

Slice mark morphology: Slice mark located on medial face. Multiple slices in one area. Dull, deep, |_| shaped.



Figs A-D. Dino-Lite microscopy of slice marks. A. and B. 35x magnification top angle. C. and D. 220x magnification aerial angle which are out of focus to the limited depth of field. The slices reflect filleting and were initially identified as metal.



Fig. E. SEM micrograph of slice mark. A. 2mm aerial angle. The striations (along the red arrow) characteristic of stone is visible.

Appendix A.8

Sample: #199

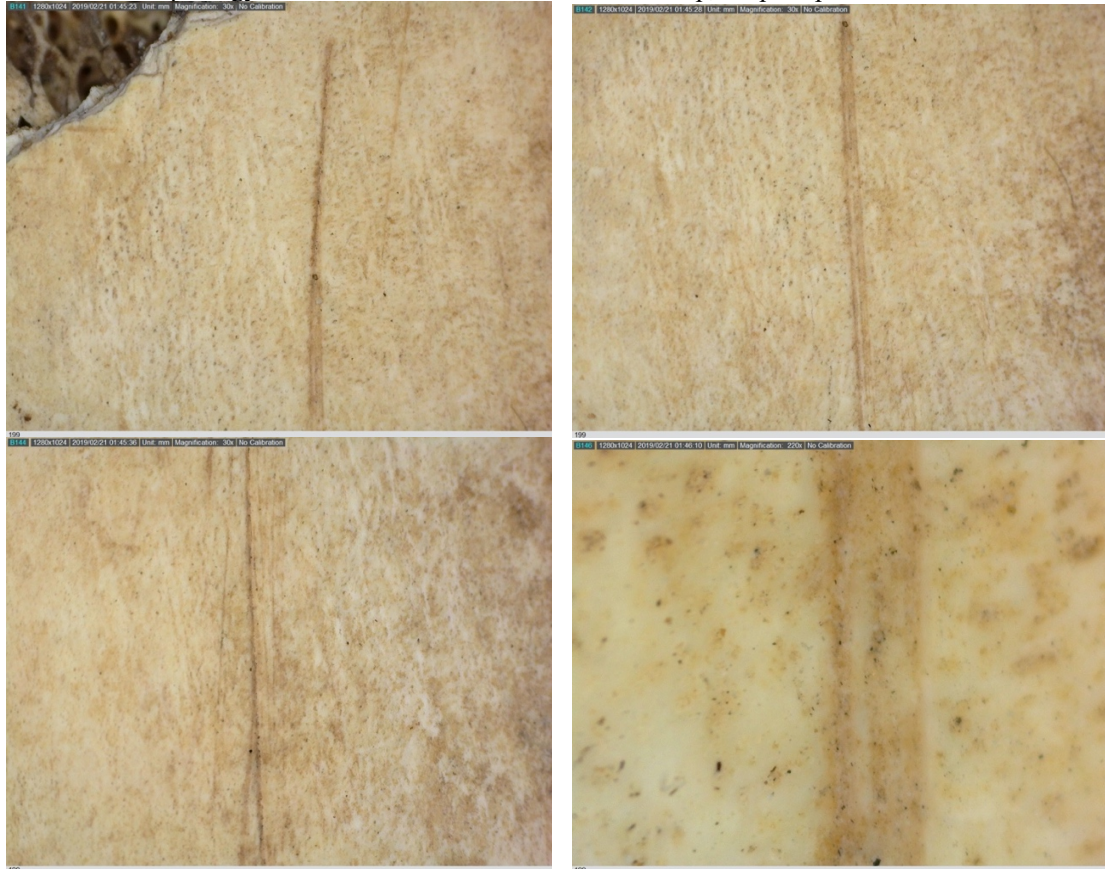
Taxa: Bos taurus

Age: Adult/subadult.

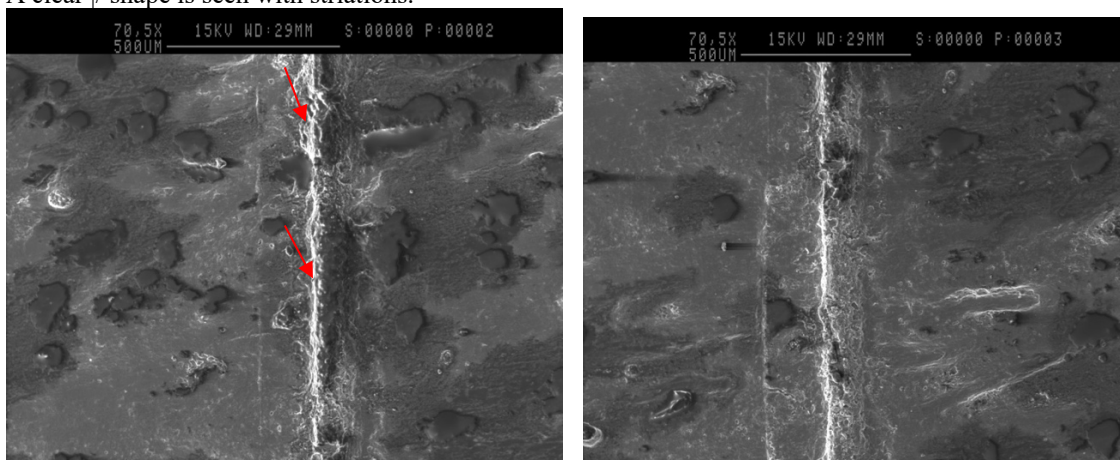
Element: Right rib

Part: Shaft fragment.

Slice mark morphology: Slice mark located on medial face. Sharp, deep shaped.



Figs. A-D. Dino-Lite microscopy of slice marks. A. and B. 30x magnification top angle. They appear to have more than one slice in the same area. C. 30x magnification aerial angle shows the multiple slices. D. 220x magnification. A clear // shape is seen with striations.



Figs. E-F. SEM micrography of slice mark. A. and B. 500 μ magnification aerial angle. A clear // shape is seen with striations characteristic of stone tool-type.

Appendix A.9

Sample: #204

Taxa: Bos taurus

Age: Adult/subadult.

Element: Left rib

Part: Rib fragment.

Slice mark morphology: Multiple slice marks located on medial face. Sharp, deep shaped.



Fig. A. Dino-Lite microscopy of slice marks. A. 26x magnification top angle. They appear to have more than one slice in the same area. Identified as metal due to their deep shape.



Fig. B. SEM micrograph of slice marks. A. 500 μ aerial angle. A clear V shape is seen in all three slices with striations (red arrow) characteristic of stone tool-type and multiple slices.

Appendix A.10

Sample: #205

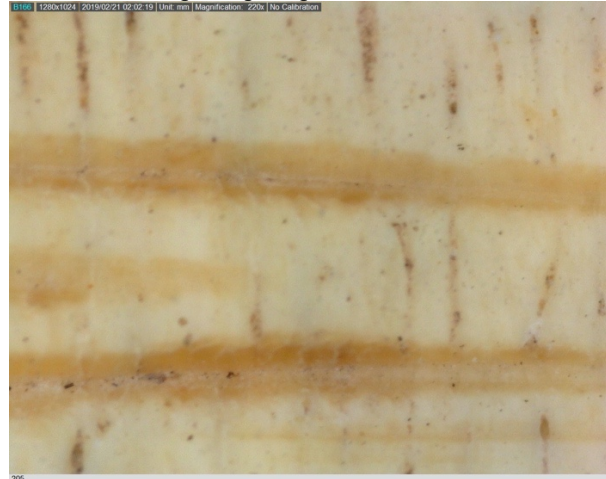
Taxa: Bos taurus

Age: Adult/subadult.

Element: Left rib

Part: Rib fragment.

Slice mark morphology: Multiple slice marks located on medial face. Sharp, deep shaped.



Figs. A-B. Dino-Lite microscopy of multiple slice marks. A. 30x magnification aerial angle. B. 220x magnification. You can see what appears to be a clear, deep, V shape characteristic of metal.



Fig. C. SEM micrography of slice marks. A. 500μ aerial angle. A clear _ / shape is seen in the slices with striations (red arrow) characteristic of stone tool-type.

Appendix A.11

Sample: #220

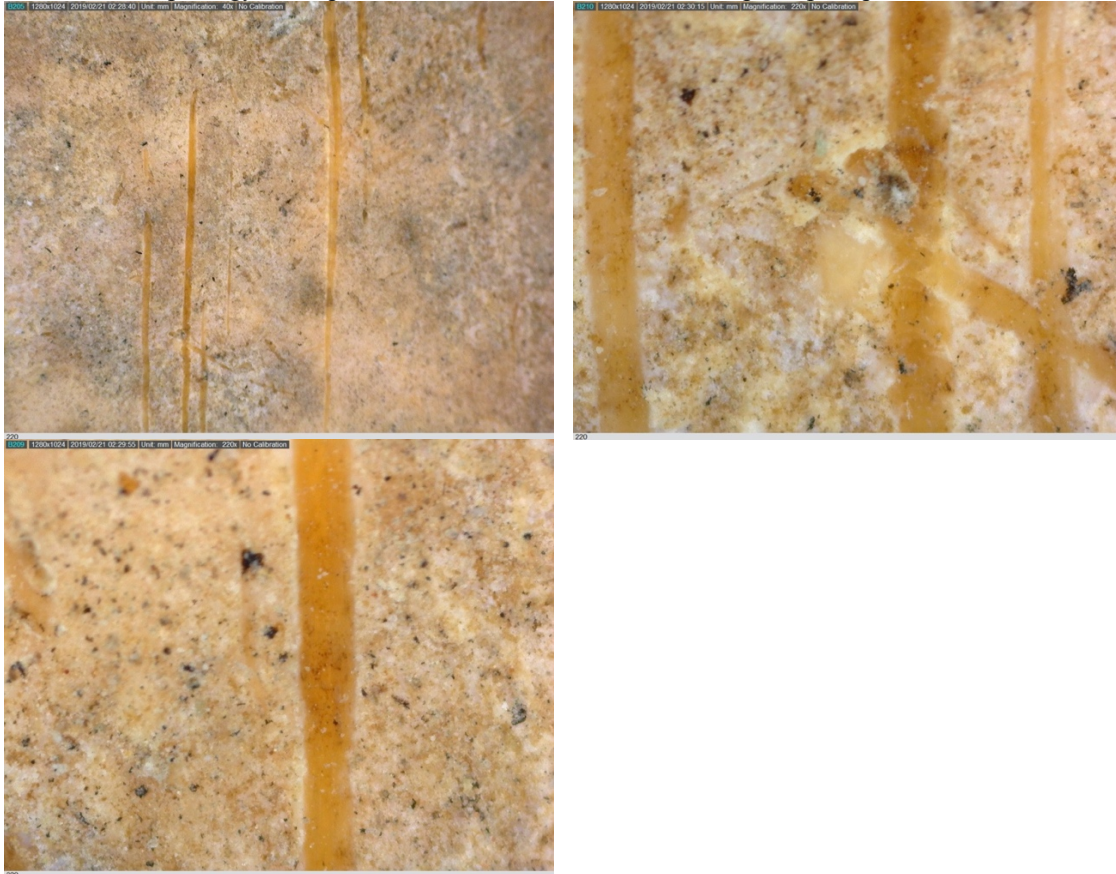
Taxa: Bos taurus

Age: Adult/subadult.

Element: Long bone.

Part: Shaft fragment.

Slice mark morphology: Multiple slice marks located mid-shaft. Sharp, deep shaped.



Figs. A-C. Dino-Lite microscopy of multiple slice marks. A. 40x magnification aerial angle. B. 220x magnification. C. 220x magnification. You can see a V shape but is slightly distorted from the lighting. Initially identified as metal.

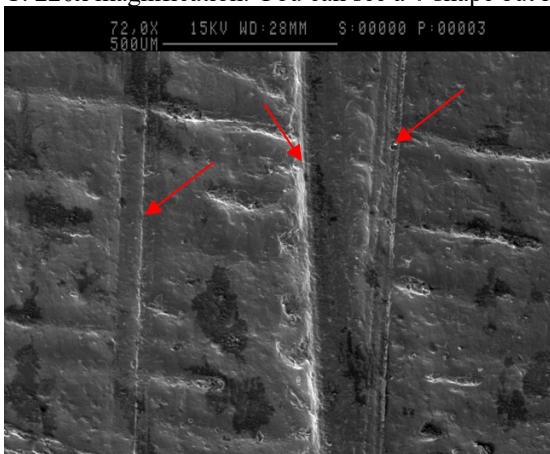


Fig. D. SEM micrography of slice marks. A. 500 μ aerial angle. Multiple striations are viewed in these slices which may be caused from multiple slices in one area or by a stone tool.

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