The Evolution of Technological Behaviour: An Analysis of Lithic Artifacts from the Magubike Archaeological Site, Tanzania

by

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ABSTRACT

Most Palaeolithic archaeologists now believe that a series of advancements in the behavioural and cultural complexity of early *Homo sapiens* occurred during the Middle and Later Stone Age in Africa. However, a lack of uninterrupted archaeological sequences has made it difficult to identify the cause and pacing of this transformation confidently. Despite a lack of transitional sites in southern and northern Africa, it has been suggested that East Africa might possess such localities due to its relatively stable climate over the course of the Pleistocene. Furthermore, it has been proposed that environmental refugia in East Africa were critical for the development and transmission of cultural data that some researchers associate with modern culture and cognition such as advanced technology and symbolically mediated behaviour. Despite these recommendations little work has been done to determine where these refugia might be located, how they worked, and if the refugia theory can be validated. On account of the importance of East Africa for the study of modern human origins, several sites were excavated by Dr. Pamela Willoughby in Southern Tanzania, starting in 2006. One of these sites, Magubike, contains stratified Middle Stone Age, Later Stone Age, Iron Age, and historic deposits, allowing the long-term behaviour of the site's inhabitants to be analyzed. A preliminary study of the lithic assemblage from a portion of Magubike revealed long-term continuity among the typological and technological variables that were investigated, consistent with enduring environmental and social conditions.

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Chapter 1 Introduction and Background

Anatomically modern *Homo sapiens* are currently believed to have evolved in Africa by at least 195 ka (thousand years ago) (Fu et al., 2013; McDougall et al., 2005). The cultural products of these earliest modern humans belong to an archaeological industry called the Middle

Stone Age (MSA) (or Middle Palaeolithic [MP] in North Africa), which can range in age from 350 to 30 ka (McBrearty and Brooks, 2000). The MSA/MP is characterized by a number of important technological advances over the preceding Acheulean, including a reduction in the size of finished tools; likely for the purpose of hafting, and the proliferation of more complex reduction methods, such as the Levallois technique (Ambrose, 2001; Van Peer, 1992). Although the MSA was advanced technologically, evidence of art, ritual behaviour, and personal adornment during this period is scarce, and sometimes controversial (d'Errico and Henshilwood, 2011). These types of symbolically charged items became common only around 50 to 30 ka, during the Later Stone Age (LSA), at which time a number of additional changes in social and technological behaviour occurred. This evidence led some scholars to suggest that while *Homo sapiens* was anatomically modern by 195 ka, our species was not behaviourally modern until much more recently, during the LSA (Klein, 2009). Conversely, the more accepted position is that modern behaviour has its roots deep within the MSA, during which time it emerged asynchronously as a result of normal processes of discovery, innovation, and transmission (McBrearty and Brooks, 2000).

Despite growing acceptance of this idea, the precise cause and timing of the MSA/LSA behavioural shift has yet to be established with any certainty. A key obstacle is a lack of transitional sites which date to both the late MSA and LSA, due in part to the large-scale abandonment of much of northern and southern Africa during the late Pleistocene (Ambrose, 1998). This hiatus is theorized to have been the result of fluctuating periods of glacial climate, which decreased the carrying capacity of habitable regions, and forced the mass movement of people and animals. In contrast to much of Africa, however, there are indications that some parts of equatorial East Africa remained climatically stable even during these severe glacial episodes, making it an attractive place for long-term human occupation (Blome et al., 2012; Finch et al., 2009; Mumbi et al., 2008). Moreover, it has been suggested that these East African refugia were critical centers of behavioural evolution, even during periods of environmental stress elsewhere (Ambrose, 1998; Stewart and Stringer, 2012). Although the importance of refugia has been noted, "few studies have considered exactly where such refugia existed, how they might have worked, and whether this theory is supported by archaeological evidence." (Basell, 2008: 2484). What is more, because most scholarship on the MSA and LSA has, until now, highlighted the northern and southern extremes of the continent, some parts of East Africa have remained comparatively understudied despite their archaeological significance.

The archaeological potential of East Africa led Willoughby, in 2005, to conduct a tour of rockshelters and open air sites in the Iringa region of southern Tanzania. The initial results of the investigation were promising, and excavation at two sites was conducted in the years following. The materials for the present thesis derive from one of these sites – Magubike, a rockshelter complex located near the village of the same name. A series of test pits have been excavated, producing a sequence which includes three separate MSA occupations, two LSA occupations, and at least one Iron Age / historic occupation. The chronometric dating of mammal teeth with Electron Spin Resonance (ESR) has shown that the oldest MSA levels (those from Test Pit 3, excavated in 2006, as well as Test Pits 6 – 12 from 2012) were approximately 250 ka. The dating of the site also demonstrated a general degree of coherence and continuity between the various stratigraphic units. An analysis of the lithic artifacts from Test Pit 12 was performed in an attempt to detect and explain patterns of behavioral variability over time, particularly during the MSA and LSA, when modern human behaviour is purported to have evolved. In order to accomplish this task, a mixed investigation of technological and typological factors was adopted.

The remainder of this chapter explores the general topic of modern human origins in more detail. Chapter 2 describes the contents and context of Magubike, as well as the results of previous excavation, and the dating of the site. Chapter 3 outlines the methods by which the lithic artifacts were described, categorized, and analyzed. Chapters 4 and 5 contain the results of the typological and technological analyses that were performed, respectively. Lastly, Chapter 6 contains the discussion and conclusions that were drawn from the results, their implications for modern human origins research, and suggestions for future work.

1.1 The First Anatomically Modern Humans

On the basis of genetic and fossil evidence, anatomically modern *Homo sapiens* is thought to have first appeared in Africa as early as 195 ka, having likely evolved from an earlier archaic human species such as *Homo heidelbergensis* (Stringer, 2012).

DNA Evidence

DNA analysis has been invaluable to understanding the evolution of modern humans, as it has allowed researchers to accurately reconstruct phylogenetic affinities between species, and to determine when and where specific genetic lineages arose. For this purpose, mitochondrial DNA (mtDNA) has proven to be particularly important. Found external to the nucleus within animal cells, mitochondria are the organelles responsible for providing cells with the energy they require to function. Whereas most of the cell's genetic material is stored in the nucleus, the mitochondria also contain packets of genetic information. Some portions of this information do not have any discernible effects on the expression of physical traits (they are considered non-coding or "junk" DNA), nor are they altered by selective processes (Ingman et al., 2000). These non-coding sequences *do,* however, undergo regular change as mutational errors in their structure accumulate over time. Since these mutations are hypothesised to accrue at a consistent rate, mtDNA is a powerful chronological tool with which to estimate the time that separates genetically related sub-populations (the neutral theory of mutation). As mtDNA mutates much more rapidly than nuclear DNA, changes in its structure are also simpler to detect over shorter timeframes. By exploiting this feature of mtDNA in living humans from different parts of the globe, Cann et al. (1987) were able to determine the mutation rate of mtDNA by recording differences in the number of substitutions between human groups that had become removed from each other at a known place in time (an in-group method). Through a comparison of living mtDNA in native North Americans, Australians, and New Guineans, Cann and colleagues concluded that mtDNA changes at a rate of 2-4% mutations per million years. Using the mutation rate they had calculated, the authors were then able to estimate when in time the modern human mtDNA gene-pool originated: sometime between 143 and 288 ka. In a related study, Vigilant et al. (1991) used an out-group method, analyzing chimpanzee mtDNA to calibrate and confirm the age range purported by Cann et al. (1987).

A new series of papers, conversely, have proposed that not only has the pace of genetic mutation been vastly overestimated, but that its rate may be much more variable and prone to change over time than geneticists had previously predicted (Diogo et al., 2013; Endicott et al., 2009; Gibbons, 2012; Scally and Durbin, 2012). For most studies, the speed of gene substitution is calibrated using securely dated fossil and archaeological remains as temporal markers, allowing the number of substitutions in a given timeframe to be enumerated (Fu et al., 2013). Recent studies of *de novo* substitutions (novel mutations not inherited from either parent) on the other hand, do not rely on fossil calibrators; and instead, these methods extrapolate the mutation rate from the minute differences accumulated in the genes of parent and offspring from living populations (Scally and Durbin, 2012). The results of the latter research indicate that the rate of mutation is nearly half as fast as had been calculated earlier; a finding which would significantly push back the timing of genomic events such as the appearance of the modern human gene pool. While this debate is still ongoing, new research, using fossil calibrators that span the last 40 ka, has concluded that the rate of mutation is similar to that initially postulated by Cann and colleagues in 1987 (Fu et al., 2013).

DNA research has also played an essential role in locating where modern human genes first arose. In the same foundational study by Cann et al. (1987), the genes of 147 modern people whose ancestry could be traced respectively to five separate geographical regions, including Africa, were sampled. The genes of the participants from these separate regions exhibited different levels of internal variation, the extent of which was concluded to correlate with the respective age of that lineage. The most significant finding was that the mtDNA of native Africans was the most diverse, and was therefore also likely the oldest. In light of this observation, it was concluded that African populations were ancestral to all other human groups. Although some aspects of this project have been criticized (Ayala, 1995; Hedges et al., 1992), more recent studies have corroborated their results; and a near consensus has emerged concerning the African origins of *Homo sapiens* (Ingman et al., 2000).

Fossil Evidence

Fossil materials are a valuable counterpoint to genetic studies, and are often used to verify the dates they provide with "on-the-ground" facts. In the case of modern human origins, the two approaches are generally complementary, with both lines of evidence pointing to a similar age for the speciation of modern *Homo sapiens* around 195 ka (McDougall et al., 2005; Spoor et al., 1998). The East African fossil record, specifically, has yielded a number of likely candidates for the oldest *Homo sapiens*, such as the Singa calvarium, discovered in Sudan in 1924. The calvarium exhibits a mixture of morphological traits, including an archaic looking supra-orbital torus, contrasted by a rounded, modern-like vault shape. The mix of features suggests that the skull represents an early member of *Homo sapiens*, or an immediately ancestral species like *Homo heidelbergensis*; and the ESR dates taken from the surrounding sediment show that the fossil is likely older than 150 ka (McDermott et al., 1996; Spoor et al., 1998). Similarly, 3 hominin crania (2 adults and 1 juvenile) recovered from Herto, Middle Awash, Ethiopia, have been dated to 160 ka (White et al., 2003). The skulls retain morphologically archaic features, such as a large projecting face and narrowing behind the brow, but are also more modern looking than earlier specimens such as Bodo and Broken Hill (*Homo heidelbergensis*). The mixed morphology of the Herto specimens has occasioned some authors to recommend that these individuals be placed intermediately on a morphological continuum spanning 600 ka to 100 ka, and given the sub-species designation *Homo sapiens idaltu* (White et al., 2003). Lastly, a hominin cranium classified as *Homo sapiens* was recovered from the Kibish Formation in the Omo River Valley, Ethiopia, in 1967. Omo 1 is considered to be modern, while the other specimens from a nearby locality (Omo 2) are commonly classified as *Homo heidelbergensis* or archaic *Homo sapiens*. Since then, debate as to the antiquity of the Omo 1 specimen has been ongoing, but the advancement of chronometric dating methods such as the $^{40}Ar/^{39}Ar$ technique have allowed archaeologists to confidently date the formation containing the remains to as old as 195 ka, making it the oldest known example of an anatomically modern human (McDougall et al., 2005).

1.2 The Archaeology of the Middle Stone Age

The Palaeolithic is the archaeological unit of time that began with the appearance of the first stone tools (2.6 mya) and ended with the introduction of more sedentary lifestyles, incorporating domestic animals and plants, at the end of the Pleistocene ice ages (between 20 and 10 ka). In addition to referring to a specific chronological era, the Palaeolithic is also used in a geographic sense to describe the archaeological records of Europe, Asia, the Middle East, and occasionally northern Africa. The sub-Saharan African record of this period is delineated similarly; but is called the Stone Age, due to the conventions established by Goodwin and Van Riet Lowe (1929) to describe sites in South Africa (In North Africa, the European naming convention is generally used, but more and more researchers are adopting the Goodwin and Van Riet Lowe terminology). The tripartite structure of the Palaeolithic (into Lower, Middle, and Upper stages) is also preserved to divide the African Stone Age into Earlier, Middle, and Later phases. Though alike in concept, the academic separation of the Palaeolithic from the Stone Age is founded on separate histories of scholarship, as well as the recognition of the unique chronology and regional archaeology of both Europe and Africa.

The MSA dates to approximately 350 – 30 ka, following the Earlier Stone Age (ESA); and coincides with the emergence of *Homo sapiens* around 195 ka (McBrearty and Brooks, 2000). All of the lithic flaking methods implemented by MSA hominins emerged in the later Acheulean, but the MSA is generally distinguished from this earlier period by a lack of large bifaces and similar heavy-duty tools. MSA assemblages are predominantly composed of retouched flake tools such as scrapers and points which were commonly manufactured from flakes struck from radial or circular cores, and then retouched. Levallois prepared core methods were also employed to produce similar tools (Ambrose, 2001). The MSA is also contrasted by the LSA which succeeded the MSA starting around 50 to 30 ka, depending on the location in Africa. LSA humans relied more strongly on prismatic blades and bladelet cores, as well as a greater variety of retouched tools. In addition, items of personal adornment such as beads, and other symbolic artifacts, became more common in the LSA than they were in MSA.

At one time the MSA was thought to have been produced exclusively by archaic humans such as *Homo heidelbergensis* whereas the more sophisticated assemblages of the LSA were believed to have been the province of modern *Homo sapiens* alone. Yet as sites in Africa and the Near East began to divulge anatomically modern human remains in association with MSA artifacts, it became clear that modern humans could be linked to both traditions. This observation posed an interpretative problem to scholars who struggled to understand why the behavioural evolution of *Homo sapiens* humans failed to parallel their anatomical development, which appeared modern far earlier. Although an increasing number of "modern" behaviours have been demonstrated to occur in the MSA, this model is still commonly deployed to conceptualize the behavioural evolution of early *Homo sapiens;* and has compelled researchers to explain the transition between the MSA and LSA (Klein, 2009; McBrearty and Brooks, 2000).

Adaptive Strategies in the Middle Stone Age

Habitat Expansion

Compared to the ESA, the niche of MSA humans appears to have expanded significantly as people moved to occupy difficult habitats such as jungles (in the eastern Congo) and coastlines (South Africa and Eritrea) in which resources are meagre, patchy, or difficult to access (Arzarello et al., 2013; Yellen et al., 1995). The specialized knowledge required to fully exploit coastal or alluvial systems, for instance, and to procure fish, was once thought to be exclusively a feature of LSA people; yet, a number of sites from across Africa have shown this notion to be untrue (McBrearty and Brooks, 2000). Evidence for fishing most commonly consists of fish bones in unlikely natural contexts. At sites such as Blombos Cave, the human transport and utilization of deep-water fish is inferred by eliminating other possible non-human agents such as predators or natural deposition that might have introduced the remains to the site. It is also argued that the characteristic damage to the vertebral spines of the fish bones at Blombos Cave is consistent with the live capture of the animals and not with non-human predation or scavenging by humans (Poeggenpoel, 1999).

With the remains of marine fauna, several coastal sites have shown that the occupation of littoral bases may greatly pre-date the MSA/LSA transition. Previously, the oldest dated evidence of coastal adaptation was a 125 thousand year old site along the Red Sea coast, where it was surmised that people were making using of the edible shellfish species present along the shoreline (Walter et al., 2000). Subsequent discoveries at Pinnacle Point, South Africa, in the interim have extended this date back to nearly 164 ka. In particular, a number of artifacts and marine taxa were found in a series of caves, including an overwhelming majority of brown mussels that could have easily been recovered from the beach below. Marean et al. (2007) comment that for hunting and gathering populations not relying on fish/shellfish, coastal habitats feature few attractive alternatives; and suggest that if people were choosing to establish themselves in these sea caves, they were almost certainly incorporating marine fauna into their diets.

Perhaps the best evidence of fishing comes from the eastern Congo basin at Katanda, where barbed and un-barbed bone points were recovered in association with the remains of large river catfish. As the remains were exclusively of adult fish, it was concluded that fishing must have taken place during the rainy season, when this species spawns. Furthermore, as there is only a limited window during which this particular species can be accessed due to its spawning behaviour, it is argued that the Katanda fish remains represent important evidence of pre-planning and seasonal awareness (Yellen et al., 1995).

Hunting Strategies

Among other sites, the faunal assemblage at Klasies River, South Africa, has indicated to some researchers that MSA peoples were not principally engaged in hunting prime-age individuals or dangerous animal species, and were potentially scavenging much of their animal protein (Binford, 1984; Klein, 2009). As a result, authors such as Klein (2009) have argued that MSA people lacked the necessary social hunting strategies, and requisite technology, in order for this type of game to be effectively accessed. In contrast, there is evidence from southern and eastern Africa of MSA mass kill-sites, which were most likely produced by the human interception of entire herds. Data from Lukenya Hill, Kenya, for example, reveals that humans were the primary accumulators of faunal remains at the site, with little evidence of carnivore ravaging (Marean, 1997). A stone tool fragment embedded in the cervical vertebrae of a large bovid from Klasies River, South Africa also contradicts the theory that MSA hunters restricted themselves to docile or vulnerable animals (Milo, 1998). The bovid species in this case was an ancestor to the modern Cape buffalo, which although smaller than its relative at Klasies River, is considered to be amongst the most dangerous of extant African wildlife.

Social Organization

Although MSA humans were conventionally thought to have organized themselves into small, relatively isolated social units, there are indications that MSA people exploited large home ranges and/or participated in long-distance systems of trade. Obsidian found at Nasera, northern Tanzania, for example, comes from quarries 240 km away, while samples from Mumba, Tanzania, have been sourced to outcrops 320 km distant (Mehlman, 1989). This evidence implies that the inhabitants of Mumba and Nasera were either personally traversing these distances required in order to access stone resources, or that goods were traded “down-the-line” rather than transported directly. If items were traded, it is also possible that the exchange of goods was accompanied by ritual or symbolic acts meant to foster the formation of alliances and further interaction (McBrearty and Brooks, 2000).

The formal organization of space is likewise believed to be a product of modern human cognition (Mellars, 1996). The internal structuring of campsites into distinct activity zones is one of the most cited examples of this form of spatial awareness, and is detectable at a number of MSA localities. The vertically superimposed hearths from Klasies River, South Africa, when viewed in section, for instance, demonstrate that the MSA occupants of the site retained a sense of where previous campfires had been, and endeavoured to place them consistently on the same location. Further evidence for built structures from several MSA localities is even more convincing. Post-molds at several sites along the Mediterranean coast indicate the presence of structures, while wind-breaks were found at the Zambian site of Mumbwa (Barham, 1996; McBrearty and Brooks, 2000).

Technology

Most MSA operational chains involved the reduction of simple radial and circular cores to create flake blanks, which were further modified into a variety of scrapers and points (Klein, 2009). Many of these finished tools were then likely hafted by affixing them to shafts of wood or bone, increasing the reach of the implement and force that could be applied (Lombard, 2007). The composite tools of the MSA had a number of advantages over the large handheld tools of the Acheulean, but would have required a high level of regularity in flake shape and size. The necessity for consistent flake morphology is conjectured to have been addressed by the development of complex reduction strategies such as the Levallois technique. Detectable in lithic assemblages as early as the late Acheulean, by 500 ka, the Levallois technique became widespread during the MSA; and is hypothesized to confer added control over the morphology of detached pieces. Firstly, flakes are removed radially around the peripheral edges of the core in order to establish the dimensions of a Levallois flake in the center. Once shaped, a platform is isolated at one end, and the Levallois flake is extracted from the dorsal surface. This flake is then commonly utilized, without further retouch (Sandgathe, 2004; Van Peer, 1992). The Levallois method may be used to produce ovate flakes as well as points and blades. The products of Levallois flaking share recognizable similarities such as a radial dorsal flake-scar pattern and a multi-faceted platform.

Blade industries characterized by thin, parallel-sided flakes were also present during the MSA. Although it is quite common for long, parallel-sided flakes to be produced during the course of knapping, the creation of true blades entails a specific set of steps and strategies. Firstly, a series of longitudinal ridges on the surface of the core are established. These ridges then guide the morphology of further flake removals. Once a series of ridges is formed, blades are typically removed from a single striking platform, resulting in an inverted, cone-shaped core. Although the previous method of blade production is common in the LSA and Upper Palaeolithic, blades may also be produced using different strategies, such as the Levallois technique.

On the basis of technological analyses, the oldest blades derive from two sites from the Kapthurin Formation in Kenya, dating to between 509 and 545 ka (Johnson and McBrearty, 2010). Blades of similar age were also recovered from Kathu Pan 1, South Africa; and are estimated to be approximately 500 ka (Wilkins and Chazan, 2012). Though these sites actually predate the MSA, more recent finds at sites such as Klasies River, Diepkloof, Sibudu, Qesem Cave, and the Kapthurin Formation, Kenya, among others, have also shown that blade industries, which were thought to be a defining characteristic of LSA and Upper Palaeolithic technology, were commonplace in the MSA as well (Bar-Yosef and Kuhn, 1999; Shimelmitz et al., 2011).

The stone tool industries of the MSA are also notable as they are among the first to show patterns of regional variation (Clark, 1988). As of yet it is unclear whether or not these patterns are related to long-term adaptation to particular environments; or if they were produced by emerging, spatially restricted, cultural units. McBrearty and Brooks (2000), for instance, assert that differences in point typology correlated to regional, and perhaps, cultural/ethnic standards of production on a continent-wide scale. They nonetheless warn that attempting to parse out such distinctions on a smaller, more detailed level might not be possible.

Some of these regional variants also contain typologically advanced elements, more emblematic of the LSA. The Howiesons Poort industry, found at several South African sites, is notable for its precocity, consisting in part of small blades as well as backed geometric pieces, similar to those observed in later periods. The initial description of the Howiesons Poort originates from a single occupation site of the same name. It was surmised to be a macrolithic LSA until it was found stratified between typical MSA deposits at other sites such as Klasies River, Apollo 11 Cave, and Border Cave. The systematic dating of Howiesons Poort sites using a number of chronometric methods has resulted in an approximate age of between 70 ka and 60 ka, after which point it seems to have disappeared (Lombard, 2005).

The Still Bay is another MSA industry characterized by sophisticated artifact types. Predating the Howiesons Poort, the Still Bay industry dates from roughly 75 ka to 65 ka; and has been recovered from a number of South African sites such as Blombos Cave (Henshilwood et al., 2001) and Sibudu Cave (Wadley, 2007). The *fossile directeur* of the Still Bay is a form of distinctive and finely worked bifacial point. The Still Bay is also associated with symbolic behaviours such as the use of pigments like ochre (Henshilwood et al., 2001).

Bone Tools

It is unclear why creating bone tools would be beyond the capabilities of most hominins; nevertheless, evidence for the working of bone and horn seems to be concentrated in later chronological periods, namely the LSA and onward. Be that as it may, industrial complexes with bone tool elements were still relatively common in the MSA; and were in evidence prior to their ubiquity in European tool kits by 35 ka (McBrearty and Brooks, 2000). The previously mentioned barbed bone points from Katanda are some of the least contentious examples, which may be as old as 90 ka. The points have been dated consistently by of a number of different chronometric techniques; and come from secure contexts at three different sites, leaving their provenience relatively indisputable. Blombos Cave also appears to have supported a bone tool industry at approximately 75 ka. Included among the 21 bone artifacts recovered there are polished and ground points, as well as awls and other functionally ambiguous tools/ornaments.

Evidence of Symbolically Mediated Culture in the Middle Stone Age

Mortuary Practices

The purposeful inhumation of the dead in contemporary human societies is a particularly symbolically charged activity, often accompanied by ritual and some form of belief in the continuation of personal identity after death. Although the specific meanings of archaeological mortuary practices are difficult, if not impossible to know, evidence of burial practices are a powerful indicator of symbolically mediated culture and beliefs (d'Errico and Henshilwood, 2011). The oldest evidence of purposeful inhumation is found at Jebel Qafzeh, Israel, and dates to 100-130 ka (d'Errico and Henshilwood, 2011; McBrearty and Brooks, 2000); however, further burials have also been found within Africa that predate the MSA/LSA transition. At Border Cave, South Africa, an infant burial, discovered in a deposit containing MSA artifacts, may be the oldest, dated to 60-76 ka (Bird et al., 2003; Millard, 2006). As described by the excavators, the child was buried in a shallow grave and was accompanied by a perforated *Conus* shell (Cooke et al., 1945). The shell may have represented a funerary commodity or offering; though this inference is not certain, given the limited context. There is also evidence from European and Middle Eastern sites to suggest that Neandertals likewise buried their dead, sometimes including engraved stone slabs or bones, as well as tools (d'Errico and Henshilwood, 2011). Alternatively, the symbolic content of these sites has been challenged by those who argue that the burial of Neandertal and modern human individuals need not imply advanced, symbolically-based cognition (Burdukiewicz, 2014; Gargett et al., 1989; Sommer, 1999).

Art

Although any item may potentially store coded, culturally sensitive information, artwork is inherently symbolic, making it an exceptional indicator of modern cognition/behaviour (d'Errico et al., 2005; Wadley, 2001). Arguments in provision of the symbolic interpretation of early forms of art include 1) a lack of clear functional purpose, 2) consistencies in the choice of worked material, 3) the preparation of those materials prior to artistic modification such as engraving, 4) the consistent sequence and ordering of necessary steps, 5) the appearance of regular motifs and patterns, 6) temporal continuity in the production of certain motifs, 7) and similarities in motifs from spatially separate sites (d'Errico and Henshilwood, 2011).

Although artwork is less frequently encountered in the MSA than the LSA, there are still well preserved examples. The earliest widely recognized evidence of artwork, dating to 75 ka, was found in the Still Bay level of Blombos Cave, South Africa; and consists of two piece of ochre incised with a series of lines arranged to form an abstract, cross-hatched pattern (Henshilwood et al., 2002). Similar, although smaller, examples were also found at the site; and date to 70-100 ka (Henshilwood et al., 2009). The authors contend that the unique patterns present on the artifacts are inconsistent with the effects of natural abrasion or utilitarian purposes. Moreover, since this practice seems to have persisted for over 25 ka at the site, and bears similarities to artifactual behaviours identified at other localities, it may be considered part of a widespread tradition (Henshilwood et al., 2009).

In total, 270 engraved ostrich egg-shell pieces were recovered from the Howiesons Poort layer of Diepkloof Rock Shelter, South Africa. The designs, like those from Blombos Cave, are generally linear, featuring cross-hatching and "ladder" designs. Based on the ethnographic study of extant African hunter/gatherers, it is argued that the fragments once constituted storage containers used for transporting water (d'Errico and Henshilwood, 2011). Also, similar to Blombos Cave, there appears to be evidence of temporal continuity in the production of these motifs, as engraved egg-shells are found throughout the sequence, starting at 60 ka.

A painted stone slab found in an MSA context at Apollo 11 Cave, Namibia, perhaps exhibits the clearest signs of artistic intent. The slab depicts a quadrupedal predator, possibly feline; and its discoverers argue that it may be the first evidence of mobiliary art. The dating of associated ostrich egg-shell with amino acid racemization has produced a date of nearly 60 ka; though more conservative estimates using radiocarbon place the age of the slab more recently, at 27 ka (d'Errico and Henshilwood, 2011).

Personal Adornment

Personal adornment is considered to be another important element of behavioural modernity, which has been found in the MSA as well as the LSA. Much like art, personal adornment conveys culturally sensitive information about the wearer within a common symbolic framework (Wadley, 2001). Beads are the most common type of adornment found in the MSA. For example, 49 perforated shell beads were found at Blombos Cave, some of which are stained with ochre, that date to 75 ka (d'Errico et al. 2005; Henshilwood et al. 2004). The shells were perforated through the parietal wall, likely using a bone implement, and a microscopic analysis of the usewear around the bore suggests that they were strung together and worn. Shell beads were also found in LSA layers of the site, but because of the differences between them, it is unlikely that one type could be mistaken for the other. Shell beads stained with ochre have also been recovered at the site of Jebel Qafzeh in Israel dating to 90 ka (Bar-Yosef Mayer et al., 2009). The 10 beads from the site were made using marine shells, collected from the Mediterranean shoreline, 35 km away. Although the perforations are considered to be natural, there are indications that the beads may have been threaded together and worn. Specifically, 4 of the 10 beads display shallow, polished, and abraded notches worn into the perimeter of the bore; features consistent with being strung using a length of fibre. A number of beads recovered from North Africa also considerably antedate the LSA. Discovered in the Grotte des Pigeons in Morocco, several marine shells, perforated and stained with red ochre, were found in association with MSA artifacts (Bouzouggar et al., 2007). Though the agent responsible for the perforations is unknown, the uniform location of the bore on each of the shells is very rare in natural assemblages, suggesting that even if humans were not responsible for creating the holes, they could have been purposefully selecting shells with this specific set of properties. Moreover, the shells were found over 40 km from the shoreline of the Mediterranean, favouring the interpretation that they were transported there by humans. Luminescence and Uranium series dating of the cave deposits has revealed an age of ~82 ka.

Curiously, bead making in Africa and the Near East appears to have undergone several distinct hiatuses and revivals. In particular, the production of beads seems to all but disappear after 70 ka; and is renewed again only later than 40 ka (d'Errico and Henshilwood, 2011). When beads do appear again, they are produced mainly using ostrich egg-shell rather than marine shells (d'Errico and Henshilwood, 2011). The excavations at Magubike, for instance, have revealed some of the oldest ostrich eggshell beads so far recovered, which are likely around 50 ka (Miller and Willoughby, in press).

Pigment Use

The presence of pigments in archaeological assemblages is often interpreted as a proxy for symbolic, and therefore, modern behaviour, with regular pigment use beginning in the African MSA at about 160 ka (Marean et al., 2007) and perhaps dating to as early as 280 ka (in the Kapthurin Formation, Kenya) (McBrearty and Brooks, 2000). However, the potential of pigment to indicate symbolic behaviour is disputatious for a number of reasons. On one hand, since colourants such as red and yellow ochre are contemporarily valued for their appearance, it is possible that past people, similarly appreciating this feature, used this substance to dye a variety of items such as clothes, bodies, or other adornments. Evidence of the use of pigments in this fashion includes a number of shell beads recovered from Blombos Cave and the Grotte des Pigeons that are stained with red ochre (Bouzouggar et al. 2007; d'Errico et al. 2005; Henshilwood et al. 2004). It is also suspected that ochre was used as body paint, although this use is more difficult to confirm archaeologically (Marean et al., 2007; Zilhão et al., 2010). Conversely, pigments such as ochre may be used in a number of utilitarian ways (Wadley, 2001). For example, ochre has been found to be an important mastic agent when used in combination with other ingredients, to affix stone tools to handles of bone or wood. Using a collection of Howiesons Poort artifacts dated to 60 ka, Lombard (2007) detected several instances of ochre and other residues present on the backed or butt ends of stone tools, consistent with known hafting practices. Other studies of ochre have also proven its usefulness as sunscreen, medicine, and insect repellent (Wadley, 2001). All or none of these properties may have attracted early humans to the substance. Lombard (2007) nevertheless contends that people's initial interest in ochre may have been utilitarian; but that its importance in this role may have led to its use for symbolic reasons, or that it was valued equally in several symbolic and utilitarian roles.

1.3 The Archaeology of The Later Stone Age

The LSA succeeded the MSA in sub-Saharan Africa somewhere between 50 and 30 ka, lasting until the appearance of farmers or pastoralists in the Neolithic and/or Iron Age. Depending on the location, the LSA persisted until as recently as 3,000 years ago (eg. in the southern part of East Africa), or into the ethnographic present (eg. the San in southern Africa). The LSA is characterized by a number of novel technologies and advanced archaeological behaviours that emerged or became widespread after 50 ka. Among these, LSA people began crafting more elaborate and sophisticated tools such as blades and microliths with greater frequency; and the materials that they employed expanded to include higher quality stones as well as bone, shell, and ivory with greater regularity. The emphasis on high quality materials often necessitated travel over larger distances than before, sometimes hundreds of kilometres, in order to access lithic resources. The long-distance transportation of lithic materials suggests either large home ranges and considerable landscape knowledge, or the existence of complex social networks and down-the-line trade (Klein, 2009). LSA people also appear to have altered their subsistence strategies to incorporate a wider range of resources, both plant and animal, terrestrial and aquatic, allowing them to subsist in a wider range of environments. Lastly, there is more evidence of art, personal adornment, and ritual practices. These signs of behavioural modernity are often associated with the intensification and exportation of individual and group identity (Klein, 2008; McBrearty and Brooks, 2000).

In general, the lithic industries of the LSA exhibit an increase in typological diversity from the scraper and point industries of the MSA. While blade production is traceable to as early as 500 ka (Johnson and McBrearty, 2010; Wilkins and Chazan, 2012), an important amplification of this technology occurred during the LSA (Clark, 1969; Shea, 2013). This use of stone is thought to be highly efficient, providing a longer functional edge than traditional flaking techniques; although this interpretation has been questioned (Eren et al., 2008). A common method of implementing blades in the LSA was to truncate or "back" them to make them more amenable to hafting or prehension. This practice involved retouching sharp edges away until they were nearly 90 degrees, effectively blunting them. Along with blades, common LSA tool types include a wide range of scrapers and engraving tools (Klein, 2009).

1.4 The First Behaviourally Modern Humans

Though the meaning of "modern behaviour" remains problematically ill-defined, it is typically recognized by two, complementary lines of evidence. The first, and likely the more important, is the "capacity to attribute specific meaning to conventional signs" (d'Errico and Henshilwood, 2011, p. 50) - to think symbolically. Though this facility is shared by a number of non-human animals, what makes this attribute unique in humans is the further ability to generate symbols with shared social meanings, capable of conditioning the actions of others (d'Errico and Henshilwood, 2011). Archaeologically, this capacity is believed to be demonstrated by the creation of art, personal adornment, and ritual artifacts. Secondly, modern behaviour is characterized, more diffusely, by the ability to conceive and implement novel, complex, and flexible technological and social adaptive strategies. Archaeological support of this aspect of modern behavior includes a list of traits such as an increased environmental awareness, the deployment of advanced resource procurement strategies, the production of technologically sophisticated artifacts, and engagement in trade and exchange.

Disagreement over what precisely is meant by modern behaviour has made it difficult to determine how and when in time it evolved and why. Nevertheless, many now believe that behaviourally modern traits accumulated slowly, in a piecemeal fashion, due to natural processes of innovation and transmission, potentially stimulated by the convergence of changing demographic, social, and environmental conditions during the late Pleistocene (McBrearty and Brooks, 2000). What remains to be known in any detail is how these factors interacted to impact human behaviour, and what the pace and manner of this change was. Conversely, there is a minority who assert that this transformation occurred abruptly at 50 ka, in synchrony with the beginning of the LSA, due to rapid cognitive evolution that fundamentally changed the structure of the human brain (Evans et al., 2005; Klein, 2008).

Genetic/Cognitive Explanations for Modern Behaviour

Rapid cognitive evolution has been the most outspokenly supported by Klein (2009, 2008, 1995, 1992), who advocates for what is called the “neural hypothesis”. He maintains that the transition from the MSA to the LSA can be best explained by a structural shift in the physiology of the brain, caused by a “fortuitous mutation” which produced a significant improvement in cognitive abilities (Klein, 2008, p. 271). Klein does not deny that evidence of behavioural modernity occurred much earlier in the archaeological past; but argues that if symbolic culture did exist prior to 50 ka, it was then only weakly and infrequently articulated. In addition, Klein (2009) considers much of the modern material antedating 50 ka to be of earlier provenance and association, and therefore unreliable.

Possible proximal causes of Klein’s fortuitous mutation include a change to FOXP2, a gene which in humans is associated with language faculty. Research into the gene has shown that it underwent a series of mutations thought to be related to the production of modern speech abilities around 40 ka (Enard et al., 2002; Fisher and Ridley, 2013). Since many have theorized that complex language plays a direct role in structuring and directing human cognition, the sudden activation of FOXP2 at 40 ka would have represented a substantial adaptive advantage over other human species, including contemporary *Homo sapiens* who lacked the new form of the gene. (Klein, 2009; Wadley, 2001). More recent work on decoding the Neandertal genome however, has revealed the presence of an identical form of FOXP2 in these humans as well, suggesting that it was extant in the common ancestor of *Homo sapiens* and *Homo neanderthalensis* (Krause et al., 2007).

A mutation of the gene *Microcephalin*, known for its role in regulating brain-size, has also been offered as the basis for behavioural modernity. A study by Evans et al. (2005) demonstrated that at about 40 ka a variant of this gene underwent significant positive selection in human populations, increasing at a frequency unexplainable by chance mutation or genetic drift. Though what precisely was being selected for in order to disperse this gene, or what its effects on cognition would have been, is unknown, the authors suggest that it might be associated with the behavioural florescence that took place ~50 thousand years ago.

Social/Demographic and Climatic Explanations of Modern Behaviour

Novel discoveries, such as those discussed in the section on MSA archaeology, and the renewed dating of existing archaeological materials, have led most researchers to affirm that behaviourally modern traits accumulated non-synchronously early on in human evolution (McBrearty and Brooks, 2000). The independent addition of new behaviours in the MSA and LSA is believed to have been the product of normal processes of discovery and innovation without requiring a genetic catalyst (McBrearty, 2013). It is now believed that symbolic culture was present in Africa by 150 ka, in the Near East as early as 100 ka, and in Europe by 60 ka (d'Errico and Henshilwood, 2011). In addition to symbolically mediated behaviour, many adaptive strategies and technologies thought to be hallmarks of the European Upper Palaeolithic and African LSA have been identified in the preceding MSA as well. Moreover, these traits do not appear in the archaeological record synchronously, as part of a complete package. Rather, there appears to be major discontinuities in the transmission of cultural data, with these behaviours surfacing and disappearing at multiple points during the MSA (McBrearty and Brooks, 2000). There is also growing evidence for modern symbolic behaviour among Neandertals, an observation which substantially challenges the behavioural and genetic uniqueness of modern humans (Zilhão et al., 2010).

Demography

A number of authors have proposed that the effects of demographic expansion and contraction during the MSA would have had widespread impacts on how people organized their subsistence and social activities, most notably on the formation and maintenance of complex culture (Forster, 2004; Forster et al., 2001; Powell et al., 2009; Watson et al., 1997). McBrearty and Brooks (2000), for instance, argue that population pressure caused by an increase in population density was responsible for the diversification and intensification of resource acquisition practices in the MSA and LSA, as favoured sources of food and materials became scarcer or were subject to competition from other human groups. Attempts to ameliorate this pressure included exploiting previously un-accessed resources, and making more conservative use of those that were still accessible. In fact, many of the hallmarks of advanced behaviour, such as changes in lithic technology and land-use behaviour, can be understood as responses to scarcity and stress (Henshilwood and Marean, 2003). As an additional consequence of rising population density, communities found themselves in more frequent contact than before. This situation is claimed to have produced a rise in symbolically mediated behaviour as humans devised new systems to proclaim individual and group identities, and to forge relationships and alliances (McBrearty and Brooks, 2000).

Others have remarked on the role that demographic elements likely had on the initial development and subsequent communication and preservation of cultural complexity (Henrich, 2004; Powell et al., 2009). Simply, a larger pool of potential innovators is more likely to produce technological advances than a smaller group. Similarly, the chance of ideas being successfully transmitted and continued through time is higher when a large number of people are capable of reproducing it. Demographic modeling has confirmed this concept, at least hypothetically; although further work correlating these results with estimated population records is required to fully advance this hypothesis (Powell et al., 2009).

Climate

While demography provides a powerful explanation for the appearance and continuation of modern human behaviour, supplemental mechanisms must be supplied in order to account for changes in demography (Klein 2009). As a result, demography and climate are often understood as tandem processes, with climatic factors influencing human ones (Blome et al., 2012; Forster, 2004; Hetherington and Reid, 2010; Lahr and Foley, 1994; Oppenheimer, 2003; Stewart and Stringer, 2012; Stringer, 2000).

This hypothesis is further confirmed by paleoclimate records globally and from the different regions of Africa specifically. At the start of the Pleistocene, the periodicity of glacial cycling changed dramatically. From that point on, quickly vacillating intervals of warm and cold dominated the next 2.6 mya until present (Raymo and Huybers, 2008). Germane to the evolution of modern humans, conditions around 70 ka appear to have deteriorated quickly as a result of a series glacial episodes, coinciding with the appearance of many new and advanced human behaviours (Ambrose, 1998; Blome et al., 2012; Lane et al., 2013). Changes to population pressure would have been the primary effect of fluctuating climatic conditions, but these same changes may also have presented unique opportunities for human migration. Sea level drop at the mouth of the Red Sea, for example, might have provided a route for modern humans making their way into the Arabian Peninsula (Armitage et al., 2011). Similarly, evidence for ephemerally forming rivers in the Sahara desert during interglacial periods would have presented modern humans with corridors across what is a now a formidable geographic barrier (Drake et al., 2011; Osborne et al., 2008).

Critics of the demography/climate model note that contrary to expectations, as signs of advanced behaviours were emerging in Africa, human populations seem to have been declining, not expanding (Klein, 2009). While true, an increase in population pressure results not only from demographic growth but by a decrease in resource availability, such as that resulting from glacial climate. As conditions worsened over the last 70 ka, people may have been concentrated into refugia, the effect of which would have been an increase in population density despite an overall decline in human numbers (Stewart and Stringer, 2012; Willoughby, 2012).

Behaviourally Modern Neandertals

There are also indications that, behaviourally, Neandertals did not differ substantially from modern humans; and that they may have experienced a symbolic, social, and technological florescence of their own. This fact has not only changed how Neandertal behaviour is studied;

but has shifted the discussion of behavioural modernity in modern humans away from genetically contingent models, and towards socio-demographic ones (Zilhão et al., 2010).

For the better part of the time that Neandertals have been studied, it was believed that they were fundamentally incapable of generating behaviour similar to modern humans. The difference is thought to be evident in the relative disparity in sophistication between Neandertal and *Homo sapiens* archaeological assemblages, and by their differential evolutionary success - the final result of which was the eventual extinction of the former group (Banks et al., 2008). Given the differences in the behaviour and anatomy of Neandertals and modern humans, authors such as Klein (2009) have argued that these populations probably differed substantially on a genetic level as well; the immediate, and most significant, effects of which had to do with cognitive capacity and language. The concept of the close merging of Neandertal biology and behaviour has further implications for the study of *Homo sapiens*. In particular, as MSA people shared many behavioural characteristics with Neandertals, the door was opened for comparison, with scholars such as Klein (2009) claiming that MSA people were most likely genetically and therefore cognitively deficient as well.

The genetic distinctiveness of modern humans and Neandertals is not supported by recent DNA research, however; and the presence of Neandertal genes in the coding regions of modern human cells provisions the hypothesis that viable interbreeding was not only possible between these taxa, but that it produced fertile offspring (Green et al., 2010). On the basis of these findings, it seems unlikely that the respective genomes of Neandertals and moderns contributed significantly to differences in their behaviours and evolutionary success. “Whatever adaptive advantage early modern human biology may have conferred, it was extremely subtle and was frequently overridden by other pressures.” (Trinkaus, 2013, p. 400). Klein (2009) nevertheless argues that some genes, like FOXP2, may only be active and therefore expressed in the presence of other genes that were potentially lacking in Neandertals. Similarly, he maintains that the physiology of Neandertal vocal tracts was ill-suited for the production of speech sounds, even in the event that they retained the necessary genes for sophisticated language. Moreover, Klein (2009) is optimistic that further research into the Neandertal genome will find that vital genes responsible for advanced cognition or language will be found absent.

In addition to DNA research, archaeology has proven to be a valuable tool with which to approach this issue. Of these materials, a number of Châtelperronian assemblages (first named at la Grotte des Feés, Châtelperron), found at the sites of the Grotte du Renne and Saint-Césaire in France, are perhaps the most famously debated. In association with Neandertal remains, these sites contain typologically advanced artifacts such as bone tools and pendants closer in style to the modern human (Aurignacian) layers stratified above them. Regardless, the stratigraphic integrity of the sites is questionable; and it is possible that these items were found in a secondary context, having migrated from higher in the sequence. As these localities were excavated early in the 20th century, it is also possible that proper archaeological controls were not exercised; and the excavation resulted in the accidental mixing of cultural materials from Aurignacian levels. Lastly, it is possible that the characteristics of European Neandertal assemblages were influenced by interface and acculturation with modern human groups living in the region contemporaneously.

Two major papers have attempted to resolve this issue by chronometrically dating the Châtelperronian material from the Grotte du Renne. Higham et al. (2010) focused on radiocarbon dating the modified bone ornaments and personal adornments, of suspected Aurignacian origin, from Châtelperronian level X, in an attempt to determine the original association of the artifacts.

The range of dates they calculated was both extremely varied and in some cases overlapping, indicating a high degree of stratigraphic mixing and calling into question the Neandertal origin of the finds. In contrast to their findings, they provide an age for a bone awl concomitant with a lower, Neandertal occupied level, dated to approximately 38,100 ± 1,300 BP. Higham et al. (2010) remark that although the awl is culturally non-diagnostic, its presence low in the stratigraphic sequence would imply that Neandertals were fabricating bone tools, an Upper Palaeolithic trait, well before the arrival of modern humans into the region.

More recently, Hublin et al. (2012) attempted a similar project to determine the stratigraphic reliability of the Châtelperronian levels at the Grotte du Renne using radiocarbon dating. In contrast to earlier findings by Higham et al. (2010), the dates obtained by this study demonstrate only nominal intrusion and mixing. Hublin et al. (2012) suggest that this disparity in age estimates may have resulted from the incomplete decontamination of samples and the use of poor sampling methods by their predecessors. Moreover, as previous research emphasized the dating of ornaments and other modified bone artifacts, there may have been less datable collagen preserved in the cortical bone of these samples compared to the unmodified bone that they used. Though they conclude that Neandertals were responsible for the Châtelperronian artifacts at the Grotte du Renne, Hublin et al. (2012) also estimate that these layers post-date the arrival of behaviourally modern humans in neighbouring parts of the region. The timing of events indicates that cultural ideas were likely transferred from early modern humans to Neandertals by a process of acculturation. Although borrowed from their modern neighbors, the ability of Neandertals to integrate foreign cultural concepts and technology into their own may be a reflection of their advanced cognitive capabilities.

Additional evidence of modern Neandertal behaviour is found in other parts of the Old World as well. Douka and Spinapolice (2012), for example, report on a series of sites from the Italian and Grecian coasts that reveal evidence of shell tools used by Neandertals. The finds date to a period when the use of marine resources was rare, even for modern humans. Nonetheless, excavators noted over 300 shell tools with visible retouch and use-wear, dated to approximately 110 to 50 ka. The shell tools are reported to have been produced quite predictably on a single species of shell, *Callista chione,* a pattern which might suggest some degree of selectivity. The tool types produced using shells were typical of the Neandertal tool kit, with the shell scrapers resembling those rendered more commonly on lithic materials. This shift in tool materials is interpreted as an adaptation to scarcity, which resulted from preferred lithic sources becoming depleted or inaccessible. In support of this hypothesis is the presence of exotic, non-local lithic materials in conjunction with the shell scrapers (Douka and Spinapolice, 2012). The presence of these materials indicates either that these Neandertals occupied a very large home ranges in order to exploit lithic resources, or that members of the community were integrated into long-distance networks of relationship and trade. Both of these scenarios demonstrate that Neandertals were engaged regularly in higher order mental tasks, involving the application of prognosticative and social reasoning.

Materials from two Middle Palaeolithic cave sites in Spain (Cueva de los Aviones and Cueva Antón) also indicate that Neandertals engaged in symbolically mediated behaviour (Zilhão et al., 2010). Specifically, the excavators recovered perforated and pigment stained shells, thought to be body ornaments, in addition to shells potentially used as “paint cups”. What is exceptional is that the artifacts date to 50 ka, nearly 10 thousand years before modern humans are thought to have entered into northern Spain, a fact possibly representing a species-independent origin for symbolic behaviour. While Zilhão et al. (2010) recognize that ochre is a common adhesive component, they note that the substance is not found on tool surfaces as one might expect if it were being used to haft lithic implements.

When taken together, studies of Neandertal behaviour demonstrate that "modern" behaviour is much older than the LSA and that it is not necessarily restricted to *Homo sapiens.* Furthermore, the behavioural similarities between Neandertals and coeval Africans has shifted explanations of modern human behavioural origins away from genetic/cognitive models and towards social/demographic ones (Zilhão et al., 2010).

1.5 Definitional and Theoretical Criticisms of Behavioural Modernity

While the origins of modern behaviour have divided scholars, there is also concern regarding the continued use of the concept of modernity to reconstruct the human past. Specifically, what is the nature of modernity, what defines it, and how might it be detected archaeologically (Stringer, 2002)?

These issues are partially rooted in the history of scholarship on the topic. As most early research concerned the prehistory of Europe, owing mainly to the geographic appointment of scholars there, the definitions and models used to classify modern behaviour have tended to emphasise the archaeology of the European Upper Palaeolithic. When scholars began to form interests in places outside of Europe, the models that were derived from European culture-history were inappropriately transposed to other regions of the world, resulting in interpretive problems that continue to plague modern human origins research in places like Africa, Asia, and the Near East (Henshilwood and Marean, 2003).

Secondly, the “laundry list” definition of behavioural modernity that has emerged comes with the tacit proposition that modern traits appeared as part of a complete package. Discoveries in the last decade and a half, however, have shown that the traits that compose this list are better understood to have emerged independently and non-synchronously (McBrearty and Brooks, 2000). Furthermore, needless confusion has arisen because there is no agreed-upon measure of how modern attributes weigh against each other in terms of their relative evolutionary significance. Should evidence for blade production be considered more emblematic of modern behaviour than the use of pigments; or, how many traits in aggregate are required before an assemblage can be considered modern?

Thirdly, research into behavioural modernity is complicated by the antiquity and often poor preservation of the collections germane to this period. Purely as a function of time, the assemblages of the older MSA are expected to be fewer and less well preserved than the more recent LSA. With fewer materials preserved, the almost inevitable interpretive consequence is that MSA peoples were less behaviorally advanced than humans from later periods. This concept may be further reinforced by the desire to view history and nature as a lineal progression of ever increasing sophistication and complexity. For example, the production of tools using perishable materials such as wood and bone has been used to signify modern behaviour despite the susceptibility of these materials to degradation due to time and burial environment. Since it is not reasonable to expect these items to survive in the ground for several hundred thousand years, it ought to be equally unreasonable to suggest that their absence in older archaeological sequences was because the humans of that time did not, or could not, make them. While incomplete and missing data are an inescapable part of archaeology, archaeologists must strongly consider the most likely impact of missing data on the conclusions they form. In particular, it is important to deliberate critically on the easy conclusions that might result from natural taphonomic processes.

Lastly, concern has been expressed regarding the ability of many archaeological traits to unambiguously, and robustly, indicate modern cognition/behaviour (Henshilwood and Marean, 2003). In the case of subsistence-related indicators, such as fishing or the exploitation of seasonal resources, many can be suitably, if not more parsimoniously, explained by changing ecological and demographic factors than by a newly evolved awareness or capacity (Stringer, 2002). Moreover, as these traits can be related to the intensification of resource exploitation, it is improbable that they would be expressed under benign condition such as the early MSA. Other "modern" archaeological attributes have been targeted for lacking strong theoretical support. The suggestion that adhering to a seasonal pattern of mobility is symptomatic of modern cognition, for example, is especially problematic. Not only is seasonal landscape use diversely expressed in hunter-gatherers of the present-day and more recent past, but many animals also migrate in response to the changing of the seasons (Henshilwood and Marean, 2003).

Suggestions as to how to proceed have emphasised an increased focus on the evolution of symbolic behaviour (Henshilwood and Marean, 2003), the abandonment of the concept of modernity in favour of investigating the individual causes of archaeological variation (Shea, 2011a, 2011b, 2011c), as well as the application of theory derived from human behavioural ecology (Clark, 2009; Stringer, 2002).

Chapter 2 Site Description and History of Excavation

2.1 Field Work

2005 Exploration

Initial exploration of the area around the town of Magubike in southern Tanzania was undertaken by Dr. Pamela Willoughby in the summer of 2005. With the assistance of the District Cultural Officer for Iringa Rural, Joyce Nachilima, several rockshelters, including Magubike and Mlambalasi, as well as potential open air localities were recorded. Artifacts were found on the present surface at Magubike Rockshelter, but were not collected until the following year when a research permit was obtained for Iringa. They comprised lithic, ceramic, and faunal materials, in addition to iron slag and ceramic fragments of an iron furnace. Further artifacts were found on the surface of a farmer's field near the shelter. These were of similar composition to those found in the rockshelter, and were thought to indicate the presence of a secondary site; however, the excavation of test-pits in the fields surrounding the main site in the following years failed to yield further archaeological materials.

Magubike Rockshelter is a large granite overhang located at 7º45.790'S, 35º28.399'E near the village of the same name. The site is situated at 1541 meters above sea level, and overlooks a nearby farmer's field. The main site under the rockshelter was designated HxJf-01using the Standardized African Site Enumeration System (SASES) while the potential open air site in the fields below the shelter was given the designation HxJf-03. See Appendix III for pictures and maps.

2006 AND 2008 EXCAVATION

Preliminary excavations at Magubike Rockshelter were carried out in 2006, and included the collection of surface finds. During this season, three test-pits (Test Pits 1 to 3) were excavated within the shelter in order to test the extent of the cultural presence at the site. Further excavations were conducted outside the shelter (Test Pits 4 and 5; Hxjf-03 Test Pits 1 to 3) in 2008 with the intention of determining the spatial limits of the site. A survey of the surrounding terrain was also undertaken in 2008 with the aid of topographic and geological maps in an attempt to locate potential raw material sources. Although no quarries were identified, it is likely that a large percentage of the lithic materials were local, having originated from nearby streambeds no more than 10 km from the site.

2012 EXCAVATION

The most recent field work at Magubike took place during July and August of 2012, directed by Dr. Pamela Willoughby. Other members of the team included Pastory Bushozi, Anne Skinner, and Frank Masele, as well as a number of undergraduate students from the University of Dar es Salaam. Over the course of the season seven new excavation units were placed (Test Pits

6 to 12) in the main shelter near Test Pits 2 and 3 from 2006. Levels were excavated in arbitrary 10 cm levels (due to poor stratigraphic resolution) using trowels, and the sediment was screened by hand in large basins. A plan drawing was created for every 10 cm level, and upon the completion of each excavation unit a wall profile was drawn to record the stratigraphy (Figure 2.2). The nature of the matrix was also recorded for each level, and soil samples were taken.

The artifacts underwent a cursory process of sorting on site; and were classified as lithic, ceramic, faunal, bead, shell, slag, or iron; after which they were bagged and labelled. They were later washed and more formally sorted off-site. The artifacts are currently on loan from the Division of Antiquities, Ministry of Natural Resources and Tourism, Government of Tanzania; and are stored at the University of Alberta under the supervision of Dr. Willoughby. Once brought to the University of Alberta, the lithic artifacts were subject to a further round of cleaning which involved a vinegar bath in an attempt to remove concretions adhered to the surface of much of the material, as well as immersion in a sonic cleaner. They were then labeled with their respective SASES designation, level, excavation unit, and catalogue number. Finally, the artifacts were classified according to Mehlman's (1989) typology; and a number of metric and non-metric attributes, described in Chapter 3, were recorded. The typology developed by Mehlman for his doctoral thesis has become a standard means of communicating lithic data in Tanzania and his classification methodology was adopted for this reason.

During excavation, a similar cultural sequence to that of Test Pit 3 was observed across most of the site. In general, the top ~50 cm contained historic and Iron Age lithics, ceramics, and faunal remains, as well as furnace fragments and iron slag. Below the Iron Age in some parts of the site was a LSA component; then, between ~50 cm and the base of the profile at around 200 cm, the cultural materials were diagnostic of the MSA.

TEST PIT 12

Test pit 12 was the last excavation unit to be placed during the 2012 field season, and contained the materials that were studied for this thesis. It reached a depth of 200 cm, at which point the bedrock was contacted; and contained historical, Iron Age, and MSA archaeological layers. Included amongst these layers were lithic artifacts, faunal remains, ostrich eggshell beads, land-snail shells, slag, furnace fragments, human fossils, and pottery. The abrupt transition between the MSA and the Iron Age without an intervening LSA would seem to indicate an occupational hiatus. However, several ostrich eggshell beads dated to ~45-50 ka point to a LSA presence in Test Pit 12, similar to adjacent units (see samples 1 and 2 from Table 2.3). A likely explanation for the apparent absence of the LSA is that it is mixed with, and occluded by Iron Age materials that have infiltrated down through the sediment. Due to the similarity in the lithics of the LSA and Iron Age, further work is required to differentiate these assemblages. Table 2.1 describes the contents and cultural affiliation of each level in more detail.

The excavation of Test Pit 12 was conducted in arbitrary 10 cm levels. However, due to an accident, levels 110 – 130 cm and 180 – 200 cm were overshot; and thus were twice as deep as the remaining levels. Furthermore, in order to determine the extent of a pit of yellow ochre between the depths of ~20 and 40 cm, the feature was pedestalled and then later excavated once the surrounding sediment was removed. This process resulted in a separate level comprised of the sediment from the pit, labelled as: “yellow ochre feature”. Similarly, an Iron Age furnace feature cross-cut the top 50 cm of the unit; and was excavated separately, gaining its own level designation in the process.

Soil samples were taken at each 10 cm level; and after the completion of the unit, the wall profile was further divided into six main sedimentary units. The colour of each of these units was described using a Munsell colour chart, the results of which are summarized in Table 2.2. Pictures of Test Pit 12 can be found in Appendix III.

2.2 Dating of the Site

Radiocarbon

In 2006, two samples of land-snail (*Achatina*) shell were taken for radiocarbon dating in order to establish the antiquity and continuity of the cultural sequence at Magubike. The shells used for this purpose came from Test Pit 3, from layers 20 - 30 cm and 130 - 140 cm, respectively. The uncalibrated ages show that the snails from 20-30 cm dated to approximately 2,990 ± 60 BP (TO-13422) and those from 130-140 cm to 41,790 ± 690 BP (TO-13423). Further AMS dates were obtained on snail shells from Test Pit 12 in 2012. The sample taken from level 20-30 cm dated to 4,477 ± 32 BP (OxA-27438), approximately 1,500 years older than the age estimate of the same level in Test Pit 3. The specimen from level 60 – 70 cm was dated to 49,200 ± 900 BP (OxA-27439); while the snail shell from below it in level 90 – 100 cm was younger, dating to 47,550 ± 700 BP (OxA-27440).

The reversed ages in Level 60 – 70 cm and Level 90 – 100 cm is likely attributable to the burrowing habits of *Achatina,* which habitually migrates into the sediment of rockshelters to estivate. Therefore, any dates obtained using this method must be considered a provisional minimum age for the deposit from which the snail shell samples originated. As we cannot determine to what depth the snails infiltrated before expiring, these dates are almost certainly out of sequence to some degree. Additionally, it is important to consider that radiocarbon dates become less reliable as they approach ~50 ka. Nevertheless, the dates serve to confirm the general antiquity and chronology of the site.

Three ostrich eggshell beads from Test Pit 12 were also directly dated using AMS radiocarbon, the results of which are presented in Table 2.3. The beads are much older than similar specimens from other sites; and are potentially the oldest currently known, at around 50 ka (Miller and Willoughby, in press). As visible in Table 2.3, the non-sequential dates of several of the beads suggest that they were likely vertically displaced in the sediment to some extent. For example, beads from layers containing Iron Age pottery and slag in Test Pit 12 dated to approximately 50 ka, closer to the established LSA chronology. This instance is a likely a sign of post-depositional disturbance, or an archaeological palimpsest, which may have formed as a result of a low rate of sedimentation in the shelter (Bailey and Galanidou, 2009). Although probably out of sequence with the Iron Age, the ages of the beads in Test Pit 12 point to a LSA component, similar to the ones in adjacent units, obscured by Iron Age materials which have migrated downward in the sediment.

Optically Stimulated Luminescence

In order to reconstruct the chronology of the site, a number of different chronometric techniques were employed. Among them, optically stimulated luminescence or OSL was used to determine the last time that sediment samples were exposed to sufficient radiation to free the electrons trapped within the lattice network of individual sediment grains. For buried sediments, this radiation source is most often sunlight, so the dates provided by OSL represent the last time, before the present, that a particular layer of sediment was left exposed to the surface. Sediment samples were taken for dating from Test Pit 12 at 25 cm, 55 cm, 97 cm, 132 cm, 163 cm, and 194 cm below the present ground surface. The samples are currently being processed by Dr. James Feathers at the University of Washington, and the results are expected soon.

Electron Spin Resonance

The third chronometric method that was attempted was electron spin resonance or, ESR, performed by Dr. Anne Skinner of Williams College. Electron spin resonance quantifies the amount of natural radiation that a particular type of material has absorbed, since its formation, from the surrounding burial environment. For the purpose of ESR, teeth are one of the most easily datable materials; but mollusk shells, such as those in Test Pit 12, may also be used. The preliminary dates derived from mammal teeth are presented in Table 2.4, showing a degree of stratigraphic coherence across the excavation units that were sampled. Conversely, the dates obtained from the snail samples could not be meaningfully correlated with depth, likely for the reasons described above (i.e., the snails almost certainly had burrowed into the deposits from above). It is probable, given the teeth dates, that the oldest occupation of the site began around 250 ka and was sustained, semi-continuously, until the historical period.

Despite tentative successes using ESR, there are still a number of chronological inconsistencies, such as inversed stratigraphic units and pronounced disparities between the ESR and AMS radiocarbon dates from both snails and ostrich eggshell beads. In general, however, the chronology of Magubike demonstrates a satisfactory degree of coherence.

2.3 Paleoclimatic Reconstruction

While climate and environment do not necessarily determine behaviour, most archaeologists agree that these factors contribute substantially to the choices made by human populations; in particular, people who rely on hunting and foraging (Blome et al., 2012). It is therefore no surprise that the climate of Africa during the MSA and LSA has been thoroughly investigated as a root cause of behavioural change (Marean et al., 2007; McCall, 2007). For instance, many have hypothesized that changing conditions, including increased aridity and lower temperatures, initiated range expansions and contractions, as well as regional migrations such as the archaeological abandonment of northern and southern Africa, at around 60 ka (Ambrose, 1998). However, it is important to recognize that climatic events, like aridification, had different local impacts dependent on the type of environment already present. The thinning of wooded areas in tropical Africa during glacial periods, for example, may actually have made these areas more attractive to foraging humans, while other areas, such as marginal ecotones along the borders of the Sahara, may have been made uninhabitable (Blome et al., 2012). Moreover, different regions of Africa experienced dissimilar and asynchronous climate regimes over their respective histories. So, while southern and northern Africa were depopulated over the last 70 ka, East Africa likely experienced a comparatively muted response (Basell, 2008).

On a smaller scale, certain regions of eastern Africa are especially well known for their environmental continuity, including the study area around Magubike. The Eastern Arc Mountains in Tanzania and Kenya, ~40 km to the east of Magubike, are well-renowned as a biodiversity hotspot, supporting a wide array of plant and animal species (Finch et al., 2009). Moreover, it is hypothesized by Finch et al. (2009) that climate stability was a key factor in creating the present conditions. In order to test this assertion, two separate projects drilled sediment cores from sphagnum bogs located in the Tanzanian extent of the Eastern Arc Mountains (Finch et al., 2009; Mumbi et al., 2008). By identifying the pollen grains in the samples and comparing the pollen types to existing ecosystems, the researchers were able to reasonably predict the genera and species that existed there in the past, and in what proportions. Samples of the core were also dated using radiocarbon in order to provide a temporal record of environmental change.

The results obtained from these cores were mutually supportive, indicating long-term climatic stability since at least ~48 ka, and even during a 20 thousand year envelope encompassing the Last Glacial Maximum (approximately 20-18 ka). The constancy detected in the cores is notable even with respect to other mountainous areas in East Africa, and the surprising retention of tropical and temperate forest during the Last Glacial Maximum is likely due to the moderating influence of the Indian Ocean. Although the paleoclimatic records produced by this research do not extend back to the initial occupation of Magubike, they give reason to suspect that the area remained stable over other periods of aridity such as those that characterized the past 150 ka in Africa, when modern human behaviour was evolving (Blome et al., 2012). Since others have noted that many of the behaviors of the LSA can be interpreted as responses to scarce food, water, and lithic resources, Magubike may provide a rare case to observe how Palaeolithic humans made use of localized refugia; and to observe the extent to which adaptations to population and environmental stress are present (Henshilwood and Marean, 2003)

Figure 2.1. Planform Representation of Magubike (created by Frank Masele).

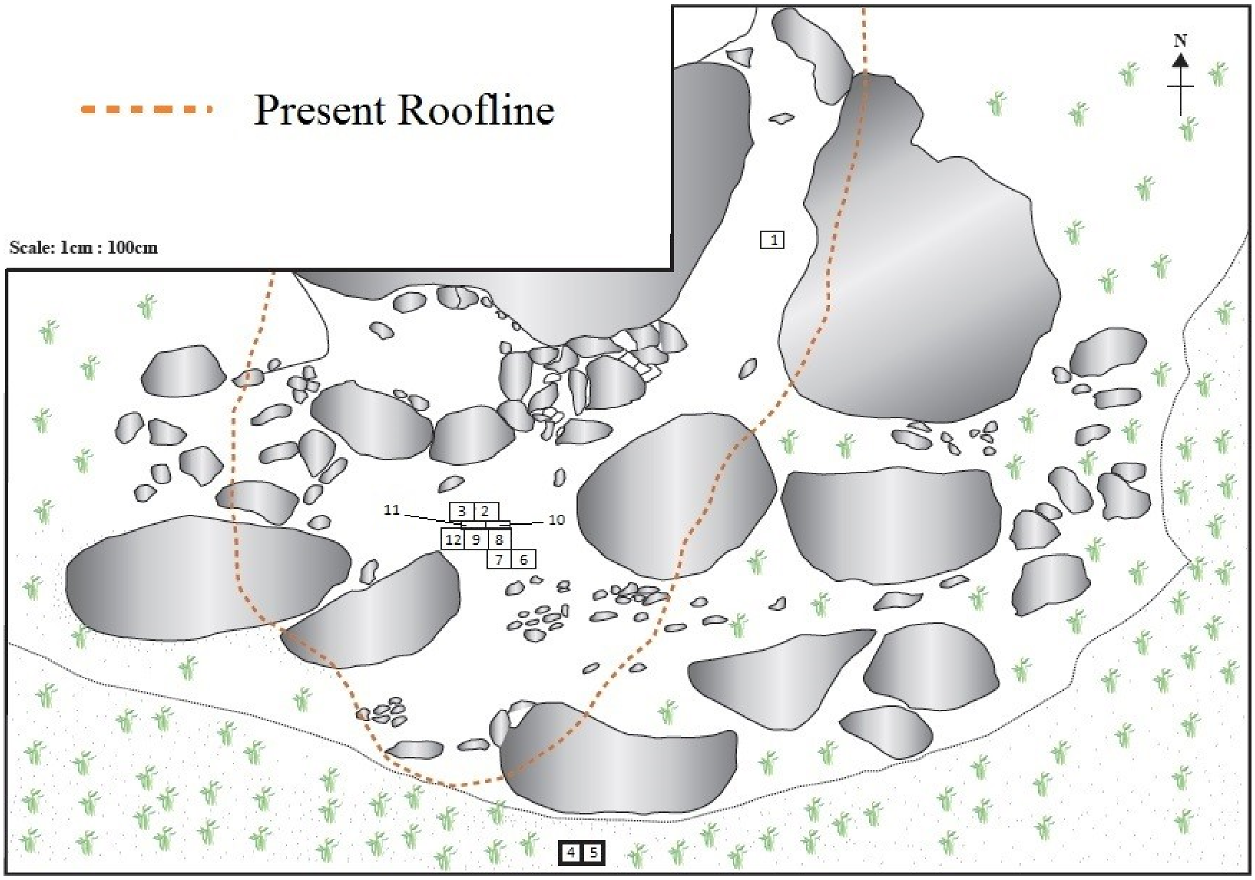


Figure 2.2. Stratigraphic Profile of Test Pit 12 (created by Jennifer Miller).

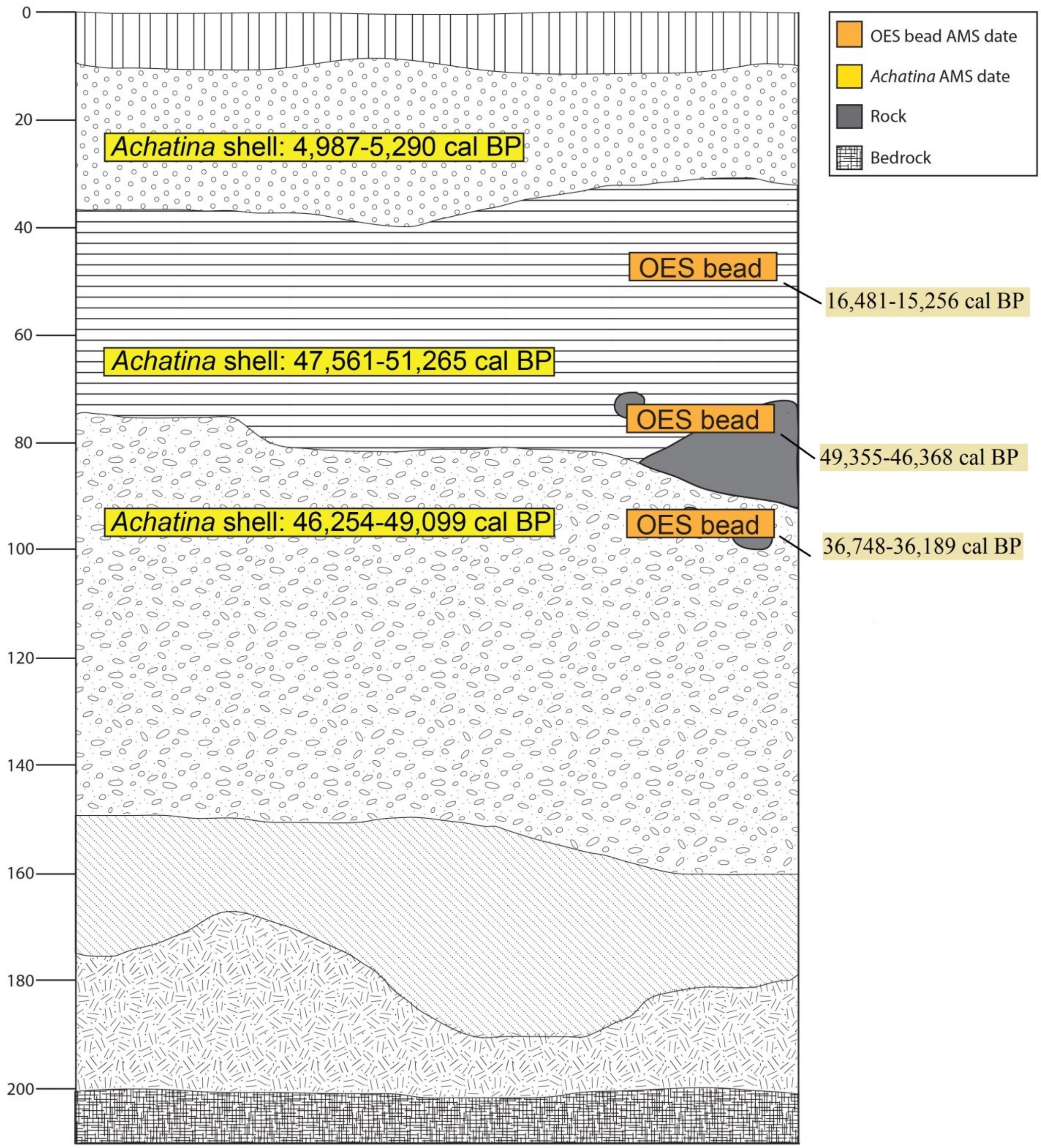


Figure 2.3. Stratigraphic Profile of Test Pit 8 and 9 (created by Jennifer Miller).

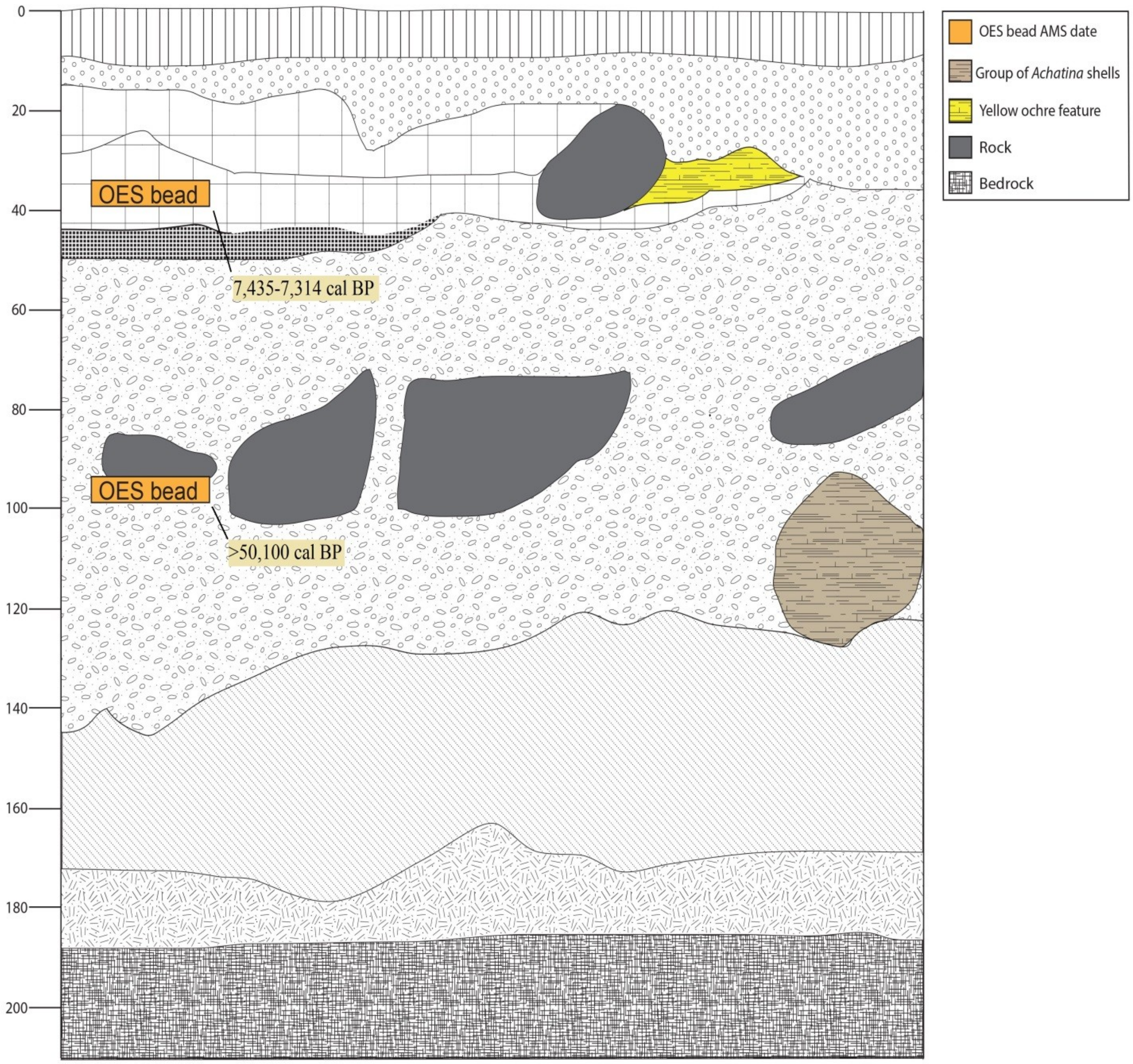


Table 2.1. Test Pit 12: Contents by Level.

Level (cm)	Culture	Notable Finds (not including lithics)
0-10	Historic and Iron Age	➢ Modern Glass Beads ➢ Modern and Historic Metal Artifacts ➢ Furnace Remains ➢ 1 Ostrich Eggshell Artifact ➢ Pottery ➢ Slag
10-20	Iron Age	➢ Furnace Remains ➢ Pottery ➢ Slag
20-30	Iron Age	➢ Furnace Remains ➢ Yellow Ochre Feature (Pit) ➢ 1 Ostrich Eggshell Artifact ➢ Pottery ➢ Slag
30-40	Iron Age	➢ Furnace Remains ➢ Slag
40-50	Iron Age	➢ 6 Deciduous Human Teeth ➢ Pottery ➢ Slag ➢ 4 Ostrich Eggshell Artifacts
0-50 Furnace	Iron Age	➢ Furnace Remains ➢ Slag
50-60	Iron Age/MSA	➢ Pottery ➢ 1 Ostrich Eggshell Artifact
60-70	MSA	
70-80	MSA	➢ Broken Bead Preform

80-90	MSA	➢ 1 Ostrich Eggshell Artifact
90-100	MSA	
110-130	MSA	
130-140	MSA	
140-150	MSA	
150-160	MSA	
160-170	MSA	➢ Bedrock Appearing in Section
170-180	MSA	➢ Reddish Concretions ➢ Bedrock Rubble
180-200	MSA	➢ 6 Fossil Human Teeth

Table 2.2. Soil Profile of Test Pit 12.

Stratigraphic Unit	**Munsell Designation**	**Colour**
Unit 1 (0-10 cm)	10 YR 2/1	Black
Unit 2 (10-37 cm)	5 YR 2.5/2	Dark Reddish Brown
Unit 3 (37-75 cm)	5 YR 4/4	Reddish Brown
Unit 4 (75-148 cm)	7.5 YR 4/5	Strong Brown
Unit 5 (148-176 cm)	7.5 YR 6/5	Reddish Yellow
Unit 6 (176-200 cm)	10 YR 4/6	Red

Table 2.3. Radiocarbon Dates of Ostrich Eggshell Beads from Magubike.

Test Pit	Lab#	Depth (cm)	Uncalibrated years (BP)	Age (cal BP)
8	OxA-27629	30-40	6,465 ± 33	7,435-7,314
12	OxA-27625	40-50	13,125 ± 50	16,481-15,256
12	OxA-27627	80-90	31,810 ± 180	36,748-36,189
12	OxA-27626	70-80	47,750 ± 750	49,355-46,368
11	OxA-27628	90-100	>50,100	

Table 2.4. Dates of Mammal Teeth at Magubike (created by Dr. Anne Skinner).

Sample	TP/Depth(cm)	Early Uptake Age (ka)	Late Uptake Age (ka)
PT85	TP9 30-40	92.7 ± 5.1	99.2 ± 5.9
PT90	TP9 50-60	141 ± 9.2	158.6 ± 11.0
PT91	TP9 70-80	171.8 ± 14.7	200.5 ± 13.6
PT86	TP7 110-120	164.0 ± 10.0	192.8 ± 13.1
PT82	TP8 130-140	144.0 ± 11.6	154.3 ± 13.0
PT83	TP8 130-140	115.0 ± 8.7	152.9 ± 12.3
PT98	TP12 170-180	218.8 ± 12.6	262.9 ± 16.7

Chapter 3 METHODOLOGY

Although the manufacture and use of stone tools is widely acknowledged by archaeologists to encompass only a small part of the possible cultural behaviours of past people, their enduring nature lends to their domination of the Palaeolithic record. As a result of their prevalence in Palaeolithic assemblages, lithic analysis remains a significant line of evidence from which past behaviour is assayed.

The purpose of this thesis is to assess and interpret the variation in the lithic materials excavated from Test Pit 12 in 2012 in order to gain an understanding of the factors responsible for behavioural change during the MSA and LSA. To achieve this objective, a mixed methodological approach involving both typological and technological analyses was adopted. Typology is the categorization and study of artifact forms, a method which has traditionally been used in archaeology to assign artifacts to separate cultures, regions and time periods. The investigation of technological variables, conversely, has as its objective the reconstruction of discrete lithic reduction sequences, or operational chains; and is separable from typology, which primarily concerns the final form of artifacts, and to a lesser extent, the processes that created them. The combined strategy employed in this study is important establishing the culture-history of the site, and for detecting changes in the way in which artifacts were used and produced. Both types of information were used to form conclusions concerning the causes of lithic variation at Magubike.

3.1 Typological Variables

Given the nearly infinite number of forms that chipped stone can take, it is important to create standardized frameworks in order to categorize and describe assemblages. Such description allows artifacts to be grouped and analyzed more effectively, and for the results of such analysis to be communicated to other researches as well as compared to other regions of study. While necessary for archaeological investigation, assigning artifacts to exclusive classes is by no means simple and free of ambiguity or subjectivity; and requires the appreciation of several caveats. The continuous variation that characterizes most lithic assemblages is often difficult to divide non-arbitrarily, and few artifacts are perfectly representative of the category to which they are assigned; rather, most artifacts exhibit some degree of deviation from a set of central tendencies, but are recognizable by fundamental similarities which are usually established beforehand. This process of sorting involves a necessary amount of subjective assessment, which is nevertheless constrained by the parameters of the typology being used and the form of the analyzed lithics.

It is also important to be aware that few, if any, of these artificial categories would have been acknowledged by the original makers and users of the lithic artifacts. Lacking further functional analyses, these typological categories are predominantly analytical, and are not intended to reflect the design objectives of ancient people or the function of the tools themselves. Nevertheless, functional language such as “scraper” is still employed, and must be separated from vernacular usage. Furthermore, the morphology of a given artifact at the time of its recovery by archaeologists is the product of a complex set of processes, both human and non-human. In addition to taphonomic processes, most tools undergo progressive episodes of reshaping over their lifetime of use and reuse (Bar-Yosef and Van Peer, 2009; Rolland and Dibble, 1990). Given how substantial this alteration can be, there is a good chance that the typological categories created by archaeologists to define artifacts do not represent discrete tool types, but actually refer to the different life-stages of tools which may have looked very similar at the point of their creation. Currently, the most promising method of distinguishing discrete original categories from sequential ones is by reproducing likely reshaping phases experimentally, and comparing them to archaeological assemblages. Despite these difficulties, the assignment of lithic artifacts to standardized types still constitutes a basic and necessary step in the process of analyzing them.

The typology employed for this study was developed by Mehlman (1989) for his categorization of the lithic material from Mumba and Nasera in northern Tanzania. As this typology is commonly used by scholars working on Tanzanian MSA and LSA sites, the use of it for this project will facilitate the transmission of data, and prompt comparison with other sites. Minor modifications to the typology have been made by Willoughby to better suit the needs of the project, and to better reflect the unique nature of the artifacts from Magubike Rockshelter (these changes are discussed further in the text as necessary). Mehlman categorized the lithics from Mumba and Nasera according to four primary groupings, (trimmed pieces, cores, debitage, and non-flaked stone) the details of which are expanded upon below.

Trimmed Pieces

The first of these four categories is trimmed pieces. Mehlman defines trimmed pieces as any piece of stone demonstrating secondary modification – that is, any piece of stone that was retouched subsequent to its extraction from a core or objective piece. This basic grouping is further subdivided into 10 additional types which include scrapers, backed pieces, points, burins, bifacially modified pieces, becs, composite tools, *outils écaillés*, heavy duty tools, and other/sundry tools (Mehlman, 1989: 127).

Scrapers

A scraper is identified generally by the presence of secondary retouch on any margin of the tool. The angle of this retouch, relative to the ventral surface, is generally between 45 and 75 degrees and may not exceed 90 degrees. The shape and location and of this retouch, in relation to the proximal end of the piece, is used to assign scrapers to summary types. These types are as follows: small convex scrapers, convex end scrapers, convex double end scrapers, convex end and side scrapers, circular scrapers, nosed end scrapers, convex side scrapers, convex double side scrapers, nosed side scrapers, sundry double end scraper, sundry and side scraper, sundry side scrapers, sundry double side scrapers, concave scrapers, concavities, notches, sundry combination scrapers, convex end and concave combination scrapers, convex side and concave combination scrapers, *divers* scrapers including microburins, convergent scrapers, and scraper fragments. Scrapers generally form a large component of MSA assemblages; but are also attributed to a number of different industries, regions, and time periods (Klein, 2009).

Backed Pieces

This category refers to lithic segments that have been blunted or "backed" by retouching one, or several margins, of a flake or blade at or near to a 90 degree angle. This edge-blunting is done to enable prehension or hafting, and the edge opposing the backing is often left unmodified and sharp. Mehlmen, preferring not to discriminate between size categories in his typology, as done elsewhere, does not explicitly distinguish microlithic and macrolithic backed pieces. As the presence of backing is the only unifying attribute for this class of artifacts, possible subtypes are many; and include crescents, triangles, trapezes, curved back pieces, straight backed pieces, orthogonal truncation, oblique truncation, angle-backed pieces, *divers* backed, backed awl/drill/perçoir, and backed fragments. While backed tools are often found in LSA and later assemblages, backed pieces from MSA contexts have also been recovered; but are more often made on flakes rather than blades, and tend to be larger and less uniform (Barham, 2002; Klein, 2009).

Points/Perçoirs

Points are defined as pieces which have been retouched along two margins that converge to form an acute angle - usually less than 45 degrees. This retouch may be either unifacial or bifacial; and the angle of retouch tends to be low, less than 30 degrees, to form a cutting rather than scraping edge.

Levallois points have been added to this category by Willoughby despite lacking secondary modification. Levallois points are instead created by first establishing a series of intersecting ridges on the core in the desired shape (usually triangular). After that procedure, a perpendicular striking platform is prepared at one end of the core, from which the point can be extracted fully formed. As a result of the steps involved, Levallois points normally exhibit a number of platform facets greater than one, and a triangular-shaped dorsal scar pattern originating from the proximal end. These points are then normally employed without further modification. Although the absence of secondary retouch would strictly preclude them from the trimmed piece general category, they are nevertheless included here on account of their technological significance and likely functional similarity to other point forms. Other point types include unifacial points/perçoirs, alternate face/edge points/perçoirs, and bifacial points. Like scrapers, points make up a large proportion of the trimmed pieces in MSA assemblages; and decrease in number into the LSA (Klein, 2009).

Burins

Burins are trimmed pieces that exhibit a square, chisel-like tip from the removal of one or more flakes, called burin spalls. Each burin spall is usually a small, narrow flake removed obliquely from one end of a flake, blade or bladelet. These instruments are generally believed to be used to engrave bone and wood, although Mehlman (1989) makes no functional assumptions about this typological category. Burin subtypes include dihedral burins, angle burins, and mixed/other burins. Generally the use of tools, such as burins, to make other tools and objects is thought to be a hallmark of the LSA and Upper Palaeolithic.

Bifacially modified pieces

This class of tools refers to any piece with bifacial retouch that is not easily classed as a point, core, or heavy duty tool. Retouch is considered bifacial if it is present on both the dorsal and ventral surface of a stone. Subtypes for this category are discoids, point blanks, and miscellaneous bifacially modified pieces.

Becs

Becs display two short lines of retouch converging to form a robust spur or corner. All becs are subsumed under this category.

Composite tools

Composite tools are any trimmed piece which combines elements of two different tool categories. Composite tool subtypes are sundry composite tools, burins and other composite tools, backed and other composite tools, and scraper and other composite tools.

Outils écaillés

Outils écaillés, or scalar pieces, are one of the by-products of bipolar flaking, during which a core is placed on an anvil and percussed with a hammerstone from above. This procedure tends to produce flakes with evidence of crushing/battering on one or more opposing margins, as well as a series of opposing step-fractures on the dorsal surface. There are no subtypes of *outils écaillés.*

Heavy Duty tools

These generally robust tools are represented by large cutting tools as well as choppers, and tend to be greater than 50 mm in size (longest dimension). Subtypes of this category include core/large scrapers, handaxes, core choppers, cleavers, picks, core axes, and other heavy duty tools. Heavy duty tools are associated with the Acheulean, itself a component of the ESA, which preceded the MSA in Africa. Once hafting technology became widespread, these tools were phased out; although they may still be found in MSA and later periods, and were likely used in a variety of different roles.

Sundry Modified Pieces

Sundry modified refers to a "catch-all" or miscellaneous grouping into which can be placed trimmed pieces that do not satisfy the requirements of any other category, or are fragmentary. This category includes the types: sundry modified, cutting edge, bulbar thin/talon reduced, and tool fragment.

Cores

A core is defined as an objective, or original piece, from which subsequent secondary pieces are be removed (Andrefsky, 2005). By this definition, most cores are usually larger than other forms of lithic waste; and bear scars or flake negatives from previous extractions. Second generation cores are also possible in which a flake, struck from a core, is successively reduced to produce new flakes. This behaviour is especially common in the LSA (Mehlman, 1989). Cores under this typology are assigned to five further categories (Mehlman, 1989: 140).

Peripherally Worked Cores

Peripherally worked cores show evidence of centripetal flaking around their outer margin. The location and nature of this primary retouch determines the summary type to which each core is assigned. Peripherally worked cores can be subdivided into the following four categories: part-peripheral cores, radial/biconic cores, disc cores, and Levallois cores. This type of flaking was practiced in a number of different regions and time periods. In the context of African Stone Age archaeology, peripherally worked cores, particularly radial and Levallois cores, are associated with the MSA.

Patterned Platform Cores

These cores are variable in shape, ranging from sub-rectangular to sub-cuboid to tabular. The element common to all of them is the presence of a distinct series of striking platforms, positioned at an angle approximately 90 degrees to the surfaces from which flakes were extracted. The subtypes established by Mehlman (1989) are pyramidal/prismatic single platform core, *divers* single platform core, single platform core/core scraper, opposed double platform core, opposed double platform core/core scraper, adjacent double platform core, adjacent double platform core/core scraper, and multiple platform core. These types of cores are usually related to the blade and bladelet industries of the LSA.

Intermediate cores

Intermediate cores are described as comprising elements of more than one different core type. This category is further subdivided into platform/peripheral cores, platform/peripheral core/core scrapers, platform/bipolar cores, platform/bipolar core/core scrapers, and bipolar/peripheral cores.

Bipolar cores

Bipolar cores are created by placing cores on an anvil and percussing them from above with a hammerstone. This procedure tends to produce unique "pillow-shaped" cores with evidence of crushing/battering and overlain step fractures on opposing ends. In addition, these cores typically display longitudinal flake negatives originating from either end. This category includes bipolar cores and bipolar core fragments. Although not chronologically diagnostic, bipolar flaking is commonly deployed in response to a number of different raw material constraints, such as poor quality lithic material, small package size, spherical stones, or limited access to lithics.

Amorphous Cores

The amorphous core category is a residual one meant to encompass all cores that are not readily ascribed to one of the preceding groups. All cores assigned to this category are referred to as amorphous cores.

DEBITAGE

Debitage refers to the waste products of the lithic reduction sequence, excluding cores, which are classed separately (Andrefsky, 2005). For the purpose of this typology, this category also includes pieces that show ambiguous signs of trimming or utilization, equally explainable as non-anthropomorphic edge damage. Mehlman's (1989: 148) typology includes five different debitage categories.

Angular Fragments

This category refers to any piece lacking regular retouch and a definable proximal end (defined as the presence of a striking platform and bulb of percussion). The subtypes of this category include core fragments (chunks), angular fragments (chips), trimmed/utilized angular fragments, medial or distal blade segments, and trimmed/utilized blade segments.

Specialized flakes

Specialized flakes are removed in order to create a specific effect - typically the creation of a burin. They tend to be long, narrow, and triangular in cross-section. This category includes burin spalls and tool spalls.

Flakes

This category includes debitage pieces that lack regular retouch, though otherwise exhibiting identifiable flake characteristics, namely a ventral and dorsal surface, a platform, and a bulb of percussion. Several exceptions to this rule exist including blades, specialized flakes, and Levallois flakes which are classed separately. Flake subtypes are whole flake, trimmed/utilized whole flake, flake talon fragment, and trimmed/utilized flake talon fragment.

Blades

A blade is a unique type of flake that is generally twice as long (from the proximal to distal end) than it is wide. Blades also tend to have parallel sides and a dorsal ridge that runs longitudinally from the proximal to distal end. Blade subtypes include whole blades, trimmed/utilized blades, blade/talon fragments, and trimmed/utilized blade talon fragments.

Although the production of blades dates to the Earlier Stone Age, an increase in the scale of blade manufacture, using patterned platform cores, occurred during the LSA in many parts of Africa.

Levallois Flakes

Levallois flakes are produced using the Levallois techniques, described previously, in which the parameters of the flake are established by removing flakes adjacent to it on the core. A platform is then carefully prepared, and the Levallois flake extracted fully formed and ready for use without further modification. This category encompasses the subtypes Levallois flake, and trimmed/utilized Levallois flake. The Levallois technique, although developed in the Earlier Stone Age, attained a position of significance in the MSA before fading out in the LSA.

Non-Flaked Stone

Though un-flaked, these pieces of stone nevertheless show evidence of manufacture or use, visible as a combination of crushing, battering, pecking or grinding. There are seven primary categories of non-flaked stone (Mehlman, 1989:152). Grinding stone to make implements and decorative items was not common in the MSA, and was practiced more often in the LSA and Upper Palaeolithic.

Hammerstones

Hammerstones are generally spheroidal stones that show localized evidence of battering or pecking on their extremities. Hammerstones are not additionally subdivided.

Anvils

Anvils also show evidence of localized pitting and battering, but are generally large and slab-like. Anvil subtypes include the following: edge anvil, pitted anvil, as well as edge and pitted anvil.

Pestle Rubbers

This category includes oblong, rounded stones bearing one or more ground facets. Within this category, pestle rubbers are subdivided into pestle rubbers and dimpled rubbers.

Polished Axes

Polished axes are flat, tabular stones with a sharp bit at one end formed by grinding. This grouping is further subdivided based on the morphology of the end opposite the bit; and encompasses lobed axes and "other" axes.

Stone Discs

This category includes relatively flat, thin, circular pieces of stone. The face may be cortical or ground to produce a smooth surface. Mehlman (1989) divides stone discs into the pecked disc and dimpled disc sub-categories. Stone discs are difficult to describe in functional terms, and are normally thought to be decorative.

Sundry Polished/Ground

This category is intended to classify non-flaked stone artifacts that are not easily assignable to the categories previously described. This grouping is not subdivided further.

Manuports

Manuports are lithic items introduced to the site through human action that otherwise lack evidence of intentional modification. This term usually applies to unshaped stones that are non-local to the study area.

Raw material

A number of different raw material types were recognized and recorded for each lithic piece. These categories were quartz, rock crystal (macro-crystalline quartz), quartzite, cryptocrystalline silica, chert, volcanic (excluding obsidian), obsidian, granite, andesite, tuff, "other metamorphic" (excluding quartzite), mudstone, siltstone, sandstone, and "other". These raw material variables are important for a number of further analyses, including studies of lithic resource-use strategies, mobility, and trade (Barut, 1994). Certain resource types may also have been used selectively for the production of specific implements. However, in order to better address these questions, the lithic source areas which contributed to the material composition of Magubike need to be located. Despite a lack of success finding quarries, the source areas are suspected to be predominantly local or semi-local. In particular, raw stones may have entered the site from nearby stream-beds, within 10 km.

3.2 Technological Variables

A number of technological variables were also recorded for each artifact. For whole and trimmed/utilized flakes, as well as blades, the following variables were documented: Toth types, platform breadth, platform length, platform angle, number of platform facets, planform shape, dorsal flake-scar pattern, and number of dorsal scars. Where possible, these variables were also noted on trimmed pieces. For trimmed pieces, two additional variables were recorded: the angle and intensity of retouch. Cores likewise were described using supplementary variables: the percentage of remaining cortex, and the number of flake negatives. For all lithic artifacts, the length, breadth, thickness, weight, and degree of abrasion was recorded.

Toth types

On the basis of the amount of cortex remaining on their dorsal surface and platform, flakes were assigned to relative lithic reduction stages, or Toth types (Toth, 1987). Toth types were documented for whole and incomplete flakes, as well as blades and Levallois flakes that retained a striking platform. In instances in which it was possible, a Toth type was also recorded for tools made on flakes and blades. By assigning flakes to different lithic reduction stages, it becomes possible to determine which portions of the reduction sequence were practiced on site. This analysis informs researchers if any previous reduction of cores occurred before they were introduced to the site, or if some other process of sorting has acted on the assemblage.

Type I – Fully cortical platform and dorsal surface. These flakes are few, and tend to represent the first flakes removed from an unaltered core. Their presence in a lithic assemblage represents an early stage in the lithic reduction sequence.

Type II – Cortical platform and partially cortical dorsal surface. These types of flakes generally represent an early stage of lithic manufacture while indicating that prior processing of the core has already occurred.

Type III – Cortical platform and non-cortical dorsal surface. This type of flake is typically produced when the reduction of a cortical platform has progressed such that no more cortex remains on the primary surface from which flakes are detached. Alternatively, type III flakes can result from using the cortical or semi-cortical dorsal surface of a flake as a platform for subsequent extractions.

Type IV – Non-cortical platform and a completely cortical dorsal surface. Type IV flakes are typically the first products of bifacial flaking. Alternately they may be produced by detaching further pieces from a cortical flake, using the ventral surface as a platform.

Type V – Non-cortical platform and a semi-cortical dorsal surface. These types of flakes are generally produced as a result of the bifacial reduction of a core. They are also the likely products of unifacially working a flake with a partially cortical dorsal surface.

Type VI – Entirely non-cortical platform and dorsal surface. Type IV flakes correspond to the final stages of core reduction, when little if any cortex remains on the core.

Type VII – Willoughby created a Type VII residual category into which can be placed flakes that do not conform to any of the above categories, usually because the platform is absent. This category is generally reserved for tools.

Planform

The overall shape of each artifact was described for whole/utilized flakes and blades, as well as trimmed pieces. The shape was assessed from above, with the dorsal aspect facing upwards and the proximal end oriented towards the viewer. While lithic artifacts are highly variable in form, they were assigned to one of the following six general categories: convergent, divergent, parallel, intermediate, circular, and unknown. These categories are derived from McBrearty (1986: 198–199); however, Willoughby has appended the circular and unknown types.

Dorsal flake scar count

This variable represents a simple sum of the flake negatives on the dorsal surface of a flake or tool. This variable may indicate the relative intensity of resource utilization, with more flake scars reflecting greater exploitation intensity, or different reduction strategies. Nevertheless, flake scar counts are largely dependent on other variables such as the size of the flake, which would need to be corrected for in order to provide meaningful behavioural data (Andrefsky, 2005).

Dorsal scar pattern

This variable describes the respective orientation of flake negatives on the dorsal aspects of flakes and tools, and is used to indicate the particular reduction sequences and strategies employed to create pieces. As the choice of reduction strategy is dependent on a number of overlapping social and environmental factors, recognizing these different techniques may help to reconstruct the broader context in which the tools were manufactured and used. Strategies of radial flaking, for instance, are often associated with the industries of the MSA, while parallel patterns are more frequently related to LSA strategies. Other techniques such as bipolar flaking are theorized to be used in response to lithic shortages and low quality materials. The dorsal scar pattern, though potentially complex, was categorized according to one of eight groupings. These groups are radial, same platform simple, same platform parallel, opposed platform, transverse, convergent, none (cortical), bipolar, missing/NA, and unknown.

Platform facets and angle

If the flake or tool retained an intact platform, the number of facets that it exhibited was documented. A value of greater than 1 may indicate prior preparation of the striking platform, correlating to a number of potential reduction techniques. Most importantly, Levallois flakes, a diagnostic component of the MSA, are identified, in part, by a multi-faceted platform. Platform angle is similarly suggestive of particular reduction strategies. For instance, biface thinning tends to produce flakes with low platform angles. Platform angle refers specifically to the angle formed between the platform and the ventral surface.

Retouch intensity and angle

Retouch intensity refers to how far onto the interior surface of the flake retouch extends. This variable is derived from the work of Clark and Kleindienst (1974: 85) and is divided into three categories: marginal, semi-invasive, and invasive. The intensity of retouch is thought to represent the amount of effort and time invested in tool manufacture. This factor in turn may represent different technological/organizational strategies that emphasize formal (curated) versus expedient tools (Andrefsky, 2005). Trimmed pieces with retouch restricted to the outer edges of the tool were described as having marginal retouch. When the retouch extended onto either the dorsal or ventral face, but stopped short of encompassing the entire piece, the artifact was labelled as semi-invasive. Finally, pieces that were categorized as invasively modified were retouched over their entire surface.

The angle of retouch at the margin of the tool was also measured. As noted elsewhere, different retouch angles are better suited for particular tasks (Collins, 2008). Retouch that is less than 30 degrees is usually termed “cutting retouch”, and is more effective at slicing soft materials such as meat and plant fibers. Retouch angled between 30 and 90 degrees is often referred to as “scraper retouch” because it is more appropriate to scraping tasks such as processing hides or wood.

Cortex cover and flake scar count

Both of these variables pertain to cores exclusively, and are used to infer the relative intensity of reduction. It is generally assumed that cores with little cortex and many flake scars were more heavily utilized than those with fewer scars and more cortex. Cortex cover is represented as the percentage of cortex remaining on the total outer surface of the core. For example, an entirely unmodified stone would have a cortex cover value of 100. Flake scar count was achieved by summing the total number of visible flake scars. Like dorsal flake scar count for flakes, blades, and trimmed pieces, flake scar count for cores is usually heavily dependent on additional factors, most significantly the size of the core.

Size measurements

The basic dimensions of each lithic artifact were recorded including length, breadth, and thickness. For pieces with no clear proximal end, length was recorded as the maximum dimension; breadth, the second longest dimension perpendicular to the length; and thickness as the third longest dimension. For flakes, trimmed pieces, and blades that retained a platform, the length was measured from the proximal to the distal end; the breadth was the longest dimension perpendicular to length, and thickness was the third longest dimension perpendicular to both length and breadth. The weight of each piece was measured in grams to one decimal point. If the proximal end was present and intact, then the length and breadth of the platform was recorded as well. From these two measurements, the platform area was calculated.

Chapter 4 Typological Analysis

This chapter presents the typological data from Test Pit 12, Magubike. Detecting temporal variation in the assemblage was of primary interest, and so much of the analysis is concerned with the vertical distribution of artifacts on a level-by-level basis. It should be remembered, however, that since excavation of the site was conducted in arbitrary 10 cm levels, the individual spits do not necessarily conform to the natural stratigraphy of Test Pit 12. As the site has yet to be comprehensively dated, these levels are only a loose measure of relative time. It is also worth remembering that not all levels were of equal dimensions; namely, an accident during excavation resulted in Level 110 – 130 cm and Level 180 – 200 cm being twice as deep as the other 10 cm spits. In order to account for this discrepancy when performing statistical tests, any variables that were correlated with depth were first converted into a percentage of the population of artifacts in each level. As opposed to raw counts, this approach negates the influence of the overall greater numbers of artifacts in these two larger levels, removing the effects of variable artifact density from the calculations.

A total of 14,708 stone artifacts were excavated from Test Pit 12. The artifacts were distributed unevenly in the stratigraphy; some levels contained less than 20 artifacts while others contained over 2000 (Figure 4.1). Between 0 and 40 cm artifact density was low (~377 artifacts/level); but at 40 - 50 cm, artifact density more than doubled to just over a thousand artifacts per level. Below 50 cm artifact density gradually increased with depth before reaching a peak at 80 to 90 cm (2236 artifacts/level). Artifact density declined steadily again below 90 cm, until the base of the sequence was reached at 200 cm. The last 20 cm of the deposit contained only 36 artifacts.

Tracing changes in artifact density is important for interpreting the length and frequency with which each phase of the site was occupied (Barut, 1994). However, numerous external variables such as sedimentation rate and post-depositional disturbance complicate inferences of this kind. As research at Magubike has produced only suspicions about the site formation processes, these inferences were not pursued in any detail in this study. Further efforts to resolve these issues are planned.

4.1 Raw Materials

Artifacts of a number of different raw material types were recovered from Test Pit 12 (Table 4.1). The main categories were quartz (44.1%, n=6484), which comprised the majority of the assemblage, “other metamorphic” (40.9%, n=6009), chert (7.6%, n=1119), quartzite (5.6%, n=826), and “other” raw materials (1.8%, n=270). In this case the “other” category included negligible amounts of rock crystal (macrocrystalline quartz), crypto-crystalline silica, granite, andesite, tuff, mudstone, siltstone, and sandstone; all of which were present in quantities less than 1% of the total assemblage.

Quartz artifacts dominated the upper levels of Test Pit 12 between 0-40 cm, with relatively few “other metamorphic” stones. Below that, “other metamorphic” stones were preferred between ~50-200 cm. Because the levels between 0 and 50 cm are thought to correspond roughly to the historic, Iron Age, and/or the LSA occupation of the site, the change in lithic technology from the MSA may also have been associated with a change in raw material preference. Conversely, the use of quartzite and chert seems to have remained relatively stable in Test Pit 12 (although quartzite may have been slightly more common the lower levels of the unit), and made up only a small proportion of the lithics in each level. Raw material types other than this contributed only nominally to the assemblage. See Figure 4.2 and Figure 4.3 for more detail.

In order to detect monotonic relationships in the data between raw material and depth, several independent Spearman’s rank-order correlations were performed. This statistic is capable of identifying relationships between two, non-normally distributed, ranked variables, in addition to indicating the direction of any such correlations (i.e., if one variable increases, does the other increase or decrease?). When computed using the proportion of quartz in each level as one variable, the test revealed a strong negative association with depth, showing that as depth increased the percentage of quartz in each level decreased (r_s= -.8679 (df=16), $p < .0001$, r^2=.7533). When the same test was performed on the proportion of “other metamorphic” stones in each level, the inverse of the previous pattern emerged; that is, as depth increased the proportion of "other metamorphic" stones in each level increased (r_s=.8411 (df=16), $p < .0001$, r^2=.7074). The results generated for quartzite and chert were less predictable. A chi-square test revealed that the distribution of quartzite within Test Pit 12 was likely not the product of chance (χ^2 = 183.031 (df=17), $p < .0001$); although a Cramer's V shows that the relationship between quartzite and depth to be weak (V=.113). In this case, the high significance of the chi-square test is likely a function of the large sample size used to compute the statistic; and the low value of V is likely a more meaningful measure (Drennan, 1996). A Spearman's rank-order correlation also revealed that although a significant positive relationship exists, it is only moderately strong, accounting for ~24% of the variation (r_s=.4858 (df=16), p=0.04, r^2=.2360). Chert showed no significant relationship to depth, and is considered to have been present in consistent proportions in all levels of Test Pit 12 (r_s= -.0674 (df=16), p=.7906, r^2=.0057).

4.2 General Categories

The lithic artifacts from Magubike were classified most broadly according to four general categories: trimmed piece, core, debitage and non-flaked stone. As non-flaked stones accounted for only six of the 14,708 lithic artifacts recovered, they are excluded from the following analyses. In total, trimmed pieces accounted for 5.4% (n=797) of the total artifacts; cores for 3.9% (n=574); and debitage for 90.7% (n=13,331). The relative proportions of each general category per level can be found in Figure 4.4 and Figure 4.5.

Several statistical tests were applied to these data in an attempt to determine whether or not a relationship between each general category and depth existed. A Spearman's rank-order correlation revealed a negative association between the percentage of trimmed pieces and depth

(r_s= -.7007 (df=16), p=.001, r^2=.4910). In other words, there were a greater proportion of trimmed pieces in the most recent levels of Magubike. Debitage, conversely, was proportionally more abundant in the lower levels of Test Pit 12 (r_s=.5707 (df=16), p=.013, r^2 =.3256). Cores showed no relationship with depth and were found to be distributed relatively evenly in each level of the sequence (r_s= -.1601 (df=16). p=.5249, r^2=.0256). More detailed analyses were performed on each of the general categories below.

Trimmed Pieces

Trimmed pieces consist of any piece of stone with evidence of secondary edge modification, and are interchangeably known as tools (though it is recognized that unretouched pieces were almost certainly used as tools as well). Within Mehlman's (1989) typology this category included scrapers, backed pieces, points, burins, bifacially modified pieces, becs, composite tools, *outils écaillés* (scalar pieces), heavy duty tools, and an "other" category. Backed pieces and scrapers easily constituted the most numerous categories at 37.3% (n=297) and 32.4% (n=258), respectively. Scalar pieces were next at 15.6% (n=124), and points at 9.7% (n=77). This number was followed by bifacially modified pieces and burins at 2.3% (n=18 for both) of the total assemblage each. Becs, heavy duty tools, and "other" tools each made up less than 1% of the total trimmed pieces; and no composite tools were recovered. This information is also presented in Table 4.2.

When averaged out over the life-span of the site and across the different typological categories, there appeared to have been clear raw material preferences for the production of trimmed pieces (Table 4.3). In particular, most trimmed pieces were created from quartz (66.2%, n=528). "Other metamorphic" stones were the next most utilized raw material category (14.3%, n=114), followed by chert (9.5%, n=76), quartzite (5.1%, n=41) and "other" materials (4.8%, n=38).

Because certain tool types are considered to be diagnostic of particular archaeological industries, they were given special analytical treatment; namely, MSA assemblages are usually characterized by high numbers of scrapers and points, whereas the LSA is typified mainly by backed microlithic tools and an expansion in the scale of blade production (Klein, 2009). It is important to recognize that even though certain tools types are more prevalent in some periods and locations than others, most are found in at least some number in every assemblage; and are not by themselves indicative of any one archaeological period or culture. Detecting differences in the proportion of these artifact types is key to identifying and interpreting changes in technological behaviour. The changing proportions of trimmed pieces are represented in Figure 4.6 and Figure 4.7, and discussed in the following sections.

Backed Pieces

Backed pieces were the most common type of trimmed piece found in Test Pit 12 (37.3%, n=297). The three most common backed tool categories recovered were *divers* backed (43.8%, n=130), oblique truncation (24.6%, n=73), and trapeze (13.5%, n=40). Other backed tool categories included crescent, triangle, straight backed piece, curved backed piece, orthogonal truncation, angle backed piece, backed awl and backed fragment; each of which made up less than 4% of all backed pieces (Table 4.4). The high percentage of backed pieces characterized as *divers* (miscellaneous) is probably related to the high proportion of quartz used to make them (81.5% of backed pieces were quartz). Not only is quartz notoriously difficult to analyze precisely, efforts to shape it are often unpredictable, resulting in a range of potential forms

(Mehlman, 1989). The high number of quartz backed pieces also reveals a clear lithic preference for the material; neither does the raw material preference for quartz appear to fluctuate significantly by level (r_s= -.0199 (df=13), p=.9453, r^2=.0004). The next most used material is chert, which makes up only 8.1% (n=24) of the backed pieces in Test Pit 12. A full account of the raw materials can be found in Table 4.5.

Although the material used to make backed pieces does not appear to vary significantly over time, backed pieces themselves were strongly associated with the upper levels of the unit (r_s = -.8155 (df=15), p < .0001, r^2=.6650). Furthermore, backed pieces were not found in any number below 160 cm; and by 140 cm appear to have dropped off to only one or two backed pieces per level. The transition to backed pieces also appears to coincide with the rise in the prevalence of quartz between 0 and 40 cm, and it is likely that the two variables are related.

Scrapers

Scrapers were the second most numerous category of trimmed pieces after backed pieces (32.4%, n=258). A large number of different scrapers are recognized by Mehlman's (1989) typology, but most of the scrapers in the Test Pit 12 assemblage belonged to just a few types: concave scraper (27.1%, n=70), circular scraper (17.8%, n=46), and convex end scraper (10.5%, n=27). Other types were found in insignificant numbers; and include the following: convex end and side scraper, nosed end scraper, convex side scraper, convex double side scraper, nosed side scraper, sundry end scraper, sundry end and side scraper, sundry side scraper, sundry double side scraper, concave scraper, concavity, notch, sundry combination scraper, convex end and concave combination scraper, convex side and concave combination scraper, convergent scraper, and scraper fragment (Table 4.6).

Like backed pieces, the majority of scrapers in Test Pit 12 were made from quartz (51.6%, n=133). More commonly than backed pieces, however, scrapers were made from “other metamorphic” stones and chert (Table 4.7). Raw material preference for scrapers, unlike backed pieces, appears to have changed appreciably over the history of the site. The number of scrapers in each level was concluded to be too low to allow for any appropriate statistics to be run, but it appears graphically as though scrapers in the upper levels of the unit were more likely to be made of “other metamorphic” materials than those found in the lower levels (Figure 4.8 and Figure 4.9). This pattern is contrasted by generally higher percentages of quartz artifacts overall in the top 40 cm of Test Pit 12, and may represent the selection of raw materials for certain tasks.

Since scrapers are considered to be a diagnostically important MSA artifact type, a Spearman’s rank-order correlation was performed to determine if the proportion of scrapers in each level was related to the depth of the sequence. The test revealed that scrapers were more common in the MSA levels of the unit, and declined proportionally in the Iron Age/LSA (r_s=.5623 (df=14), $p < .0194$, r^2=.3162). This result is consistent with other reports of MSA and LSA assemblages (Barut, 1994).

Points

Points are trimmed pieces with retouched margins that converge at an acute angle. The exceptions to this rule are Levallois points which do not bear secondary retouch, but are hypothesized to have been used without further modification once detached from a core. Although the function of any stone tool is difficult to establish with any certainty, based on their morphology, most points are believed to have been used to tip projectiles such as spears, darts, and arrows. The two most common point types in the assemblage are Levallois points (64.9%, n=50) and unifacial points (29.9%, n=23). All other points made up less than 5% of the total point assemblage, and consist of alternate face/edge points and bifacial points (Table 4.8).

Only one point was found in the top 40 cm of the unit, and no points were found below 180 cm. The apparent distribution of points in the sequence is likely the product of a number of different factors including chance introduced by the overall rarity of points in the assemblage, as well as low artifact densities in the top and bottom of Test Pit 12. Nevertheless, the distribution of points in Test Pit 12 reveals a positive relationship with depth, in which points made up a relatively larger percentage of the tool types in the lower MSA levels of the unit, in comparison to the Iron Age/LSA ones (r_s=.9355 (df=15), $p < .0001$, r^2=.8751). It is possible that site use may have changed during Iron Age/LSA or that armature technology changed to incorporate microlithic tools (Leplongeon, in press).

Unlike backed pieces and scrapers, points were made predominantly on "other metamorphic stones" (39%, n=30), while quartz points made up 36.4% (n=28). Chert and quartzite each contributed over 10% of the raw materials, and "other" stones only 2.6% (n=2). This information is also present in Table 4.9. Like scrapers, no statistics linking raw material preference to depth were performed because of the low numbers of points in each level. When observed graphically, however, there appears to have been little or no change in the types of lithic raw materials used to make points throughout the sequence in Test Pit 12.

Because Levallois technology is diagnostic of early MSA deposits (Tryon et al., 2005), the proportion of Levallois points by level was plotted against the depth of the sequence. It was hoped that demonstrating a relationship might assist in detecting changes over time in the largely undifferentiated MSA components of the site. A graph, however, showed no indications of such a relationship; and the small numbers of points in each level would almost certainly prevent a reliable statistical result from being achieved. Several other observations can be made, however. Most notably, Levallois points were absent between 0 and 30 cm, the top of the sequence; but were otherwise fairly evenly distributed throughout the rest of the levels, although, as mentioned earlier, this pattern may be a product of chance due to failing artifact densities in the upper layers and not an abandonment of the technology.

Outils écaillés

A further category of trimmed pieces that warrants further scrutiny are *outils écaillés*, or scalar pieces. These particular types of flakes are thought to be one of the primary by-products of bipolar percussion, a strategy of core reduction that relies on striking a core stabilized on an anvil. As a result of this relationship, the proportion of scalar pieces by level is an effective means of tracing the use of bipolar strategies; and thus changes in technological behaviour through time. Scalar pieces are numerous in Test Pit 12, and comprise 15.6 % (n=124) of the total assemblage of trimmed pieces. In order to test for a statistical relationship with depth, a Spearman's rank-order correlation was performed. The results of the test show a significant positive correlation between the proportion of scalar pieces per level and depth (r_s=.75 (df=15), p =.0012, r^2 =.5625). The outcome of the statistic indicates that the proportion of scalar pieces was highest in the lower levels of Test Pit 12, signaling that the reliance on the bipolar reduction technique diminished over time. The result of this test is contrasted by the relationship between bipolar cores and depth discussed below.

Not surprisingly, scalar pieces were made overwhelmingly on quartz (81.5%, n=101). On account of the fracture properties of quartz, it is frequently selected for reduction via bipolar percussion, as noted elsewhere (Barut, 1994; Mehlman, 1989). Quartz also seems to have been consistently reduced using the bipolar technique over time, as little fluctuation by level was noted graphically. The raw material of scalar pieces is presented more thoroughly in Table 4.10.

Cores

Test Pit 12 contained a total of 574 cores. The vast majority of these were bipolar (85.2%, n=489), while amorphous and intermediate cores each contributed less than 1% of all cores, and patterned platform and peripheral cores made up 6.8 (n=39) and 6.6 (n=36), respectively (Table 4.11).

Like other artifact categories, core types are indicative of different lithic reduction strategies which in turn may relate to separate time periods, regions, and industries. In particular, peripherally worked cores are thought to be diagnostic of MSA deposits, while patterned platform cores are more often associated with the blade and bladelet industries of the LSA. Bipolar cores are less chronologically predicative, and are commonly thought to be a reflection of material quality and availability.

In Test Pit 12 a clear raw material preference was shown for quartz (57.7%, n=331). After quartz, “other metamorphic” material (19.3%, n=111) was the second most abundant stone, followed by chert (11.7%, n=67), quartzite (8.2%, n=47), and “other” stones (3.1%, n=18). A chi-square test also confirmed that the differences in raw material selection was significantly related to core type (χ^2=42.254 (df=4), $p < .0001$, V = .205). In order to meet minimum number requirements for each case, intermediate and amorphous cores were excluded from the test, as were the quartzite and “other” lithic raw material types. The raw material of all core types is presented in Table 4.12. The outcome of the test shows that quartz was the favoured material for bipolar and peripheral cores while “other metamorphic” stones were preferred for patterned platform cores. Chert was also used in higher proportions to make peripheral cores relative to other core types.

Bipolar Cores

Like *outils écaillés*, the proportion of bipolar cores by level is a strong indicator of the prevalence of the bipolar flaking technique. In order to detect potential temporal variation, a Spearman's rank-order correlation was performed. Level 180-200 cm was excluded because of low artifact counts. The results show no relationship between the proportion of bipolar cores and level (r_s=.1925 (df=15), p =.4590, r^2 =.0370). This result is in contrast to scalar pieces, another indicator of bipolar percussion, which proportionally decreased from the oldest levels of the unit to the most recent.

Most bipolar cores and bipolar core fragments were made of quartz (62.0%, n=303), followed by "other metamorphic" stones (17.4%, n=85), chert (10.0%, n=49), quartzite (8.2%, n=40), and "other" lithic materials (2.5%, n=12). This information is also present in Table 4.13. Since quartz cores are frequently small and fracture unpredictably, they are commonly selected to be reduced bipolarly, accounting for the high number of quartz bipolar cores in this study. In an attempt to determine whether or not bipolar cores were consistently produced using quartz throughout the history of Test Pit 12, another Spearman's rank-order correlation was performed. Level 180-200 cm was once again excluded due to low counts. The test revealed a significant, negative trend, showing that quartz bipolar cores were proportionally more numerous in the upper levels of the unit, whereas "other metamorphic" material types were used with increased frequency (though not more commonly than quartz) in lower levels (r_s= -.6417 (df=15), p =.0055, r^2 =.4117). The pattern is likely related to the lower frequency of quartz artifacts below ~50 cm.

Despite a shift in raw material preference, from "other metamorphic" stones to quartz, the use of bipolar methods to produce flake blanks remained relatively stable.

Patterned Platform Cores

A total of 39 patterned platform cores were recovered from Test Pit 12. Patterned platform cores included the following sub-categories: pyramidal/prismatic single platform core, *divers* single platform core, single platform core/core scraper, opposed double platform core, adjacent double platform core, and multiple platform core (Table 4.14). Many of these core types are associated with LSA technologies, and are therefore expected to be concentrated in the top ~50 cm of the test pit.

Patterned platform cores were made mostly on "other metamorphic" stones (46.2%, n=18), followed by quartz (20.5%, n=8), chert (17.9%, n=7), quartzite (7.7%, n=3), and "other" lithic materials (7.7%, n=3) (Table 4.15). While there were too few patterned platform cores to determine statistically whether raw material use changed with depth, there appears to be little relationship between material type and level.

Likewise, there were not enough patterned platform cores to statistically determine whether or not they are associated with any particular levels. Nonetheless, it is noted that patterned platform cores did not appear below 160 cm; although this distribution is likely a function of decreasing artifact densities below this point in the sequence. Furthermore, patterned platform cores were only spottily distributed in other parts of the sequence, and were absent between 0 and 10 cm, 20 and 30 cm, and between 40 and 60 cm.

Peripheral Cores

Thirty eight peripheral cores were excavated from Test Pit 12 (Table 4.16). The majority were part peripheral cores (42.1%, n=16), and the remaining cores were assigned to the following categories: radial/biconic core, disc core, and Levallois core. The presence of only a single Levallois core is perplexing, given that other evidence of Levallois technology, such as points and flakes, were frequently identified. It is possible that Levallois cores were exhausted beyond recognition, or that exhausted Levallois cores were further reduced using other methods such as bipolar percussion.

Peripheral cores were materially more like bipolar cores and less like patterned platform cores, in that the majority of them were created using quartz (47.8%, n=18), with lesser proportions of chert (28.9%, n=11), "other metamorphic" stones (10.5%, n=4), quartzite (7.9%, n=3), and "other" lithics (5.3%, n=2). Interestingly, peripheral cores were made on chert more often than both bipolar cores and patterned platform cores (Table 4.17).

Because peripheral cores are an important diagnostic element of the MSA, they were plotted proportionally by level in order to detect any changes in their frequency through time. Although there were too few cases to reliably run any statistical tests, it was nevertheless concluded that peripheral cores shared little relationship to level. Peripheral cores made up only a small proportion of the levels in which they were present, and were missing from many more. In general, they appeared to follow the overall trend in artifact density; that is, the number of peripheral cores peaked around 80 – 100 cm and declined above and below this level.

Debitage

A total of 13,331 of the 14,708 artifacts catalogued from Test Pit 12 were coded as debitage (90.6%). A very large percentage of these were angular fragments (71.4%, n=9521), followed by flakes (25.3%, n=3370), blades (2.3%, n=313), Levallois flakes (.8%, n=103), and specialized flakes (.2%, n=24). Like the rest of the assemblage, "other metamorphic" stones (43.4%, n=5780) and quartz (42.2%, n=5625) made up the bulk of the debitage that was excavated. These values were distantly shadowed by chert (7.3%, n=976), quartzite (5.5%, n=737), and "other" lithics (1.6%, n=213). This information can be found in Table 4.18 and Table 4.19.

Although debitage is considered to be the unintentional waste products of the lithic manufacturing process, it still embodies vital information about past technological behaviour. Although most debitage is non-diagnostic, other types serve as indicators of particular technological approaches which may be further related to time periods, regions, and technological traditions. In particular, the Levallois strategy of core reduction which results ultimately in Levallois flakes, blades, and points is considered to be a hallmark of MSA assemblages. Conversely, blades and bladelets, although encountered during the MSA as well, are thought to be more representative of the LSA and Upper Palaeolithic.

Angular Fragments

Only three angular fragment sub-types were recorded in Test Pit 12: angular fragments (62.2%, n=5918), core fragments (36.0%, n=3429), and medial and distal blade segments (1.8%, n=174) (Table 4.20). This is the most numerous category of debitage, representing mostly small pieces of non-diagnostic shatter or flake fragments. Interestingly, a Spearman's rank-order correlation shows that the proportion of angular fragments, as compared to other types of debitage, declined in the lower levels of Test Pit 12 and increased in the upper layers (r_s= -.7981 (df=16), $p < .0001$, r^2 =.6369). This pattern may be related to the increased use of quartz in the Iron Age/LSA levels of the unit, as this material tends to fracture unpredictably, producing more shatter than other material types. The proportion of core fragments to angular fragments remained fairly consistent throughout the sequence. There is, however, one major deviation from this pattern in Level 140 – 150 cm, in which core fragments jump to 86.2% (n=430) from an average of 36.0% per level and angular fragments fall to just 11.8% (n=59), from an average of 62.2% per level. While a trend in the proportion of blade debitage might have indicated changing technological strategies, blades were found throughout the sequence in negligible amounts.

Most angular fragments were quartz (50.6%, n=4817) or “other metamorphic” stones (42.0%, n=4003). There were also minor amounts of quartzite (2.0%, n=191), chert (4.6%, n=440), and “other” lithics (.7%, n=70) (Table 4.21). There also appears to be major changes in the distribution of material types over time. In particular, the use of quartz increased over time (r_s= -.8184 (df=16), $p < .0001$, r^2 =.6698) while “other metamorphic” materials decreased (r_s=.8056 (df=16), $p < .0001$, r^2 =.6490), congruent with the overall change in raw material use in Test Pit 12. The use of quartzite, chert, and “other” lithics seems to have remained stable; and these material types were likely used in small amounts during each phase of the site’s history.

Flakes

Test Pit 12 contained 3370 flakes. These were divided into whole flakes (44.9%, n=1513), trimmed/utilized whole flakes (13.9%, n=468), and flake talon fragments (41.2%, n=1388). Little apparent change to the percentage of these types, relative to one another, seems to have occurred with depth (Table 4.22). Overall, conversely, there was a significant shift in the proportion of flakes with respect to other types of debitage over time (r_s=.8023 (df=16), $p <$ .0001, r^2=.6437). Specifically, the proportion of flakes decreased over time from the MSA to the Iron Age/LSA, as angular fragments came to occupy more of the assemblage. The decrease in flakes is likely partially related to the increase in the use of quartz during the Iron Age/LSA, as quartz flaking regularly produces non-diagnostic shatter rather than spalls with recognizable flake characteristics.

Flakes were made predominantly using “other metamorphic” stones (46.5%, n=1566). Quartz (21.8%, n=735) was the next most used material, followed by quartzite (14.3%, n=481), chert (13.8%, n=466), and “other” materials (3.6%, n=122) (Table 4.23). The high proportion of “other metamorphic” to quartz flakes is likely due to their respective fracture properties. Not only is it easier to produce well defined flakes on “other metamorphic” materials, but it is notoriously more difficult to identify flake characteristics on quartz flakes, resulting in some degree of sorting error (Mehlman, 1989). Following the trend established by the general analysis of raw material types above, the proportion of quartz flakes increased towards the modern surface while “other metamorphic” flakes declined. Chert, like quartz, also demonstrated a strong negative relationship with depth, increasing in proportion from the MSA to the Iron Age/LSA (r_s= -.7235 (df=14), p = .0015, r^2=.5235). Quartzite, being a metamorphic stone itself, unsurprisingly followed the trend established by “other metamorphic” materials decreasing in proportion as the modern surface was approached.

Blades

A total of 313 blades were excavated from Test Pit 12 (table 4.24). Of these, 43.5% (n=136) were classified as whole blades, while 56.5% (n=177) were categorized as blade talon fragments (only the proximal end of the blade). Generally blades are considered to diagnostic of LSA and Upper Palaeolithic assemblages, although, they are also commonly found in MSA contexts as well. Because of their diagnostic potential, the proportion of blades per level was compared to depth. Contrary to expectations, it was found that blades were proportionally more numerous in the lower levels of the site and declined in their presence over time (r_s=.6998 (df=15), $p = .0018$, r^2=.4897).

Blades were produced primarily on "other metamorphic" stones (48.6%, n=152), while quartz blades made up only 15.3% (n=48) of the blade assemblage (Table 4.25). Because quartz does not fracture as predictably as "other metamorphic" materials, it was probably found to be unsuitable for blade production by the inhabitants of Magubike. The material type most favored after "other metamorphic" was chert (16.9%, n=53), followed by quartzite (13.7%, n=43) and "other" materials (5.4%, n=17). There is evidence of changing raw material preferences over the history of the site; and as "other metamorphic" materials became less favoured during the Iron Age/LSA layers overall, the proportion of blades produced using this material type also declined (r_s=.7713 (df=15), $p < .0001$, r^2=.5949), replaced to some extent with chert and quartz blades.

Levallois Flakes

The 103 Levallois flakes from Test Pit 12 were divided simply into whole Levallois flakes (75.7%, n=78) and trimmed/utilized Levallois flakes (17.5%, n=18). With respect to other types of debitage, the proportion of Levallois flakes per level did not show a relationship with depth. Despite this distribution, Levallois flakes were not found in the top 40 cm of the deposit; and were first encountered in Level 40 – 50 cm, near the suspected transition between the Iron Age/LSA and the MSA components of Magubike. Although tentative, given the low artifact density in the levels above 40-50 cm, this finding does support outside assertions that Levallois technology was predominantly an MSA technological feature (Tryon et al., 2005).

Over half of all Levallois flakes were made of "other metamorphic" materials (55.3%, n=57), 20.4% (n=21) were made of quartzite, 14.6% (n=15), 5.8% (n=6) on quartz, and 3.9% (n=4) were made from "other" materials (Table 4.26). No clear pattern of raw material preference change emerged, although it is worth noting that between approximately 60 and 140 cm, Levallois flakes were increasingly made from a range of materials, including higher frequencies of quartz, chert, and quartzite, while more conservative raw material choices seem to have been made above and below this point.

The 103 Levallois flakes in Test Pit 12 are contrasted by the presence of a single Levallois core, perhaps because cores were reduced elsewhere and the flakes transported to the site. It is more likely, however, that Levallois cores were reduced, on site, beyond recognition, perhaps bipolarly after they became too small to be effectively flaked.

Specialized Flakes

The only specialized flake type recovered was plain burin spall (n=24). The low number of burin spalls is not surprising given the low numbers of burins that were excavated. Most burin spalls were concentrated towards the middle of the sequence – only two were found in the top 40 cm, nearest the modern ground surface; and none were found below 150 cm.

Most burin spalls were made of quartz (79.2%, n=19) while one was made of quartzite, two of chert, and two of “other metamorphic” (Table 4.27). Due to the insignificant numbers in which burin spalls were recovered, there is little chance that statistical analyses would produce any meaningful patterns.

Figure 4.1. Number of Artifacts by Level.

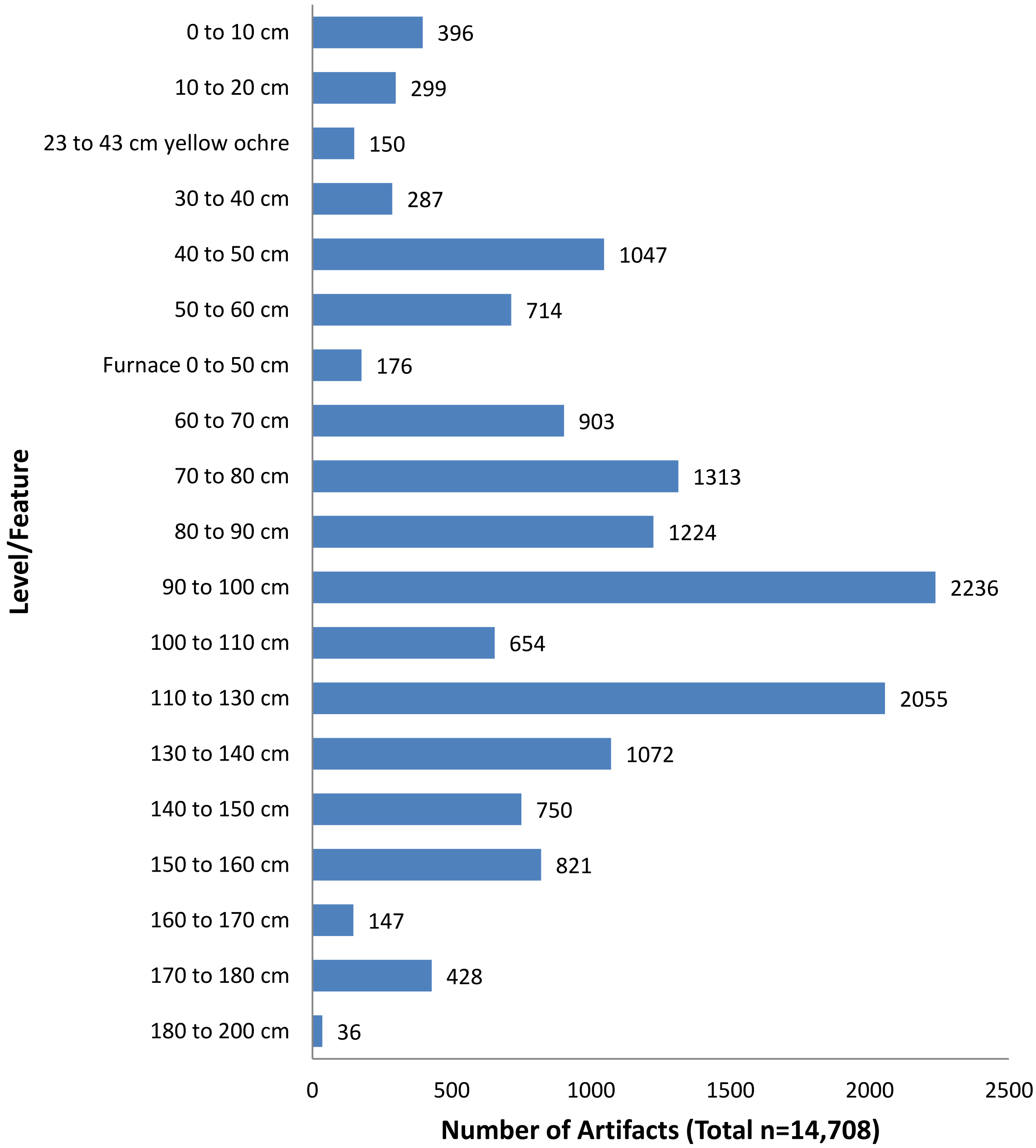


Figure 4.2. Raw Material Counts by Level.

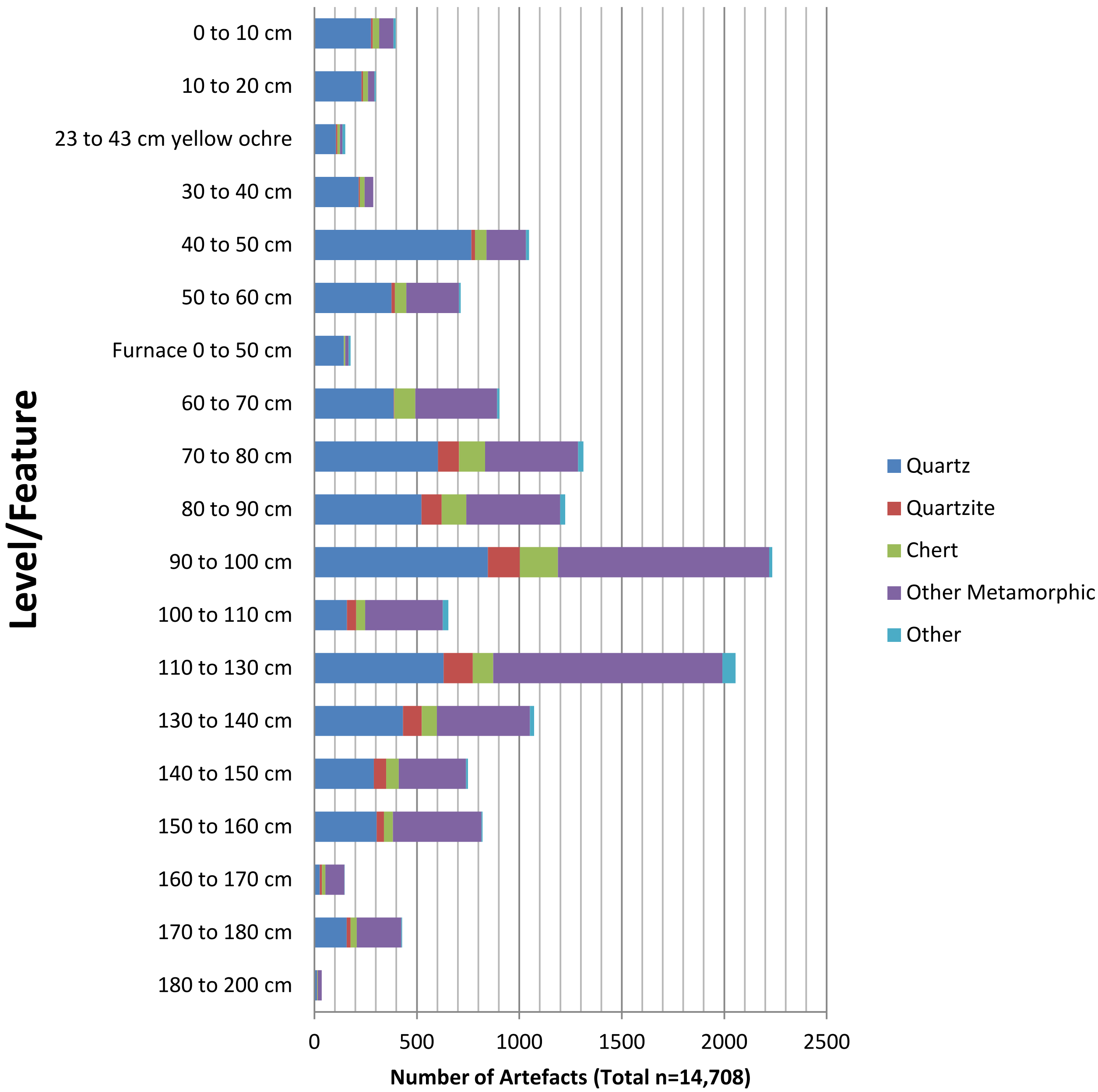


Figure 4.3. Proportions of Raw Material by Level.

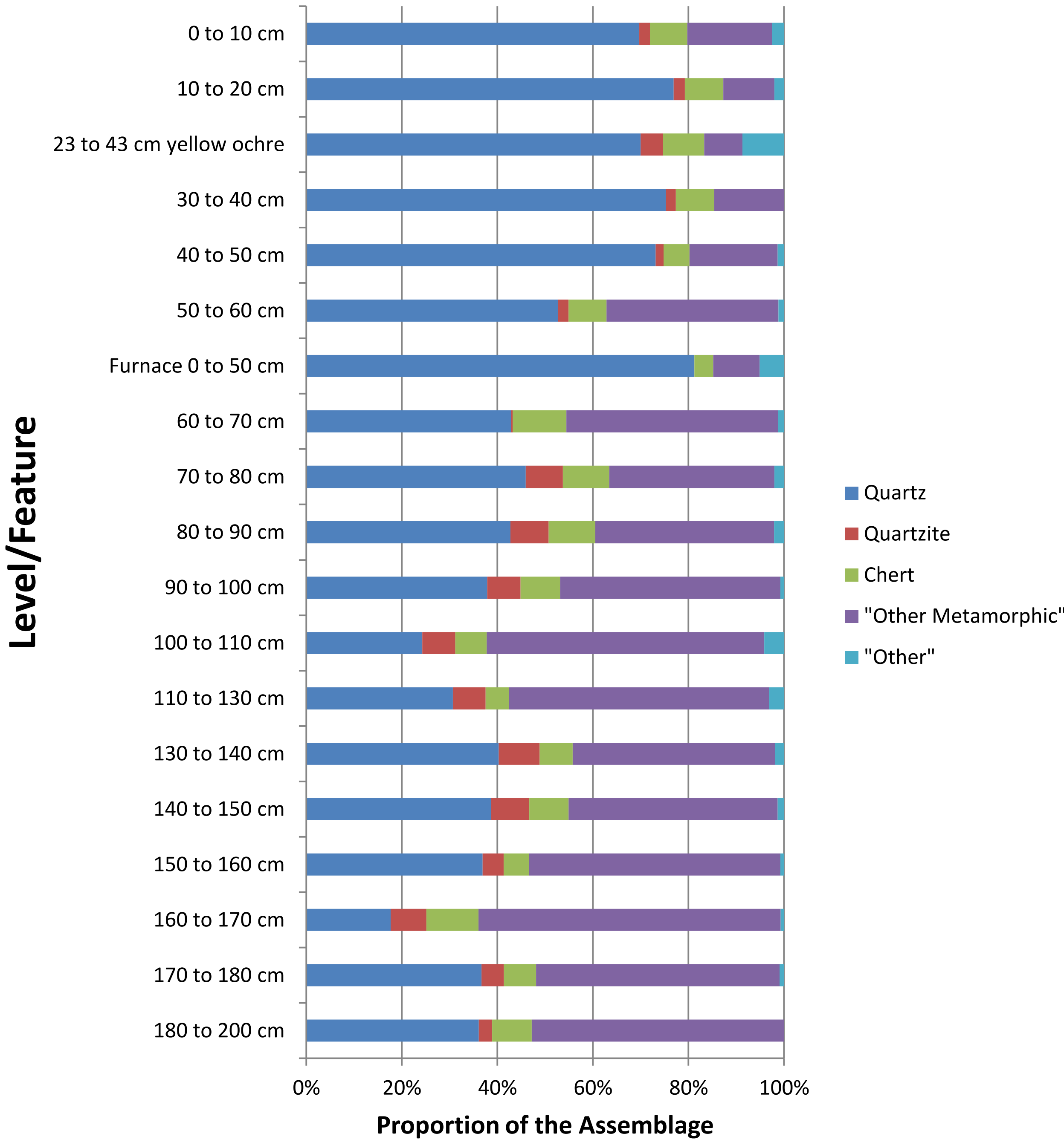


Figure 4.4. Number of General Categories by Level.

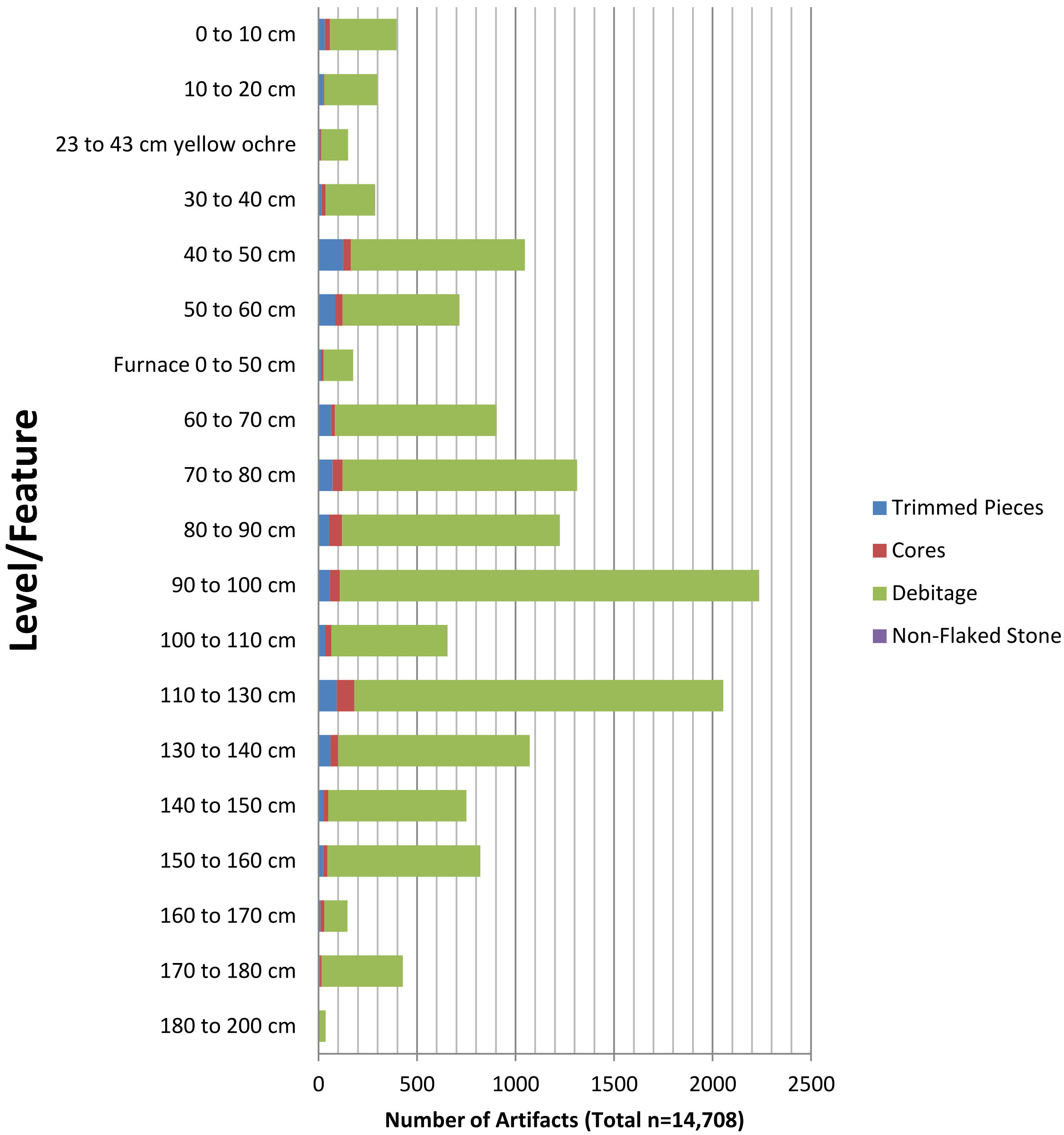


Figure 4.5. Proportions of General Categories by Level.

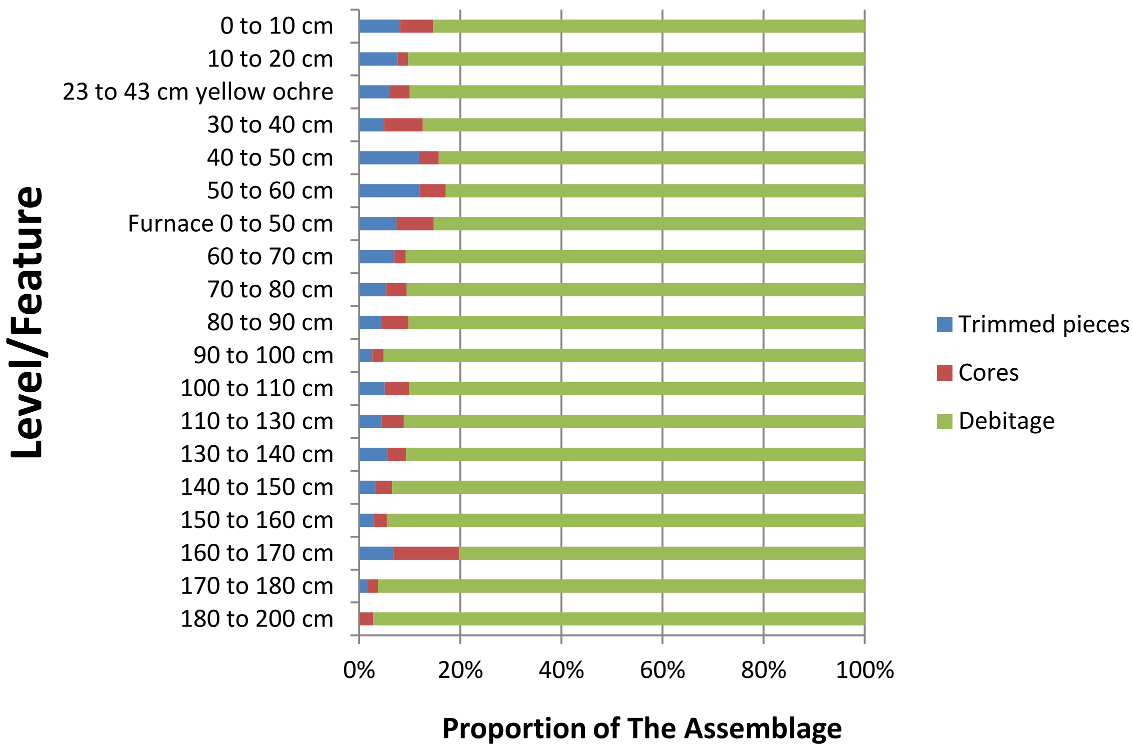


Figure 4.6. Number of Trimmed Pieces by Level.

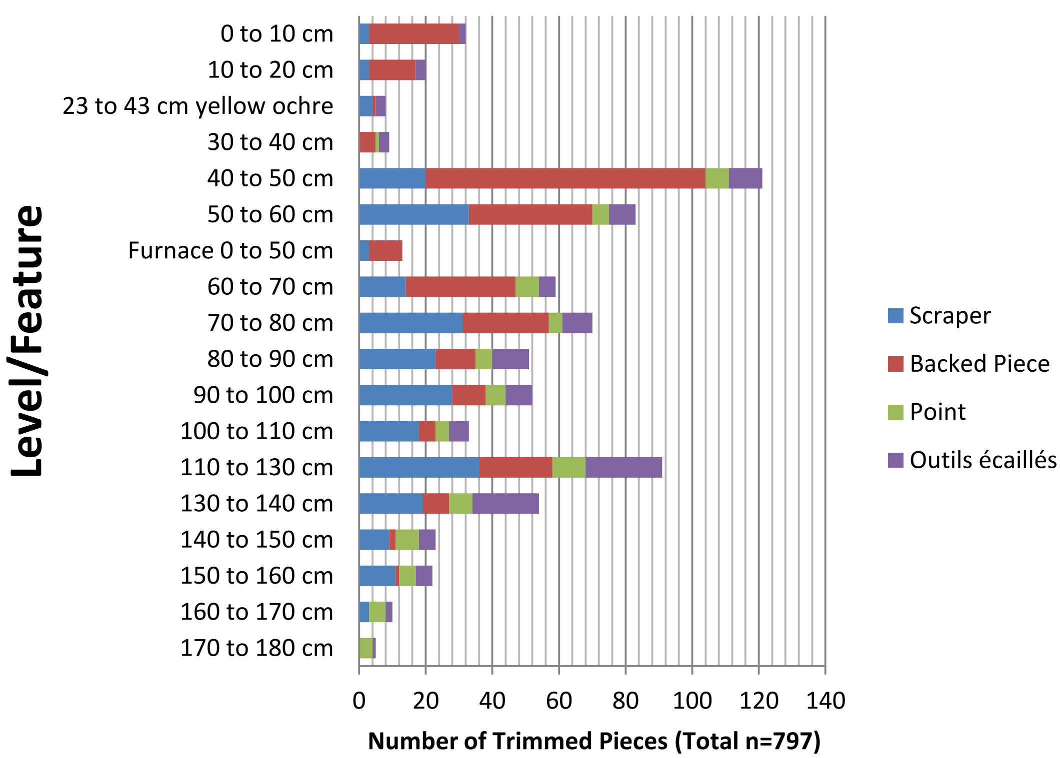


Figure 4.7. Proportions of Primary Trimmed Pieces by Level.

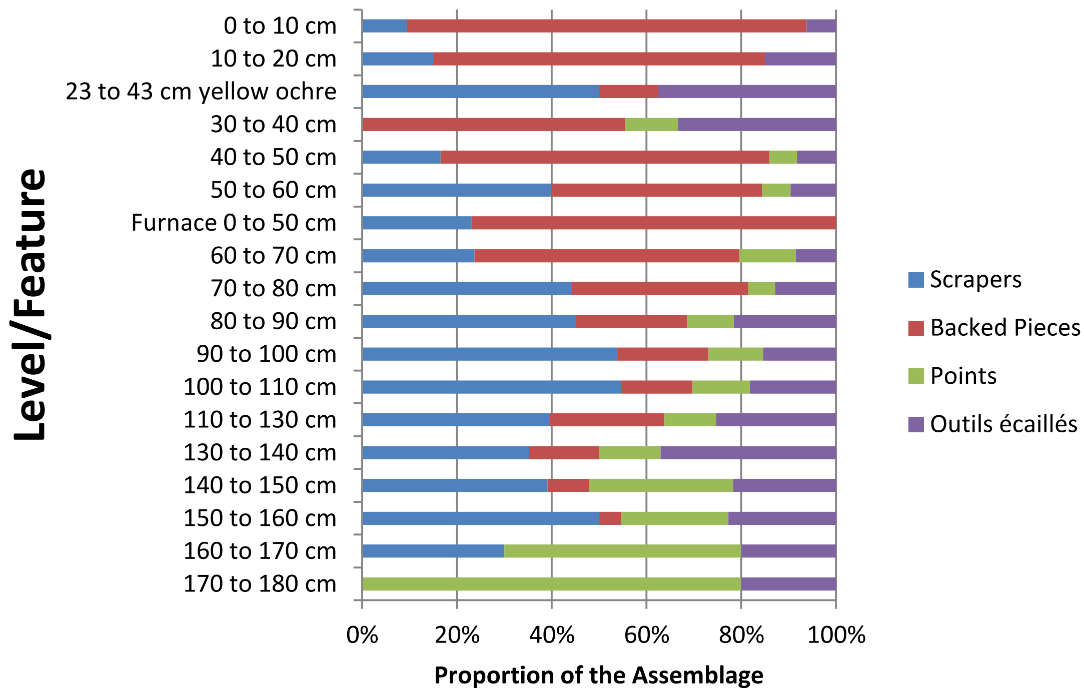


Figure 4.8. Trimmed Pieces: Number of Raw Material by Level.

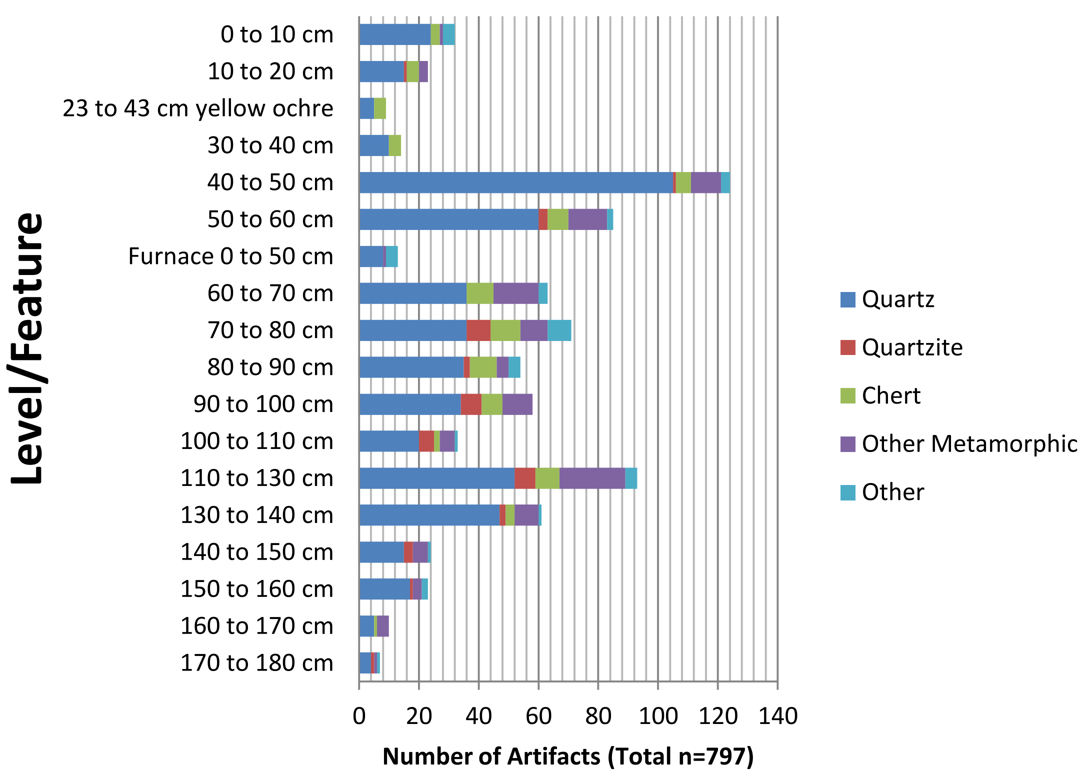


Figure 4.9. Trimmed Pieces: Proportion of Raw Material by Level.

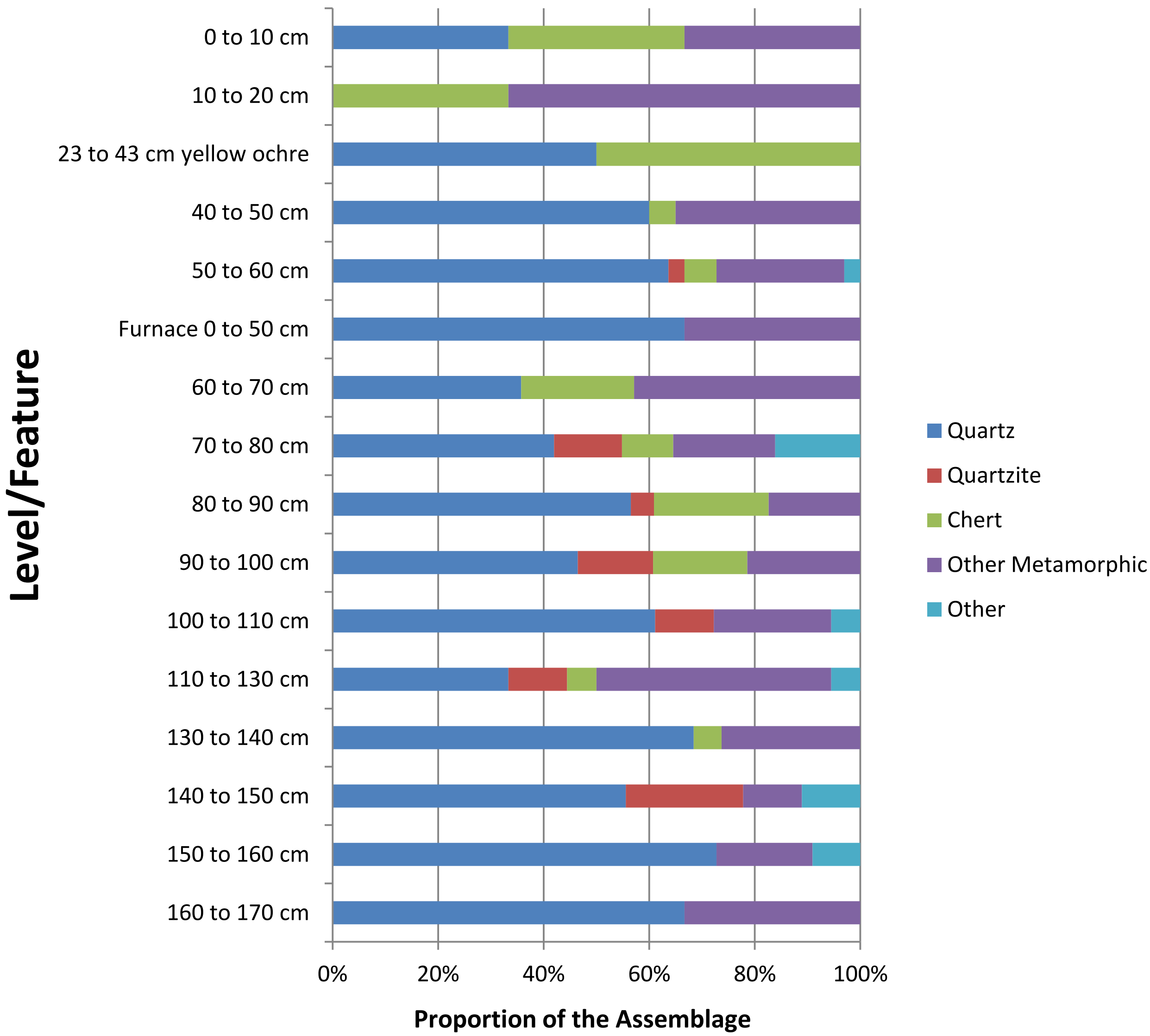


Table 4.1. Test Pit 12: Raw Materials.

Raw Material Type	N	Percent
Quartz	6484	44.1
Quartzite	826	5.6
Chert	1119	7.6
Other Metamorphic	6009	40.9
Other	270	1.8
Total	14708	100

Table 4.2. Trimmed Pieces: Tool Types.

Tool Type	N	Percent
Scraper	258	32.4
Backed Piece	297	37.3
Point	77	9.7
Burin	18	2.3
Bifacially Modified Piece	18	2.3
Bec	1	.1
Outils écaillés	124	15.6
Heavy duty tool	3	.4
Other tool	1	.1
Total	797	100.0

Table 4.3. Raw Material of Trimmed Pieces.

Raw Material	N	Percent
Quartz	528	66.2
Quartzite	41	5.1
Chert	76	9.5
Other metamorphic	114	14.3
Other	38	4.8
Total	797	100.0

Table 4.4. Backed Pieces: Sub-Types.

Tool Sub-Type	N	Percent
Crescent	6	2.0
Triangle	12	4.0
Trapeze	40	13.5
Curved Backed Piece	7	2.4
Straight Backed Piece	7	2.4
Orthogonal Truncation	7	2.4
Oblique Truncation	73	24.6
Angle Backed Piece	7	2.4
Divers Backed	130	43.8
Backed Awl	6	2.0
Backed Fragment	1	.3
Dihedral Burin	1	.3
Total	297	100.0

Table 4.5. Backed Pieces: Raw Material.

Raw Material	N	Percent
Quartz	242	81.5
Quartzite	5	1.7
Chert	24	8.1
Other Metamorphic	9	3.0
Other	17	5.7
Total	297	100.0

Table 4.6. Scrapers: Sub-Types.

Tool Sub-Type	N	Percent
Convex End Scraper	27	10.5
Convex End and Side Scraper	3	1.2
Circular Scraper	46	17.8
Nosed End Scraper	17	6.6
Convex Side Scraper	12	4.7
Convex Double Side Scraper	2	.8
Nosed Side Scraper	3	1.2
Sundry End Scraper	13	5.0
Sundry End and Side Scraper	7	2.7
Sundry Side Scraper	23	8.9
Sundry Double Side Scraper	6	2.3
Concave Scraper	70	27.1
Concavity	6	2.3
Notch	1	.4
Sundry Combination Scraper	2	.8
Convex End and Concave Combination Scraper	1	.4
Convex Side and Concave Combination Scraper	1	.4
Convergent Scraper	10	3.9
Scraper Fragment	8	3.1
Total	258	100.0

Table 4.7. Scrapers: Raw Material.

Raw Material	N	Percent
Quartz	133	51.6
Quartzite	18	7.0
Chert	26	10.1
Other Metamorphic	70	27.1
Other	11	4.3
Total	258	100.0

Table 4.8. Points: Sub-Types.

Tool Sub-Type	N	Percent
Unifacial Point	23	29.9
Alternate Face/Edge Point	1	1.3
Bifacial Point	2	2.6
Levallois Point	50	64.9
Total	77	100.0

Table 4.9. Points: Raw Material.

Raw Material	N	Percent
Quartz	28	36.4
Quartzite	9	11.7
Chert	8	10.4
Other Metamorphic	30	39.0
Other	2	2.6
Total	77	100.0

Table 4.10. *Outils écaillés*: Raw Material.

Raw Material	N	Percent
Quartz	101	81.5
Quartzite	6	4.8
Chert	10	8.1
Other	7	5.6
Total	124	100.0

Table 4.11. Cores: Tool Types.

Tool Type	N	Percent
Peripheral Core	38	6.6
Patterned Platform Core	39	6.8
Intermediate Core	5	.9
Bipolar Core	489	85.2
Amorphous Core	3	.5
Total	574	100.0

Table 4.12. Cores: Raw Material.

Raw Material	N	Percent
Quartz	331	57.7
Quartzite	47	8.2
Chert	67	11.7
Other Metamorphic	111	19.3
Other	18	3.1
Total	574	100.0

Table 4.13. Bipolar Cores: Raw Material.

Raw Material	N	Percent
Quartz	303	62.0
Quartzite	40	8.2
Chert	49	10.0
Other Metamorphic	85	17.4
Other	12	2.5
Total	489	100.0

Table 4.14. Patterned Platform Cores: Sub-Types.

Tool Sub Type	N	Percent
Pyramidal/Prismatic Single Platform Core	3	7.7
Divers Single Platform Core	8	20.5
Single Platform Core/Core Scraper	9	23.1
Opposed Double Platform Core	7	17.9
Adjacent Double Platform Core	2	5.1
Multiple Platform Core	10	25.6
Total	39	100.0

Table 4.15. Patterned Platform Cores: Raw Material.

Raw Material	N	Percent
Quartz	8	20.5
Quartzite	3	7.7
Chert	7	17.9
Other Metamorphic	18	46.2
Other	3	7.7
Total	39	100.0

Table 4.16. Peripheral Cores: Sub-Types.

Tool Sub-Type	N	Percent
Part Peripheral Core	16	42.1
Radial/Biconic Core	13	34.2
Disc Core	7	18.4
Levallois Core	1	2.6
Bipolar Core	1	2.6
Total	38	100.0

Table 4.17. Peripheral Cores: Raw Material.

Raw Material	N	Percent
Quartz	18	47.4
Quartzite	3	7.9
Chert	11	28.9
Other Metamorphic	4	10.5
Other	2	5.3
Total	38	100.0

Table 4.18. Debitage: Tool Types.

Tool Type	N	Percent
Angular Fragment	9521	71.4
Specialized Flake	24	.2
Flake	3370	25.3
Blade	313	2.3
Levallois Flake	103	.8
Total	13331	100.0

Table 4.19. Debitage: Raw Material.

Raw Material	N	Percent
Quartz	5625	42.2
Quartzite	737	5.5
Chert	976	7.3
Other Metamorphic	5780	43.4
Other	213	1.6
Total	13331	100.0

Table 4.20. Angular Fragments: Sub-Types.

Tool Sub-Type	N	Percent
Core Fragment	3429	36.0
Angular Fragment	5918	62.2
Blade Segment-Medial or Distal	174	1.8
Total	9521	100.0

Table 4.21. Angular Fragments: Raw Material.

Raw Material	N	Percent
Quartz	4817	50.6
Quartzite	191	2.0
Chert	440	4.6
Other Metamorphic	4003	42.0
Other	70	.7
Total	9521	100.0

Table 4.22. Flakes: Sub-Types.

Tool Sub-Type	N	Percent
Whole Flake	1513	44.9
Trimmed/Utilized Flake	468	13.9
Flake Talon Fragment	1388	41.2
Total	3370	100.0

Table 4.23. Flakes: Raw Material.

Raw Material	N	Percent
Quartz	735	21.8
Quartzite	481	14.3
Chert	466	13.8
Other Metamorphic	1566	46.5
Other	122	3.6
Total	3370	100.0

Table 4.24. Blades: Sub-Types.

Tool Sub-Type	N	Percent
Whole Blade	136	43.5
Blade Talon Fragment	177	56.5
Total	313	100.0

Table 4.25. Blades: Raw Materials.

Raw Material	N	Percent
Quartz	48	15.3
Quartzite	43	13.7
Chert	53	16.9
Other Metamorphic	152	48.6
Other	17	5.4
Total	313	100.0

Table 4.26. Levallois Flakes: Raw Material.

Raw Material	N	Percent
Quartz	6	5.8
Quartzite	21	20.4
Chert	15	14.6
Other Metamorphic	57	55.3
Other	4	3.9
Total	103	100.0

Table 4.27. Specialized Flakes: Raw Material.

Raw Material	N	Percent
Quartz	19	79.2
Quartzite	1	4.2
Chert	2	8.3
Other Metamorphic	2	8.3
Total	24	100.0

Chapter 5 TECHNOLOGICAL ANALYSIS

The following chapter contains the results of the technological analyses that were performed. The attributes assayed here record vital information about how the artifacts were created, in turn reflecting aspects of past site-use, mobility, lithic raw material-use intensity, and reduction strategies. For each artifact, the weight, breadth, length, and thickness was recorded. For whole and trimmed/utilized flakes, as well as some trimmed pieces, the following variables were documented: Toth number, platform breadth, platform length, platform angle, platform facets, planform, dorsal flake scar number, dorsal flake scar pattern, flake area, and platform area. For tools, the additional variables of retouch intensity and retouch angle were added. Several unique variables for cores were also noted: cortex cover and flake scar number. Each of these attributes is discussed in more detail in Chapter 3.

5.1 Trimmed Pieces

Retouch Intensity

Retouch intensity was recorded only for retouched tools, and is an overall measure of the extent to which an artifact was shaped subsequent to its removal from the core. Retouch intensity was recorded for 611 artifacts; and was divided into three types: marginal, semi-invasive, and invasive. The number of pieces for which retouch intensity was recorded is somewhat less than the total number of trimmed pieces, as some tool types such as Levallois points were included despite lacking secondary modification. Most of the artifacts exhibited only marginal retouch (96.1%, n=587); and far fewer displayed semi-invasive (3.7%, n=23) and invasive retouch (.01%, n=1). The artifacts that demonstrated either semi-invasive or invasive retouch were recovered mainly between 80 and 140 cm.

In addition to differences in the distribution of retouched pieces within the sequence, a series of z-tests revealed statistically significant differences between the raw materials that were only marginally retouched and those that were semi-invasively and invasively retouched. Specifically, quartz was less likely to be selected to be transformed beyond marginal phases of retouch (z= -2.433, p=.0151), while "other metamorphic" materials were just as likely to be marginally or semi-invasively retouched (z=.5231, p=.6030). Chert was the key exception, and a z-test confirmed that tools with semi-invasive retouch were about three times more likely to have been made from chert than those tools with only marginal retouch (z=2.6133, p=.0091).

A clear association between retouch intensity and tool type was also demonstrated using a z-test. Bifacially modified pieces, specifically, were much more likely to be more intensively retouched than other tool types ($z=11.5837$, $p<.0001$). In total, 10 of the 18 bifacially worked tools in the assemblage showed evidence of semi-invasive retouch.

Retouch Angle

The angle of retouch refers to the angle formed by the dorsal and ventral surfaces of the trimmed piece, either or both of which may be retouched. In order to be an effective cutting or scraping implement, the angle of retouch usually falls between 30^{o} and 70^{o} (Mehlman, 1989). The mean angle of retouch for all trimmed pieces in Test Pit 12 was 64.71^{o}, with a standard deviation of 26.860^{o}. This value represents a middle ground between backed pieces, which were retouched to an average angle of 88.22^{o} with a standard deviation of 5.931^{o}; and scrapers, which were retouched to a mean angle of 42.21^{o} with a much larger standard deviation of 18.356^{o}. Interestingly, a t-test revealed that the mean retouch angle of points (34.82^{o}, $SD=12.944^{o}$) was approximately 8^{o} less than scrapers ($t=2.0735$ ($df=284$), $p=.0390$). Nonetheless, it is difficult to say without further experimentation whether or not a difference in angle of 8^{o} would have substantially altered the effectiveness of either tool category. Retouch angle data was documented using a protractor, and can be found in Table 5.1.

Size Measurements

In order to detect changes in tool size over time, the average weight per level of several different tool types was tested independently by depth. The types that were investigated were backed pieces, scrapers, and points. For points, the tip cross-sectional area was also calculated using measurements of breadth and thickness. Further information on the mean values of length, breadth, thickness, and weight can be found in Table 5.2.

Backed Pieces

Although backed tools are acknowledged to occur in the MSA, they were often larger and less standardized than LSA types (Leplongeon, in press). In order to test this assumption in Test Pit 12, the average weight of backed tools was compared to their position in the chronological sequence (Figure 5.1). A Spearman's rank-order correlation revealed a positive relationship, suggesting that the average weight of backed pieces increased with depth, consistent with other reports of MSA technology (r_s=.7832 (df=10), p=.0026, r^2=.6134).

Scrapers

A similar test was performed on scrapers in Test Pit 12 (Figure 5.2). A Spearman's rank-order correlation was conducted on all scrapers, irrespective of raw material, in order to generate acceptable sample sizes for each level. The test revealed no statistically significant relationship between average scraper weight and level (r_s=.2273 (df=15), p=.5016, r^2=.0517). So, unlike backed pieces, which were slightly larger in the lower levels of Test Pit 12, scraper size remained relatively unchanged throughout the sequence.

Points

Lastly, the average weight of points by level was plotted against depth (Figure 5.3). Much like the scraper category, a Spearman's rank-order correlation showed no relationship (r_s= -.1596 (df=11), p=.5999, r^2=.0255).

Tip cross-sectional area (TCSA) is widely accepted to be one of the best methods of distinguishing the armatures of different weapons systems: hand-cast spears, darts, and arrow points (Hughes, 1998; Villa and Lenoir, 2006). TCSA is also key variable which affects the penetrating power of low powered projectiles such as those employed in the Paleolithic and Stone Age. Specifically, an armature must balance a low TCSA in order to penetrate effectively, with a basic degree of robusticity to withstand the force of impact with the target. Because there was little size variation over time and the data were normally distributed, the points in Test Pit 12 were analyzed collectively; and the results were compared to known TCSA values, each of which corresponds to a different projectile delivery method (Shea, 2006).

TCSA = ½ maximum width multiplied by maximum thickness

The mean TCSA of the projectiles in Test Pit 12 was 137 mm^2, somewhere between the values provided for spear tips and dart tips in Table 5.3. A t-test, however, revealed that although the mean value of the Test Pit 12 projectile points was different from the mean value of spear points, it was not statistically dissimilar at a 95% confidence interval ($t=1.6745$ ($df=103$), $p=.0971$). The same test performed between Test Pit 12 projectiles and dart points, however, showed that the two categories were statistically different ($t=6.0067$ ($df=115$), $p < .0001$). From this result it can be concluded that, although smaller than the spear tips surveyed by Shea (2006), the projectile points excavated from Test Pit 12 likely tipped hand-cast or thrusting spears. This conclusion is consistent with other technological interpretations of MSA projectile point technology from Klasies River, Sibudu Cave, and Rose Cottage Cave (Shea, 2006; Villa and Lenoir, 2006)

5.2 Cores

Cortex Cover

The mean cortex cover for all cores was 21.42%, with a standard deviation of 21.051%. Overall there is not a significant correlation between depth and the average cortical cover of cores per level (r_s=.2785 (df=15), p =.2803, r^2 =.0776). Nevertheless, cores from the bottom of the sequence have, on average, less remaining cortex than cores higher up.

The percentage of cortex was also calculated for the three primary core types individually, all of which showed approximately equal means (Table 5.4). Specifically, the mean cortex percentage remaining on bipolar cores was 21.34%, with a standard deviation of 21.034%. Peripherally worked cores were similar to bipolar cores (mean=20.39%, SD=16.497%), as were patterned platform cores (mean=22.56%, SD=23.364%). Cortex does not appear to be significantly associated with material type, either (F=.808 (df=4), p=.521).

Core Flake Scars

The cores in Test Pit 12 had, on average, 4.68 flake scars (SD=3.206), although some bipolar cores had as few as 0 (bipolar cores which were split down the center of the core prior to any external flaking), while other cores had as many as 17 flake scars (Table 5.5). Bipolar cores had the fewest average flake scars (mean=4.12, SD=2.760), while peripheral cores (mean=9.53, SD=3.446) and patterned platform cores (mean=6.41, SD=3.050) each displayed substantially more (t=4.9471 (df=526), $p < .0001$). Furthermore, the mean number of flake scars on peripheral cores and pattern platform cores also differed significantly from each other, suggesting different degrees of lithic resource-use intensity or different reduction strategies (t=4.2098 (df=75), $p < .0001$).

The average number of core flake scars per level also shows a negative relationship with depth (r_s= -.6103 (df=15), p = .0093, r^2 =.3725). This statistic indicates that cores recovered from lower in Test Pit 12 had fewer flake scars on average than those found higher in the sequence (Figure 5.4). Nonetheless, flake scar counts are highly dependent on other variables, including the size of the core (Andrefsky, 2005). In order to test for such a relationship, a Spearman's rank-order correlation was performed using the variables of core weight (as a proxy for size) and flake scar number. The test showed that the two are statistically associated; and that as the weight of a typical core increases, so does the average number of flake scars on its surface (r_s=.218 (df=572), p < .0001, r^2 =.0475). Raw material type was also found to be statistically related to flake scar count (F=8.105 (df=4), p < .0001). In this case, chert cores had the highest number of flake scars (mean=6.25, SD=3.408), while quartz cores had the fewest (mean=4.11, SD=3.015). Overall, the variation in flake scar count may reflect dissimilar reduction strategies, the initial size of unmodified stones, or inherent difficulties identifying flake negatives on certain materials such as quartz, leading to their underrepresentation.

SIZE MEASUREMENTS

The lengths, breadths, thicknesses, and weights of all cores in Test Pit 12 are presented in Table 5.6. Once again, weight was taken to indicate the overall size of cores for the purpose of analysis and comparison. The mean weight of the cores in Test Pit 12, excluding bipolar core fragments, was 32.445 g, with a large standard deviation of 55.2642 g. The data were also skewed strongly to the right, as most of the cores fell to the left of the mean, with a long tail to the right representing anomalously heavy cores. Substantial differences in the average weight of discrete core types were also detected. Unsurprisingly, bipolar cores, excluding core fragments, were the smallest (mean=21.450 g, SD=18.0939 g); but also the most consistently sized. Peripheral cores were much larger on average (mean=42.674 g, SD=76.1964 g); and patterned platform cores were larger still, albeit with a much higher standard deviation (mean=105.931 g, SD=113.7062 g).

The mean weight of quartz and "other metamorphic" cores per level were independently tested to detect change over time (Figure 5.5 and 5.6). Quartz cores showed remarkable stability with depth, and did not tend to fluctuate in size (r_s=.1642 (df=15), p =.5318, r^2 =.0270). "Other metamorphic" cores, conversely, exhibit a strong negative trend, decreasing in size with depth (r_s= -.8818 (df=15), p =.0003, r^2 =.7776). The differences in mean weight by material type noted here may be related to changing reduction strategies or lithic resource-use intensity practices through time. In particular, quartz cores were predictably reduced using bipolar flaking throughout the history of the site, while the ways in which "other metamorphic" stones were used appears to have changed.

5.3 Debitage

Toth Types

Toth types were assigned to each piece with a recognizable platform, dorsal surface, and ventral surface, including many categories of debitage but also some trimmed pieces that retained these features. Toth types correspond loosely to the lithic reduction stage from which a flake was derived; and may assist in detecting selective transport of debitage, whether by anthropogenic agents or natural processes; and location-dependent reduction practices such as early core preparation off-site (Toth 1982). In total, the Toth types of 4295 artifacts were recorded. The number and percentage of each type can be found in Table 5.7. The most frequent types were VI and V, which correspond to late stage reduction. This distribution is quite common in complete assemblages, given the volumetric properties of most cores (i.e., the majority of flakes will be initiated from the interior of the core). Types I through IV are each present in proportions less than 4%, a distribution which is also not unusual. The proportion of Toth types was similar when flakes were isolated from other types of debitage and trimmed pieces, although the mean Toth value was found to be higher (5.36 as compared to 3.39 for the entire collection).

In order to determine if there were differences in the frequency of Toth types by depth the average Toth number was calculated for each level and then plotted using a Spearman's rank-order correlation (Figure 5.7). The test revealed that the Toth mean became slightly larger with depth, indicating that less of the cortical surface was retained in the lower deposits of the site (r_s=.5294 (df=16), p =.0237, r^2 =.2803). This pattern may imply any combination of processes, including the differential and selective transport of materials in and out of the site, changing reduction strategies, changes in lithic resource-use intensity, or post-depositional disturbance.

The Toth type mean also appeared to be related to raw material type (F=33.241, $p <$ .0001). In particular, the mean Toth statistic for "other metamorphic" stones was highest (mean=5.56, SD=.868), while quartzite was the lowest (mean=5.05, SD=1.326). The values for quartz, chert, and "other" stones fell between these two extremes (Table 5.8).

Since the mean proportion of each Toth type resulting from typical MSA reduction sequences is not known at this time, it is difficult to make behavioural predictions on the basis of the Toth types in Test Pit 12. Future work at the site must include reduction experiments, if Toth types are to be effectively interpreted (Toth, 1987). The presence of each type in Test Pit 12 at least indicates that all reduction stages were present to some degree.

Planform

The planform of a number of different lithic artifacts was recorded, including debitage and tool categories where possible. The shape of each piece was described as convergent, parallel, divergent, intermediate, or circular. Planform was assigned to a total of 4664 artifacts. Of these, most were divergent (43.1%, n=2008), followed by parallel (28.2%, n=1314), convergent (23.6%, n=1102), circular (4.5%, n=211), and intermediate (.6%, n=29). See Table 5.9 for more complete information.

A chi-square was performed in order to determine whether or not certain flake planforms were preferred for different tool categories. Because retouch intensity was mostly marginal, it was concluded that secondary flaking had little effect on the planform of most trimmed pieces, allowing the original shape of the flake to be estimated accurately. In order to achieve acceptable counts in each cell, only convergent, parallel, and divergent planforms were computed. Points were shown to be composed of convergent flakes almost exclusively (96.1%, n=73), and were subsequently excluded from the test due to low counts in both the parallel and divergent columns. The only tool types remaining in any number were backed pieces and scrapers. The results support the hypothesis that differently shaped flakes, were preferentially selected for transformation into these two primary tools categories ($\chi^2 = 8.030$ (df=2), p =.018, V=.129). Specifically, scrapers were more often made using divergent and convergent flakes while backed pieces were made more commonly than scrapers on parallel sided pieces.

Flake Scar Pattern

Flake scar pattern refers to the directionality and arrangement of flake negatives on the dorsal surface of a piece. Like planform, flake scar pattern was recorded where possible; and so includes a cross-cut of debitage and trimmed pieces. The number and proportions of each flake scar pattern type are presented in Table 5.10. This variable was recorded for a total of 4707 artifacts; among these, “same platform, simple”, was the most frequent category (46.9%, n=2209). A further analysis of this pattern revealed that the proportion of “same platform, simple” flakes did not change significantly with depth (r_s= -.4035 (df=16), p =.0975, r^2 =.1628). Furthermore, there does not appear to be any significant change in the relative proportion of each other flake scar pattern type over time, either. Flake scar pattern was also very weakly, although significantly, related to raw material type, possibly indicating that certain raw materials were selected for use within different reduction pathways (χ^2 = 79.948 (df=18), p < .0001, V=.077).

Dorsal Scar Number

Of the debitage and trimmed pieces for which dorsal scar number was recorded, all had a count between 0 and 8. The mean number of flake scars was 2.34 (SD=1.215), and the data are skewed slightly to the right. There does not appear to be any variation in the mean number of dorsal scars over time (r_s= .3914 (df=15), p =.1197, r^2 =.1532). Although raw material is statistically associated with flake scar counts, a multiple regression analysis revealed that the length and breadth of the flake account for more of the variation. Much like flake scar counts for cores, dorsal scar counts must be used cautiously, as they are heavily dependent on a number of supplementary factors.

Apart from additional sources of variation such as raw material type and individual differences in flake length and breadth, there appears to be a significant relationship between scar pattern and dorsal scar number (F=502.228, p < .0001). Specifically, flakes that were chipped radially had the highest mean number of dorsal scars (mean=4.12, SD=1.164), while those which were produced with convergent flaking had a mean of 3.09 (SD=.393). The other categories surveyed all had dorsal scar counts that centered on the total mean, around 2.34.

Platform Facets

A number of platform facets greater than one may be indicative of a degree of platform preparation and thus specific lithic reduction strategies such as Levallois flaking. The mean number of platform facets was found to be just over one (1.29, SD=.578), and every piece fell between one and five facets. The data also possessed a strong right skew because few flakes had more than two or three platform facets. Because the data were non-normally distributed, a Spearman's rank-order correlation was used to detect changes in the mean number of platform facets with depth (r_s= .7514 (df=15), p =.0005, r^2 =.5649). The results suggest increased levels of core preparation during the MSA levels of the site, congruent with current interpretations of MSA and LSA technology (Figure 5.8).

Size Measurements

The mean measurements for length, breadth, thickness, and weight can be found in Table 5.11. Since these measurements were not taken for angular fragments or core fragments, the values in the table reflect only the dimensions of the remaining 3986 pieces of debitage. A plot of general debitage size, as represented by weight, showed that although there are likely to be significant associations between size and level, the data were non-monotonic, making a Spearman's rank-order correlation inappropriate (Figure 5.9). Described broadly, the mean size of debitage appeared to peak around 90 – 120 cm; and declined above and below this concentration. The debitage above 40 cm, in the Iron Age/LSA levels also appears to be smaller.

Figure 5.1. Weight of Backed Pieces by Level.

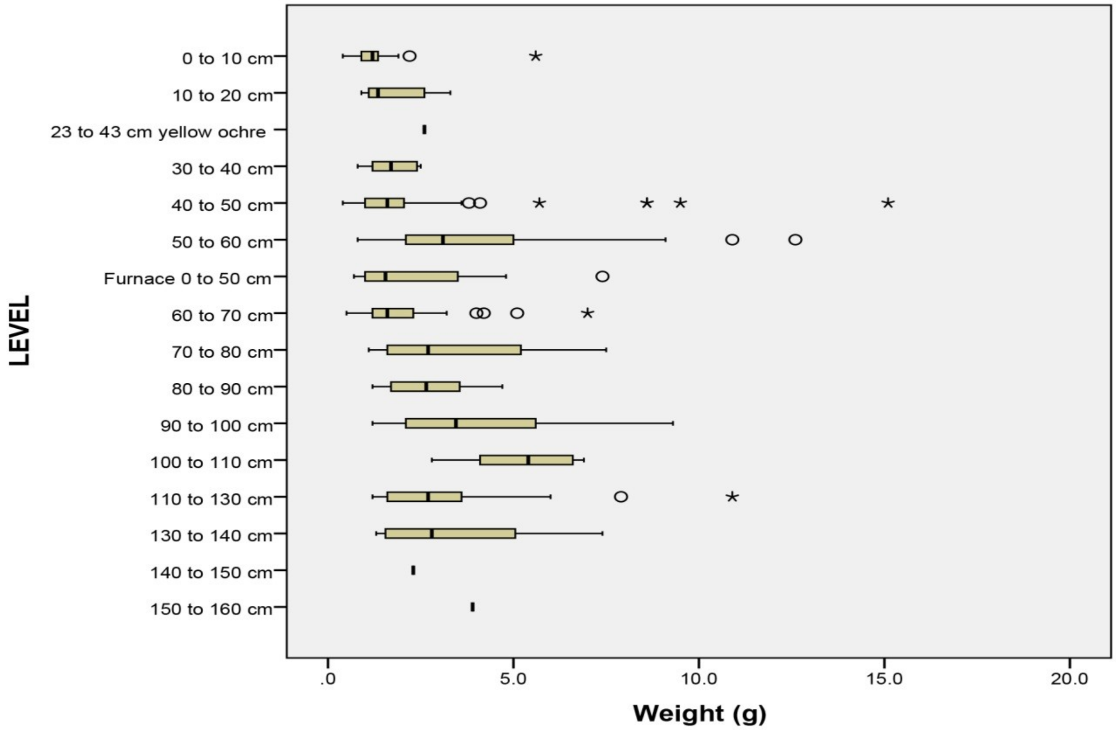


Figure 5.2. Weight of Scrapers by Level.

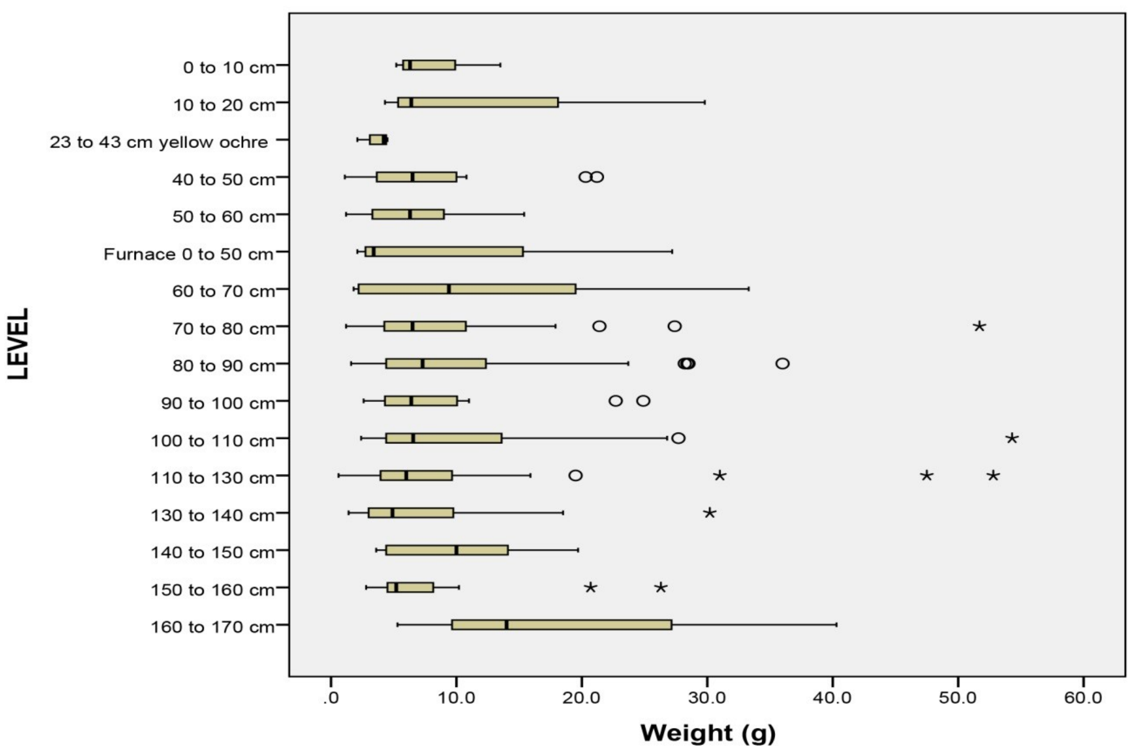


Figure 5.3. Weight of Points by Level.

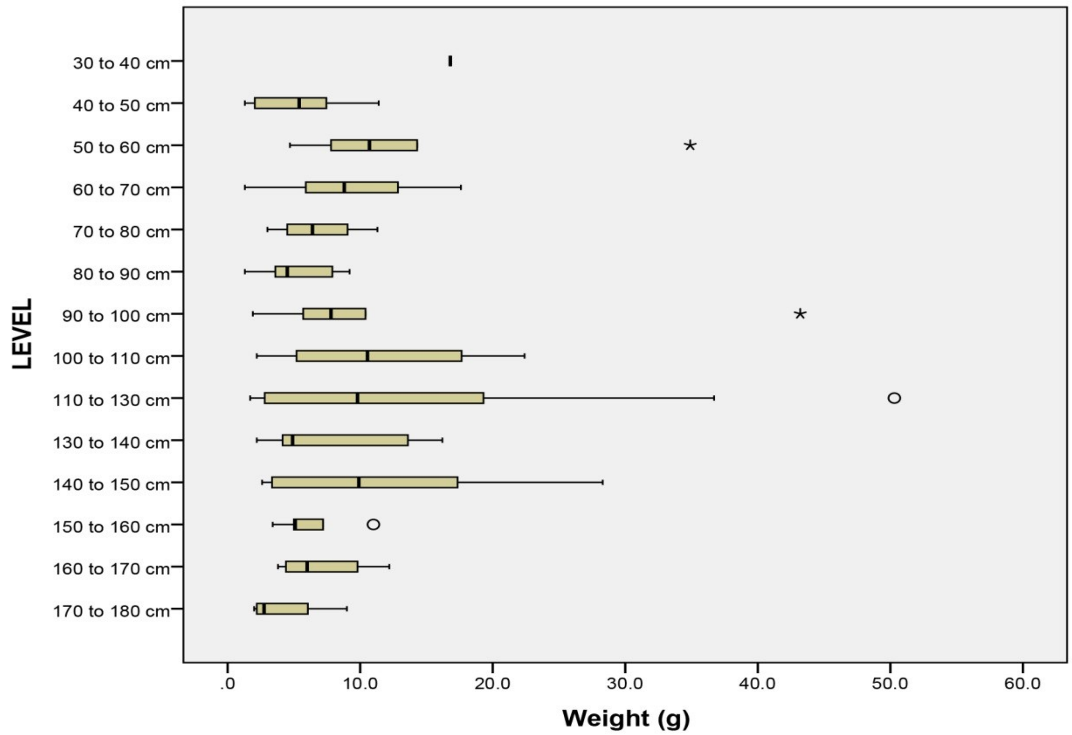


Figure 5.4. Flake Scars by Level.

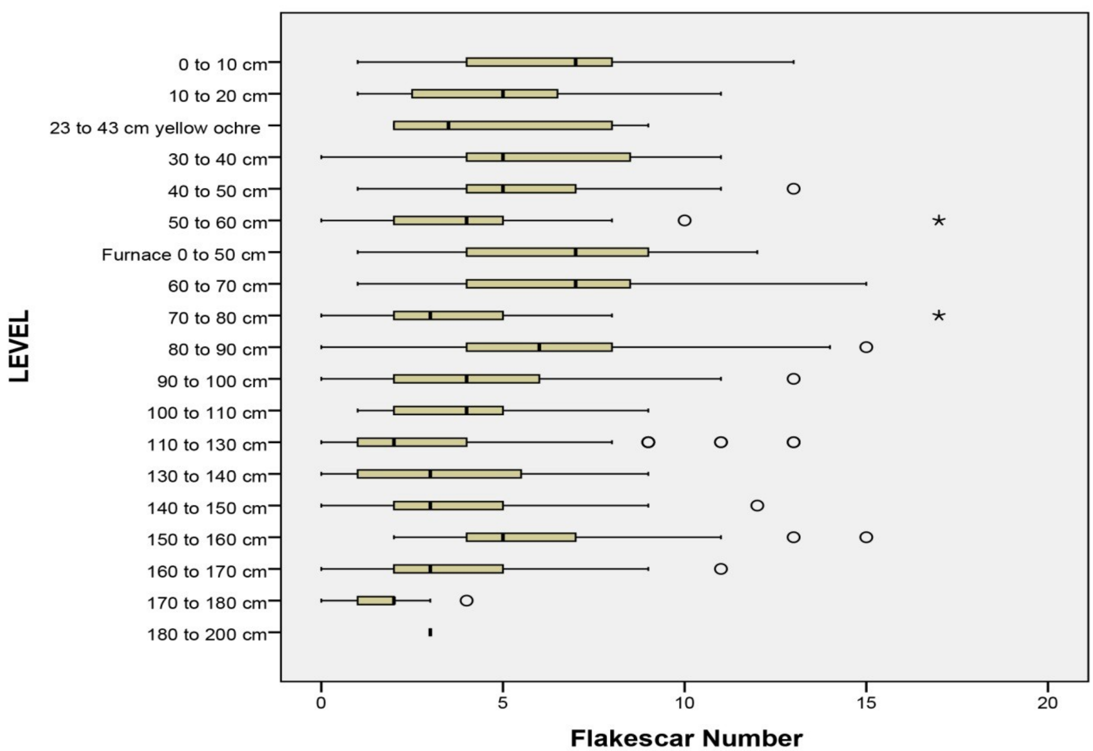


Figure 5.5. Weight of Quartz Cores by Level.

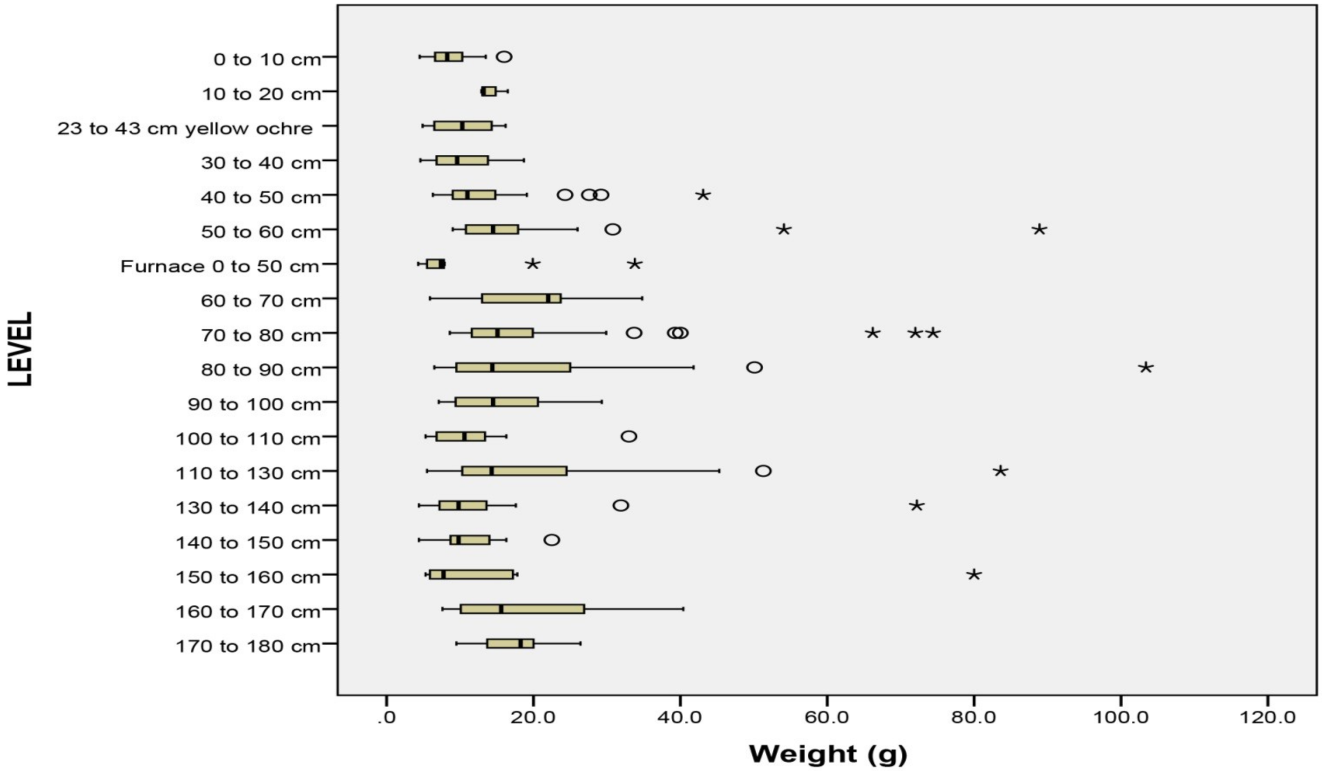


Figure 5.6. Weight of "Other Metamorphic" Cores by Level.

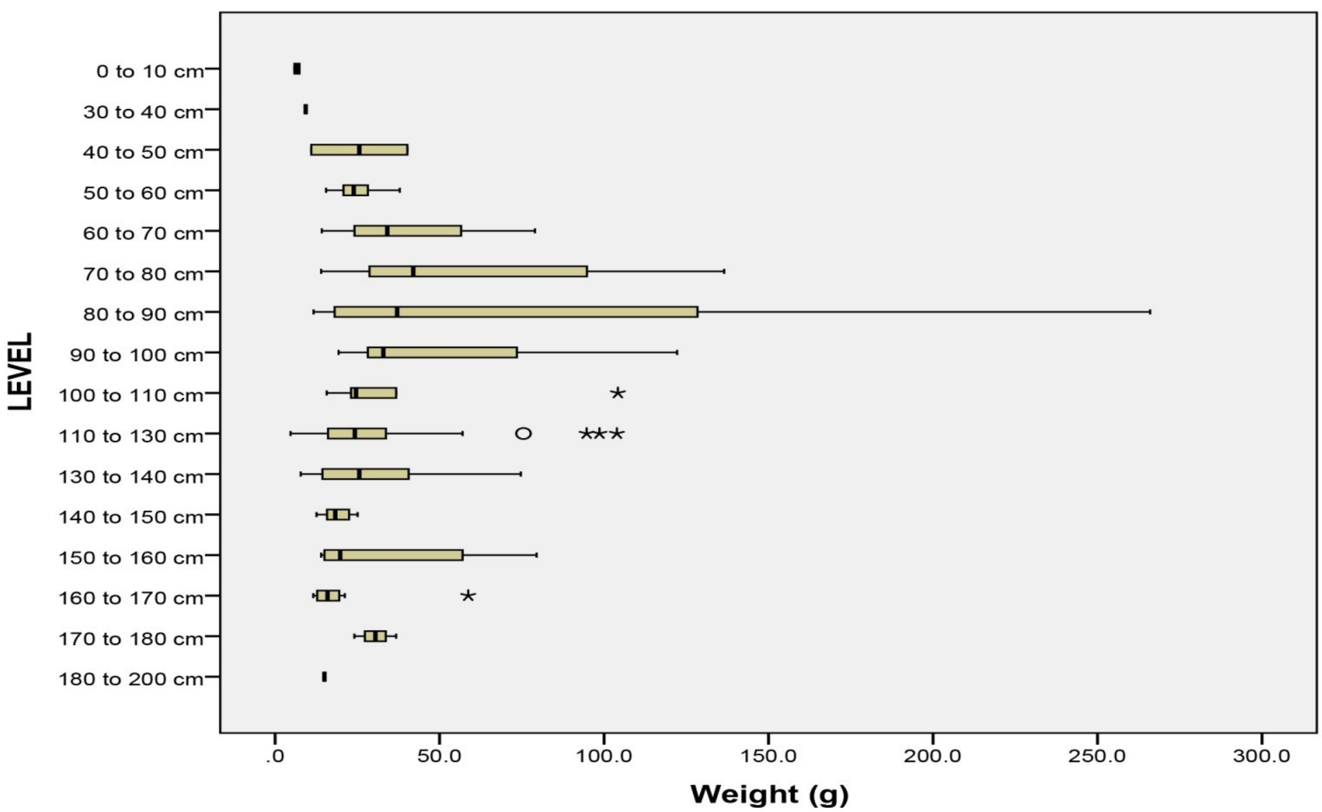


Figure 5.7. Distribution of Toth Number by Level.

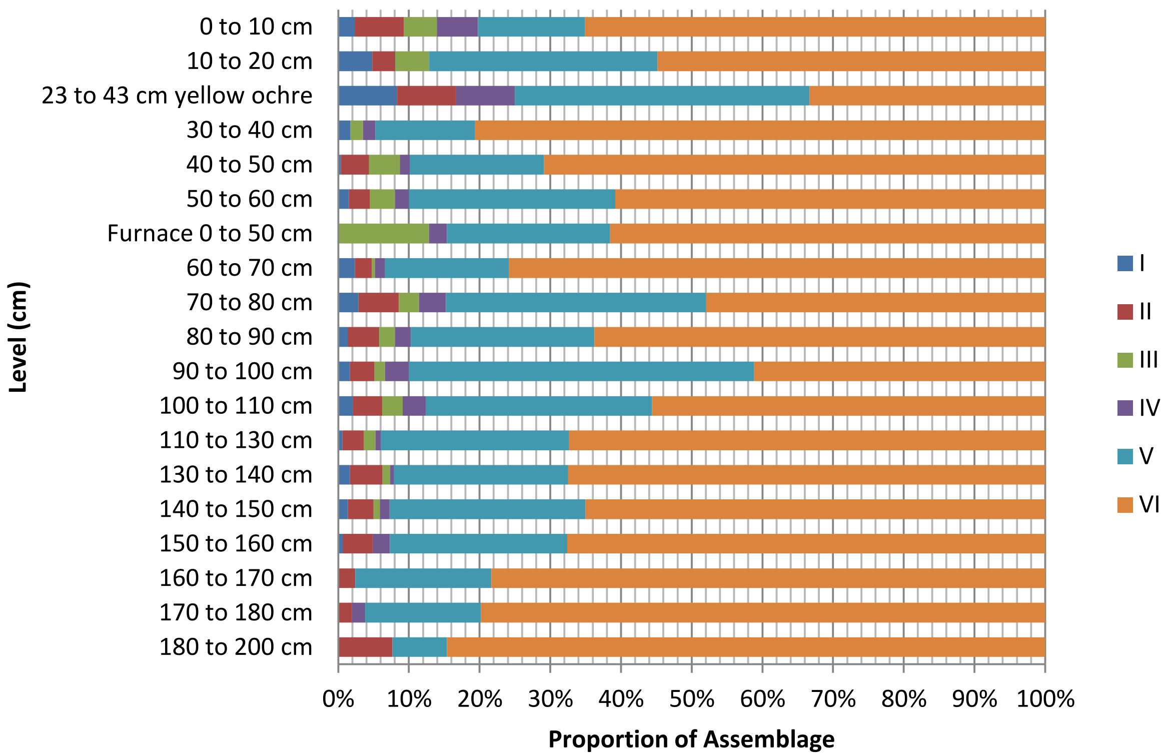
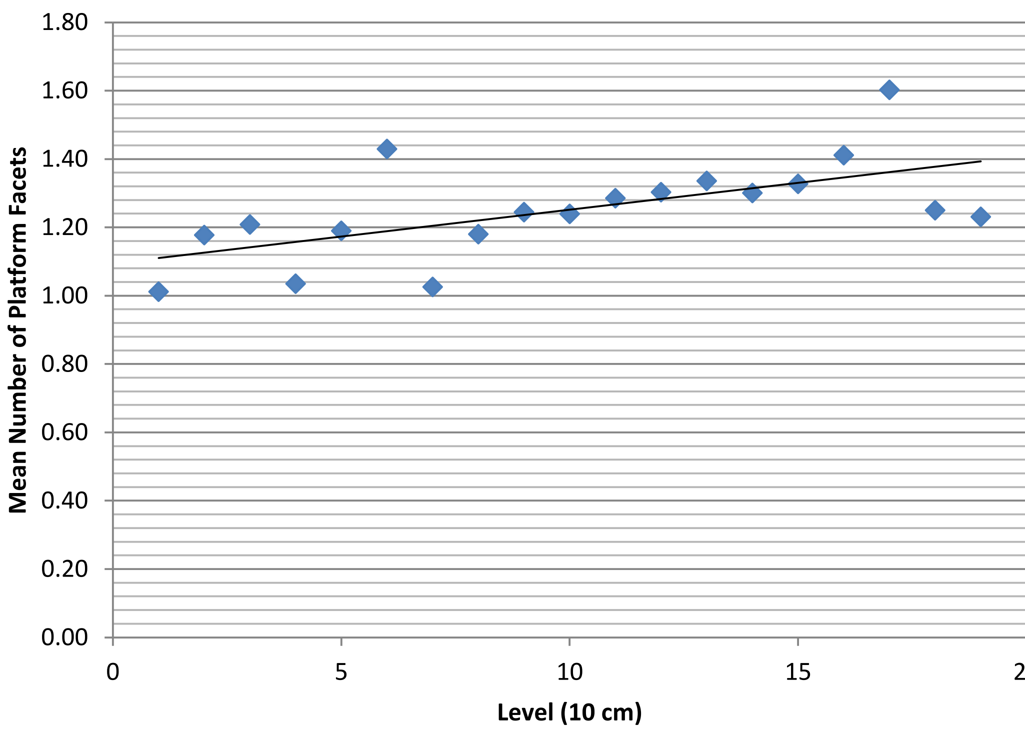


Figure 5.8. Mean Number of Platform Facets by Level.



(r_s= .7514 (df=15), p =.0005, r^2 =.5649)

Figure 5.9. Weight of Debitage by Level.

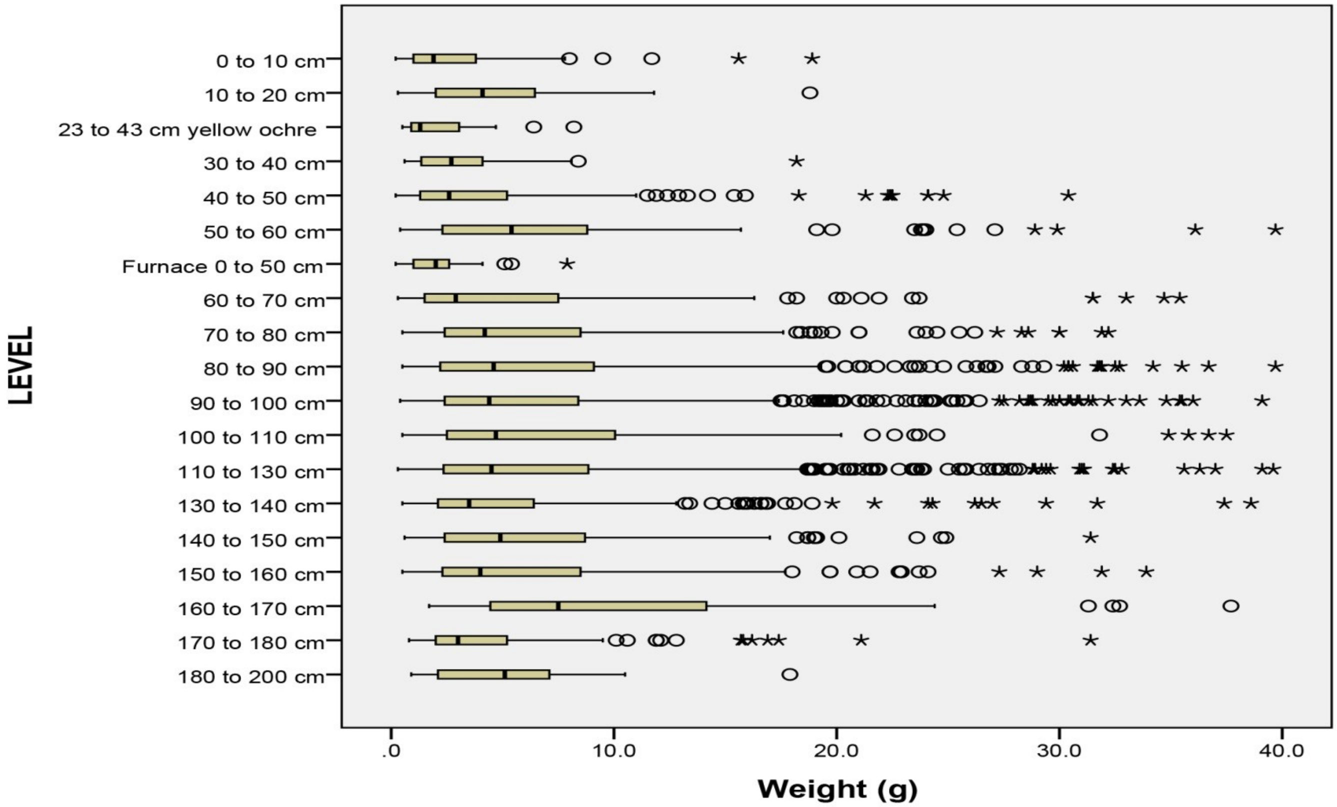


Table 5.1. Angle of Retouch by Tool Type.

Tool Type	Mean (Degrees)	N	SD
Scraper	42.21	258	18.356
Backed Piece	88.22	261	5.931
Point	34.82	28	12.944
Burin	90.00	8	0.000
Bifacially Modified Piece	44.44	18	12.935
Bec	45.00	1	
Outil Ecaillé	85.29	35	15.762
Heavy Duty Tool	53.33	3	25.166
Total	64.71	612	26.860

Table 5.2. Mean Dimensions of Trimmed Pieces.

Tool Type		Length (mm)	Breadth (mm)	Thickness (mm)	Weight (g)
Scraper	Mean	32.546	28.951	8.637	9.250
	N	258	258	258	258
	SD	10.3922	9.6635	3.1723	8.9872
Backed Piece	Mean	22.049	18.261	5.815	2.613
	N	297	297	297	297
	SD	5.7537	5.5333	1.8824	2.2169
Point	Mean	35.852	29.843	8.605	9.697
	N	77	77	77	77
	SD	11.6921	10.0000	2.5568	9.3949
Burin	Mean	26.589	21.250	6.644	4.189
	N	18	18	18	18
	SD	5.9316	4.3624	1.8750	2.5233
Bifacially Modified Piece	Mean	35.144	33.878	12.000	21.650
	N	18	18	18	18
	SD	13.6179	12.5160	5.5002	32.3917
Bec	Mean	11.400	17.700	4.100	.600
	N	1	1	1	1
	SD				
Outil Ecaillé	Mean	25.703	22.381	7.818	4.803
	N	124	124	124	124
	SD	5.7356	5.0557	2.0043	3.3327
Heavy Duty Tool	Mean	98.200	71.767	40.700	329.533
	N	3	3	3	3
	SD	35.6787	17.8875	9.6576	168.4212
Other Tool	Mean	46.500	44.200	12.200	26.500
	N	1	1	1	1
	SD				

Table 5.3. Mean TCSA of different point delivery systems.

Samples	Mean (mm^2)
Arrowhead	33
Dart Tip	58
Spear Tip	168
Magubike Projectiles	137

Table 5.4. Remaining Cortex by Core Type.

Tool Type	Mean	N	Std. Deviation
Peripheral Core	20.39	38	16.497
Patterned Platform Core	22.56	39	23.364
Intermediate Core	11.00	5	15.166
Bipolar Core	21.34	489	21.034
Amorphous Core	50.00	3	40.000
Total	21.42	574	21.051

Table 5.5. Mean Number of Flake Scars by Core Type.

Tool Type	Mean	N	Std. Deviation
Peripheral Core	9.53	38	3.446
Patterned Platform Core	6.41	39	3.050
Intermediate Core	8.40	5	5.128
Bipolar Core	4.12	489	2.760
Amorphous Core	6.67	3	3.786
Total	4.68	574	3.206

Table 5.6. Mean Dimensions of Cores.

Tool Type		Length (mm)	Breadth (mm)	Thickness (mm)	Weight (g)
Peripheral Core	Mean	42.311	34.508	20.834	42.674
	N	38	38	38	38
	SD	12.7046	10.8582	9.3322	76.1964
Patterned Platform Core	Mean	60.241	44.136	26.967	105.931
	N	39	39	39	39
	SD	17.8922	15.1349	12.4068	113.7062
Intermediate Core	Mean	63.960	45.820	25.840	129.800
	N	5	5	5	5
	SD	19.4445	16.5110	16.5425	219.2766
Bipolar Core	Mean	38.665	29.046	16.955	21.450
	N	350	350	350	350
	SD	10.2876	11.0243	4.2677	18.0939
Amorphous Core	Mean	42.067	38.567	27.267	68.000
	N	3	3	3	3
	SD	11.2010	10.6397	10.6922	48.5142
Total	Mean	41.232	31.134	18.365	32.445
	N	435	435	435	435
	SD	13.2213	12.3873	6.9695	55.2642

Table 5.7. Distribution of Toth Types.

Toth Type	Percentage (%)	N
I	1.5	57
II	3.9	148
III	1.7	64
IV	2	77
V	29.6	1121
VI	61.2	2316
Total	100	3783

Table 5.8. Distribution of Toth Types by Raw Material.

Raw Material							Total
Toth Type		**Quartz**	**Quartzite**	**Chert**	**Other Metamorphic**	**Other**	
I	N	22	11	3	20	1	57
	%	38.60%	19.30%	5.30%	35.10%	1.80%	100.00%
II	N	23	49	33	36	7	148
	%	15.50%	33.10%	22.30%	24.30%	4.70%	100.00%
III	N	14	16	26	6	2	64
	%	21.90%	25.00%	40.60%	9.40%	3.10%	100.00%
IV	N	25	17	14	20	1	77
	%	32.50%	22.10%	18.20%	26.00%	1.30%	100.00%
V	N	246	192	176	465	42	1121
	%	21.90%	17.10%	15.70%	41.50%	3.70%	100.00%
VI	N	458	259	282	1227	90	2316
	%	19.80%	11.20%	12.20%	53.00%	3.90%	100.00%

Table 5.9. Distribution of Planform Types.

Planform	N	Percentage (%)
Convergent	1102	23.4
Parallel	1314	27.9
Divergent	2008	42.6
Intermediate	29	.6
Circular	211	4.5
Unknown	46	1.0
Total	4710	100.0

Table 5.10. Distribution of Flake Scar Pattern Types.

Flake Scar Pattern	N	Percentage (%)
Unknown	18	.4
Radial	595	12.6
Same Pattern, Simple	2209	46.9
Same Pattern, Parallel	453	9.6
Opposed Platform	801	17.0
Transverse	359	7.6
Convergent	88	1.9
None	170	3.6
Bipolar	14	.3
Total	4707	100.0

Table 5.11. Mean Dimensions of Debitage.

Tool Type		Length (mm)	Breadth (mm)	Thickness (mm)	Weight (g)
Angular Fragment	Mean	30.424	16.105	6.097	3.532
	N	176	176	176	176
	SD	9.3562	5.7039	2.1837	3.6265
Specialized Flake	Mean	21.438	7.692	5.050	.750
	N	24	24	24	24
	SD	5.4805	1.7949	1.2043	.3257
Flake	Mean	27.329	26.922	7.924	7.455
	N	3370	3370	3370	3370
	SD	11.1332	10.0931	3.6281	10.6871
Blade	Mean	36.793	19.844	7.963	6.576
	N	313	313	313	313
	SD	12.4363	6.7892	3.1002	6.4753
Levallois Flake	Mean	37.312	37.858	10.572	15.620
	N	103	103	103	103
	SD	10.7089	10.9558	3.4558	12.0212
Total	Mean	28.431	26.055	7.897	7.384
	N	3986	3986	3986	3986
	SD	11.5273	10.3885	3.5752	10.3367

Chapter 6 DISCUSSION AND CONCLUSIONS

The primary objective of this thesis is to explain the lithic variation in Test Pit 12, with the intention of reconstructing the larger environmental and social context of the MSA and LSA during which modern human behaviour evolved. This thesis also explores the possibility that Magubike was a Pleistocene refugium, a key centre for long-term habitation and behavioral evolution. Furthermore, because Magubike is a relatively new site, located in an archaeologically understudied region of Tanzania, the information presented here will be a vital source for future comparative work.

As rockshelters often accumulate cultural materials faster than they can be buried and stratified, the resolution of the analyses considered here is suspected to be low. Under these conditions the formation of an archaeological palimpsest is likely; and the individual levels of Test Pit 12 potentially represent tens of thousands of years and multiple phases of habitation conflated into narrow bands of sediment. Further uncertainty is introduced by the possibility of post-depositional stratigraphic disturbances. Nevertheless, when the entire sequence of Test Pit

12 is considered, a number of significant observations can be made with regard to the average tendencies of the assemblage (Bailey and Galanidou, 2009).

6.1 Typological Analysis

Raw Material

In Test Pit 12 there were two major lithic raw material types that formed the bulk of the assemblage: quartz and “other (than quartzite) metamorphic” stones. Small packages of quartz were the preferred raw material type during the LSA/Iron Age and later. Although quartz is considered a low quality raw material, high quality quartz artifacts were found which had been skillfully transformed. Nevertheless, the high prevalence of bipolar technology in Test Pit 12 was almost certainly a response to the properties of quartz; namely, the inherent difficulty in dependably removing usable flakes. Despite a lack of success in locating quarries, the high proportion of quartz artifacts in the assemblage, and its low quality status, suggest that it is, and was, probably locally and widely available (within ~10 km of the site). Although quartz dominated most of the sequence, above 40 - 50 cm it was increasingly relied upon by the site’s inhabitants. This change in raw material inclination is associated with additional typological and technological transitions that are thought to indicate the end of the MSA and the beginnings of the LSA/Iron Age at the site. Without better dates, it is difficult to determine whether or not these periods are contiguous or if there was a hiatus in occupation.

The other major source of lithic material in Test Pit 12 was “other metamorphic” stones. These were generally fine to course-grained, dark in colour, and found in larger package sizes than quartz. While most artifact categories were preferentially produced on quartz, several classes, such as points, showed a preference for “other metamorphic” materials. Chert and quartzite each made up relatively small proportions of the assemblage, and their use remained consistently minor in every level of the unit (chert: 7.6%, n=1119; quartzite: 5.6%, n=826).

The change in lithic material preference in Test Pit 12 has a number of possible behavioural explanations which may reflect alterations to the social and environmental context of Magubike. As both the late MSA and LSA are the thought to be characterized by periods of intermittent scarcity, brought on by glacial episodes, a number of attendant changes in human behaviour, mobility patterns, and site-use strategies were encouraged to develop (Henshilwood and Marean, 2003). In particular, resources such as food and water probably decreased in abundance, while lithic resources may have become less accessible due to increased competition between human groups. Vacillating periods of glacially-induced aridity were also responsible for substantially altering ecosystems across Africa during the late Pleistocene, resulting in the archaeological abandonment of certain regions (Ambrose, 1998).

As human populations became concentrated in narrower habitable zones, interactions between communities likely became more frequent and intense. It is possible to speculate, based on the proliferation of social technologies commonly used to mark individual and group identity, that a greater sense of territoriality emerged during this period. The partitioning of the landscape by humans might have resulted in smaller home-ranges and fewer opportunities to access previously exploited raw material sources. Since the procurement of lithic materials is shown ethnographically to be embedded within other resource procurement cycles, non-local sources may have become less accessible or excluded entirely due to changing mobility patterns (McCall, 2007). Also likely, some technological approaches practiced in the LSA and Iron Age, such as the production of backed microliths, might have favoured quartz over other raw material types. In Tanzania, a similar pattern of raw material change was also noted at Nasera by Mehlman (1989) in his observation of the MSA and LSA there.

General Categories

General categories are the broadest division of lithic artifacts within Mehlman's (1989) typology, and include four classes: trimmed pieces, cores, debitage, and non-flaked stone. Over time, changes in the proportion of some of these categories with respect to one another were observed. Specifically, from the oldest levels in Test Pit 12 through to the most recent, the proportion of trimmed pieces increased while the proportion of debitage declined. The proportion of cores remained relatively stable throughout the history of occupation. Non-flaked stones were not investigated in any detail because only six pieces were found, and some of these are of questionable anthropogenic origin.

A possible explanation for the increase in trimmed pieces and decline of debitage is that expedient tool industries in the MSA eventually gave way to the production of more formal implements in the LSA/Iron Age. Trimmed pieces are easily recognized as tools; however, a great number of stone flakes were undoubtedly used without further alteration once removed from cores. These so-called expedient tools are difficult to recognize archaeologically, and consequently are usually classified with the debitage (Andrefsky, 2005). The lack of retouch on many MSA artifacts, despite their use as tools, may have contributed to an inflated number of debitage pieces in these levels. The difference might also be related to the ways in which the site was used during these respective periods. MSA people, for instance, may have used the site to manufacture tools that were subsequently removed from the site for use elsewhere. On the other hand, the LSA/Iron Age inhabitants of Magubike might have been using and discarding a higher proportion of tools on-site, rather than exporting them.

The typological distribution of trimmed pieces is generally consistent with other East African localities such as Lukenya Hill (Barut, 1994). Backed pieces, for instance, were found in all levels of Test Pit 12 but were most common in the levels above 40 – 50 cm, which are thought to correspond to the LSA and Iron Age. In the MSA layers below, points and scrapers were more typical.

Blades are considered an important typological criterion of LSA and Upper Palaeolithic industries; but, contrary to expectations, blades were most common in the MSA levels of Test Pit 12. The decline in blade production during the LSA/Iron Age may be due to the increased reliance on quartz during this period. As quartz tends to shatter, it may not have been well suited to the creation of viable blade blanks.

Three primary core types were reliably found throughout the sequence of Test Pit 12. By proportion, the most numerous of these were bipolar (85.2%, n=489), followed by patterned platform cores (6.8%, n=39) and peripheral cores (6.6%, n=38). As mentioned earlier, the large number of bipolar cores was probably a means of processing rounded cores of obstinate quartz. Although patterned platform cores and peripheral cores are thought to have chronological connotations, they did not exhibit any significant relationship with depth. To conclude, the end products of the reduction sequence appear to have exhibited change over time, but the methods of producing flake blanks remained relatively constant.

6.2 Technological Analysis

Trimmed pieces

While there was an increase in the number of trimmed pieces during the Iron Age and LSA, the methods used to create them did not change substantially; one of the few exceptions, backed pieces were found to be slightly larger during the MSA than in the LSA/Iron Age. Since it has been suggested that the high numbers of backed pieces in the MSA layers of the site is due to the downward migration of LSA lithics, it is important to consider these results (Alexander, 2010). While vertical movement is possible, the overall larger size of the MSA backed pieces also suggests technological differences between the two components of Test Pit 12. Furthermore, large MSA backed segments have been observed at other sites such as Twin Rivers and Kalambo Falls in Zambia (Barham, 2002). Within East Africa specifically, large backed segments were also recovered at Mumba; and date there to around 130 ka (Mehlman, 1989).

The extent to which most trimmed pieces were retouched was also not strongly correlated with depth. Most tools were only marginally retouched, a feature which changed little depending on their position in the sequence. What variation that did exist was mostly related to raw material and tool type. In particular, quartz was almost never retouched beyond marginal, while chert tools and bifaces were much more frequently selected for more extensive modification.

Because the size of the points in Test Pit 12 showed little variation, it was possible to group them and calculate their average TCSA (tip cross-section area). Based on the result of this analysis, it was determined that they likely tipped hand-cast or thrusting spears. Moreover, the large size of the points would have made them unwieldy as arrow-heads or darts. This conclusion is in accordance with descriptions of MSA technology elsewhere (Shea, 2006). Although there is evidence that backed microliths served as armatures for arrows propelled by bows, this practice appears relatively late in the MSA; and was not specifically addressed in this study (Lombard, 2005).

Cores

Core reduction methods in Test Pit 12 also underwent few changes over the lifetime of the unit. Most of the variation in core size existed between typological categories, reinforcing the strength of these groupings but contributing little to discussions of temporal change. Size variation over time by material type was detected; however, and is presented in the section on lithic resource-use intensity.

Debitage

The presence of Toth types I through VI in Test Pit 12 indicates that all stages of lithic manufacture were practiced at the site. However, without experimental data on the approximate proportion of each type produced by common MSA and LSA reduction sequences, there is little more that can be interpreted. Even so, it is worth noting that Toth types were related not only to raw material type but also to depth in the sequence. The highest Toth mean value was documented for “other metamorphic” stones, for instance, while quartzite had the lowest. It is possible that the difference in Toth types indicates that the two materials were reduced to disparate degrees, or that they belonged to separate operational chains. The mean Toth number also increased with depth, possibly demonstrating that lithic resources were used more intensively in the lowest MSA levels of the site, or that more off-site core preparation occurred during this time.

The mean number of platform facets was also shown to increase with depth, potentially indicating more intensive core preparation in the lower levels of Test Pit 12. This distribution is consistent with current assumptions regarding MSA technology, particularly Levallois flaking, which is discussed separately below.

6.3 Levallois Technology

Levallois technology is considered a hallmark of the MSA. Developed in the terminal Acheulean, the Levallois method became widespread in parts of Africa, the Middle East, and Europe during the MSA and Middle Palaeolithic (Tryon et al., 2005). The technique is thought to provide added control over the morphology of detached flakes, and may have been a means of standardizing lithic manufacture for the purpose of hafting (Brantingham and Kuhn, 2001). Subsequent to the emergence of blade and bladelet industries during the LSA, however, the technology appears to have faded out.

A number of different indicators of Levallois flaking were detected in Test Pit 12, including Levallois flakes, points, and a single Levallois core. The presence of just a single Levallois core, excavated from Level 130 – 140 cm, is potentially problematic, calling into question the classification of a number of other Levallois products. Nevertheless, as noted by Van Peer (1992), the presence of Levallois cores appears to be a variable component of Levallois assemblages at some sites; the most likely explanation is that Levallois cores were simply reduced beyond recognition.

Despite the recovery of only a single Levallois core, the majority of the points recovered from Test Pit 12 were Levallois, a frequency which suggests a substantial reliance on the technology to produce projectile armatures. Otherwise, Levallois points were missing from the top 30 cm of the deposit; but were distributed evenly throughout the remaining levels.

Conversely, Levallois flakes comprised only a very small proportion of the total flakes found in Test Pit 12. This distribution is not necessarily surprising given that the reduction of a Levallois core may only result in only one Levallois flake, while many non-diagnostic flakes are produced simultaneously. Like points, Levallois flakes were not found in the top 40 cm of the unit; and only appeared in the MSA levels. Below that, they showed no relationship to the depth of the sequence.

Finally, the mean number of platform facets per flake increased with depth. As platform facets are thought to indicate relative degrees of core preparation, they may assist in detecting changing technological strategies over time. Although not specifically related to Levallois technology, core and platform preparation is a feature of Levallois flaking; and the relationship might indicate a higher prevalence of Levallois or related techniques during the MSA of Test Pit 12.

In summary, the occurrence of Levallois pieces during the MSA, paired with their relative absence during the LSA/Iron Age of Test Pit 12, accords with typological patterns observed at other MSA and LSA sites (Tryon et al., 2005).

6.4 Lithic Raw Material-Use Intensity

Many authors argue that the appearance of modern human behaviour was stimulated by environmental and socio-demographic pressure on African hominins during the Late Pleistocene (McBrearty and Brooks, 2000). As populations moved into new areas and/or were condensed into existing habitable zones, new adaptive and social strategies were required in order to cope with changing patterns of resource availability, and greater exposure to unfamiliar people. A likely result of this contact was an increase in competition for resources such as lithic raw materials, causing a shift in preference for technologies that made more efficient use of cores and blanks. It is hypothesized here that periods of limited resource availability, such as those that typified the Late Pleistocene, ought to be characterized by an increase in technologies intended to maximize lithic materials (McCall, 2007). If this hypothesis is true, an increase in lithic resource-use intensity from the oldest deposits at Magubike to the most recent ones is expected.

In order to investigate this possibility, a number of typological and technological variables were selected and compared with respect to their position in the sequence. Foremost amongst these indicators was evidence of the bipolar reduction strategy in each level of the unit, specifically the proportion of bipolar cores and scalar pieces. Since the bipolar method is an effective way of producing flakes from naturally small, rounded stones, or cores exhausted using other flaking methods, its use is hypothesized to be sensitive to changes in resource type and availability. The remaining cortical cover of cores was also employed as an indicator of lithic resource-use intensity. It was hypothesized that cores that had been more exhaustively reduced would retain less of their outer surface than those that had been only casually flaked. Similarly, the average weight of cores per level was plotted with depth. It was hypothesized that cores that were flaked more intensively would be smaller, irrespective of core type, a feature which was shown to be consistent across the levels of the site. The average number of flake scars per core was considered as a predictor of resource-use intensity, but was rejected once flake scar count was determined to be more heavily dependent on core size, type, and raw material.

In spite of expectations, the distribution of bipolar cores demonstrated that the prevalence of the bipolar technique remained relatively stable over the occupational history of Magubike.

Specifically, a Spearman's rank-order correlation showed no relationship between the depth of the sequence and the proportion of bipolar cores in each layer (r_s=.1925 (df=15), p =.4590, r^2 =.0370). Scalar pieces, on the other hand, were proportionally more numerous in the oldest levels of the site compared to the more recent ones (r_s=.75 (df=15), p =.0012, r^2 =.5625). This result actually suggests that bipolar flaking became less common from the oldest layers of the site to the most recent ones: the inverse of the expected pattern.

The mean cortical cover (measured in percent) for each level was found to be heavily influenced by outlier cases. Rather than use the mean, the median of the data set was determined to be a better indicator of central tendency. Even so, a Spearman's rank-order correlation showed the median cortical cover to be an inconclusive measure of lithic resource-use intensity (r_s=.2785 (df=15), p =.2803, r^2 =.0776).

Because core weight is a function of several different factors, including raw material type, mean core weight was calculated separately for quartz and "other metamorphic" stones. Quartz cores were on average smaller than "other metamorphic" cores, and a Spearman's rank-order correlation revealed that they were similar in size in each level of the sequence (r_s=.1642 (df=15), p =.5318, r^2 =.0270). "Other metamorphic" cores, conversely, were found to be smaller in the lower levels of the unit and larger in the upper layers, possibly indicating a change in lithic resource-use intensity (r_s= -.8818 (df=15), p =.0003, r^2 =.7776).

Of the variables used to predict lithic resource-use intensity, all were found to be consistent with a pattern of continuity or decline in resource-use intensity over time – none showed an increase. These findings are the opposite of the anticipated outcome, which predicted an increase in lithic resource-use intensity over time. The pattern may be related to the climatic stability of Magubike relative to other African sites during the Late Pleistocene. Instead of facing lithic scarcity like African hominins elsewhere, the people of Magubike may have been buffered against climate and population stresses to some degree. There are, however, several alternate explanations for the change in material behaviour that need to be acknowledged.

Firstly, it is possible that the change to local, low quality quartz stones was an attempt to ameliorate raw material constraints as a result of limited access to higher quality "other metamorphic" stones. The end result would be continuity, or even decline in lithic resource-use intensity as widely available quartz sources were exploited more heavily, despite an overall increase in competition for other types of stones.

A similar pattern in lithic resource-use intensity might also be observed due to changing site-use habits or mobility patterns. Other research has shown that more sedentary hunter/gatherer groups tend to rely more strongly on expedient technology and localized lithic materials. Mobile groups, alternatively, typically produce and curate more formalized tools, as the presence of suitable stones is not always assured to them (Andrefsky 2005). If sedentism increased over time at Magubike, a reliance on local but ubiquitous stones might have resulted in a decline in lithic resource-use intensity.

6.5 Implications for the Study of Behavioural Evolution

The lithic artifacts of Test Pit 12 reveal remarkable typological and technological continuity, given the extended time period during which the site was occupied. However, a number of temporal trends did emerge. In particular, several hallmarks of the LSA, such as blade technology, actually appeared to decline in prominence through time; and are nearly absent after the MSA. Evidence of advanced behaviours, such as range expansion or the long-distance trade of exotic lithic materials during the LSA/Iron Age and MSA components of the site, was also lacking. Rather, the technologies employed at Magubike seem to have been greatly influenced by the properties of the local raw materials available to the site's inhabitants.

Furthermore, the lithic assemblage in Test Pit 12 supports a piecemeal advent for several different hallmarks of modernity which were likely added to, and dropped from, the technological repertoire of the site's inhabitants as the situation warranted or allowed. These findings confirm current assertions that modernity emerged idiosyncratically and non-synchronously, although the timeframe of these changes remains unclear (McBrearty and Brooks, 2000).

The research presented here also underscores the inherent dangers of relying on a "laundry-list" definition of modernity, especially behaviours related to technology or subsistence. Such lists are unlikely to encompass the total range of variation in the archaeological record, and say little about the cognitive abilities of the people that produced it. A simple presence and absence type dichotomy is also likely to be stymied by taphonomic forces and the effects of local site-use and context. As per the suggestion of other scholars, this thesis has instead attempted to target and explain, in behavioural terms, specific sources of variation and their probable causes (Henshilwood and Marean, 2003).

The work here also supports the possibility that Magubike was a refugium, and thus vital for the study of behavioural evolution and transition during the Late Pleistocene (Basell, 2008; Stringer, 2012; Willoughby, 2012). The apparent long-term abandonment of important MSA sites from northern and southern Africa during MIS 4 and 2 has left an unfortunate a gap in our understanding of the behavioural change that characterized the MSA and LSA (Ambrose, 1998). The evidence for climatic stability at Magubike and the near continuity of its archaeological deposits, however, makes it a unique test case from which to test models of behavioural evolution.

6.6 Future Work

In order to push future analysis forward, it is important to acknowledge shortcomings in the present study and to recommend prospective avenues of inquiry. Firstly, a key question that remains unresolved is the pace of the transition that characterized the MSA and LSA. Regrettably, the temporal resolution of the site is not yet well enough understood to estimate the rate of change in the lithic assemblage. Given that a degree of stratigraphic disturbance is suspected, obtaining this level of temporal control will likely be challenging. Nonetheless, the dating of Magubike's stratigraphy is still ongoing; and although some of the results reveal the possibility of complications, a generally coherent pattern has emerged. Interpreting these dates in conjunction with a more thorough understanding of the relevant site formation processes is important for reconstructing the temporality of Magubike.

Secondly, the analysis was performed on the materials from only a single excavation unit. While analysis of a limited sample was necessary to meet the requirements and constraints of a thesis project, it is hoped that further efforts will build on what has been established. In particular, previous work has already been completed on Test Pits 1 and 3 (Alexander, 2010), making an intra-site comparison possible.

Thirdly, every typology features a unique set of strengths and weaknesses that are important to acknowledge. Specifically, the need to balance the universality of a typology against its ability to describe singular assemblages creates unavoidable shortcomings in both areas. Depending on the scope of the typology, certain essential details of an assemblage may be lost if the typology is too general; or the typology might be unable to effectively communicate and compare results between assemblages if too specific. In the case of Mehlman's (1989) typology, several artifact categories that have been noted in other archaeological projects were missing. Levallois points, although an important component of the sequence at Magubike, for instance, were not included. Similarly, there was not a discrete category for denticulate pieces. Although possibly limiting the opportunity for comparison, the lack of some categories was resolved by appending additional ones (such as Levallois points). Mehlman's typology also does not contain a category for trimmed pieces with an angle of retouch below ~30 degrees (so-called cutting retouch). For the purpose of this study, all trimmed pieces that otherwise matched the criteria were labeled as scrapers despite retouch angle. In doing so, however, it is possible that functional information with respect to angle of retouch was lost.

The inclusion of scalar pieces within trimmed pieces (despite a lack of intentional modification) is also a product of convention more than it is an intuitive method of organizing the typology. In addition, as pointed out by (Alexander, 2010), the decision to classify core fragments as debitage with the exception of bipolar core fragments, potentially inflates the frequency of bipolar cores with respect to other core types if not properly accounted for. Furthermore, as each of these issues is likely to be addressed differently by different researchers, it becomes more difficult to share results between studies and across sites.

Lastly, Toth types record valuable behavioural information about the use of lithic materials within a specific site, or series of sites. The information provided by Toth types enables archeologists to detect activities such as the transport of lithic materials, and the pre-processing of cores off-site; and provides a way to gauge lithic resource-use intensity (Toth, 1987). However, in order to interpret Toth types effectively, the mean proportion of each type for a given reduction sequence must be established experimentally in advance. This procedure requires a large amount of initial input, and was not attempted given the constraints of this project. The creation of an experimental assemblage is therefore a vital next step in the continued lithic analysis of Magubike.

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APPENDIX I: ARTIFACT CODEBOOK

Codebook: Stone artifact analysis (2012) P. R Willoughby
Variables for Iringa Stone Age Archaeological Project (IRAP)

Variable #	Variable Name	Value Labels	Min/Max
1		Site / Square	
Magubike (HxJf-1)		(1) tp6	1/7
		(2) tp7	
		(3) tp8	
		(4) tp9	
		(5) tp10	
		(6) tp11	
		(7) tp12	
		(999) missing	
2	Level	(1) 0 to 10 cm	1/28
		(2) 10 to 20 cm	
		(3) 23 to 43 cm – yellow ochre feature (tp11)	
		(4) 20 to 50 cm non-ochre (tp11)	
		(5) 20 to 30 cm	
		(6) 30 to 40 cm	
		(7) 40 to 50 cm	
		(8) 50 to 60 cm	
		(9) Furnace 0 to 50 cm (tp12)	
		(10) 60 to 70 cm	
		(11) 70 to 80 cm	
		(12) 80 to 90 cm	
		(13) 90 to 100 cm	
		(14) 90 to 103 cm- (big rock cleaning (tp10)	
		(15) 103 to 110 cm (tp10)	
		(16) 100 to 110 cm	
		(17) 110 to 120 cm	
		(18) 110 to 130 cm (tp12)	
		(19) 120 to 130 cm	
		(20) 130 to 140 cm	
		(21) 130 to 140 cm cleaning (tp11)	
		(22) 140 to 150 cm	
		(23) 150 to 160 cm	

		(24) 160 to 170 cm (25) 170 to 180 cm (26) 180 to 190 cm (27) 180 to 200 cm (tp12) (28) 190 to 200 cm	
3	Case # (for each site)	0001 to n	1/n
4	Cultural Designation (Culture)	(00) Not known (01) ESA (02) MSA (03) LSA (04) Neolithic (05) Iron Age (06) ESA + MSA (07) MSA + LSA (08) LSA + Neolithic (09) LSA + Iron Age (10) Neolithic + Iron Age (11) LSA, Neolithic + Iron Age (12) MSA, LSA, Neolithic + Iron Age (13) MSA and Iron Age (14) MSA, LSA and Iron Age (99) Missing	0/14
5	Stone Raw Material (Rawmat)	(1) Quartz (2) Rock crystal (3) Quartzite (4) CCS (5) Chert (6) Volcanic but not obsidian (7) Obsidian (8) Granite (9) Andesite (10) Tuff (11) Metamorphic (12) Mudstone (13) Siltstone	0/15

		(14) Sandstone	
		(15) Other	
		(99) Missing	

Note: variables 11 to 13 taken from Mehlman 1989:111-157

6	General Category (Gencat)	(1) Trimmed pieces=tools	1/4
		(2) Core	
		(3) Debitage	
		(4) Non flaked stone (inc. ground stone)	
		(9) Missing	
7	Tool type (subset of v6) (Tooltype)	TOOLS	01/27
		(01) Scraper	
		(02) Backed pieces	
		(03) Points/perçoirs	
		(04) Burins	
		(05) Bifacially modified pieces	
		(06) Becs	
		(07) Composite tools	
		(08) Outils écaillés	
		(09) Heavy duty tools	
		(10) Others	
		CORES	
		(11) Peripherally worked core	
		(12) Patterned platform	
		(13) Intermediate	
		(14) Bipolar	
		(15) Amorphous	
		DEBITAGE	
		(16) Angular fragments	
		(17) Specialized flakes	
		(18) Flakes	
		(19) Blades	
		(20) Levallois flakes	

		NON-FLAKED	
		(21) Hammerstones	
		(22) Anvil stones	
		(23) Pestle rubbers	
		(24) Polished axes	
		(25) Stone discs	
		(26) Sundry ground/polished	
		(27) Manuports	
8	Tool Subtype		1/110
	(subset of v7)	(001) Small convex scraper	
	(Subtype)	(002) Convex end scraper	
		(003) Convex double end scraper	
		(004) Convex end and side scraper	
		(005) Circular scraper	
SCRAPERS (01)		(006) Nosed end scraper	
		(007) Convex side scraper	
		(008) Convex double side scraper	
		(009) Nosed side scraper	
		(010) Sundry end scraper	
		(011) Sundry double end scraper	
		(012) Sundry end and side scraper	
		(013) Sundry side scraper	
		(014) Sundry double side scraper	
		(015) Concave scraper	
		(016) Concavity	
		(017) Notch	
		(018) Sundry combination scraper	
		(019) Convex end + concave combination scraper	
		(020) Convex side + concave combination scraper	
		(021) Divers scraper	
		(022) Convergent scraper	
		(023) Scraper fragment	
BACKED PIECES (02)		(024) Crescent	
		(025) Triangle	
		(026) Trapeze	
		(027) Curved backed piece	
		(028) Straight backed piece	

	(029) Orthagonal truncation
	(030) Oblique truncation
	(031) Angle-backed piece
	(032) Divers backed
	(033) Backed awl/drill/perçoir
	(034) Backed fragment
POINTS (03)	(035) Unifacial point/perçoir
	(036) Alternate face/edge pt/perçoir
	(037) Bifacial point
	(106) Levallois points
BURINS (04)	(038) Dihedral burin
	(039) Angle burin
	(040) Mixed/other burin
BIFACIALLY MODIFIED PIECES (05)	(041) Discoid
	(042) Point blank
	(043) Bifacially modified piece
BECS (06)	(044) Becs
COMPOSITE TOOLS (07)	(045) Sundry composite tool
	(046) Burin + other composite tool
	(047) Backed + other composite tool
	(048) Scraper + other composite tool
OUTILS ECAILLES (08)	(049) Outils écaillés
HEAVY DUTY TOOLS (09)	(050) Core/large scraper
	(051) Handaxe
	(052) Core chopper
	(107) Cleaver
	(108) Pick
	(109) Core axe
	(110) Other heavy duty tool
OTHER (10)	(053) Sundry modified
	(054) Cutting edge

	(055) Bulbar thin/talon reduced
	(056) Tool fragment

CORES

PERIPHERALLY WORKED (11)	(057) Part-peripheral core (058) Radial/biconic core (059) Disc core (060) Levallois core
PATTERNED PLATFORM (12)	(061) Pyramidal/prismatic single platform core (062) Divers single platform core (063) Single platform core/ core scraper (064) Opposed double platform core (065) Opposed double platform core/ core scraper (066) Adjacent double platform core
PATTERNED PLATFORM (12)	(067) Adjacent double platform core/ core scraper (068) Multiple platform core
INTERMEDIATE (13)	(069) Platform/peripheral core (070) Platform/peripheral core/ core scraper (071) Platform/bipolar core (072) Platform/bipolar core/ core scraper (073) Bipolar/peripheral
BIPOLAR (14)	(074) Bipolar core (075) Bipolar core fragment
AMORPHOUS (15)	(076) Amorphous/casual

DEBITAGE

ANGULAR (16)	(077) Core fragment (078) Angular fragment (079) Trimmed/utilized angular fragment (080) Blade segment-medial or distal (081) Trimmed/utilized blade segment
SPECIALIZED FLAKES (17)	(082) Plain burin spall (083) Tool spall
FLAKES (18)	(084) Whole flake (085) Trimmed/utilized flake (086) Flake talon fragment (087) Trimmed/utilized flake talon fragment
BLADES (19)	(088) Whole blade (089) Trimmed/utilized blade (090) Blade talon fragment (091) Trimmed/utilized blade talon fragment
LEVALLOIS FLAKES (20)	(092) Levallois flake (093) Trimmed/utilized Levallois flake

NONFLAKED STONE

HAMMERSTONES (21)	(094) Hammerstones
ANVIL STONES (22)	(095) Edge anvil (096) Pitted anvil (097) Edge and pit anvil
PESTLE RUBBERS (23)	(098) Pestle rubber (099) Dimpled rubber
POLISHED AXES (24)	(100) Lobed axe (101) Other axe

STONE DISC (25)	(102) Pecked disc (103) Dimpled disc
SUNDRY (26)	(104) Sundry ground/shaped item
MANUPORTS (27)	(105) Manuports
	(999) Unknown

<u>For all stone pieces measure</u>:

9	Length (L) (mm.)	none	0/?
10	Breadth (B) (mm.)	none	0/?
11	Thickness (mm.)	none	0/?

For cores: length > breadth > thickness

12	Weight (gm.)	none	0/?
13	RatioBL (B / L)	none	0/1
14	RatioTB (T / B)	none	0/1
15	RatioTL (T / L)	none	0/1
16	Abrasion/ rolling (Abrasion)	(1) Fresh (2) Worn (9) Missing	1/2

For cores or core tools measure

For non-cores: put in value of 9 in each column for missing data (not applicable) for variables 22 to 22.

17	Cortex (%)	none (999) missing	0/100
18	# flake scars (Flakscar)	none (99) missing	0/n

For whole flakes and blades, as well as blade and flake tools, measure:

19	Toth flake # (Tothnum) (Toth 1982:73-75)	(1) I (2) II (3) III (4) IV (5) V (6) VI (7) VII (includes missing for tools) (9) Missing	1/7
20	Platform length (mm) (PL) (Platleng)	none (999.9) missing	0/?
21	Platform breadth (mm) (PB) (Platbred)	none (999.9) missing	0/?
22	Platform area (mm^2) (Platarea) (PB x PL)	none (9999.9) missing	0/?
23	Platform angle (Platangl) (to ventral)	none (999) missing	0/?°

24	# platform facets (Plafacet)	(0) none (1) 1 (2) 2 (3) 3 (4) 4 (5) 5 (6) >6 (7) Unknown (9) Missing	1/7
25	Flake area (B x L) (mm^2) (Flakarea)	none	0/n
26	Platform area / flake area (Relarea) (%)	none (9.99) Missing	0/1
27	# dorsal flake scars (Dorscars)	(0) none (1) 1 (2) 2 (3) 3 (4) 4 (5) 5 (6) 6 (7) 7 (8) 8 or more (9) Missing	0/8
28	Dorsal scar pattern (Scarpat) (McBrearty 1986:183)	(0) Unknown (1) Radial (2) Same platform, simple (3) Same platform, parallel (4) Opposed platform	1/8

		(5) Transverse	
		(6) Convergent (=point)	
		(7) None (=cortical)	
		(8) Bipolar	
		(9) Missing/not applicable	
29	Planform (McBrearty 1986:198-199)	(1) Convergent	1/6
		(2) Parallel	
		(3) Divergent	
		(4) Intermediate	
		(5) Circular	
		(6) Unknown	
		(9) Missing/not applicable	

<u>For retouched tools only</u>:

30	Angle of retouch (Anglreto) (to side retouch released from)	none	0/90°? (score >90° as 91) (99) Missing
31	Type of retouch (Retouch) (Clark and Kleindienst 1974:85)	(1) marginal	1/3
		(2) Semi-invasive	
		(3) Invasive	
		(9) None/missing	

32 Striking platform direction on points

	(Pointbot)	(1) End struck
		(2) Left side struck
		(3) Right side struck
		(9) Missing

APPENDIX II: STATISTICAL TEST RESULTS

Distribution of Quartzite and Level

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	183.031[a]	17	.000
Likelihood Ratio	255.396	17	.000
Linear-by-Linear Association	53.965	1	.000
N of Valid Cases	14707		

a. 1 cells (2.6%) have expected count less than 5. The minimum expected count is 2.02.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.113	.000
	Cramer's V	.113	.000
N of Valid Cases		14707	

Raw Material Preference by Core Type

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	42.254[a]	4	.000
Likelihood Ratio	36.929	4	.000
Linear-by-Linear Association	8.558	1	.003
N of Valid Cases	503		

a. 2 cells (22.2%) have expected count less than 5. The minimum expected count is 4.40.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.290	.000
	Cramer's V	.205	.000
N of Valid Cases		503	

Planform Type by Tool Type

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.030[a]	2	.018
Likelihood Ratio	8.132	2	.017
Linear-by-Linear Association	.397	1	.529
N of Valid Cases	482		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 58.56.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.129	.018
	Cramer's V	.129	.018
N of Valid Cases		482	

Flake Scar Pattern by Raw Material Type

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	79.948[a]	18	.000
Likelihood Ratio	83.659	18	.000
Linear-by-Linear Association	5.027	1	.025
N of Valid Cases	4490		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.51.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.133	.000
	Cramer's V	.077	.000
N of Valid Cases		4490	

APPENDIX III: PICTURES AND MAPS OF MAGUBIKE

Map of Tanzania (created by Dr. Pamela Willoughby).

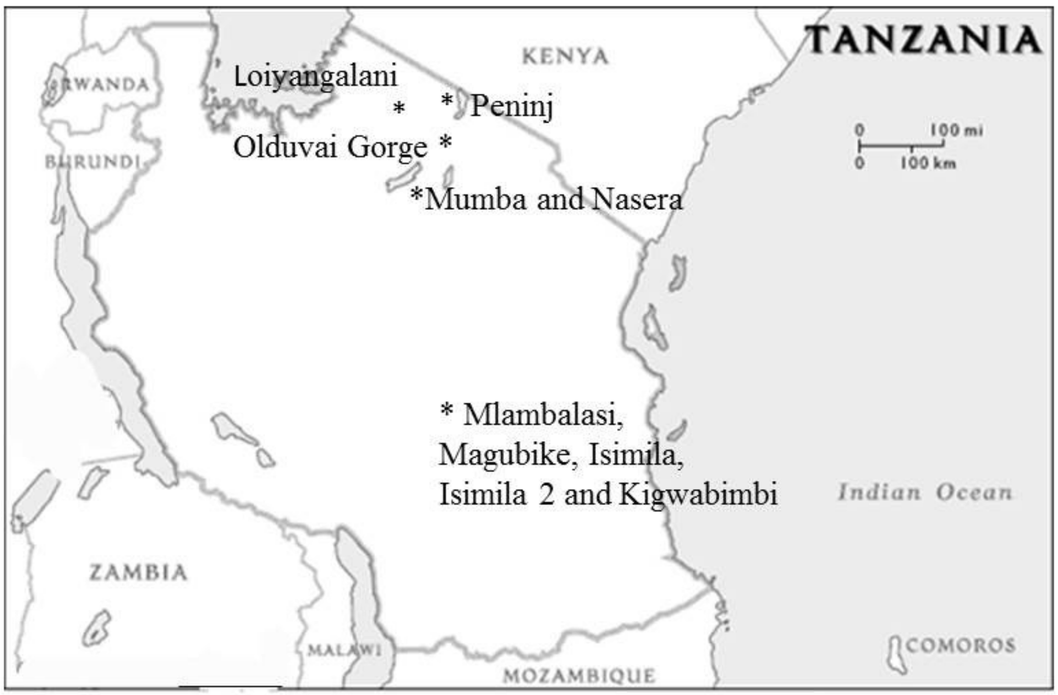

Photo of Magubike Rockshelter from below (photo by Dr. Pamela Willoughby).

Photo of Test Pit 12: Level 140-150 cm (photo by Dr. Pamela Willoughby).

Photo of Test Pit 12: Level 120-130 cm (photo by Dr. Pamela Willoughby).